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Trade-Based Global Supply Chain and Transport Logistics Hubs: Trends and Future Development

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Traditionally, sea and air shipping were seen as two separate activities but more recently, under the influence of globalization, they have been evolving into an integrated service profession. The *C.Y. Tung International Centre for Maritime Studies (ICMS), The Department of Logistics (LGT*), The Hong Kong Polytechnic University (PolyU)* is organizing the second **International Forum on Shipping, Ports and Airports (IFSPA 2008)** which will take place on PolyU's main campus during 25 – 28 May 2008.

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In addition, the Conference will dedicate a special session celebrating the 10th anniversary of the Hong Kong International Airport, and we are expecting a wide range of attendances from Asia-Pacific and other overseas regions attending IFSPA 2008.

As Conference Chairman, I sincerely hope that you will enjoy IFSPA, and Hong Kong.

Professor John Liu
Chairman, IFSPA 2008
Director, ICMS
Chair Professor of Maritime Studies
Head, Department of Logistics and Maritime Studies
The Hong Kong Polytechnic University

* The Department of Logistics (LGT) has, with effect from 1 September 2008, been renamed to the Department of Logistics and Maritime Studies (LMS).

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Effects of Competition and Policy Changes on Chinese Airport Productivity: An Empirical Investigation

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Abstract

This paper investigates the influence of competition and aviation policy reform (for example, the airport localization program and listing airports on stock markets) in China on the efficiency of Chinese airports. By using Data Envelopment Analysis, we estimate both the productivity level and its growth for twenty-five sample Chinese airports. After controlling for hub status and other airports' characteristics, we find that: (i) publicly listed airports are significantly more efficient than non-listed airports; (ii) airports with more competition are more efficient than their counterparts; (iii) the airports' efficiency and the technical progress are positively correlated with the airport localization program; and (iv) the impacts of "open skies" agreements and airline mergers on the airports' efficiency are statistically insignificant.

Keywords: Airport; Efficiency; Localization; Competition; DEA; Malmquist Index

1. Introduction

In the past few decades, rapid economic growth has significantly increased the demands for air services in China; between 1980 and 2005, the number of air passengers and cargo tonnage grew at an average rate of 16.8 percent and 18.2 percent per annum, respectively. This increasing air demand has placed enormous pressure on China's airport infrastructure. The situation is expected to get worse, as air travel is forecasted to grow at the still fast rate of 7.4 percent per year for the Chinese market over the next twenty years.[2] Thus, in addition to the infrastructure investment, there is an urgent need to improve the productivity of Chinese airports in order to relieve the pressure. Furthermore, as the liberalization of the airline industry continues, more foreign airlines will be allowed to operate in China, and will have increasing freedom to choose where they base their gateways in China. This would also put pressure on Chinese airports to further improve their own productivity, as the airlines want to locate at efficient airports in order both to reduce their operating costs and to improve the quality of their service. Thus an empirical investigation of factors affecting Chinese airport productivity has become important.

Assessment of airport productivity has become the focus of a large number of studies. Different methodologies have been used to measure the productivity of airports in different regions around the world (see Oum, *et al.*, 2003, for a comprehensive review). Due to a lack of data, however, it is difficult to assess airport productivity in China. A recent paper by Fung, *et al.* (2008) attempted to calculate the productivities for twenty-five major Chinese airports between 1995 and 2004. They found that over that period, airport efficiency was improving and the productivity among airports from different regions was converging. Using their data Zhang and Yuen (2008) further investigated whether privatization through public listing improves airport performance. Although they found a positive and statistically significant relationship between Chinese airport productivity and public listing, a large portion of the variance in productivity and its growth are still left unexplained by their regression models. Furthermore, their panel dataset does not capture the effects of policy changes on Chinese airport productivity after 2004, during which several important industry reform measures have taken place.

This paper investigates the effects of China's competition and aviation policy reform (for example, the

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[2] A forecast made by Boeing (http://www.boeing.com/companyoffices/aboutus/boechina.html).

airport localization program and listing airports on stock markets) on the efficiency of Chinese airports. Our sample data consist of a panel of twenty-five major airports for the period from 1995 to 2006. This new dataset may provide a better basis for investigating the effectiveness of recent policy changes on improving the Chinese airport productivity. In particular, we use Data Envelopment Analysis to compute efficiency scores for each airport. We then run regressions to examine the effects of the competition and aviation policy reform on the efficiency scores by controlling a set of airport characteristics and event variables.

Our empirical results reveal that airport localization has a strong impact on airport efficiency; the productivity of the localized airports is significantly higher than that of their counterparts. Furthermore, there is statistically significant evidence suggesting that airports with more competition are more efficient than their counterparts. There is also strong evidence that publicly listed airports are significantly more efficient than non-listed airports. We do not find, however, any statistically significant correlation between Chinese airport productivity and two specific policy changes at the airline level, namely the signing "open skies" agreements, and airline mergers arranged by the China's State Council in 2003. Finally, we use the Malmquist index method to investigate the effects of the competition and aviation policy reform on *changes* in the efficiency of Chinese airports. We find that efficiency growth and its component, technical efficiency, do not have a statistically significant relationship with the airport localization program, competition intensity or stock market listing. However, technical progress – the other component of efficiency growth – is positively, and statistically significantly, correlated with the airport localization program dummy.

This paper is organized as follows. Section 2 describes recent policy changes in the Chinese aviation market and their potential effects on airport productivity. Sections 3 and 4 discuss, respectively, the methodology and data employed by the paper. Section 5 reports the empirical results on airport efficiency levels, and Section 6 examines the changes in airport efficiency. Section 7 contains concluding remarks.

2. Recent Policy Changes and Airport Productivity

As part of the general economic reform, the reform of the aviation industry in China began in the late 1970s (see Zhang, 1998; Zhang and Chen, 2003; and Zhang and Yuen, 2008, for reviews). The "Report on Civil Aviation Reform Measures", which was passed by the State Council in January 1987, stated that the long-term goal of the industry reform was to separate the Civil Aviation Administration of China (CAAC) as the regulator from direct involvement in airline and airport operations. This goal would be achieved through the airport localization program, in which airports are turned over to local governments. As a pilot program of the airport localization program, operation of the Xiamen Airport and Shanghai Hongqiao International Airport (including all fixed and working capital and all personnel) was transferred to their municipal governments in 1988 and 1993, respectively. The CAAC, however, was still heavily involved in the late 1980s and 1990s. The localization program regained momentum in the early 2000s and was completed by 2003, when the CAAC transferred ownership and control of all its remaining airports, except the Beijing and Tibet Airports, to their respective local governments.

The airport localization program, on one hand, increased the initiatives for local and private investment in airport capacity expansion. On the other hand, airport productivity was expected to improve after the implementation of the localization program. As pointed out by Zhang and Yuen (2008), as opposed to the "soft budget" approach taken by the CAAC, the localization program made the airports more financially accountable and consequently improves their efficiency.[3] Furthermore, as the efficiency of airports has significant implications for local economies, local governments may have greater incentives to improve their airport efficiency than would the CAAC.

The second recent policy change that may affect Chinese airport productivity is allowing Chinese

[3] As part of the localization program, the central government began to phase out its subsidization of airports in 2006.

airports to be listed on stock markets. Although attracting private funds was one rationale for airport listing, the principal objective was to improve airport efficiency (Zhang and Yuen, 2008). Since the initial public offering (IPO) of Xiamen Gaoqi International Airport, six Chinese airport companies have been listed on stock exchanges in Hong Kong, Shanghai, and Shenzhen. In the literature, there are a number of studies empirically examining the performance of Chinese listed companies. Sun and Tong (2003) found that there was an improvement in state-owned enterprises' earnings ability, real sales and workers' productivity, but not in profit returns or leverage after listing. Wang (2005), on the other hand, found a sharp decline in post-issue operating performance of IPO firms. Zhang and Yuen (2008) investigated the effect of listing on Chinese airport productivity, and found that the listed airports had higher efficiency scores than did unlisted airports, while the correlation between productivity growth and listing was statistically insignificant.

The policy changes in the *airline market* may also affect Chinese airport productivity. One of the prominent changes there is the opening of the market to foreign airlines gradually. For the past five years, China has been moving toward a more liberal international policy regime, which has significantly increased the number of international connections for China's airports (Zhang and Yuen, 2008). The bilateral "open skies" agreements may increase the passenger and cargo traffic at airports. Given a fixed amount of input, this will imply a productivity improvement. This will, however, also increase the percentage of international traffic at the airports; and Oum, *et al.* (2003) found that the airports with heavy reliance on international passenger traffic had lower gross total factor productivities (TFPs) than average airports.

Another major change in the airline market is the consolidation of the airlines in China. In October 2002, under the State Council's arrangement, the three megacarriers – Air China, China Southern Airlines and China Eastern Airlines – took over fourteen relatively minor carriers (most of which were under the CAAC control). This substantial change in the market structure of the downstream carriers may have significant implications for Chinese airport productivity. For example, after the mergers, the bargaining power of the three new airlines groups was likely strengthened in their negotiation with airports. Thus, they might be able to impose more pressure on airports for further improvement of their productivities, leading to a possible reduction of airport charges.

3. Methodology

To investigate the effect of competition and policy changes on Chinese airport productivity, we use a two-stage procedure. See, for example, Ali and Flinn (1989) and Kalirajan (1990) for an application of the two-stage analysis. In the first stage, we calculate the productive efficiency from 1995 to 2006 for each airport. In the second stage, we run regressions to examine the effects of competition and policy changes on the productive efficiency of airports, while controlling for a set of independent variables.

In particular, in the first stage, we need to calculate the productive efficiency of airports, which is reflected by the relationship between the outputs the airport produces and the inputs the airport uses in a given period of time. Empirical applications of the efficiency measurement are feasible by a non-parametric technique known as Data Envelopment Analysis (DEA).[4] A DEA model gives an efficiency score for each airport in each year. For the output-oriented model, the efficiency score has a value between zero and one. Airports with an efficiency score of unity are located on the frontier in the sense that their outputs cannot be further expanded without a corresponding increase in input. Airports with an efficiency score below one are inefficient. The DEA model defines the efficiency score of any airport as the fraction of the airport's output that can be produced for an airport on the efficient frontier with the same level of input.

The DEA approach is widely used in measuring the performance of airports, as it does not require any assumption concerning either the technology or the behaviors of actors (for example, cost minimization)

[4] Useful references on DEA include Farrell (1957), Banker, *et al.* (1984, 1989), Charnes, *et al.* (1978, 1981), Seiford and Thrall (1990), and Lovell (1993).

(Pels, *et al.*, 2001) and can be done without some detailed operating information (such as input costs). Gillen and Lall (1997) applied DEA to assess terminal and airside operations of twenty-one top US airports from 1989 to 1993. This is followed by a number of papers using DEA to evaluate performance of airports in different countries (for example, Parker, 1999; Sarkis, 2000; Vasigh and Hamzaee, 2000; Chin and Siong, 2001; Martin and Roman, 2001; Pels, *et al.*, 2001; Abott and Wu, 2002). In order to measure Chinese airport productivity, Fung, *et al.* (2008) applied DEA to assess productive efficiency for twenty-five major Chinese airports over the 1995-2004 period. They focused primarily on whether airport efficiency was improving over the time period and whether productivity among the airports from different regions was converging, and found positive answers to both questions.

In the second stage, in order to investigate the influence of competition and aviation policy reform in China on the efficiency of Chinese airports, we consider the efficiency scores as a function of:

- the airport localization program;
- competition intensity;
- public listing;
- airport characteristics;
- other important events in the Chinese aviation market.

In particular, we run the following ordinary least squares (OLS) regression to examine the effect of the airport localization program (*LOCAL*), competition intensity (*d*), and public listing (*LIST*) on the productive efficiency of airports while controlling for airport characteristics and other factors:

$$\theta = \alpha + \beta_1 LOCAL + \beta_2 d + \beta_3 LIST + \sum_{i=1}^{15} \beta_{4i} X_i + \varepsilon \tag{1}$$

where θ is the DEA efficiency scores; *LOCAL* is a dummy for the airport under airport localization program; *d* is a proxy for the competition intensity; *X* is a set of controlling variables, including a dummy variable for airline mergers in 2003, hub dummy, dummies for tourist city and coastal city, city population, provincial per-capita gross domestic product (GDP), and input and output indexes. Additionally, we also include the “Guangzhou New Airport” dummy and “Shanghai Pudong” dummy to capture the effects of opening new airports in Guangzhou and Shanghai in 2004 and 1999, respectively. The next section will further discuss how we construct the variables.

It is notable that as the efficiency scores have an upper bound of one, there may be a truncated bias in the OLS regression model. Thus, as in Gillen and Lall (1997), we also run the Tobit regression model (Tobin, 1958). Our Tobit model can be represented as follows:

$$\hat{\theta} = \alpha + \beta_1 LOCAL + \beta_2 d + \beta_3 LIST + \sum_{i=1}^{15} \beta_{4i} X_i + \varepsilon$$

$$\theta = \begin{cases} 1 & if \;\; \hat{\theta} \geq 1 \\ \hat{\theta} & if \;\; \hat{\theta} < 0 \end{cases} \tag{2}$$

where the variables in the Tobit regression model are the same as that in our OLS regression model.

4. Sample Airports and Variable Construction

4.1 Sample airports

We consider a panel dataset for twenty-five major Chinese airports in the period between 1995 and 2006. Our sample includes airports in China that represents different ownerships, operational characteristics, and regional locations (as shown in Table 1). The data are complied from various sources, including Statistical Data on Civil Aviation of China, Chinese Statistics Yearbooks (various years) and company annual reports of listing airports.

Table 1: Sample airports and operating characteristics in 2006

	Region	Runway length (meter)	Terminal size (square meter)	Passenger volume (person)	Cargo volume (ton)	Aircraft movement (flight)
Beijing Capital International	Northern	7,000	336,000	48,748,298	1,148,259	378,888
Changsha Huanghua	Central and South	2,600	34,000	6,592,602	60,094	71,139
Chengdu Shuangliu International	Southwest	3,600	92,000	16,280,225	285,127	155,484
Chongqing Jiangbei International	Southwest	2,800	13,321	8,050,007	116,512	88,929
Dalian Zhoushuizi International	Northeast	3,300	33,000	6,351,089	105,838	56,374
Guangzhou Baiyun International	Central and South	7,400	320,000	26,222,037	626,598	232,404
Hailar Dongshan	Northern	2,600	2,490	150,561	606	2,584
Harbin Taiping International	Northeast	3,200	67,000	3,643,232	41,540	33,863
Hefei Luogang	Eastern	3,000	13,835	1,851,464	20,284	24,000
Hohhot Baita	Northern	3,200	19,339	1,509,643	8,883	21,468
Jinan Yaoqiang	Eastern	3,600	11,000	3,696,305	36,269	41,901
Kashi	Northwest	3,200	7,931	444,332	1,294	4,017
Kunming Wujiaba International	Southwest	3,400	76,700	14,443,607	215,389	135,573
Lanzhou Zhongchuan	Northwest	3,600	27,000	1,861,148	13,253	21,902
Nanning Wuxu	Central and South	2,700	25,885	2,244,234	26,668	27,248
Qingdao Liuting	Eastern	3,400	15,650	6,791,240	97,835	72,008
Sanya Fenghuang	Central and South	3,400	18,230	3,905,956	23,827	32,850
Shanghai Hongqiao International	Eastern	3,400	82,000	19,336,517	323,518	177,626
Shenyang Taoxian International	Northeast	3,200	83,538	5,343,566	85,590	48,931
Shenzhen Baoan International	Central and South	3,400	111,026	18,356,069	549,879	169,493
Taiyuan Wusu	Northern	3,200	25,800	2,843,482	26,250	38,356
Tianjin Binhai International	Northern	3,200	25,500	2,766,504	95,820	54,948
Urumqi Diwopu International	Northwest	3,600	68,359	5,136,028	72,592	51,602
Xiamen Gaoqi International	Eastern	3,400	127,000	7,501,004	169,574	77,355
Xian Xianyang International	Northwest	3,000	25,700	9,368,958	93,349	99,315

Source: Aviation Policy and Research Center (APRC)

To measure the productive efficiency by DEA (i.e., the efficiency scores), one must first identify outputs that an airport produces and the inputs it uses in producing those outputs. The summary statistics for the inputs and outputs that we consider for DEA is given in Table 2. In particular, on the input side, we consider two physical capital input measures: runway length and terminal size. In our sample, the average runway length of the twenty-five airports was 3,500 meters in 2006; the Beijing and Guangzhou Airports had two runways, while others had one each. The terminal size ranged from 2,500 square meters (the Hailar Airport) to 336,000 square meters (the Beijing Airport). It is noted that operational costs, the number of employees, the number of gates, soft-cost input, and passenger satisfaction are also considered as inputs in some other DEA studies (for example, Gillen and Lall, 1997; Sarkis, 2000; Pels, *et al.*, 2001). The data for these input measures are not available for most Chinese airports, however.

Table 2: Summary statistics of inputs and outputs for DEA analysis

Year	Average runway length (meter)	Average terminal size (square meter)	Average passenger volume (person)	Average cargo volume (ton)	Average aircraft movement (flight)
1995	3,139	19,236	2,878,981	41,600	27,734
1996	3,191	20,178	3,113,395	50,940	31,136
1997	3,203	30,997	3,197,762	60,778	33,464
1998	3,227	30,997	3,284,180	69,987	37,822
1999	3,331	41,298	3,497,035	88,635	39,735
2000	3,343	50,847	3,723,238	93,164	41,004
2001	3,343	56,633	4,146,812	97,686	46,187
2002	3,375	57,063	4,687,961	108,805	51,031
2003	3,375	57,063	4,618,482	105,234	51,695
2004	3,375	57,063	6,416,740	121,874	65,398
2005	3,536	66,492	7,654,047	140,545	74,711
2006	3,536	66,492	8,937,524	169,794	84,730

On the output side, we consider passenger volume, air cargo volume, and the number of aircraft movement as outputs of airports in our DEA. The number of passengers served is the most commonly used output for measuring airport productivity. In China, most airports primarily serve passenger traffic; during the study period (i.e., 1995-2006), the growth of the average passenger volume of our sample airports increased by 210.4 percent. We also consider cargo traffic as another output, as its importance has increased over the years (Zhang, *et al.*, 2004). For instance, the average cargo traffic increased substantially, by 308.2 percent, in the study period. The third output is aircraft movement, which also grew rapidly during the study period (i.e., by 205.5 percent). Several other measures, including operating revenues and general aviation, have been considered in the literature (for example, Sarkis, 2000). Another important output for airport performance measurement is non-aeronautical revenue (Zhang and Zhang, 1997; Oum, *et al.*, 2003). In addition to their aviation business, airports also derive revenue from concessions, retailing, advertising and other services. The proportion of non-aeronautical revenue to the total revenue varies significantly among airports around the world. For example, in 2003, non-aeronautical revenue accounted for only 27 percent of New York John F. Kennedy International Airport's total revenue, while it constituted 68 percent of total revenue at the Brisbane Airport (Oum, *et al.*, 2003). In China, the portion of non-aeronautical revenue for airports is still relatively low. For example, it only contributed 27.3 percent to the total revenue of the Beijing Airport in 2006. Nevertheless, the non-aeronautical business is becoming a more important source of revenue for Chinese airports (for example, in 2006, 47.3 percent of total revenue at the Guangzhou Airport was from its non-aeronautical business). Although we cannot include the non-aeronautical revenue as an output measure in our DEA due to the data limitation, it would be worthwhile to include the output measure in the future studies on Chinese airport performance if the data are available.

4.2 Variable Construction

In the second stage, we run the regression models in (1) and (2) to examine the effects of the airport localization program, competition intensity, and public listing on the productive efficiency of airports, while controlling for airport characteristics and other factors. The independent variable is the efficiency score θ, obtained from DEA in the first stage. Three explanatory variables in our regression models are the airport localization dummy (*LOCAL*), the listing dummy (*LIST*), and competition intensity (d). The dummy variable for airport localization (*LOCAL*) is one for airports in a particular year if under the local government ownership and control, and zero otherwise. An exception is Beijing Capital International Airport, which is excluded from the CAAC's localization program. In constructing the airport localization dummy variable, we consider the Beijing Airport to be one for all years. Since the CAAC has direct control over the airport, potential agency problems between CAAC and local governments would not arise for the Beijing Airport. The listing dummy (*LIST*) is one for airports in a particular year if the airport is listed on stock exchanges, and zero otherwise. Table 3 shows the airports in our sample that are listed on different stock exchanges in different years.

Table 3: Listing airports

Airport	Listing year	Stock exchange	State share in 2003 (%)	State share in 2006 (%)
Beijing Capital International	2000	Hong Kong	65	53.8
Guangzhou Baiyun International	2003	Shanghai	60	52.4
Shanghai Hongqiao International	1998	Shanghai	63	57.6
Shenzhen Baoan International	1998	Shenzhen	64	54.7
Xiamen Gaoqi International	1996	Shanghai	75	68.0

Source: Zhang and Yuen (2008)

In order to investigate how competition affects airport productivity, we need to construct a proxy for the intensity of airport competition. The most commonly used proxy for market competition is the Herfindahl index (HHI). For example, Zhang, *et al.* (2001) quantified the effect of market competition (and also ownership) on the productive efficiency and efficiency growth of Chinese industrial firms by using HHI as a proxy for market competition. The construction for HHI for our analysis is less feasible. In practice, airports serve many different markets (for example, long- and short-distance markets, transshipment markets, and different origin-destination markets) through air carriers. Thus to construct HHI for each airport, it requires very comprehensive market data in the whole study period, which are not available for the Chinese aviation market. Consequently, we instead use another proxy for the intensity of airport competition: (log) distance of a particular airport with another nearest airport in our sample airports, or the Hong Kong and Incheon Airports, which may be competing with our sample airports. Thus, we consider an airport to be facing more competition if there is another one in proximity. For example, the distance between the Shenzhen and Hong Kong Airports is only about thirty-two kilometers, indicating that the Shenzhen Airport is considered to be facing strong competition from the Hong Kong Airport in our analysis.

To control for airport characteristics and other potential factors to explain the Chinese airport productivity, we further consider fifteen controlling variables in our regression models:

Airport Characteristics

We consider eleven variables that capture the major airport characteristics of our sample airports:

- **Hub Status:** We control for the size and location advantages possessed by hub airports. Specifically, we have the hub dummy for the international and regional hubs. As in Zhang and Yuen (2008), the Beijing, Shanghai and Guangzhou Airports are considered as the three international hubs, while the Chengdu, Kunming, Shenyang, Shenzhen, Urumqi, and Xian Airports are the six regional hubs in our regression models.

- **Local Economy:** The provinical per-capita GDP of the province an airport located is used as an proxy for the local economy.

- **Coastal City:** We consider a dummy for airports located at coastal cities. Since 1978, the economy at the coastal provinces in China has been growing at a much faster rate than its inland counterparts; Jones, *et al.* (2003) found that annual growth rates of coastal cities were, on average, three percentage points higher than they were in non-coastal cities. The difference in economic devleopment between the coastal provinces and non-coastal provinces may explain the difference in enterprise productivity in China. For example, Fleisher and Chen (1997) showed that the TFP was roughly twice as high in the coastal provinces as they were in non-coastal provinces; they demonstrated that investment in higher education and foreign direct investment helped explain this productivity gap. As did Fleisher and Chen, we also consider Beijing to be a coastal city.

- **Tourist City:** A tourist city dummy is introduced to reflect that particular airports with a high percentage of leisure passengers. In our analysis, we consider the Sanya and Kunming Airports are located at tourist cities.

- **Population:** The population of the city that an airport is located is used as a proxy for the market size served by the airport.

- **Demand and Supply Shocks:** Airports are a capital intensive industry and the capital investment in runways and terminals are largely indivisible (see for example, Oum and Zhang, 1990; and Zhang and Zhang, 2003). This characteristic can affect the role that the yearly efficiency scores play in measuring airport performance. Similarly, demand shocks might significantly alter the efficiency scores through a large output expansion. To control for these potentially external shocks, we consider the following input and output indexes:

  —— , —— (3)

  where ( ) is the input (output) level at time *t*, with and . The input variables are runway length and terminal area indexes, whereas the output variables are passenger, cargo and aircraft movement indexes.

Event Variables

In addition to airport characteristics, we also control for four important events in the Chinese aviation market that may have potentially affected the productivity of our sample airports during the study period:

- **Airline Mergers (AMERGER):** As discussed in Section 2, the airline mergers in China may have affected airport productivity; we consider a dummy for the airline-mergers event.

- **Open Skies Agreements (OPENS):** In our empirical analysis, we particularly focus on two major air service agreements: the liberal air service agreements signed between China, and the United States and Hong Kong in July and September 2004, respectively. It is because the two regions have close economic relationships with China; the United States and Hong Kong were the largest and third largest trading partners of China in 2005, respectively. As international hub airports are more likely to be affected by the open skies agreements, we consider a dummy (*OPENS*) for the international hubs in 2005 and 2006.[5]

- **Guangzhou New Airport Dummy:** A new Guangzhou Baiyun Airport was opened in August 2004. Compared to the old airport, the terminal increased 3.8 times in size; additionally, the new airport operates one more runway than did the old airport. This may suggest a structural change in its operation. We capture this potential effect on its productivity by introducing a dummy for the new airport.

[5] To check the robustness of our results, we also use a dummy for all airports that affected by the open skies agreements and find that our main results remained unchanged.

- **Shanghai Pudong Dummy:** In 1999, Shanghai Pudong International Airport was opened and replaced Shanghai Hongqiao International Airport (our sample airport) as Shanghai's international airport, and took over all of international flights, including regional flights to Hong Kong and Macau. Consequently, in 2000, the passenger traffic of Hongqiao Airport was decreased by 15.4 percent, while that of our sample airports was increased by 6.4 percent. To control for the demand shock, we add a dummy to capture this structural change in demand at Hongqiao Airport.

5. Empirical Results

In this section, we discuss the results for our two-stage analysis. First, we report the DEA efficiency scores for our twenty-five sample Chinese airports in the period between 1995 and 2006. In addition to this, we will investigate the influence of competition and aviation policy reform in China on the efficiency of Chinese airports through a discussion of the results from different regression models.

5.1 Efficiency Scores

The results of the DEA efficiency scores of the twenty-five sample airports in the period between 1995 and 2006 are shown in Table 4. The scores of the airport in the first nine years (i.e., 1995 to 2004) are also reported in Fung, *et al.* (2008). Yet, it should be noted that the scores in 2004 calculated in this paper are different from that in Fung, *et al.*, as we adjust for the input changes due to the opening of the new Guangzhou Baiyun Airport in that year.[6] With the new dataset, we find that the pooled average efficiency score of the period in 2004-2006 increased by 6 percent, compared to that in the period of 1995-2003.

Additionally, the Beijing, Shanghai, Shenzhen and Chongqing Airports were considered to be efficient, while the Kashi, Hailar, Hohhot, Lanzhou and Harbin Airports were the least efficient airports in the last three consecutive years (2004-2006). We also observe that among our sample airports during that period, Guangzhou Baiyun Airport recorded the greatest drop of efficiency scores, from 1.000 in 2003 to 0.584 in 2006. The reason for this drop in efficiency is most likely because the inputs (i.e., runway length and terminal size) of the airport were increased significantly after the opening of the new airport. As discussed above, the capital investments in airports are largely indivisible. This drop in efficiency score, therefore, may not necessarily indicate that the airport become less efficient. This potential problem will be controlled for in our regression analysis.

[6] In Fung, *et al*. (2008), the terminal size and runway length of the old airport are used as the inputs of the Guangzhou Airport for calculating the efficiency scores for the airports in that year, while we adjust the input on the pro-rata basis.

Table 4: Efficiency Scores, θ

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Beijing Capital International	0.798	0.795	1.000	1.000	0.616	0.819	0.844	0.819	0.793	1.000	1.000	1.000
Guangzhou Baiyun International	1.000	1.000	0.997	0.942	0.942	1.000	1.000	1.000	1.000	0.884	0.620	0.584
Shanghai Hongqiao International	1.000	1.000	1.000	1.000	1.000	1.000	0.989	0.897	0.781	1.000	1.000	1.000
Shenzhen Baoan International	0.567	0.596	0.703	0.707	0.709	0.556	0.636	0.718	0.835	1.000	1.000	1.000
Kunming Wujiaba International	0.536	0.667	0.822	0.907	1.000	0.534	0.534	0.578	0.586	0.690	0.695	0.788
Chengdu Shuangliu International	0.866	0.838	1.000	1.000	1.000	0.414	0.455	0.495	0.548	0.735	0.739	0.825
Xian Xianyang International	0.622	0.575	0.596	0.625	0.595	0.935	1.000	1.000	0.829	0.948	0.993	0.925
Xiamen Gaoqi International	1.000	1.000	0.418	0.399	0.309	0.333	0.321	0.356	0.384	0.423	0.409	0.427
Chongqing Jiangbei International	0.651	0.590	0.743	0.809	0.783	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dalian Zhoushuizi International	0.522	0.354	0.340	0.390	0.369	0.512	0.497	0.467	0.453	0.579	0.553	0.544
Qingdao Liuting	0.374	0.447	0.727	0.755	0.751	0.863	0.925	0.747	0.693	0.782	0.755	0.718
Shenyang Taoxian International	0.362	0.360	0.595	0.502	0.436	0.712	0.219	0.233	0.249	0.296	0.270	0.292
Changsha Huanghua	0.608	0.615	1.000	1.000	1.000	0.588	0.569	0.579	0.620	0.657	0.631	0.675
Harbin Taiping International	0.342	0.354	0.147	0.150	0.145	0.161	0.170	0.176	0.183	0.215	0.211	0.218
Urumqi Diwopu International	0.282	0.182	0.310	0.328	0.309	0.391	0.126	0.158	0.261	0.340	0.311	0.306
Jinan Yaoqiang	0.200	0.364	0.538	0.475	0.401	0.618	0.727	0.647	0.601	0.612	0.597	0.571
Sanya Fenghuang	0.116	0.111	0.209	0.370	0.245	0.214	0.263	0.296	0.308	0.381	0.369	0.388
Tianjin Binhai International	0.412	0.775	1.000	0.609	0.370	0.433	0.374	0.296	0.349	0.539	0.538	0.540
Nanning Wuxu	0.319	0.348	0.191	0.215	0.197	0.252	0.264	0.246	0.247	0.264	0.277	0.274
Hefei Luogang	0.462	0.467	0.452	0.325	0.211	0.308	0.321	0.270	0.210	0.228	0.248	0.260
Lanzhou Zhongchuan	0.495	0.223	0.693	0.550	0.556	0.843	0.173	0.160	0.164	0.191	0.182	0.176
Taiyuan Wusu	0.093	0.069	0.086	0.161	0.172	0.260	0.357	0.265	0.263	0.254	0.330	0.340
Hohhot Baita	0.280	0.151	0.097	0.095	0.134	0.137	0.172	0.141	0.126	0.166	0.182	0.203
Kashi	0.051	0.048	0.087	0.092	0.071	0.129	0.068	0.071	0.085	0.106	0.099	0.093
Hailar Dongshan	0.070	0.085	0.174	0.130	0.122	0.177	0.209	0.172	0.124	0.115	0.154	0.155
Average Efficiency	0.481	0.481	0.557	0.541	0.498	0.528	0.489	0.471	0.468	0.536	0.527	0.532
Standard Deviation	0.289	0.303	0.336	0.319	0.320	0.297	0.316	0.305	0.289	0.316	0.306	0.305

5.2 Regression Results

In the second stage, we run the OLS model given in (1) and the Tobit model given in (2) to examine the effects of the airport localization program, competition intensity, and public listing on the productive efficiency of airports while controlling for airport characteristics and other factors. The regression results are presented in Table 5. The adjusted R-square of the OLS regression model is 0.66, which means that our model can explain 66 percent of the variation of the airport productivity in our panel dataset. Thus there is a significant improvement in explanatory power of our OLS model, comparing with that in Zhang and Yuen (2008), in which the adjusted R-square is from 0.29 to 0.41.

Table 5: OLS and Tobit Regression Results on Efficiency Scores

	OLS Model		Tobit Model	
	Coefficient	t-value	Coefficient	t-value
Airport Localization dummy	0.081**	2.17	0.087**	2.06
Log (distance)	-0.107**	-2.20	-0.073	-1.32
List	0.298***	5.22	0.367***	5.46
I Hub	0.267***	5.39	0.327***	5.65
R Hub	0.253***	8.41	0.248***	7.55
Tourist City	-0.034	-0.71	-0.027	-0.52
Coastal City	0.234***	6.25	0.233***	5.72
Runway Length Index	-0.235	-0.97	-1.131	-0.07
Terminal Area Index	-0.025***	-6.27	-0.029***	-6.50
Passenger Index	0.005	0.37	0.002	0.11
Cargo Index	-0.007	-1.70	-0.006	-1.41
Air Movement Index	0.041***	3.05	0.040***	2.77
City Population (10,000)	0.000***	11.30	0.000***	10.7
Per Capita GDP	-0.000***	-5.00	-0.000***	-4.25
Open Skies Dummy	0.086	0.80	0.985	0.06
Airline-Mergers Dummy	0.006	0.16	0.010	0.24
Guangzhou New Airport Dummy	-0.236	-1.26	-0.374	-1.83
Shanghai Pudong Dummy	0.051	0.48	-0.142	-0.99
Constant	0.810***	2.89	1.608	0.09

Number of observation: 300
Adjusted R-square for OLS model: 0.6598
Log of the likelihood function for Tobit model: 26.156
** The coefficient is significant at the 95% level.
*** The coefficient is significant at the 99% level.

As expected, both the OLS model and the Tobit model show that the efficiency scores are positively correlated with the airport localization program dummy and that the coefficients are statistically significantly different from zero. The result suggests that the airport localization program effectively improved Chinese airport productivity. It also provides an empirical evidence to support the argument made in Zhang and Yuen (2008) that, by making the airports more financially accountable through the localization program, the airports would improve their efficiency.

We also find that the relationship between airport productivity and the (log) distance with the nearest airport (a proxy for airport competition) is statistically correlated in the OLS model. The negative sign of the coefficients suggests that airports with more competition are more efficient than their counterparts. However, this negative correlation is found to be statistically insignificant in the Tobit model. On the other hand, the efficiency scores are positively correlated with public listing and the coefficients are statistically significant. This result is consistent with Zhang and Yuen (2008). It should be cautioned, however, that the correlation result we find in the regression does not imply causation between the two variables. As also noted in Zhang and Yuen, this listing effect on efficiency level does not necessarily imply that privatization through public listing improves airport performance; the positive listing effect might arise because the Chinese government chose the most efficient airports to be listed.

For the airport characteristics variables, the impact of hub status – whether airports are international or regional hubs – on the efficiency score is positive and statistically significant. The results may suggest that hub airports possess the size and location advantages. We also find that the airport location and market size may explain the productive efficiency of our sample airports; the efficiency score is positively correlated with the coastal city dummy and city population. A negative relationship between the efficiency score and provincial per-capita GDP, however, is found, and is statistically significant. It would probably be better to use the per-capita GDP at the *city* level (rather than at the *provincial* level) but unfortunately, the complete data were not available for the sample airports. Finally, the results suggest that the efficiency score is negatively correlated with the terminal area index and that the coefficients are statistically significant. At the same time, the coefficients of the aircraft movement index are positive, and statistically significant, while the coefficients of passengers and cargo indexes are statistically insignificant.

We did not find any statistically significant correlation between Chinese airport productivity and the four event variables we controlled for, namely the signing open-skies agreements, airline mergers and the opening of new Guangzhou and Shanghai Pudong Airports. This may be because, first of all, the effects have already been captured by other control variables including the input and output indexes. For instance, the significant change in the runway length and terminal size after the opening of new Guangzhou Airport have already been reflected in the runway length and terminal area indexes. Second, it is also possible that the period of our panel dataset is not long enough to fully reflect the effects of the events. For instance, the Sino-US air service agreement signed in July 2004 will double the number of airlines that can fly between the countries and will permit a nearly five-fold increase in Sino-US air services over the next six years from 2004. Since, our dataset, however, only covered the first two years of the agreement, it may not fully reflect the impact of the agreement on Chinese airports and their productivities.

6. Growth in Productivity

Having examined levels of productivity for the sample airports, we will now turn to the changes in levels of productivity. This examination is useful in that, if the low level of productivity at some airports is due to their low starting point, a faster growth rate in productivity after the policy changes could reduce and eliminate the gap. For instance, Fung, *et al.* (2008) found that productivity among the airports from different regions was converging. The growth of productive efficiency is measured by the Malmquist index:

$$M_O^{t+1}(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_O^{t+1}(x^{t+1}, y^{t+1})}{D_O^t(x^t, y^t)} \times \left[\frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_O^t(x^t, y^t)}{D_O^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}, \qquad (4)$$

where D_O is an output distance function of airport *O*. The distance function is the inverse of the output-oriented efficiency score, which we calculated in Section 5. The superscripts on D_O indicate the time periods within which the efficiency scores are calculated. The superscripts on *x* and *y* indicate the time periods of the data used in the calculation of the efficiency scores. As a measure of the overall efficiency change, a Malmquist index M_O^{t+1} greater (less) than unity indicates that the overall efficiency of airport *O* has increased (declined) from period *t* to period *t+1*.

Note that equation (4) also represents a decomposition of efficiency change from period t to period $t+1$. The ratio outside the bracket on the right-hand side measures the change in "technical efficiency (*EFFECH*)" of airport O from period t to period $t+1$. Greater (smaller) than unity implies that the technical efficiency has improved (declined) in reference to the production frontier from period t to period $t+1$. The bracketed term represents the geometric mean of the shift in production frontier. When the value of this term is greater (less) than unity, it implies that the "technology (*TECH*)" of the industry has progressed (regressed) from period t to period $t+1$.

Table 6: Descriptive Statistics of Productivity Growth Rates

	Malmquist productivity		Technical efficiency (*EFFECH*)		Technological change (*TECH*)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1996	1.132	0.367	1.013	0.319	1.116	0.033
1997	0.968	0.345	1.303	0.579	0.766	0.137
1998	1.140	0.286	1.033	0.272	1.109	0.065
1999	1.058	0.223	0.921	0.174	1.148	0.084
2000	0.918	0.247	1.193	0.357	0.782	0.109
2001	1.029	0.321	0.956	0.298	1.080	0.048
2002	1.084	0.131	0.973	0.126	1.116	0.054
2003	1.053	0.165	1.021	0.176	1.036	0.074
2004	1.262	0.164	1.163	0.147	1.086	0.086
2005	1.163	0.131	1.005	0.120	1.159	0.044
2006	1.172	0.067	1.015	0.056	1.156	0.059

Table 6 presents the descriptive statistics for productivity growth rates and its two components. The results for the period between 1996 and 2003 are the same as those reported in Fung, *et al.* (2008), while those for 2004 are different due to the input adjustment for new Guangzhou Airport as discussed in Section 5, and the results for 2005 and 2006 are newly reported. We find that Chinese airport productivity grew at a faster rate in the period between 2004 and 2006 than it did prior to 2004; the mean of the Malmquist index in the period is 1.198, while the mean in the period between 1996 and 2003 is only 1.045. The increase in productivity growth rates is mainly due to the improvement in the technological change of the industry, as the mean of technical progress increased from 1.008 to 1.133 in the period between 2004 and 2006. The results suggest that the overall Chinese airport productivity has improved, which might be attributed to the recent policy changes in the Chinese aviation market.

We run the OLS regression model to investigate the effect of competition and policy reform on the growth of productivity and its two components. All dependent variables are the same as in Section 5, except the input and output indexes for demand and supply shocks. In this section, we will consider indexes for the growth rates of the input and output variables. Table 7 presents the regression results of productive efficiency growth rates. The adjusted R-square of the OLS regression is 0.74, implying our model can explain 74 percent of the data variations of the airport productivity growth.

Table 7: OLS Regression Results on Malmquist Index and it Components

	Malmquist Index		EFFECH		TECH	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Airport Localization dummy	0.026	0.87	-0.049	-1.00	0.071**	2.30
Log (distance)	0.021	0.62	0.043	0.73	0.001	0.02
List	0.030	0.88	0.066	1.11	-0.044	-1.18
I Hub	-0.002	-0.07	0.028	0.45	-0.040	-1.00
R Hub	0.005	0.21	0.010	0.24	-0.014	-0.57
Tourist City	0.004	0.14	-0.027	-0.47	0.005	0.13

Coastal City	0.066**	2.35	0.046	0.96	0.011	0.35
Runway Length Growth Index	-0.473***	-3.36	-0.554**	-2.28	0.068	0.44
Terminal Area Growth Index	-0.076***	-12.98	-0.067***	-6.58	-0.026***	-4.04
Passenger Growth Index	0.096	1.38	-0.163	-1.29	0.128	1.60
Cargo Growth Index	0.108***	5.90	0.052	1.63	0.040*	1.96
Air Movement Growth Index	0.835***	16.86	0.906***	10.57	-0.035	-0.64
City Population (10,000)	0.000	1.28	0.000	-0.04	0.000	0.39
Per Capita GDP	-0.000**	-1.92	0.000	-1.14	0.000	0.16
Open Skies Dummy	0.081	0.67	0.020	0.16	0.049	0.61
Airline-Mergers Dummy	0.033	1.26	-0.008	-0.17	0.022	0.77
Guangzhou New Airport Dummy	-0.146	-0.96	-0.123	-0.60	0.040	0.31
Shanghai Pudong Dummy	0.034	0.49	0.034	0.24	-0.006	-0.07
Constant	0.898***	9.20	0.899***	5.34	0.998***	9.35
Adjusted R-square	0.7365		0.4025		0.1388	
Number of Observation	275		275		275	

** The coefficient is significant at the 95% level.
*** The coefficient is significant at the 99% level.

The OLS regression results show that the efficiency growth does not have a statistically significant relationship with the airport localization program dummy, the (log) distance with the nearest airport (a proxy for airport competition) or public listing. For the airport characteristics variables, we find that the efficiency growth is positively correlated with the coastal city dummy and the coefficient is statistically significant. This result is consistent with other productivity studies on Chinese enterprises (for example, Jones, *et al.*, 2003). Furthermore, the coefficients of the two input growth indexes are negative and statistically significant. At the same time, the efficiency growth is positively correlated with the cargo growth and aircraft movement growth indexes and the coefficients are statistically significant. For the event variables, we do not find any statistically significant correlation between the Chinese airport productivity growth and the four events which we controlled for.

The regression results of technical efficiency (*EFFECH*) in Table 7 show that we do not find any statistically significant correlation between the technical efficiency improvement and the airport localization program dummy, the (log) distance with the nearest airport (a proxy for airport competition), or public listing. We, however, find that the technical efficiency improvement is negatively correlated with the two input growth indexes and the coefficients are statistically significant. At the same time, the coefficient of the aircraft movement index is positive and statistically significant. Finally, as for the event variables, we do not find any statistical correlation between the technical efficiency improvement and the four events we controlled for.

The OLS results in Table 7 show that the technical progress (*TECH*) is positively correlated with the airport localization dummy, and statistically significant. This result suggests that the airport localization program has a positive impact on the technical progress of the industry. This may be due to the fact that, besides the Shanghai and Xiamen Airports, airport controls were transferred from the central government to the provincial or municipal governments almost at the same time. As a result, after the completion of the airport localization program in 2003, the productivity of most Chinese airports has been improved. Thus, we observe technical progress in the industry in the period after 2003. However, we do not find any statistically significant correlation between technical progress and the (log) distance with the nearest airport or public listing. For the airport characteristics variables, the coefficient of the terminal area growth index is negative and statistically significant. Again, for the event variables, we do not find any statistical correlation between the technical progress and the four events we controlled for.

7. Concluding Remarks

The main purpose of this paper is to assess the effects of China's competition and aviation policy reform on both the level and growth of productive efficiency of its airports. In particular, the newly available panel dataset enabled us to investigate the effect of recent policy changes, including airport listing and the airport localization program, on airport efficiency. We found that there is strong evidence that publicly listed airports are significantly more efficient than non-listed airports. This result, however, requires special attention, as it does not necessarily imply that public listing can cause an improvement of airport efficiency (as also discussed in Zhang and Yuen, 2008). Furthermore, by using a larger panel dataset, we found results similar to Zhang and Yuen, that the correlation between listing and productivity growth is statistically insignificant.

Our empirical results further supported the argument made by Zhang and Yuen (2008) that, as airports would be financially more accountable after the airport localization program, the program could result in an improvement in the efficiency of airports. There is also some evidence suggesting that airports with more competition are more efficient than their counterparts. Finally, the policy changes at the airline level, namely the airline mergers and signing open-skies agreements, do not seem to have a statistically significant correlation with the Chinese airport productivity.

Due to data limitation, we only considered two inputs and three outputs of Chinese airports when estimating the efficiency scores by DEA. In practice, different airports are very different in their operating characteristics and in their services provided. Exclusion of some inputs and outputs may yield biases in measuring airport productivity. For example, if the so-called soft cost input, which is measured by all expenses not directly related to capital and personnel, is not included, the efficiency measurement may favor the airports that outsourced most of their services (Oum, *et al.*, 2003). On the other hand, as discussed in Section 3, non-aeronautical businesses are getting more important for Chinese airports. Exclusion of non-aeronautical revenue as an output may bias productivity against the airports that generate more revenues from non-aeronautical businesses. Further research may need to consider extending our analysis by using a larger set of inputs and outputs in measuring the airports' efficiency.

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Selection Criteria of air hub in Pearl River Delta (PRD) Region: From shippers' perspective

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Abstract

Without doubt, Hong Kong, which entitled as a major air hub in Asia-Pacific, has handled over 3.6 million tonnes of cargo and 44.5 million passengers in 2006. Hong Kong International Airport (HKIA) is the world's fifth busiest international passenger airport and had one of the most active air cargo operations worldwide. However, the increasing number of air cargo volume shipped directly from mainland airports; improving infrastructure development and aviation standard among PRD airports are challengeable for our leading position. In this paper, it aims to review of research and identify the selection criteria of air hub in PRD region from shippers' perspective. A comprehensive study reported in the literature that has focused on the selection criteria of air hub in PRD region which are required to fill the research gap. Recommendations and strategies are provided in order to maintain sustainability of HKIA in next decades.

Keywords: Selection criteria; Air hub; Hong Kong

1. Introduction

In today's competitive environment, it is essential for the government to develop the ability to determine the critical selection criteria for the airport in order to meet the users' need and requirement and attract them to make use of the airport for shipment. The important element that meets the customers' need is in the development of a positioning strategy. It involves the differentiation of the airport as well as the services from the competitors. Also, the government must also need to realize the selection criteria of the shipper in selecting the airport.

For the shippers choose those airports, there are three main components that they must considered, these are the cargo should be handled reliably, efficiently and economically (Fleming and Hayuth, 1994). Shippers can be mainly categorized into two types: those who are using the freight forwarders to perform the consolidation and those that are independent shippers. In this study, it considers freight forwarders as well as the large independent shippers as the decision makers for the airport. In reality, there are many factors affect an airport's ability to attract the air cargo shipment, including airport cost, location, infrastructure capacity, sufficient quality service provided, time used in handling the cargo as well as the overall cargo handling capacity.

In this study, we will identify the selection criteria that the shippers consider important when selecting an air hub and find out the future positioning for Hong Kong International Airport. The objectives of this study are as follows:

- To determine the selection criteria that shippers consider important when selecting an air hub and how these criteria are prioritized according to their importance
- To determine shipper' preference of three air hub which located in South China: Hong Kong International Airport, Guangzhou Baiyun Airport and Macau International Airport
- To determine the shippers' overall preferences of the air hub
- To analysis the future position of Hong Kong International Airport being an air hub.

2. Literature Review

2.1 Hong Kong International Airport

Hong Kong International Airport (HKIA) is a government – invested facility and commenced operated in July 1998. It is managed by Hong Kong Airport Authority (HKAA). It has been ranked as the busiest airport for international cargo since 1996 and the fifth busiest for international passengers Figure 1. It handles about 10,000 tons of air cargo and 120,000 passengers everyday with 800 flights daily to 150 major destinations including 40 cities in Mainland China (Hong Kong International Airport, 2007).

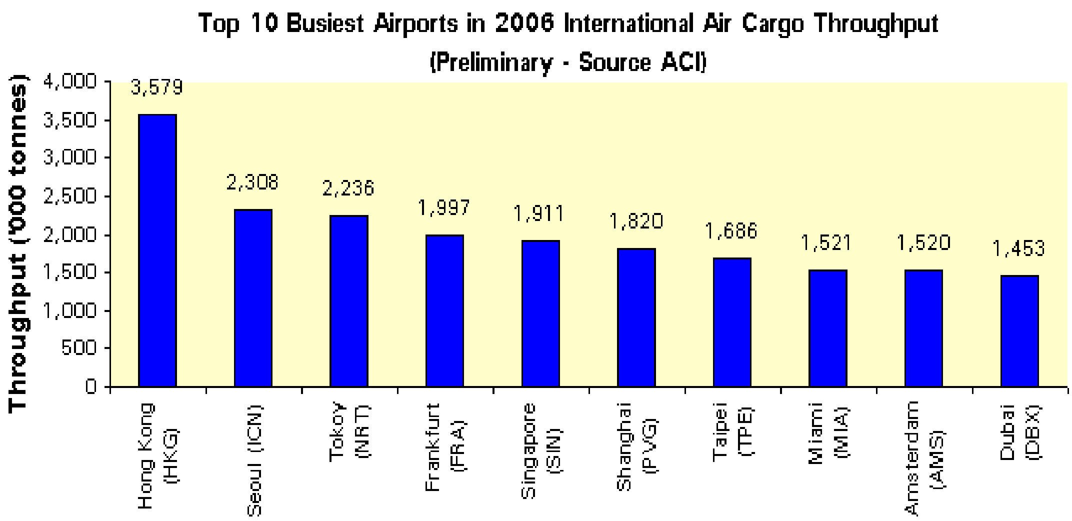

Figure 1: The Top 10 Busiest Airports in 2006 international Air Cargo Throughput

According to Mr. Stanley Hui, the chief executive officer of the Airport Authority Hong Kong, if we take Hong Kong as a centre, it can cover half of the world population within 5 hours flying time (Hongkong Industrialist, 2007). HKIA handling a record 3.6 million tons of international cargo in 2006 and 3.7 million tons in 2007 Figure 2. It can demonstrate that air cargo logistics is important sector for Hong Kong. Even the air cargo accounted for only 1 per cent of Hong Kong's total cargo throughput, but it constituted 34.5 per cent of Hong Kong's total external trade in 2006 and 39 per cent in 2007 Figure 3. Skytrax, a market research firm specializing in the air transport industry, award the HKIA as the best airport for five consecutive years from 2001 to 2005 and again in 2007.

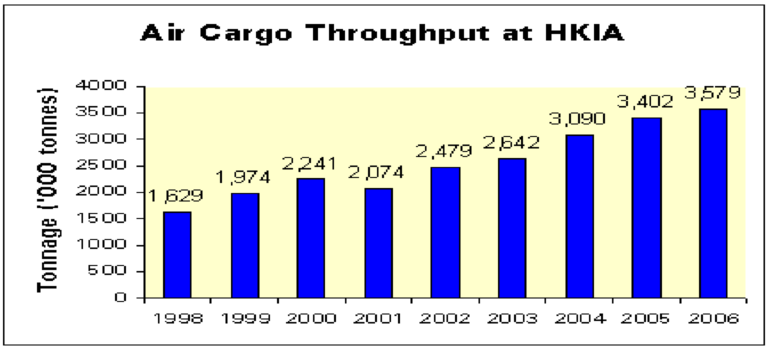

Figure 2: Air Cargo Throughput at HKIA from 1998 to 2006

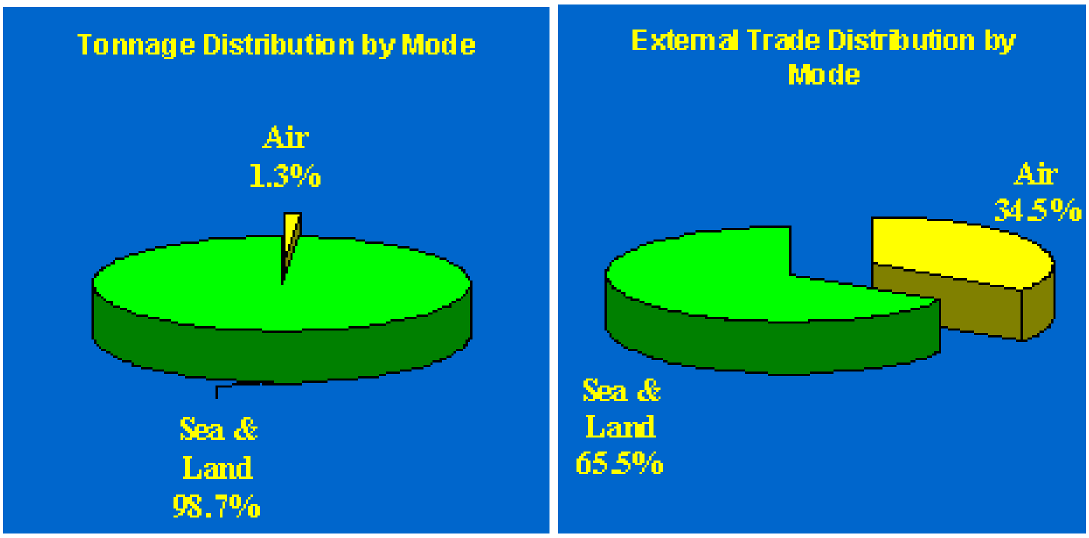

Figure 3: 2006 Hong Kong Air Cargo Throughput and External Trade value

2.2 Guangzhou Baiyun Airport

The new Guangzhou Baiyun Airport commenced operation in August 2004 with a total investment of 19.8 billion RMB. It covers an area of 15 square kilometers. Guangzhou Baiyun Airport is the first airport which located in Mainland China that was designed and built in the light of hub concept. In 2006, it handles about 650,000 tons of the air cargos and 26,200,000 passengers with 230,000 flights to 110 cities in Mainland China and 50 cities of worldwide. Baiyun Airport has set up business relations with 33 airlines. If we take Guangzhou Baiyun Airport as a centre, it can cover half of the major cities in the world within 18 hours flying time (Shu Cheong, 2007).

Nowadays, it has two parallel runways with advanced cargo handling system, safety checking system and the second largest cargo terminal. The terminal area was designed to accommodate a projected 800,000 tons of air cargo in 2010 while increased 20 times compared with the old Baiyun Airport. All the facilities and equipment in the airport are up to the international standard (Yuen *et al.*, 2006).

2.3 Macau International Airport

Macau International Airport commenced operation in November 1995. Since then, it has rapidly established itself as a vital link between the Pearl River Delta and the rest of the world. Macau International Airport is a fully functional 24-hour airport. The airport is equipped with a full range of passenger and cargo facilities designed to handle six million passengers and 165,000 tons of air cargo a year. According to the cargo handling figures, the cargo volumes are increasing at a stable level (Macau International Airport, 2007) Figure 4.

Macau International Airport was honored to receive the Asian Freight and Supply Chain award for Best Emerging Airport in 2007. Despite the airfreight facility of Macau International Airport is not the best among the five airports in the PRD and facing the intense competition from them, Macau International Airport are pleased that they can still achieve remarkable result during 2006, with annual 220,000 tons. To cope with the future demand and development, they striving to enhance the airfreight logistics facility of the airport, including terminal expansion. They also want to introduce more value added services to the customer, such as the newly established airfreight trucking services between Guangzhou and Macau Airport.

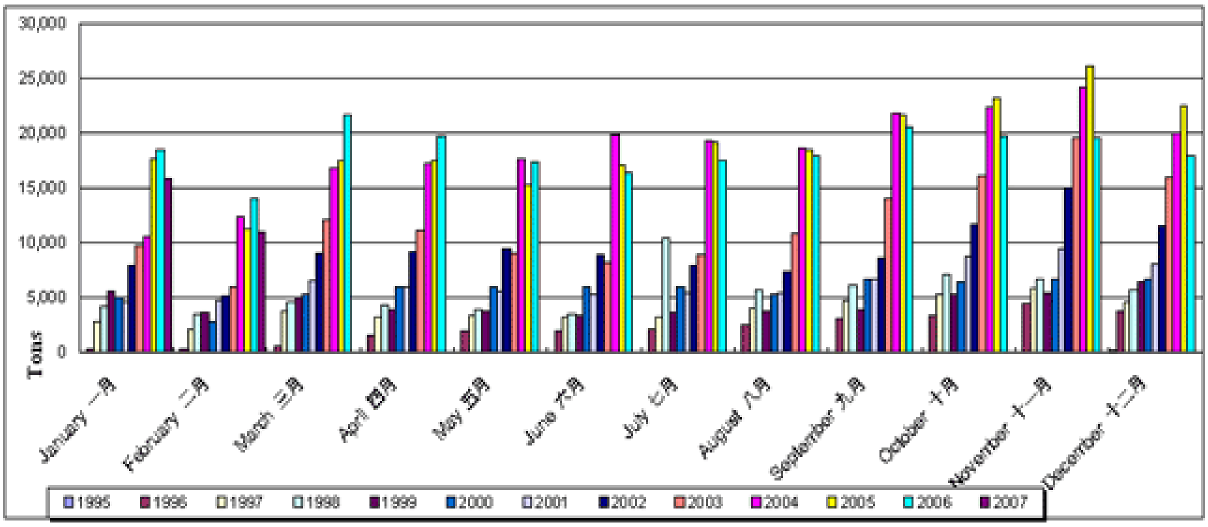

Figure 4: Air Cargo throughput in Macau international airport from 1995 to 2007

<u>2.4 Selection criteria of air hub</u>

There have been few studies carried out on the selection criteria determining air hub choice. According to Hirpshi Ohashi (2004), there are several factors affecting the transshipment hub selection and the ability of the airports to attract transshipment cargo traffic, including the airport's current traffic flow patterns; airport infrastructure capacity and activities; linkage with regional and intercontinental airport network; service quality and airport cost factor. In this paper, the research framework is focusing on two major factors, including monetary cost (e.g. line-haul cost and airport charges) and time cost (e.g. flight time, connecting time at the transshipment airports, loading & unloading time as well as the time used in custom clearance). Finally, this paper finds that transshipment volume is more sensitive to time than monetary cost; most of the shippers would be willing to pay more than $1,000 in airport charges to achieve one-hour reduction in transportation and processing time. It showed that it would be effective for the airport operators to reduce the air cargo connecting time rather than airport charges (Hirpshi Ohashi *et al.*, 2004).

Besides, there are several studies provide some discussion on the effect of the selection criteria in which affecting the selection of the air transshipment hub (Caves, 1996; Oum and Park, 2004). In this studies, it offer some evidence on how the service quality of the airport as well as the transport cost factors affect the choice of the transshipment hub in Northeast Asia (NEA) region.

Moreover, there is a research about the air cargo service competitiveness of major Asian airports (Yonghwa Park, 2005). This study can act as a reference for my research to identify the important elements while compared with different airports. There are six important elements were chosen by 35 aviation affiliated experts while used to compare the competitiveness with different airports, including the number of airlines served; commissioned nations and cities; the size of the cargo handling facilities; scale of the freight terminal; annual freight volume and freight terminal capacity. All these elements also reached the score of 80 or above out of 90 (Yonghwa Park, 2005).

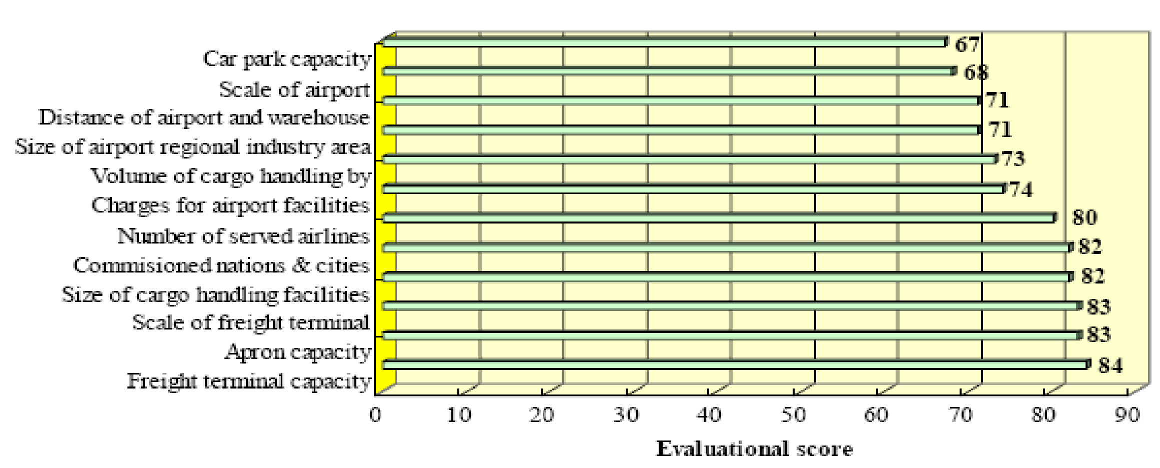

Figure 5: The survey result of input variable selection by aviation affiliated experts

Furthermore, a well-established organization which called "Air Cargo World" had conducted a survey to highlight the top-rated airlines and airports in 2007. The "Air Cargo World's Air Cargo Excellence" survey found the top-rated airlines and airports very closely rated in responses from customers on a wide range of performance criteria, including (A) Airport performance; (B) Competitive price level; (C) Infrastructure and (D) Regulation system, e.g. custom clearance (Air Cargo World, 2007. All these information can provide some ideas in this research about the important selection criteria while choosing the air hub and compared with each other.

However, due to lack of pervious literature on selection criteria of air hub, we would develop a research framework to identify the major selection criteria of air hub in PRD region.

<u>2.5 Research framework of selection criteria of air hub in PRD region</u>

2.5.1 Airport charges / cost

Airport Charges generally include landing fees, airport parking fees, security charges and government tax (Air Cargo World, 2007). As large proportion of the airport charges are contributed to the landing fees and airport parking fee. Therefore, we will focus on these two components in this study. Landing fee is the charge for the aircraft by using the runways and taxiways. Airport parking fee is the charge for the aircraft by using the parking stands, it is calculated by the length of the parking period and the type of parking stand used (Hong Kong International Airport, 2008). Actually, the airport charges vary enormously across different airports. These airport charges are generally related to the Maximum Take Off Weight (MTOW) of the aircraft. Because of the limited data availability of the airport charges of Guangzhou Baiyun International Airport, so we can only quote the airport charges of Hong Kong International Airport and Macau International Airport as a reference.

2.5.2 Cargo handling capacity

An Efficiency and effectiveness cargo handling capacity is a critical element for an airport to regard as an air hub (Tongzon, 1995; Yonghwa Park, 2005; Chinonye Ugboma *et al.*, 2006; Jose L. Tongzon *et al.*, 2007). To achieve this, there are several things that an airport should contain, including efficient cargo operation with sufficient skilled labors; extensive Information Technology application in the cargo operation; highly automated cargo handling facilities and equipment. All these elements would be included.

2.5.3 Infrastructure

Infrastructure is generally structural elements that provide the framework supporting an entire structure. The term has diverse meanings in different fields, but is perhaps most widely understood to refer to roads, airports, bridges, and utilities. All-round connectivity and the frequency of the aircraft visits also rely on the well developed infrastructure of the airport. Connectivity defined as the number of direct cargo destinations. Frequency of aircraft visits defined as the number of cargo flights. In order to increase the destination that the aircraft can visit and the frequency of aircraft, a well developed infrastructure is an important factor to attract the airlines to cooperate with the airport. In Hong Kong, there are over 85 airlines operating about 750 flights daily to 150 major destinations in the world including 40 Mainland China destinations (Hong Kong International Airport, 2008). In Guangzhou Baiyun International Airport, there are more than 150 destinations, including about 110 Mainland China destinations and 50 worldwide destinations (Logistics Magazine, 2007). In Macau International Airport, it operates about 160 flights daily to 45 destinations in the world (Macau International Airport, 2008) Table 1.

Table 1: Statistics about the daily flights and the number of destination

	Daily Flights	International Destination	China Destination	Total Destination
Hong Kong International Airport	750	110	40	150
Guangzhou Baiyun International Airport	630	50	110	160
Macau International Airport	160	45	/	45

2.5.4 Value – added service

Value – added service defined as the services providers offer some services in which adding value to the standard service provide. By doing so, it can increase the competitive advantage for the service providers. To apply the term of "Value – added services" into the air cargo handling operation, there are several factors that may be included, for example, One-Stop-Shop services; High safety & security system and Cargo Tracking Platform. All these services also can increase the confidence of the shippers to handle air cargo in airport.

2.5.5 Location

Strategic Geographic Location is also one of the critical elements for competitive success (Fleming and hayuth, 1994; Chinonye Ugboma *et al.*, 2006; Jose L. Tongzon *et al.*, 2007). A central location is an important factor for the airport to become an air hub. It is because the airport can develop a good connection to the other parts of the region with easy assessing. In Hong Kong, it can cover half of the world population within 5 hours flying time while the Guangzhou Baiyun International Airport can cover half of the major cities in the world within 18 hours flying time.

2.5.6 Time used for handling cargo

Cargo loading and unloading time and customs clearance time are considered as the indicators of service quality at an airport (Hirpshi Ohashi *et al.*, 2004). Basically, shipper likely to try to avoid a route which requires a long customs clearance at the airport. They are higher willingness to pay for the airports that have efficient customs administration. In fact, simplified customs procedure by computerizing shipment information will makes it more efficient by handling the air cargo, such as Electronic Data Interchange (EDI) system. Furthermore, the operation period of 24 hours a day and 7 days a week is a must for the airport to handle the cargo at any time.

Based on the literature, there are six major factors identified for selection criteria of air hub in PRD region: air charge / cost; cargo handling capacity; infrastructure; service provided; location and time. Figure 6 shows the research model for selection criteria of air hub in PRD region.

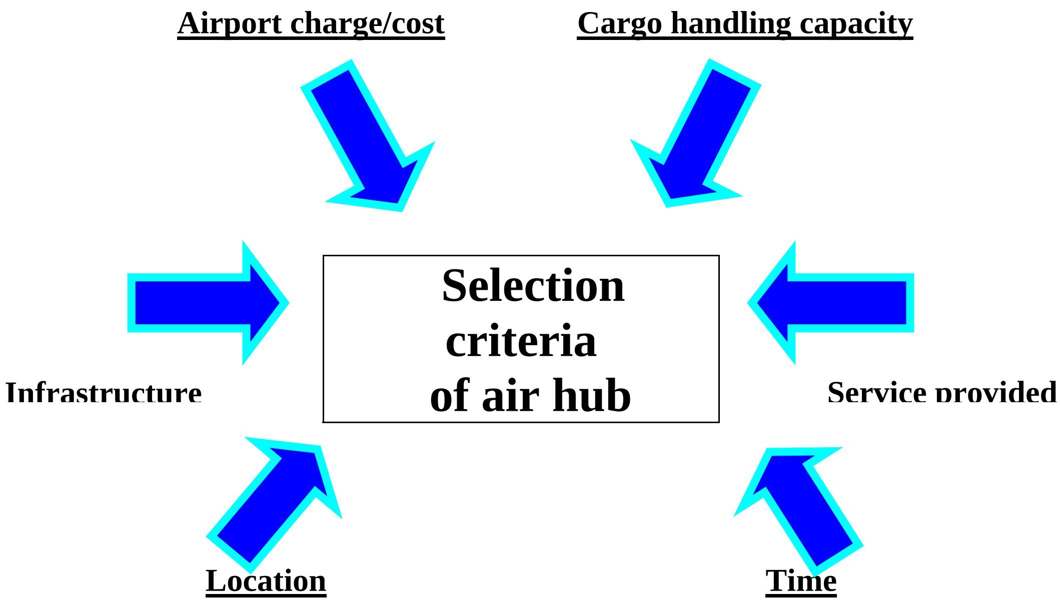

Figure 6: Research framework of Selection criteria of air hub in PRD region

3. Methodology

In order to achieve the objective of the study, qualitative research has used. The purpose of interview questions which attached in appendix are to collect their views and information from selected interviewees, it includes the views of selection criteria; service quality as well as competitiveness of airport in PRD region.

In this study, it focuses on the airports which located in South China. However, since the major concentration of airport competition within this region are Hong Kong International Airport (HKIA); Guangzhou Baiyun Airport and Macau International Airport. As a result, the focuses of the research further narrowed down to determine the air hub choice from the shippers' perspective including freight forwarder as well as the large independent shippers that based on the three airports stated above.

With the support of industry practitioners and professional bodies, four logistics professionals which in different frames have interviewed to understand more about the selection criteria that they think important when choosing the air hub. It also generates very rich and professional information and recommendation on selection criteria of air hub in Pearl River Delta (PRD) Region.

4. Findings and Implications

Based on the research methodology of this study, which had been mentioned, this study would gather different views and perspectives from our “insiders”. A total of 4 companies and organizations were interviewed. It includes:

- Mr. Vincent Lau, General Manager, Hong Kong Air Cargo Terminals Limited
- Mr. Johnny F.K. Tao, General Manager, Ports Express Limited
- Mr. Pietro P.S. Lam, Shipping Manager, Prosperity Steamship Company Limited
- Mr. William Yip, College Tutor, VTC School of Business and Information Systems (SBI).

First of all, regarding to the selection criteria that the interviewees think important when choosing an airport for air cargo shipment, three important selection criteria can be sum up according to their opinion, including value-added service provided; location and airport charges. In fact, value-added service is one of the important factor which affecting the air hub selection. Besides, the location of the airport is another important factor while the selection criteria of airport charges are chosen.

Regarding to the strengths and weaknesses that Hong Kong International Airport (HKIA) have, there are several strengths of Hong Kong International Airport can be rounded up, including high frequency of flights; modern cargo handling equipment; sufficient and skilled labor and advanced I.T. application. According to their opinion, all of them also considered that high frequency of flights are one of the strengths of HKIA. Besides, sufficient, professional and trained labor is the strength that Mr. Yip and Mr. Tao take into account. Furthermore, the advanced I.T. infrastructure and modern cargo handling equipment can be found out from all of their comment.

In contrary, all of the interviewees have their own opinion about the weaknesses of HKIA while all the answers are separated, including poor connection; non-uniform custom clearance; lack of cross border connecting route and road system; no nearby factories in Hong Kong; insufficient financial support; lack of Free Trade Zone and high freight rate.

In prioritizing the three airports, all the interviewees have the same sequence and that is Hong Kong International Airport, Guangzhou Baiyun Airport and Macau International Airport.

Regarding to the recommendation for the airports, Mr. Yip and Mr. Lam suggested that HKIA may collaborate with other airports in order to act as a back up between each other for the purpose of handling the air traffic jam. Also, Guangzhou Baiyun Airport may need to improve the language problem while providing sufficient training to their staff in order to enhance the international position of Guangzhou Baiyun Airport. For Macau International Airport, Mr. Yip and Mr. Tao also suggested that airport should concentrate their service to particular market, especially niche market like South Pacific, Africa and Eastern Europe in order to enjoy her "Economic of Scale".

Moreover, they all explained that HKIA can maintain its competitive advantages in the coming three to five years, even ten years. In addition, Mr. Yip also considered that Guangzhou Baiyun Airport and Macau International Airport can maintain their competitive advantages by having their own strategic position.

For the last part regarding to the opportunity of the cooperation between the five major airports in PRD region, Mr. Yip and Mr. Lam also explained that there is an opportunity for these airports to collaborate in the future to solve the air traffic jam in the peak season, but mutual benefit should be identified with each other and depends on whether there is a central authority that can solve all the conflicts among themselves. Otherwise, the cooperation may not be achieved. Also, some small airports within the region may be shut down because these airports are quite closed and increase the possibility of traffic jam. The summary of research findings and implications are shown in Table 2.

Table 2: Summary of research findings and implications

Research Area(s)	Opinion /Suggestion(s)
(1) Important selection criteria for air hub	(1) Value-added services (2) Airport charges/ Cost (3) Location
(2) Strengths of HKIA	(1) High frequency of flights (2) Modern cargo handling equipment (3) Sufficient skilled and trained labors (4) Advanced I.T. Infrastructure
(3) Weaknesses of HKIA	(1) Poor connection with Mainland China (2) Non uniform custom clearance system (3) Lack of cross border connecting route (4) Insufficient road system (5) Lack of Free Trade Zone (6) No nearby factories (7) High freight rate

(4) Priority of the airports	(1) Hong Kong International Airport (HKIA) (2) Guangzhou Baiyun International Airport (3) Macau International Airport
(5) Recommendation for Airports (a) HKIA (b) Guangzhou Baiyun Airport (c) Macau International Airport	(1) Collaborate with other airports (2) Improve the language problem (3) Concentrate the service to particular region
(6) Airport(s) that can maintain its competitive advantages	(1) Hong Kong International Airport (HKIA)
(7) Opportunity for the airports to cooperate in the future	Possible

5. Conclusion

Based on research findings and analysis, the research framework of this study is confirmed and identified the selection criteria of air hub in PRD region. Value-added services; Airport charges / Cost and Location are top three determinants for airport selection from shippers in Hong Kong. In order to enhance airport competitiveness of HKIA within the region, co-operation and collaboration, which clearly identify and develop strategic functions and roles among airports in PRD region, are vital to achieve their mutual benefit. Therefore, it not only generates economic benefit, but also consolidates our sustainable development of air transport in Asia pacific region.

To sum up, this study enrich the literature of air hub selection criteria; fills the literature gap and provides a solid foundation for further studies of airport competitiveness in Hong Kong, PRD and Asia pacific region.

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Appendix

<u>Interview Survey : Selection Criteria of air hub in Pearl River Delta (PRD) Region: From shippers' perspective</u>

(A) <u>Selection Criteria of Air Hub</u>

1. Can you choose three important selection criteria in which affecting the air hub selection?
   - ☐Airport charges/ Cost
   - ☐Cargo handling capacity
   - ☐Infrastructure
   - ☐Value-added services provided
   - ☐Location
   - ☐Time used for handling the cargos

2. According to Question 1, why do you consider these three factors as the most important selection criteria in choosing the air hub?

(B) <u>Opinion for airports in PRD Region</u>

3. As Hong Kong International Airport (HKIA) is being an air hub in the world, what are the strengths that you think HKIA have?

4. Nowadays, an increasing number of air cargo volume produced by the Mainland China are shipped directly through the air hub located in Pearl River Delta except Hong Kong to worldwide in these few years, e.g. Guangzhou's Baiyun Airport and Macau International Airport. Therefore, what are the weaknesses that you think HKIA have while compared with its competitors?

5. In General, what is the priority of the following airports?
   (1 = The first priority, 2 = The second priority, & so on)
   - □ Hong Kong International Airport (香港國際機場)
   - □ Guangzhou Baiyun Airport (廣州新白雲機場)
   - □ Macau International Airport (澳門國際機場)

6. <u>Why do you have this arrangement</u>?
   (A) Hong Kong International Airport
   (B) Guangzhou Baiyun Airport
   (C) Macau International Airport

(C) Recommendation for airports in PRD Region

7. Do you have any recommendation(s) for the following airports that can be improved in order to enhance the overall service quality and their competitiveness?
   (A) Hong Kong International Airport
   (B) Guangzhou Baiyun Airport
   (C) Macau International Airport

8. Which of the following airports that you think will maintain its competitive advantages in South China in the following three to five years? Why?
   ☐ Hong Kong International Airport
   ☐ Guangzhou Baiyun Airport
   ☐ Macau International Airport

9. Actually, Hong Kong International Airport and Shenzhen International Airport have already built up some cooperative project.   What do you think the impact towards Pearl River Delta Region?

10. Do you think that the five most important airports located in South China (Hong Kong International Airport; Guangzhou Baiyun Airport; Macau International Airport; Shenzhen International Airport and ZhuHai Airport) have the opportunity to cooperate in the future? Why?
    ☐ Yes
    ☐ No

11. Do you think that these five airports can identify its strategic position in order to facilitate cooperation and coordination among themselves? How these five airports can identify the strategic position?
    ☐ Yes
    ☐ No

~ End ~

****Thank you for your kind co-operation****

** All information will be used for academic purposes only

Air-Crew Scheduling In Transportation Problems:
An Experiment Way to Apply Meta-heuristics Algorithms

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Abstract

Air–crew scheduling is classified into NP-hard problems, which has been a challenge for both planners and researchers. Meta-heuristics algorithms have been known as powerful ones to find out "high quality" alternatives. In this paper, a systematic way to construct and solve air-crew scheduling problems is presented. First of all, a set of possible pairings or tours are generated; consequently, a sub set of feasible tours are selected; finally, fleets are assigned to responsible for them. Meta-heuristics algorithms, column selection in set partitioning algorithm or longest processing time one, are used to prefer a sub-set of feasible parings. Besides, to assign fleets undertake the tours, a greedy algorithm is used. Results can be used as an initial, feasible, and good solution. It is a foundation to help managers adjust and refine to satisfy requirements of the problem.

Keywords: Air-crew scheduling; Transportation network; Meta-heuristics.

1. Introduction

Transportation network is one of the most important parts of logistics systems, not only in manufacture but also in service. In airline transportation industry, operating costs possess an essential proportion in total costs, so constructing an optimum network is a vital requirement in any airline company. From the suitable network, a good air-crew scheduling is arranged.

Air-crews scheduling problem is an assignment one, in which a transportation network is determined and then fleets or air-crews are allocated to be responsible for. It is classified as NP-hard problems, because its scope is large and it is affected under strict constraints such as national rules, international rules, and company rules. An optimum transportation network and optimum assignment of air crews with minimizing total transportation cost or time are expected.

So far, many relative researches have been done. A.C. Kankas and A. Michael presented the design and implementation of an air-crew assignment system based on the artificial intelligence principles and techniques of adductive reasoning as captured by the framework of adductive logic programming. Claude P. Medard and Nidhi Sawhney introduced two steps to solve crew-scheduling problem in their topic, airline crew scheduling from planning to operations. In the first step, the working patterns are created; then in the second step, they are assigned to individual crews.

This paper presents a systematic way, in which steps to construct as well as apply meta-heuristics to solve the problem will be stated in section 2, and 3. The air-crew scheduling problem in Vietnam Airline is considered in section 4. Finally, in section 5, the way to apply in the real world, some limitations, and extensions are discussed.

2. Model construction

In a predefined period, any airline company has a flight schedule consisting of a set of flight legs, which are nonstop flights among airports. Managers have to determine an optimum allocation of air-crews to responsible for them in the way that minimizes the air-crew operating costs under restrictions.

The flying-crew costs are a very high cost-element in operating costs, which are the second highest one beside fuel cost. These costs can be saved through constructing an optimum transportation network and assigning suitable fleets. Because of their importance, minimizing total flying-crew costs is a main objective in this paper.

Generally, air-crew scheduling problems are solved by gathering as much detailed information as possible, formulating a mathematic model, and identifying solutions in detail by means of numerous decision variables. Because the data collection effort can be onerous, sometimes decisions are made with no systematic analysis. In addition, the numerical optimization problem is NP-hard and decisions are made on the basis of heuristic solutions, which are not particularly insightful.

Simplification is an alternative approach for logistics systems planning and analysis that means problems can be solved approximately with an approach that ignores details. The succinct models based on data summaries proved very effective. These near-optimal solutions are then used to formulate guidelines for the design of implementable solutions.

The detail formulation for air-crew scheduling problem is given now, which is a concise model. Base on it, the more complicated models can be constructed.

- Parameters:

D set of airport terminals in the network.
S set of main airport centers
Cl_i costs of flight leg i
L set of flight legs on the network which must be covered
F set of fleets or air-crews
C_2 initial costs for each fleet, fix costs per fleet
C_3 penalty costs for each transfer of fleets
W set of transfer legs per fleet.
T set of possible tours or rotations
LTt limited time per tour.
LTf limited time per fleet.
ST_i start time of tour i.
FT_i finish time of tour i.
Tf_i set of tours are assigned to fleet i
Sl_i start time of leg i.
Fl_i finish time of leg i.
P_j time at airport terminal j

- Decision variables:

$x_{ijk} \epsilon \{0, 1\} \ldots 1,$ if a leg i is included in tour j and undertaken by fleet k.

$fl_{ij} \in \{0, 1\} \dots 1$, if fleet j of main airport i is chosen

$t_{ijk} \in \{0, 1\} \dots 1$, if a transfer flight-leg k in tour j undertaken by fleet i occurs $\forall\{i\epsilon F, j\epsilon T, k\epsilon W\}$,

- Objective function is that minimizes sum of three cost-elements including flight-legs costs, fleets cost, and transferring-flight-legs costs. The first one belongs to the quantity as well as characters of flight-legs; the second one is fixed-costs paid for fleets such as salary; the last one is penalty costs incurred when an air-crews move without mission.

- Constraints:

  - Each flight leg is serviced at least by one tour and by one air-crew.
  - Each tour includes at least one flight leg.
  - At one time, a fleet only services one flight leg.
  - Each fleet belongs to at least one main airport center.
  - Total service time of any pairing does not exceed a permitted limitation.
  - Total service time of any fleet does not exceed a permitted limitation
  - At any airport, the starting time of next leg in the legs-chain has to satisfy the possible time conditions.
  - After finishing missions, the fleets have to return to main airport centers.

- Model:

$$Min(\sum_{i\epsilon F}\sum_{j\epsilon T}\sum_{k\epsilon L} Cl_{ijk}xl_{ijk} \quad + \ C_2\sum_{i\epsilon S}\sum_{j\epsilon F} fl_{ij} + \ C_3\sum_{i\epsilon F}\sum_{j\epsilon T}\sum_{k\epsilon W} t_{ijk}) \quad (1)$$

Subject to

$$\sum_{i\epsilon F}\sum_{j\epsilon T}\sum_{k\epsilon L} xl_{ijk} \quad \geq 1 \qquad (2)$$

$$\sum_{k\epsilon L} xl_{ik} \geq 1, \forall i\epsilon T \qquad (3)$$

$$\sum_{i\epsilon L} fl_{ijt} \leq 1, \forall j\epsilon F \qquad (4)$$

$$\sum_{j\epsilon S} fl_{ij} \geq 1, \forall i\epsilon F \qquad (5)$$

$$FT_i - ST_i \leq LTt, \forall i\epsilon T \qquad (6)$$

$$\sum_{i\epsilon Tf_j} FT_i - ST_i \leq LTf, \forall j\epsilon F \qquad (7)$$

$$Sl_i \geq Fl_{i-1} + P_j, \forall j\epsilon D, \forall i\epsilon T \qquad (8)$$

3. Experiment procedures

Air-crew scheduling includes complex tasks, so it is divided into three main phases to simplify. First of all, a set of possible tours are generated; then a sub-set of tours which cover all flight legs at the lowest total transportation costs are determined; finally, fleets are assigned to undertake them. Each phase is described following in detail.

<u>3.1 Phase 1: Generate a possible set of tours</u>

A set of feasible tours are created from relative data, in which a feasible tour is defined as a chain of flight-legs satisfying all of constraints. In this phase, the objective function is temporarily ignored.
They are processed through two steps in sequentially.
In the first one, a set of leg-chains including at least one leg and satisfying constraints are created in a determined period. However, starting location or finishing one in any chain is any airport where fleets belong to or not. Information flows are described in Figure 1. From definition of a leg-chain, each flight-leg can be considered as a leg-chain. Other ones are pondered in turn, which can be integrated to create new leg-chains if they meet required conditions. Final results are a large number of leg-chains, which become input-data for next step.

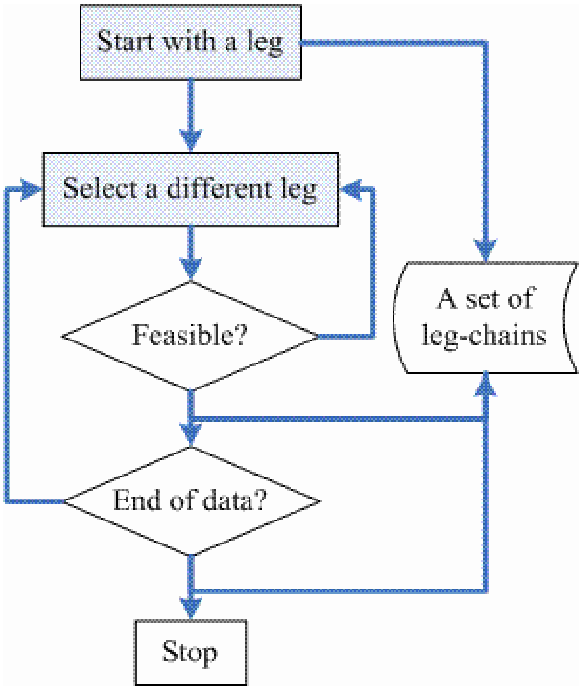


Figure 1: Process of Generating a Set of Leg-Chains

In the second step, a set of possible pairings are created. A pairing is defined as a sequence of legs, in which the starting and finishing points have to be located in main airports. They are generated from the set of leg-chains, results of step 1, under required constraints. The procedure in this step is shown in Figure 2. Leg-chains are considered in succession. From definition of a pairing, only ones with starting locations in main airports are considered to become pairing(s) or tour(s). If their finishing locations are main airports, they can be stored as pairing(s). In the other hand, they search for other suitable leg-chains to make new pairing(s) as many as possible. Finally, a large number of tours or pairings are generated.

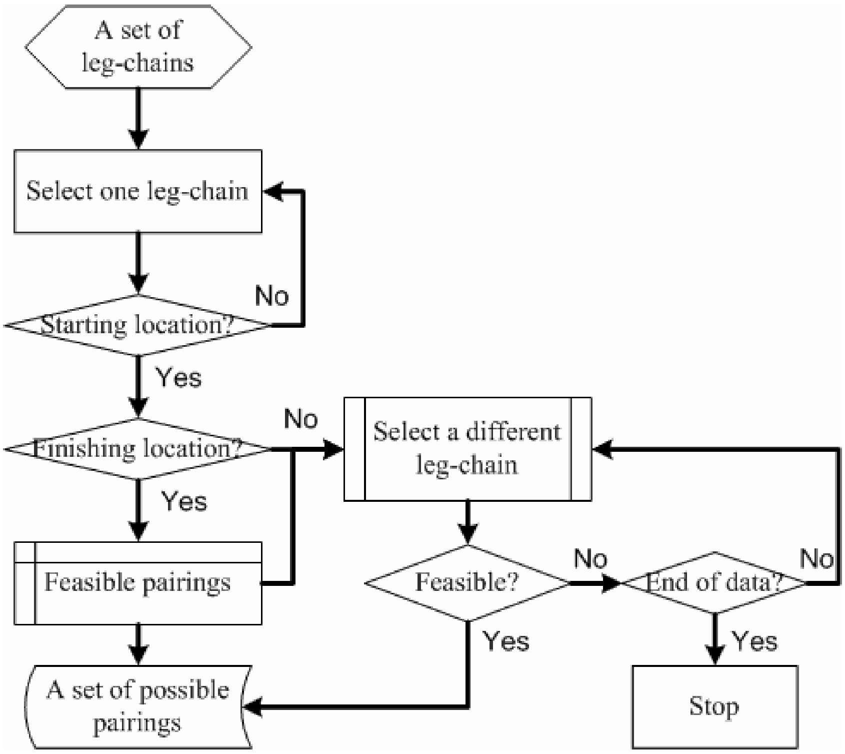


Figure 2: Information Flows in Generating-Pairings Procedure

3.2 Phase 2: Determine the optimum alternative

An optimum alternative is determined in this phase, which has to cover all flight-legs at the lowest total costs. From the set of possible tours, results of previous phase, an optimum sub-set of possible pairings are decided, which do not violate any constraint. The original model is now converted into integer programming model through phase 1, which is described as following.

Integer programming model:

Objective function: Min $\sum_{j=1}^{N} c_j x_j$ (9)

Subject to: $Ax = e_m$, x_j {0,1} for j = 1, …, n. (10)

$$x_j \epsilon \{0,1\} \ldots 1, if\ pairing\ j\ is\ chosen$$
$$c_j\ \ cost\ of\ pairing\ j$$

e_m a vector having *m* elements with value 1.
m the number of flight-legs having to be covered.
n the number of possible pairings.
A a matrix with elements a_{ij}, in which

$$a_{ij} = \begin{cases} 1, & if\ leg\ i\ is\ included\ in\ pairings\ j \\ \ \ 0 & \end{cases}$$

In matrix A, each row presents a flight-leg and each column presents a possible pairing.

One of meta-heuristics algorithms, column selection in set partitioning algorithm, is used in this paper to figure out the optimum transportation network. It is described following in detail.

A set of partition is a feasible solution, which is a set of feasible pairings with

$J^l = \{ j \mid x^l_j = 1\}$: the l^{th} partition.

The l^{th} partition has a row prices value in correspondingly

$\pi^{-l} = (\pi_1^{-1}, \pi_2^{-1}, \ldots, \pi_n^{-1})$

So,

$$\sum_{i=1}^{m} \pi_j^l a_{ij}, \forall j \in J^l$$

When the solution is moved from J^1 to J^2, their objective values are modified correspondingly

$$Z^2 = Z^1 - \sum_{j \epsilon J^2} \sum_{i=1}^{m} (\pi_j^l a_{ij} - c_j)$$

With

$$\delta_j = \sum_{i=1}^{m} (\pi_j^l a_{ij} - c_j)$$

δ_j are called potential savings.

The goal of this algorithm is finding out a new J^{l+1} solution that is better than J^l solution. If J^l solution

has $\sum_{i=1}^{m} (\pi_j^l a_{ij} - c_j) \leq 0, j = 1, \ldots, n$, an optimum solution is achieved.

The column selection in set partitioning algorithm is described following.

Step 1: Set up $J^2 = 0$ and $N = \{1,2, \ldots, n\}$

Step 2: Calculate potential savings:

$$\delta_j = \sum_{i=1}^{m} (\pi_j^l a_{ij} - c_j), j = 1, \ldots, n$$

And then determine *k* value which has maximum δ_k value.

Step 3: $\forall i, i = 1, .., n$; if $a_{ik} = 1$, $then\ a_{ij} = 0, \forall j \neq k$

Step 4: Update $J^2 = J^2 \cup \{k\}$ and $N = N - \{k\}$.

Delete all column j which only has $a_{ij} = 0, \forall i, i = 1, \ldots, m$

Step 5: If N = 0, stop; Else return to Step 2.

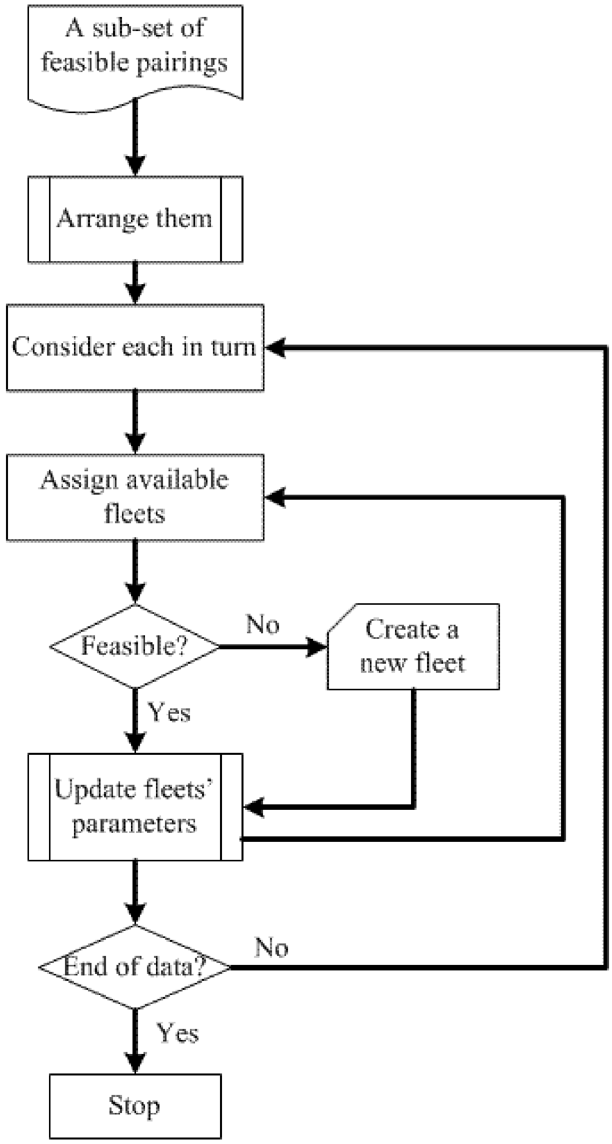


Figure 3: Process of Assigning Fleets

3.3 Phase 3: Assigning fleets

After determining an optimum sub-set of pairings, next step is to assign fleets to responsible for them. Greedy algorithm is used to find a possible solution. The information flows are shown in the Figure 3. A set of feasible tours or rotations is ordered following EDD (Earliest Due Date) rule, where the tour with earliest finishing time is the first one considered to assign to available fleets. This rule is used because of noting to relaxing time of fleets. If a tour has to be undertaken, among available fleets which has a longest relaxing time is responsible for. If there is not any available fleet, which can undertake it, a new fleet is required.

Through this procedure, each flight-crew undertakes feasible pairings as many as possible. As a result, the number of required air-crews is expected at a minimum level.

3.4 Vietnam Airline problem

Every week, Vietnam Airline makes an air-crew scheduling plan, which has to cover a set of flight-legs. Required information is provided from relative departments, which includes flight number (F_no), airplane (T_ap), destination place (F_ti), arrival airport (E_pl), and flight-time information as shown in Table 1.

Table 1: Information of Flight Legs

F_no	Ac	T_ap	F_pl	E_pl	F_ti	Edd	Etd	Eda	Eta	N_p
VN311	9	320	HAN	DAD	01:10	12/5/2000	06:45	12/5/2000	07:55	150
VN310	9	320	DAD	HAN	01:10	12/5/2000	08:40	12/5/2000	09:50	150
VN790	9	320	HAN	HKG	01:55	12/5/2000	10:50	12/5/2000	13:45	150
VN791	9	320	HKG	HAN	01:50	12/5/2000	14:55	12/5/2000	15:45	150
VN919	9	320	HAN	SGN	02:00	12/5/2000	16:50	12/5/2000	18:50	150
VN236	9	320	SGN	HAN	02:00	12/5/2000	19:45	12/5/2000	21:45	150
VN741	9	320	HAN	SGN	02:00	13/5/2000	07:20	13/5/2000	09:20	150
VN741	9	320	SGN	SIN	01:50	13/5/2000	10:20	13/5/2000	13:10	150
VN740	9	320	SIN	SGN	02:00	13/5/2000	14:10	13/5/2000	15:10	150
VN928	9	320	SGN	TPE	03:25	13/5/2000	16:25	13/5/2000	20:50	150
VN929	9	320	TPE	SGN	03:30	14/5/2000	08:00	14/5/2000	10:30	150
VN851	9	320	SGN	BKK	01:30	14/5/2000	11:30	14/5/2000	13:00	150
VN850	9	320	BKK	SGN	01:30	14/5/2000	14:00	14/5/2000	15:30	150

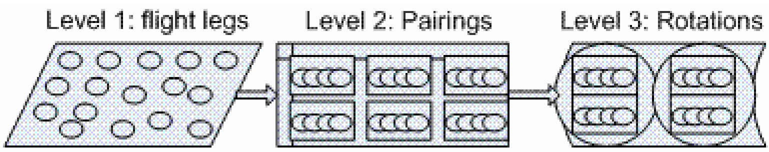


Figure 4: General Information Flows

Besides, air-crew scheduling plan must satisfy many constraints, such as time and place constraints, safety rules, national rules, and international rules, which are regarded in process. Actually, it is a complicated one, so, to simplify, the problem is solved through three phases. Figure 4 depicts the information flows in each phase. Results of previous phase become input data of next one. At the level 1, information of flight-legs is formatted and coded in a standard form, which is used as input data in next processing. Because of difference in time zone among areas, flight time is converted to GMT system through Equation (11).

$$\left(d_{dp} - d_{min}\right) \text{ x } 24 \text{ x } 60 + \left(t_{dp} - t_d\right) \text{ x } 60 + m_{dp} = t_{GMT} \quad (11)$$

Note:
d_{dp}: local time in day(s)
d_{min}: min time in day(s) in the flight time data
t_{dp}: local time in hour(s)
t_d: different time in hour(s) between local and GMT times
m_{dp}: local time in minute(s)
t_{GMT}: converted time in minutes(s)

In level 2, it is processed through two phases to determine the optimum sub-set of parings, in which meta-heuristics algorithms are used. In this paper, column selection in set partitioning algorithm described above and longest processing time one are used. The later is characterized as following. In the set of possible pairings, the pairing which has the longest duration is the first one is selected. This action is repeated until all flight legs are scheduled. The quality of the solution from the first algorithm is actually better than the second one, but it absorbs longer computing time.

The results of level 2 are an optimum set of pairings, in which a pairing, for example, is presented like Figure 5. Consequently, they become input data at level 3.

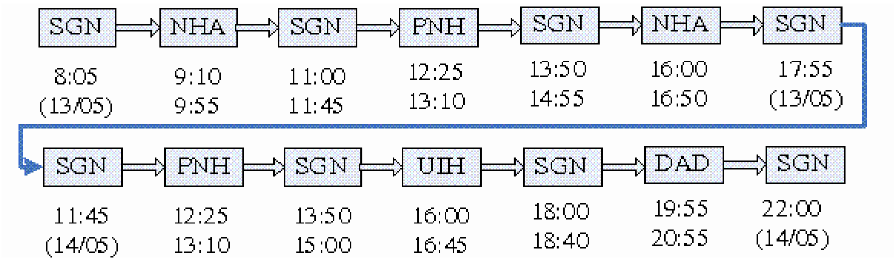
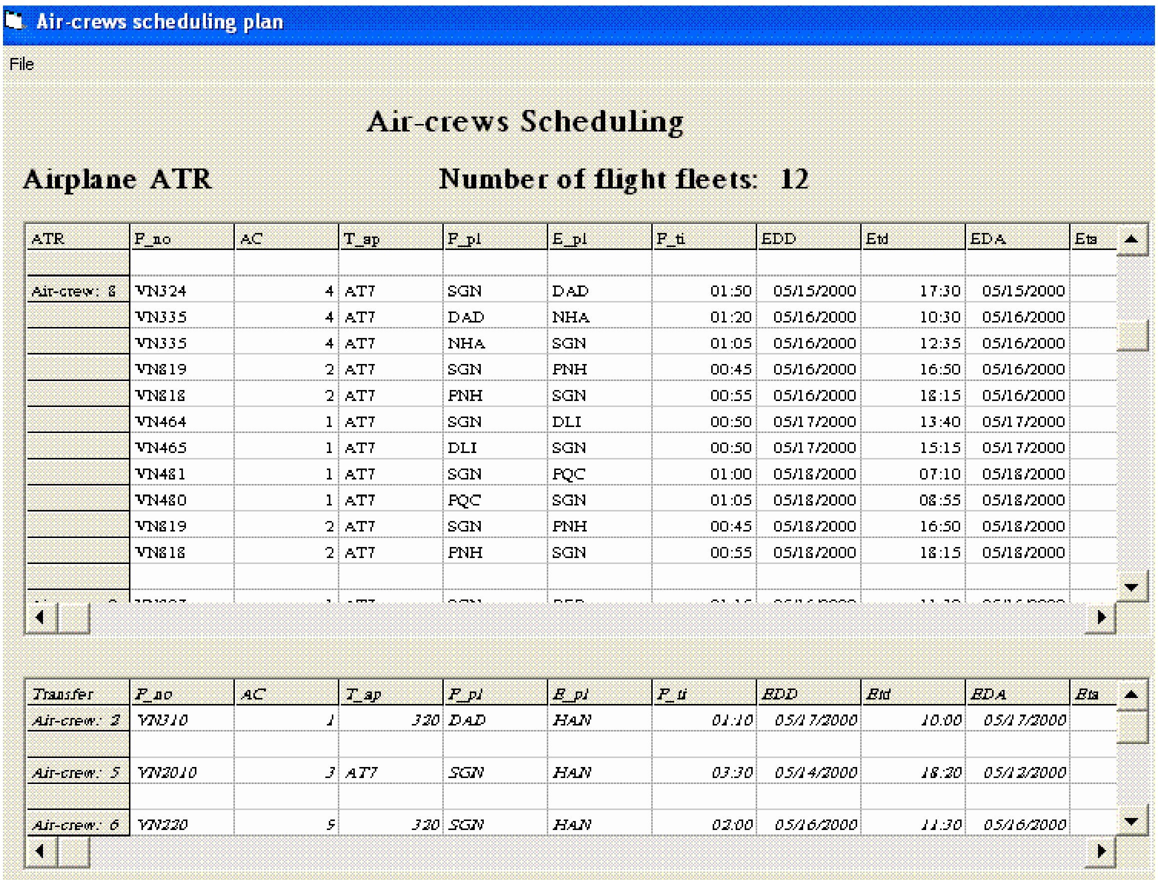


Figure 5: An Example Pairing

To assign air-crews responsible for pairings, greedy algorithm is used. The results of this phase are presented in an air-crews scheduling plan in a determined period. It includes all information of flight-legs, which are undertaken by air-crews in separately. Results are shown in Figure 6.



ATR	F_no	AC	T_ap	F_pl	E_pl	F_ti	EDD	Etd	EDA	Eta
Air-crew: 8	VN324	4	AT7	SGN	DAD	01:50	05/15/2000	17:30	05/15/2000	
	VN335	4	AT7	DAD	NHA	01:20	05/16/2000	10:30	05/16/2000	
	VN335	4	AT7	NHA	SGN	01:05	05/16/2000	12:35	05/16/2000	
	VN819	2	AT7	SGN	PNH	00:45	05/16/2000	16:50	05/16/2000	
	VN818	2	AT7	PNH	SGN	00:55	05/16/2000	18:15	05/16/2000	
	VN464	1	AT7	SGN	DLI	00:50	05/17/2000	13:40	05/17/2000	
	VN465	1	AT7	DLI	SGN	00:50	05/17/2000	15:15	05/17/2000	
	VN481	1	AT7	SGN	PQC	01:00	05/18/2000	07:10	05/18/2000	
	VN480	1	AT7	PQC	SGN	01:05	05/18/2000	08:55	05/18/2000	
	VN819	2	AT7	SGN	PNH	00:45	05/18/2000	16:50	05/18/2000	
	VN818	2	AT7	PNH	SGN	00:55	05/18/2000	18:15	05/18/2000	

Transfer	F_no	AC	T_ap	F_pl	E_pl	F_ti	EDD	Etd	EDA	Eta
Air-crew: 2	VN310	1	320	DAD	HAN	01:10	05/17/2000	10:00	05/17/2000	
Air-crew: 5	VN2010	3	AT7	SGN	HAN	03:30	05/14/2000	18:20	05/12/2000	
Air-crew: 6	VN220	5	320	SGN	HAN	02:00	05/16/2000	11:30	05/16/2000	

Figure 6: A Part of Air-Crew Scheduling Plan

In air-crews scheduling plan, missions of each fleet is included, where flight-legs as well as transfer-flight-legs are involved. Based on which planners are easier in managing or making fleets scheduling plan

4. Conclusion

This research gives a general direction to solve the air-crew problem, with which more complex issues are worked out by using the experience gained from this application as an illustration. It might be effective in constructing the transportation network by adding some suitable modifications, which is one of the most important problems of the logistics system.

The succinct models reveal quite clearly trade-offs between the flexibility they affords and the accuracy of their results underlying their recommendations. It is really useful, because it can be a convincing communication bridge between the analyst and decision-maker when recommendations for action are being made, and it may point to better solutions than those allowed by the original formulation. This may lead to a reconsideration of the original question, perhaps suggesting that the scope of the problem should be expanded.

With the big and complex air-crew scheduling problems, suitable heuristics algorithms are considered in solving them. Although finding the optimum solutions is not sure, good solutions can be reached. In addition, randomize factors did not mention in this paper. In practice, transportation cost or time is not a constant, so simulation method could be used to figure out the best alternative, which is another research.

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Reducing Aircraft Emissions on the Ground

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Abstract

Climate change has received increasing attention. A major contributor to global warming is emissions from transportation modes. Emissions from aircraft are considerable and should be tackled. This study investigates measures that could reduce aircraft emissions on the airfield: operating fewer engines during taxiing, using ground power units (GPU) instead of auxiliary power units, and extended towing of aircraft. Singapore's Changi Airport is used as a case study. Results indicate that significant reductions in emission and fuel consumption could be achieved with these measures. Overall, taxiing with fewer operating engines and use of GPU appear to be more feasible in the short term.

1. Introduction

Climate change has been the concern of environmentalists for several decades. It has also received attention from governments and businesses in recent years. A major contributor to global warming is emissions from various transport modes. It is acknowledged that land transportation generates much greater amounts of air pollutants than other transport modes, due mainly to the sheer volume of motorized vehicle trips made around the world in moving people and goods. However, emissions from air transportation are also quite considerable. This is especially true for the Asia-Pacific region as air travel has increased rapidly in the past two decades and is projected to continue on the same, if not higher, growth path. Consequently, jet fuel consumption will also increase considerably, notwithstanding advances in airframe and engine technology which have made possible lower fuel consumption rates. This means significant increases in pollutant emissions from air transportation can be expected. The challenge to the aviation industry is to minimize the environmental impacts without significantly affecting growth in air travel. Hence, it is desirable that measures to minimize these pollutant emissions be investigated and feasible ones implemented.

This paper presents findings from a study of potential measures that could reduce emissions from aircraft operations. Airport emission sources include: aircraft operations in the idle, taxi, takeoff, climbout and landing modes; ground service equipment; fuel handling and storage; and engine maintenance. In addition, the operation of auxiliary power units (APU) which are small on-board gas turbine engines that provide both hydraulic and electrical power while the main engines are not in operation is also an emission source. The focus of this study is on measures to control aircraft ground operations that could be implemented to achieve reductions in pollutant emission. As such, only emissions resulting from aircraft operations on the airfield in the idle and taxi modes were studied. Singapore's Changi Airport (SCA) is used as a case study to illustrate the potential emission reductions achievable.

2. Pollutants from Aircraft Operations

Combustion of aviation fuel from aircraft operations results in the emission of carbon monoxide (CO), volatile organic compounds (VOC or hydrocarbons HC), oxides of nitrogen (NO_X), sulfur dioxide (SO_2), and particulate matter (PM). These pollutants can cause harm to the respiratory systems of human beings, plants and animals, damage the ozone layer, and contribute to global warming. They can

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also cause haze and reduce visibility.

Complete combustion of aviation fuel would result in the emission of carbon dioxide (CO_2) and water vapor. The release of CO_2 contributes to the greenhouse effect. However, combustion during aircraft movement on an airfield is usually incomplete and produces CO and VOC in the process. Hence, CO and VOC (i.e., HC) emissions are higher during taxi and idling of aircraft. CO can cause harmful effects to the cardiovascular and central nervous systems of humans by reducing oxygen delivery to the body's organs and tissues. It also contributes to the formation of smog which can trigger respiratory problems. VOC can cause eye and respiratory tract irritation, dizziness, memory impairment, and contributes to ozone formation and acid rain. They are also deposited on soils and surface water where they are taken up by plants or ingested by animals.

PM is a complex mixture of solid and liquid droplets less than 10 micrometers in size. These are able to pass through the nose and throat to enter the lungs and cause serious health problems to people. They can also retard photosynthesis and plant growth, as well as reduce visibility. PM emissions are highest during takeoff and climbout due to the high fuel consumption in those operating modes.

NO_x and SO_2 are formed when fuel is burned at high temperatures, and the amounts released are highest during takeoff when engines are at high power settings. They cause a variety of health problems such as lung irritation and lower resistance to respiratory infection. The environmental impacts of NO_x and SO_2 include, among others, contribution to global warming and acid rain. The amounts of CO, HC and NO_x emitted during aircraft ground operations are much more than those of the other pollutants. These are, therefore, the pollutants of interest in this study.

3. Potential Measures to Reduce Pollutant Emissions

The aviation industry had been looking into measures to reduce fuel consumption in response to fuel supply and cost concerns. Manufacturers have spent significant resources in airframe and engine design to improve fuel efficiency. Alternatives to reduce aviation fuel consumption have also been proposed. For example, the Air Transport Association of America (ATA, 2006; Heimlich, 2006) recommended strategies for fuel conservation which involved: (i) better flight planning and improved air traffic control procedures to increase flight operation efficiency; (ii) increase in airfield capacity to reduce congestion; and (iii) improving aircraft ground operations. The latter included redistributing cargo in the aircraft belly to move the center of gravity forward, employing self-imposed ground delays to reduce airborne holding, changing paint schemes to minimize heat absorption, as well as using ground power instead of APU to provide electricity and conditioned air. Since the amount of pollutants emitted is directly related to fuel consumption, measures that could reduce fuel consumption would also reduce emissions.

As stated earlier, the focus of this study is on measures to reduce air pollutants emitted during aircraft ground operations. The measures investigated include: operating fewer engines during taxiing, using ground power units (GPU) and pre-conditioned air instead of APU at the gates, and replacing taxiing with extended towing of aircraft. In the remainder of this paper, the procedures and the concerns related to these strategies are described first. The potential reductions in emissions associated with each strategy are then estimated.

3.1 Operating fewer engines during taxiing

Typically, aircraft require very low engine thrust to provide power for taxiing on the airfield. This means aircraft could operate fewer engines during taxiing to reduce fuel consumption and pollutant emissions. To compensate for the loss of power due to fewer operating engines, the engine(s) in use would operate at a higher power setting so as to maintain taxi speed. The higher power setting allows more efficient fuel burn with almost no increase in fuel consumption above that required for idle thrust.

This results in lower emissions of HC and CO, and a slight increase in NO_X due to the higher operating temperature. The higher thrust also means taxiing aircraft need to be kept farther apart due to the increased exhaust velocity.

There would be delays to departing aircraft due to time spent waiting for engine start and warm-up before taking off. These would not be critical if there is a departure queue and the aircraft has to wait anyway. There is also a concern that an engine may fail to start before an aircraft departs, resulting in delays as the aircraft would need to go back to the terminal area or require the dispatch of a ground crew to service the engine. In addition, fire-fighting equipment may be needed near the area where the aircraft will start the remaining engine(s), if a CFR (crash, fire and rescue) facility is not located nearby. This, however, does not appear to be of significant concern as it has been practiced at many airports, albeit on a voluntary basis and not all airlines do this even at the same airport.

3.2 Use of ground power units instead of auxiliary power units

If 400 Hz GPUs and pre-conditioned air (PCA) systems are available at the parking apron, the use of APUs would not be needed. GPU/PCA systems supply electric power and temperature-controlled air to the aircraft. Thus, fuel can be conserved by turning off the APUs while aircraft are parked for loading/unloading. As a result, pollutant emissions can be reduced.

3.3 Extended towing of aircraft instead of taxiing

Moving aircraft with a tow tug has been limited mainly to pushback maneuvers from the gates or over short distances within a confined apron area; and between the terminal area and maintenance facilities. Regular extended towing of loaded aircraft between the terminal and the runways has not been conducted, although it was considered by the US Department of Energy (Fan and Haney, 1981).

Extended towing requires arriving aircraft to taxi to a designated area, shut down the engines, and then be towed by a tractor to the apron area. Departing aircraft would be towed from the parking apron to a staging area near the departure end of the runway before aircraft engines are started. As fuel consumption and emission rates of tractors and APUs are lower than those of an aircraft, reductions in emission could be achieved. However, there may be safety, operational and cost concerns in the implementation of such towing operations (see Fan and Haney, 1981).

Briefly, the safety concerns relate to the stresses imposed by towing on the nose gear. Studies commissioned by the US Federal Aviation Administration (Lockheed, 1980; Douglas, 1980) revealed that loads from extended towing were within safe design ranges. A shock-absorbing device built into the tow bar could reduce the loads on the nose gear, and frequent inspection and replacement of certain nose gear components could also enhanced safety. Another issue is that the control of aircraft is placed with the tractor driver rather than the pilot who is legally responsible for the safety of the passengers and the aircraft. There are also concerns regarding engine-startup and fire protection for departures, similar to those for operating fewer engines during taxiing.

The operational concerns include increased air traffic controller workload resulting from the higher tow tractor traffic around the airfield. Also, engines need to attain thermal stability before takeoff, which implies that a large area at the departure end of the runway would be required. The slower tractor speeds compared to the normal taxi speeds also cause additional travel time and delay. Obviously, there are costs in acquiring more tractors and starter trucks, tow bars, communication equipment, and extra tractor crew members. In addition, separate roadways are needed for returning tractors to their stations after towing operations. If separate paths are not provided, the flows of traffic would have to be interrupted to allow two-way movements on the same path and ground traffic congestion might result. Thus, it may be necessary to construct tractor roadways for this purpose which would mean additional costs. These costs may be partially or fully offset by savings in fuel costs.

4. Estimation of Pollutant Emissions

For the purpose of estimating the amount of pollutant emissions from aircraft ground movements, the following data are required: (1) aircraft fleet mix and traffic levels, (2) aircraft taxi and idle times between runway(s) and apron-gate positions; and (3) fuel consumption and pollutant emission rates for various types of engines.

To estimate emission reductions achievable from implementing the control measures to be studied, information concerning (1) aircraft engine shutdown times under each measure, and (2) fuel consumption and emission rates for APUs and tow tractors are also required. The actual effects of the measures at an airport would clearly depend on the specific characteristics such as airfield layout, taxi routes, aircraft fleet mix and operation levels at the airport. In this study, Singapore Changi Airport is used to illustrate the reduction achievable with each of the measures investigated.

4.1 Aircraft operation data for Singapore Changi Airport

The *Air Transport Statistics* published by the Civil Aviation Authority of Singapore (CAAS) provided the number of commercial passenger flights that took place at SCA. In 2006, a total of 214,224 commercial passenger aircraft operations was recorded (CAAS, 2006a). Information on fleet mix for the Year 2006 was extracted from the website of SCA (CAAS 2006b) and is summarized in Table 1.

Table 1: Aircraft Fleet Mix and Average Fuel Consumption Rates (Singapore Changi Airport)

Aircraft Model	Percent of Total Fleet	Average Fuel Consumption Rate (kg/h)	Aircraft Model	Percent of Total Fleet	Average Fuel Consumption Rate (kg/h)
A300-600	2.16	1476.0	B737-400	4.75	856.8
A310	1.04	1364.4	B737-500	1.04	856.8
A319	5.71	684.0	B737-700	1.69	720.0
A320	14.92	820.8	B737-800	2.81	810.0
A321	0.56	936.6	B747-300	1.29	3222.0
A330-200	2.42	1753.2	B747-400	13.10	3304.8
A330-300	6.60	1756.8	B757-200	1.13	1188.0
A340-200	0.96	1785.6	B767-200	2.17	1382.4
A340-300	0.87	1785.6	B767-300	2.00	1872.0
A340-500	1.04	3312.0	B777-200	16.78	2145.6
B712	0.56	691.2	B777-300	11.55	2221.2
B737-300	4.02	856.8	MD11	0.82	2116.8

There are two parallel runways (02L/20R and 02R/20L) at SCA, with a third parallel runway ready but yet to serve commercial operation. Aircraft operations are to the Northeast about half of the year, and to the Southwest the other half of the year. For this study, only three passenger terminals at SCA were in operation: Passenger Terminal 1 (T1), Passenger Terminal 2 (T2), and the Budget Terminal (BT) used by low-cost carriers. Passenger Terminal 3 was not included as it was not in service at the time of this study. In addition, operations at BT accounted for a fairly small percentage of aircraft operations at SCA, and were also excluded from this study. There were 109 aircraft parking bays (67 contact gates and 42 remote positions) for use by passenger flights at T1 and T2. Figure 2 shows the airfield layout in the vicinity of T1 and T2 at SCA.

It was not practical to collect taxi/idle times for each individual aircraft operation that took place at SCA in 2006. Instead, average values were estimated and applied to all aircraft operations. First, the taxi distances between the runways and parking positions were measured from the layout of SCA. Next, a sample of taxi speeds of arriving and departing aircraft was obtained from field observations. An analysis of these observations revealed that the average arrival taxi-in and departure taxi-out speeds were about 25 knots (46 km/h) and 12 knots (22 km/h), respectively. A slower speed for departures is expected due to the heavier fuel loads that these aircraft carry and the longer ground delay in the departure queue.

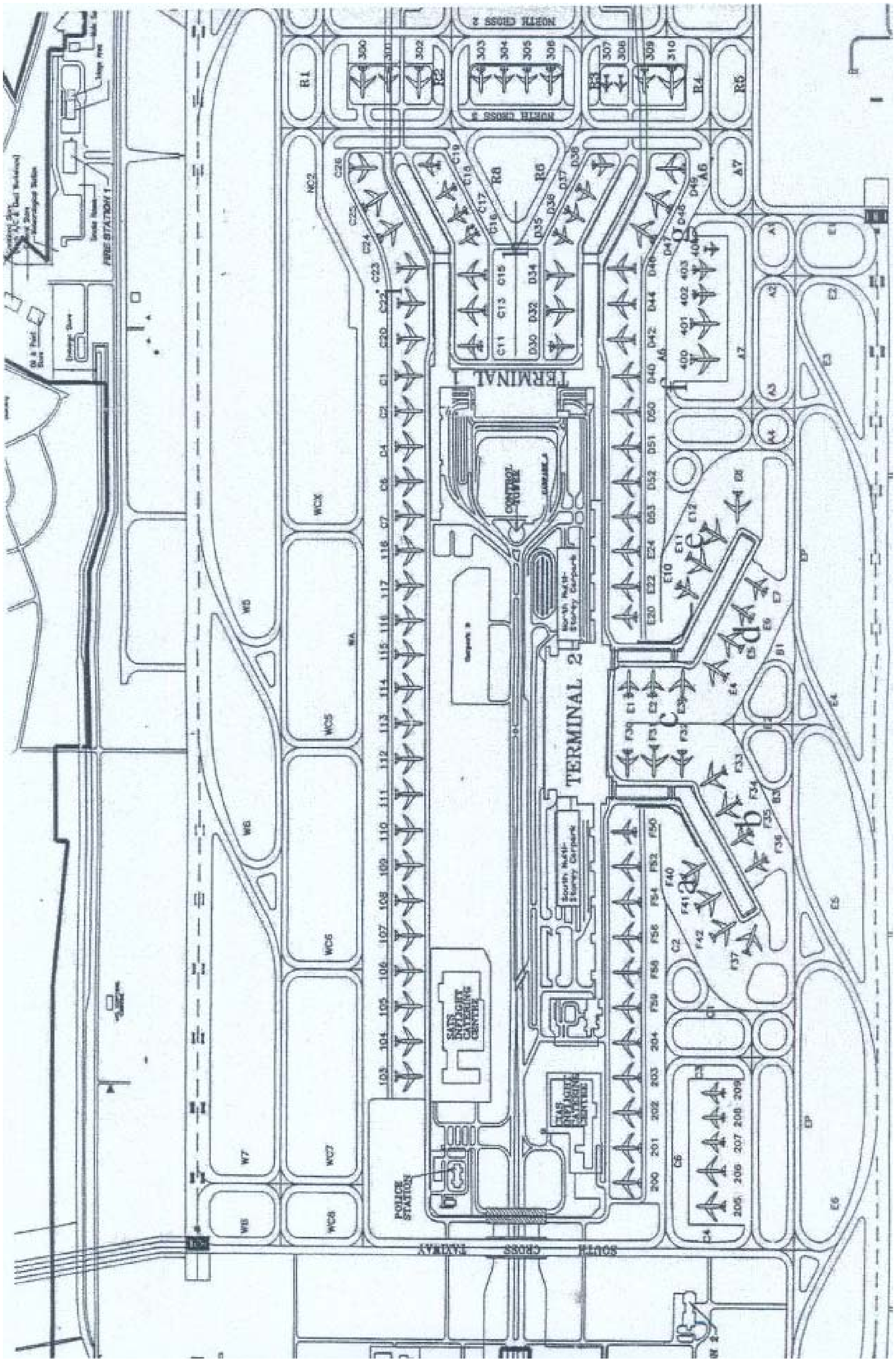

Figure 1: Airfield Layout – Singapore Changi Airport

Average travel times between the parking positions and the runways were computed using the measured distances and average taxi speeds. Clearly, the speeds observed in the field reflected the time spent taxiing between the runways and the parking positions, as well as delays experienced during taxiing. Therefore, they represent the average taxi/idle times for aircraft ground movements.

4.2 Average fuel consumption and pollutant emission rates

The types of engines and APUs for each aircraft model in the fleet mix at SCA were obtained from the websites of the manufacturers (Airbus, 2006; Boeing, 2006). Fuel consumption and emission rates for the aircraft engines, APUs and tractors were obtained from data published by the US Environmental

Protection Agency (EPA, 1999), supplemented by information from the engine manufacturers (GE, 2006; P&W, 2006; RR, 2006). Even for the same aircraft model, the type of engine installed may differ from airline to airline, and it was not feasible to obtain such information from all the airlines that operate at SCA. Hence, average fuel flow and emission rates for each aircraft model were used in this study. The average fuel consumption rates for each aircraft model (see Table 1) were estimated based on an equal weighting for the available engine types for that model. Table 2 shows the emission rates of the three pollutants of interest in this study for these aircraft.

Table 2: Average Aircraft Pollutant Emission Rates

Aircraft	Emission Rate (kg/1000kg of fuel)			Aircraft	Emission Rate (kg/1000kg of fuel)		
Model	HC	CO	NO_X	Model	HC	CO	NO_X
A300-600	1.78	20.99	4.80	B737-400	3.33	38.5	3.90
A310	0.74	12.76	4.90	B737-500	2.14	33.4	4.00
A319	1.69	26.42	3.16	B737-700	1.78	27.81	3.33
A320	1.85	28.93	3.46	B737-800	2.00	31.29	3.75
A321	2.19	34.21	4.10	B747-300	26.8	52.94	3.57
A330-200	1.57	11.97	3.85	B747-400	6.39	28.33	4.13
A330-300	1.58	12.02	3.87	B757-200	2.49	20.71	4.37
A340-200	2.21	34.49	4.13	B767-200	11.17	48.02	3.70
A340-300	2.21	34.49	4.13	B767-300	0.50	11.70	4.80
A340-500	0.43	10.04	4.12	B777-200	15.95	30.35	3.44
B712	1.44	7.80	2.17	B777-300	16.47	31.49	3.59
B737-300	3.33	38.50	3.90	MD11	9.96	44.41	3.79

4.3 Baseline emission levels at Singapore Changi Airport

Pollutant emissions from a particular aircraft can be obtained by first computing the fuel consumed in the taxi/idle mode, which is the product of its fuel consumption rate in the taxi/idle mode and the estimated taxi-in/taxi-out/idle times. To this, must be added the pushback times for departures, estimated to average 2.5 minutes during which engines are warmed up. The total fuel consumed is then multiplied by its emission rate for each pollutant. Finally, the total amount of emissions of a specific pollutant is obtained by summing emissions of that pollutant from all aircraft operations at the airport. Fuel consumed by running APUs at the terminal parking area and the pollutants emitted should also be included.

Table 3: Estimated Fuel Consumption and Pollutant Emissions For Various Control Measures (Singapore Changi Airport)

Study Scenario	Fuel Consumed (kg)	Pollutant Emissions (kg)		
		HC	CO	NO_X
Baseline aircraft -- taxi/idle	32,498,800	282,800	920,300	123,600
-- pushback	7,812,400	55,900	222,900	29,200
Subtotal	40,311,200	338,700	1,143,200	152,800
Baseline APU	18,604,100	6,700	59,500	105,100
Baseline Total	58,915,300	345,400	1,202,700	257,900
Taxi with fewer operating engines and use of APU during parking				
-- taxi on one engine	35,893,100	154,900	546,100	169,900
-- with one engine off	41,626,400	197,100	716,200	193,100
Taxi with fewer operating engines and use of GPU/PCA during parking				
-- taxi on one engine	17,288,900	148,200	486,600	64,800
-- with one engine off	23,022,200	190,400	656,700	88,000
Extended aircraft towing				
-- with use of APU	42,582,800	179,000	671,200	212,000
-- with use of GPU/PCA	23,978,700	172,300	611,600	106,900

Table 3 summarizes the estimated fuel consumption and pollutant emissions at SCA based on the 2006 traffic level. It was estimated that aircraft ground operations and APUs consumed a total of 58.92 million kg of fuel in 2006 which produced about 345,400 kg of HC; 1,202,700 kg of CO; and 257,900 kg of NO_X. Of these an estimated 40.31 million kg of fuel was used by aircraft operations during taxi and pushback maneuvers, and emitted about 338,700 kg of HC; 1,143,200 kg of CO; and 152,800 kg of NO_X. The remaining portion of fuel consumption and pollutant emissions can be attributed to the use of APUs when aircraft are parked at the terminal area.

4.4 Emission reduction from operating fewer engines during taxiing

For this measure, two scenarios were investigated: (a) each aircraft would operate only one engine during taxiing; and (b) each aircraft would shut down one of its engines during taxiing. The fuel consumption and pollutant emissions associated with these two scenarios are shown in Table 3 which included also fuel consumption and pollutant emissions due to the operation of APUs in the terminal area, as well as pushback times for departing aircraft. As can be seen, the two scenarios under this measure resulted in significant decreases in the amounts of fuel consumed and pollutants emitted. Table 4 summarizes the reductions in pollutant emissions and fuel consumption compared to the 2006 baseline values for SCA.

Table 4: Estimated reductions in fuel consumption and pollutant emissions for various control measures (Singapore Changi Airport)

Control Measure	Fuel Consumed (kg)	Pollutant Emissions (kg) HC	CO	NO_X
Taxi with fewer operating engines and use of APU during parking				
-- taxi on one engine	23,022,200	190,400	656,700	88,000
-- with one engine off	17,288,900	148,200	486,600	64,800
Taxi with fewer operating engines and use of GPU/PCA during parking				
-- taxi on one engine	41,626,400	197,100	716,200	193,100
-- with one engine off	35,893,100	154,900	546,100	169,900
Use GPU instead of APU	18,604,100	6,700	59,500	105,100
Extended aircraft towing				
-- with use of APU	16,332,500	166,400	531,600	45,900
-- with use of GPU/PCA	34,936,600	173,100	591,200	151,000

At the 2006 air traffic level, taxiing on only one engine would save an estimated 39% (or 23.02 million kg) of fuel compared to the baseline and achieve reductions in HC and CO emissions of 55% (190,400 kg and 656,700 kg), and 34% (88,000 kg) in NO_X emissions. If taxi maneuvers were to be conducted with only one of the engines shut down, the corresponding reductions would be 17.29 million kg (29%) of fuel; 148,200 kg (43%) of HC; 486,600 kg (41%) of CO; and 64,800 kg (25%) of NO_X. The differences between these two scenarios are not very large due to the predominance (82%) of two-engine aircraft at SCA.

4.5 Emission reduction from the use of ground power units

It was not possible to obtain information on the duration of APU operation for the various aircraft types at SCA. Clearly, short- and medium-haul flights would have shorter APU operating durations, while long-haul flights would have longer durations. For the purpose of this study, it is assumed that in the absence of GPU/PCA, APUs would be in operation at the parking position for an average of 75 minutes for each aircraft. The average emission rates used for HC, CO and NO_X are, respectively, 0.36, 3.20 and 5.65 (in kg per 1,000 kg of fuel).

Currently, only some of the gates at SCA are equipped with GPU and PCA. It is estimated that about 60% of the aircraft operations use APUs at the terminal apron area. The amounts of fuel consumed and pollutants emitted from operating APUs by these aircraft operations at SCA are also shown in Table 3.

If all the parking positions are provided with GPU/PCA, there would be no need to use APU as a source for supplying electric power and temperature-controlled air to aircraft. This would result in an estimated saving of 32% (18.6 million kg) in fuel, slight reductions of 2 to 5% in HC and CO emissions (6,700 kg and 59,500 kg), and rather significant reductions of 41% (105,100 kg) in NO_X emissions.

If this measure is combined with taxiing on fewer operating engines, the reduction in fuel consumption and pollutant emissions would be more significant. For the case of taxiing on only one engine an estimated 41.63 million kg (71%) of fuel could be saved and reductions of 197,100 kg (57%) of HC; 716,200 kg (60%) of CO; and 193,100 kg (75%) of NO_X may be achieved. If taxi maneuvers were to be conducted with shutting down only one of the engines, the corresponding reductions would be 61% (35.89 million kg) of fuel; 45% of HC and CO emissions (154,900 kg and 546,100 kg), and 66% (169,900 kg) of NO_X emissions.

It is noted that while the use of GPU/PCA instead of APU would reduce pollutant emissions at the airport, there may be an increase in emissions at the power plant which generates the electricity for use by the GPU/PCA systems, depending on the material used in generating electricity. However, compared to APUs, even power plants that use fuel would probably produce lower levels of pollutants as they typically need to meet stringent emissions standards.

4.6 Emission reduction from extended towing of aircraft

At SCA, there is little space between the runways/taxiways and the terminal aprons to provide an area designated for arrivals to be hooked up to a tractor before shutting down their engines. Furthermore, arriving aircraft are essentially at the terminal area after exiting from the runway. Consequently, it would not be of much benefit to tow arriving aircraft. Hence, for the purpose of this study, extended towing will only be applied to departing aircraft at SCA.

Departing aircraft are to be towed to an area designated for tractor disconnection, and would start their engines there. After an engine warm-up period, the aircraft would taxi to its takeoff point. The engine shutdown duration is hence the sum of pushback time and taxi/idle time that an aircraft would normally incur between its parking position and the tractor disconnection area, less the time required for engine warm-up. Since engine warm-up for normal taxiing aircraft usually takes place during pushback (sometimes while taxiing-out), it is assumed that the taxi/idle times for departures represent the net aircraft engine shutdown times for this measure.

Unlike normal taxiing operations, APUs would be in operation during extended towing to provide electricity and ventilation to the aircraft, as well as for starting the main engines. Thus, fuel consumed and emissions produced by APUs in the course of extended aircraft towing need to be accounted for. The same is true for fuel consumed and pollutants emitted by operating the tow tractors. As tow tractors operate at relatively low speeds, on-airfield travel times for towed aircraft would increase significantly, compared with those for aircraft taxiing under engine power. Hence, the period during which APUs are in operation would also be longer than the normal taxi/idle times of departing aircraft.

Furthermore, each tractor will travel double the taxi-out distance for a given towing operation – once for towing the departing aircraft and another for the return trip back to its base. It was assumed that tractor speed is 18 km/h when towing a wide-body aircraft, 25 km/h when towing all other aircraft types, and 40 km/h when it is not towing an aircraft. The average tractor emission rates used for HC, CO and NO_X are, respectively, 9.75, 48.70 and 51.0 (in kg per 1,000 kg of fuel).

The estimated fuel savings and pollutant emission reductions from implementing this measure at SCA are also shown in Table 4. As can be seen, at the 2006 traffic level, a total of 16.33 million kg (28%) of fuel may be conserved, with reductions of 48%, 44% and 18% (166,400 kg, 531,600 kg and 45,900 kg), respectively, in HC, CO and NO_X emissions at SCA.

If this measure is implemented together with replacing the use of APUs with GPU/PCA at the terminal, more significant reductions in fuel (34.94 million kg or 59%) and NO_X emissions (151,000 kg or 59%) could be achieved. The changes in HC and CO reductions would be quite modest (an additional 2% and 5%).

5. Summary and Conclusion

This study aims to investigate the potential emission reductions that could be achieved from the implementation of three measures to control aircraft ground operations: operating fewer engines during taxiing, using ground power units and pre-conditioned air instead of APU in the parking area, and extended towing of aircraft. The impacts of these measures at Singapore Changi Airport are used as an illustration.

Considerable reductions in fuel and pollutant emissions may be achieved through the implementation of these control measures. Compared to extended towing of aircraft, operating fewer engines during taxiing, and replacing APU with GPU/PCA offer moderately better fuel savings and emission reduction, especially if these two measures are implemented together. It is estimated that, at the 2006 SCA traffic level, 17 to 23 million kg (or 29 to 39% of baseline amounts) of jet fuel could be saved if fewer engines were operated for aircraft taxi maneuvers, which would yield reductions of 40 to 55% of HC and CO emissions, and 25 to 34% of NO_X emissions. If GPU/PCA systems are used in the terminal area instead of APUs, 18.6 million kg (or 32%) of jet fuel could potentially be saved and NO_X emissions could be reduced by 41%. However, reductions in HC and CO emissions are not very significant.

Even though fuel savings and emission reductions from extended towing of aircraft at SCA are significant, there are concerns that need to be addressed prior to its implementation. These included reliability of aircraft nose gear structure, responsibility for aircraft and passenger safety, delays to aircraft operations, and costs associated with the extra manpower and equipment requirements. If aircraft towing is to be implemented, it would be prudent to conduct a pilot towing program to confirm the findings on aircraft safety and on operational issues before large-scale towing is put into operation.

When the overall feasibility of each measure is evaluated, operating fewer engines during taxiing and replacing APUs with GPU/PCA in the parking area appear to be the most viable measures. The implementation of these measures would result in substantial reductions in HC, Co and NO_X emissions as well as fuel savings; with no apparent safety concerns; and they could be implemented immediately.

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The Impact of E-services in a State-owned Airline

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Abstract

The introduction of advanced electronic services to airline operations is a necessity. The forefront of these services is the full implementation of e-ticketing which was globally imposed by IATA regulations (Reg. 722H) by May 2008. The launch of these services has provided airlines with several new tools with which to woo customers and to improve customer services in many different areas of operations. Furthermore, the minimization of the operational costs are expected from airlines, implemented these services. However, these services bring a lot of changes to an airline's daily operation and the whole process of 'doing businesses is being transformed. The relationship between providers, airlines and customers has been changed. Therefore, airlines need to establish the appropriate organizational culture to flourish and take advantage of the benefits. The nature of organizational changes they need to make depend on the nature of their organization. Firms based on a simple organization structures may find it easier to adopt the changes, on the other hand, complex beauracratic organizations find it more difficult to support the new electronic products and services. In addition, most of airlines outsource these electronic services and face the resistance of their employees. In the paper we will examine how the launch of the new electronic services affect scheduled airlines operations and what organizations changes should take place. We will propose a new methodological framework for assessing the impact of the e-services to an airline and for adapting the organizational structure to new technologies

1. Introduction

The introduction of electronic services may provide powerful strategic and tactical tools for organizations and may strengthen organization competitiveness (Porter, 1985 and Porter, 2001). Competitiveness in the travel industry and airlines in particular bring them at the forefront of using electronic services. The implementation of e-ticketing imposed by International Air Transport Association (IATA regulation 722) is a necessity and brought significant changes in the industry and to the schedule airlines in particular. Due to the implementation of e-ticketing, airlines change their reservation systems, airport control systems, introduce new advanced web services, improve their frequent flyers systems, introduce revenue management systems, etc. All these services are called Passenger Services System (PSS), although frequent flyers systems and revenue management are not included in this term, according to air transport terminology. The PSS services provide functionalities, which enable the airline to optimize its operation so as to maximize its profit (SITA, 2006). This can be achieved by adopting those services, which offer to airlines significant competitive advantage. In addition, this requires many changes to take place and many processes and practices to be replaced. We selected Olympic Airlines, the national carrier of Greece, to examine the implications of these services to airlines. Olympic Airlines was created out from Olympic Airways in 2003 in order for the firm to become more attractive to private funds and offer operation functions. All the other functions are still under the management and belong to Olympic Airways services. In this paper, we use the term Olympic and this includes both of companies. The airline outsources PSS services, establishing a close co-operation with another big IT services provider, which is not going to be named in this paper.
This paper is consisted of five parts, particularly after the introduction in part 2. the Evolution of e-services is described . Next the research objectives and methodology are presented following by relative results. Finally in part 5 Conclusions, limitations and implications for further results are

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discussed.

2. Evolution of E-services

The introduction of e-services affect the daily operation, structure and strategy of organizations. The competitiveness of these firms to a great extent depends on the success in the implementation of these services. Innovations force most organizations to rethink the way they do business and how they re-engineer their business processes (Buhalis, 2004). Porter 1989) stresses that technology can totally transform the way an entire business is done. New advanced e-services contribute towards efficiency, productivity and improve the competitiveness of both inter-organisational and intra-organisational systems. The fierce competition in the airline industry press carriers to find ways to reduce costs and to improve services to customers. The adoption of new IT services assist airlines to this direction.

The introduction of new PSS services, with key point the implementation of e-ticketing, as this is initiated by IATA, under the program 'Simplifying the Business'. According to IATA (n.d.):
this program "leverages technology, automates and streamlines processes to reduce complexity and cost, whilst making the transportation of passengers and freight more convenient. This initiative is taken by IATA in order to bring a WIN-WIN situation to all stakeholders involved delivering annual industry savings of US$ 6.5 billion. The benefits and the savings from this initiative are the followings:

Benefits:

- For the customer this means stress-free ticketing, no tickets to lose and no last minute queues for tickets on departure, together with greater opportunities for using self-service kiosks.
- For the travel agent, electronic ticketing will allow them greater opportunities to manage the corporate travel experience by being able to make changes to the actual ticket whilst the customer is on the telephone.
- For airlines, it is estimated that approximately 9 US dollars in savings could be made when an electronic ticket is issued instead of a paper ticket.

Savings:
100% e-ticketing will save the industry up to US$ 3.0 billion per year.

- IATA processes 300 million paper tickets each year
- An e-ticket costs US$1 to process
- Paper tickets cost up to US$10 to process".

However, except the implementation of e-ticketing, the extended usage of internet changes the whole process of 'doing business'. Airline managements should understand the fundamental nature of the changes that are already taking place in their customer relations and maximise the benefits internet and e-commerce can bring. The effectiveness of the internet to sales and distribution has an increasingly important role and transforms dramatically the way that airline services and products are marketed and distributed (Doganis, 2001). However, facilities that the internet technology offer are used to other services such as airport functionalities, frequent flyer systems, etc.

The introduction of new e-services to airport operations facilitate airlines and passengers. The introduction of web check-in, the self-service kiosks are some of the recent developments offering significant advantages to airlines and to passengers. Airlines that offer self-service, easy to use devices to their passengers have experienced strong adoption among all customer types (up to 70%), helping to shorten queue time, reduce congestion at ticket and gate counter locations and optimise airport staffing (Sabre Airline Solutions, 2006).

In order to respond to increased competition and to low growth, airline managements focus on in the development of the existing customer base. Knowledge about customer's behaviours and the value they represent to a company is a precondition for applying successful loyalty policies and customer development strategies such as Frequent Flyers Programmes (FFPs). Although, the airline loyalty market has reached a state of maturity, few loyalty programmes can claim true competitive differentiation (ICLP, 2006, a.). However, a well-designed Frequent Flyer Programme offers an airline enormous benefits, holding important data for program members that those responsible for the program must analyse in order to generate true customer insight, which in turn must be intelligently and promptly acted upon. It is necessary to utilise this customer knowledge in order to offer a differentiated service, enhancing the customer experience and his/her loyalty (ICLP, 2006, b.). Thus, the new frequent flyer solutions offer airlines and their customers more choices with mutual benefits.

Implementing revenue management products, airlines achieve improved seat utilisation rates across multiple routes, optimisation of segmented pricing and generated increased profit. Revenue management and pricing are considered to be the most important strategic and powerful tools available to management delivering dramatic return on investment. Thus, a McKinsey study presented that a 1% improvement in price translates to an 11% increase in operating profit (PROS, n.d.)

Mobile technologies and mobile commerce expected to change significantly a number of industries and press organisations to reconsider their strategic management (Barnes, 2002). Organisation managements are generally confident that customers are, or will soon be, ready to receive marketing messages, make payments, download product information and make other relatively sophisticated transactions over mobile devices. According to the Economist Intelligence Unit survey, 71% of the respondents believe that mobile devices and applications will enable firms to offer better customer service, and 54% of the respondents believe that these services will assist a firm's marketing to existing and potential customers. In addition, the use of mobile services has enabled employees at most firms to enhance their personal productivity, in some cases substantially (Economist Intelligent Unit, 2007).

The above-described PSS services should be accompanied by clear strategic goals and commitment for the development of an appropriate strategy, the development of web sites and other technological solutions (Kowtha and Choon, 2001). The PSS services can assist airlines to offer a differentiated, modern product, which can fulfil customer needs. Cost effectiveness and flexibility are important elements and assist airlines to cut costs and maximise their efficiency. Furthermore, airline managements should continuously assess exogenous-environmental factors such as competition and their offerings, government regulation, technology, and other environmental forces that affect customer needs and preferences (Kohli and Jaworski, 1990). In addition, the close monitor of the current and potential customer needs is necessary. This collected information should be distributed to all functions, which can consequently adapt themselves offering a competitive product. The horizontal communication between departments is necessary to co-ordinate people and departments to facilitate the attainment of overall organizational goals. Effective intelligence dissemination, therefore "provides a shared basis for concerted actions by different departments" (Kohli and Jaworski, 1990). Also, the close monitor of the 'what the competitor is doing' regarding customer services and what kinds of PSS services are used are important.

Using advanced PSS services airlines can differentiate their products, customizing the final offer and adding value according to individual customer needs. The PSS services have revolutionized the entire system and have profound implications for both the strategic and tactical management of airlines. More significantly they have changed the industry structure and altered the competitiveness of all players in the market place (Buhalis, 2003 and O'Connor, 1999).

PSS services required significant organizational changes to flourish. In many cases, there is a resistance to this, setting obstacles to the success of change. In many cases, companies use external IT capabilities in order to achieve their organizational goals, when they cannot provide them themselves (Massey and Walker 1999; Thong, Yap and Raman 1996). However, conflicts may arise between internal and external IT capabilities and this can diminish the overall productivity of an organizational IT. In addition, the internal IT staff may play the role of spoiler if it feels threatened by an outside vendor or can be unwilling to disseminate knowledge transferred from the vendor (Bettencourt, et. al., 2002). There are cases, the internal IT staff may sabotage the work of external contractors (Nevo, Wade and Cook, 2006).

Firms use IT external staff because they may not have sufficient knowledge or expertise in-house, or they may be under time or budget pressures (Bathelemy, 2001; Gantz, 1990; Sengupta and Zviran, 1997). The success of outsource IT projects depends, to a large degree, on the commitment of the client to the project, on the skills of the consultants, on the collaboration between the client and the vendor, and on the level of information sharing between client and the vendor [Bettencourt, *et al*. 2002; George and Chattopadhyay, 2005; Slaughter and Ang, 1996). In addition, Nevo, Wade and Cook (2006) pointed out that open and honest communication, the availability of in-house dedicated staff, and contract management are required for a successful completion of a project. The cultural compatibility between the two organizations and the understanding of the client's business goals are necessary. Also, the Nevo, Wade and Cook (2006) study stressed that firms should firstly evaluate their internal IT knowledge and whether this is weak, then should use external assistance which affect positively firm's productivity.

However, whether an airline adopts new technological systems or enter into alliance should change its culture in order to promote and benefit from them. Most airlines should change their strategies, organization, route structure, equipment and basic approaches in order to survive and to compete with Low Cost Carriers (Shackford, 2005).

Many airlines have changed their PSS services in order to improve their product and efficiencies. The tremendous evolution of technology and the wide use of Internet change the industry.

In early 1950s, airlines have started to invest in these services. However, many reservations, ticketing, airport control tasks have been made manually. In 1962, American Airlines introduced its SABRE Computer Reservation System, which was related to the expansion of the carrier fleet. By the mid 1970s, SABRE was further developed and its technology provided the base for generating flight plans for aircraft, tracking spare parts, scheduling crews and developing a range of decision support systems for management (Coller, 1989; Knowles and Garland, 1994).

Since every airline use similar services developed then by own, purchase or lease them in order to satisfy specific needs.

In the 1970s, the USA air transport deregulation enabled the airlines to offer various types of fares, to change their routes in order to respond to the increased competition. This situation created an enormous growth of air traffic as well as greater demand for information (Freedman, 1991; Wheatcroft and Lipman 1990). The increased demand for efficient and effective internal and external communication with all airline stakeholders generated the need for the creation of Computer Reservation Systems (CRSs) as a central planning administration and commerce platforms for airlines. The CRSs assist airlines to improve their internal organization and provide a powerful tool to manage their inventory. In addition, the CRSs offered airlines the ability to communicate with travel agencies, consolidators and other distributors and to update routes, seats availability and prices constantly. The CRSs effectively became marketing and distribution systems and contributed significantly to the competitiveness of vendor/host airlines (Boberg and Collison, 1985; Truitt, Teye and Farris, 1991). In the mid-1980s, CRSs extended their services to travel agencies and they transformed into much more comprehensive Global Distribution Systems (GDSs) to offer a wider range of tourism products, such as hotel and car rental services. Thus, SABRE, Amadeus and Galileo have provided significant services to airlines such as to keep a large amount of information in their databases and assist airlines into their operation. Since the early 1990s, GDSs increased their provided services, becoming travel supermarkets, offering information and reservation capabilities for the entire range of travel products including hotel accommodation, car rental, etc. GDSs developed good relationships with airlines, as they controled and distributed the vast majority of the airline seats. Strategic alliances, consolidations, mergers and interrelations between CRSs have a result four major GDSs to become the key players, namely SABRE, Worldspan, Amadeus, and Galileo (Karcher, 1996). These GDSs compete fiercely, developing a number of value-added services for travel agencies and airlines (Slaughter, 2003).

However, the known GDSs evolved more and started to offer a wider range of Passenger Service Systems (PSS) services to airlines such as departure control systems for airport operation, internet platforms, revenue management systems, flight operations systems etc. Except GDSs, other players offer this kind of services like EDS, Lufthansa systems, SITA, etc. Airlines outsourced these PSS services using the above mentioned PSS providers to compete more efficiently.

From Olympic Airways to Olympic Airlines

Olympic Airways dates back to 1957 when Greek shipping magnate Aristotle Onassis purchased the state-owned TAE-Greek National Airlines and merged it with Aero Metafora Ellados.

In 1971, a subsidiary, Olympic Aviation, was formed for managing short-haul, light aircraft and overhaul operations. In 1972, Olympic Airways' scheduled services were extended to the Far East and Australia. Onassis withdrew in 1974 following heavy losses and the airline was grounded pending re-organisation. The Greek Government bought the airline's shares in 1975 and operations resumed in January 1976 but continued to require government subsidy. In 1991, Olympic Airways established its subsidiary 'Galileo Hellas' that provides the carrier's advanced Computer Reservations System (CRS) services. In 1992, Olympic Aviation started to operate autonomously from Olympic Airways and the new subsidiary, Macedonian Airlines, was established to serve charter passenger traffic.

While Olympic Airways frequently made an operating profit, the servicing of its large debt meant that it was pushed into a spiral of annual losses (Doganis, 2001). Olympic Airways posted net losses every year from 1978 to 1994. The carrier's financial position was improved in the mid 1990s as a result of a restructuring program which begun in 1994 and which involved 'state aid' of US$2.3 billion. Prior to the 1995 write off under the agreed state aid package, the carrier had long-term debts of over US$2 billion.

In 1994, the first restructuring plan[3] was implemented (R. 2271/1994). The fundamental requirements of this plan were financial restructuring, cost reduction, primarily through reduced staff numbers, and higher labor productivity, a revised and probably slimmed down route network, accompanied by fleet rationalization. However, some of the restructuring plan requisites were not implemented, for example the Tokyo route closed, but the carrier extended its network to Eastern European destinations. The carrier's costs declined through the postponement of fleet expansion, the two Airbus A300-B4s were returned to the leasing company in 1994. Furthermore, labor costs declined through the early retirement of 1,050 staff and wage levels were frozen for 1994 and 1995.

In 1996, Olympic Airways established a secondary hub in Thessaloniki, serving various European destinations, in co-operation with its subsidiary Olympic Aviation, which operated these routes. However, the carrier faced new financial problems.

In 1998, a new restructuring plan (R. 2602/1998) was implemented. Again some of the requirements of this plan were not adopted. Thus, an efficient Management Information System (MIS) was not developed, and the government intervention in the carrier's management was continued.

Following the 1998 restructuring plan an audit by the European Commission found that the 1998 restructuring plan had not been put in place, that none of the financial objectives had been met and the viability of the company was not assured in the short or medium term. Olympic Airways had lacked equity since 1999 and remained very much in debt (Commissions Press Room, 11/12/2002). This led to the Commission's decision (11 Dec. 2002) to penalize Olympic Airways for not achieving the objectives of the second restructuring plan (R. 2602/1998).

In June 1999, Speedwing, the consultancy subsidiary of British Airways, signed a contract worth US$8.85m to manage Olympic Airways for 30 months. Speedwing's brief was to turn around the loss-making carrier and prepare it for possible privatization. However, Speedwing's contract was terminated in May 2000 after British Airways declined to take up its option to acquire a 20 per cent

[3] Restructuring Plan: An agreement between the Greek state and EU regarding the re-organisation of Olympic Airways.

stake. In August 2000, the privatization process continued with the appointment of accountancy firm Pricewaterhouse Cooper to audit Olympic Airways finances and carry out 'due diligence'. However, with the airline's accumulated debt, thought to be around US$105 million, privatization at this point seemed unlikely. To compound matters, the European Commission barred further state-aid, meaning the future of Olympic Airways remained uncertain. In the years 2001 and 2002 two further privatization efforts took place but were not successful. Clearly, Olympic Airways was in a bad financial position for the examined period 1990-2001. The carrier had the opportunity to improve its financial and market position through the two restructuring plans but this did not come about. In 2003, Olympic Airlines was created, getting from Olympic Airways the operations part and the related staff. This happened in order for Olympic Airlines to become more attractive to private investors. In addition, the airline implemented the new PSS services and took up the related costs in order to become more competitive and easier to private funds.

Doganis (2001) lists the main characteristics of the state owned carriers, and particularly Olympic Airways and Olympic Airlines, as: a) the occurrence of substantial losses, b) the existence of an overpoliticised structure, c) the existence of strong labor unions, d) overstaffed and low labor productivity, e) no clear development strategy, f) bureaucratic management and e) poor service quality.

The major problem for all state owned carriers and particularly for Olympic is the continuous government intervention (Doganis, 2001).

Olympic's powerful unions also interfere in the airline management. Traditionally, union power has been used to resist change, unless the employees received some financial compensation. Thus, early in 1996, Olympic's union leaders resisted the introduction of sleeper seats in business class on the carrier's long-haul B747s even though this was an essential part of a strategy to improve the product. Moreover, a consequence of being overpoliticised and over-unionised is that Olympic Airways was overstaffed. Thus, Olympic Airways quickly became what we call a 'distressed carrier', which is a carrier with financial problems for consecutive years. As such Olympic Airways lacked a clear and explicit development strategy. The government and union interference contributed to this. Having too many different aircraft types, bureaucratic and overcentralised management and poor service quality both in the air and on the ground are the main symptoms of the "distressed state airline syndrome", which Olympic Airways clearly suffered from (Doganis, 2001).

High seasonality and focus on low yield passengers were crucial problems for Olympic that had important implications for its financial and market position.

From 1998 onwards, due to fierce competition from other Greek carriers, Olympic lost a significant share in the domestic market. The same applies to its international operations due to intensification of international competition. This reflects the fact that Olympic has been unable to respond to increased competition through improving the offered service.

Olympic should therefore focus on making improvements in the cost areas and more commercial oriented strategies had to be adopted in order to achieve both short and long term survival.

The main domestic competitor of Olympic is Aegean Airlines. This was initially set up in 1992 as Aegean Aviation, and was the first private Greek carrier to be issued with an operator's license. In 1999, following a capital injection from a number of Greek entrepreneurs, Aegean Airlines entered the scheduled domestic market on four trunk routes with two Avro RJ100s. It positioned itself to offer a high quality service with two classes of service on all scheduled routes, superior aircraft interiors (all leather seats), and fares that mainly matched those of Olympic Airlines. In late 1999, Aegean Airlines took over Air Greece when Minoan Lines[4] joined Aegean's shareholders by increasing the latter's capital base with Air Greece's shares as well as introducing new equity (Aegean Airlines, 2000). Aegean Airlines has used e-ticketing and PSS services few years before Olympic. Therefore, the pressure to Olympic management was higher as the main competitor used and offered to its customers

[4] Minoan Lines: a passenger shipping company

advanced services.

Olympic Airlines and Olympic Airways has decided to introduce PSS services later than the other airlines and a year before the deadline for the e-ticket implementation imposed by IATA (31 May, 2008). The two airlines (i.e. Olympic Airlines and Olympic Airways) management decided to change reservation, airports departure control, internet sales, frequent flyer and revenue management systems. This project was extremely crucial for the companies' viability, due to the introduction of major changes in a short time period. In addition, Olympic Airlines and Olympic Airways managements decided to outsource these services, so some employee resistance was expected, as the previous systems were developed and maintained internally. In the previous system, the majority of the work was done by the airline's IT Division. Thus, "Olympic invited bidders for the tender of IT services, including essentially a Passenger Services System (reservation, ticketing/fares, departure control systems, internet booking engine), a Frequent Flyer System and a Yield Management System, on a "hosted" environment to assist with several facets of the company's commercial and operational business" (Olympic Airlines, Request for Proposal, 2006) in order to find the more efficient for the company provider. Most of the biggest providers responded to this invitation and submitted their proposals. Olympic Airlines and Olympic Airways appointed technical and financial committees in order to select the provider, who offered the best of the airlines solutions in technical and financial terms. The migration project started in 13 February 2007 and was completed in 17 June 2007. Since then, the airline uses the new services with significant implications on their operations and in extent to the services that the carrier offers to passengers.

3. Research Objectives and Methodology

This paper analyses the use and the implications of PSS services, as those described above, to a schedule, state-owned airline. The airline that will be examined in this paper is Olympic Airlines, the national carrier of Greece. Olympic Airways as the mother company provides many services and personnel to Olympic Airlines. The introduction of PSS services are expected to have more implications to state-owned scheduled airlines than to low cost carriers, which implement these services earlier with good, results mainly in costs terms. The same happened with charter airlines, which have different structures and use different operational mechanisms. However, the distinction between these types of airlines is increasingly becoming unclear, as each type of carrier is trying to use other types practices and methods.

The objective of this paper is to examine the implications of the PSS services to Olympic Airlines airline operations, in conjunction with Olympic Airways, how these has accepted and supported from the carrier employees.

Considering the emerging nature of PSS and the constantly moving structures of the airline industry, this paper aims to answer the "how" and the "why" questions rather than to quantify and verify particular variables. Exploratory research through secondary data (e.g. passenger traffic, revenue data etc.) and semi-structured interviews with key persons were used, due to insufficient research on the topic since the use of PSS services in airlines is fairly recent and it is evolving dynamically. The data underwent a descriptive and critical analysis so that we reach conclusions about the effectiveness of the PSS project and the effects it had on the company. The implementation of the PSS services for Olympic has taken place in 2007, so the effectiveness of these services is not clear yet. Therefore, the initial effectiveness of the new PSS services is described. However, the advantage of this study is the actual participation of one of the researchers in the project from the beginning of this process. In particular, one of the researchers participated in the construction of the request for proposal (RFP), was member of the technical committee and finally took on the role of the Project Manager. All this involvement is extremely useful for the quality of this study.

This single case of development of PSSs is examined in-depth. By examining a single case a deeper understanding can take place. The detailed and in-depth description of the examined case provides, to reader and to researcher, the ability to understand the "empirical foundations of the theory" (Hamel, Dufour and Fortin, 1993, p. 33). In this way, the choice of the case is very important for the quality of the study, in that its uniqueness should produce interesting results. Furthermore, case studies are the preferable research tool when the researcher is trying to find answers to 'when' and 'why' questions and he "has little control over events, and when the focus is on a contemporary phenomenon within some real life context" (Yin, 1984, p. 13).

Hamel, Dufour and Fortin (1993) characterize case studies, like any other qualitative method, by three key words: describing, understanding and explaining (pp. 39). While Yin (1984) pointed out that case studies are "verbal reports and are used in order to understand complex individual, organisational, social and political phenomena" (p. 14). Therefore, the literature suggests that the case study method is ideal to examine the implications of the implementation of particular services.

The main disadvantage of case studies is that they are highly dependent on the skills and sensitivities of the researcher. Therefore, an experienced and able researcher may achieve higher quality case studies than a less experienced and less able researcher. An important problem that the present and other similar studies face is respondent bias. Respondents tend to support that their adopted policies and strategies are the most proper and provide a number of reasons for this (Moss and Goldstein, 1979, pp. 51). However, finding information about the examined subject from various other sources can help overcome the respondent bias. Furthermore, because co-operation is guaranteed there is no problem with accessibility to the right person, the person who holds the information that can assist the researcher to answer the research questions. The personal visits, for example, of the researcher to the other Departments, the discussions with the staff of these Departments about their daily actions, and the collection of published and unpublished secondary data were very important for the overall quality of the study.

A serious aspect influencing the potency of this project is the researchers' professional relationship with the airline industry and specifically with the examined carrier. These close relationships between the researcher and the subject of study are very important for gaining access to information. The deep and sustained involvement with particular organizations has often led to new insights, ideas and questions. This relationship can have implications for the extent to which the researcher will be able to move around and gather information and perspectives from many sources (Easterby-Smith, Thorp and Lowe, 1991).

According to Easterby-Smith, Thorpe and Lowe (1991), the most important issue is to have the right contact within the examined firms or in the related organizations (p. 54). The research team using its professional relationship found it easier to contact the appropriate persons who participated in the Project and other employees who have less involvement and this is vital to the successful completion of the case study. In addition, access to the written documents such as prospectuses and speeches or testimony by the firm executives, press releases, product literature, manuals, published company histories, transcripts of annual meetings, and even advertising provided very useful information. According to Easterby-Smith, Thorp and Lowe, (1991) internal reports, Chairman's statements, and newspaper articles, have always provided a valuable source for the researcher (pp. 119). The relationship of the research team with the Project Leaders who were responsible for the Project and the established mutual trust and co-operation was beneficial for this study. Conducting open-ended semi-structured interviews and asking Project Leaders particular questions about their experiences regarding the running and implementing the Project assisted the research team to find the necessary information. Furthermore, this long relationship significantly assisted the research team to understand the respondent bias. Thus, extra questions for clarification were asked and further statistical data were used, when the research team felt that bias might be an issue. Consequently, the relationship of the research team with the examined airline is an important advantage of the present thesis.

The selected case (Olympic Airlines and Olympic Airways) brings all the characteristics of a state-owned airline. Therefore, similar airlines – mainly state-owned - which are in the same situation will also be able to learn from the Olympic Airways and the Olympic Airlines experience. In addition, firms from unrelated businesses, that have some similarities with the airline industry, can also benefit from the present paper.

4. Research Results

Following the analysis of the interviews and the secondary statistical data useful conclusions were extracted. The results from the first days of operation of the new services are extremely good for the airline. After implementing the new services:

- the number of passenger traffic has increased by 5-6%, for the months the new services offered. This can partly be explained by the introduction of e-ticketing.

- the average fare has slightly decreased (<1%) and this can be explained by the delay of the implementation of the new revenue management system.

- the workload of the ticket counters has significantly decreased by almost 50%. Extra decrease is expected when additional ticket functionalities will be added. The airline should move the ticket counter extra staff to new jobs that the new services have added. Thus, the telephone sales with the implementation of e-ticketing has high workload and extra staff is needed.

- more agreements with other airlines, which have implemented e-ticketing services (interline e-ticketing), have contributed to Olympic Airlines passenger traffic and revenues.

- further co-operation with the Global Distribution Systems (GDSs) has positive results to passenger traffic and revenues.

- the number of customers who use the carrier's web site has tremendously increased (>150%) and the generated revenues from those passengers have similarly increased.

- the passengers' queues at the airports have decreased from the first day of implementation of the new departure control system. Thus, a check-in agent needs 15-20 seconds to check a passenger in at the airport when a check-in agent needed approximately 1 minute to do the same job with the previous system. In addition, the interface of the new departure control system with the carrier's frequent flyer system has significantly improved Olympic Airlines customer services.

- Olympic Airlines has also significant gains from the decrease of the telecommunication costs. However, further changes to hardware and to telecommunications lines (replacement of the SITA lines with connections with virtual private network –VPN) will save the carrier from 1.420.000 USD annually.

- many cost savings generated the implementation of e-ticketing in Olympic Airlines which did not only cut the distribution costs but also reduced back-office accounting work. There are cases in which revenue account support staff has decreased by as much as 50% with the increase in automation and the use of electronic data. In Olympic Airlines case the back office accounting work reduced by almost 20% and can be further minimized. The carrier implementing the e-ticketing service can receive payment from passenger with the e-ticket issuance. Furthermore, the carrier has on-time revenue data, which are helpful to management to make fast important strategic decisions based on these data.

Except the above mentioned benefits for the carrier, adding new services that the provider offers the carrier may reap more commercial and financial benefits by replacing the current systems such as the flight planning, fares system, crew management, cargo, etc. Implementing new systems for the staff travel and customer behavior monitoring (CRM) may offer additional benefits to the airline.

However, the delay of the new revenue management and the implementation of frequent flyers systems has apparent results. Thus, the carrier's revenues and the number of frequent flyers have not increased. Furthermore, the new web check-in, the new self-service kiosks will assist Olympic Airlines to offer new advanced services to customers.

The reasons for the Project success for migration from the previous system and then the implementation of the new services are:

- The right choice of the provider: The top priority for this Project was the airline to achieve 100% e-ticketing, in accordance with applicable IATA Resolution the latest until the 31 May, 2008. The provider was selected for two reasons: I) for earlier cutover i.e. the time of change from one system to another was at the beginning of June 2007 compared to the others which promised a latter date (Autumn 2007). This was an advantage because if the system presented dysfunctionalities the airline had to have time to find another solution, and II) the new services did not require significant changes in computers and the cost that this can accrue.

- The good co-operation of Olympic Project Leader with the provider staff: This was significant for the Project success because a trustworthy, professional and good co-operation between the two parts assisted the problem solving process.

- The right choice of the Project Leaders: selecting very experienced and educated people was an advantage as some of them had participated in the past for two previous similar projects. These employees were the key informants of this research.

The main obstacles of the Project Olympic to implement new advanced PSS services was the incongruity between the Olympic Airways and Olympic Airlines top managements in some cases. This created some problems and in particular in the case of contract finalization with the provider. This was a significant risk as the contract was signed a few days before the migration from the previous system to the new.
The lack of the promotion of the new PSS services in order for them to become known to the public is still a major problem. The commercial and financial benefits for the airline will be higher with the right promotional campaigns.

The organizational restructuring of the firm has remained unchanged. Only the Commercial Unit has made a new organizational restructure according to the new requirements that the new services have generated. However, a new integrated organizational structure for all the company is necessary in order to respond to the new needs.

The resistance of the airline's employees in some cases created problems. Thus, this resistance was expected in particular from the employees of the IT Unit, as these have the control of the previous services. A resistance from unions was expected but it did not happen.

The morale of the staff was low due to the rumored company privatization and this was taken into consideration by the Project Management team.

The above-described obstacles impacted the project success and some of these issues were carefully handled.

5. Conclusions, Limitations and Implications for Further Research

The present paper proves that the introduction of the PSS services can crucially improve the offered customer service with significant benefits for an airline. However, the Olympic case shows that the leaner and simpler organizational structures may assist to the success of Projects for implementation of such services. However, new roles should be found for those staff and departments who lose some of their responsibilities. This should be done in good time in order to avoid the expected resistance by the staff. A preparation of employees, the current and the potential customers are necessary. This can assist firm's employees to adopt new practices in time and contribute to the success of the implementation of new services. Also, a firm should scrutinize all the candidate providers and select the ideal according to the firm's specific requirements. Moreover, well-experienced and educated Project Leaders should have the control of these kind of Projects, which are very crucial for the company's viability. Furthermore, as we can see in the case of Olympic, earlier decisions should be made by the top management and issues should not be left up to the last moment. The current case study is beneficial to other airlines and industries, which are going to introduce similar services and go through a similar restructuring.

The current study will be able to assess the results and problems further when the full services are implemented. One other limitation of the current study is the number of interviews, which is limited. Interviewing more employees, who participated in this Project, especially those who resisted to it, will enable deeper insights to the situation. The provider Project Leaders and some interviews with project participants from other airlines who implemented similar services will be useful.

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Optimising Investment in Regulated Airports

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Abstract

Regulation is known to change the incentives a firm faces to invest, inducing some firms to invest too much, and others too little. Regulators must set prices to achieve several conflicting objectives, including providing the incentive to invest. Optimising investment is a particular problem in regulated airports, and many of the inefficiency problems noted with airports can be ascribed to inadequate or excessive investment. Airport regulation is also expected to address issues of congestion, quality of service and productive efficiency, while, in many cases, at the same time achieving distributional objectives. This paper explores the properties of alternative forms of regulation, including price caps and cost plus, in achieving the optimal level of investment, along with meeting other objectives. Cost based regulation can have advantages over price caps in some contexts. The optimisation task is helped considerably by the existence of secondary instruments, including slot controls and conditional price caps.

Keywords: Price caps; Cost based regulation; Congestion; Efficient pricing; Airport slots

1. Introduction

Several of the more obvious efficiency problems at airports stem from the difficulties in ensuring that investment in capacity is at the right level. For many regulated airports, investment has been too low, and as a result quality is poor, output is restricted, and in some cases, delays are excessive. Sometimes, especially in Europe and Japan, it is environmental and planning constraints that are the major cause of inadequate investment. However, the regulatory arrangements that many airports now operate will also be a potent cause of investment inadequacy. The model to which many countries are moving their airports is one of privately owned airports subject to a price cap. This model is known to give the regulated firm only weak incentives to invest.

In this paper we explore how different regulatory arrangements affect investment in airports. The investment problem is complicated because it is part of a more comprehensive optimisation exercise- the regulator is simultaneously trying to achieve efficiency in the use of existing capacity, deliver the right quality, minimise costs, and also provide incentives for the warranted level of investments in capacity. Typically, regulators rely on a limited range of instruments, often simple hybrid price caps, and the result is that airports perform better in some dimensions than others. Often it is capacity expansion which suffers. We analyse how different instruments, such as cost based regulation and price caps, along with quality rewards, slots, and conditional trigger mechanisms for investment can be used. A mix of instruments can lead to a much more satisfactory solution – for example, if slots are used, prices can be freed from their role in short run optimisation, and they can be used with conditional triggers to ensure efficient investment in capacity. Some problems still remain- notably the problem of giving the airport incentives to minimise the costs of its investments.

We begin by discussing the general problem of incentives for investment under regulation, and apply this discussion to airports. In the following section we examine the different efficiency problems which airports pose. We then examine the instruments which regulators can use to influence airport performance. In the next section we analyse how different regulatory approaches can be combined with these instruments to promote efficiency – use of slots, quality rewards and conditional triggers for investment can be used to improve the performance of price caps as compared to cost based regulation. Finally, we draw some conclusions and highlight the key results.

2. Regulating Airport Investment

Ensuring an efficient level of investment is achieved in a regulated industry is inherently difficult (Guthrie, 2006). This is so not just for airports – it has been a problem for UK regulators ensuring investment in rail track, and for Australian regulators supervising export coal loaders. Regulators have a limited number of instruments, and they must balance a range of conflicting objectives, such as ensuring cost recovery, encouraging efficient use of available capacity, the meeting of environmental constraints, and ensuring investment is neither excessive nor inadequate. Information asymmetry is typical in a regulatory context, with the regulator knowing less than the regulated firm about feasible minimum cost levels, and the amount of investment which is required. Not surprisingly regulatory gaming takes place – regulators may behave opportunistically to keep prices low, and regulated firms may induce the regulators to set high prices to cover their investments, yet they may not actually deliver on the promised investment (Export Infrastructure Task Force, 2005).

Regulation has become much more important for airports over the past two decades. Before this, most airports were publicly owned, and were not subject to direct regulation. Privatisation has changed this. Many airports have now been privatised, either partially or fully, and those which have not been privatised have often been corporatized, and instructed to act in a more commercially focussed manner. The UK privatised the BAA airports, including most of the London airports, in the 1980s, New Zealand and Australia privatised their major airports in the 1990s. There have been several privatisations in Europe, with Copenhagen, Budapest, Brussels Athens Paris and Vienna airports being fully or partly privatised. Some airports in Asia are now being privatised. Airports often have strong market power, and under private ownership, they have the incentive to use this power, and set high prices to earn high profits. When airports are privatised, governments usually implement price regulation. Sometimes this takes the form of light handed regulation, as in Australia (Forsyth, 2002) and New Zealand, but more often, explicit price regulation, often in the form of price caps, is imposed. Airports are free to maximise profits, subject to prices not exceeding the price cap.

Regulation has typically encountered problems with investment. Under the older form of regulation, cost based rate of return regulation, it was recognised that the regulated firm would have an incentive to invest excessively (the Averch and Johnson effect) (Armstrong, Cowan and Vickers, 1994). Since the firm was permitted to earn a rate of return on a regulated asset base, it could increase its profits if it could increase its asset base, by investing. This was one of the reasons for the move away from rate of return regulation to newer forms of regulation such as incentive regulation (the other main reason was the encouragement given to cost padding under rate of return regulation). Most countries have moved towards some form of incentive regulation, such as price caps, when regulating private or corporatized monopolies, including airports. Pure incentive regulation, whereby the regulator takes no note of the firm’s actual cost when setting the price cap is rare – most actual forms of regulation are of a hybrid type, whereby price caps are set for a period, such as three to five years, after which the price cap is reset with reference to the firm’s actual cost outcomes, along with the firm’s projections of capital expenditure. Price caps give the firm a strong incentive to keep costs low, but they may do this by lowering service quality or by not undertaking sufficient investment. This has been recognised as one of the downsides of incentive regulation (Helm and Thompson, 1991). It is a problem which can be overcome if the regulator sets explicit rewards for higher quality, and if it explicitly takes investment into account when setting future price caps. This does mean that the regulator becomes much less “light handed” and becomes more intimately involved with the investment decisions of the firm.

The airport investment problem is often made more complex by the existence of environmental and planning requirements. Investment in airports, to improve quality or to increase capacity, may be held up for environmental reasons. Airports create noise, and local neighbourhoods frequently oppose expansion. City airports typically have very constrained sites, and expansion ideally requires more land – this will not be feasible where the airport is bordered by built up areas. Airports also generate surface traffic, putting pressure on land based infrastructure- this too may be very difficult to expand. Expansion may not be totally prohibited, and it is often feasible to increase capacity at a constrained site, but only at very high cost. This makes it difficult for the regulator, who is asked to approve sharply increasing prices in order to fund investments which are much more expensive than past investments.

London Heathrow airport will have trebled its prices in ten years, just to fund terminal investments, with no increase in runways (Civil Aviation Authority, 2008). In this paper we do not discuss environmental aspects directly, though they need to be recognised as an important underlying constraint on airport investment.

Investment, and its implications for prices, is often not a major issue at time of privatisation. Sometimes there is heavy investment prior to privatisation. Thus when the BAA London airports, the Australian airports and European airports such as Hamburg were privatised, the price caps set initially allowed for a fall in the real prices charged (CPI-X regulation was imposed with X being positive). Airport investment typically comes in indivisible lumps, and after a time, substantial programs of investment are required. If the airport is facing increasing costs of expansion on a constrained site, or if prices were set initially on the basis of historical rather than replacement costs for assets, increases in prices will be required if the airport is to cover its costs. Price caps will need to be set with real prices increasing for a period, not decreasing as is normally the case immediately after privatisation.

The experience of BAA's London airports, particularly Heathrow, provides a good example of the problems. When the airports were privatised, a price cap with a positive "X" was set- real prices fell. There was limited investment in the airports, but demand grew and outstripped capacity, leading to a fall in the quality of service, as facilities such as terminals became congested. Capacity extensions were difficult to achieve because of environmental problems and a very slow planning process. Eventually capacity increases were approved, but these were very much more expensive than older facilities. The regulator, the CAA, allowed for price increases at Heathrow to fund the new terminal, Terminal 5. Significantly, it used a trigger mechanism, whereby BAA was only permitted to increase prices when it had achieved investment targets (Civil Aviation Authority, 2008).

In this context, investments have been made, and hopefully they will achieve the objectives as set. However, it has been extremely difficult to get investment right, in the sense of being neither inadequate nor excessive, and timely (Starkie, 2006) . The process has been very slow, and users have been very critical of the low quality of service, and of the sharp rises in prices. BAA may be exaggerating the need for investment, and it may not be seeking out the least cost ways of achieving capacity increases- it may be gold plating its investments. Nevertheless, the CAA is under strong pressure to approve investments and thereby alleviate the quality crisis. There appears to be strong dissatisfaction with the performance of the airports, with many users calling for the breakup of BAA (though it is not clear how this would resolve the problems, since the main airports face considerable excess demand and would not be effective competitors). It is also the case that the regulator now has a very strong role in determining how much the airports invest – it is not simply setting prices and allowing the airports to determine how much they want to invest. The regulator must rely, to a considerable extent, on the airports' own claims as to what levels of capital expenditure are required.

Thus the airport regulatory problem is a complex one, especially when significant increases in capacity or quality are required. Airports are congestible facilities, with runways and terminals both becoming congested when demand presses against capacity- this creates a delicate short run problem of optimising existing capacity. If airports are privately owned and not subsidised, cost recovery is a requirement if the airport is to sustain operations. Airports involve substantial indivisibilities, which means that capacity is more than adequate for some years, and cost recovery is a problem, but demand is excessive, and creates congestion, at other years. Service quality is a variable, and price caps will induce the airport to undersupply quality. Prices need to be set at a level to induce the airport to undertake efficient levels of investment. Thus prices need to serve at least three conflicting roles- achieving efficient use of capacity, ensuring cost recovery and providing incentives for investment. In addition to this, there are two distinct principal agent problems. One is the problem of giving the airport an incentive to minimise costs of operation- this can be achieved by setting price caps which are not based on the airport's costs. The second is the problem of achieving the right level of investment. The regulator knows less about the efficient level of investment required than does the firm, but the firm has little incentive to inform the regulator of what this is. This is a more difficult problem to solve than the first.

In this paper we assume that the regulator seeks to promote the public interest, through maximising welfare (possibly with different weights on different parties). This need not be the case for all regulators in reality. We also assume that investment issues cannot be resolved by direct negotiations between airports and airlines – for small airports serving only a few airlines, this may be feasible, and negotiations over specific facilities in airports may be feasible in larger airports. However, achieving agreement over major investments between diverse airlines and the airport is likely to be difficult in large airports, and a regulatory approach will have to be resorted to.

3. Efficiency and Distributional Objectives in Regulating Airports

When regulating airports, a regulator will seek to achieve a range of objectives. Efficiency is an objective, but there are several distinct aspects to this. The regulator may have some distributional objectives. In addition, the regulator may have some environmental objectives to advance or constraints to meet- for example, it may wish to reduce airport noise. We do not analyse these here, though we recognise that they could be an important extra aspect to the regulatory problem for airports.

3.1 Short run optimsation- use of fixed capacity

In the short run, an airport will have fixed capacity of several facilities, such as runways, terminals and aprons. In the short run, it is desirable that the airport make the most efficient use of the available facilities. Costs will depend on the level of these facilities. Taking willingness to pay for the airport as a measure of welfare (this will be questioned below), welfare can be measured by the sum of consumers' surplus and profit. This is maximised when prices are set equal to short run marginal cost. These costs include operating costs, but also the costs of congestion.

Airports are congestible facilities. This is so especially for runways, but also for terminals and other facilities. More utilisation of a facility means more congestion, in the form of delays, crowding and overall lower quality. The important aspect of congestion is that it creates an externality. Each user faces some congestion cost, but also imposes costs on other users. Thus the pricing problem involves setting prices to users which reflect the costs they are imposing on others. As has been noted, some large users of airports internalise some though not all of the congestion costs they create – since one flight by an airline delays other flights of the same airline, some of the congestion externality will be internalised. Given that airlines differ in the extent to which they internalise the congestion externality, different prices will be optimal for different users, with smaller users being charged higher prices than larger users (Brueckner, 2002).

Congestion is an aspect of quality of service, but it is also an aspect which is associated with an externality. Investments in capacity lower congestion, and also reduce the externality (on congestion and investment, see Oum and Zhang, 1990).

As noted above, we are taking willingness to pay for airport services as a measure of welfare. This would be appropriate if airlines were perfectly competitive, and the value of the marginal product of an input was equal to its marginal revenue product. If airlines have market power, they will not be pricing competitively, and the value of the marginal product (which is the measure of the welfare gain from using an additional unit of an input) will exceed the marginal revenue product, and the airline will use less of the service than is optimal. In this case, ideally airports would compensate for this by reducing their prices, thereby offsetting this distortion. We recognise this problem, but abstract from it in this discussion.

A constraint of short run optimisation may be that of cost recovery. The regulator will need to allow the airport a high enough price to enable cost recovery – otherwise a private airport would cease to supply. This is an issue for airports which have excess capacity and no congestion, though it is not likely to be a major problem for airports which face high demand and for which investment in additional capacity is warranted.

Thus the regulator's problem is to use price or other instruments to ensure that the efficient utilisation of the airport is achieved.

3.2 Regulating quality

The regulator will seek to achieve an efficient level of quality of service. Many forms of quality at airports are not like congestion, and do not pose any externality issues. Higher quality can be achieved by spending more on operating costs, or by investing more. Under price caps, an airport will tend to under provide quality, cutting costs and not investing sufficiently, since it can add to profits by cutting costs. The regulator can give the airport incentives to provide higher quality, by offering it a higher price conditional on providing the higher level of quality (Rovizzi and Thompson, 1992). The problem is that the regulator has poor information on the costs and benefits of quality. Since the price is regulated and there is not price/quality trade off facing users, the regulator will not have reliable information on the willingness of users to pay for quality. In addition, it will have to rely on the airport to inform it on what quality cots to provide, and the airport does not have any incentive to tell the truth to the regulator.

Thus the regulator faces a principal agent problem of setting instruments such as prices such that the airport provides the efficient level of quality.

3.3 Achieving productive efficiency in the short run

The welfare maximising regulator will seek to minimise costs. It faces a typical principal agent problem in doing this, since it does not know what the minimum feasible level of costs is, and the airport will not tell it. A price cap is a solution to this problem, since by fixing the price that the airport is allowed to charge, the airport has an incentive to minimise costs given any cost savings will add to its profit. A price cap is a blunt instrument, since it imposes strong risks on the agent airport – its inflexibility can lead to revenue crises for the airport (this happened to regulated airports in Australia in 2001 – see Forsyth, 2004).
The regulator's problem is to use its instruments in a way consistent with the airport having an incentive to minimise its operating costs.

3.4 Long run optimisation- achieving efficient investment in capacity

The regulator seeks to give the airport incentives to invest in the right level of capacity. Additional capacity is costly, but it leads, lower congestion costs, and enables more output to be catered for, and possibly to lower operating costs. It may also enable higher service quality. More capacity lowers the congestion externality, and when the capacity increase is large and it leaves the airport with ample capacity, it can eliminate the congestion problem entirely, at least until demand catches up. Thus investment in capacity changes the short run pricing problem.

The regulator's problem is one of using its instruments such as prices to ensure that the airport as the incentive to actually make the investments which are warranted.

3.5 Productive efficiency in the long run

The regulator faces another principal agent problem. The airport knows what level of capital expenditure is needed to provide a given level of capacity expansion or quality improvement, but the regulator does not. The airport does not have an incentive to inform the regulator- rather it will have the incentive to exaggerate the cost of the investment, since by so doing it can get the regulator to allow it a higher price.

The regulator has several options. It can:

- Accept the airport's assessment of the cost of increasing capacity- this is essentially a case of long run cost plus regulation;

- Employ a monitoring solution, by gathering together its own information about he likely cost of expanding capacity, and essentially do its own cost benefit analysis of the proposals. Some regulators have done this, to an extent. Or,

- Attempt to set up instruments which give the airport an incentive to provide the right level of investment at minimum cost. This option has been suggested by Hendriks and Andrew (2004). The regulator could reward the airport according to the outcomes of higher investment- more output, lower congestion higher service quality etc. The airport would have an incentive to invest to improve its outcomes and revenue, but it would also have a strong incentive to keep the costs of achieving these to a minimum. The regulator would still have the problem of determining at what level these incentives should be put in place- how low congestion should be, how much extra output is warranted, and how much to increase regulated prices by. This is not an option which has been applied, though it is an approach which offers the possibility of reducing the regulator's reliance on the airport for information about what level of capital expenditure is needed.

Thus the regulator's problem is one of using its instruments such that the airport minimises the cost of achieving capacity increases, and actually makes them.

3.6 Distributional objectives

The regulator may seek to achieve efficiency by simply maximising the sum of consumers'' surplus and profits. Alternatively, it may seek to pursue distributional objectives by putting different weights on consumers' surplus and profits.   In the airport case, there are three groups of stakeholders at least. The airport gains profits, and the airline passengers gain consumers' surplus. However the airline is a user of the airport, and it also gains profits. Lower airport charges may mean higher consumers' surplus, higher airline profits, or both. Lower airport charges do not necessarily lead to lower air fares- in the case where excess demand for airport capacity is rationed by slots, lower airport charges will be enjoyed solely by the airlines.

In situations where there is limited capacity and high demand, efficient airport prices would be very high, leading to very high airport profits. Regulators are often under pressure to ensure that monopoly facilities are not highly profitable. In the airport case they may keep regulated prices low, and transfer the profits to the airlines, though not their passengers (regulators will have little influence over air fares which they do not control directly). Airlines, of course, will pressure the regulator to keep airport prices low.

Thus the regulator's task is to determine its distributional weights and seek to use the instruments open to it to maximise the weighted sum of passengers' consumers' surplus, airline profits and airport profits.

4. Instruments of Regulation

Regulators of airports have a number of instruments at their disposal. Some have been used extensively, such as price caps. Others, such as conditional triggers, have only been used occasionally.

4.1 Price regulation

For our purposes, three main types of price regulation can be identified:
- Cost based regulation
- Incentive regulation; and
- Hybrid regulation.

4.2.1 Cost based regulation
A regulator can set prices such that they are sufficient to cover the costs of the airport (as reported by the airport). Cost plus regulation is a general form of regulation, and one variant, rate of return regulation has been extensively employed in the past, especially in the US. It is being supplanted by incentive regulation, but it is still being implemented in some airports. Regulation of Düsseldorf airport

has only recently been changed from rate of return to incentive price caps. Under cost plus regulation, costs are the main determinant of allowable prices. Prices are set to cover costs and perhaps earn a small profit. When capital investment is involved, as it invariably is, its costs are shared over the years according to some amortisation formula. Cost based regulation can involve the regulator setting prices in detail. In practice, regulators were not active in setting price structures which promoted efficiency, such as setting peak and off peak price differentials. The problem with cost based regulation is that it gives the airport little incentive to minimise costs, and it also facilitates excessive investments in capacity.

4.2.2 Incentive regulation

Incentive regulation was developed in response to the problems observed with cost based regulation. Allowable prices are set without reference to the airport's actual costs. One form of incentive regulation is the price cap, under which the regulator sets a maximum price path for a number of years – an index or average of the airport's prices is not permitted to exceed the set price. Under CPI-X (RPI-X in the UK) regulation the price path allows for a fall in prices each period by a percentage "X". The X may be negative- i.e. the airport may be permitted to increase real prices each year during the regulation period. Under pure incentive regulation, the regulator sets the price path without reference to the airport's costs- thus the airport has a strong incentive to reduce costs, since any cost reductions add to its profit. Typically the airport has the freedom to choose its price structure, and under many forms of price caps, it will have the incentive to set prices efficiently.

4.2.3 Hybrid price caps

The most common form of price regulation for airports is now that of hybrid price caps. Price caps are set for a period, say three to five years, and after the end of the regulation period, a new cap is set with reference to the airport's actual costs, and expected future costs. These include expected capital expenditure. The airport faces incentives to lower costs, but these are lessened by the inclusion of actual and expected future costs in setting the allowable prices for the future (Baldwin and Cave, 1999).

4.3 Airport slots

Slots are now used extensively, except in the US, to ration demand to capacity (especially for runways) at busy airports. To use the airport during a given period, a flight must possess a slot. The maximum number of slots at an airport is declared, and slots are allocated to airlines. In the past this has been done by "grandfathering", or allocation on the basis of past use, but other methods, such as auctions could be used (Menaz and Matthews, 2008). Airports or slot administrators can allow secondary trading in slots, which should enable allocation of the slots to the flights with the highest willingness to pay. The significance of slots here is that they can be used to solve the short run optimisation problem – slots are set such that the value of the slot is equal to the marginal external congestion cost of a flight (Forsyth and Niemeier, 2008). Slots do the capacity rationing task, and prices do not. Prices can be set lower than at the capacity rationing level (which might imply very high airport profits) and short run efficiency is still achieved.

4.4 Conditional triggers

A regulator can alter price caps, in a pre determined way, according to the behaviour of the airport. It can allow higher prices if specified investment is carried out. The critical point is that this is conditional. It is one thing for the regulator to set a price cap high enough for the costs of investment to be recovered. This often happens. However there is no guarantee that the airport actually makes the investment- and often it does not. Airports will argue for a higher price cap, and when the regulator has obliged, the airport adds to its profits rather than make investments which are to the benefit of its users, through lower congestion. A way around this problem is for the higher price cap to be made conditional on the investment actually taking place. When Australia had price caps for airports there was a conditional trigger, whereby price caps could be raised if the airport was undertaking specified investments (Australian Competition and Consumer Commission, 2000; Forsyth, 2002), and conditional triggers are being used by the UK CAA in its regulation of the London airports (Civil Aviation Authority, 2008).

With this instrument, the regulator assesses the airport's actual investment spending, and allows price increases conditional on meeting investment targets. It allows the cost of investment to be passed on, and to this extent, it is a cost plus element, within a framework of hybrid price caps. While it is a useful means of resolving the problem of non delivery on promises for investment, it does not give the airport an incentive to minimise the costs of adding to capacity.

4.4.1 Monitoring

Regulators can sometimes use monitoring to address the principal agent problem they face. Thus they can collect evidence on the costs of benchmark airports to help them determine how high a price cap should be. They can also directly collect information about the costs and benefits of a proposed investment, and only approve price increases if the costs of the investment are lower than the benefits. This adds to the regulatory task, but it can result in a more efficient pattern of investments being made.

5. Regulating Airport Investments- Assessing the Options

In this section, we compare approaches to regulation and their implications for investment in airports. We start with two broad approaches- generic cost plus regulation and price caps. We then allow for additional instruments, to see what difference they make. We consider rewards for quality, slots and conditional trigger price caps. This section is partly based on a more detailed analysis of some of the issues (Czerny and Forsyth, 2008). The relative merits of the simple cost plus and price cap approaches are summed up in Table 1.

Table 1: Regulation and Efficiency Outcomes: Base Case

Efficiency Aspect	Cost Plus Regulation	Price Cap Regulation
Short Run Optimisation	Fair	Moderately Good
Quality Choice	Moderately Good, but Possibly Excessive	Too Low
Short Run Productive Efficiency	Poor	Good
Long Run Investment Choice	Very Good (if no Averch and Johnson Effect)	Poor
Long Run Productive Efficiency	Poor	Poor

The table can be interpreted as follows. In terms of short run optimisation, cost plus regulation is only fair. Prices are set purely according to cost- they are not set so as to ensure efficient use of the available capacity. With a price cap, it is possible for the regulator to optimise the price set taking into account short run optimisation. If it is not constrained to achieve zero profits, it can set prices higher so as to price congestion and ration demand.

Cost based regulation performs better with the quality dimension. If the airport offers a higher quality, its costs will be higher, but the regulator will allow it higher prices to cover the higher costs. There is, however, a danger that the airport will offer too high a quality. Under a price cap, the firm has only a limited incentive to supply quality, and thus it will under provide it. The short run productive efficiency aspect (keeping operating costs down) is where the cost plus approach falls down badly- it is, after all, the main reason why the price cap alternative was developed. A price cap has strong incentives for the airport to keep its costs down, since it can keep any cost savings it makes.

In terms of the long run investment choice, cost plus regulation can perform well. Where investment is warranted, the regulator will allow the firm a price sufficient to cover the cost of this investment. Thus, assuming that the regulator is sufficiently well informed about demand and the cost of investment, it can use its instruments to bring about the required investment. Under price caps, the airport will have some incentive to invest, but this incentive is attenuated. More investment means less congestion, and less congestion means higher demand. Depending on how high the price is, the airport can gain from undertaking the investment. The regulator is, however, choosing price to optimise over the short and long run –too high a price will mean that the utilisation of the airport in the optimum will be too low. Thus while the price cap will work better than cost plus regulation in short run optimisation, this gain is achieved at the cost of weaker incentives for investment.

Neither system of regulation works well when it comes to incentives for the airport to keep the cost of investment down. In both cases, the regulator must rely on the airport for information about what level of capital expenditure is warranted, and the airport will not inform the regulator accurately.

Introducing quality incentives

It is possible to improve the performance of the price cap by introducing rewards for higher quality (and penalties for below target quality). This gives the price capped airport an incentive to increase quality- its performance will rise to good, comparable to that of cost plus regulation. In neither case is the outcome optimal, since the regulator only has limited information about the cost of providing quality and the value that users put on it.

Introducing slots

Slots can be used to replace prices as a rationing device, so long as the effective rationing price is above the price that would be chosen by the regulator (e.g. to encourage investment). This is so when demand is high relative to capacity. In such circumstances, it is feasible to achieve short run optimisation under both cost plus and price cap regulation. By lessening the welfare cost of having inadequate investment in capacity (a risk with price caps) they tilt the balance towards price caps.

There is an asymmetry with slots. They can be used to optimise the use of the airport when the regulated price is below the efficient rationing price, but not when the efficient price is below the regulated price. Thus, if the regulator chooses to allow a high price to encourage investment, slots cannot be used to increase utilisation of the airport towards the optimum. However, in the airport case, this may not be much of an efficiency problem. Airports can price discriminate very effectively- their weight or passenger based charges for runway use are a form of price discrimination (or a rough form of Ramsey pricing). The deadweight loss from having a regulated average price which exceeds the efficient single price will be quite small (Morrison, 1982). In this situation, the average price level does not play a major role in achieving short run optimisation.

This decoupling of prices from short run optimisation has implications for regulatory choices- prices can be set solely to optimise investment choice, at minimal cost in terms of short run efficiency.

Introducing conditional triggers

With a conditional trigger, the regulator is able to offer the airport a higher price if and only if it actually undertakes investment to increase capacity or improve quality. This means that a price capped airport now has a strong incentive to undertake the investment. This amounts to an effective way of addressing the main disadvantage of price caps vis a vis cost plus regulation. If slots are not used, such conditional triggers come at a cost. Regulated prices are low when the airport has not invested, and capacity is at a premium, but they are low when there is ample capacity, once the investment has been made. However, as noted above, this short run efficiency problem is minimised when slots are used. The combination of slots and conditional triggers for investment is a powerful combination.

Cost plus and price cap regulation and investment – a revised comparison

If use is made of the various mechanisms which have been discussed above, the relative attractiveness of the alternative approaches to regulation changes significantly. The new comparison is summed up in Table 2.

Table 2: Regulation and Efficiency Outcomes: Revised Case

Efficiency Aspect	Cost Plus Regulation	Price Cap Regulation
Short Run Optimisation	Very Good	Very Good
Quality Choice	Moderately Good, but not Ideal	Good but not Ideal
Short Run Productive Efficiency	Poor	Good
Long Run Investment Choice	Very Good (if no Averch and Johnson Effect)	Very Good
Long Run Productive Efficiency	Poor	Poor

The use of the additional mechanisms such as slots has tilted the balance towards price caps. Both price caps and cost plus regulation score better in terms of short run efficiency- if reliance is made on slots and price discrimination in airport charges, achieving efficient utilisation of available airport capacity is no longer much of a problem. The quality performance of price caps can be improved, though neither form of regulation is without problems. Conditional triggers and slots make a big difference to the performance of price caps in terms of providing incentives for efficient levels of investment.

None of the mechanisms discussed will address the last aspect of efficiency, namely that of creating incentives for the airport to be cost efficient when it provides the new capacity. The regulator still relies heavily on the airport for information on what the costs of expanding capacity are. Explicit monitoring of costs and benefits, or introduction of new incentive arrangements such as those discussed by Hendriks and Andrew (2004) may be needed to break the impasse.

6. Conclusion

Regulation of investment in airports is an inherently difficult task. Regulators, with some significant exceptions, have tended to rely on simple regulatory formulae, such as simple hybrid price caps. While these seem to work for a while, problems develop when major investments are required. In particular it is difficult for the regulator to ensure that adequate but not excessive investments in capacity and quality are made.

The problem is complex because the regulator is seeking to optimise on several fronts: short run efficiency in the use of congestible capacity; keeping costs low; delivering the right service quality; encouraging the right amount of investment and ensuring that the cost of the additional capacity is minimised. Regulators rely heavily on prices, yet prices are being used to address several conflicting tasks, including optimising use of existing capacity, allowing cost recovery, and providing incentives for investment. For example, when an airport is subject to excess demand and is congested, high prices are warranted for efficiency, but when investments have been made and capacity is ample, prices should be low. On the other hand, the regulator will need to offer high prices when investment is being made to provide the airport with incentives to invest. It is not surprising that simple regulatory solutions are unsatisfactory.

The problem of ensuring efficiency can be lessened if regulators employ additional instruments. These include rewards for quality, slots and conditional trigger mechanisms for investment. Some key points to emerge from this discussion are:

Slots enable a solution to the short run optimisation problem which does not rely on the prices being set by the regulator. In this way they free prices to be used to provide incentives to invest.

Conditional trigger mechanisms, whereby the regulator sets a higher price cap conditional on investments being made, can be used to get around the problem of price caps leading to under investment.

The downside of conditional triggers is that they are essentially cost based, and thus they do not provide the airport with incentives to minimise the costs of the investment. Resolving this problem will depend on using additional mechanisms, some of which have been suggested though not operationalised so far.

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Reform and Opening up :
Way to the Sustainable and Harmonious Development of Air Transport in China

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Abstract

The global air transport has been undergoing wings of change in the past 30 years as a result of deregulation and liberalisation. It has been both a facilitator and beneficiary of globalization. During this period, the air transport in China has also been undergoing significant transformation and rapid growth following the reform and opening up policy of China since 1978. China has become the world's second largest air transport system since 2006. Its burgeoning growth has significant impact on the air transport industry and leads the growth of air transport in Asia Pacific region as well as the world. The reform of China's civil aviation has been based on its policy in socialist market economy as well as the liberalisation of air transport. In order to sustain the rapid and continuous development in civil aviation, China should continue to implement scientific management and development, deepen the reform and opening up and continue liberalization. This paper reviews the development of the air transport policy of China since its reform and opening up in the past 30 years and examines the challenges and way forward on the development of China's air transport policy in the 21st Century.

Keywords: China; Air Transport Policy; Civil Aviation; Airport Development Plan; Air Traffic; Liberalisation; Reform and Opening up

1. Introduction

The global air transport has been undergoing wings of change in the last 30 years as a result of deregulation and liberalisation. Over the same period, the air transport in China has also been undergoing significant transformation following the reform and opening up policy[1] of China since 1978.

In the past 30 years, China has been implementing the three-step strategy for modernization, leading to China's sustainable rapid growth which is unparallel in the world. China has become the fourth largest economy in the world, and its import and export volume is now the third in the world. China's economic system has successfully transformed from mandatory planning to 'guidance' planning [french-style planification] to a socialist market economy which is wholly market-orientated economy[2] and from the closed, semi-closed to an open economy. China's ranking in the Human Development Index has improved from "low" to "upper middle" level where her incomes of about 250 million people have risen above the government's poverty line.[3] China's development has not only enabled its people to move steadily towards prosperity and happiness, it has also contributed substantially to the world's economic growth and progress in the civilisation of mankind.

China's air transport industry was administered based on the military system and was a typically monopolistic system. Despite being the fundamental industry and an important component of the national economy, China's air transport industry was severely underdeveloped. The reform and Opening up has significantly improved the productivity of China and has also been fostering the rapid and harmonious development of China's air transport industry. China has become the world's second largest air transport system since 2006. Its burgeoning growth has significant impact on the air transport

[1] Reform and Opening Up Policy of China was based on the theory of Deng Xiaoping and enacted by Third Plenum of the 11th Party Congress of the People Republic of China, held during December 18 - 22, 1978.
[2] Howe, C., Kuel, Y.K., Ash, R. (2003) *China's Economic Reform*, Routledge Curzon.
[3] Kuroda, H. (2008) *Towards Inclusive Economic Development in China*, Asian Development Bank.

industry and leads the growth of air transport in Asia Pacific region as well as the world.

This paper reviews the development of China's air transport policy since its reform and opening up 30 years ago and examines the challenges and way forward on the development of China's air transport policy in the 21st Century.

The burgeoning growth of China's air transport is a result of the phenomenal economic growth of China following its reform and opening up and the effect of globalisation. The economy of China has been experiencing average annual growth of over 9%[4] in GDP and average per capita GDP growth of more than 8% in the past 30 years while the average annual growth in total revenue tonne-kilometres, number of air passengers and air cargo and mail are 18%, 16.3% and 15.3% respectively as shown in Table 1. However, the air transport development in terms of airlines and airports in China as shown in Table 2 are considered underdeveloped given its vast geography and large population when compared with the USA.

Table 1: Air Traffic Statistics of China 2007 vs 1978

Indicators	2007	Growth over 1978	% c.a.g.
Total Revenue Tonne-kilometres (million tonne-km)	36,100	120.9 times	18%
No. of Air Passengers (million passengers)	185.19	80.2 times	16.3%
Air Cargo & Mail (million tonnes)	3.95	61.9 times	15.3%

Table 2: Comparison of Demographics between China and USA

Items	USA (2000)	China (2007)
Area (million km^2)	9.37	9.6
Population (billion)	0.22	1.3
Total No. of Airports (2000)	19,281	
No. of Public Airports	5,317	
No. of Airports with scheduled flights	651	142
Density (No. of Airports with scheduled flights per 10,000 km^2)	0.69	0.148

2. Development of Air Transport Policy in China

Following the national policy of reform and opening up driven by Deng Xiaoping since 1978, the air transport industry has also been undergoing reforms. The development in China's air transport is a good example to demonstrate the significant implication of "Reform and Opening up" in strengthening China. China's air transport policy is generally reviewed once every five years based on the national five year plan. The development of China's air transport policy can be classified into three phases and the key milestones are highlighted in Table 3. The scope and scale of the civil aviation reform in 2002 was the largest in China in terms of both breadth and depth since the inception of reform and Opening up. It has initially established a new management and operational system based on socialist market economy.

Table 3: Three Phases Development of Air Transport Policy in China – Key Milestones

i. ***First Phase: 1950 ~ 1978***

Owned and controlled totally by government and Slow development

The government and state-owned enterprises (SOE) including air traffic control, airlines and airports were centrally administered under military leadership.

- On November 2, 1949, the establishment of the China People's Revolutionary Military Commission Civil Aviation Authority marked a new era of China's civil aviation industry.
- The administration of civil aviation had undergone six reforms during 1950-1980.

[4] Kuroda, H. (2008) *Towards Inclusive Economic Development in China*, Asian Development Bank.

- In 1978, the Third Plenum Session of the 11th Communist Party Congress approved to establish socialist market economy and implement "Reform and Opening Up".

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ii. Second Phase: 1979 ~ 2002

Reform and open-door policy and Rapid growth

Since the implementation of "Reform and Opening up", China has experienced phenomenal growth and became a dominant civil aviation nation in the world during this phase.

- In 1979, established regional "Civil Aviation Administration Bureau" as the accountable unit to independently administer and audit the profit and loss as well as to examine the economic and technical performance indicators of each region. In order for each regional bureau to share its airport cost, the allocation of revenue would be based on the revenue tonnes kilometres. This reform had mitigated the need for the subsidization of enterprises by the central government.
- In 1980, Deng Xiaoping gave directive on corporatisation of aviation enterprises such as airlines. The State Council and Central Military Commission decided to reform the structure of civil aviation industry.
- In January 1985, the State Council approved the "Implementation of the program in the civil aviation system administration structure".
- In January, 1987, the State Council approved the "Report on the Proposal to Reform the Civil Aviation Administration System and Implementation Programme" to reform the administration based on separate administration and establishment of the civil aviation administration authority, airlines and airports. To separate air transport from airports, it has since set up six trunk airlines, six large airports including Beijing, Shanghai and Guangzhou, and established six civil aviation administrations in North China, East China and Central-South China, Southwest China, Northwest China and Northeast China.
- Jan-Feb 1992 Deng Xiaoping undertook the 'Southern Journey' and affirmed that reform and opening policies had to last for 100 years and that the market was not a capitalist institution.
- In October, 1992, the 14th Meeting of the Communist Party of China National People's Congress (CCPCC) established the reform objectives for the socialist market economic system.
- In November 1993, the Third Plenum of the 14th Party Congress approved the full adoption of the "CPC Central Committee on the establishment of the socialist market economy Decision on Several Issues". It clearly indicated the direction for deepening the reform in the China's civil aviation, fostering a new era for the profound reform.
- In September 1994, the 4th Plenum of 14th CCPCC called for strengthening of party building and Stressed Deng Xiaoping's theory of 'building socialism with Chinese characteristics'.
- In March 1996, the 4th session of 8th China National People's Congress approved the 9th Five Year Plan and 10 Year Development Programme

  The Goal was to accomplish the second strategic phase of modernization and reduce poverty. Speed up establishment of a modern enterprise system, and build the socialist market economic system; the main objectives of national economic and social development by 2010 were to double 2000's GNP and so people could lead a richer life.
  - build comprehensive transportation system to ease bottleneck of communication and transportation. Promote economic development in central and western China
  - Promote structural reform of SOE and strengthen supervision and management of SOE.
  - open up transportation, agriculture, energy, and other basic industrial and infrastructure sectors to interested foreign parties
- In 1996, the 9th Five Year Plan (1996-2000) for civil aviation
  - Designated Beijing, Shanghai and Guangzhou as the international hubs; and
  - consolidate airlines to form three major airlines, Air China, China Southern and China Eastern
- In 2001, 5th Plenary Session of the Fifteenth CPC Central Committee adopted the 10th five Year Plan for National Economic and Social Development[5]
  - build highways, railways, ports, channels, airports and pipelines in order to establish a comprehensive modern transportation system
- In 2001, the 10th Five Year Plan (2001-2005) for civil aviation
  - policy to separate the administration of SOE from government and decentralise airport management to local authorities from CAAC
  - corporatisation of the three major airlines
- In January 2002, at the 121st meeting of the State Council's Prime Minister Office, it officially endorsed the proposal for structural reform of China's civil aviation.

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[5] Report on the Outline of the Tenth Five-Year Plan for National Economic and Social Development (2001) , document available at: http://english.gov.cn/official/2005-07/29/content_18334.htm

- In February 2002, the CAAC convened the National Civil Aviation Council meeting to announce a series of new reform measures. The objectives included separation of SOE from government ownership; redefine roles and responsibilities; reorganization of assets, optimization of resource allocation, break through monopolies, introduction of appropriate competition; strengthening monitoring; ensuring safety; decentralization of the management of airports by local authorities; enhancement of efficiency, and services improvement.

iii. *Third Phase: 2003 ~ 2020*

Deepen reform, enhance the open-door policy and accelerate development

- In 2003, China, at ICAO's Fifth World Air Transport Conference, agreed to positively, progressively, orderly and safely to facilitate liberalisation of air transportation.
- In July 2004, following the formal transfer of the management of civil airports in Gansu province to local government, the new reform of civil aviation system was completed.
- In 2004, China became a council member of ICAO
- In 2004, CAAC implemented more liberalised air services agreements
  - China granted 5th freedom rights for all cargo airlines to Xiamen and Nanjing to Singapore
  - designated Hainan as a pilot province for 3rd, 4th and 5th freedoms.
  - more liberalised China-US air services agreement
- In 2006, the 4th Session of the Tenth National People's Congress endorsed the 11th Five Year Plan (2006-2010). The heart of the 11th Five Year Plan is to build an overall well-off society.
  - adopt the development philosophy of "Scientific Approach to Development" and "Constructing a Harmonious Socialist Society."
  - Also for the first time, efforts are to be made to strengthen the service industries
- In 2006, the 11th Five year Plan for Civil Aviation's strategic goals include:
  - Fast growth in air transport and greater improvement in service quality
  - Increase in general aviation and better structure
  - More efforts on infrastructure development and better capability to meet demand, total investment RMB140 billion, no. of airports to increase from 142 to 190 by 2010
  - Improve organisational and regulatory system
  - Further modernise air traffic management system
  - Comprehensive application of IT technology
  - Alleviate the shortage of professionals for pilots, crews, air traffic management, maintenance etc
  - Develop a new generation of air transport system
  - To play a more prominent role in the national comprehensive transport system and meet the economic and social needs by 2010
- In May 2007, China made an agreement with the US to open the air transport market and next discussion in 2010 to review the timetable and the agreements for complete liberalization of the Sino-US air transport market.
- In 2007, CAAC issued "China's Airport Development Plan 2020"
  - China's GDP to quadruple that of 2005 with an annual average growth rate of 7.2%
  - Annual average growth rate of 11 % during 2010-2020
- In 2008, the 11th National People's Congress announced the establishment of the super ministry for road, air and water transport. The CAAC and State Postal Bureau are merged into the new Ministry of Transport.

The air traffic statistics of 1950-2007 are summarised in Table 4 and the trends of total revenue tonne-kilometres, revenue passenger-kilometres, no. of air passengers, air cargo and mail throughput and revenue freight tonne-kilometres of all airports in mainland China are shown in Figures 1-5.

Table 4: Air Traffic Statistics in China in 1950, 1978, 1980, 2002 and 2007

Year	1950	1978	1980	2002	2007*
No. of Scheduled Air Routes	7	135 (year 1975)	180	1,176	
Distance ('000 km) (repeatable distance)	12.1	236.66	310.887	1,638	
No. of Air Passengers ('000 passengers)	10	2,310	3,430	85,940	185,190
Air Cargo and Mail (tonnes)	767	63,815	88,866	2.02 million	3.95 million
Total Revenue Tonne-Kilometres (million tonne-km)	1.57	298.66	429.35	16,492.66	36,100

Source: CAAC, 2007, Statistical Data on Civil Aviation of China
* preliminary results

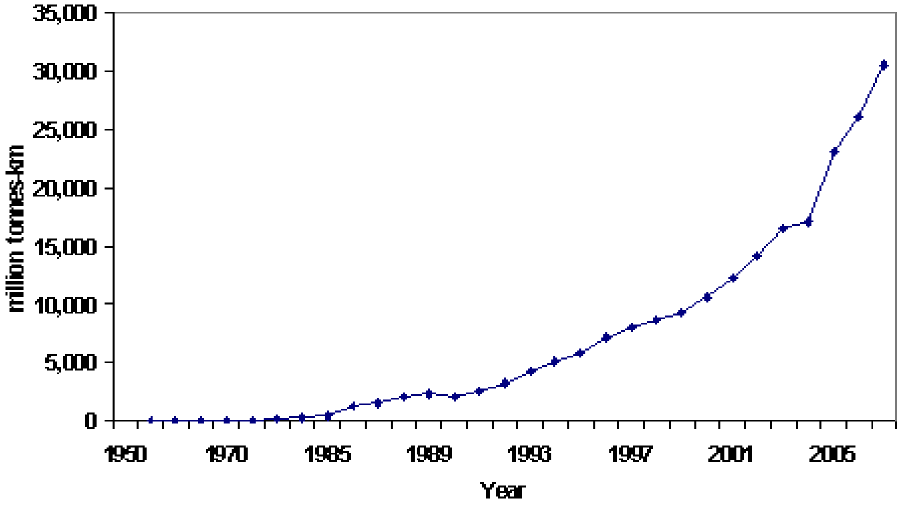


Figure 1: 1950-2006 Total Air Traffic Revenue Tonne-Kilometres

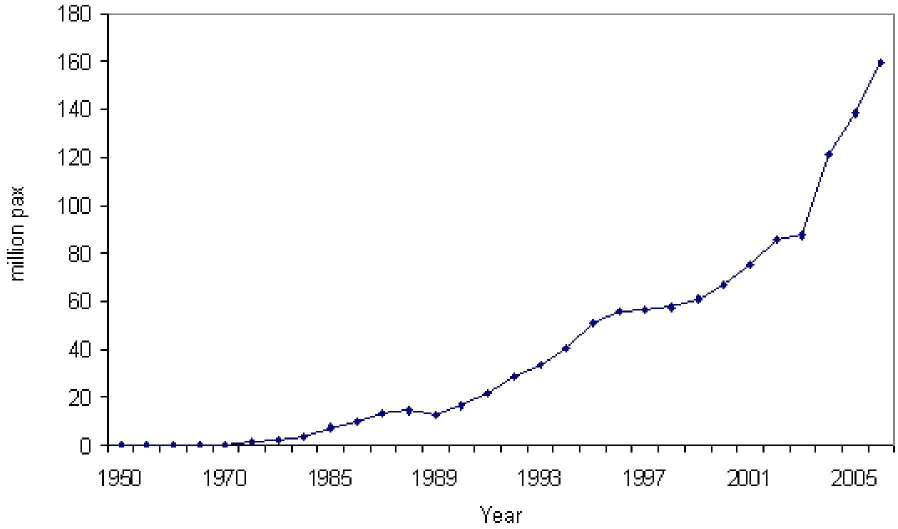


Figure 2: 1950-2006 Total Passenger Throughputs

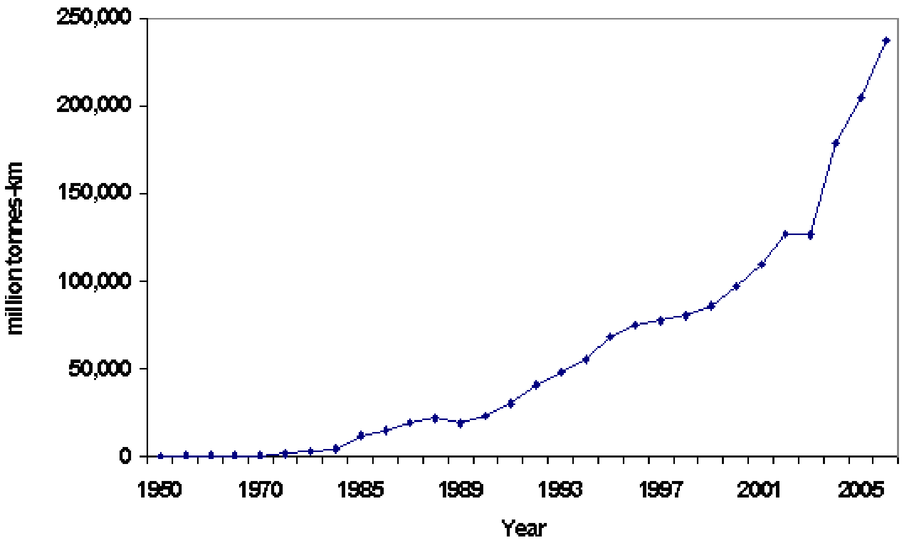


Figure 3: 1950-2006 Total Passenger Revenue Turnover

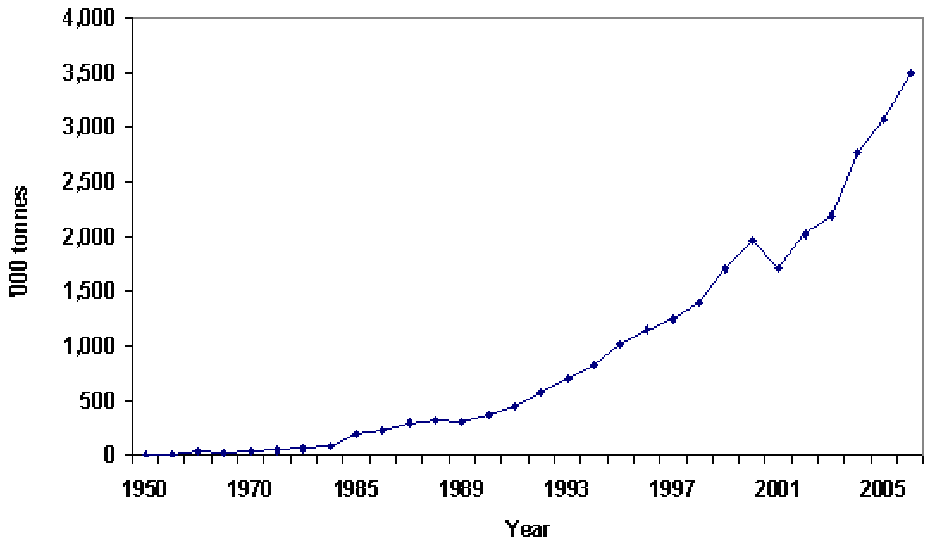


Figure 4: 1950-2006 Total Cargo & Mail Throughput

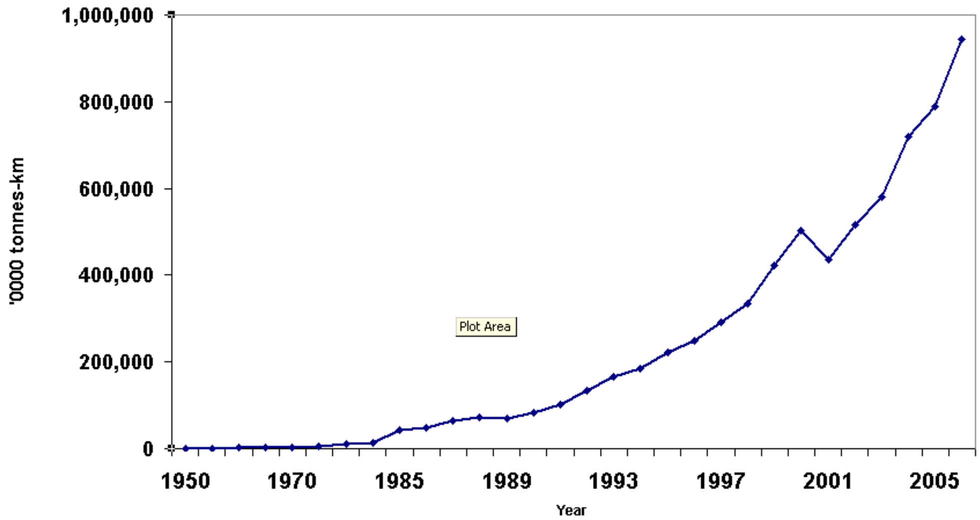


Figure 5: 1950-2006 Total Cargo & Mail Revenue Turnover

The growth rate of China's air transport was three times that of the world and its ranking in air traffic has surged from the 37th position in 1978 to No. 5 in 2002 among ICAO contracted states and became No. 2 since 2006. The 2007 air transportation production indicators and 2008 forecast indicators are shown in Table 5.

Table 5: Performance Indicators for 2007 China Air Transport

Indicators	Unit	2007*	2006	Growth %	2008 Forecast
Total Revenue tonne Kilometres	100 million tonne-km	361	306	18.0%	420 million tonne-km (growth over 2007 - 16%)
Domestic	100 million tonne-km	234	203	15.3%	
International	100 million tonne-km	127	103	23.3%	
Total No. of Passengers	0000 persons	18519	15968	16.0%	210 million passengers (growth over 2007- 14%)
Domestic	0000 persons	16841	14553	15.7%	
International	0000 persons	1678	1415	14.15%	
Total Cargo and Mail Throughput	0000 tonnes	396	349	13.1%	4.45 million (growth over 2007 12%)
Domestic	0000 tonnes	282	257.26	9.7%	

International	0000 tonnes	113	92.17	22.8%
Aircraft utilisation	Hour	9.5	9.5	0.00%
Passenger Load Factor	%	76.2	73.6	2.7%
Cargo Load Factor	%	67.2	65.7	1.5

✷ Provisional Data

Source: Planning and Development Department of CAAC

The “11th Five-Year Plan of China’s Civil Aviation Development” is to facilitate the development of a new generation of air transport system and the key performance indicators are summarised in Table 6. In December 2007, the State Council approved The General Administration of Civil Aviation of China (CAAC)’s “China’s Civil Aviation Airports Development Plan 2020" and the layout plan of the Chinese airports in 2006 and 2020 are shown in Figure 6 and 7 respectively. The distribution of existing airports in 2006 and the new airports by 2020 by region are listed in Table 7.

Table 6: Key development indicators of the 11th Five-Year Plan of China’s civil aviation

Category	Indicators	2005	2010	Compound Annual Growth %
Development Scale	Total Revenue Tonne-Kilometres (100 million tonne-km)	261	500	14
	Total No. of Passengers (100 million persons)	1.38	2.7	14.5
	Total Cargo and Mail (‘000 tonnes)	3,070	5,700	13
	General Aviation (10000 hours)	8.5	14	10
	Proportion of Air Passengers of all transport modes (%)	11.8	17.8	
Perfomance and Efficiency	On-Time Performance (%)	82	85	
	Average flight delay (minutes)	58	< 43	
	Load Factor (%)	65	>70	
	Aircrafts Utilisation Rate (hour/day)	9.4	≦9.5	
	Fuel Consumption per tonne-kilometre (kg)	0.336	0.302	
Capacity	No. of Aircrafts (1000)	2,450	>4,600	13.5
	Civil Aviation Airports	142	190	

Table 7: Distribution of China’s Civil Aviation Airports by Region

Airport Group	North Airport Group	East China Airport Group	Indochina Airport Group	Southwest Airport Group	Northwest Airport Group
Province	Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang	Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong	Guangdong, Guangxi, Hainan, Henan, Hubei, Hunan	Chongqing, Sichuan, Yunnan, Guizhou, Tibet	Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang
Existing Airports	Beijing capital, Nanyuan, Tianjin,. Shijiazhuang, Qinhuangdao, Taiyuan,. Yuncheng, Tatung, Changzhi,	Shanghai Pudong, Shanghai Hongqiao, Nanjing, Wuxi, Changzhou, Xuzhou, Lianyungang, Nantong, Yancheng,	Guangzhou, Shenzhen, Zhuhai, Meizhou, Shantou, Zhanjiang, Nanning, Guilin, Beihai, Liuzhou, Wuzhou, Haikou, Sanya,	Chongqing, Wanzhou, Chengdu, Jiuzhai. Trenches, Panzhihua, Xichang, Yibin., Mianyang and Nanchong, Luzhou,	Xi'an, Yan'an, Yulin, Hanzhong, Ankang, Lanzhou, Dunhuang, Jiayuguan, Qingyang, Xining, Golmud,Yinchua

	respiratory and. Gallant special, Baotou, Hailar, Man. Chau, Xilin, Chifeng,. Tongliao, Wulanhaote, Wuhai,Shenyang, Dalian, Dandong, Jinzhou, Chaoyang, Changchun, Yanji, Kazakhstan. Seoul Foreshore, Mudanjiang, Qiqihar., Jiamusi, Heihe	Hangzhou, Ningbo, Wenzhou, Zhoushan, Huangyan, Yiwu, Quzhou, Jinan, Qingdao, Yantai, Weihai, Linyi, Weifang, Dongying, Hefei, Huangshan, Anqing, Fuyang, Yang, Nanchang, Ganzhou, the Jinggang Mountains,. Jiujiang and Jingdezhen, Fuzhou, Xiamen. Jinjiang, Wuyishan, Citylink	Zhengzhou, Luoyang, Nanyang, Wuhan, Yichang, Enshi, Xiangfan, Changsha, Zhangjiajie., Changde, Yongzhou, Huaihua	Guangyuan, Dazhou, Kunming, Xishuangbanna,Lijiang, Xishuangbanna,Dali, Mans, Diqing, Baoshan, Lincang, Simao, Zhaotong, Wenshan, Guiyang, Tongren, Xingyi, Anshun, Liping, Lhasa, Qamdo, Nyingchi	n, Urumqi, Kashi, Yining, Korla, Altay, Aksu and Hotan, Tacheng, Kuqa, and Qiemo,Naladi, Karamay
No. of Existing Airports	30	37	25	31	24

Total Existing Airports in China: 147

Airport Group	North Airport Group	East China Airport Group	Indochina Airport Group	Southwest Airport Group	Northwest Airport Group
Province	Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang	Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong	Guangdong, Guangxi, Hainan, Henan, Hubei, Hunan	Chongqing, Sichuan, Yunnan, Guizhou, Tibet	Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang
New Airports	Second Beijing airport, Liangxiang, Handan, Hengshui, Chengde, Zhangjiakou., Luliang, Wutai Mountain, Ordos, Aershan, Erlianhaote, Bayannaoer, Ejin Banner of the cloth, Huo. Forest River, Jiageda-long sea. Changbai Mountain, Tonghua, Baicheng, Mohe, Daqing, Jixi, Yichun , Fuyuan	Huaian, Soviet Union, Lishui, Jining, Jiuhuashan, Bengbu, Wuhu, Yichun. Jiangxi East, Sanming, Ningde, Pingtan	Shaoguan, Baise, Hechi, Yulin, Dongfang, Wuzhishan, Qionghai,Xinyang, Shangyou, Shenyijia,Shangqiu, Shennongjia, Hengyang, Yueyang, Wugang, Shaodong	Qianjiang, Wushan, Leshan, Kangding,Aden, Maerkang, Tengchong, Red River, Nujiang, Huize, Mengla, Lugu Lake, Libo, Bijie,. Liupanshui, Zunyi, Huang Ping, Qianbei,Ali, Xigaze, Nagqu	Hukou, Baoji, Shangluo, Tianshui., Xiahe, Jinchang, Longnan, Zhangye, Wuwei, SkyCity, Yushu, Huatugou, Delingha, Guoluo. Qinghai Lake, Guyuan, Zhongwei,. Kanas, Turpan, Hami,. Bole, Kuitun, Loulan, Fuyun, Tajikistan, Shihezi
No. of New Airports	24	12	14	21	26

Total New Airports in China: 97

Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong	Guangdong, Guangxi, Hainan, Henan, Hubei, Hunan	Chongqing, Sichuan, Yunnan, Guizhou, Tibet	Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang

Source: CAAC, 2007, “China’s Civil Aviation Airport Development Plan"

Figure 6: China’s Civil Aviation Airport Layout Plan (2006)

Source: CAAC, 2007, "Development Plan of China's Civil Aviation Airport Layout Plan"

Figure 7: China's Civil Aviation Airport Layout Plan (2020)

Meanwhile, China has also been actively developing the bilateral air service agreements with other countries, to facilitate regional air transport collaboration and further the opening up of the air transport market to the world. It also emphasises particular attention to meeting the needs of western China, northeast China and central China to facilitate their economic and social development as well as the construction of the hub airports for meeting the anticipated needs of liberalising international air services**.** By the end of 2007, China has signed air services agreements with 110 countries.

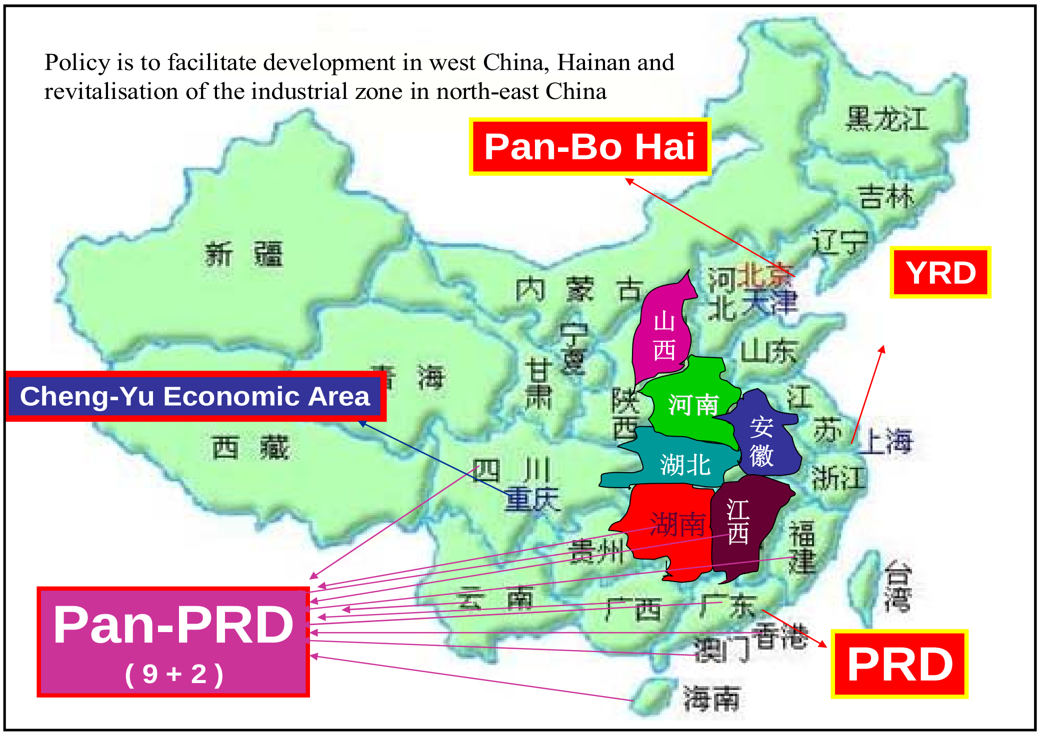
As reflected in the development of US air transport policy and regulation, it is reviewed that deregulation does not imply that all aspects can be free from government control. It is reviewed that deregulation is applied to the area that can be driven by the market and the government would not need to intervene. On the other hand, for the area that cannot be driven by the market such as international bilateral agreements, domestic commuter air services, aviation safety and security, air traffic control and anti-trust regulation, it is necessary for the government to exercise its impartial administrative role and apply necessary regulation for the benefit of the nation and customers.

The development policy of China's economy is to implement both the market economy and macro economic control as part of the socialist market economy. China needs to develop its fundamental function of market economy in resource allocation, enhance the vibrancy and competitiveness of enterprises.

The 21st century is the era of aviation. With the emergence of economic globalization and liberalization of air transport, it is anticipated that air transport will continue to grow. Following the trend of liberalisation, China would liberalise its air transport positively, progressively and orderly, according to China's economic development approach and development needs of the civil aviation industry.

3. Challenges for Air Transport Development in China

Following 30 years of reform and opening up, the airport system in China has started to take shape since the turn of the century, with gradual increase in density of the airports, scale and degree of modernization. The policy for economic development is to encourage development in western China, revitalisation of the industrial region in north-east China and Hainan. The development of civil aviation is based on the China's Strategic Economic Development Plan as shown in Figure 8.



Remark:

- Pan-Bohai includes Beijing, Tianjian, Hebei, Liaoning and Shangdong
- YRD denotes Yangtze River Delta including Shanghai Municipality, Nanjing, Yangzhou, Suzhou, Wuxi, Nantong, Zhenjiang, Changzhou, Taizhou; Hangzhou, Ningbo, Jiangxing, Huzhou, Shaoxing, Zhoushan, Taizhou
- PRD denotes Pearl River Delta including Guangzhou, Shenzhen, Zhuhai, Foshan, Jiangmen, Dongguan, Zhongshan, Huizhou, Huiyang county, Huidong county, Boluo county,Zhaoqing, Gaoyao and Sihui
- Pan-PRD includes nine provinces in south China, Hong Kong SAR and Macau SAR
- Cheng-Yu Economic Area includes Chengdu and Chongqing urban agglomeration

Figure 8: China's Strategic Economic Development Plan

The key international hubs including Beijing, Shanghai, Guangzhou and Hong Kong have been established while airports at provincial capital including Chengdu, Kunming, Chongqing, Xi'an, Urumqi, Wuhan, Shenyang, Shenzhen and Hangzhou are designated as regional hubs which are to be complimented by regional feeder airports. Although the total air passengers and air cargo and mail throughput in China have experienced unparallel compound annual growth of 16.3% and 15.3% respectively during 1978-2007, the air cargo and mail throughput only constitutes 0.02% of total cargo and mail throughput by all transport modes while air passengers throughput only constitutes 0.8% of the total passengers throughput by all transport modes.

Although both international and local aviation researchers have forecasted that China will continue to experience double digit growth in air transport, it is reviewed that the air transport industry in China will inevitably encounter challenges.

<u>3.1 Comprehensive Transport Development Plan and Increasing Modal Competition</u>

Transport has in hitherto been a key engine to drive economic growth. To facilitate both economic and social development, China has been promoting the development of comprehensive transportation system since the 10th Five Year Plan (2001-2005). There has been significant progress in the development of infrastructure for various transport modes and their service quality. The comprehensive transportation system has entered the stage for coordinated development and service enhancement and the development of a modern integrated transportation system to meet the forecast demand under the 11th Five- Year Plan as shown in Table 8.

Table 8: China "11th Five-Year Plan" Transportation Demand Forecast

Mode	Unit	2005	2010	Growth Rate%	2005 Modal Distribution %	2010 Modal Distribution %
Total Cargo Traffic	100 million tonnes	186	232.1	4.5		
Railway	100 million tonnes	26.9	35	5.4	14.5%	15.1%
Road	100 million tonnes	134	168	4.6	72.0%	72.4%
Sea	100 million tonnes	22	29	5.7	11.8%	12.5%
Air	10,000 tonnes	306.7	570	13.2	0.02%	0.02%
Total Cargo Revenue Tonne-Kilometre	100 million tonnes-km	80257	105154	5.6		
Railway	100 million tonnes-km	20726	27000	5.4	25.8%	25.7%
Road	100 million tonnes-km	8693	12000	6.7	10.8%	11.4%
Sea	100 million tonnes-km	49672	56000	5.8	61.9%	53.3%
Air	100 million tonnes-km	78.9	154	14.3	0.1%	0.1%
Total Passenger Traffic+A15	100 million	185	259.9	7		
Railway	100 million	11.6	15	5.3	6.3%	5.8%
Road	100 million	170	240	7.1	91.9%	92.3%
Water	100 million	2	2.2	1.9	1.1%	0.8%
Air	100 million	1.4	2.7	14	0.8%	1.0%
Total Revenue Passenger-Kilometre	100 million passenger-km	17467	26913	9		
Railway	100 million passenger-km	6062	8000	5.7	34.7%	29.7%
Road	100 million passenger-km	9292	15000	10.1	53.2%	55.7%
Water	100 million passenger-km	68	68	0	0.4%	0.3%
Air	100 million passenger-km	2045	3845	13.5	11.7%	14.3%

Source: the 12th edition of 2007 "Integrated Transport" by the State Development and Reform Commission

In early 2008, China has completed 35,000 kilometres initial highways including five major highways linking north and south China, and seven major highways linking east and west China (Five vertical and seven horizontal) as shown in Figure 9 and 10.

Figure 9: China National Highway Network

Figure 10: "Five Vertical and Seven Horizontal" National Major Highways – Schematic Diagram

From 1997-2007, China's railway system has undergone six major rapid track improvements to accelerate the speed, enhance the infrastructure, improve the quality and increase the capacity as shown in Table 9. By 2020, the total length of its railway system will reach 100,000km as illustrated in the medium-long term development plan of China's railway system in Figure 11.

Table 9: Development Progress of China's Railway since 1997

Phase	Time	Development Progress of China's Railway
1	April 1, 1997	the 3 main railways: the Beijing-Guangzhou, Beijing-Shanghai, Beijing Route Kazakhstan, with Shenyang, Beijing, Shanghai, Guangzhou, Wuhan and other large cities as the centre - up to a maximum speed of 140 km/hr and an average speed of 90 km/hr - 40 fast trains and 64 overnight trains
2	October 1, 1998	Beijing-Guangzhou, Beijing-Shanghai, Beijing and Kazakhstan section to accelerate to a maximum speed of 140 to 160 km/hr. The Guangzhou-Shenzhen line to accelerate to a maximum speed of 200 km/hr . he average speed of passenger trains reached 55.16 km / hour.
3	Oct 21, 2000	Longhai Europe-Asia Continental Bridge, the new-line, Beijing-Kowloon line and Zhejiang-gan line; - restructuring the resource allocation of trains and services;

		- integrated ticket sales enabling more than 400 larger stations to sell rail tickets for any destinations
4	Nov 21, 2001	Development of rapid track covers most of the large cities and regions, for instance, Wuchang to Chengdu line, Beijing-Guangzhou line, Beijing-Kowloon line, Zhejiang-Gan line, Shanghai-Hangzhou line and the Kazakhstan line.
5	April 18, 2004	Development of rapid track is mainly for the Beijing-Guangzhou Beijing-Shanghai, Beijing-Kowloon, Beijing and Kazakhstan, Longhai and Zheganxian lines up to maximum speed of 200 km/hr. The train speed between major cities is generally increased which greatly reduce the travel time of both the passenger and cargo train.
6*	April 18, 2007	Development of rapid track for the Beijing and Kazakhstan line, Beijing-Shanghai, Beijing-Guangzhou, Longhai, Zhejiang-Jiangxi, Jiaoji, Wuhan-Kowloon, Guangzhou and Shenzhen to a speed of 200km/hr, with maximum up to 250km/hr.

*The Phase 6 covers 17 provinces and municipalities, more than 120 km/hr, covering a total rail length of 22,000 km, which is 6000km more than Phase 5. The 160-km line and 200-km line would be extended to 14,000 km and 6003 km respectively, covering the Beijing and Kazakhstan, Beijing-Shanghai, Beijing-Guangzhou, Longhai, Zhejiang-Jiangxi, Jiaoji, Wuhan-Kowloon, Guangzhou and Shenzhen major network. The section of Beijing and Kazakhstan, Beijing-Shanghai, Beijing-Guangzhou, Jiaoji can reach 250km/hr.

Source: Zhang Zhenyi, Dec 2007, The Impact of the 6th Rapid Track Development on Air Transport, Journal of Macau Civil Aviation No.6

Figure 11: Medium-Long Term China's Railway Network Development Plan

The total port cargo throughput and container throughput in China have ranked World's No. 1 for four consecutive years. Over 90% of China's export depends on sea transport. The sea transport industry has been the lifeline in supporting the globalization of economy and the development of China's external trade. The distribution of ports in China is shown in Figure 12. There are five major port clusters including Pan-Bohai, Yangtze River Delta, South-east coastal region, Greater Pearl River Delta and South-west coastal region to facilitate the transportation of eight major commodities including coal, crude oil, mineral ore, containers, food, commercial vehicles, RORO and passenger transport. With the increase in port capacity, increase in the capacity of ocean-going vessels, their shorter lead time and the improvement in supply chain management, some air commodities could be shifted to sea transport as a result of its improved reliability and lower cost.

Figure 12: National Coastal Port Layout Plan

Although China now ranks No. 2 in air transport and has developed a total of 1,400 scheduled air routes serving 61% of the national population, there is still significant gap in meeting the economic needs and to facilitate social development and enhance the quality of life. The proportion of air transport is relatively small when compared to other modes of transport for both passenger and cargo as shown in Table 10 and 11. In view of the national policy to strengthen the development of railway and highways, it is inevitable that the domestic air transport will encounter competition from high speed surface transport.

Table 10: 2006 China Passenger Volume, Growth Rate and Modal Distribution of All Transport Modes

Indicator	Unit	Passenger Volume	Growth Rate%	Modal Distribution %
Total Passenger Traffic	100 million	200.8	8.7	100
Railway	100 million	12.6	8.7	6.27
Road	100 million	184.5	8.7	91.84
Water	100 million	2.2	6.3	1.10
Air	100 million	1.59613	15.4	0.8
Total Revenue Passenger-Kilometres	100 million passenger-km	19202.7	9.9	100
Railway	100 million passenger-km	6622.0	9.2	34.48
Road	100 million passenger- km	10135.9	9.1	52.78
Water	100 million passenger-km	74.9	10.5	0.39
Air	100 million passenger-km	2369.9	15.9	12.34

Source: Zhelin, Integrated Transport Research Institute of the State Development and Reform Commission《2006 Integrated Transport System Development and related views》

Table 11: 2006 China Cargo Volume, Growth Rate and Modal Distribution of All Transport Modes

Indicator	Unit	Cargo Volume	Growth Rate%	Modal Distribution %
Total Cargo Traffic	100 million tonnes	202.5	8.9	100
Railway	100 million tonnes	28.8	7.1	14.22
Road	100 million tonnes	146.1	8.9	72.14
Sea	100 million tonnes	24.4	11.0	12.05
Air	100 million tonnes	0.035	13.9	0.02
Pipes	100 million tonnes	3.2	6.7	1.58
Total Revenue Tonne-Kilometre	100 million tonnes-km	86921.2	8.4	100
Railway	100 million tonnes-km	21,954	5.9	25.26
Road	100 million tonnes-km	9,647	11.0	11.10
Sea	100 million tonnes-km	53,907.8	8.5	62.02
Air	100 million tonnes-km	94.3	19.5	0.11
Pipes	100 million tonnes-km	1,318.2	29.5	1.52

Source: Jushilin,Zheng An,Integrated Transport Research Institute of the State Development and Reform Commission《2006 Integrated Transport System Development and related views》

3.2 Domestic and international competition

In view of the significant improvement and development plan in both highway and railway under the 11th Five-Year Plan, domestic air transport will inevitably face increasing competition.

(a.) Road transport has the advantage for intercity journey within 500 km while rail transport will have the advantage for intercity journey within 500-1000 km. Following the implementation of highways and acceleration of railway, it is inevitable that air transport for short-haul trips has been withdrawn from the market including the Shenzhen-Guangzhou, Chongqing-Chengdu and Dalian-Shenyang routes.

(b.) In view of the construction of high-speed railways, for example, the Beijing-Shanghai route, Guangzhou-Changsha, Changsha-Wuhan, Wuhan-Zhengzhou, Guangzhou-south, Shenzhen-Xiamen, the competition between the railway and the air transport will be intensified. As shown in Table 12, for instance, the travelling time of the intercity service via the new Beijing-Shanghai high-speed railway (at 300km/hr) will be about 5 hours while the total travelling time including flight time, airport processing time and ground transportation time to/from airport is about 4.5 hours by air. In addition, the relatively lower rail cost will attract more passengers to choose the rail. To compete with the railway on short-medium haul passengers, Air China starts to create the "Beijing-Shanghai Air Express" and the "Jing-Rong Air Express".

Table 12: China High-Speed Railways Development Plan

Route	Origin/ destination	Start/ Completion time	Designed speed	Note	Travel time	Travel time by air
PRD inter-city railway	Guangzhou/ Zhuhai, Shenzhen	Dec 18, 2005 /2009	200km/hr	total length: 595m		
YRD inter-city railway	Shanghai/ Nanjing, Hangzhou	Planning stage	300km/hr	including Shanghai-Nanjing, Shanghai-Hangzhou		
Beijing-Tianjin inter-city railway	Beijing/ Tianjin	Jul 4, 2005 / 2007	200-300 km/hr			
Beijing-Shanghai inter-city railway	Beijing/ Shanghai	start from 2007	250-300 km/hr	R&D, wheel-rail technology		
Wuhan-Guangzhou	Wuhan/	Jun 23,	200km/hr	total length:	5 hours	4.5

high-speed railway	Guangzhou	2005/2010		995km		hours
Shanghai-Hangzhou-Ningbo passenger line	Hangzhou/ Ningbo/ Shenzhen	Planning stage	200km/hr	total length: 1600km		
Beijing-Guangzhou passenger line	Beijing/ Guangzhou	Beijing-Shijiazhuang route soon to start	300km/hr	total length: 2230km	7.5 hours	7 hours

Source: Zhang Zhenyi, Dec 2007, The Impact of the 6th Acceleration in Railway Speed on Air Transport, Journal of Macao Civil Aviation No. 6

(c.) Although the liberalization of air services and further opening up to the world are progressing in China, the development of its airline industry has been slow and is facing fierce competition from the foreign airlines. As demonstrated by the distribution of weekly international flights by international and Chinese carriers at the three key international hubs in Figure 13 and 14, international carriers provide similar weekly air services as the Chinese carriers. This is because Chinese airlines do not have enough capacity in terms of fleets and flight crew. For a successful international air services, the Chinese carriers would also need to establish comparable sales network and marketing at the destination country to effectively increase clientele to increase the load factors.

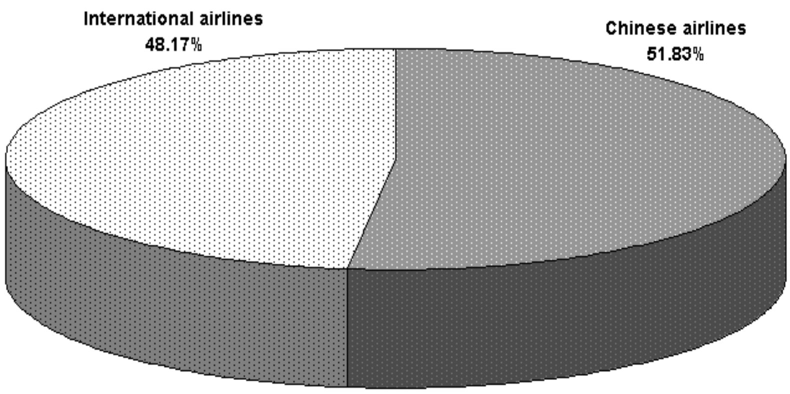


Figure 13: Comparison of Weekly Scheduled Passenger Flight Movements at the Three Key International Hubs in China 2007 between Chinese Airlines and International Airlines

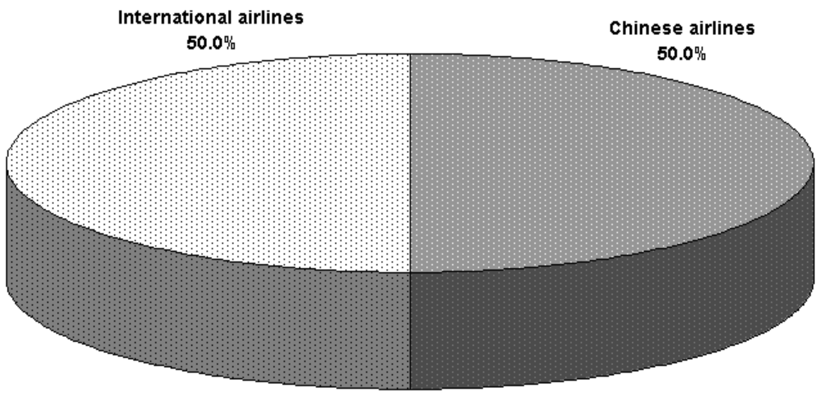


Figure 14: Comparison of Weekly Freighter Movements at the Three Key Hubs in China 2007 between Chinese Airlines and International Airlines

3.3 Insufficient airports, airspace capacity and air services

Despite the substantial expansion of existing airports and development of new airports and increases in air services, the airport infrastructure and air services are not adequate to meet the anticipated demand. Although liberalisation has facilitated more international services and carriers, the network coverage of international services and domestic services are yet to be expanded to meet increasing demand. The increase in flight movements also demands rationalization and optimization of airspace and air traffic management for civil aviation and the division of labour between the military and civil aviation.

In 2007, the total passenger traffic of all mainland airports, excluding the Hong Kong and Macau airports, have increased 16.8% to 388.6 billion, where 35.1% was contributed by the three main airports at Beijing, Shanghai and Guangzhou. The distribution of passenger traffic by region is 17.1%, 5.6%, 30.3%, 25.5%, 15.1% and 6.3% for north China, north-east China, east China, south China, southwest and the northwest respectively as shown in Figure 15. The total cargo and mail throughput handled by all Chinese airports excluding Hong Kong and Macau airport, has increased 14.3% to 8.61 million tonnes where 58.8% was contributed by Beijing, Shanghai and Guangzhou airport. The distribution of air cargo and mail traffic by region is 18.7%, 3.6%, 45.8%, 20.1%, 9% and 2.8% for north China, north-east China, east China, south China, southwest and the northwest respectively as shown in Figure 16. It is revealed that development of air transport is imbalance, especially for the central and western regions, which are lagging behind.

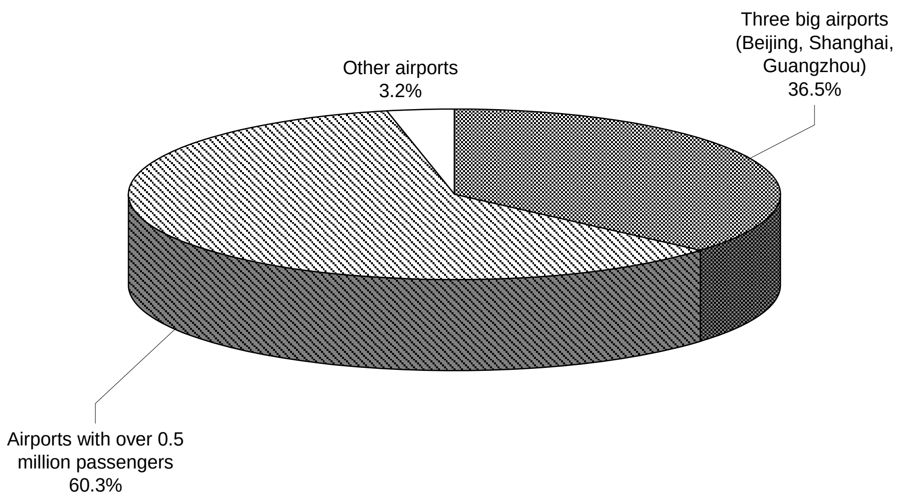


Figure 14: 2006 Distribution of Air Passenger Traffic in China

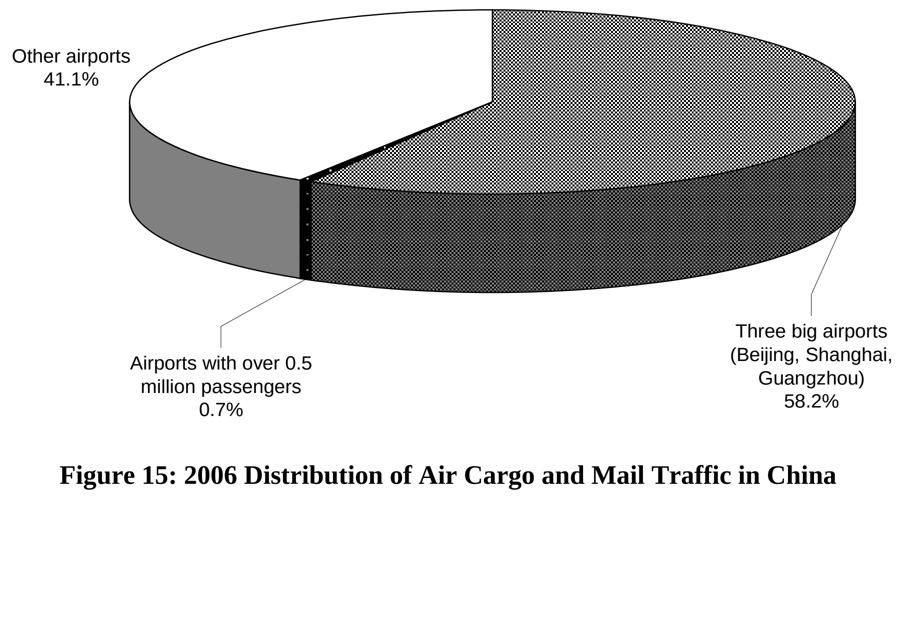


Figure 15: 2006 Distribution of Air Cargo and Mail Traffic in China

3.4 Gap in management level between China's civil aviation enterprises and international practices

It is reviewed that the development of the Chinese enterprises are not compatible with the burgeoning growth of air transport.

(a.) It is not apparent that the developments at various airports which were implemented ahead of demand have brought significant impacts to the regional economic and social development. In the east, central, western and northeast region of China, the development of air transport is imbalance. This undermines the function of air transport as a driver to facilitate economic development and integration of society.

(b.) The relatively low customer satisfaction level in air transport is mainly due to imperfect air service network, unreasonable route structure, inconvenient transfer of flights, low flight frequency and serious delay of flights.

(c.) The application and innovative research, and development in scientific technology in civil aviation such as air traffic management and control, maintenance and marketing still lag behind the developed countries. The related regulatory departments and the enterprises in the air transport industry would need to enhance the calibre of their workforce in modern public administration and management in particular in aviation safety and security, engineering design and management of aviation facilities, legal, finance and scientific management methodology to optimise the utilisation of scarce resources. This is to ensure its sustainable development and compliance with both national and international conventions,

(d.) There is significant gap in human resources to meet the anticipated demand and development plan of civil aviation in China where a total of over 37,300 and 70,500 civil aviation personnel (pilots, maintenance and air traffic controllers) will be required in 2006-2010 and 2011-2015 respectively as highlighted in Table 13. Moreover, it is also necessary to nurture the professionals as well as senior and middle management in all aspects of the civil aviation industry to meet the development needs.

Table 13: Highlights of Human Resources Requirement in the 11th Five Year Plan and 12th Five Year Plan

	11th Five Year Plan (2006-2010)	12th Five Year Plan (2011-2015)
Pilots	9,100	16,500
Maintenance Personnel	25,000	50,000
Air Traffic Controllers	3,200	4,000
Total	37,300	70,500

4. Way Forward on Sustainable and Harmonious Development

Following the successful reform in the past 30 years, it is reviewed that it is necessary to seek continuous improvements in the reform and opening up to meet market dynamic demand, to eliminate the institutional obstacles that constrain productivity and development, and to maintain the continuous and harmonious development of air transport industry in accordance with the spirit of the policy reinforced at the 17th National Congress of the CPC[6] in 2008.

4.1 To accelerate the reform of civil aviation administrative system

The 17th National Congress of the CPC has endorsed the acceleration of the reform of the administrative system. It is to establish a service-oriented government which aims at promoting scientific development, protecting and enhancing the livelihood of the people, strengthening the integration of departments, and exploring the reorganization and consolidation of government departments. On February 27, 2008, the 2nd Plenary Meeting of the 17th Central Committee of the CPC

[6] CPC denotes Communist Party of China

adopted the "On the Views of Deepening the Reform of the Administrative system" and the "State Council's Institutional Reform Plan. After the approval in the 1st Session of the 11th National People's Congress convened on March 5, 2008, this significant reform has commenced, including the establishment of the new Ministry of Transport (MOT), replacing the original Ministry of Communications and the General Administration of Civil Aviation of China. The new set up of the Civil Aviation Administration of China and State Post Bureau are under the MOT. The MOT is to oversee the road, air and sea transport except railway[7] to ensure better coordination among different transport modes so as to facilitate integrated transportation planning, development, management and more effective emergency management in response to disasters.

The restructure of MOT is in accordance with the requirements of developing market economy and the principle of streamlining role and responsibility, decision-making, execution, supervision that require mutual coordination and control. It has horizontally merged the departments with similar role and responsibility and has thus broadened the scope of administration in building a more vibrant, efficient, and open organisation conducive to scientific development. Its prerequisite is to transform the role and responsibility of government and move forward to a service-oriented government. It is believed that after the reorganisation, the Ministry of Transport would be able to optimize resource allocation according to market demand and strengthen the enterprises and their competitiveness. At the same time, it is to strengthen and enhance macro economy control, optimize transportation planning, maximize the overall benefits and efficiency, and facilitate the development of an integrated transport system for all transport modes that is hassle free, efficient and safe.

4.2 New legislation to enhance the development of socialist market economy and to sustain development of airlines

With the transition from planned economy to socialist market economy, the Chinese government has put considerable efforts into drafting laws to recognise the core characteristics of market economy including level playing field, integrity and credibility, fair competition, fair trade and market driven pricing. The central government of China has enacted two legislations in 2007. On March 16, 2007, the "Property Law" has been approved and has been effective since October 1, 2007. On August 30, 2007, China has enacted the "Anti-Monopoly Law", which will be effective from August 1, 2008.

Liberalisation has intensified competition of airlines. To enhance their competitiveness, the Chinese airlines need to strengthen their management, lower their operational cost and tariffs and improve customer services in order to increase its market share. Under the new "Anti-Monopoly Law", the airlines could increase its market share through merger and acquisition, reorganization, joint venture and alliance based on microeconomics. As long as such commercial activity is in compliance with the anti-monopoly legislation, the government would not interfere the commercial deals among the airlines. It is common for any enterprise to seek "economies of scale", but it does not imply that the larger the scale, the more cost-effective. The economies of scale will be dependent on the management of the enterprises including business development, financial management, revenue management and cost control as well as engineering and quality management to ensure effective design and management of resilient facilities and systems. The key to deepen the reform of China's air transport industry is to establish a modernised enterprise system, meet the requirements based on market driven economy, implement the "low-cost" development strategy, reform in the air tariff mechanism, enhance the service quality, establish its own branding, develop innovative marketing strategy and enhance market competitiveness both locally and internationally.

4.3 To facilitate airport infrastructure development and decentralise airport management to local authority

To address the inadequate infrastructure problems, the CAAC has established the "China's Civil Aviation Airport Development Plan 2020", which has taken into account the overall social and economic development strategies, market demand, regional economic and geography, interconnectivity

[7] Railway is under Ministry of Railway

with other modes of transport, coordination among various civil aviation and related enterprises, as well as the integrated principles of conservation of land, energy and other resources as well as the ecological environment. By 2020, the total number of China's civil aviation airports will be increased by 97 to a total of 244 which would be set up under five regions - the north, east and south, southwest and northwest China. Upon full implementation, over 80% of the county-level administrative unit can have access to air service within 100 km or 1.5 hours ground travelling time. The 2020 airport development plan will be able to serve 82% of China's population, representing 96% of GDP. In other words, the plan will serve all the provincial cities, special economic zones, key tourist areas, airports would be linked to medium and small cities. The establishment of hubs and spokes airports and commuter airports would strengthen the overall development of air transport as well as enhance the international competitiveness. The inter-connectivity with other modes of transport would facilitate more harmonious urban development, increase in scope of services and enhance quality of services. According to preliminary estimation, the completion of the plan would require capital investment of about RMB450 billion. By the end of the "11th Five-Year Plan", there will be about 190 civil aviation airports and the total estimated cost for constructing 45 new airports would be about RMB140 billion.

In 2002, the State Council endorsed the "Proposal to Reform Civil Aviation Administration System" to decentralize the airport management to local authority. Its objective was to motivate the participation of local authority in strengthening airport development so as to facilitate the local economic and social development. However, majority of the airports require the financial support and subsidies from the government. It is reviewed that there are over 90 small airports with annual air passenger traffic below 500,000 in China, the market share of passenger traffic only accounts for 3.3% of China and the majority is losing money and hence these airports have difficulty to undergo expansion. In recent years, the CAAC has closely worked with the local governments to actively support the local authority to undertake development in civil aviation business and to facilitate the development of the civil aviation industry together. On 22 February 2002, the CAAC issued a CAAC notice Document No. 34 which clearly defined the airport infrastructure as public utility and formulated ten policy measures to guide and facilitate the development of airports, especially for small airports. On January 23, 2007, the CAAC convened a small airport management forum to promote the "Proposals on Further Development of Small Airports".

To implement the localization of airport management, it is necessary to define the function and position of the airports. The local government should incorporate the airport development in its regional economic development plan. The airport management will be managed by the local authority and administered by the CAAC. The airport management would be standardized, adopt the franchise operation as appropriate, ensure airport security and safety, and operate the airport orderly and effectively.

4.4 Reform in air traffic management and control system to optimise utilization of airspace

The sustainable development of air transport includes the airport infrastructure and associated ground transportation system, airlines as well as the scarce resource of airspace. The airspace is a scarce resource and with the increasing air traffic demand, the airspace is subject to congestion and saturation which may cause delays and affect aviation development. As demonstrated in the developed aviation economies such as the USA, the United Kingdom and the European Union, the civil aviation administrations have recognised that they cannot forever increasing airport infrastructure as there is a finite capacity constraint in the airspace and hence significant research has been invested in the optimisation of airspace applying operational research to satisfy the need of both civil aviation and national defence[8]. The airspace of China covered 10.8 million km^2 plays a significant role in the national economy and national defence. It is essential to optimize the utilisation of airspace resource effectively by scientific division of the airspace for the civil aviation and military aviation development, economic development, national defence and air travel.

[8] Luk, M. (1999) *Application of Operational Research in the Planning and Design of Airports*, The University of Hong Kong, available: http://sunzi1.lib.hku.hk/ER/detail/hkul/3195222

According to China's Civil Aviation Law, Article 70 states that "China's airspace is under unified management" while Article 71 stated that "division of airspace shall take into account the needs of national defence and national security as well as the interests of the public so that the airspace is reasonably, fully and effectively used". To have effective and reasonable usage of the airspace, the civil and military aviation relationships shall be properly coordinated and the air traffic management shall be well organized and managed. Since the reform and opening up, China has adjusted the direction of air traffic management such that its purpose is to "facilitate economic development during the peaceful period taking into consideration the civil aviation as well as the military needs. In the event of war, everything must be subverted to the needs of war." This has laid a foundation for sustainable, rapid and healthy development in China's air traffic management. The State Council and the Air Traffic Commission (ATC) of the Central Military Commission have set up the "three-step" development strategy to promulgate a steady and active reform in air traffic management. After the first and second phase of reform in air traffic management, a preliminary structure for a centralized controlled airspace is established. In 2002 the civil aviation reform initiated the establishment of the General Administration of Civil Aviation of China and formed several regional air traffic management bureaux and 37 air traffic centres (stations) for the integrated and centralized operations and management of the air traffic control and management.

Under the 11th Five-Year Plan for the development of air traffic management and control as shown in Table 14, it has initially consolidated an integrated air traffic management system. In April 2007, another reform was carried out to separate the administration function of air traffic control from its operations, and to establish vertical integration of the air traffic control system so as to enhance the operation efficiency and support capability of the air traffic control system. In Nov 2007, the CAAC has implemented the reduced vertical separation minimum (RVSM) to rationalise the utilisation of the three dimensional airspace between military and civil aviation. In April 2008, the CAAC has reviewed and concluded that successful implementation of RVSM has increased the capacity of airspace, enhanced the efficiency of flight operations and air traffic control while ensuring aviation safety. The CAAC would continue to undertake research and apply advanced technology to optimise the resource allocation airspace and would promulgate the advancement in future air transportation system.

Table 14: The Development Plan of the Air Traffic Management and Control System in the "11th Five Year Plan of China Civil Aviation Development"

Items	Development Scope
Airspace management	• designation of eight flight information region and high-attitude control zones at Shenyang, Beijing, Shanghai, Guangzhou, Chengdu, Xi'an, Urumqi and Sanya; • designation of eight terminal control zone at Beijing, Shanghai, Guangzhou, Wuhan, Chengdu, Xi'an and Zhangjiang; • Six Approach Control Districts are located at Qingdao, Jinan, Zhengzhou, Ningbo, Guilin and Urumqi
Route Optimisation	Eleven new horizontal and four vertical routes have been added to the civil aviation framework of China, which were originally formed by 26 horizontal and 15 vertical routes
Radar Control	Fully implement the radar control at the high attitude control terminal (approach) of Harbin, Shenyang, Beijing, Xian, Chengdu, Kunming at east China, central China and western China, as well as the approach zones. Separation between aircrafts can be reduced under the radar monitoring conditions. The service of ADS surveillance and VHF/HF or CPDLC communication mode are provided in other areas.
Communication systems	• Expansion and upgrading of the civil aviation ATM data communication network; • reconstruct the airport communication network; • expansion of KU satellite communication network expansion, • upgrade of the route automatic reporting system • Transformation of Beijing, Shanghai and Guangzhou as the centre of the airport terminal system for mobile communication and networking; • construction of radio monitoring system
Navigation System	• Upgrading of the landing system of Beijing, Shanghai and Guangzhou hub airports to Class 3 ILS; • Upgrade the landing system of Shenzhen and Xiamen airports to Class 2

Surveillance system	• Upgrading the old radar to the Alenia radar data processing system; • Establish the new secondary radar in the busy international flight routes and the border point; • Configuration scenes at the main airport surveillance radar.
Meteorology	• Set up the Doppler weather radar, wind profile instrument, lightning locator such as automatic weather observation system portfolio detection system in the terminals of those airports having busy and complex weather; • Construction of the numerical prediction model systems and operation forecasting system; the numerical prediction system was built in the Beijing, Shanghai and Guangzhou airports; • Establishment of the important aviation weather warning system

Source: CAAC, 2006, The 11th five Year Plan of China Civil Aviation Development

4.5 To continue opening up to facilitate reform and development

On September 28, 2007, the Political Bureau of the CPC Central Committee conducted a study on the opening up to the outside world and safeguard national economic security. President Hu Jintao emphasized that it was the fundamental national policy to continue the opening up to the outside world. The Third Plenum of the 11th National Party Congress in 2008 has reinforced that China is to focus on opening up to devise strategies in accordance with the international developments and changes to develop socialism with Chinese characteristics.

It has been proven that by opening to the outside world, China can make full use of domestic and international markets and resources. It helps to promulgate China's economic and social development and to promote her scientific and technological progress and innovation. It can enhance China's international competitiveness and influence. It will be conducive for China to cultivate an advantageous international environment and is the way to promote the modernization of China's socialism. Following the globalization of economy and continuous improvement in China's socialist market economy, the internal and external conditions encountered by China is experiencing profound changes. The opening up of China provides a good opportunity to promote fast and good economic development. It also posts serious challenges for China to manage its development amidst the intensifying international competition, and to safeguard national economic security.

In accordance with the spirit above, China’s civil aviation would continue the reform to facilitate development, and would proceed with active, progressive, orderly liberalisation of the international air transport market, and steadily expand international bilateral air services agreements. China would actively participate in ICAO’s multilateral affairs in devising the ICAO standards and guidelines so that China’s civil aviation can play a constructive role in the ICAO, to continue to use bilateral cooperation and exchange mechanism, and improve the level of opening up and the quality of external cooperation.

4.6 To implement scientific development concept to promote the fast and good development

According to the theory of Deng Xiaoping on reform and opening up, it would be necessary to solve problems from various angles and on various levels through a continuous exploitation and summation of past practice. He stressed that the essence of socialism is to liberate and develop the productive forces, eradicate exploitation, abolish social polarisation and achieve the ultimate goal of a common prosperity. [Selected works of Deng Xiaoping Vol. 3, P.373, 1992]

At the 17th National People's Congress in October 2007, it has been approved to incorporate the concept of scientific development into the party constitution. The primary objective of the policy is to enhance the essence of development, the core focus of development must be people-oriented while the basic requirement is to have a balanced approach on comprehensive, coordinated and sustainable development.

(a.) *To ensure that the development of civil aviation are in line with national economy and social development*

The development of civil aviation is the foundation of the national economy and leading industry which should be in line with the development of the national economy and social development and could appropriately be undertaken in advance of the demand to promote national economic and social development. In the meantime, China's air transport continues to develop and strives to narrow the gap in accordance with its 11th Five-Year Plan on Civil Aviation.

(b.) *To Adhere to the "People-Oriented" Principle to effectively improve the quality of air transport services*

According to the 6th Plenary Session of the 16th Central Committee of the Party to implement a harmonious socialist society, the CAAC has recommended that it is strategic to implement a harmonious air transport system based on the "People-Oriented" principle to promote service quality of the air transport system. Although air transport is experiencing sustainable growth, there are potential factors affecting the harmonious development. These include:

- relatively weak aviation safety and security and is not compatible with growth;
- significant gap between the service quality and expectation of passengers, significant delay in on-time performance, inadequate consumer protection;
- incomprehensive development of the industry, the management system and coordination within the industry stakeholders is weakened, the practice of management could be further enhanced; and
- inadequate labour system under the socialist market economy has caused instability and concerns in integrity and ethics of employees.

It is recommended that the quality of air transport should be improved. Firstly, the performance targets for air transport by 2020 include but not limited to the followings should be implemented:

- proportion of passenger revenue-tonne kilometre by air to reach 20% and above among all transport mode;
- aviation safety incident to be no more than 0.29 per million flight movement by 2010 and no more than 0.15 per million flight movement by 2020;
- customer satisfaction to exceed 90%;
- aircraft on-time performance to be at 85% and above and the average delay to be within 0.5 hours;
- respect and ensure aviation consumer protection and their rights in accordance with the law;
- improvement in environmental management and protection to develop environmentally friendly airports; and
- strengthen contingency management in managing ad hoc crisis including aviation security matters.

Secondly, it is necessary to simplify the procedures for boarding and alighting. Thirdly, it is necessary to improve the ground handling interfaces and access facilities to avoid any obstacles and to streamline process on the ground.

To further establish aviation market economy, it would be prudent to further reform the air transport pricing mechanism to encourage fair market competition, strive for lower costs, reduce tariffs and improve service quality, and have an effective system to protect the legitimate rights and interests of consumers. Apart from putting customer first, it is also paramount for all aviation enterprises to have effective people management system to manage and develop their staff as well as to build up the competitive Chinese brand in air transport.

(c.) *To persist on a comprehensive, coordinated and sustainable yet fast development for civil aviation*

It is also reviewed that the integrated transport (including all transport modes – road, rail, air and sea), regional planning and environment approach for planning and development of airports is necessary to facilitate the sustainable development of economy and both international and domestic air transport.
With the advancement in the aviation technology and the improvement in management, most of

the civil aviation industry can operate according to prudent commercial principle. In accordance with the establishment of the socialist market economy and reform of civil administration, the civil aviation authorities and enterprises should speed up their changing roles and functions in the new era. This is to facilitate the optimisation of resource allocation based on the market, and to strengthen the necessary macroeconomic regulation and control, in accordance with "Administrative License Law" and "Civil Aviation Law", so as to eliminate any unnecessary approval process and strengthen government control.

Moreover, in accordance with the "Anti-Monopoly Law" and the "Anti-Unfair Competition Law", it is prima facie to establish a good market mechanism for air transport, to respect the prominent position of airlines and standardize the market entry and exit mechanism of airlines, to improve the administration system to facilitate the localisation of airport management and to clarify that the airport infrastructure is a public utility to promote local economic development. It is also essential to further deepen the reform of the air traffic management system, establish good coordination between military and civil aviation to optimise the effective and reasonable utilisation of airspace so as to facilitate the economic development and to development of seamless air traffic flow.

(d.) To adhere to the role of balance, correctly understand and properly handle the various areas of civil aviation

Air transport contains many complex interrelated systems and enterprises that should be correctly understood and properly handled. Otherwise, they will affect the overall situation and impede the sustained, rapid and healthy development of civil aviation. For example, the relationship among the interests of country, industry and enterprise, between the individual interest and the overall interests, between the local interest and overall interest, between the immediate interest and long-term interest, between the military and civil aviation, between aviation security and efficiency, the relationship between the opening to the outside world and domestic development, the relationship between the market-oriented mechanism and macro-economic control, and the relationship between liberalization of air services and government control. To resolve these issues, a fundamental methodology of the concept of scientific development is coordination and consideration. As pointed out by President Hu Jintao, "we should co-ordinate the overall situation of both domestic and international arena, have a world perspective, strengthen strategic thinking, and have the ability to analyse the changes in international situation so as to embrace the opportunities, to deal with the risk and challenges, and to create an amicable international environment. Not only is it necessary to consider the overall situation and to be able to coordinate and plan, it is also essential to identify the key areas that would affect the overall situation and the outstanding issues relating to public interests, and to arduously seek breakthrough in key areas.

To conclude, it is important for China to implement the "scientific concepts of development[9]" in civil aviation as the core principle to deepen the reform and opening up for China's civil aviation to sustain the rapid and coordinated development in the new era.

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Air policies in the 21st century: China, the EU and the Establishment of an Open Aviation Area

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Abstract

Liberalisation of air transport services serves as a strong vehicle for promoting commerce between nations and regions in the world. The ICAO World Air Transport Conference of 2003 recognised that "Economic liberalization in international air transport should proceed in a gradual, progressive and orderly manner, with appropriate safeguards to ensure safety, security and fair competition."[2] Ideas for enhancing the liberalisation of air traffic services are floating since the 1980s. The relationships between China and the EC-US agreement on air transport of 2007, which entered into force on 30 March 2008, as a reference point when discussing word wide liberalisation of air transport. This article will subsequently address:

1. Liberalisation in China
2. The establishment of an Open Aviation Area between the EU and the US
3. Implications for third states and their airlines
4. Conclusions

1. Liberalisation in China

1.1 Guiding principles

During his speech to the China Civil Aviation Development Forum, held in Beijing on 10 may 2007, entitled "ICAO - Leading Aviation through Challenging Times", Dr. Taïeb Chérif, Secretary General of ICAO commented that, "as positive as liberalisation is, we must ensure that it unfolds according to universally accepted principles." In that context, reference was made to the 'guiding principles endorsed in the Chicago Convention' and the general policy framework for liberalisation developed by ICAIO through the worldwide air transport conferences, in 1994 and 2003 respectively.

The Secretary General noted the phenomena of globalisation and commercialisation of air services, as underpinned by the creation of multi-national alliances and cross border investment in the airline industry so as to achieve economies of scale and scope. In conclusion, he stressed the need for cooperation between states and global stakeholders.[3]

The above ideas and objectives will come back in the course this article. Before further exploring the effect of globalization, commercialisation and liberalisation of air transport relations between China and other jurisdictions, in particular the EC and its Member States, attention will be paid to the legal and air policy situation in China. [4]

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[2] See ATConf/5-WP19 of 6 March 2003, ICAO Secretariat, 'Declaration of Global Principles for International Air Transport', Declaration (point 3.3) made at the fifth Worldwide Air Transport Conference on Challenges and Opportunities of Liberalization, convened by the International Civil Aviation Organization (ICAO) in 2003, which can be found at: ww.icao.int/icao/en/atb/atconf5/docs/ATConf5_wp019_en.pdf, visited on 18 April 2008

[3] As published on www.icao.int/icao/en/osg/osg_2007_China_en.pdf visited on 18 April 2008

[4] This section is based upon research carried out by the author of this article, Final Report of *A* 'Study of EU-China Aviation Relations', prepared for the Directorate General Energy and Transport of the European Commission by Booz Allen Hamilton Ltd, London (2006). Obviously, he 'stands to be corrected' as a 'non-native researcher'.

1.2 China's legal and air policy framework

1.2.1 Governance

The above guiding principles are reflected in China's regulatory framework. The Civil Aviation Law of China[5] confirms the principle that the "People's Republic of China has complete and exclusive sovereignty over its airspace." which principles are laid down in the opening articles (1 and 2) of the Chicago Convention on *international civil aviation*.

The Chinese airline industry is subject to the regulations and policy of the Civil Aviation Administration of China (CAAC). Coming directly under the State Council,[6] the CAAC provides a unified supervision and administration of civil aviation activities in the entire country. This regime appears to draw clear lines of responsibility, based upon state responsibility for civil aviation matters. A similar pattern exists in the US, with centralised powers for the Federal Aviation Authority (FAA), and related bodies, and the Department of Transportation (DoT) in relation to safety, security, infrastructural and technical matters, and economic and air policy matters respectively.

The European Union has yet to find a balance in the field of governance as there are a number of actors engaged with civil aviation. Member States are – ultimately – responsible for international civil aviation under the Chicago Convention and as "guardians" of bilateral air services agreements. However, the European Union and its bodies are increasingly becoming engaged with international civil aviation tasks. The – vertical – mandates exercised by the European Commission in external aviation relations, as to which see the second part of this article regarding the development of EU-US relations, the growing competencies European Aviation Safety Agency (EASA) in certain aspects of safety, in particular airworthiness and certification, and the objectives of yet another organisation, to wit, Eurocontrol, tasked with the safe, orderly and efficient management of air traffic in European airspace, give evidence of a less centralised and more multifaceted organisation of civil aviation in Europe.

At the same time, a moderate trend towards decentralisation in China may be noted – especially so in the organisation of the airline industry. This trend will be concisely touched upon in the next sub section.

1.2.2 The organisation of the airline industry

In 2002, the government restructured its state-owned industry, merging separate operators and creating the three new holding companies, controlled by the CAAC, to wit,[7] the China National Aviation Holding Company, incorporating principally Air China, the China Southern Air Holding Company, incorporating principally the Southern Air Group Company and the China Eastern Air Holding Company, incorporating principally the Eastern Air Group Company. These three holding companies are independent inasmuch as they have their own legal personality, they are free from direct governmental (including the CAAC's) economic intervention, whereas their ownerships are separated from each other. However, the three holding companies are owned by the state.

Ownership is regulated in a number of laws, including the Civil Aviation Law,[8] and other regulations as referred to below. The Civil Aviation Law lists requirements for the establishment of a public air transport enterprise, including the condition that such an enterprise must have the registered capital not less than the minimum amount stipulated by the State Council. The Civil Aviation Law does not draw up conditions on the ownership of such capital, but does refer to the provisions of the Company Law when introducing the organisational form and structures of public air transport enterprises. Foreign investors are "encouraged" to construct civil airports, and to invest in existing airlines.[9] However,

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[5] See: http://www.law999.net/law/doc/1/1995/10/30/00076552.html

[6] Sometimes referred to as the State Department

[7] See also: Composition of Six Group Companies (October 11, 2002) at: http://finance.sina.com.cn visited on 22 January 2002 (Chinese version only)

[8] See, Article 93 of Chapter VIII of the Civil Aviation Law dealing with "Public Air Transport Enterprise"

[9] See Article 3(1) and (2); see also: the Provisions on Foreign Investment in Civil Aviation which entered into force in 2002, henceforth also referred to as the Decree of 2002.[9]

foreign investments made into the management and operation of air traffic control systems are expressly forbidden.[10]

With respect to airlines, the Chinese regulations provide that foreign investors may not own more than 25 per cent singly, or 49 percent collectively, of the share capital.[11] The regulations limit the period for the operation of joint ventures with foreign investment to thirty years.[12] There are also requirements for the imposition of charges made by airlines with foreign investments, which must comply with domestic standards.[13]

Questions pertaining to the issuance of shares overseas and increase of the share capital are subject to governmental approval.[14] Investors established in the Special Administrative Regions of Hong Kong, Macao and Taiwan area are regarded as "foreign" investors for the purpose of applying the above regulations.[15]

Opportunities for foreign investment into Chinese airlines have been relaxed under a new regulation which came into force on 1 August 2002.[16] This regulation broadens the scope of the total foreign investment percentage from 35 to 49 percent, taking into account the special provision of maximum *single* foreign shareholder ownership of 25 percent.

The above requirements can be said to be similar to European standards, be it that the requirement pertaining to the single shareholder ownership does not exist under European Community law. From that point of view, the Chinese regulations resemble the US regulations which are also designed to limit foreign ownership to 49 percent, which US regulations fine-tune this condition by making a distinction between voting and non-voting rights attached to ownership of shares.[17] EC nationals are not allowed to own more than 25 % voting shares of a US airline.[18]

1.2.3 The bilateral regime linking China with EU states

China seems to have a preference for the conduct of its international air transport relations via bilateral rather than regional, supra- regional or multilateral channels. For instance, China is not a party to the Multilateral Agreement on the Liberalization of International Air Transportation (MALIAT) which entered into force on 21 December 2001 between a number of states located around the Pacific Ocean such as Brunei Darussalam, Chile, New Zealand, Singapore and the United States. The Protocol to this agreement provides for parties to exchange seventh freedom passenger and cabotage rights.[19] In addition, there also appears to be a reluctance to grant so called Fifth Freedom rights – in which circumstances third countries must be involved.

This can in part be explained by the fact that China is a region in itself. However, there may be other policy including air policy considerations playing a role such as the objective to keep control of the

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10 See Article 3

11 See Article 6

12 See Article 7

13 See Article 8

14 See Articles 13 and 14

15 See Article 16:

"These Provisions shall be referred to if companies, enterprises, other economic organizations or individuals from the Special Administrative Region of Hong Kong, the Special Administrative Region of Macao and Taiwan area invest in civil aviation in other Chinese provinces, autonomous regions and municipalities directly under the Central Government."; see also, section 11 of the Circular of 1994, referred to below:

"11. If a company, enterprise or other economic organization or individual from Taiwan, Hong Kong or Macao invests in or participates in holding shares of a civil aviation enterprise on the mainland, matters shall be handled under this Interpretation."

16 That is, the *Provisions on Foreign Investment in Civil Aviation*; See: http://www.fdi.gov.cn/ltlaw/lawinfodisp.jsp?id=ABC00000000000008718

17 As explained in Annex 4 of the US-EC Agreement on *air transport*, published in OJ L 134/1-41 (2007)

18 See Article 1(1) of Annex 4 of the EC-US Agreement referred to in the previous footnote.

19 See: www.maliat.gov.nz , visited on 21 April 2008

rapid expansion of China's economy.

Also, China's relationships with EC States are governed by bilateral air services agreements which are relatively traditional; there are so far no so called Open Skies agreements governing aviation relations between China and European States. It appears that Chinese policy makers, that is, for the time being, attach great importance to maintaining and enforcing nationality criteria for airlines.[20] The concept of Community air carriers designed to bring a regional or, of one so wish, multilateral element into air policy discussions, has so far not yet been implemented in bilateral air agreements between EC States and China. The same reservations may apply to the acceptance by China of a further going, that is, vertical mandate granted to the Commission in relation to the China, if the European Council of Transport Ministers would proceed to such a step.

Also, the bilateral air services agreements between China and EC states are marked by emphasis on controlling market access, capacity and pricing. For instance, there is no reference to the role of the International Air Transport Association's (IATA) role in regard to tariff coordination. However, *ad hoc* opportunities may be gained by third, including EC states if policy and economic conditions so dictate. Such conditions pertain to, amongst others, perceived market growth.

Code sharing and other commercial opportunities which Chinese airlines may want to engage into with their European and US counterparts may be regulated in bilateral air services agreements with the relevant states. The introduction of commercial opportunities into these agreements may form a first step towards recognising the merits of a more market oriented approach towards the operation of international air services without immediately giving in on the more traditional bilateral processes and formulas. Such a stance might lead to the adoption of more a competitive framework in international aviation.[21]

China-US air transport relations have received an important boost in 2007, thanks to the new agreement concluded by the two states. The principal objectives of the agreements are doubling of passenger flights between the United States and China by 2012, while expanding commercial freedoms for air cargo companies by 2011. A new round of negotiations foreseen in 2010 is to establish a timetable to achieve the mutual objective of *full liberalisation*.[22]

In conclusion, there are some challenges ahead of us when liberalisation of air services along bilateral or even more so multilateral lines should be achieved. The recent history of the air transport industry shows that airlines have not hesitated to maximally benefit from all the openings the bilateral system yields.
Hence it cannot be excluded that Chinese airlines will use opportunities which the Chinese policymakers will create for them, either on an *ad hoc* or on a more long term policy basis. If that development is materialised, attention must also be paid to the enactment and enforcement of a competition law regime governing market conduct of airlines (see the next sub-section).

1.2.4 The establishment of a competition law regime
Privatisation and commercialisation go hand in hand with the need to draw up and enforce a competition law regime. Market forces must somehow be controlled if the airline industry is moving from ex ante governmental regulations pertaining to market access, capacity, frequencies and pricing to a free or freer market situation. A competition law regime, if properly enforced may then provide ex post regulation, control and enforcement.

[20] See, the rather strict formulation of nationality criteria for airlines designated to operate the agreed international air services, laying down that the airlines "*shall* remain under the ownership and control of the other Contracting Party or its nationals." (*italics added*)
[21] See next sub section
[22] See: http://www.dot.gov/affairs/dot5207.htm visited on 22 April 2008

The *Civil Aviation Act* of China has only indirect relevance for air transport competition matters. Pricing of domestic services falls under the supervision of governmental authorities.[23] Other provisions affecting the economic operation of air services could not be found.

In 1996, the General Administration of Civil Aviation of China promulgated Order No. 47 entitled the "Regulation against Unfair Competition Acts in the Civil Air Transportation Market". The regulations are to:

- Maintain "normal order in the civil air transportation market" in China;
- Encourage and protect "fair" competition;
- To prevent "unfair" competition;
- "Protect the lawful rights and interests of operators, passengers and shippers";
- Safeguard the healthy development of the civil air transportation market.

The regulations apply to civil air transport operations carried out by legal persons and other business organisations "*within* the territory of the People's Republic of China."[24] Since non-Chinese air carriers will, for the time being, not be engaged with the performance of operations *within* the territory of China, it seems that these regulations have no direct relevance for the purpose of international air transport operations.

Hence, it seems unlikely that the above Chinese regulations will be applied in an extra-territorial fashion. The question, whether the operation of international air services operated from, via and into the territory of China, will be affected by irregular behaviour of airlines, may be regarded under the relevant provisions of bilateral air services agreements rather than the Chinese competition law regime. "Irregular behaviour" does not necessarily mean "anti-competitive behaviour" as bilateral air services agreements may sanction such anti-competitive belabour for reasons set out in such agreements. Indeed, the operation of international air services from and to a state are still regarded as a public service designed to support the national economic in a larger sense of the term which service should not be made subject to market forces.
For the sake of completion, mention is made of the publication of China's Competition Law in 1993,[25] defining, amongst other things, a number of acts of unfair competition, and the *Regulations of the State Council Concerning Prohibiting the Implementation of Regional Barriers in the Course of Market Economy Activities*.[26]

There is no evidence of case law or other acts of enforcement of the above competition regulations, in so far as air transport is concerned. There is hardly any provision on how a market participant can sue another market participant in court. Therefore, when a company finds another company practising unfair competition, the former will probably report to the relevant governmental agencies who may take action by way of issuing a new policy directive or a notice in order to restore market conditions.

For example, in 2002, the selling of air tickets in domestic market became chaotic when airlines and their agencies sold air tickets at an extremely low price, that is, below cost price in order to obtain larger market shares. On August 20, 2002, five governmental agencies – the CAAC, the Public Security Ministry, the National Planning Commission, the Tax Bureau of China, and the Industry and Commerce Bureau – issued a notice designed to stop such practices.[27] Subsequently, the mentioned agencies formed a supervising committee in order to find and punish those who were accused of anti-competitive behaviour under the competition law regime of China, including the above Notice. As a result, the joint supervising committee established unlawful acts and imposed fines.[28]

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[23] See Article 97
[24] *Italics added*
[25] See: http://www.ultrachina.com/english/doc.cfm?OID=274
[26] See: http://www.chinanews.com.cn/2001-04-30/26/89168.html (Chinese version only)
[27] See: 'Notice on Firmly Attacking Acts of Selling Domestic Air Tickets by Blind Discount and Illegally Selling and Marketing Domestic Air Tickets in order to Rationalise the Order of the Air Transport Market.'
[28] See: http://business.sohu.com, September 7, 2002

Obviously, the European Union and the US have somewhat different views on this matter. The European Court of Justice, interpreting the EC Treaties on this point, regard the operation of air services, whether on an intra European basis or in a wider context, as just another economic activity which is now fully subject to all EC Treaties based competition regulations. A similar but perhaps a bit less articulated approach exists in the US. The question then becomes which competition law regime has to be applied and enforced in regard to the pretended anti-competitive operation of international air services: the EC or the US regime, or yet another regime? The second part of this article will demonstrate that this question is as yet unresolved.

Enforcement is also different in the EC and the US. The EC Commission is investigating a number of airline practices which it deems to be anti-competitive under applicable competition regulations. The enforcement of these regulations in relation to applicable bilateral provisions which may be designed to sanction so called anti-competitive practices is yet an open question; a further discussion of this question, however interesting, falls outside the scope of this article.

1.2.5 Conclusion

It seems that Chinese policy makers adopt a step by step approach in regard to the liberalisation of air transport. China's position in world transport is obviously a special one as it has myriad challenges ahead of it, which are partly air transport and partly general policy related. To give a complete overview of all the considerations which may come into play regarding the gradual relaxation of conditions imposed upon the operation of international – and domestic – air services falls outside the scope of this article and above all outside the abilities of the author. It would be too courageous for an 'outsider' to guess and predict the objectives which Chinese policymakers may have in mind, let alone should have in mind.

That is why an examination of recent and future developments in the EU-US relations may be a more adequate or appropriate next subject matter in this article. To begin with the history of that relationship will be concisely addressed as this places the subject of liberalisation of international air services into a hopefully interesting perspective.

2. The establishment of an Open Aviation Area between the EU and US

<u>2.1 The proposals for the establishment of a Common Aviation Area in the 1990s</u>

The establishment of an Open Aviation Area between the EU and the US has a relatively long history. A discussion and analysis thereof falls outside the scope of this article. However, as stated above, it may be interesting to have a brief look at the principal milestones. In 1996, the Council of EC Ministers of Transport stated in a mandate regarding liberalisation of Transatlantic air services addressed to the European Commission the following:

> "The long term purpose of the Europe Community in this area is to establish a Common Aviation Area where air carriers of both sides could freely provide their services in the EC and the US on the basis of commercial principles ensuring for airlines the possibility to compete on a fair and equal basis and equivalent regulatory conditions. Such an objective is different from and goes beyond the negotiation of a conventional air agreement."[29]

Upon which the Association of European Airlines – hereafter also referred to as: <u>AEA</u> - made a paper in 1999, called "Towards a Transatlantic Common Aviation Area", also referred to as the <u>TCAA</u>. This paper had the status of a policy statement, attempting to fill in the very ambitious objectives of the quoted statement.

The ambitious part of the message from the Council of Transport Ministers and the AEA stems from the following:

[29] As quoted in: Association of European Airlines (1999), 'Towards a Transatlantic Common Aviation Area'

- the freedom for carriers of both sides to provide services;
- under a regime which goes beyond conventional air services agreements – in that the Transatlantic area should be considered as one area, or one market place, and mostly:
- under “equivalent regulatory conditions”.

The idea was to implement these objectives through lifting of ownership and control restrictions for airlines whose states would participate in the TCAA, introduction of the right of establishment so as to permit transatlantic mergers and acquisitions as well as enhancing market access. Also, a new body would have to be created which should act as a single unit, whose principal task would be to seek regulatory convergence. Regulatory convergence might affect jurisdictional competencies in the field of competition, which is a sensitive issue. Not unimportantly, the TCAA was developed as a *plurilateral* effort: third parties could join provided they would be prepared to adopt the open market approach adopted by the TCAA participants. This plan to create a TCAA as concisely explained before was a bridge too far in 1996. Perhaps not just one bridge but a few bridges too far, as the current draft of the EC-US agreement, mirrored against the TCAA objectives, could be called a *set back*. This is so because of the following land mark events after 1996, which formed draw backs for the realisation of these objectives:

- to begin with, the EC Council did not grant a mandate to the EC Commission until 2003 to discuss the creation of a market oriented approach in the Transatlantic area till 2003, as to which see below;
- the 9/11 events formed a reason to respect a standstill period so that airlines, and especially so US airlines, could recover from those events;
- during the 5th ICAO world wide conference which was held in 2003, the Assembly recommended that liberalisation should be made in such a fashion as to enable all states to follow the approach of their own choice and pace. ICAO said that liberalisation should be promoted, but it should be carried on in a progressive – that is, step by step – and orderly way. “Orderly” probably means that the interests of all states and stakeholders must be taken into account when changing regimes, and that the bilateral system should be respected.[30]

In between, and perhaps opposite to the above events, the European Court of Justice, - henceforth also referred to as: ECJ - made the well-known Open Skies decisions of 5 November 2002.[31] These decisions have been cited, interpreted, appraised and criticised in many ways and from many sides. Insiders – intra EU people - and outsiders commented upon it.[32] Outsiders were not always happy with the approach chosen by the ECJ, or at least the way it was interpreted, not least by the Commission. The above decisions formed the basis for the mandate which the Council of Transport Ministers of the EC granted to the EC Commission in 2003. This was a so-called “vertical mandate” – quite exceptional as the Commission, under a vertical mandate, is allowed to talk about *all* aspects of bilateral agreements, from market access to safety and security to commercial opportunities, leasing, environment and dispute resolution, as opposed to “horizontal mandates”.[33]

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[30] See the ‘Declaration of Global Principles for the Liberalization of International Air Transport’ made at the concluding meeting of the WATC/5: http://www.lfv.se/site/pilot_info/air_traffic_society/activity/international/icao/liberalization_intair.pdf

[31] See, for instance, the case of the Commission versus the Federal Republic of Germany, in the matter of Germany's Open Skies agreement with the US, Case C-476/98, par. 144-162, document available at http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexplus!prod!CELEXnumdoc&lg=en&numdoc=61998J0476

[32] See, Mendelsohn A., ‘Myths of International Aviation’ (2003) , *Journal of Air Law and Commerce* 68(3), pp. 519-535; Rutger Jan toe Laer (2006), The ECJ Decision: A ‘Blessing in Disguise’?, *Air and Space Law* XXXI(3), pp. 19-49.

[33] In its aforementioned judgement of 5 November 2002, the ECJ recorded infringements of Community law in bilateral air agreements concluded between EC Member States and the US. In order to remedy the inconsistencies signalled by the ECJ in bilateral air agreements concluded between EC Member States and third states, the EC Council of Transport Ministers mandated on 5 June 2003 the EC Commission to bring the concerned clauses of bilateral air services agreements in line with Community law through the conclusion of ‘horizontal agreements’ (to begin with). Those clauses concern Community ownership and control instead of national ownership and control of designated airlines, slot allocation, pricing on intra-Community routes and other provisions coming under Community law and policy such as taxation of fuel.

Again it would be interesting to check the results so far achieved against the premises of the mandate, but that would lead the discussion outside the scope of this article. More importantly, it may be more relevant to examine the possible repercussions of the draft EC-US agreement for third states and third parties, especially airlines of third states, as to which see section 3 of this article. Before drawing up these implications for third parties, a brief analysis of the principal parameters of the agreement on the creation of an Open Aviation Area will be made (as to which see the next sub-section).

2.2 Towards an Open Aviation Area between the EC and US

2.2.1 Objectives
The stated objective of the 2003 mandate is designed to realise an Open Aviation Area,

> "where air carriers *of both sides* can freely establish themselves and freely provide their services on the basis of commercial principles and be able to compete on a fair and equal basis and subject to equivalent or harmonised regulatory conditions." (*italics added*)

The mandate goes on to say that "such an objective is different from and goes beyond the negotiation of a conventional air agreement." Finally, the mandate acknowledges that the Open Aviation Area can only be created by a step by step approach, with room for *progressive* liberalisation.

The words "of both sides" have been italicised as they appear to be the first receivers of the rights exchanged under this agreement. As to the position of third states and their airlines, see again section 3, below.

2.2.2 Status of the agreement
What is the current state of affairs, in the light of this mandate and the above land mark events?

The EC-US agreement is a mixture between a bilateral and a multilateral agreement. It has a bilateral character when looking at the two principal negotiating parties – the EC, in the first place represented by the EC Commission, but in practice, backed, inspired, encouraged and perhaps even sometimes dominated by representatives of the EC Member States, and the US, represented by the State Department and the Department of Transportation (DoT). However, it is a multilateral agreement when the parties signing and ratifying the agreement are taken into account.

There are 29 parties: the US, 27 EC Member States and the EC. Obviously, the multilateral character of the agreement comes from Chicago Convention and ICAO based principles: by virtue of Article 6 of the Chicago Convention, only states, as opposed to regional economic integration organisations, can give access to their airspace, whether on a bilateral, regional or multilateral basis.[34]

The multilateral nature of the EC-US agreement is evidenced by the cabotage issue: Under this agreement, cabotage is Madrid-Barcelona in Spain, Hamburg-Munich in Germany or Milan-Rome in Italy, and not Paris-London or Copenhagen-Athens, which are still considered as international air services.

The EC-US agreement on air transport suspends or supersedes the existing twenty-two agreements, or fill in gaps in five cases, namely, where five EU states have not yet entered into bilateral agreements with the US. The agreement is not designed to *cancel* the existing agreements – which may serve perhaps one day as a fall back option, or to cover specific points which are not regulated under the EU-US agreement.

It goes without saying that those 29 parties represent myriad interests. States, organisations, airlines, airports, safety, security, labour, environment and consumers and so on have to find their place in this

[34] See Article 6 on *Scheduled air services*
"No scheduled international air service may be operated over or into the territory of a contracting State, except with the special permission or other authorization of that State, and in accordance with the terms of such permission or authorization."

agreement, which – it has to be confirmed – covers an impressive market place, also in financial and economic terms.[35] From that point of view, the stakes are high. It is not a surprise that there are so many stumbling blocks, varying from air policy, regulatory and labour to commercial and considerations.

2.3 Comparison with Open Skies agreements

When compared with the current Open Skies agreements concluded between the US and EC Member States, there are some changes, as to which see further below. As briefly stated above, the objective is to achieve a "single market for air transport between the EU and the US" by the adoption of a *step by step* approach – in reality, the step by step approach merits some emphasis, as the new regime does not create a single market, which can be compared with the intra-EC internal market, in which freedom of establishment and freedom to provide all air services, including cabotage, are guaranteed under a more or les uniform regulatory regime for market access, safety, security, competition, air traffic management, infrastructure, environment and liability.

However, when compared with current Open Skies agreements, there are a number of new features:

- There is an attempt to *liberalise ownership and control restrictions* – to level them up or down – depending on one's perspective – to the EC level, that is: to reach the absolute majority level for ownership and fine tune the effective control concept. European Community air law dictates that for a carrier to qualify as a Community air carrier, such a carrier must be owned for at least 50.1 per cent and effectively controlled by nationals of EC Member States, whereas the air carrier must have its principal place of business in one of the EC Member States.[36] Current US law is stricter as it requires the president of the airline and at least two-thirds of the board of directors and other managing officers to be U.S. citizens in order to accommodate the EC negotiating team, whereas at least 75 percent of the voting interest must be owned or controlled by US citizens.[37] The 'effective' or 'actual' control test as proposed by the US DoT upon four criteria, namely, whether US citizens will control decisions as to defense, safety, security and the establishment of corporate documentation of the airline, justifying its US citizenship.[38] The four criteria do not include "commercial control", which is used by opponents of the DoT initiative to vote against the proposed rule. This is currently the main stumbling block in the EU-US discussions.

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[35] See, 'The Economic Impact of an EU-US Open Aviation Area' - a report by the US Consultancy, the Brattle Group, commissioned by the European Commission and published in December 2002. According to this study, the Open Aviation Area will create more than €8 billion in economic benefits per year. A report drawn up by Booz Allen Hamilton on the same subject, updating and elaborating the findings of the Brattle Group, has appeared in January 2007 (*The Economic Impacts of an Open Aviation Area between the EU and the US*); it found that the creation of an Open Aviation Area would produce 3.8 billion Euros in consumer benefits in any one year.

[36] See Article 4 of EEC Regulation 2407/92 on *licensing of Community air carriers*
"1. No undertaking shall be granted an operating licence by a Member State unless:
(a) its principal place of business and, if any, its registered office are located in that Member State; and
(b) its main occupation is air transport in isolation or combined with any other commercial operation of aircraft or repair and maintenance of aircraft.
2. Without prejudice to agreements and conventions to which the Community is a contracting party, the undertaking shall be owned and continue to be owned directly or through *majority ownership* by Member States and/or nationals of Member States. It shall at all times be effectively controlled by such States or such nationals." (*italics added*),
whereas the term "effective control" is explained in Article 2(g) of the same Regulation:
"(g) 'effective control' means a relationship constituted by rights, contracts or any other means which, either separately or jointly and having regard to the considerations of fact or law involved, confer the possibility of directly or indirectly exercising a decisive influence on an undertaking, in particular by:
(a) the right to use all or part of the assets of an undertaking;
(b) rights or contracts which confer a decisive influence on the composition, voting or decisions of the bodies of an undertaking or otherwise confer a decisive influence on the running of the business of the undertaking; "

[37] See, 49 U.S.C. § 40102(a)(15)

[38] See: http:www.dot.gov/affairs/jeffshane020806.htm

- The EC is stressing the need for the introduction of the *Community air carrier clause*, which need stems from the aforementioned Open Skies decisions of the ECJ made in 2002. For EC air carriers, the Community air carrier clause can only be exercised in combination with an *establishment*, which concept should, by the way, further defined.[39] The term "principal place of business" forms. EC airlines are also entitled to operate air services from side or secondary offices or hubs in other EC Member States qualifying as "an establishment" as formulated under the decisions of the ECJ of 5 November 2002.

- Although some but far from all bilateral Open Skies agreements provide for the grant and operation of *seventh freedom all-cargo services*, the EC-US agreement extends this freedom to all cargo operations from a point in the US and the EU – provided of course that the consent of the third state in which the service ends agrees with the concerned service.

- Authority to provide international air services is typically refused when ownership and control restrictions are not met, or when minimum ICAO safety regulations are not complied with. The EC-US agreement also foresees in revocation of authority in case security measures are not satisfied – which may be a consequence of the 9/11 events.[40]

- A new item concerns the allowance of *wet lease operations* on international, that is, Transatlantic and intra-EC fifth freedom routes, but not on domestic or cabotage services. This permission is subject to FAA approval.

- *Environment* is also subject to the application of ICAO standards. In addition, the introduction of new environmental standards must be accompanied by a cost and benefit analysis. This condition may also apply to the proposed introduction of an *Emission Trade System*.

- *Consumer protection* is clearly an EU point, as it dominates the EC internal policy agenda since many years. The Joint Committee, as to which see further below, may be involved with consumer protection issues.

- *Common institutional frameworks* are typically lacking in classical bilateral agreements. The idea of a single market would have been underpinned by the creation of an institutional body, as promoted by the TCAA. The draft EC-US agreement makes a very prudent step towards something like a Transatlantic institutional body in that it creates a *Joint Committee*. However, the tasks of such a joint committee are limited to discussion and consultation. Unfortunately, higher, that is liberal objectives such as the convergence or harmonisation of regulatory and competition regimes are for the time being not on the agenda of the Joint Committee.

2.4 Further challenges

Again, the EC-US agreement must be placed against the background of the events which occurred in the years before 2003, when the negotiations started, and the myriad interests which had to be reconciled. This state of affairs explains perhaps why no results could be achieved so far in the following domains:

- there is no reference to the *right of establishment*, which found its place in the preparation of the above mentioned TCAA (see above);

- *Seventh freedom rights* are restricted to all-cargo services. Passenger and combined passenger-cargo services do not enjoy this freedom.

[39] The EC Treaty introduces national treatment for all operators having an establishment in the European Community. The EC based principle of 'national treatment' placed in the context of the Freedom of Establishment necessitates the conclusion of 'horizontal agreements'
[40] See above

- The same is true for *cabotage* rights which are not exchanged under the agreement.

- There is *no reference to convergence* let alone harmonisation of regulatory regimes. Each jurisdiction will stick to its own rules, although, of course, cooperation in the field of competition cases (see next point) and environmental matters are provided for, whereas outside this agreement, a lot of work has been achieved in the field of harmonisation of safety – through discussions regarding JARs and FARs – and security. In the latter case, an agreement has been annulled by the ECJ for procedural reasons, but a new agreement is currently being prepared.[41]

- Equally, there is no reference to the *EC-US agreement on cooperation in the field of competition of 1995*, providing for 'positive comity'. However, Annex 2 of the EC-US Agreement concerns "Cooperation with respect to competition issues in the air transportation industry". This cooperation is designed to:
  - "enhance mutual understanding" on their respective competition regulations and procedures;
  - "facilitate understanding" between all stakeholders on competition in the international air transport market;
  - "reduce the potential for conflicts" in the application and enforcement of the respective competition law regimes, by:
    organising meetings, holding consultations and timely notifications of competition related proceedings or matters in each of the two jurisdictions. There are also provisions for the use and disclosure of classified and other information which plays a pivotal role in competition cases with an international dimension.

2.5 Conclusions

The EC-US agreement on air transport contains interesting new dimensions with respect to the promotion of the liberalisation of sir services. Market access has been quite substantially broadened whereby enlarged access to the London Heathrow airport is regarded as an important victory of the US and US airlines who were denied such access so far. London Heathrow Airport forms the most important hub and gateway for air carriers serving the US from Europe.

Next, and perhaps this is important for the long term policy objectives of the agreement, room has been made for institutionalising cooperation by the creation of the Joint Committee. This committee has met a couple of times. The first official meeting since the entry into force of the EC-US agreement was held in Washington DC from 14 to 16 April 2008. The Joint Committee provides a platform for discussing all matters coming under the agreement. It may hopefully pre-empt conflicts on thorny issues which are still ahead of us, including those on the maintenance of nationality criteria for airlines.

3. Implications for Third States and Their Airlines

The EC-US agreement on air transport is a multilateral and not a plurilateral agreement. Hence, it is only binding upon the 29 parties to it, so that it would be better to call it a "Common" than an "Open" Aviation Area. On the other hand, the TCAA could have been termed an "Open" rather than (just) a "Common" Aviation Area.

However, the following effects may be yielded by the last mentioned agreement:

- Since US carriers enjoy *unlimited access to intra-EC fifth freedom routes*, both Community air carriers and carriers from third states may be faced with more competition on those routes – as

[41] Judgment of the ECJ of 30 May 2006 in the Joined Cases C-317/04 and C-318/04. The ECJ decision annulled the Council Decision concerning the conclusion of an agreement between the European Community and the US on the processing and transfer of personal data because that decision was based upon the wrong legal provisions of Community law.

mentioned above, this could be Paris-London, Dublin-Warsaw or Madrid-Helsinki but not Milan-Rome or Barcelona-Madrid, which continue to be considered as cabotage and, hence, reserved to Community air carriers. This said, the actual exercise of such rights by non-EC carriers, including of course Chinese carriers may be questioned as they are not necessarily commercially attractive, so that this effect may be written on paper rather than being materialised.

- The same may be true for the exercise of *seventh Freedom all cargo rights*, which is subject to third country approval.

- There may be a positive spin-off in terms of *alliance building*, in that the spirit of liberalisation provoked by the agreement may make competition authorities of the concerned jurisdictions (US and EC) more lenient towards airlines whose states subscribe the principles endorsed by this draft agreement. Reference is made to a discussion of this subject in a Chinese context in section 2, above.

- In practical terms, regional cooperation may be reinforced in other parts of the world. Such experiences concern the coming into being of a Common Market in East and South Africa (COMESA), but there are more to be found in South East Asia (ASEAN), Latin America (MERCOSUR, the Andean Pact) and the Pacific. Reference has been made to the successful *Multilateral Agreement on the Liberalisation of International Air Transport*.[42]

Last but not least, the EC-US Agreement on air transport contains a somewhat hidden provision making room for the extension of the agreement so as to include third "countries" – as opposed to other regional economic integration organisations.[43] Hence, China could theoretically perhaps accede to the agreement. As shown above it does not seem likely that this will happen – to begin with in the shorter term.

4. Concluding Remarks

It goes without saying that China is rapidly developing not only its economic sector but also its regulatory regime. That may impact the organisation and development of the air transport sector which it increasingly looks for linking up with the outside world. As stated above, the achievements so far are impressive. It depends on the objectives of the policymakers if, to what extent and at what pace further steps will be taken. Areas of attention could be the future enactment of the competition law regime, market access and consumer protection, a subject which has not been dealt with in this article.

As to the EC-US agreement, it must be recognised that the EC side stresses the objective of *regulatory convergence* in international aviation discussions. This policy is working well in relation to states which are located in the geographical vicinity of the EC. States including but not limited to Morocco, Balkan states, Turkey and Near East (Arab) states are interested in enhancing their relationship with the EU. That may explain why they have an interest in aligning with Community law and policy.

However, this policy may have to be fine tuned when states or areas do not share that geographical and perhaps cultural affinity with the EU. As concisely explained above, the US has a long standing aviation bond with EC Member States, and shares values in terms of market access. It is therefore to be hoped that the EC-US agreement will proceed along the lines which are drawn by all those who are involved with it, and that it may form a template for other parts of the world.

Here again, a parallel can be drawn with China which may, for the time being not place regulatory

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[42] See sub section 1.2.3

[43] See Article 18(5): "The parties share the goal of maximizing the benefits for consumers, airlines, labour and communities on both sides of the Atlantic by extending this Agreement to include third countries. To this end, the Joint Committee shall work to develop a proposal regarding the conditions and procedures, including any necessary amendments to this Agreement, that would be required for third countries to accede to this Agreement."

convergence on its list of top priorities in relation to the EU, or for that matter, in relation to third states generally. The impression is made that China prefers to adopt a step by step approach, whereby its internal developments will be aligned with the conduct of an external policy. One thing is certain – more news from China in this field will reach us in the coming years. We look forward to sharing this information with our Chinese counterparts and discussing such new initiatives for the benefit of understanding each other and thus promoting the air transport industry. The present International Forum on Shipping, Ports and Airports, held in Hong Kong from 25-28 May 2008, forms a unique vehicle for achieving this purpose.

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China's economic rise and its implications for logistics: the Australian Case

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Abstract

China's economic rise has had a significant impact on the global economy in terms of trade patterns and orientation. Much has been done to quantify the impact of China's economic rise on international trade, but very little has been done to assess its implications for logistics. In this paper, we examine the effects of China's continued economic rise on the Australian logistics sector. Unlike previous work that used partial equilibrium models, we use a Computable General Equilibrium (CGE) model. This allows us to capture the direct and indirect ramifications of trade and other economic developments associated with China's economic rise. The results are mixed between sub-sectors, but overall the Australian logistics sector would potentially benefit significantly from China's continued economic rise. However, these potential benefits will hinge partly on the Australian logistics sector's ability to respond to these opportunities.

Keywords: Computable General Equilibrium model; China, trade trends; Australia

1. Introduction

China is now the second largest economy in purchasing power parity terms and the world's third largest trading nation (Australian Department of Foreign Affairs and Trade, 2005). It is also the fourth most important maritime state by way of number of merchant fleet and contribution to the world's total tonnage (UNCTAD, 2005). The spectacular economic development of China has been mainly driven by its export-oriented industrialization strategy. Its GDP increased at an average rate of 9.7 percent in the 1980s and 10.7 percent in the 1990s with an annual growth continuing at 7-9 percent to date and is projected to continue despite the efforts by the Chinese government to slow down the economy. Underlying its spectacular growth is its trade. In 2005, exports rose by 28 percent to $762 billion while imports grew by 17.6 percent to $600 billion producing a $102 billion trade surplus (Morrison, 2006).

The economic rise of China has spawned a major shift in the trade structure and orientation of a number of countries. For example, China is now Australia's largest trading partner. Trade between the two countries has been growing at an unprecedented rate in both scale and depth, partly due to the two countries' strong economic performance and closer economic cooperation. China is Australia's largest export market, with Australia's agricultural exports to China trebling over the past decade, making China Australia's 3rd largest agricultural export market and largest export market for minerals and fuels.

No one can dispute the fact that China's economic rise has caused significant repercussions for the global economy in terms of trade patterns and orientation. Much has been written on its trade implications, but very little in-depth study if any has been done to assess the implications for international logistics sectors in Australia. This paper therefore aims to study the implications of China's economic growth and trade for Australia's logistics sector. Specifically, it tries to examine the implications of continued economic growth of China for Australia's logistics sector by quantifying its

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impact in terms of growth and nature of demand for shipping and air transport services in Australia, assess the capacity and constraints facing the Australian logistics sector in accommodating the changing level and pattern of trade between Australia and China and on the basis of the findings draw out business and policy implications of the development of the Australian logistics sector.

The rest of the paper is organized as follows: section 2 of the paper briefly presents the conceptual and methodology; section 3 presents the major findings and implications followed by a conclusion.

2. Conceptual Framework and Methodology

Logistics is a derived demand. Demand for logistics depends largely on trade volume and trade pattern (i.e. the composition and balance of trade). The flow of causation can also occur from logistics to international trade. Development of the transport and logistics industry results in a better service quality and more services available to customers, including multimodality and door-to-door delivery. At the same time, operations with economies of scales and the use of technology in information management, shipbuilding, and cargo handling and tracking, have lowered transport costs. This encourages international trade by facilitating exporters and importers and reducing the costs of exporting and importing. On the other hand, international trade could affect the transport and logistics sector. International trade directly contributes to higher demand for transport and logistics services, thereby creating more business opportunities for expansion and investment. These imply that the trade-logistics causality may be bidirectional. Economies like those of Singapore and Hong Kong have grown rich partly because their past investments in superior logistics have facilitated trade (Carruthers, Bajpai and Hummels, 2003), while economies like that of China continue to be driven by its exports, which has brought substantial changes to the logistic network with new flows of raw materials, parts, and final products (Lee and Rodrigue, 2006, Frankel, 1998).

While the bidirectional flow of causation may be in theory but it may not be so in practice. In the case of Australia-China trade, it has been shown that the flow of causation is unidirectional, i.e. Australia-China trade causes Australian logistics but not the other way around. Using the Vector Autocorrelation (VAR) framework, Nguyen and Tongzon (2008) found that the growth of Australia-China trade Granger-causes the growth of the Australian logistic sector, but *not* vice versa.

The following factors could be responsible for this nature of trade-logistics nexus. First, the effect of the development of the transport and logistics sector on international trade could have been dampened by increases in the costs of fuel and other inputs including wages and financial capital. Second, with low population density, investment in the transport system, especially infrastructure, cannot often be justified unless demand is sufficiently large. There is a strong positive relationship between population density and development of the transport system (Nguyen and Tongzon, 2008). Countries with low population density tend to experience a lower rate of transport infrastructure development. Third, growth in international trade may have failed to encourage the development of the transport and logistics industry in Australia which could be due to poor management (for example, under the ownership of the government) and access to only an insignificant share of the market dominated by foreign-owned companies.

Having established the nature of the trade-logistics nexus in Australia, this paper aims to quantify the impact on the Australian logistics sector by using the Computable General Equilibrium (CGE) analysis on the assumption that the demand for international logistics is derived from international trade. The use of a general equilibrium approach is necessary to capture the direct and indirect impacts of trade and other economic developments associated with China's economic growth. The inter-sectoral and inter-regional linkage effects are therefore taken into account in a general equilibrium framework. To perform the analysis, the latest version of the Global Trade Analysis Project (GTAP) Model, a multi-region computable general equilibrium (CGE) model based on the latest GTAP database, is used. The use of this general equilibrium model has other advantages. First, since it is a multi-regional model of world production and trade, it can take into account the overall trade implications (trade with third country markets as well as with China). Second, it contains a database for the different sectors or industries and thus, can explore the trade consequences for various sectors of interest with logistics implications. Moreover, although the logistics implications of China's economic rise have been assessed in previous studies, they were done qualitatively and in partial equilibrium framework [for example, see Yap *et al.* (2006); Yap and Lam (2006)]. Partial equilibrium approach is only useful in assessing the implications in each sector separately because it ignores the possibility of inter-sector linkages and existence of spillover effects between sectors.

Specifically, to quantify the likely implications for the Australian logistics sector of China's continued growth, a comparative static simulation exercise is conducted using the latest version of the GTAP6 multi-regional trade database.[3] Two scenarios are compared. Scenario 1 captures the impact of China's continued growth based on the assumption that the values of the underlying growth factors such as China's labor and capital remain as they are in the base data and Scenario 2 captures the impact of China's continued growth under the assumption that the values of the growth factors will grow by 10% on average. This is China's average growth rate over the past decade. For each scenario the model will generate results regarding the effects on China-Australia trade, nature of cargoes generated and the demand for sea and air transport. The differences between the two scenarios are our estimates of the impact of China's continued growth.

The above analysis should reveal the business opportunities presented by the increasing and changing trade between China and Australia. But whether the Australian logistics sector can take advantage of these opportunities is an interesting issue. The capacity analysis will be done in two phases. The first phase will look at Australia's overall international transport infrastructure (sea as well as air) and its capacity to deal with the changing traffic between Australia and China. The capacity of its maritime transport infrastructure can be calculated based on weekly shipping capacity (yearly ship visits multiplied by the average ship size of liners that operate between China and Australia). The capacity of its air transport infrastructure is calculated based on yearly air transport capacity (yearly frequency multiplied by cargo volume). We need to see whether there is a balance or imbalance of trade and transport network. Any imbalance between trade and transport network should lead to investigate the underlying causes of these imbalances and to recommend ways to address these imbalances.

A CGE model consists of equations describing model variables and a database consistent with the model equations. The main assumptions of the model are presented in Appendix 1. A CGE model is also referred to as **AGE** (applied general equilibrium) models which are descended from the input-output models pioneered by Wassily Leontief, but assign a more important role to prices. CGE models are useful whenever we wish to estimate the effect of changes in one part of the economy upon the rest. They have been used widely to analyze trade policy. There are many CGE models of different countries, and one of the most well-known CGE models is GTAP model of world trade. CGE models are useful to model the economies of countries for which time-series data are scarce or not relevant. For more detailed explanation of this approach, see Bandara (1991); Hertel and Tsigas (1997); Shoven and Whalley (1992) and Tongzon (2001).

Since the GTAP database is in value and not in volume terms, the trade values are expressed at constant prices wherever possible to reduce the possibility of gaps between values and volumes. The results generated here are, however, based on stylized simplifications of the world economy and on certain *ceteris paribus* assumptions. The resulting estimates, therefore, should be interpreted as indicative rather than as precise forecasts. To further differentiate the estimated trade impacts by cargo type, the various commodities in the GTAP database are grouped into the following cargo types: containerizable agricultural products (contagri); containerizable manufactures (contmanu); dry bulk (drybulk); liquid bulk (liquidbulk), special and break bulk (breakbulk) products. The regions are further classified into groups consisting of the Australia and other countries some of which are aggregated into their

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[3] This is a comparative-static exercise because it is only meant to capture the impact at only one point in time. For policy analysis, results from such a model are often interpreted as showing the reaction of the economy in some future period to one or a few external shocks or policy changes. That is, the results show the difference (usually reported in percent change form) between two alternative future states (with and without the policy shock). The process of adjustment to the new equilibrium is not explicitly represented in such a model.

respective economic groupings. See Appendix 1 for the GTAP model and the aggregation of the various commodities into cargo types and countries into regions used in the analysis.

3. Main Findings and Implications

Table 1 presents the percentage changes in Australia-China trade by cargo type and sub-sector as a result of a continued 10 percent growth of China. It is notable that the percentage changes are generally noticeable. In the case of Australian exports to China, it is evident that Australia's sub-sectors particularly the sea and air transport sub-sectors would be positively affected by China's continued economic growth. There would be an increased demand for China-bound sea and air transport services in Australia by 6.35 percent and 7.34 percent. All types of China-bound exports (classified by cargo type) are expected to rise with significant increases from Australia's containerizable agricultural products (10.88%) and break bulk commodities (13.38%). In the case of China's exports to Australia, exports of sea and air transport services are likely to grow by roughly 5 percent, respectively. However, containerizable agricultural and break bulk cargoes destined for Australia would decline by 4.41 percent and 10.15 percent, respectively. It is interesting to see that the predicted increase in Australian exports to China would occur at the expense of having reduced exports to the rest of the world. This trade-off would not however happen in the case of China's exports to Australia and the rest of the world. In fact, overall China would benefit most in terms of overall growth of exports compared to other countries.

It can be inferred from these simulation results that there would be an increase in demand for sea and air transport services in Australia to accommodate predicted increases in the export of containerized and break bulk cargoes as Australia-China trade continues to grow. On average, the demand for sea and air transport services in Australia is likely to grow by 6 to 7 percent per annum. Given that there would be a significant increase in the flow of containerized and break bulk cargoes roughly by 5 percent on average between Australia and China, there should be a corresponding increase in demand for container and break bulk shipping services by 5 percent.

The findings in Table 1 have further confirmed the massive trade reorientation of the Australian trade towards China which would further generate a significant reorganization and/or relocation of its logistics sector to exploit the growing intensity of trade around China. The enormous business opportunities within China have already attracted more and more third-party logistics service providers to make their presence in and/or near China. More logistics companies have already used China as their warehousing and distribution hub to reduce their supply chain costs. The express operators such as DHL, FedEx, TNT and UPS have already developed their operations significantly in China. These logistics services providers will have to manage a more globalized supply chain if they want to exploit the tremendous business opportunities in China, although this implies more competition facing the logistics providers. There are costs as well as benefits associated with the extension of the supply chain to encompass more countries with various policy and economic environments. For example, warehousing and distribution costs are on the rise in and around the Chinese ports as logistics providers are employing the strategy of relocation to China (*Logistics Management*, 2002). The effectiveness of their operations would now depend highly on the quality and efficiency of China's physical and human infrastructure.

Table 1: Percentage Changes in Australia-China Trade By Cargo and by Sub-Sector (%)

Cargo Types	ASEAN	ASEAN4	China	NEA	REAsia	NAFTA	EU	ROW
Australian exports to China and othe countries								
Contagri	0.04	0.09	10.88	0.15	0.96	-0.45	-0.46	-0.36
Contmanu	-1.07	-1.41	5.67	-1.45	-3.76	-1.29	-0.84	-0.84
Drybulk	-0.49	-0.72	6.87	-0.59	-0.77	-0.66	-0.46	-0.43
Liquidbulk	-0.45	-1.85	6.27	-0.31	-1.6	-0.59	-0.48	-0.46
Special	-0.13	-0.52	6.53	-0.32	0.14	-0.33	-0.3	-0.27
Breakbulk	0.14	0.11	13.38	-0.28	1.65	-0.47	-0.52	-0.25
Seatrans	-0.09	-0.33	6.35	0.14	0.21	-0.35	-0.05	-0.16
Airtrans	-0.25	-0.35	7.34	-0.18	0.32	-0.3	-0.25	-0.24
Others	-0.26	-0.28	6.25	-0.17	0.26	-0.35	-0.34	-0.31
China exports to Australia and other countries								
Contagri	-4.16	-4.31	-4.41	-4.09	-3.23	-4.94	-4.99	-4.62
Contmanu	8.8	8.38	8.47	8.32	5.93	8.41	8.91	8.9
Drybulk	4.63	4.34	4.56	4.31	4.14	4.39	4.55	4.59
Liquidbulk	8.23	6.74	8.09	8.35	7.05	8.1	8.25	8.25
Special	7.28	6.97	7.32	7.01	7.48	7.07	7.12	7.13
Breakbulk	-9.13	-10.15	-10.56	-10.51	-5.61	-10.78	-10.76	-10.37
Seatrans	5.65	5.41	5.56	5.88	5.95	5.39	5.69	5.59
Airtrans	5.23	5.13	5.33	5.3	5.8	5.18	5.23	5.24
Others	5.96	5.94	6.09	6.04	6.49	5.88	5.89	5.92

Source: GTAP simulation results

Greater opportunities from logistics provision and increasing degree of competition arising from China's growing economic dominance can lead further to more vertical and horizontal integration within the logistics industry. The acquisition and merger activity in the third party logistics industry in Australia, for example, has seen Toll Holdings take over Patrick Corporation and Linfox buy out Maynes and FCL. To strategically position itself to take advantage of the greater opportunities in East Asia, Tolls has expanded into East Asia with the purchase of Singaporean headquartered integrated logistics company, SembCorp Logistics. Toll Asia has a 51 percent owned joint venture with China Merchants Group – ST Anda that provides multinational companies and small and medium enterprises in China with supply chain solutions.

China's continued economic rise should also contribute to the increasing intra-East Asian trade by acting as final destination for other countries in East Asia and as source of their imports. Although this reorientation of trade and logistics services could offer more business opportunities for the logistics sector in East Asia, this could also mean an increase in business for the Australian logistics sector as more bilateral trade between Australia and China could occur, for example, this could be an increase in demand for more direct shipping and airline services between these two countries which would generate sufficient local freight to warrant direct calls.

To see whether Australia has the capacity to deal with the increasing trade between Australia and China and especially with the increasing flow of containerized and break bulk cargoes, we need to examine its existing capacity to see whether its existing capacity is sufficient to deal with this anticipated increase in cargo traffic both at sea and air. It is alarming to note that the Australian transport and logistics sector only managed to grow on average at less than 1 percent over the 1988-2006 period – a miniscule compared to the forecast growth in demand for logistics services in Australia resulting from China's continued economic rise (Australian Bureau of Transport and Regional Economics, 2006).

It is possible that the capital-intensive nature of transport and the high per capita cost of logistics inhibit Australia's ability to quickly adjust and respond to changes in demand for logistics services. This seems to be consistent with what is currently happening to the Australian transport and logistics sector, "At a time of unprecedented prosperity and in the midst of an international resources boom, there could be no more potent images of lost opportunity, than the sight of queues of up to 50 vessels off three of our major ports" (Standing Committee on Transport and Regional Services, 2007, p. vii). Thus, from a policy perspective, there is a need for the sector to examine its existing capacity and to improve its capacity to respond more expeditiously to the changing business environment and global trade. For example, the industry's monitoring of international trade and more frequent discussions and information exchanges among the industry bodies and transport and logistics operators may be necessary. It should be noted that the Australian logistics sector's contribution to GDP has remained below 5%, while Australian international trade has increased to more than double, from 17% to 37% for the past 20 years.

Table 2 presents a summary of shipping services at Australian ports from 2000-2001 to 2005-2006 (the period for which shipping services are available). In the absence of data on the average ship sizes per annum, we assume that the average size of ships calling at the Australian ports is constant over the period 2000-2001 to 2005-2006. This seems to be a realistic assumption since, as the last column of Table 2 shows, the average size of the Australian trading fleet has not been increasing consistently over the period for which data are available. Although there has been a marked increase in the average size of bulk carriers particularly from 2004-2005 due to the increased demand in Australia for dry bulk tonnage necessary to carry increase in exports of minerals and energy commodities, this could not be applied to the size of container ships calling at the Australian ports (Australian Bureau of Transport and Regional Economics, 2005).

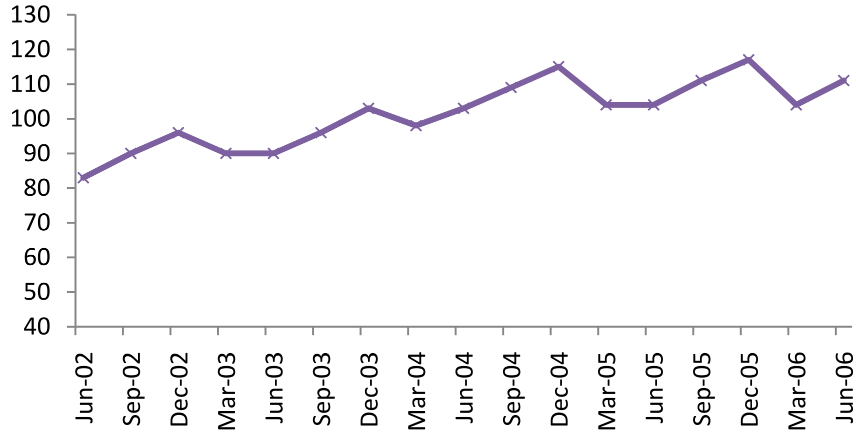
By comparing the average growth rate of Australia's supply of shipping services (which grew on average by 2 to 3 percent per annum) and the predicted increase in demand for shipping services in Australia as a result of China's continued growth (which is expected to grow on average by 6 percent), it is clear that Australia's supply of shipping services may be inadequate to cope with the predicted increase in demand.

Table 2: Shipping Services at Australian Ports: 2000-2006

	# of Ships Calling	% Growth	# of Ship Calls	% Growth	Average GRT (Aus)
2000-2001	3164		21857		21781
2001-2002	3140	-0.758533502	21419	-2.003934666	20620
2002-2003	3140	0	22826	6.568934124	22002
2003-2004	3361	7.038216561	23570	3.259440988	20045
2004-2005	3530	5.028265397	25489	8.141705558	26751
2005-2006	3517	-0.368271955	25571	0.321707403	
Total		10.9396765		16.28785341	
Average		2.1879353		3.257570681	

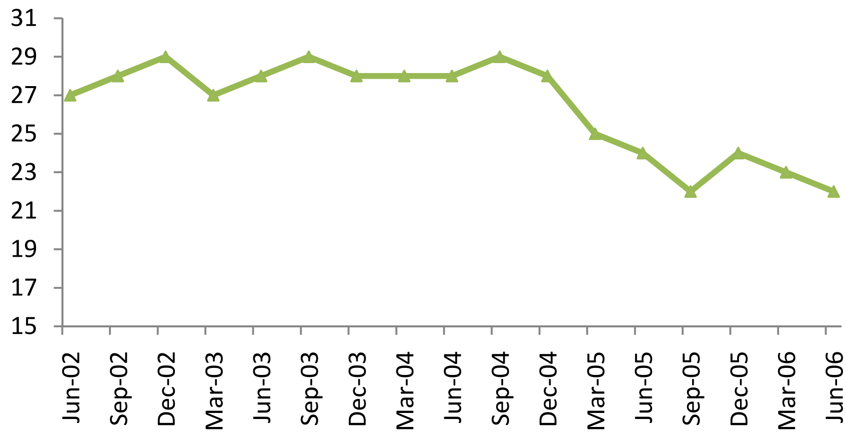
Source: Australian Transport Statistics 2007, Australian Bureau of Transport and Regional Economics

Figures 1 to 3, adapted from ABTRE (2006) for the five largest Australian container terminals, can further indicate what would happen to the Australian port sector as a result of an increase in demand for port services. Figure 1 shows container throughput measured by the number of containers per berth squared metre, and Figure 2 shows the crane utilization rate measured by percentage of container idle time. Both Figures 1 and 2 show more efficiency of port operations, which could have generally been achieved through more efficient management.



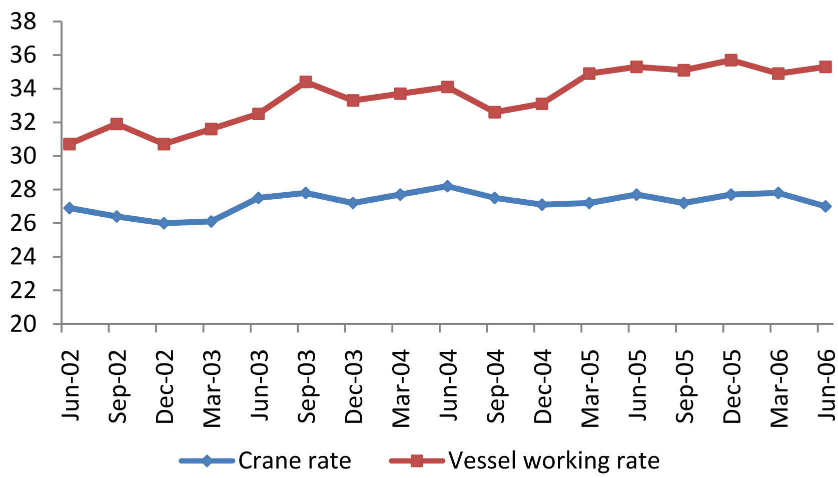
Source: Australian Bureau of Transport and Regional Economics (2006)

Figure 1: Container throughput (containers per berth squared metre)



Source: Australian Bureau of Transport and Regional Economics (2006)

Figure 2: Crane idle time (%)



Source: Australian Bureau of Transport and Regional Economics (2006)

Figure 3: Container handling productivity (containers per hour)

Despite these positive signs, Figure 3 shows, with the actual physical capacity of port crane to handle cargo being virtually fixed, that the crane rate has slightly decreased or remained steady while the vessel working rate increased significantly during the period 2002-03 and remained relatively stable after that. The above trends imply that while better management can improve the efficiency of cargo handling at Australian container ports, cargo handling technology has not been improved. This may reveal capacity constraints faced by Australian ports in terms of physical capital investment. If the scope of improvement due to better management is limited, ports have no alternative but rely on investment of physical capital, i.e. cargo handling machine and equipment. Thus, so far as port congestion remains serious in many ports as mentioned earlier, and demand for cargo transport between Australia and China grows at 5-7% per year, there is a need for Australia to upgrade its port facility and increase the scale of operation.

Table 3 shows the trends in international freight and aircraft movements across Australia for the period of 1995-96 to 2005-06 (the year for which the latest data are available). The third column of Table 3, which shows the growth rates for international freight movements by air over the period, indicates a low annual growth averaging at 2.66 percent – lower than the anticipated growth in demand for air transport services as a result of China's continued economic growth. Although the actual international freight movements are not the same as the air infrastructure capacity, they can be useful indicators of Australia's air transport infrastructure capacity.

Table 3: International Freight and Aircraft Movements

Year	Total Freight Movements (tonnes)	Percent Change (%)	Total Aircraft Movements	Percent Change (%)	Average freight per movement (tonnes)
1995-96	564 913		1 260 752		0.4481
1996-97	614 945	8.86	1 272 858	0.96	0.4831
1997-98	645 638	4.99	1 269 967	-0.23	0.5084
1998-99	645 588	-0.01	1 284 719	1.16	0.5025
1999-00	687 247	6.45	1 287 041	0.18	0.5340
2000-01	665 685	-3.14	1 353 578	5.17	0.4918
2001-02	634 341	-4.71	1 082 782	-20.01	0.5858
2002-03	634 910	0.09	1 090 183	0.68	0.5824
2003-04	627 002	-1.25	1 155 678	6.01	0.5425
2004-05	702 418	12.03	1 187 669	2.77	0.5914
2005-06	725 798	3.33	1 191 200	0.30	0.6093
Average	649862.27	2.66	1221493	-0.30	0.5431

Source: Australian Bureau of Transport and Regional Economics

4. Conclusion

The simulation results have shown that China's continued economic rise would have significant implications for the Australian logistics sector. China and Australia's logistics sectors would benefit in terms of increased cargo throughput and increase in demand for logistics services. As far as Australia is concerned, there would be a significant increase in demand for China-bound sea and air transport services in Australia by 6.35 percent and 7.34 percent. All types of China-bound exports (classified by cargo type) are expected to rise with significant increases from Australia's containerizable agricultural products (10.88%) and break bulk commodities (13.38%). Moreover, there would be a significant reorientation in Australia's trade with anticipated declines in their cargo flows to other countries, although this reorientation is not evident in the case of China's trade.

The above analysis has also indicated that Australia's limited transport infrastructure may prevent Australia from taking advantage of this increase in logistics business opportunities. The average growth rate and trend of Australia's shipping and airline services in the past seem to indicate that the Australian transport infrastructure may be inadequate to cope with the predicted increase in demand. This finding has serious policy and strategic implications. First, it underscores the need to upgrade and expand its exiting port infrastructure. Second, it points to the importance of attracting more ships and airlines to make calls in the Australian seaports and airports and/or of existing ships and airlines to increase their frequency of visits in Australia. To achieve these things, one must identify and assess the underlying factors responsible for the inadequacy of Australia's transport infrastructure before adopting appropriate policies and strategies. Further, one must also understand the factors that would have a significant influence on the transport providers' decision to choose their ports of call. There is therefore more considerable scope for undertaking more studies particularly into the problems and impediments facing the logistics industry in Australia.

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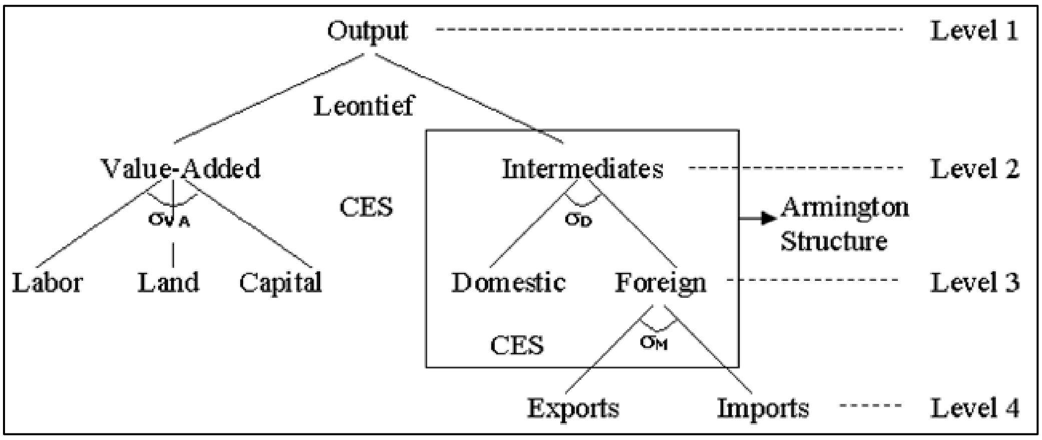
Appendix 1: The GTAP Model and Aggregation Adopted

A graphical presentation of the GTAP model with particular emphasis on the accounting relationships is given by Brockmeier (1996). A more rigorous approach is presented by Hertel and Tsigas (1997). The GTAP model assumes perfectly competitive markets, where the zero profit condition holds, and that all the markets are cleared.

The regional household allocates expenditures across three categories: private households, government, and savings. It derives income from the "sale" of primary factors to the producers, which combine them with domestically- produced and imported intermediate composites to produce final goods. These final goods are in turn sold both domestically to private households and the government, and exported to the rest of the world. Both government and private households also import final consumption goods from the rest of the world. A global bank intermediates between global savings and regional investments by assembling a portfolio of regional investment goods and selling shares in this portfolio to regional households in order to meet their savings demand. Finally, a global transport sector assembles regional exports of trade, transport and insurance services and produces a composite good used to move merchandise trade among regions (Hertel and Tsigas 1997: 16).



Source: Hertel (1997)

Figure 1. Production Structure in the GTAP Model

The specification of economic behavior is as follows:[4] The production structure in the GTAP Model is illustrated in Figure 1. The production process assumes constant returns to scale technology and is characterized by a Leontief aggregation function specified between value-added and intermediate demands, which implies non-substitution between composite intermediates and primary factors. Value-added demand is a Constant-Elasticity-of-Substitution (CES) aggregation of three primary factors: land, labor and capital, of which land is specific to the agriculture sector and labor and physical capital perfectly mobile within a region. Demand for intermediates is specified in a CES aggregation of imported and domestically-produced intermediates, with imported intermediates sourced from different regions. This treatment of intermediate imports follows what is known as the Armington specification.

The Armington assumption treats products produced in different regions as heterogeneous rather than homogeneous across countries: products are differentiated by their country-of-origin[5]. This treatment is convenient as it accommodates "cross hauling", the simultaneous export and import of a certain commodity by the same country, in international trade statistics[6]. The GTAP model employs a

[4] See Shoven and Whalley (1992), chapter 4 on the specification of functional forms in CGE modeling.
[5] This implies that the source of product differentiation is exogenous to the model (Hertel et al 1998:260).
[6] Adopting the Armington specification also rules out extreme specialization effects under trade policy changes. Moreover, model calibration becomes more straightforward as a demand function for imported goods can be identified separately from the demand for domestically produced commodities (Bandara 1991:15). For a discussion on the use of the Armington specification in multi-country CGE models, see Srinivasan and Whalley (1986). A critique is that models which adopt this specification are characterized by implausibly strong terms-of-trade effects (Brown 1987, Srinivasan and Whalley 1986:25). Another criticism pertains to the failure to account for endogenous product differentiation (See Hertel and Tsigas 1997:41).

two-level nested approach in specifying import demand, represented by Equation 1[7]:

$$C_i = g\,[D_i, h(M_{ir}, M_{is}, \ldots)] \qquad [1]$$

The composite commodity C_i ($i \in I$, where I is the set of all tradables) is a function of the domestic good D_i and a composite of imports M_i sourced from the other regions r and s. Both g and h of the respective "top" and "bottom" level nests are CES functions. The elasticities of substitution σ_D and σ_M in the intermediate input branches of the production tree in Figure 1 are also known as the Armington parameters: σ_D describes the ease of substitution between the domestic good and the composite import by sector, while σ_M describes the ease of substitution among imports from different regions (Huff et al 1997: 126). The Armington structure described also implies two restrictions on the structure of international trade. First, imports are made separable from the domestic good: changes in relative prices among imports do not affect the quantity demanded of the domestic good, and a change in the price of the domestic good does not affect the relative quantities demanded of the various imported goods (Hertel et al 1998: 262). Second, the CES specification assures not only that the elasticities of substitution σ_D and σ_M at the two levels are constant, but also that the elasticity of substitution at the lower level (σ_M) is identical for each pair of imports.

The regional households dispose of total regional income according to a Cobb-Douglas per capita utility function specified over three forms of final demand: private household and government expenditures on composite goods, and savings (Hertel and Tsigas 1997: 47)[8]. The government conditional demands for composite tradable goods are derived via the Cobb-Douglas assumption of constant budget shares across composite goods[9]. Import demands are subsequently derived from nested-CES utility functions analogous to that of the firms.

The model differs from most other multi-region CGE models in its representation of private household demands. It utilizes the non-homothetic Constant Difference of Elasticities (CDE) expenditure function, which allows for variations in the income responsiveness of demand in different regions depending on both the level of development of the region and the particular consumption patterns observed in that region (Bach et al, forthcoming). Specifically, the use of the CDE functional form relaxes the restrictions of unitary income elasticities in the Cobb-Douglas and CES utility functions, and unlike in the non-homothetic Linear Expenditure System (LES) of demand equations, allows marginal budget shares to vary with expenditure levels (Huff et al 1997)[10].

Model Closure[11]

As the GTAP Model is a comparative static CGE model, there is no inter-temporal mechanism for the determination of investment. However, the treatment of aggregate investment is important as a reallocation of investment across regions will affect production and trade through its effects on the profile of final demand (Hertel and Tsigas 1997:52). In the GTAP model, the determination of investment appears both at the global and regional levels[12]. Consider the following two balancing identities in the absence of international income flows and transfers:

Savings (S) – Investment (I) = 0 [2]

Savings (S) – Investment (I) = Current Account [3]

At the global level, investment is determined by identity [2], which is present implicitly in the model by Walras' Law. The model closure at this level is neoclassical as investment adjusts to accommodate

7 Hertel et al (1998), equation 9.1.

8 Under the standard closure, income is disposed to the three recipients on a constant share basis.

9 The Cobb-Douglas function is a special case of the CES function, with a substitution elasticity (in this case, among composite goods in the government's utility function) of one.

10 Marginal budget share is defined as $p_i\partial q_i/\partial E$, where p_i and q_i represents the price and quantity demanded for good i, and E is the total expenditure.

11 The term "closure" can be defined as "the specification of endogenous and exogenous variables in the model" (Bandara 1991: 16). Dewatripont and Michel (1987) discusses the closure problem in CGE models.

12 The global closure is a unique feature of the GTAP model. In most other multi-country CGE models, each regional economy is closed, then linked via trade. For details of the closure problem in the GTAP model, see Hertel and Tsigas (1997).

changes in global savings13.

At the regional level, the model determines the current account via identity [3]. However, GTAP provides two alternative mechanisms in allocating investment across regions. Under the standard closure, the global bank allocates investment in fixed shares across regions. The alternative rate-of-return mechanism depicts the scenario where the global banking sector's investment portfolio is highly responsive to changes in the relative rates of return across regions. Hence, investment will be allocated in such a way as to equalize *expected* rates of returns across regions; to maintain this equilibration, the model will produce large changes in regional investments and in the current account[14]. Finally, the GTAP Model is calibrated to 2001 data and implemented via the General Equilibrium Modeling Package (GEMPACK).

A nine-sector (9) commodity breakdown shown below is adopted. In the case of the regional breakdown, Australia, China, ASEAN countries (which include Indonesia, Malaysia, Philippines, Singapore and Thailand), ASEAN4 (which include Brunei, Cambodia, Laos, Myanmar and Vietnam) and other regional groupings are modeled as separate regions in order to distinguish the individual trade and logistics effects of policy simulations.

Commodity Aggregation
1. Containerizable agricultural products (Contagri) Paddy rice, vegetables, fruits, animal products, raw milk, wool, silk-worm cocoons, fishery, cattle meat, sheep meat, horse meat, meat products nec, vegetable oils & fats, dairy products, processed rice, food products nec.
2. Containerizable manufactured products (Contmanu) Beverages, tobacco products, textiles, wearing apparel, leather products, wood products, paper products, metals nec, metal products, transport equipment nec, electronic equipment, machinery & equipment nec, manufactures nec.
3. Dry bulk products (Drybulk) Wheat, cereal grains nec, oil seeds, sugar cane, sugar beet, plant-based fibers, crops nec, forestry, coal, minerals nec, sugar, mineral products nec, ferrous metals.
4. Liquid bulk products (Liquidbulk) oil, gas, petroleum, coal products, chemicals, rubber, plastic products
5. Special Motor vehicles and parts
6. Break bulk products (Breakbulk) Live animals
7. Maritime transport (Seatrans) Sea transport services
8. Air transport (Airtrans) Air transport services
9. Other Services (Others) Electricity, gas & water, construction, trade, transport nec, communication, financial services nec, insurance, business services nec, recreational services, public administration and defense, health, education and dwellings

Source: GTAP Database

[13] In the model, global savings is the sum of regional savings gathered by the global banking sector, which assemble a portfolio of regional investment goods.

[14] Under this mechanism, capital is flowing internationally in order to equalize *expected* rates of return, although not fast enough to affect physical capital stocks within the simulation period. This point is attributed to Tom Hertel at GTAP.

Evaluating key logistics service capabilities for Taiwanese liner shipping firms

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Abstract

This study empirically evaluates crucial logistics service resources and logistics service capabilities and their effects on Taiwanese liner shipping firms' performance. Based on factor analysis, three logistics service resources were identified: network resource, information equipment resource, and corporate image; whereas four logistics service capabilities were identified: value-added service, service reliability, relationship building, and information integration and flexibility capabilities. Results of regression analysis indicated that logistics service resource has a positive effect on logistics service capabilities and firm performance. The results also revealed that logistics service capability has a positive effect on firm performance. Theoretical and managerial implications of the research findings for liner shipping firms are discussed.

Keywords: Resource-based view; Logistics service capability; Liner shipping firms

1. Introduction

In today's time-based competition marketplace, global operations require the integration of global manufacturing with logistics service capabilities and transport support for efficient and effective business performance (Bowersox and Closs, 1996). The changing structure of global markets and consequently demands of shippers have forced liner shipping firms to rethink their business process to better satisfy shippers' needs. They have had to become involved in logistics management in order to more effectively manage and control transport chains and seamlessly integrate global production systems. Basically, liner shipping firms have three kinds of strategy to develop logistics management, including (1) extending the service they offer; (2) horizontal integration; and (3) through acquisition or strategic alliance, in order to expand the geographical scope of their operations and to reduce operating and transaction costs (Notteboom and Winkelmans, 2001; Heaver, 2002; Cheung *et al.*, 2003; De Souza *et al.*, 2003).

Over the past few years, cooperative operating strategies such as mergers and acquisitions or strategic alliances with other business have been treated by liner shipping firms as a means to internally generate corporate growth (Evangelista and Morvillo, 2000; Heaver *et al.*, 2001; Midoro *et al.*, 2005; Brooks and Ritchie, 2006). In particular, most liner shipping firms have enlarged their involvement in logistics by an aggressive takeover strategy. For example, A. P. Møller acquired Sea-Land in 1999 and P&O Nedlloyd in 2005, Hapag Lloyd acquired CP in 2005, and CMA CGM acquired Delmas in 2006 (Containerisation International, 2006). However, these ways may not always be applicable and sustainable to shipping firms wishing to improve their market share and competitiveness (Panayides, 2003).

Further, the concentration resulting from both horizontal and vertical integration in the liner shipping industry has also led to poor financial results and increased the pressure in the liner shipping industry (Notteboom and Winkelmans, 2001). In particular, Taiwan is an island-based economic entity and its

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prosperity is highly dependent on export trade. Accordingly, international transportation plays an important role for foreign trade in Taiwan. Due to significant growth in foreign trade, the shipping industry in Taiwan has become highly competitive, and the percentage of foreign maritime firms entering this market has remained consistently high (Lu, 2007). Therefore, it is increasingly important for liner shipping firms to build logistics service capabilities that are inimitable and durable to reduce cost and increase service satisfaction (Lai, 2004; Tseng *et al.*, 2005).

The concept of capability has been strongly emphasized in the strategic management literature. Logistics capability particular has been recognized as a crucial source to lead superior performance (Bowersox and Closs, 1996). Further, the application of logistics management has been reported to contribute to liner shipping firms' more efficient, effective and economic operations and, more importantly, to provide value-added services to customers (Warusavitharana, 2004). However, to our knowledge, with the exception of Jenssen (2003), Jenssen and Randøy (2006) and Lu (2007) have discussed the application of the concept of capability in shipping industry, few studies have empirically explored logistics service capabilities in the liner shipping context. Thus, it is worthy to identify crucial logistics service resource and logistics service capability dimensions in Taiwanese liner shipping firms and examine their effects on firm performance based on the resource-based view of the firm.

There are five sections in this study. The second section reviews the literature on resource-based view of firm and shipping service attribute and discusses the conceptual framework and related research hypotheses. Section 3 describes the methodological context, including questionnaire design, sampling technique, and methods of analysis. Section 4 presents the results and findings of the survey. Conclusions drawn from the analyses and strategic implications for liner shipping companies are discussed in the final section.

2. Theory and Research Hypotheses

2.1 Resource-based view

Over the last two decades, due to the changing and dynamic environmental conditions, the emphasis in the field of strategic management has shifted from viewing competitive advantage as primarily determined by external environment to a resource-based view (Rouse and Daellenbach, 1999). The resource-based view (RBV) of the firm which started with Wernerfelt (1984) asserts that firms can gain and sustain competitive advantages by deploying valuable resources and capabilities (Wernerfelt, 1984; Day, 1994). Thus, the source of superior firm performance can ultimately be attributed to the ownership of strategic resources possessing the characteristics of rareness, value, imperfect imitation, and non-substitutability (Barney, 1991). However, what are the strategic resources of organization?

Different scholars have been using different terms such as resources (Grant, 1991; Peteraf, 1993), capabilities (Grant, 1991; Amit and Schoemaker, 1993), competences (Prahalad and Hamel, 1990; Meyer, 1991), skills and assets (Aaker, 1989; Amit and Schoemaker, 1993) as basic construct of RBV (Carmeli, 2004). Several studies have asserted that any of a wide range of firm attributes controlled by a firm can be considered resources, such as assets, capabilities, competencies, information, knowledge and so forth (Barney, 1991, Collis and Montgomery, 1995), while others have argued that capabilities are not part of resources and have therefore sought to differentiate between resources and capabilities (Grant, 1991; Amit and Schoemaker, 1993). According to (Amit and Schoemaker, 1993), capabilities are the results of resource deployment and organizational processes having the dynamic "doing" nature. Capabilities should therefore be treated independent from resources.

2.2 Logistics service resource and service capability attributes

The logistics capability concept has been discussed in several logistics studies based on the resource-based view (RBV) and has demonstrated its effect on firm performance and competitive advantages (Morash and Lynch, 2002; Sinkovics and Roath, 2004; Shang and Marlow, 2005). As regards liner shipping industry, most shipping service attributes were logistics related activities. The selection of logistics service resource and service capability attributes therefore is based on previous maritime and transport-related studies. A large number of studies have explored the shipping service attributes in the shipping industry. Brooks (1985) investigated the determinants affecting shipper choice of a container carrier. Cost of service was regarded as the most important selection criterion by shippers, followed by frequency of sailings, reputation, transit time and directness of sailings.

Chiu (1996) evaluated the logistics performance of liner shipping based on both shippers' and carriers' points of view. Result revealed that the six most important service attributes to shippers were prompt response from carrier to any problem, transit time, reliability, documentation services, notice of delay and assistance with loss/damage claims. Murphy *et al.* (1997) compared the relative important of the carrier selection factors between shippers and carriers. Results revealed that equipment availability, transit time, financial stability loss and damage, freight rates, rate changes, cargo tracing, linehaul service, and claims were found to be higher important accorded by shippers than carriers. Lu (2003, 2004) evaluated the market segmentation of international distribution centers based on shippers' logistics service requirements. Result concluded that the key logistics service dimensions of distribution centers were value-added services, support services, distribution services, information and transportation services, cargo related services, consolidation services, and storage services.

Recently, Paixao and Marlow (2005) investigated the competitiveness of short sea shipping in multimodal logistics supply chains within the European Union. Eight factors were identified which could be developed and integrated in multimodal logistics chains in a more competitive way. These factors were carrier's logistics network design and speed, cost of service and reliability/quality, carrier's representatives sales and after-sales behavior, involvement in the forwarding industry, service guarantee, corporate image, investment policy, and commercial/operational and carrier-shippers' relationship policies. Lu (2007) evaluated key resources and capabilities for liner shipping services based on the resource-based theory. Based on a factor analysis, three resources dimensions, namely, marine equipment resource, information equipment resource, and corporate image resource were identified; whereas seven capability dimensions, namely, purchasing, operation, human resource management, customer service, information integration, pricing, and financial management were identified.

An appraisal of the shipping service attributes, the primarily liner shipping firms' logistics service resources and service capabilities can be summarized in Table 1. Based on the review of literature relating to shipping service attributes, nine service resource attributes and 27 service capability attributes were selected for use in a questionnaire survey. They are presented in the analysis of findings derived from the survey in Section 4.

Table 1: Previous studies on shipping service attributes

Service attributes	Previous studies
Reputation	Brooks, 1985; Murphy *et al.*, 1997; Lu and Marlow, 1999; Paixao and Marlow, 2005; Voss *et al.*, 2006; Lu, 2007
Loss and damage	McGinnis, 1979; Coulter *et al.*, 1989; Murphy *et al.*, 1997; Lu, 2007
Equipment	Coulter *et al.*, 1989; Murphy *et al.*, 1997; Lu and Marlow, 1999; Voss *et al.*, 2006; Lu, 2007
Information system	Murphy *et al.*, 1997; Tseng *et al.*, 2005; Lu, 2007
Network	Brooks, 1985; Coulter *et al.*, 1989; Paixao and Marlow, 2005; Lu, 2007
Value-added service	Lu and Marlow, 1999; Lu, 2003, 2004; Lai, 2004
Reliability of service	McGinnis, 1979; Coulter *et al.*, 1989; Frankel, 1993; Chiu, 1996; Lu and Marlow, 1999; Paixao and Marlow, 2005
Customer service	Chiu, 1996; Liang *et al.*, 2006; Paixao and Marlow, 2005; Voss *et al.*, 2006; Lu, 2007
Freight rate	McGinnis, 1979; Collison, 1984; Brooks, 1985; Coulter *et al.*, 1989
Information integration	Frankel, 1993; Murphy and Poist, 2000; Lai, 2004; Paixao and Marlow, 2005; Tseng *et al.*, 2005; Lu, 2007

2.3 Research hypotheses

A large number of logistics studies have concluded that logistics capability was significantly related to firm performance in terms of financial and non-financial performance (Lynch *et al.*, 2000; Zhao *et al.*, 2001; Lai, 2004; Autry *et al.*, 2005; Shang and Marlow, 2005; Tracy *et al.*, 2005; Kim, 2006). Most of those are focused on the manufacturing arena but seldom on shipping industry. Based on the RBV theory and previous studies on logistics capability, this study proposed a conceptual model as shown in Figure1

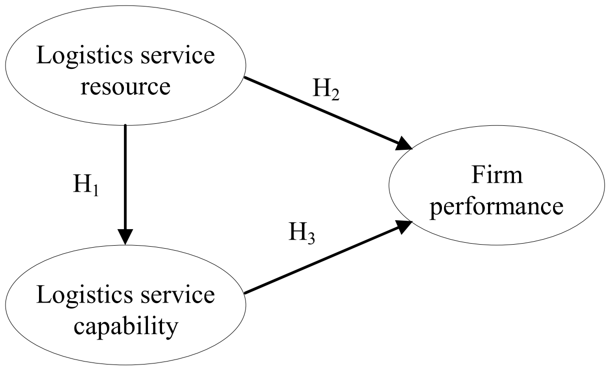

Figure 1: A conceptual model of the study

Resources are the inputs into the organization's value chain and have been viewed as the source of a firm's capability (Grant, 1991). Given the differences in firms' resources, liner shipping firms will have different types of logistics capabilities. Moreover, the differences in firms' resources and capabilities in turn affect their firm performance. Hence, liner shipping firms with a higher degree of logistics service resources and logistics service capabilities should satisfy customers' requirements and, therefore, achieve better firm performance. Accordingly, this study hypothesizes that:

H_1: Logistics service resource has a positive effect on logistics service capability in liner shipping firms.
H_2: Logistics service resource has a positive effect on firm performance in liner shipping firms.
H_3: Logistics service capability has a positive effect on firm performance in liner shipping firms.

3. Methodology

Data for this study were collected from a questionnaire survey which was designed based on the stages outlined by Churchill (1991). The measures for logistics service resource and service capability attributes of shipping firms in the study were drawn from previous studies and then to ensure their validity were discussed with liner shipping executives and experts. Accordingly, content validity was ensured through basing questionnaire items on previous studies and discussions with shipping experts. To identify the crucial logistics service resource and service capability dimensions to the liner shipping firms, respondents were asked to rate how well they consider their companies performed relative to their competitors, using a five-point scale where "1=very poor" and "5=very good". With respect to firm performance, eight performance indicators commonly used in previous logistics research were used to measure customer service performance (service quality, customer satisfaction, and customer loyalty) and financial performance (profit rate, market share, sales' growth rate, return on investment, and reduced operation cost). Each performance variable was assessed using a five point Likert scale, ranging from "1= very poor" to "5= very good".

The sample of liner shipping firms was drawn from the Directory of the National Association of Shipping Agencies and Companies and Members of International Ocean Freight Forwarders and Logistics Association in Taiwan. The survey questionnaire was sent to 513 managers-- 21 international liner shipping companies, 87 international liner shipping agencies, and 405 ocean freight forwarders in November 2007. The potentially effective population size was reduced to 499 as 14 managers had left companies or businesses were no longer in existence. The initial mailing elicited 81 usable responses. A follow-up mailing was sent four weeks after the initial mailing. An additional 42 usable responses were returned. Therefore, the total usable number of responses was 123, of which 19 were from liner shipping companies, 30 from liner shipping agencies, and 74 from ocean freight forwarders. The overall response rate for this study was 24.65 per cent.

Although the total response rate of this study is reaching 24.65%, it is important to deal with the potential problem of non-response bias. A comparison of early (those responding to the first mailing) and late (those responding to the second mailing) respondents recommended by Armstrong and Overton (1977) was carried out in this study to test for non-response bias by t-test analysis. The 123 survey respondents were divided into two groups, namely, early (n=81, 65.9%) and late (n=42, the remaining 34.1%) respondents based on their response wave (first and second). T-tests were performed on the two groups' perceptions of the satisfaction of the various logistics service resource and service capability attributes. With the exception of cargo tracking system facilities, results indicated that there were no significant differences between the two groups' perceptions of the satisfaction of the various items at the 5% significance level. Results therefore suggested that non-response bias was not a problem since late respondents' responses appeared to reflect those of first wave respondents.

This study aims to examine the key logistics service resource and logistics service capability dimensions and their effects on firm performance. Firstly, an exploratory factor analysis was employed to identify the key dimensions. A multiple regression analysis was subsequently used to examine the effects of logistics service resources and logistics service capabilities on firm performance.

4. Results of Empirical Analysis

4.1 Characteristics of respondents

The profiles of respondents' companies and their characteristics are displayed in Table 2. Results revealed questionnaire survey respondents were vice presidents or above (39 %), managers/assistant managers (32.5 %), clerks (11.4 %), director (6.5 %), sales representative (5.7 %), and other positions (4.9 %). In general, managers are actively involved in and anchor operations in businesses. The high percentage of responses from managers, vice presidents or above thus endorsed the reliability of survey findings. To endure the reliability and objectivity of questionnaire surveys, respondents were also asked to indicate how long they have worked in the liner shipping industry. Table 2 revealed that over 70% of respondents had worked in the liner shipping industry for more than 10 years. The finding implied that respondents had abundant practical experience to answer the questions.

Table 2: Respondents' profile

		Number of respondents	Percent of respondents
Job Title	Vice president or above	48	39.0
	Manager / assistant manager	40	32.5
	Director / vice director	8	6.5
	Clerk	14	11.4
	Sales representative	7	5.7
	Other	6	4.9
Working experience (years)	1-5	25	20.3
	6-10	11	8.9
	11-15	15	12.2
	16-20	27	22.0
	Above 20	45	36.6
Type of business	Liner shipping company	19	15.4
	Liner shipping agency	30	24.4

	Freight forwarder	74	60.2
Ownership pattern	Local firm	74	60.2
	Foreign-owned firm	32	26.0
	Foreign-local firm	13	10.6
	Others	4	3.3
Age of firm (years)	1-5	17	13.8
	6-10	16	13.0
	11-20	27	22.0
	21-30	28	22.8
	Above 30	35	28.5
Number of employees	Less than 20	36	29.3
	21~50	32	26.0
	51~100	14	11.4
	101~500	26	21.1
	501~1,000	6	4.9
	Above 1,000	9	7.3
Annual revenue (Million NT$a)b	Less than 10	21	17.6
	10 ~100	32	26.9
	100 ~ 1,000	34	28.6
	1,0000~10,000	21	17.6
	Above 10,000	11	9.3

Note: [a] One U.S. dollar equals approximately 32.5 New Taiwanese (NT) dollars.
[b] represents 4 respondents did not provide this information.

The vast majority of respondents were from ocean freight forwarders (60.2%). The remaining respondents were from liner shipping agencies (24.4%) and liner shipping firms (15.4%). As regards ownership pattern, more than 60% of respondents were local firms, while 26%, 10.6%, and 3.3% were foreign-owned firms, foreign-local firms, and others, respectively. Table 2 also showed over half (51.2%) of responding firms had been in operation for more than 20 years. Around 55% of the responding firms had less than 50 employees, while 12.2% had more than 501 employees. Respondents were also asked to provide information about their annual revenue. Results presented in Table 2 showed that 46.2% of respondents reported their firms' annual revenue was between NT$100 million and NT$10,000 million, while 44.5% as below NT$100 million, and 9.2% as NT$10,000 million or more.

4.2 Implementation of logistics service resource and logistics service capability

To evaluate the logistics service resource and service capability attributes, respondents were asked to rate how well they consider their companies performed in respect of logistics service resource and service capability attributes relative to their competitors, using a five-point scale where "1=very poor" and "5=very good". Results, as shown in Table 3, showed that financial stability was perceived as the most satisfaction resource by liner shipping firms, followed by corporate reputation and low cargo damage or loss record (their mean scores were over 3.8). In contrast, internet service facilities, cargo tracking system facilities, and EDI facilities were rated as poor in terms of satisfaction level (their mean scores were below 3.5). The findings implied that corporate image-related resources were the key resource to the Taiwanese liner shipping firms.

Table 3: The satisfaction level of logistics service attributes

Logistics service resource attributes	Mean	S.D.	Rank
Financial stability	4.008	0.752	1
Corporate reputation	4.000	0.757	2
Low cargo damage or loss record	3.894	0.699	3
Geographical coverage of service	3.740	0.734	4
High frequency of sailings	3.738	0.733	5
Number of branch companies or agencies	3.732	0.790	6
EDI facilities	3.496	0.872	7
Cargo tracking system facilities	3.496	0.843	8
Internet service facilities	3.252	0.874	9

Mean scores are based on a five-point Likert scale (1=very poor, 5=very good)

With respect to logistics service capability attributes, Table 4 revealed that the critical logistics service capability attributes of Taiwanese liner shipping firms were courtesy of sales representatives, accurate price calculation, long-term contractual relationship with customers, and reliability of booking space (their mean scores were over 4.1). In contrast, the least critical logistics capabilities were advertising in newspapers and magazines, ability to provide customs clearance service, ability to provide warehousing service, and ability to handle special cargo (their mean scores were below 3.6). The findings implied that Taiwanese liner shipping firms mainly focused on customer and service reliability-related capabilities.

Table 4: The satisfaction level of logistics service capability attributes

Logistics service capability attributes	Mean	S.D.	Rank
Courtesy of sales representative	4.154	0.736	1
Accurate price calculation	4.146	0.721	2
Long term contractual relationship with customers	4.138	0.669	3
Reliability booking space	4.114	0.704	4
Accuracy documentation	4.098	0.694	5
Prompt response to shippers' complaints	4.049	0.711	6
Ability to trace of transit cargo	4.041	0.694	7
Knowledgeability of sales personnel	4.025	0.707	8
Quality of data transmission (e.g. EDI, Fax, E-Mail)	4.016	0.640	9
Cargo safety	4.000	0.701	10
Reasonable pricing	3.992	0.794	11
Reliability of advertised sailing schedules	3.926	0.748	12
Availability of cargo space	3.917	0.685	13
Responsive to unforeseen events during transit of cargo	3.902	0.718	14
Operational collaboration with other liner shipping companies	3.878	0.685	15
Operational collaboration with downstream companies (e.g. hauler, stevedoring, customs broker)	3.870	0.757	16
Ability to provide door-to-door service	3.854	0.765	17
Ability to provide multimodal service	3.821	0.758	18
Ability to provide customized service	3.777	0.805	19
Prompt response to claim	3.715	0.784	20
Global information systems' integration	3.707	0.807	21
Linkage with related industries' information systems (e.g. port, carrier, hauler, forwarder)	3.667	0.826	22
Ability to provide consolidation service	3.618	0.854	23
Ability to handle special cargo	3.561	0.841	24
Ability to provide warehousing service	3.561	0.898	25
Ability to provide customs clearance service	3.426	0.886	26
Advertising in newspaper and magazine	3.333	0.836	27

Mean scores are based on a five-point Likert scale (1=very poor, 5=very good)

4.3 Factor analysis

Factor analysis with VARIMAX rotation was performed to identify the key logistics service resource dimensions of Taiwanese liner shipping firms. Eigenvalues greater than one were used to determine the number of factors in each data set (Churchill, 1991). Results, as shown in Table 5, indicated that three factors accounted for approximately 72.636% of the total variance and thus represented all the logistics service resource attributes of liner shipping firms.

Table 5: Factor analysis for logistics service resource attributes

Logistics service resource attributes	Factor 1	Factor 2	Factor 3
Corporate reputation	0.873	0.270	0.120
Financial stability	0.840	0.135	0.188
Low cargo damage or loss record	0.734	0.223	0.124
Number of branch companies or agencies	0.508	0.326	0.452
Cargo tracking system facilities	0.252	0.869	0.063
EDI facilities	0.185	0.789	0.209
Internet service facilities	0.238	0.756	0.283
High frequency of sailings	0.106	0.105	0.866
Geographical coverage of service	0.226	0.269	0.794
Eigenvalues	4.402	1.113	1.022
Percentage variance	48.909	12.371	11.356

To aid interpretation, only variables loading on each factor at 0.50 or higher were extracted, a conservative criterion based on Hair *et al.* (1998). An examination of results reveals all items met this requirement. Consequently, three factors were found to underlie the logistics service resource sets based on surveyees' responses. They are labeled and described below:

(1.) Factor 1, named corporate image resource, comprised four items, namely, corporate reputation, financial stability, low cargo damage or loss record, and number of branch companies or agencies. Corporate reputation had the highest factor loading on this factor. Since most items are related to corporate image, therefore, this factor was identified as a corporate image resource. It accounted for 49.19% of the total variance.

(2.) Factor 2, named the information equipment resource, consisted of three items: cargo tracking system facilities, EDI facilities, and internet service facilities. These three items are related to information equipment, therefore this factor was identified as a information equipment resource. It accounted for 12.46% of the total variance.

(3.) Factor 3, termed network resource, comprised two items, namely high frequency of sailings and geographical coverage of service. These two items are related to service frequency and routes, therefore this factor was identified as a network resource. It accounted for 11.32% of the total variance.

Furthermore, factor analysis was employed to identify the critical logistics service capability in liner shipping firms. The initial factor analysis resulted in five factors and accounted for approximately 69.515% of the total variance. Due to four items, prompt response to shippers' complaints, long-term contractual relationship with customers, availability of cargo space, and advertising in newspapers and magazines loaded on two factors or had a factor loading lower than 0.5, these four items were removed and repeated the exploratory factor analysis. Consequently, as shown in Table 6, four factors were identified and accounted for 67.912 % of the total variance. They are labeled and described below:

Table 6: Factor analysis for logistics service capability attributes

Logistics service capability attributes	Factor 1	Factor 2	Factor 3	Factor 4
Accurate price calculation	0.796	0.245	0.249	0.287
Accuracy of documentation	0.789	0.248	0.243	0.064
Reliability of booking space	0.757	0.279	0.286	0.270
Reasonable pricing	0.739	0.174	0.101	0.298
Courtesy of sales representatives	0.736	0.317	0.041	0.235
Cargo safety	0.727	0.414	0.292	0.054
Reliability of advertised sailing schedules	0.714	0.210	0.325	0.137
Ability to trace of transit cargo	0.685	0.462	0.086	0.161
Quality of data transmission (e.g. EDI, Fax, E-Mail)	0.382	0.722	0.154	0.182
Global information systems' integration	0.212	0.712	0.104	0.247
Linkage with related industries' information systems (e.g. port, carrier, hauler, forwarder)	0.196	0.675	0.286	0.249

Responsive to unforeseen events during transit of cargo	0.293	0.644	0.271	0.256
Ability to handle special cargo	0.188	0.639	0.121	0.013
Prompt response to cargo claim	0.304	0.615	0.153	0.080
Ability to provide customized service	0.267	0.527	0.303	0.409
Ability to provide warehousing service	0.171	0.276	0.801	-0.027
Ability to provide customs clearance service	0.045	0.000	0.789	0.295
Ability to provide consolidation service	0.203	0.333	0.728	0.065
Ability to provide multimodal service	0.298	0.259	0.701	0.178
Ability to provide door-to-door service	0.401	0.125	0.657	0.216
Operational collaboration with other liner shipping companies	0.311	0.127	0.137	0.746
Operational collaboration with downstream companies (e.g. hauler, stevedoring, customs broker)	0.116	0.309	0.345	0.699
Knowledgeability of sales personnel	0.354	0.270	0.081	0.621
Eigenvalues	11.198	1.891	1.403	1.127
Percentage variance	48.688	8.221	6.101	4.901

(1.) Factor 1, named service reliability capability, consisted of eight items, namely, accurate price calculation, accuracy of documentation, reliability of booking space, reasonable pricing, courtesy of sales representatives, reliability of advertised sailing schedules, and ability to trace of transit cargo. Accurate price calculation has the highest factor loading on this factor. With the exception of reasonable pricing, most service capability attributes are service reliability-related activities. Therefore, this factor was identified as a service reliability capability. It accounts for 48.688% of the total variance.

(2.) Factor 2, termed the information integration and flexibility capability, comprised seven items, namely, quality of data transmission, global information systems' integration, linkage with related industries' information systems, responsive to unforeseen events during transit of cargo, ability to handle special cargo, prompt response to claim, and ability to provide customized service. Quality of data transmission had the highest factor loading on this factor. The items, quality of data transmission, global information systems' integration, and linkage with related industries' information systems are related to information integration capability. Conversely, the items, responsive to unforeseen events during transit of cargo, ability to handle special cargo, prompt response to cargo claim, and ability to provide customized service, are flexibility-related activities. This factor, therefore, was identified as an information integration and flexibility capability. It accounts for 8.221% of the total variance.

(3.) Factor 3, designed the logistics value-added service capability, consisted of five items, namely, ability to provide warehousing service, ability to provide customs clearance service, ability to provide consolidation service, and ability to provide door-to-door service. Ability to provide warehousing service had the highest factor loading on this factor. Since all items are related to value-added service activities provided by liner shipping firms. This factor, therefore, was identified as a logistics value-added service capability. It accounts for 6.101 % of the total variance.

(4.) Factor 4, named relationship building capability, comprised three items, namely, operational collaboration with other liner shipping companies, operational collaboration with downstream companies, and knowledgeability of sales personnel. Operational collaboration with other liner shipping companies had the highest factor loading on this factor. Most items are related to the collaboration with supply chain partners. Relationship with other supply chain partners is an important strategy for liner shipping firms to provide reliability and just-in-time logistics service. Therefore, this factor was identified as a relationship building capability. It accounts for 4.901% of the total variance.

4.3 Reliability test

A reliability test based on the Cronbach Alpha statistic and corrected item-total correlation coefficients was used to test the consistency and reliability of the factors. As shown in Table 7, the Cronbach alpha values and the corrected item-total correlation coefficients of each measure were well above the suggested threshold of 0.7 and 0.5, respectively, which was considered adequate for confirming a satisfactory level of reliability in research (Nunnally, 1978; Churchill, 1991). Table 7 also shows respondents' satisfaction level with each logistics service resource and service capability dimension for their firm's performance in the current situation. Corporate image (mean=3.91) was found to be the key logistics service resource, followed by network resource (mean=3.74) and information equipment resource (mean=3.42). As regards logistics service capability, service reliability capability (mean=4.06) was perceived as the key service capability, followed by relationship building capability (mean=3.92), information integration and flexibility capability (mean=3.76), and value-added service capability (mean=3.66). Table 7 also shows liner shipping firms' customer service performance (mean=4.03) was better than their financial performance (mean=3.43).

Table 7 Results of reliability test

	No. of items	Mean	S.D.	Alpha	Range of corrected item-total correlation
Logistics service resource					
Network resource	2	3.739	0.733	0.700	0.539 – 0.539
Information equipment	3	3.415	0.863	0.821	0.655 – 0.716
Corporate image	4	3.909	0.750	0.826	0.548 – 0.784
Logistics service capability					
Value-added service	5	3.656	0.834	0.869	0.655 – 0.733
Service reliability	8	4.059	0.725	0.943	0.745 – 0.878
Relationship building	3	3.924	0.717	0.745	0.538 – 0.596
Information integration and flexibility	7	3.764	0.777	0.873	0.508 - 0.773
Firm performance					
Customer service performance	3	4.030	0.640	0.828	0.631 – 0.758
Financial performance	5	3.433	0.902	0.908	0.658 – 0.838

4.4 The effects of logistics service capability on liner shipping firms' performance

Multiple regression analysis was conducted to examine the effects of logistics service resources and service capabilities on liner shipping firms' performance. The three service resources and four service capabilities were used as independent variables in a series of regression models, with two performance measure treated as a dependent variable. Multicollinarity has been investigated by calculating the Variance Inflation Factor values (VIFs). The values are all below the recommended cut-off value of 10 and therefore within the acceptable level, suggesting no need for concern with respect to multicollinearity (Hair *et al.*, 1998). Since the data used in this study are cross-section, it is important to test the heteroscedasticity in a linear regression model. The Breusch-Pagan test was perfomed in this study. As shown in Table 8, the LM values of each model were significantly below the critical value of chi-squared distribution ($\chi_{3,\,0.05}$=7.815; $\chi_{4,\,0.05}$=9.488) at 0.05 significance level, suggesting the data of the study are homoscedasticity.

Table 8 shows the results of the regression analysis regarding the effects of logistics service resource and logistics service capability on firm performance. The first regression model (model 1a to model 1d) captured the effects of logistics services on logistics service capabilities. Results indicated that all models were statistically significant at the p=0.01 level, and explained approximately 20 to 60 percent of variance in logistics service capability. Results also showed that corporate image resource was found to have positively relationships with value-added service capability (estimate=0.407), service reliability capability (estimate=0.588), relationship building capability (estimate=0.501), and information integration and flexibility capability (estimate=0.474) at the p=0.05 significance level. Similarly, network resource was positively related to service reliability capability (estimate=0.240), relationship building capability (estimate=0.273), and information integration and flexibility capability (estimate=0.190) at the p=0.05 level, whereas the information equipment resource only had a positive effect on information integration and flexibility capability (estimate=0.140) at the p=0.1 significance level. Findings implied that liner shipping firms with high degree logistics resource services will have better logistic service capabilities. Accordingly, the results moderately support H_1.

Table 8: Results of multiple regression analysis

	Logistics service capability				Firm performance			
	Model 1a	Model 1b	Model 1c	Model 1d	Model 2a	Model 2b	Model 3a	Model 3b
Network resource	0.148	**0.240	**0.273	**0.190	0.118	**0.357		
Information equipment resource	0.015	0.058	-0.132	*0.140	*0.186	-0.025		
Corporate image resource	**0.407	**0.588	**0.501	**0.474	**0.328	**0.260		
Value-added service capability							-0.063	-0.171
Service reliability capability							**0.263	**0.305
Relationship building capability							**0.184	0.141
Information integration and flexibility capability							**0.408	0.189
F-value	13.594	58.372	22.962	34.737	15.649	14.660	31.991	13.050
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R^2	0.255	0.595	0.367	0.467	0.283	0.270	0.520	0.307
Adjusted R^2	0.236	0.585	0.351	0.453	0.265	0.251	0.504	0.283
D-W value	2.064	2.039	2.298	1.811	1.888	1.630	2.000	1.657
LM value	6.396	7.503	7.749	7.257	3.198	0.861	8.61	3.075

Note: *Significance level of $p<0.1$; **Significance level of $p<0.05$; $\chi_{3,\,0.05}=7.815$; $\chi_{4,\,0.05}=9.488$

The second regression model (model 2a and 2b) showed the relationships between logistics service resources and firm performance. These two model were all significant (adjust R^2=0.265 and 0.251, respectively) at the p=0.01 statistical level. Results revealed that corporate image resource (estimate=0.328 and 0.260, respectively) was positively related to customer service and financial performance at the p=0.05 level, respectively. The network resource (estimate=0.357) was only found to have a positive relationship with financial performance at the p=0.05 level, and the information equipment resource (estimate=0.186) was found to have a positive relationship with customer service performance at the p=0.1 level. The findings implied that liner shipping firms with high degree logistics resource services will have better firm performance. Accordingly, the H_2 was moderately supported in this study.

The final regression model (model 3a and model 3b) examining the relationships between logistics service capabilities and firm performance were also significant (adjust R^2=0.504 and 0.283, respectively) at the p=0.01 level. Results showed that service reliability capability (estimate=0.263), relationship building capability (estimate=0.184), and information integration and flexibility capability (estimate=0.408) were found to have positive relationships with customer service performance at p=0.05 significance level. However, only service reliability capability (estimate=0.305) had significantly positive effect on financial performance at p=0.05 significance level. This implied that the liner shipping firms with the better logistics service capabilities will have better firm performance. Based on the above findings, H_3 was moderately supported in this study.

5. Conclusion and Discussion

Logistics capability particular has been recognized as a crucial source to lead superior performance. This study has provided a framework for examining the effects of logistics service resources and logistics service capabilities on firm performance in the liner shipping context. The main findings of this study are summarized below.

The critical logistics service resources to the Taiwanese liner shipping firms were financial stability, corporate reputation, and low cargo damage or loss record. As regards logistics service capability, the critical logistics service capability attributes of liner shipping firms were courtesy of sales representatives, accurate price calculation, long-term contractual relationship with customers, and reliability of booking space. Factor analysis was employed to identify the key logistics service resource and logistics service capability dimensions. Results indicated that three logistics service resource were identified, namely, network resource, information equipment resource, and corporation image resource. The results are consistent with Lu's (2007) study. Four logistics service capabilities were identified, namely, value-added service capability, service reliability capability, relationship building capability, and information integration and flexibility capability.
A multiple regression analysis was subsequently performed to examine the effects of logistics service resources and logistics service capabilities on firm performance. Results of regression analysis revealed that corporate image and network resource both had significantly positive effects on service reliability, relationship building, and information integration and flexibility capabilities. However, information equipment resource was only found to positively influence information integration and flexibility capability. Results also showed that corporate image resource had significantly positive effects on shipping firms' customer service and financial performance, while network resource had a positive effect on financial performance. Accordingly, the findings imply that liner shipping firms with high degree corporate image and network resources can improve their logistics service capabilities and firm performance.

Service reliability capability was also found to have positive relationships with customer service performance and financial performance, while relationship building and information integration and flexibility capabilities were only found to positively relate to customer service performance. The findings suggested that logistics service capability had a positive effect on liner shipping firms' performance. More specific, liner shipping firms with better service reliability capability can improve customer service and financial performance. Above results are consistent with those reported in previous studies on logistics capability and performance (Zhao *et al.*, 2001; Stank *et al.*, 2003; Lai, 2004; Kim, 2006).

One of the major contributions of this study is that it is the first attempt to identify the crucial logistics service resources and logistics service capabilities in the context of liner shipping. Although several previous studies have evaluated critical service attributes for meeting shippers' requirements, few studies have investigated key logistics service resource and service capability for improving shipping firms' performance from the resource-based view. Secondly, this study treated resources independent from capabilities. Based on the results of regression analysis, logistics service resources had positive effects on logistics service capability and firm performance. The findings suggested liner shipping firms have to possess good corporate image and network resource for developing logistics service capabilities and improving firm performance. Finally, the logistics service capabilities were found to have positive effects on firm performance. Thus, to gain superior firm performance, liner shipping firms first have to develop service reliability capability.

From a theoretical perspective, the study results support use of the RBV and confirm it can provide a theoretical foundation for explaining the relationships among logistics service resources, logistics service capabilities, and firm performance in the liner shipping context. However, it suffers from several limitations. First, the differences in firm sizes, liner shipping firms may have different resources and capabilities. Therefore, future research could examine the effects of organization characteristics on logistics service resources and service capabilities. Another worthwhile direction for future research might be use of the strategic group concept to classified liner shipping firms into different capability oriented firms based on the aforementioned logistics capability dimensions. Such an approach might investigate strategic and operating differences among various firms within an industry (Porter, 1980; Lu and Marlow, 1999). Finally, the data was collected at one point in time and therefore the hypothesized relationships were examined in a static fashion. Longitudinal research could be employed to indicate how perceptions of key logistics service resources and logistics service capabilities change over time.

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A Study on Commercialization of R&D Projects in Port and Logistics Industry Case of Non-Stop Automated Gate System

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Abstract

The international business environment of port and logistics industry has been changed drastically in the last few decades. The increase of cargo volume due to globalization, advent of ultra-large container vessels, and improvements in cargo handling technologies created new requirements and resulted in fierce competition among the ports to become the hub port of their region. For this purpose, the ports are heavily investing in their infrastructure and operating systems to remain competitive, meanwhile a vast amount of research and development (R&D) projects and academic research are being carried on, most of which are government sponsored. On the other hand, there is a serious gap between the technology development efforts and actual commercialization of the developed systems. The real return on R&D cannot be fully realized if the systems are not commercialized. Hence this study proposes a model of commercialization of R&D outcomes which are developed in academic institutions under government sponsorship, by surveying related literature. The derived model is applied to the case of Non-stop Automated Gate System (NAGS), which is a typical government sponsored R&D project in port and logistics field, and the direction of commercialization was proposed. Finally the applicability of the model to other similar projects was discussed.

Keywords: Commercialization; Technology transfer; Academic research; Development

1. Introduction

Along with rapid globalization of the world economy and market opening, the importance of logistics industry is also steadily growing internally and externally, and also logistics volume is considerably increasing. To cope with increasing logistics volume, the environments of port logistics industry are also undergoing sweeping changes. Recently super container ships have emerged, and they usually call at hub ports, not visiting the other ports. In case of other small ports, small ships are carrying container cargoes. Accordingly, the hub and spoke system has been introduced to current logistics industry. Under this circumstance, major container terminals are making efforts to become a hub port, while lowering the hire of their harbors, improving their service level. At the same time, they are investing huge money in the introduction of spearhead technologies for harbor construction, loading/unloading equipments, and operating system. All these efforts focus on enhancing the efficiency and productivity of their ports.

Since sea ports are important factors of economic growth, governments are supporting port related research and development activities in order to increase terminal productivity. For example in Korea, the Ministry of Maritime Affairs and Fisheries (MOMAF) is promoting several research and development projects on intelligent port management systems. On the other hand, none of these systems have been commercialized yet, moreover previous academic study on commercialization of port related R&D projects.

Thus this paper aims to propose a method for commercialization of port related R&D projects focusing on the case of Non-stop Automated Gate System Technology Development Project.

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2. Theoretical Background

Previous studies on commercialization of R&D projects outcomes are diverse in characteristics. The study of Chung *et al.* (1998) derives several recommendations for government-sponsored telecommunications R&D in Korea by analyzing the case of TDX. Being a digital switching system, development of time division exchange was carried out in different cycles, and the paper proposes that the commercialization strategies must vary with development cycle. Along the paper, commercialization is divided into four categories, namely 1) technology-driven commercialization; 2) new market-driven commercialization; 3) product and process improvement-driven commercialization; and 4) end-game commercialization. Government-sponsored commercialization should fall in one of these categories.

Brown *et al.* (1991) classified technology transfer strategies of commercializing government-sponsored technologies into six categories: 1) contracting R&D to industrial partners; 2) working with industrial consortia; 3) licensing to industry; 4) influencing key decision makers; 5) working with broker organizations; and 6) generating end-user demand. It is also stated that contracting to industrial partners is the most frequent strategy

The study of Span *et al.* (1995) derives the measures of technology transfer effectiveness. In this paper technology transfer is defined as defined as the managed process of conveying a technology from one party to its adoption by another, and it is stated that a wide variety of descriptions and models of the transfer process has been developed but these reflect a lack of standardization and agreement about technology transfer processes, outcomes, and measures. The paper derives a framework for several measures of effectiveness according to transfer strategy (i.e. technology push vs. technology pull) and transfer models (i.e. Political Model, Out-the-Door Model, Opportunity Cost Model for push strategies and Market Impact Model and Economic Impact Model for pull strategies). The details of these models will be given in the next chapters.

The study of Capps and Fairley (2003) proposes a systematic approach to planning technology transfer campaigns, called PRISM. The methodology consists of five steps:

(1.) Pre-qualify the innovation, such as business justification.
(2.) Represent the composition of sub-audiences, since managers in different levels may have different characteristics for communication.
(3.) Investigate values and assumptions of each sub-audience with respect to the innovation, including relative advantage, complexity, compatibility, triability and observability.
(4.) Sensitivity analysis of innovational attributes to probe for areas of uncertainty, and finally
(5.) Mitigate risks by selecting an appropriate mix of engagement models, training modes, and success models. Engagement models characterize how to communicate with the recipients about the innovation, whereas success models help to set realistic expectations and manage sponsor and stakeholder relationships.

The study of Hayes and Fitzgerald (2006) argues the importance of argumentation methods in commercialization of hybrid R&D where both academic and industrial players are involved. The paper indicates that argumentation characteristics of researchers tend to be creative and to improve ideas continuously, and not to be timed, whereas argumentation characteristics of business people tent to be action-oriented, to be timed, and to be managed to a definite conclusion. Also dissent is considered as good, constructive and value in research field, whereas it is considered as a threat to group cohesion in business field. Since commercialization activities combine the discoveries of one occupational group, such as scientists, with the commercial skills of engineers and managers, bringing innovative ideas to emerging or established markets involve interactions across occupational cultures.

The study of Walsh *et al.* (2002) focuses on the differentiating market strategies of disruptive and sustaining technologies, where sustainable technologies are the ones that sustain the current manufacturing practices and technological capabilities required in an industrial setting whereas disruptive technologies are the ones that disrupt the current capability set required by a given market.

The paper proposes user application types “creative destroying” for technology push strategies and “replacement or substitute” for market pull strategies for disruptive technologies, and “new or major improvement” for technology push strategies and “replacement or substitute” for market pull strategies for sustaining technologies. Moreover, it is suggested that disruptive technologies may better be commercialized by smaller firms by a commercialization strategy is to seek an entirely new set of customers to adopt the firm’s proprietary technology as a replacement or enhancement to the existing products of the dominant firms in an industry; in this way, new firms can build a customer base rather quickly.

The study of Swasdio *et al.* (2004) focuses on the commercialization of technologies developed in public R&D institutes. The paper introduces linear view of commercialization, consisting of the steps 1) R&D 2) Product Development and Engineering 3) Product and marketing 4) incremental R&D, and segment view of commercialization, that consists of the steps 1) Imagining 2) Incubating 3) Demonstrating 4) Promoting and 5) Sustaining. In this paper a development model for each step is proposed and the commercialization activities in an organization in Thailand are evaluated on the basis of the model.

The study of Geisler and Kassicieh (1997) focuses on the use of information technologies in technology commercialization and proposes the use of several information technologies, such as Group Decision Support Systems (GDSS’s), Electronic Meetings, Computer Networks for Technology Transfer and World Wide Web. The paper proposes that main barrier of technology transfer is the cultural differences between federal laboratories and industry, thus the stages of technology transfer, i.e. idea initiation, development, and commercialization should be a participative effort between the R&D organization and the potential user.

The study of Birchall (2007) compares the relations of large companies, small and medium companies and spin-outs with universities. The study points out that there are several barriers for SME-university collaboration, whereas university spin-outs have the potential to overcome many of these barriers.

The study of Buckley (1996) focuses on the concept of Technology Commercialization Center. Such a center is based on the fact that successful technology commercialization depends on the quality and accessibility of markets, technology, business management, and sources of capital, thus it connects related parties each other for successful technology transfer.

Upon the previous literature above, a model for the commercialization of NAGS is developed as follows. The first step of commercialization should be re-qualifying and assessing the product whether it fits the requirements of the user (Capps and Fairley, 2003). This process must precede every step in the commercialization efforts since commercialization of any technology that is not business justified would not be reasonable. The second decision is to be made is whether the technology is to be transferred to an industrial company or directly commercialized through a spin-out. In case of spin-outs, basic concern is necessary financial and human resources. But in case of technology transfer, a more complex approach is necessary. The derived technology transfer is given in Figure 1.

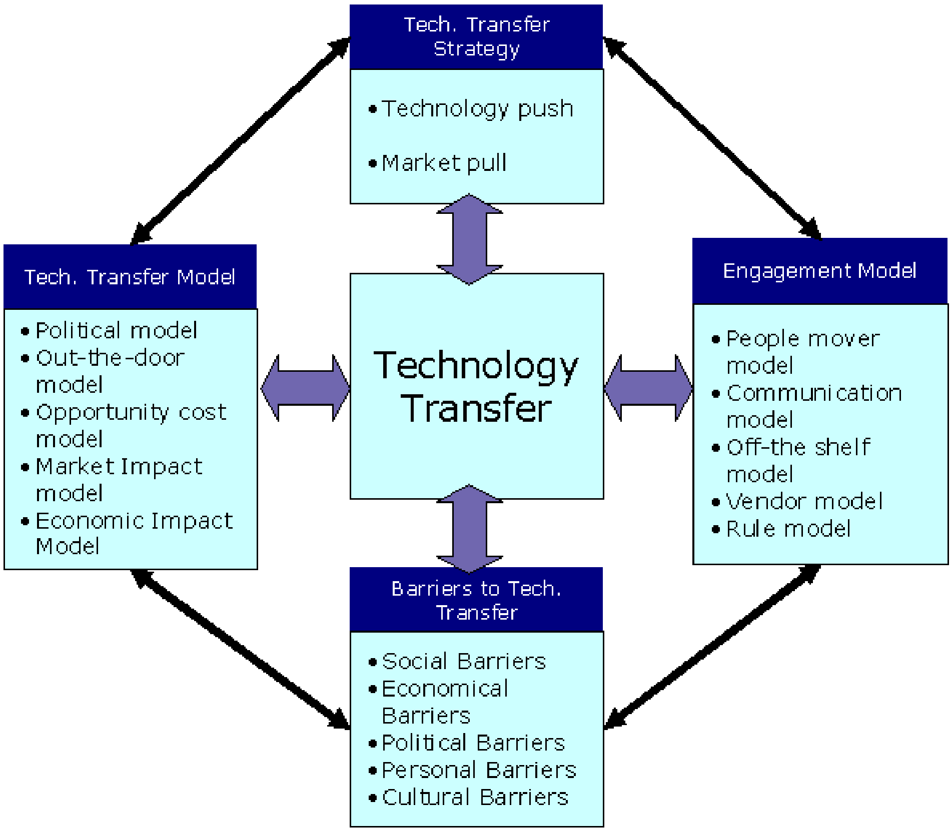

Figure 1: Technology Transfer Model - Basic logic of information systems in Kumport

Technology transfer strategies can be classified into two major groups. The first one is *technology push,* where the main idea behind technology developed in the universities or research labs are not the fulfillment of user demand but the development of the most advanced system (Chung et al, 1998). But in *market pull* strategies the source of innovation is deemed to come from the recognition of potential customer demand (Walsh *et al.*, 2002). After determination of the strategy, a technology transfer model must be selected. There are several transfer models that can be applied according to the characteristics of the product. Spann *et al.* (1995) indicates three models, namely Political Model, Out-the-door Model and Opportunity Cost Model for technology push strategies, and two models, namely Market Impact Model and Economic Impact Model for market pull strategies. Among them Out-the-door Model is the easiest one to measure since it only deals with whether the technology is transferred or not, the impact is ignored. On the other hand, Political Model concerns about the satisfaction of key stakeholders and sponsors, whereas Opportunity Cost Model deals with the effective utilization of limited financial and human resources. In the case of market pull strategies, Market Impact model concerns about the impact of the new model within the organization, either as change in behavior improvement in the competitiveness of thee organization, or the whole nation as well (Capps and Fairley, 2003; Spann *et al.*, 1995).

Another set of technology transfer models has been proposed by Ruttan and Hayami (1973) which distinguishes three phases of international technology transfer: material transfer, design transfer, and capacity transfer where licensing agreements and franchises are two practical examples of capacity transfer.

Since academicians and business experts have different debating styles (Hayes and Fitzgerald, 2006) the model of engagement is important to convey information and knowledge related to technology transfer. Zelkowitz (1996) offers four models, namely the People-Mover Model, the Communication Model, the Off-the-Shelf Model, and the Vendor Model. Among them, the People-Mover Model is the most effective one since the change agents deal directly with the prospective users. Others are based on publications, packaging with existing systems and indirect marketing through a vendor, respectively. In addition to these, the Rule Model given in Capps and Fairley (2003) proposes to change by fiat by compelling recipients to adopt and accept responsibility for the infused technology.

One final concept for technology transfer is the barriers to technology transfer. Johnson *et al.* (1997) proposes five barriers, namely social barriers, political barriers, economic barriers, personal barriers and cultural barriers to overcome for successful technology transfer.

3. Non-stop Automated Gate System (NAGS)

As a part of the Intelligent Port Logistics System Technology Development Project, Non-stop Automated Gate System Technology Development Project aims to develop an automated gate system for container terminals that can perform identification, confirmation, security and information delivery tasks without requiring the truck to stop at the gate. The project is supported by MOMAF for four years, from 2004 to 2008. In the first year, requirements for automated gate system were determined and a roadmap for technology development was composed. On the basis of this roadmap, RFID and OCR-based vehicle and container identification systems were developed. In the second year, Digital Media-based information delivery system and ACDI-based container damage confirmation system were developed. Finally, in the fourth year, system integration and commercialization is aimed.

The system consists of RFID-based vehicle and container identification system, OCR-based vehicle and container identification system, Digital Media-based information delivery system and ACDI-based container damage inspection system. The system is also designed to support several other functionalities, such as electronic container seal check, to meet the customer demands. In this section, the basic functions of NAGS will be introduced briefly.

3.1 Identification System

Identification tasks at a container terminal gate include the identification of vehicle numbers, container numbers, chassis numbers, and drivers. Conventional gate systems utilize various techniques to accomplish identification tasks, starting from direct visual identification of the gate clerk. The later systems involve closed circuit cameras, interphone systems, and identification of drivers through ID cards, based on barcode, magnetic or RF technology. But all these techniques takes long processing times and require the vehicle stop at the terminal gates, which may actually cause congestions at peak hours. On the other hand, utilization of automated recognition of vehicle and container numbers through processing digital images (OCR) is rapidly gaining ground for gate automation systems, but OCR-based systems suffer from severe misinterpretation problems.

NAGS provides a combination of radio frequency identification (RFID) and optical character recognition (OCR) systems for identification tasks in container terminal gates. The system utilizes 900 MHz passive RFID technology for vehicle identification and 433MHz active RFID for container identification. The vehicle and container numbers are also identified by OCR for cross-checking. The combination of RFID and OCR is expected to yield approximately 100% identification rates.

3.2 Information Delivery System

Information delivery tasks involve passing necessary operational information, such as location of the container in the yard, or what to do when there is a problem, to the truck driver. These tasks are very difficult to perform without information systems, since elaborate connection is needed with planning and operating system of the terminal. The early systems dealt delivery of such information by gate clerks, directly of via interphone system. The conventional systems print such information on paper. But these systems are not time efficient and require the vehicle at the terminal gates.

NAGS proposes an information delivery system through wireless communication devices, so that vehicle drivers are able to get related information on the move. The system supports various communication modules, such as SMS messages, LED display panels, and a vehicle-mounted exclusive terminal which is designed for this purpose. The equipment is called u-SLIP, and provides all necessary information through 2.45 GHz wireless communication.

3.3 Container Damage Inspection System

Container damage inspection is an essential task, since terminal gates are the points where the responsibility of the cargo is transferred from the trucker company to the terminal management. Thus an unidentified damage at the gates may result in future customer claims. Today, most terminals perform these inspections manually. Some terminals deploy line scan cameras or high-quality cameras to take and store the picture of the container if there is a future claim. On the other hand, two-dimensional images may not be sufficient to detect the damage if the damage had occurred in the third dimension.

Thus, NAGS proposes an automated container damage inspection (ACDI) system. ACDI is based on the logic that the containers are scanned by laser detectors while they are passing through the gate. The laser scan forms the three-dimensional image of the container surface and any deviation from the original shape of the container is detected as damage.

3.4 Integrated Gate Management System

Integrated Gate Management System is the application program that links and controls the sub-modules of NAGS. It enables the monitoring of all gate operations via user friendly interface and controls the data transfer between NAGS and terminal operating system (TOS). It supports variety additional features as plug-ins to satisfy user demand.

3.5 Additional features

Besides these basic functions, NAGS is designed to support various technologies at the container terminal gates, upon the demand of the terminal operators. Since the system is developed in a modular manner, the customers can deploy the whole integrated system or any individual system depending on the customer needs and terminal conditions. The additional techniques supported by the system cover e-Seal identification, vehicle and container weighing systems, barcode based identification systems, SLIP printers, connection with TOS and several network extremities, such as hand-held terminals.

3.6 The expected effect of the system

The most obvious characteristic of the system is using RFID and OCR in a hybrid form for both vehicle and container identification, while previous systems intent to use RFID for vehicle identification and OCR for containers, separately. By doing this, one hundred percent identification rates are expected, since the systems can cover each other in case of identification failures. In addition to this, NAGS replaces time consuming paper printers with digital information formats, such as LED display panels or SMS messages to cellular phones. NAGS even offers an exclusive terminal for this purpose. On the other hand, the customers do not require to adopt the system as a whole, the modules of the system can be adopted separately and can be integrated to other conventional systems, depending on the demands of the customers.

The developed system has various merits over the conventional gate systems. These merits cover controlling the entrance of unauthorized vehicles and drivers, reinforced cargo security, easiness of container information management, supplying the gate managers with statistical information about the gate operations, increasing the gate productivity by decreasing processing time at the gate under 10 seconds, and decreasing gate operational expenses, including labor fees and maintenance costs.

4. Developing a Commercialization Strategy for NAGS

For the privacy of the involved parties, the pseudonyms of the major stake holders that are used in this paper and their roles are given in Table 1.

Table 1: Pseudonyms used in this paper

Pseudonym	Role
Gatekeeper (Zelkowitz, 1996)	The academic institution, either university or a public research center that develops the system to be commercialized.
Change Agents	The researchers within the gatekeeper
Sponsor	The public organization that sponsors the research.
End user	Private enterprises that are probable to adopt and use the developed system, such as container terminals, inland depots, parking lots
Vendor	Private commercial companies that have direct access to market and experience in commercializing similar products

For successful commercialization of NAGS technology, we envisage an appropriate mixture of the models given above. First of all, direct commercialization of the system through a university spin-out is not considered as an option, since neither the sponsor nor the gatekeeper support the necessary fund for such venture. Thus, the commercialization efforts for NAGS will solely focus on technology transfer. Both direct and indirect transfer methods will be used. Direct transfers involve in licensing and cooperative researches, whereas indirect transfers are exchange of knowledge through meetings, publications and workshops (Abramson *et al.*, 1997). For this purpose, NAGS development team has published a number of journal papers, and attended several conferences, exhibitions and workshops throughout every step of the development process.

In the case of NAGS, there are two major barriers for transfer, namely economic and political barriers. The political barriers are mainly related to the rules of MOMAF that gives transfer priority to the companies that involve in the development project. Besides, the economic barriers are related to the big amount of transfer costs. In order to overcome the economic barriers, a market pull strategy is considered to be more appropriate in the beginning. A small number of domestic end users that demand gate system proposals would be easier to approach. After establishing a reliable reference site for the system, technology push strategies can be used to push the system to other domestic and foreign terminals.

On the basis of Opportunity Cost Model, a two-phase technology transfer process is offered, and the transfer of NAGS would be best realized through a vendor in order to make best use of limited resources and funds. Thus in such a model, a primary transfer would be from the university to the vendor and a secondary transfer would be from the vendor to the end user. (Fig. 2) According to the classification of Ruttan and Hayami, the primary transfer would be a capacity transfer, i.e. all know-how about the system will be transferred so that the vendor can produce and sell the system by itself, whereas the second one would be a material transfer which involves the transfer of the system only to be used by the end user.

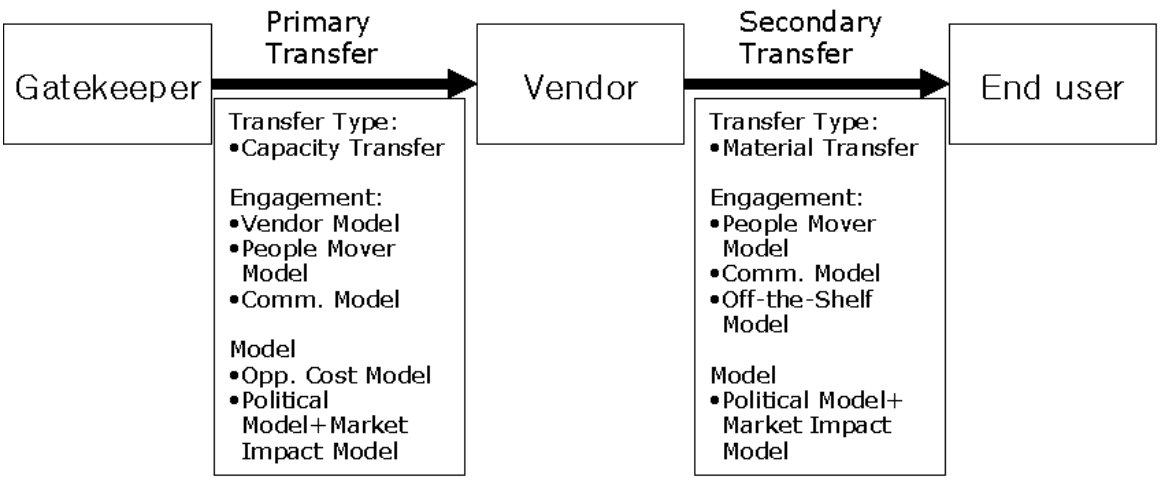

Figure 2: Proposed Commercialization Model For NAGS.

The success of the technology transfer is deeply related with the efficiency of the communication channels between the involving parties. For this reason, a mixture of engagement models will be used, except for Rule Model.

- **Between the gatekeeper and the vendor:** Limited number of domestic vendors that are trying to respond the gate system requests of the limited number of domestic terminals, is determined and directly contacted for information exchange by the change agents. As People Mover Model, which is proved to be the most effective, yet the most resource-consuming method for engagement, is selected since approaching the limited number of terminals and vendors in Korea can be achieved within the given human and financial resources.

- **Between the gatekeeper and the end-user:** As mention above, Vendor Model is quite appropriate for the system to be transferred due to efficient utilization of limited resources. Thus the gatekeeper does not intent to involve in direct marketing activities. On the other hand, it tries to support the vendor by indirect transfer methods, such as conference presentations, holding seminars and workshops and attending international fairs for transferring the NAGS related information to a wider audience, as offered by Communication Model.

- **Between the vendor and the end-user:** Various methods can be used to facilitate technology transfer, thus the vendor should prepare a marketing strategy by combining various models. The modular characteristic of the system makes it suitable for Off-the-shelf Model, i.e. the more innovative parts of the system, such as RFID, Digital Media and ACDI, can be easily commercialized by combining with more conventional systems as a package, such as OCR, barcode identification or paper SLIP printers, in order to increase the reliability of the system perceived by the end-user. The composition of the package can be customized according to the requirements of the end user.

The success of the transfer can be measured through a mixture of Political Model and Market Impact Model, in which a successful technology transfer would satisfy each of all the corresponding stakeholders and have positive behavioral and economical impacts on them. The impact of the transfer on the vendor can easily be measured through its profitability. Similarly, the impact on the end user can also be measured through increased gate productivity (behavioral impact) and decreased operational costs (economic impact). On the other hand, the impact on the sponsor is relatively difficult to measure in a short time period. The main concern of MOMAF would be increased competitiveness and market share of Korea in international port system market, which would require long term measurements for future decision making.

5. Evaluation of the Derived Model

In order to validate the derived model, an expert council consists of responsible managers of container terminals and SI companies in Korea, was set up. A meeting with council members was held in January, 2008. During the meeting, the experts were informed about the developed system and derived commercialization model. After the meeting, the members of the expert meeting were given a structured questionnaire to evaluate several aspects of the commercialization model based on 7-point-scale. The results of the questionnaire are given in Table 2.

Table 2: Evaluation results

Question	Mean (over 7)	Standard Deviation
1. Commercialization considered as technology transfer instead of spin-out.	5.333	1.155
2. Transfer strategy as market pull strategy	5	1
3. Splitting the transfer into two phases	5.333	1.155
4. Selection of the vendor as the one appointed to provide gate systems for development of a domestic terminal	4.667	1.528
5. Using a vendor in order to overcome limited resources of	5.667	1.155

	the gatekeeper		
6.	Selection of domestic container terminals as end-user	7	0
7.	The gatekeeper to refrain from direct marketing	3.667	2.887
8.	The gatekeeper to support vendor by presentations, publications, workshops, seminars, etc.	5.333	0.577
9.	Combining the newly developed systems with conventional systems as a package	4.333	1.155
10.	Measuring the satisfaction of each stakeholder to evaluate the success of the transfer	4.667	2.309

As it is seen in the table, the responds of the experts are consistent with the offered scenario with relatively small standard deviations. Except for the seventh question, where the evaluators agreed that even the gatekeeper should also participate in the direct marketing activities like the vendor.

6. Conclusion

In this research, a model of commercialization for government supported R&D was derived from previous studies and a commercialization plan was offered for Non-stop Automated Gate System, which is a product of government supported R&D project, on the basis of the derived model. According to the results, NAGS can be best commercialized through transferring developed technology through a vendor. The vendor can make use of the demands of newly developed terminals in Korea, and then push the technology to other foreign terminals by referencing the successful cases in Korea.

The derived model indicates methods for measuring success through satisfaction of each stakeholder and it can be applied to commercialization of projects in various fields, especially in port logistics systems. It is also expected to shed light on future government supported R&D projects, starting from the projects of MOMAF that are in progress along with NAGS.

Acknowledgements

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Study on Evaluation of Regional Logistics System

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Abstract

Regional Logistics, which is the basic industry of regional economy, is the mirror of the level of regional economy development. Scientific evaluation method is of great significance. Basis on the demand/supply of regional logistics and DEA method, which are the original driving forces and internal factors of regional logistics, this paper starts a new direction, which is different from the majority studies at present. This will not only give a more scientific evaluation to the level of regional logistics, but will also contribute to the analysis of the growth mechanism of regional logistics and its relationship with regional economy.

1. Introduction

At present, economic integration, regionalization is the great evolution trend of economic development. As an important function subsystem of economic system, logistics which plays a very important role in the regional economy, has been endowed with a series of important missions ,such as enhancing business / regional core competitiveness, improving the investment environment,etc. Promoting and facilitating the development of regional logistics has become a popular issue of economic work in Domestic, while it is one of the key links to understand and evaluate the development of regional logistics system.

Evaluation of logistics system is comparatively a concerned research field on the circle of present domestic theory. Some scholars have used some methods to evaluate the level of logistics, such as principal component analysis, SWOT analysis, AHP. This methods are mostly focused on the choice of evaluation index and the description of the basic situation of logistics. They are failed to reflect the interaction mechanism and adaptation degree between regional logistics and regional economics. This paper reflects level of regional logistics system basing on the interactive relationship between the logistics development and economic growth, exploring to use DEA method to set up models of regional logistics supply and demand, and trying to reflect the level of regional logistics system by the comparison between supply capability and demand level.

2. Concept and Characteristics of Regional Logistics System

There has not a unified definition yet about to concept of regional logistics in the academic circles. The more identical view holds that regional logistics is the sum of logistics activities which are associated with geographical environment of regional economics. Regional logistics system can be interpreted as defining the regional logistics with the systematic view, namely: it is a organic connected synthesis which is conformed with related logistics elements for the purpose of servicing human activity. The angle of broad sense, all logistics activities having contacts with human activity should all include in the category of logistics system; the angle of narrow sense, with the purpose of meeting economical operation's needs regional logistics system is, have prominent economic attribute. Therefore, regional logistics system should follow the efficiency constraint for economic resource distribution, which is optimizing organization structure of regional logistics system, improving operational efficiency and decreasing regional logistics costs.

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3. Summary of DEA method

Data envelope analyzes (DEA) is developed on the concept of relative efficiency by American famous operations researcher A. Charles and W.W.CooPer etc. It is a new efficiency evaluating method fused multi-disciplinary such as mathematics, operations research, mathematical economic and management science etc.

The DEA method may regard as the multi-objective decision making method dealing with the multi-input-output issue. Its principle is comparing the relative efficiency of decision-making unit (DMU) by using mathematical programming model. The DEA method based on the actual decision-making unit (DMU) of some production system sets up on the concept of "Pareto optimal" of DMU. Mainly according to keep the inputs or outputs of DMU invariant, it takes each unit to be assessed as a DMU, then colony to be assessed is made up of many DMU. According to analyze comprehensive the ratio of inputs and outputs, the DEA method takes the weight of each index of inputs and outputs as variable to evaluate and calculate, in order to determine "effective production front side". Then based on the distance status between each DMU and effective production front side, to determine each DMU is DEA-effective or not. At the same time, the reasons of DMU that is non-DEA-effective or weak -DEA-effective, direction and degree to improve, can be pointed out by using projection method.

The comprehensive efficiency quantitative indexes of each decision-making unit (DMU) can be gotten by DEA method. Based on the quantitative indexes, it can be to determine the DMU effective or not, point out the reason and degree of non-effective, provide the management and the policy-making basis to the relevant department. At present, the DEA method has been applied widely in each research area and it is one of the extremely effective methods to research the problems such as performance evaluation, nonparametric determination of the production function, multi-criterion decision-making etc.

4. Interactions Between Regional Logistics and Regional Economy

There are two main viewpoints about the interactions between regional logistics and regional economy. One view thinks that economic growth pulls the development of logistics; another is that logistics development promotes the economic growth.

The first view thinks: 1) the development of regional logistics lags behind economic growth, economic growth is the reason for the logistics demand, the actual amount of logistics activity is eventually determined by the scale of economic activitics;2)the level of regional logistics development determines the development of regional logistics[2].

The second view analyses the promotion of improvement of regional logistics environment on regional economy from several different aspects, For example: theory of the Division of Labor in Economics, theory of uneven development and growth pole in regional economics, and so on. At present, some domestic scholars analyze the promoting effects of regional logistics on economy with quantitative technologics such as system dynamics, regression analysis, and elastic coefficient[3].

The following are new analysis on relationship between regional logistics and regional economy:

Logistics activity and economic activity are two subsystems in the regional economy system; they are both mutual action and influence.

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[2] Liu Nan (2007):"Interaction between Logistics Development and Economic Growth in China". *Journal of Industrial Engineering and Engineering Management* 1, pp.151-153

[3] Sun Ying (2006): "Study on the appraisal of the logistics operation efficiency of the third party on the basis of DEA", *Commercial Economics Review* 5, pp.45-47

Logistics development and economic growth are interrelated and coexisted.

Considering the evolution of systems from dynamic perspective, although there is a gap in time between the development of logistics subsystem and economic subsystem, they have same development direction. In addition, as the producer services, modern logistics has more closely combination with regional economy system. This makes a further improvement of their interactions.

Based on these, there is no practical significance if we discuss the development of regional logistics system discarding the demand of regional economic development. In some areas of China only pursuit modernization, information, automation in Logistics Activities regardless of actual situations. This increases the logistics cost, decreases logistics system efficiency and even hinders the economic development.

Following the occurrence mechanism of logistics, this paper introduces regional logistics supply and demand to analyze the adaptation degree between regional logistics and regional economy. Through this analysis we can weigh and evaluate the level of regional logistics.

5. Analysis of Model Application

The supply and demand state of the regional logistics system can be determined by analyzing and comparing the relation between RLSI and RLDI. The model can be analyzed concretely in the practical application by setting rational supply and demand fluctuation a based on the association degree of regional economy and logistics system.

5.1 Basic definitions

1) Regional Logistics Supply (RLS) means the total amount of social public logistics service which can be offered during a specified period of time in particular area.

2) Regional Logistic Demand (RLD) means the demand of logistics service in a regular period, under certain price level, the social economic activity subject needs for meeting production, managing, consuming in some particular area[4] [5].

5.2 Model parameters

Introducing regional logistics supply index and regional logistics demand index to weigh the relation between regional logistics supply and demand[6].

(1.) Regional Logistics Supply Index (RLSI)
RLSI is used to measure the state of logistics service quantity that logistics system offers during a specified period of time; it reflects the supply ability of logistics system. The calculation formula is:
RLSI=Supply ability of present logistics system/logistics amount that logistics system finishes at present

(2.) Regional Logistics Demand Index (RLDI)
RLSI is used to measure the state of logistics amount which the social economic system demands; it reflects the potential demand for the logistics of the social economics. The calculation formula is:

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[4] Wang Li-fang: "Research on the Method and Model of Adaptability Evaluation of Road Transportation to the Development of National Economy ", Jilin: Jilin University.
[5] Wei Ji gang (2006): "Logistics Demand and Supply", China Logistics & Purchasing
[6] Wang Bo (2005): "Comprehensive Evaluation of Regional Logistics Development", *Industrial Engineering Journal* 1, pp.83-93

RLDI= Potential logistics demand that present social economy produces/ logistics amount that logistics system finishes at present

5.3 DEA Model

(1.) Regional logistics system

Regarding regional logistics system as a production system as the concept of the production function in economics, it inputs production factors (for instance: transport vehicle) and outputs logistics amount (for instance: freight volume)

Supposing logistics system is formed by n subsystems, the amounts of input/output factors are m/n. The total amount of input is (1):

$$X = \left(X_1 \quad \cdots \quad X_i \quad \cdots \quad X_n\right)^T$$

$$= \begin{pmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{pmatrix}, \begin{matrix} i = 1 \cdots n \\ j = 1 \cdots m \end{matrix} \qquad (1)$$

The total amount of output is (2):

$$Y = \left(Y_1 \quad \cdots \quad Y_i \quad \cdots \quad Y_n\right)^T$$

$$= \begin{pmatrix} y_{11} & \cdots & y_{1s} \\ \vdots & \ddots & \vdots \\ y_{n1} & \cdots & y_{ns} \end{pmatrix}, \begin{matrix} i = 1 \cdots n \\ l = 1 \cdots s \end{matrix} \qquad (2)$$

The input /output of subsystem i is $\left(X_i, Y_i\right)$.For input/output of logistics system reflecting regional logistics supply index (RLSI), RLSI of subsystem i can be got by Output-DEA Model. The model is fowling:

$$\min \frac{V^T X_i}{U^T Y_i} \qquad (3)$$

$$s.t. \frac{V^T X_j}{U^T Y_j} \geq 1, j = 1, \cdots, n$$

$$U \geq 0, V \geq 0$$

$V = \left(v_1, \cdots, v_m\right)^T$ ---- weight coefficients of input factors

$U = \left(u_1, \cdots, u_s\right)^T$ ----weight coefficients of output factors

This model is fractional programming model. Making it linearized and adopting the antithesis theory, we get the following linear antithesis model.

$\max \theta_i$

$$s.t.\sum_{j=1}^{n} X_j \lambda_j \le X_i \quad (4)$$

$$\sum_{j=1}^{n} Y_j \lambda_j \ge \theta_i Y_i$$

$$\lambda_j \ge 0, j = 1, \cdots, n$$

λ_j ----weight coefficients that reflect economic and technical characteristics;
θ_i ---- $RLSI$ of subsystem i.
$RLSI$ Of the whole regional logistics system is:

$$RLSI = \sum_{i=1}^{n} \theta_i Y_i \Big/ \sum_{i=1}^{n} Y_i \quad (5)$$

(2.) Regional economic system
Regarding the economic system as a consumption system, it inputs logistics amount and outputs income of the economic department.
The total amount of input is:

$$Y = \begin{pmatrix} Y_1 & \cdots & Y_i & \cdots & Y_n \end{pmatrix}^T$$

$$= \begin{pmatrix} y_{11} & \cdots & y_{1s} \\ \vdots & \ddots & \vdots \\ y_{n1} & \cdots & y_{ns} \end{pmatrix}, \begin{matrix} i = 1 \cdots n \\ j = 1 \cdots s \end{matrix} \quad (6)$$

The total amount of output is:

$$Z = \begin{pmatrix} Z_1 & \cdots & Z_i & \cdots & Z_n \end{pmatrix}^T$$

$$= \begin{pmatrix} z_{11} & \cdots & z_{1p} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{np} \end{pmatrix}, \begin{matrix} i = 1 \cdots n \\ l = 1 \cdots p \end{matrix} \quad (7)$$

Regional logistics demand index (RLDI) also can be got following the above method. The model of RLDI is :
$\max \theta'_i$

$$s.t.\sum_{j=1}^{n} Y_j \lambda_j \le Y_i \quad (8)$$

$$\sum_{j=1}^{n} Z_j \lambda_j \ge \theta'_i Z_i$$

$$\lambda_j \ge 0, j = 1, \cdots, n$$

θ'_i ---- RLDI of subsystem i

$RLDI$ Of the whole regional logistics system is:

$$RLDI = \sum_{i=1}^{n} \theta'_i Y_i \Big/ \sum_{i=1}^{n} Y_i \tag{9}$$

6. Analysis of Model Application

The supply and demand state of the regional logistics system can be determined by analyzing and comparing the relation between RLSI and RLDI. The model can be analyzed concretely in the practical application by setting rational supply and demand fluctuation a based on the association degree of regional economy and logistics system.

(1.) If $RLDI/RLSI < 1$, then supply capacity is less than potential demand capacity of regional logistics. The level of logistics system cannot meet the effective demand of the regional social and economic development.

(2.) If $1 \le RLDI/RLSI \le 1 + a$, then the supply and demand of regional logistics reach balanced state. The supply of regional logistics system meets the demand of regional social and economic development.

(3.) If $RLDI/RLSI > 1 + a$, then supply capacity is more than demand potential of regional logistics. It needs to analyze again. The possibilities include the throughput of regional logistics system existing idle, the spillover of regional logistics service capacity.

Furthermore, the supply capacity and potential demand of regional logistics system can be solved by $ALSI$ 、 $ALDI$. Current regional logistics efficiency status can be attained by comparing the supply capacity and potential demand with the practical completed logistics amount of current logistics system. It can be used as the basis for related logistics decision-making.

7. Conclusion

According to the original driving forces and internal factors of the regional logistics--- logistics demand and supply, the paper introduces regional logistics demand/supply index and designs theoretical model using DEA method. Then it analyzes the state between supply and demand of the regional logistics, confirms the development level and efficiency state of the regional logistics. Studying the level of regional logistics by logistics demand/supply , will not only give a more scientific evaluation to the level of regional logistics so as to definitude its improvement and development direction , but will also contribute to the analysis of the growth mechanism of regional logistics and its relationship with regional economy.

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Maintaining Efficiency with a Multi-level Warehouse Design

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Abstract

AAT has one of the latest and biggest air cargo terminals in the region, further anchoring Hong Kong's position as a leading cargo hub. Completed in Dec 2006 and costing HKD1.75 billion, it has the capacity to handle 910,000 tons per year. Confined by land restrictions, yet with the need to meet demand for growth in the next 12-15 years, AAT overcame this by building a multi-level warehouse making use of the latest equipment, innovation in operation work design and IT. Within its first year of operation, AAT has seen much improved service standards and even higher satisfaction levels among terminal users. This paper discusses the details of key factors that contribute to the efficiency of a multi-level warehouse, traditionally thought to hamper smooth operation.

1. Background of AAT

Asia Airfreight Terminal (AAT) operates one of the most comprehensive, quality driven air cargo terminals in the world, and serves the world's leading airlines. It started operations in Hong Kong on July 6, 1998, the same date as the inception of the present Hong Kong International Airport. Prior to this, there was only one air cargo terminal operator at the old Kai Tak Airport. With the purpose of maintaining Hong Kong's competitiveness and position as a major global air cargo hub, Airport Authority Hong Kong (AAHK) decided to issue a second franchise to operate a cargo terminal at the new Chek Lap Kok airport.

AAT provides a complete range of service, from physical cargo handling to documentation processing. AAT has successfully increased its international airline client base over the last 10 years from 12 to 32, with present customers including FedEx, Singapore Airlines, Lufthansa, United Airlines and Qantas Airways.

The first cargo facility was a single level cargo terminal, built at a cost of HK$1 billion with a capacity to handle 600,000 tons of cargo a year. AAT's tonnage throughput has grown remarkably with a near 53 percent jump between 2000 and 2005 to almost 579,000 tonnes. As AAT saw steady growth over the years, AAT proceeded with plans to expand its facility to satisfy the demands of the market. On 26 Dec 2006, AAT's new four-level Terminal 2 costing HK$1.75 billion went into operation, increasing its handling capacity to 1.51 mil tons a year. Operations at the new facility have gone into full swing since February 2007.

2. Projection for Growth

AAT's decision to develop a second terminal highlights the confidence of success and growth of Hong Kong International Airport (HKIA), both generally as a major global air cargo hub and more specifically as a leading gateway for Mainland China.

In establishing a business case to expand the terminal, the Strategic Overview of Major Airport Development (SOMAD) Study commissioned by Airport Authority Hong Kong in 2001 was a key reference in forming the basis of tonnage growth projection. HKIA's projected cargo growth was 6.1% p.a. (2000 - 2009), 5.1% p.a. (2010 - 2019) and 4.2% p.a. (2020 - 2040). A few factors were considered in 2003 when adopting the growth projection.

According to Boeing's forecast, world baseline cargo was expected to grow at an average of 6.4% up to

2021. Intra-Asia (which includes Hong Kong) will grow the fastest on Asian markets, averaging 8.4% growth per year, while the Asia-North America and Europe-Asia markets will expand at average annual rates of 7.5% and 7.0%, respectively.

Based on the above positive outlook on the cargo market, Hong Kong was deemed to be well poised to record strong growth in the future for the following reasons:

2.1 Strategic location

Hong Kong is strategically located as a global aviation centre with about 50% of the world's population within 5 hours' flying time. It also has a shorter flight distance to Europe and USA compared with Singapore or Bangkok.

Its extensive aviation network both within Asia and with Europe and USA is a strong attraction to importers and exporters. This is especially so with the emergence of south China region as a global exporter. Because of the political climate, Hong Kong has emerged as a link point for cargo movements between China and Taiwan.

Hong Kong is well placed as the key gateway to Mainland China to tap the manufacturing powerhouse of China, which holds enormous economic promise, notwithstanding the SARS epidemic in 2003.

Hong Kong's strategic location will place HKIA in good stead to leverage on the Pearl River Delta's ("PRD") strong manufacturing base, to continue to attract cargo and passenger traffic from the PRD region through HKIA.

2.2 Strong infrastructure backbone

Hong Kong has an extensive network connection, with direct air links to over 140 cities worldwide, including 42 in the Chinese Mainland[1].

The opening of the Marine Cargo Terminal ("MCT"), which links the airport with some 20 ports in the PRD, served to further enhance and boost HKIA's integrated multi-modal transportation system.

The development of bonded trucking, which offers seamless air-road inter-modal transport link between Hong Kong and Guangzhou, is expected to make HKIA more attractive as a regional air cargo hub.

The complementary/supporting sectors which are crucial to the operation of a successful air cargo hub are abundant in Hong Kong. For instance, Hong Kong has solidified its position as a financial centre[2], and is home to more than 500 banks (including offices of 85 of the world's top 100 banks).

In addition, Hong Kong is also a leading business service centre, where many of the world's leading consulting, legal and accounting firms use Hong Kong as a base for work throughout the region.

Hong Kong has also nurtured one of Asia's largest communities of professional service providers – from construction and marine engineers, architects and designers, to surveyors and estate agents, by virtue of the Hong Kong government's forward-looking, multibillion-dollar infrastructure spending in a variety of projects (eg. SkyMart, Disney World, etc).

2.3 Hong Kong government's push for a logistics hub

The Hong Kong government is actively pursuing a new strategy for high-end logistics, which it believes will make HKIA a jewel in Asia's air trade and help triple air cargo traffic over the next 20

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[1] "Partnering with China for a Better Future" by Mr David Pang Ding-jung, AAHK newsletter

[2] "The Hong Kong Advantage", Michael J.Enright, Edith E.Scott, David Dodwell, Hong Kong Oxford University Press 1997

years.

One of the logistics projects endorsed by the government is Tradeport Hong Kong, a facility run by a multinational consortium, which includes the Frankfurt and Amsterdam Schiphol airports. It is aimed at shippers of high-value goods that demand high service and fast throughput[3]. The keen interest shown by major international logistics players in this project is a testament of the importance of Hong Kong as an aviation hub.

Recognising the complementary role of logistics facilities and port development, the Port and Maritime Board had commissioned a study, ie. the "Study to Strengthen Hong Kong's Role as the Preferred International and Regional Transportation and Logistics Hub in Asia" to assess, inter alia, the development of potential for the establishment of "Value Added Logistics Park[4]".

A site on North Lantau will be made available to the private sector through the Value Added Logistics Park, enhancing Hong Kong's capability to offer integrated logistics services and reinforce the territory status as one of the international logistics hub of Asia[5].
Realising the importance of physical connectivity with mainland China as a key success factor to Hong Kong's logistics ambition, improvements have been made to extend the hours of the Lok Ma Chau Boundary Control Point and enhance its throughput, reducing costs for the logistics industry. The completion of the Shenzhen Western Corridor will also provide a significant boost to Hong Kong's capacity to handle cross-boundary vehicles[5].

HKIA will stand to benefit significantly from high-end logistics services, which generally attract high-value, time-sensitive and fast turnaround goods, hence boosting the cargo throughput passing through HKIA.

2.4 China's accession into WTO & signing of Closer Economic Partnership Arrangement ("CEPA")

China's membership in WTO is expected to accelerate the growth of mainland enterprises, which will need advanced services to support, expand and upgrade their operations, translating into rising demand for services from Hong Kong[6].

With the signing of the CEPA in June and September 2003 between China and Hong Kong, the latter will be "economically interlocked" with China and that smaller Hong Kong companies will benefit from the opening up and liberalisation on China beyond China's commitments in its WTO accession. Most importantly, CEPA provides long-term opportunities for Hong Kong people to establish business or work in China.

Taking into account the reasons cited above, AAT is of the view that HKIA's cargo growth projections by SOMAD, i.e. 6% p.a. which gradually decreases to 4% p.a in the next 20 years, is a reasonable assumption. AAT had projected a similar trend for its (general) cargo growth, i.e. yearly growth of 6.1% up to FY06/07, significant double-digit growths in FY07/08 and FY08/09, followed by a 4.6% growth p.a. (from FY10/11 to FY19/20), before finally tapering off to 3.8% p.a. from FY20/21 onwards. There is thus a need for AAT to increase its capacity in order to meet the growth in cargo throughput.

3. Considerations in Building Design

3 "Trading Hong Kong", Air Cargo World

4 The Value Added Logistics Park will provide not only conventional warehousing services but perform value-added activities, time-sensitive processing and e-commerce. This would require the Value Added Logistics Park to be multi (land, sea, air) transportation modes (Source: Port Development Strategy 2001, www.info.gov.hk)

5 "Logistics Remain a Key Hong Kong Advantage", www.hongkong.org, 18 July 2003

6 "Economic Forum: Competitiveness of the HK + PRD Region and a New Momentum of Growth", TDC website, 8 January 2003

3.1 Land

3.1.1 Land efficiency rate

Airports are no longer considered a public service, rather they are considered a business unit of the city and are expected to "pay their way". Thus, airports develop a long-range strategic plan and land use plan to create a sustainable, financially viable airport that will contribute to the economic health of the city it serves. Land around the airport is a valuable and closely guarded resource, which the airport management allocates to franchise operators under strategic terms and conditions. Cargo terminal operators (CTO) in building their terminals at HKIA have to meet certain minimum land efficiency rate. (Franchise terms are confidential) The design capacity of AAT was calculated at 1.51 million tonnes per annum, built on a total land area of 80,200sqm, AAT's land efficiency of 18.7 tonnes/sqm meets the minimum land efficiency rate required. Table 1 compares the land efficiency rate of other major air cargo terminals in the world.

Table 1: Land Efficiency Rate of Other Cargo Terminals

Cargo Terminal	Land Size	Design Capacity	Land Efficiency
Incheon Terminal C	40,000 sqm	750,000 tons/yr	18.8 tons/sqm
AAT	80,200 sqm	1,500,000 tons/yr	18.7 ton/sqm
Frankfurt-Hahn	6,800 sqm	90,000 tons/yr	13.2 tons/sqm
Thai Cargo	90,000 sqm	966,000 tons/yr	10.7 ton/sqm
Fraport Cargo Services	47,000 sqm	430,000 tons/yr	9.1 tons/sqm

From the airport management's perspective, setting a land efficiency rate ensures that the cargo terminal operators commit to making use of the land allocated to handle up to a level of cargo throughput. In fulfilling this commitment, AAT would have to employ designs, technology and procedures that would assist in meeting this criterion.

3.1.2 Land size and shape

Like any other airport service providers for aircraft maintenance or inflight catering, cargo terminal operators are allocated parcels of land for development. The land parcel's size and shape itself presents a constraint on the future design of the building. As a cargo terminal that acts as the intermediary for cargo between the land and airside, land shape that maximizes the length of airside interface in proportion to landside would be more ideal. The land allocated to AAT had limited airside interface and it was with this consideration that Terminal 1 was built across the full length of the airside interface (Figure 1). Subsequently, Terminal 2 and 3 would have to be built further into the landside. Nevertheless, this shortage of airside interface inherent in the land's shape was overcome by the addition of a functional design, which will be discussed later in the paper.

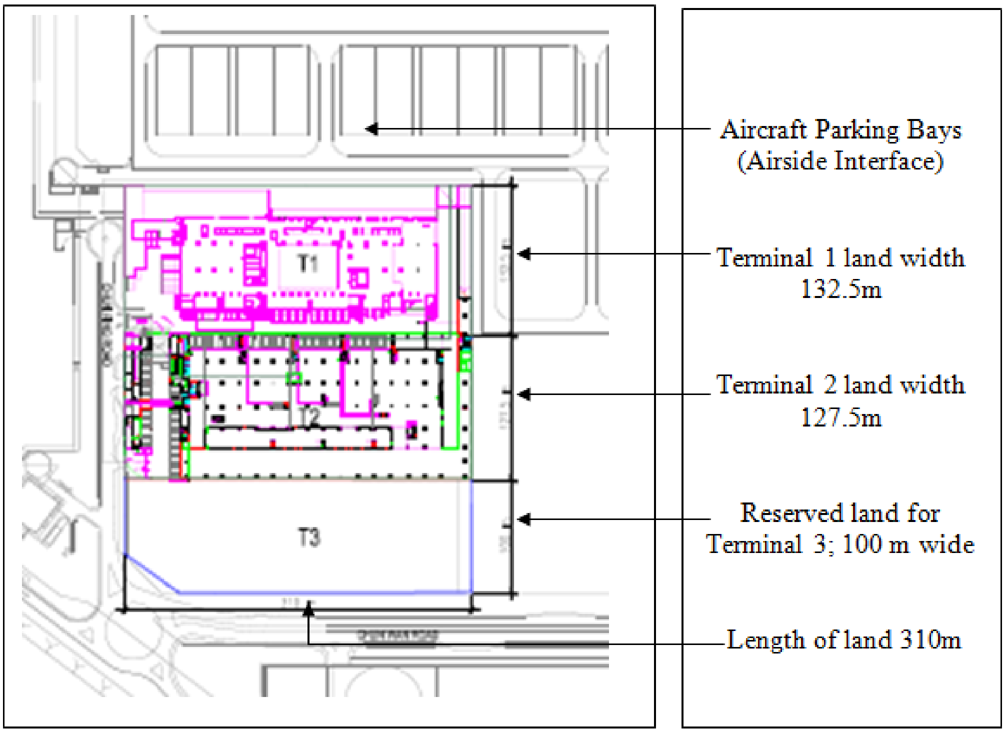

Figure 1: AAT land size

3.1.3 Land's height restriction

By virtue of the land's location in the airport where airspace has to be clear for aircraft landings and take-offs, the Civil Aviation Department (CAD) imposes height restrictions on buildings around civil aerodromes in accordance with the standards and recommended practices of the International Civil Aviation Organisation. This is to ensure that tall structures will not pose a safety hazard to aircraft operating in HKIA. According to the Hong Kong Airport (Control of Obstructions) Ordinance, building developers are required to consult CAD on the height limit of buildings during the planning / development stages. In effect, AAT's intended multi-level terminal design could not be built as high as desired. The height of the multi-level terminal was maximized to the limit at 46 meters high.

3.2 Service standards

The land efficiency that AAT committed to AAHK reflects the capacity that the terminal could handle a year. Within the terminals, facilities, processes and mechanics contribute to the handling capacity, how resources are allocated to individual processes in order to achieve the design capacity could be the decision of terminal operators. Nevertheless, the airport management had identified key processes, which were important in ensuring the service quality that maintains Hong Kong air hub status.

The service standards that the airport management was concerned with were as follows:

Landside	Target
(1) Truck Queuing Time less than 30 mins	96%
(2) Export Cargo Reception within 15 mins	96%
(3) Import Cargo Collection 30 mins	96%
(4) Empty ULD Release 30 mins	96%

Cargo Breakdown	Target
(1) General	
- Passenger Aircraft within ATA +5 hrs	96%
- Freighter Aircraft within ATA +8 hrs	96%

(2) Perishable Cargo within ATA +105 mins	96%
(3) Express Cargo within ATA +90 mins	96%
Mishandling Rates in 10,000 shipments	1.5
Late Positioning in 1,000 flights	1

In effect, the service standards imposed translates to sufficient facilities built to ensure the meeting of targets. For instance, to ensure that truck queuing time is kept within 30 mins, it was essential that the new terminal have sufficient truck docks. For speedy breakdown of perishable and express cargo, designated areas will need to be allocated within the terminal for these cargo to be channeled through quickly.

4. Maintaining Efficiency with Multi-level Warehouse Design

4.1 Cargo flow versus material flow

In a typical cargo terminal, the cargo flow is as follows:

Import Cargo Flow	Receive Cargo from Aircraft	→	Storage & Retrieve	→	Break-down	→	Storage & Retrieve	→	Deliver Cargo to Trucks
Location	Air-side Interface		Unitized Store		Work Station		Loose Store		Land-side Interface
Export Cargo Flow	Dispatch to Aircraft	←	Storage & Retrieve	←	Build-up	←	Storage & Retrieve	←	Receive Cargo from Trucks

The building designers for AAT's cargo terminal used the cargo flow as reference point to design the material flow, which is the actual route that cargo takes to complete the process. It was also to be noted that the facilities for handling import and export cargo was the same. The goal in designing the material flow is to optimize the handling process in such a way that the time, effort and resources used are in the most efficient manner. In the instance of the cargo flow, cargo moves in one direction. Inefficient designs would mean that cargo would either move against a unidirectional flow or travel unnecessary distances between each stage of the process.

4.2 Single-level versus multi-level cargo terminal

Thus, the single level cargo terminal, which supports a material handling system that mirrors the unidirectional flow of cargo with the least possible distance between each process would be considered more efficient, as compared to a multi-level warehouse where cargo needs to move vertically across different levels to proceed to the next stage of the cargo flow. It was with this consideration that in 1998, AAT's first terminal was single level. The facility had an initial handling capacity of 450,000 tonnes per annum, which was subsequently increased to 600,000 tonnes per annum with the addition of a by-pass channel for unitized cargo in 2004.

For the building of a new terminal to expand handling capacity, AAT had to take into consideration the constraints of the land, the need to maintain high service standards and provide cargo-handling capacity for at least another 10 years. A single level cargo terminal similar to AAT's first cargo terminal could provide an approximate handling capacity of 450,000 tonnes per annum, but could only sustain AAT's projected throughput for another 4 to 5 years. It would not be financially viable to only build capacity ahead for such a short-term. To maximize land use efficiency and add capacity by near 1 million tonnes per annum, a multi-leveled terminal would have to be adopted. A multi-leveled terminal presents challenges with respect to longer cargo flows and more complicated operations. Nevertheless, only when AAT was convinced that high service standards could still be maintained, that decision was made to build a multi-level cargo terminal. The rest of the paper discusses how the challenges of a multi-level cargo terminal were overcome.

4.3 A multi-single level cargo terminal

4.3.1 Allocating floor levels according to cargo type

Multi-levelled terminals would translate to longer material flows. To counter this debilitating factor, during the building design phase, the layout of every level aimed to maintain a unidirectional material flow in order to minimize the vertical movement of cargo over the shortest distance. Thus, each level of the new Terminal 2 was to function similarly to a single-level terminal, and each level serves to handle one type of cargo.

4.3.2 Access across multiple floor levels

Figure 2 shows the cross-section of Terminal 2 where facilities built emulate the cargo flow. (Only the ground floor does not provide for loose store facility as it was dedicated to handle unitised cargo and release of empty ULDs) AAT's unitized cargo storage facility was termed the Pallet Container Handling System (PCHS), and the Automatic Storage and Retrieval System (ASRS) refers to the loose cargo storage facility.

Design innovation to facilitate the unidirectional material flow and minimize vertical movements were the provision for truck-docks across all levels of the warehouse, ASRS inlet/outlet desks across 3 levels, PCHS inlet/outlet positions in all 4 levels, and transfer desks to airside on 2 levels.

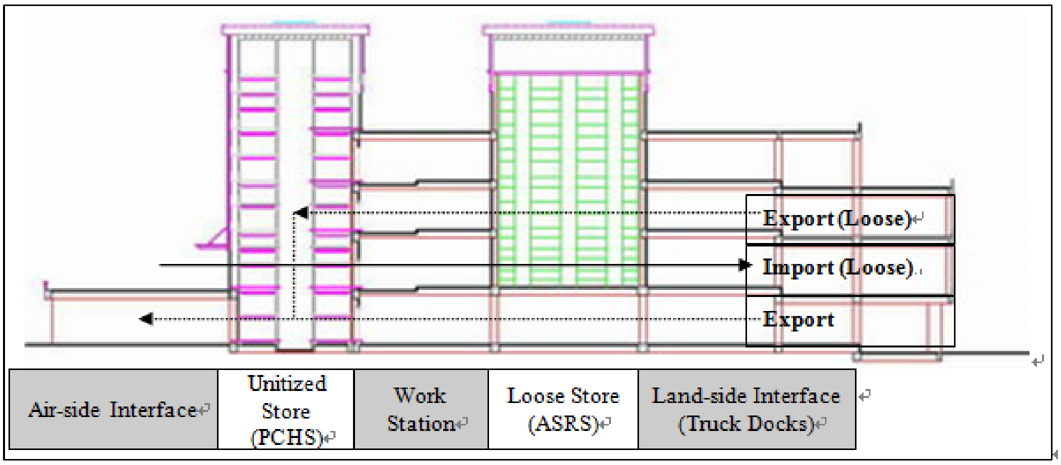

Figure 2: Cross-section of Terminal 2 building

The layout of the Terminal 2 illustrating the unidirectional material flow for export cargo is shown in Figure 3.

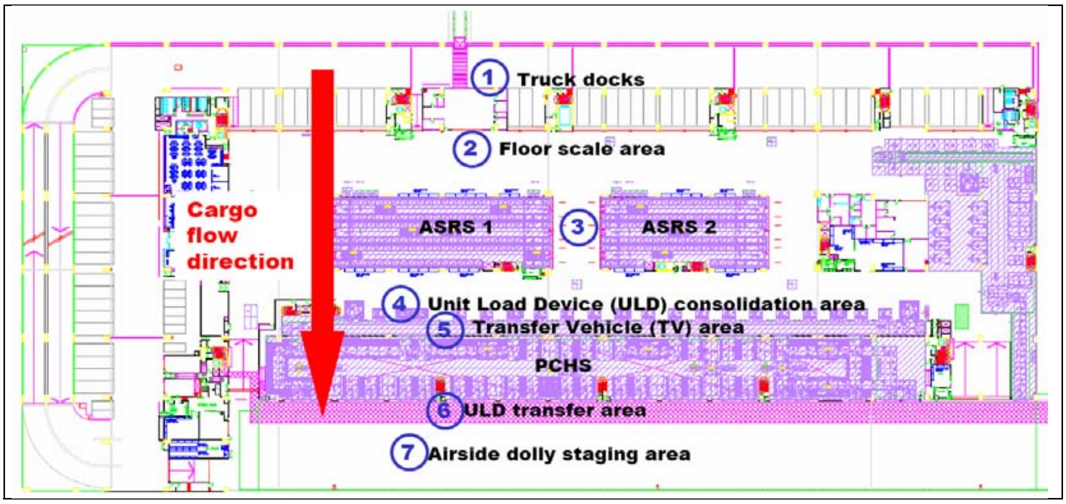

Figure 3: Terminal layout in Asia Airfreight Terminal

The result is a terminal where facilities in place on each level could serve to handle either import or export cargo very much like a single level terminal. Nevertheless, each level was designated to handle one type of cargo, in line with the aim of maintaining a unidirectional material flow.

4.4 Removing Bottlenecks in Multi-level Cargo Terminal

Bottlenecks, which slow down the flow of cargo from one stage to the next, can limit the efficiency and capabilities of a cargo terminal. Bottlenecks are especially damaging to efficiency of terminals with high cargo throughput, and where most cargo tends to arrive at peak hours. To counter the threat of bottlenecks in material flow, the facilities in place need to have sufficient capacity, input and output stations. Consultants had made calculations on the facility requirements based on maintaining efficiency during peak hours. Table 2 makes a comparison of the requirements and actual provision. In most cases, AAT had met or over-provided for the requirements.

Table 2: Comparison of the Facility Requirements and Actual Provision

Material Flow *(refer to Figure 3)*	① Truck Docks	③ ASRS Storage locations	③ ASRS Movements	④ ULD workstations	⑤ PCHS Storage Locations	⑤ PCHS Movements	⑥ ULD Transfer lanes
Requirements	101	3,402	531	46	302	162	36
Actual	169	3,550	540	60	1,188	180	40

4.4.1 Truck Docks

The provision of 67% more truck docks than required was because truck queuing time was one of the performance standards monitored by the airport authority. In addition, it was also recognized that truck movements and dwell time at the docks do depend on more variances, for instance, driver behaviour, manpower and equipment of the transport company to load and unload cargo from trucks, which may not be within the control of AAT.

4.4.2 ASRS

A design innovation to facilitate efficient movement of loose cargo was to separate the ASRS into 2 rack-locks providing 12 inlet/outlet desks per floor (Figure 3). This effectively doubles the number of inlet and outlet desks to a total of 36 inlet/outlet desks across 3 levels, removing bottlenecks at storage and retrieval of loose cargo.

4.4.3 Airside Interface

It was earlier mentioned that a challenge brought about by the land size and shape was the limit on airside interface. If Terminal 2 had shared the airside interface of Terminal 1, there would not be sufficient transfer lanes, resulting in bottlenecks for flow of cargo between airside and AAT. In resolving this, the designers had worked on providing a link via the eastern side to the south-end of the terminal (Figure 4) to extend the airside interface.

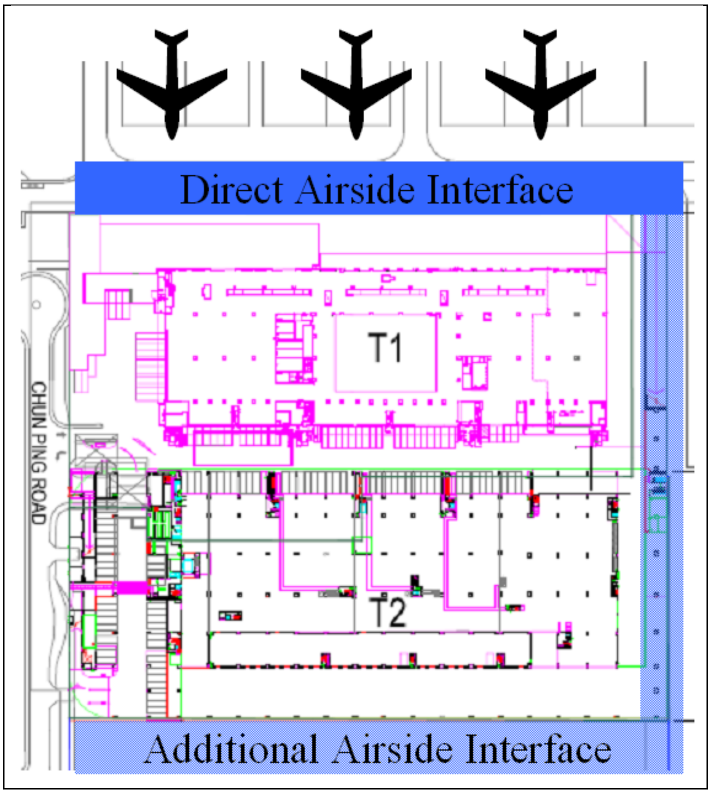

Figure 4: Additional Airside Interface

In addition to the ground floor, the designers built another airside interface on the first floor, which was accessed via a ramp (Figure 5). This two-leveled airside triples the airside interface and removes the need to share the limited direct airside interface at Terminal 1.

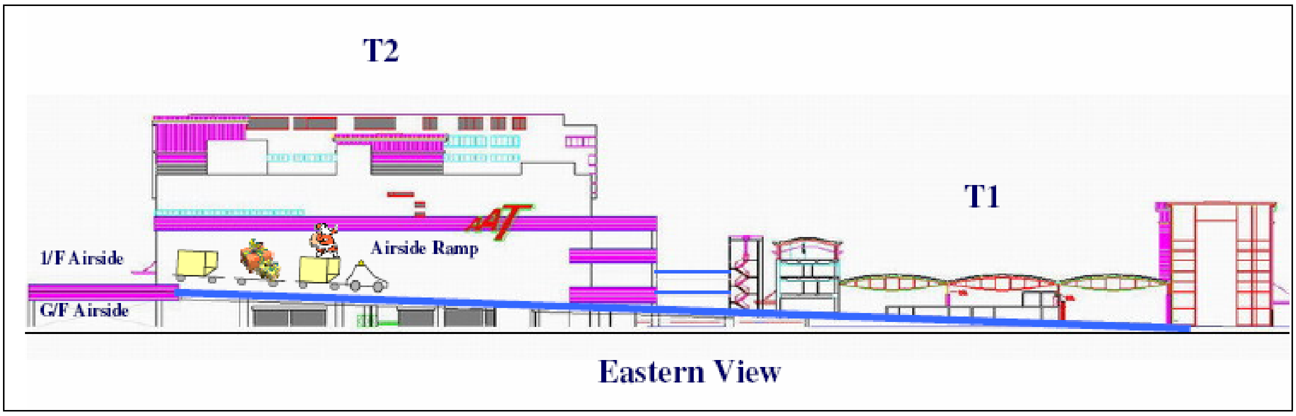

Figure 5: Airside ramp connecting 1/F airside to apron

4.5 Equipment Facilitating Effective Vertical Movement

AAT's multi-level design of 4-storey warehouse with 2-storey airside, maximizes truck dock accesses to the terminal and the airside frontage. However, this design does present the problem of vertical material movement, which slows down the whole cargo flow. To counter this, high-speed equipment to facilitate vertical movement within the ASRS and PCHS were installed. The PCHS was installed with 4 Elevated Transfer Vehicles (ETV) plus 5 cargo hoists. The ASRS has 6 aisles with 9 Automatic Storage and Retrieval Machines (ASRM). Detailed system specifications are shown in Table 3.

Table 3: PCHS & ASRS specifications

Item	Quantity
PCHS - ETV	4
PCHS - ETV vertical speed	1 m/s
PCHS - ETV horizontal speed	2 m/s
PCHS - ETV movement	At least 160 per hour
PCHS - Cargo hoist	5
PCHS - Cargo hoist vertical speed	2 m/s
PCHS - Conveyor speed	0.6 m/s
ASRM	9
ASRM Vertical speed	1 m/s
ASRM Horizontal speed	2.7 m/s

4.6 Reliable and Effective Tracking of Cargo Movement

In a terminal that handles such high numbers of throughput, it is vital that there is a reliable and purposeful computer system to keep track of the cargo within the warehouse. This allows the terminal operator to save cost and channel its focus on service delivery.

3 unique computer systems are used in AAT; they are Truck Control System (TCS), Material Handling System (MHS) and Cargo Management System (CMS). Detailed functions of the computer systems are shown in Figure 6.

CMS is the core application for AAT, essential for cargo inventory management and documentation handling to support daily operations. It allocates the most suitable storing space for cargo to reduce unnecessary transport and searching time. This web-based application is based on state-of-the-art and industry best practice software and hardware architecture, providing high availability, resilience and scalability to serve AAT's internal staff, customers and end-users' needs. The system also serves as the major messaging interface for data exchange between government agencies such as customs and trade department, and other service providers for air cargo industry such as Traxon and SITA. The system supports wireless handheld terminals that were deployed on the operation floors to enable efficiency and effectiveness. Along with AAT Internet Management System (AIMS), the systems serve as the primary interface for terminal users, AAT operations and airline customers for a comprehensive suite of e-services.

MHS is the control interface for the automatic cargo/equipment storage and retrieval system being used at AAT.

TCS manages the truck workflow within AAT. It allows authentication of all incoming trucks and coordination of truck activities. It is a system utilizing the latest RFID technologies to control truck movements within AAT's premises to allow efficient monitoring, truck flow and truck dock assignment. TCS also collates statistical data for service improvement purposes. It's a combination of mechanical hardware (entrance and exit barriers), antennae and readers based on RFID, and software (backend applications and front-end user interfaces).

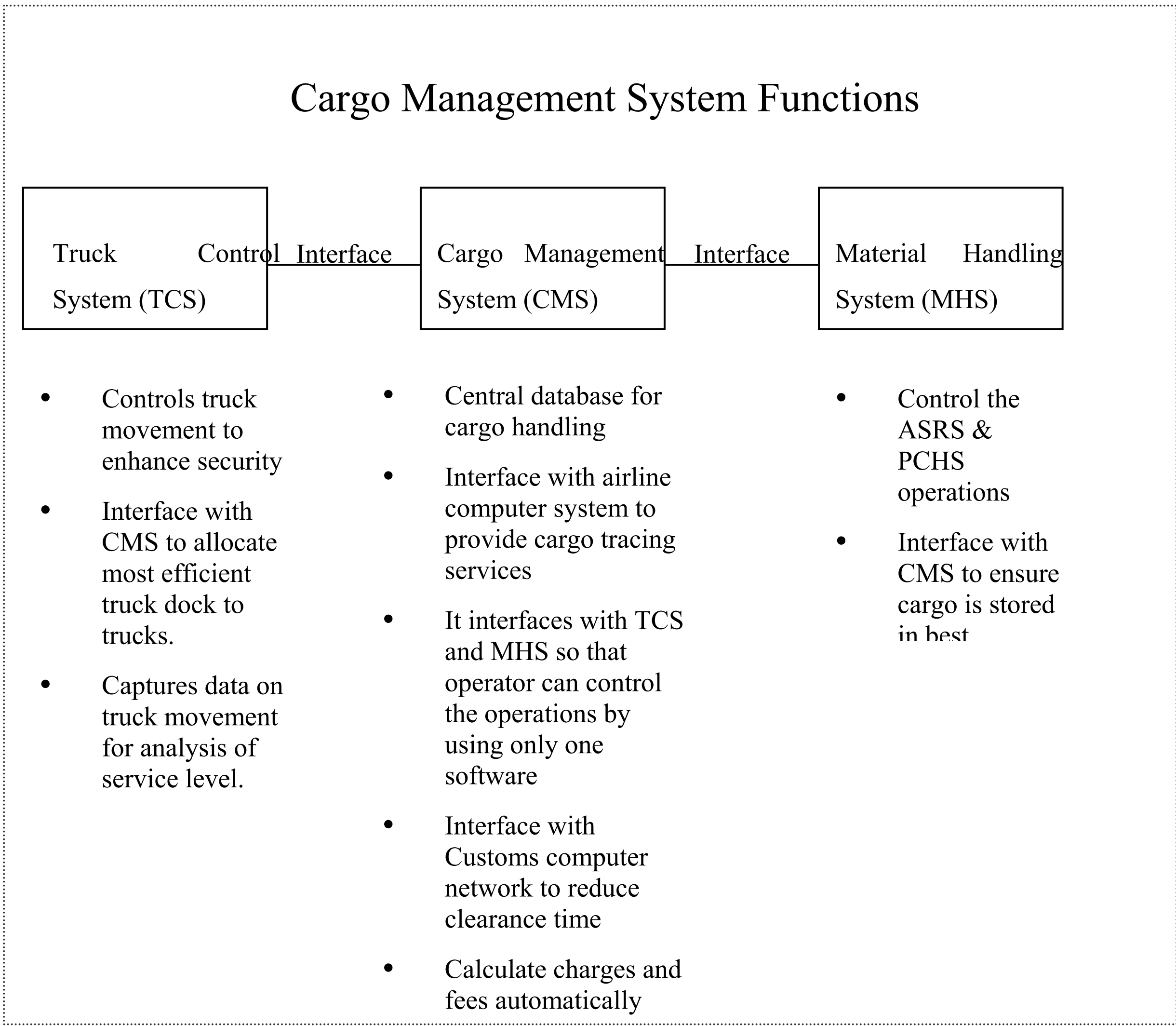

Figure 6: Cargo Management System (CMS) Functions Chart

All three systems – CMS, MHS and TCS are tightly integrated with data being exchanged between them on real-time, allowing information be shared for efficient operation. It interfaces with the MHS so that the cargo will be retrieved from ASRS and PCHS quickly to reduce cargo delivery and acceptance transaction time and more effective landside operation. It interfaces with TCS to reduce truck dock dwell time and allow truck docks to be allocated as near as possible to its cargo. CMS also interfaces with the computer network of customer airlines to provide real time cargo information to the airlines.

AAT's T2 **Data Center** facilities, in operation since January 2007, are staffed by the round-the-clock IT support team, with hardware infrastructure such as gigabit ethernet backbone, centralized data storage, backup tape library, server clusters, network routers and switches, network monitoring tools, digital CCTV, finger-print authentication and uninterrupted power supply (UPS). Along with the original data center located in T1, it provides real-time synchronization, resilience and active-active (hot standby) solution to cover any possible disaster recovery needs. Best practice IT Service Support and Delivery methodology and procedures have been implemented, enabling IT Support staff to deliver effective services to end-users.

5. Measures of Efficiency

5.1 Service Standards

AAT's Terminal 2 has gone into full swing since February 2007. Based on the comparison of service standards over years 2006 and 2007 (Figure 7), despite the move of operation to new premises, AAT was able to achieve the standards set by the industry.

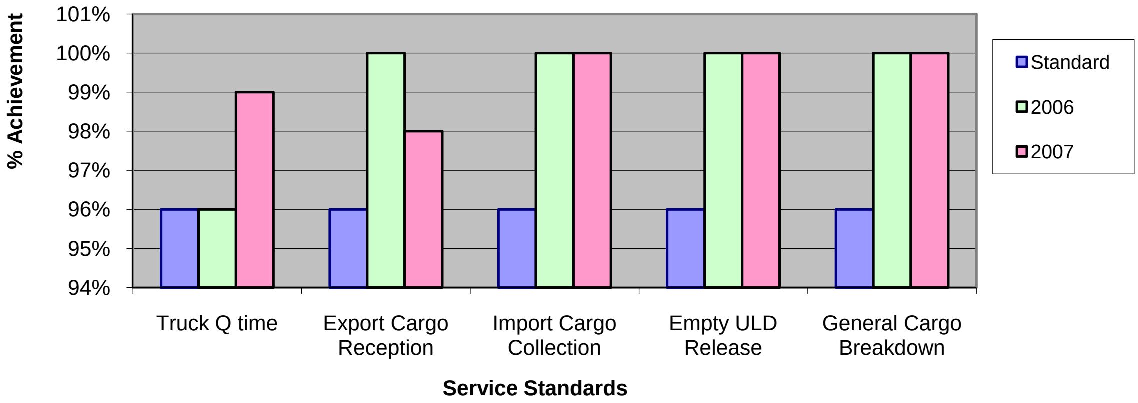

Figure 7: Comparison of Service Standards in 2006 and 2007

In ensuring the service quality of the cargo terminals, besides the quantitative measurements of key performance indicators, AAHK appoints an independent consumer research company to conduct annual air cargo terminal users survey to access the satisfaction of users on the existing cargo services and facilities. The terminal users were airlines, freight forwarders and truckers. The survey also aims to recommend areas of improvement, and to compare the previous study results to access any perceived improvements over time. Based on the results over 2006 and 2007 (Figure 8), there were improvements on satisfaction level following the move of operation to Terminal 2.

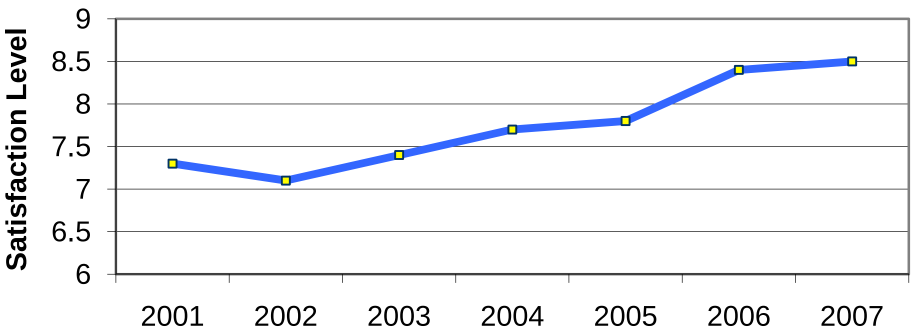

Figure 8: Comparison of Satisfaction Level

Based on both the qualitative and quantitative measurements of service, the improvement of results over the last year is a strong indication that despite the challenges of operating a multi-level cargo terminal, the measures and efforts to counter the shortcomings of a multi-level terminal were effective and serves as a point of reference for other cargo terminal operators.

Research on Forecast Method
For Logistics Node's Volume of Freight Handled in the Port Hinterland

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Abstract

With the development of the world economy and international trade, the port cargo throughput becomes not only an important sign of judging the station of a port in the international economy and trade, but also a rain glass of the flourishing degree in economy of a country or an area, the competitions among the ports are fierce increasingly in the main manifestations of Cargo throughput. However, the port-land intermodal node which appears in the form of logistics parks and the main transport channels in the port hinterland are both important guarantee for the port throughput. With the rapid development of modern logistics, the cooperation between the port and the logistics park in it's hinterland are more and more important for the increase of the port cargo throughput. Researching the methods to forecast the port-land intermodal node's volume are very important to do the prediction of the container throughput in the port properly, to guide the programming and construction of the ports, to confirm the investment scale of the ports and moreover to accelerate the development of the area. In the past, the research on forecasting method for the logistics park's volume, mostly focused on the improvement of the specific methods, while constructing a complete set of methods is still rare. This paper, considering the construction scale, functions, regional differences and other characteristics of a logistics park comprehensively, presents the "three-stage" method for logistics park volume forecasting. In the first stage, using the principal components - Gravity Model forecast the attract area of logistics nodes, and in the second stage, using the combination forecasting method forecast the attract volume of logistics node, in the last stage, using the improved grey comprehensive evaluation method forecast logistics node's volume of freight handled. finally, the paper takes Xiamen Qianchang Railway Logistics Park as an example for the model calculations and applications, and the example has validated its rationality and validity.

1. Introduction

With the rapid development of modern logistics, the cooperation between the port and the logistics park in it's hinterland are more and more important for the increase of the port cargo throughput. Researching the methods to forecast the port-land intermodal node's cargo are very important to do the prediction of the container throughput in the port properly, to guide the programming and construction of the ports, to confirm the investment scale of the ports and moreover to accelerate the development of the area. In the past, the research on the logistics park volume forecasting method, mostly focused on the improvement of the specific methods, while constructing a complete set of methods is still rare. Jianping Zhang, Yiwen Zhang and Xinfa Gao have researched the methods of the attract area of cities in a province[2 3 4]. Binglin Jiang, LinChun-yan,Reeves G R, Lawrence K D have researched on grey and combination forecasting model, showing the forecasting conditions and advantages & disadvantages of the model[5 6]

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[7]. Zhuyan Shao have studied advantages & disadvantages of grey comprehensive evaluation modal, and applying the model for evaluating of medical institutions' performance. This paper, considering the construction scale, functions, regional differences and other characteristics of a logistics park comprehensively, takes Xiamen Qianchang Logistics Park as an example for forecasting the attract volume of logistics node, while exploring the methods system construction for forecasting the attract volume of logistics node and presenting the "three-stage" method for logistics park volume forecasting, looking forward to provide reference for researching the methods to forecast the port-land logistics park's attract volume.

2. Constructing the Methods System to Forecast the Attract Volume of Logistics Park

2.1 The meaning of forecasting the attract volume of logistics park

The attract volume of freight is cargo throughput which is suitable for freight station to operate. Forecasting the attract volume of logistics park is that, according to the characters of logistics park and its environment, researching the internal discipline of the attract volume of logistics park in order to judge and estimate the volume of freight traffic as well as related logistics operations in this logistics park in the future years. The purpose for forecasting the attract volume of logistics park is judging and estimating the volume of freight in some logistics park, as a guide for logistics park's constructing scale and allocating equipment rationally, which ensures its essentially sustainable development and lays a foundation for the location planning for logistics park.

2.2 Defining the research objects of forecasting the attract volume of logistics park

Forecasting the attract volume of logistics park, which is a micro-economic monomer, should be based on the space network conditions, demand and supply conditions, policies, environmental conditions and other factors of a certain geographical scope. At present, the regional economic development in china isn't mature, and administrative division influences greatly. As a result, that forecasting the attract volume of logistics park firstly needs to choose the park's administrative space as a carrier, and then analyzing competition & cooperation relations about carriers, so as to forecast the attract volume of specific park.

The current system of administrative divisions in china, are mainly divided into provinces, municipalities, autonomous regions, prefecture-level cities, county-level cities, counties, towns, townships, villages and so on, according to the development of domestic and international logistics park experience, connection with the location planning and the function orientation for logistics park, the paper choices the prefecture-level city as the space carrier of logistics park.

2.3 Designing methods system to forecast the attract volume of logistics park

Regional economic growth and location is the main basis for the location and construction of Logistics Park. thus, it is the basical guarantee for constructing the logistics park that forecasting the attract volume, firstly, the paper taking logistics park's carrier as the study object, analyses carriers' logistics demand characteristics from several aspects such as carriers' economic development, industrial location, cargo traffic and flows as well as relations to neighboring regional economic development. Secondly, the paper analyzes competition & cooperation relations with logistics nodes in the carriers, and then forecasts the attract volume of logistics park. considering the construction scale, functions, regional differences and other characteristics of a logistics park comprehensively, This paper presents the "three-stage" method for logistics park volume forecasting. In the first stage, using the principal

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[6] Liying He. (2002): 'Forecast for the Volume of Freight Handled for Highway Transport Hub on Logistics System', *Journal of Highway and Transportation Research and Development* (6).

[7] Project Team of Beijing Jiaotong University, *The Development Planning for Marketing Survey of Xiamen Qianchang Railway Large Freight Yard[R]*. Beijing Jiaotong University, 2008(1).

components - Gravity Model forecast the attract area of logistics nodes, and in the second stage, using the combination forecasting method forecast the attract volume of logistics node, in the last stage, using the improved grey comprehensive evaluation method forecast logistics node's volume of freight handled, the methods system is shown in Figure 1.

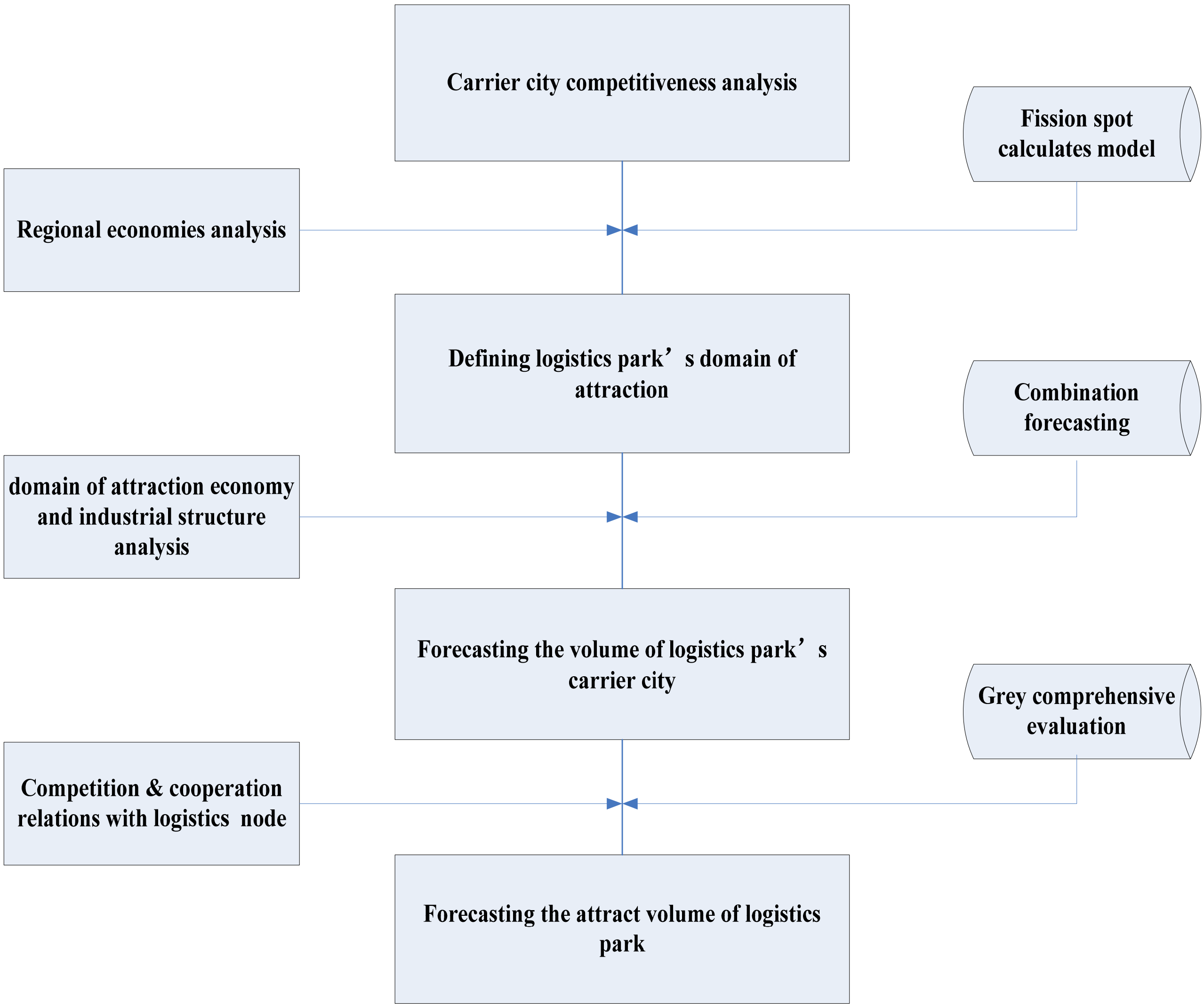

Figure 1: Methods system to forecast the attract volume of logistics park

3. Definition of Xiamen Qianchang Logistics Park's Domain of Attraction

Relying on Xiamen port, Xiamen Qianchang logistics park takes railway as leading transportation way, and takes intermodal as the development direction and value-added logistics services as the concept, which is considered as a comprehensive logistics park and becomes the main distribution center for the exchange of goods between Minnan and Gannan, Guangdong Province, North China, Northeast, East China as well as Southwest. For forecasting the attract volume of Xiamen Qianchang logistics park, above all, regarding Xiamen as a carrier of Qianchang logistics park, through analyzing the relations between Xiamen and other main port citys in the Zhujiang Delta and the Yangtse Delta, defining the logistics park's domain of attraction ,in order to achieve the regional economies coordinated development. According to China's ports competitiveness ranks in 2007, the paper selects Shanghai, Ningbo, Fuzhou, Shantou, Shenzhen and Guangzhou as the growth poles of China's southeastern coastal areas. Researching competition & cooperation relations between Xiamen and these cities about economic development and cargo traffic flows is used to define logistics node's domain of attraction when Xiamen City is a carrier.

3.1 Comprehensive stength evaluation of the regional economic center

3.1.1 The formation of comprehensive index system

Comprehensive strength of the regional economic development center or growth pole should be a more complex index, which reflects the multifaceted impact on regional development of the growth pole. This paper applys comprehensive index system to analyze seven economic centers' area of attraction, including Xiamen, Shanghai, Ningbo, Fuzhou, Shantou, Shenzhen and Guangzhou. Considering the main factors which reflect economic strength as well as present influence and potential impact abilities of economic strength, the paper puts forward several indices on the basis of each city's development scale, economic development level, people's living standards and area transportation condition. And then through analyzing the relativity and consistency of indices, some indices will be eliminated if they have more obvious and repeated implications or could be replaced easily. At last,13 major indices are selected as variables to describe economic growth pole's（centre）comprehensive strength. The major indices are non-agricultural population（X_1）, urban area（X_2）, gross domestic product （GDP）（X_3）, fixed investment（X_4）, total volume of retail sales（X_5）, total export and import volume（X_6）, total industrial output value（X_7）, the output value of the tertiary industry（X_8）, the per capita disposable income of residents（X_9）, residents per capita consumption expenditure（X_{10}）, the balance of deposits of urban and rural people（X_{11}）, the total cargo of the area（X_{12}）, the port cargo throughput（X_{13}）, the value of indices shown in Table 1.

Table 1: The data sheet of seven economic centers economy strength in 2006

	Xiamen	Shanghai	Fuzhou	Ningbo	Shantou	Shenzhen	Guangzhou
Non-agricultural population(ten thousand people)	109.2	1173.3	237.8	189	488.12	196.8	491
Urban area（m^2）	1569	6340.5	11968	9365	1956	1953	7434.4
GDP (hundred million yuan)	1162.4	10366.4	1664.1	2864.5	740.9	5684.4	6073.8
Fixed investment (hundred million yuan)	662.1	3925.1	732.3	1543	176.7	1273.7	1696.4
Total volume of retail sales (hundred million yuan)	314.9	3360.4	775.5	882.5	400.6	1671.3	2182.8
Total export and import volume (hundred million yuan)	327.9	4287.5	166.5	864.9	54.1	2374.1	637.6
Total industrial output value (hundred million yuan)	2443.8	19631.2	2230.5	7510.7	1469.9	11928.6	6610.4
The output value of the tertiary industry (hundred million yuan)	516.1	5244.2	711.1	1149.1	309.5	2655.9	3498.7
The per capita disposable income of residents	18513	20668	14321	19674	10949	32009	19851
Residents per capita consumption expenditure	14162	14762	9671.5	12665	9292	16628.2	15445
The balance of deposits of urban and rural people (hundred million yuan)	680.8	9480.3	1311.4	1792.5	850.4	3744.7	5562.4
The total cargo of the area (ten thousand tons)	4550	75184	11554	1228	1822	9013	34323
The port cargo throughput (ten thousand tons)	7792	53748	8847.8	31000	1735.9	17597.8	32816

3.1.2 The principal component analysis

Through the principal component analysis method, combine the above indices linearly; use fewer new and representative variables instead of the original variables. In this way, we could both indicate the object's characteristics more focused and typically simultaneity avoiding much reduplicate work. Firstly, using 91 parameters of seven central cities in the southeast coast to establish a 7×13 original matrix. Then, standardizing and calculating the correlation coefficients to output the eigenvalues, contribution rates and cumulative contribution rates of the correlation coefficient matrix with the Jacobi method, as shown in Table 2.

Table 2: The result of principal component analysis

Principal Component	Eigenvalues	The Contribution rates	The Cumulative Contribution rates
1	9.54013	73.38562	73.38562
2	1.95758	15.05833	88.44395
3	0.91751	7.05781	95.50176
4	0.34722	2.67092	98.17268
5	0.17557	1.35051	99.52319
6	0.06199	0.47681	100
7	7.111E-16	5.47E-15	100
8	2.633E-16	2.0254E-15	100
9	1.453E-16	1.118E-15	100
10	-5.11E-17	-3.932E-16	100
11	-1.47E-16	-1.128E-15	100
12	-2.8469E-16	-2.18993E-15	100
13	-5.52E-16	-4.248E-15	100

The extract of the PCA components is according to the calculated eigenvalues and cumulative contribution rate, the bigger the eigenvalue is, the bigger the rate of contribution will be, and also indicate the factor is more important to reflect the city's comprehensive strength, only the factor which eigenvalue is bigger than 1 can be elected as the main factor. On the general principle that the cumulative contribution rate is more than 85 percent, as Table 2, we can see that the cumulative contribution rate of the former two components has reached 88.44 percent, and their eigenvalues are both bigger than 1. It shows that the former two main factors have included the amount of information the 13 original characteristic parameters have. So the paper selects the former two main factors to replace 13 indices. The principal components and their factor loadings are shown in Table 3.

Table 3: The Principal component factor loadings and principal components

	The first principal component factor loadings	The second principal component factor loadings	The first principal component :A1	The second principal component :A2
a_1	0.8003	0.4500	0.0839	0.2298
a_2	0.0818	0.6337	0.0086	0.3236
a_3	0.9943	-0.0454	0.1042	-0.0232
a_4	0.9647	0.1576	0.1011	0.0805
a_5	0.9824	0.0629	0.1030	0.0321
a_6	0.9220	-0.1341	0.0966	-0.0685
a_7	0.9534	-0.1344	0.0999	-0.0686
a_8	0.9830	-0.0178	0.1030	-0.0091
a_9	0.4758	-0.8168	0.0499	-0.4172
a_{10}	0.6302	-0.7013	0.0661	-0.3582
a_{11}	0.9847	0.0969	0.1032	0.0495
a_{12}	0.9178	0.3068	0.0962	0.1567
a_{13}	0.9206	0.1544	0.0965	0.0789

3.1.3 The principal components' scores and the evaluation of the city's comprehensive strength

Suppose A_k denotes the kth principal component, $A_k = (a_1, a_2, \cdots, a_i)$, k = 1, 2; i = 13;

X_j denotes the evaluation matrix of city j, $X_j = (x_1, x_2, \cdots, x_i)^T$, $j = 1, 2, \cdots, 7$; i = 13;

F_{jk} denotes the kth principal component' s score of city j , then

$$F_{jk} = A_k \times X_j \tag{1}$$

B_j denotes the comprehensive strength of city j, then

$$B_j = \sum_{k=1}^{n} \partial_k F_{jk} \tag{2}$$

Where *k* denotes the *k*th principal component; *n* denotes the number of the principal component; ∂_k denotes the *k*th principal component's variance contribution rate. After calculation, the principal components' scores and the result of the evaluation of the city's comprehensive strength are shown in Table 4.

Table 4: The principal components' scores and the result of the evaluation of the city's comprehensive strength

	The first principal component's score	The second principal component's score	Synthetic evaluation result	Sequence
Xiamen	3691.05	-11059.58	104336.59	6
Shanghai	20297.52	3396.92	1540704.35	1
Fuzhou	4216.09	-3062.77	263282.75	5
Ningbo	6706.80	-7442.24	380120.26	3
Shantou	1968.56	-6783.39	42320.09	7
Shenzhen	8268.57	-16626.90	356429.69	4
Guangzhou	11270.51	-3515.58	774159.98	2

3.2 The computation of regional economic center's influence area

As the core of certain regional spatial structure, the city affects the periphery region with the functions of gathering and proliferating. The influencing area of city is called "force field" which is the concept in physics in this paper, the strength of influence is called "the strength of field" [8]. Modern city, is not only the economic center of area, but also the center of the politics, culture, infrastructural building and the collection and distribution of goods, exactly it is the organic entity of the economy, society and the material. Therefore, take the urban comprehensive strength——*B* as the synthetical variable to appraise the strength of force field, and then establish the attraction model for the city (attraction center) at any other point out of it, the formula is:

$$S_{ik} = B / d_{ik}^2 \tag{3}$$

Where S_{ik} denotes the field intensity of city i at point *k*; d_{ik} denotes the distance from city *i* to point *k*; *B* denotes the comprehensive strength of city i .
As the formula (3), the farer some point to the city, the weaker the field intensity of the city at the point is, and gradually it is replaced by another city's influence. Calculating S_{ik} and S_{jk} separately by formula (3), if $S_{ik} > S_{jk}$, then point *k* belongs to the area of city i; If $S_{jk} > S_{ik}$,then point *k* belongs to the area of city j; If point *k* is the dividing point between attraction center i and j, then $S_{ik} = S_{jk}$, finally, obtaining the formula of fracture point:

$$D_{rp} = d_{rp} / (1 + \sqrt{B_p / B_r}) \tag{4}$$

In the formula, D_{rp} is the distance from the fracture point between city *r* and city *p* to city; d_{rp} is the distance between city *r* and city *p*; B_r and B_p are city *r* and city *p*' s comprehensive strength

[8] Xiaodong Zhang. (2004): Research on the Theory of The Location Planning For Logistics Park, *Logisties Publishing House*, Beijing.

respectively. This paper takes C_r as the Attract area of city *r*, which is the area that takes point *r* as the center of circle, and takes D_{rp} as the radius; the paper also takes C_P as the Attract area of city *p*, which is the area that takes point *p* as the center of circle, and takes $d_{rp} - D_{rp}$ as the radius, C_r and C_P contact in the fracture point between point *r* and point *p*. According to formula (3), when point *k* is in the C_r, the field intensity of point *r* at point k is stronger than that of point *p* at point k, point *k* belongs to the attract area of point *r*, while point *k* is in the C_P, the field intensity of point *r* at point k is weaker than that of point at point k, point *k* belongs to the attract area of point *p*. Thus it can be seen, the field intensity of point *r* at any point inside C_r is larger than point *p*, the field intensity in the circumference of C_r is called the boundary field intensity of point *r*. Likewise, the field intensity in C_P is called the boundary field intensity of point *p*.

The paper uses 1, 2, 3, 4, 5, 6, 7 to represent Xiamen, Shanghai, Ningbo, Fuzhou, Shantou, Shenzhen, Guangzhou separately; the following will no longer give unnecessary details. Then D_{12} and d_{12} separately represent the distance from the fracture point between Xiamen and Shanghai to Xiamen and the distance between Xiamen and Shanghai. Using formulas (4) to calculate the positions of fracture point between Xiamen and six economic centers separately, which are Shanghai, Ningbo, Fuzhou, Shantou, Shenzhen and Guangzhou, and the results are shown in Table 5.

Table 5: The positions of fracture point between Xiamen and six cities（km）

	Shanghai	Ningbo	Fuzhou	Shantou	Shenzhen	Guangzhou
Distance between cities: d_{1p}	824	690	213	189	466	514
The fracture point: D_{1p}	170	237	82	115	164	138

Take C_{1i} (i = 2, 3, 4, 5, 6, 7) as circles that Take Xiamen as the center of circle, and take D_{1i} (i = 2, 3, 4, 5, 6, 7) as radiuses. Then C_{1i} (i = 2, 3, 4, 5, 6, 7) contact C_{i1} (i = 2, 3, 4, 5, 6, 7) which are the circles that take *i*(*i* = 2, 3, 4, 5, 6, 7) as the centers of circles, and take $d_{1i} - D_{1i}$ (*i* = 2, 3, 4, 5, 6, 7) as radiuses. Because the area of C_{14} is the smallest, and its boundary field intensity is the largest, the field intensity of point 1 at any point in C_{14} are larger than that of point *i* (*i* = 2, 3, 5, 6, 7). Therefore the area of C_{14} is defined as the core attract area of Xiamen. Because the area of C_{13} is the biggest, regarding the sum of the area of C_{13} and C_{i1} (*i*=2,3,4,5,6,7)as complete concourse R, regarding the sum of area of C_{i1} (*i* = 2, 3, 4, 5, 6, 7) as concourse *B*, and suppose $A = R - B$, then defining area of *A* as the expansion attract area of Xiamen. But what is unnegligible, besides the core attraction area and the expansion attraction area, there still are other nodes (cities) which have flows of cargo between them and Xiamen, therefore, defining the districts except the core attraction area and the expansion attraction area as the radiation attraction area of Xiamen. This paper mainly studies the transportation amount of logistics node from the cities in it’s core attraction area and expansion attraction area. The attraction scope of Xiamen is shown in Figure 2.

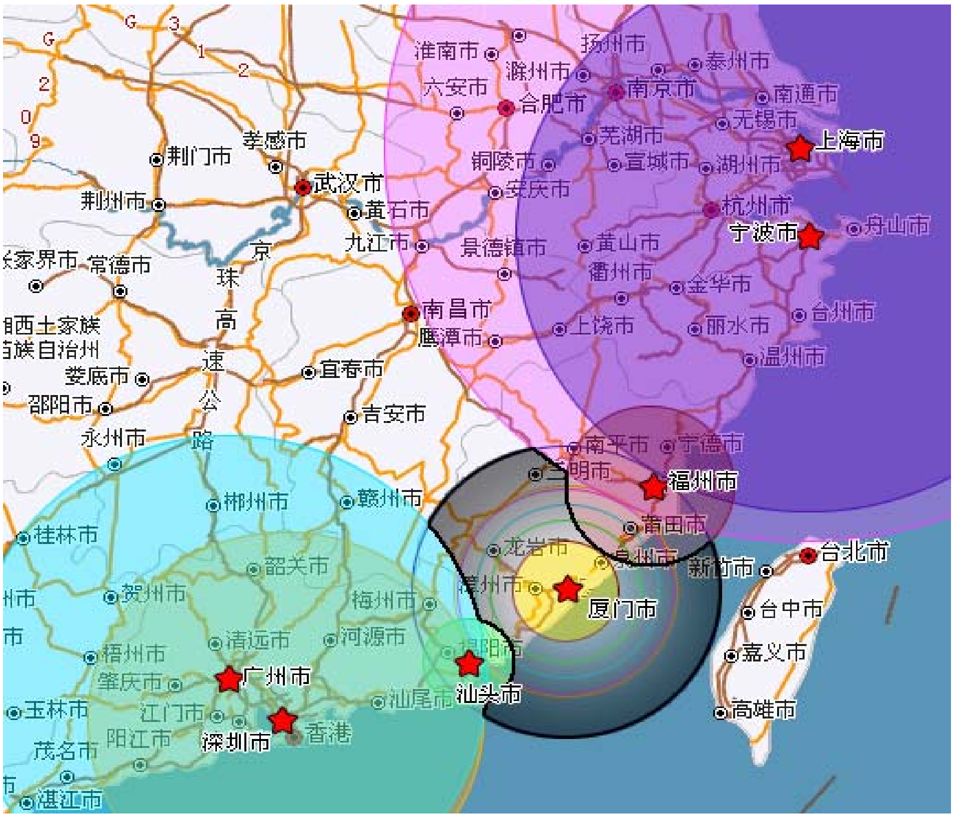

Figure 2: Picture about the attract area of Xiamen

As shown in Figure 2, the area that takes Xiamen as the center of circle, and takes 82 kilometers as radius (yellow region in Figure 2) is the core attraction area of Xiamen. It includes three locally administered cities, which are Xiamen, Zhangzhou and Quanzhou; the expansion attraction area includes both Longyan and Sanming which is locally administered cities.

4. The Forecast and Analysis on Transport Volume of Marketable Attractive Area of Qianchang Logistics Park in Xiamen

4.1 The thoughts of forecast on transport volume of marketable attractive area of the Qianchang logistics park in Xiamen

After confirming the attractive area of the Qianchang logistics park's carrier by calculation, the paper will predict the transport volume that flow into Xiamen from cities in the attractive area, so as to ensure the transport volume of the Qianchang logistics park in Xiamen. By scientific analysis and predict of the attractive transport volume amount to market of the logistics park of the Qianchang in Xiamen in the characteristic years of future(2010、2015、2020), and its main research ideas are shown in Figure 3.

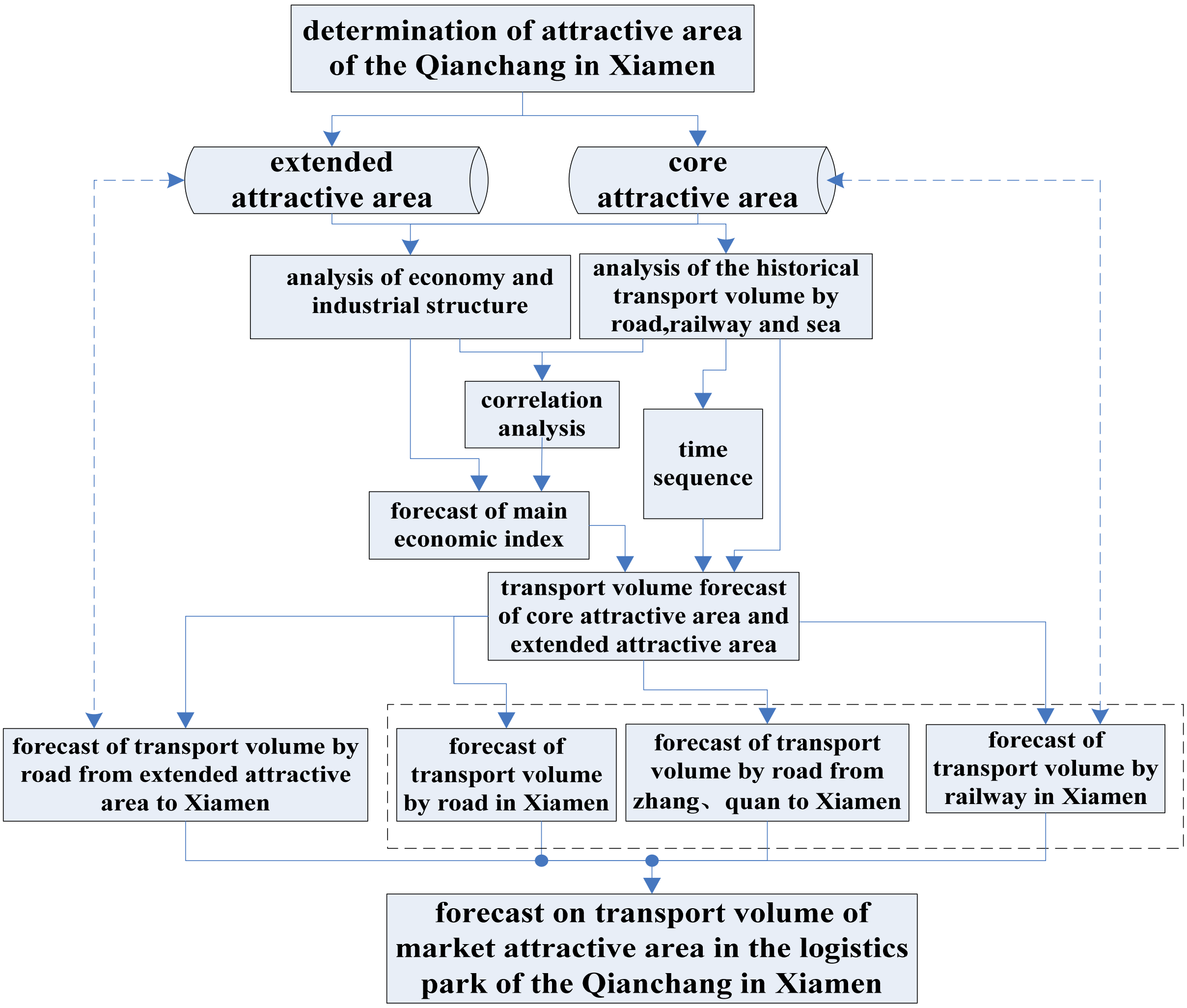

Figure 3: The thoughts of forecast on transport volume of market attractive area in the logistics park of the Qianchang in Xiamen

4.2 Choosing the model of forecast

For forecasting the transport volume of marketable attraction area in the Qianchang Logistics Park in Xiamen, firstly, the paper predicts the volume from highway and railway attracted by the Qianchang logistics park in Xiamen with the model of multiple linear regression and the model of grey predict respectively. Secondly, the paper predicts transport volume of varied transportation modes. Lastly, the paper predicts the total volume in the Qianchang logistics Park. Between these ways, grey predict which fit to predict transport volume of carrier city in attractive area is a model based on time sequence. According to the historical transport volume of Xiamen, Zhangzhou and Quanzhou, what should be pointed out is that the change of transport volume of Xiamen and Quanzhou is linear, so it can be predicted by the model of multiple linear regression. But the historical transport volume by highway and railway of Zhangzhou fluctuate greatly, which doesn't comply with the condition of linear programming. Therefore, this paper choose the predict model combined with the model of multiple linear regression and the model of grey predict to predict the transport volume of Xiamen and Quanzhou respectively, while choose the grey model to predict the transport volume of Zhangzhou, Sanming and Longyan, then get the predict of transport volume of market attractive area in the Qianchang Logistics Park in Xiamen.

4.3 The forecast on transport volume of marketable attract area in the Qianchang logistics park in Xiamen

4.3.1 The summarization of combined prediction

Because the model of multiple linear regressions and the model of grey predict are the common predicting methods, we will not expatiate here. The paper will introduce the combined predict briefly. The so-called combined predict, that is, give some single method different weights, so that we will get the integrated predict model. Theoretical study and practice indicate that the combined predict model have higher precision and it can enhance the stabilization of predict which has higher capability to adapt the changing environment in the future.

The summarization of combined prediction: the interaction of single predict methods in the combined predict generate the total error. Here we can consider it as the "symbiosis" constituted of various predict methods. We can regard the total error generated by combined predict as the "total income". We can determined the corresponding weight of single predict method in the combined predict by the distributing result which is divided from the total income to each single predict method.

Suppose the absolute value's average value of the *i*th method as E_i, the total error of combined prediction as *E*:

$$E_i = \frac{1}{m}\sum_{j=1}^{m}\left|e_{ij}\right| \tag{5}$$

$$E = \frac{1}{n}\sum_{i=1}^{n} E_i \tag{6}$$

Where, *m* is the amount of swatches; *n* is the amount of prediction methods. The calculation of error which each prediction method affords:

$$w(|s|) = \frac{(n-|s|)!(|s|-1)!}{n!} \tag{7}$$

$$E\{i\} = \sum_{s_i \in s} w(|s|)\left[E(s) - E(s-\{i\})\right] \tag{8}$$

where, *i* express the *i*th prediction method; $E\{i\}$ express the error which the *i*th prediction method affords; $w(|s|)$ express the weighting factor as contribution margin of the *i*th prediction method; *s* contain all of subclass of *i*; $s-\{i\}$ express s minus *i*; $|s|$ express the number of prediction methods in the combined method; *n* express the number of all the prediction methods in the combined prediction modal.

According to the calculate results above, confirming each weight of prediction methods called w_i, its calculation formula is:

$$w_i = \frac{1}{n-1} \times \frac{E - E\{i\}}{E\{i\}} \tag{9}$$

At last, the combined prediction formula is:

$$y = \alpha \sum_{i=1}^{n} w_i y_i \tag{10}$$

Where, y_i express the number of transport volume predicted by the ith prediction method, α express the adjustment coefficient of growth.

4.3.2 The freight volume forecast of cities in the domain of attraction

(1) The highway freight volume Forecast of Xiamen

Firstly, the paper applies multiple linear regression model to predict the highway freight volume of Xiamen. Considering that there are a number of factors affecting freight volume, this paper takes 6 indices as the independent variable parameters, which includes the population x_1, GDP x_2, gross industrial output value x_3, the total retail sales of consumer goods x_4, total import and export x_5 , and fixed capital investment quantity x_6. After analysis and calculation, the multivariate linear prediction formula is as follows:

$$y = 5003.227 - 32.715x_1 - 2.441x_2 + 4.093x_3 + 1.495x_4 - 15.332x_5 - 0.302x_6 \quad (11)$$

Using this model to forecast the future highway freight volume in Xiamen City, the result is as shown in Table 6.

Table 6: Forecast of transport volume by highway by model of multiple linear regressions

Year	2008	2009	2010	2011	2012
Transport volume	3182.2	3911.3	4829.3	5287	5767.7
Year	2013	2014	2015	2020	2030
Transport volume	6264.1	6763.8	7249.9	12496	36581

Using the grey forecasting model to forecast the future highway freight volume in Xiamen City ,the results is shown in Table 7.

Table 7: The Grey model predictive results of the Xiamen City (10,000 tons)

Year	2008	2009	2010	2011	2012
Transport volume	2344.08	2507.05	2681.36	2867.79	3067.18
Year	2013	2014	2015	2020	2030
Transport volume	3280.43	3508.51	3752.45	5251.39	10285

Selecting historical freight data series of Xiamen, and take the data from 1996 to 2006 as example, compare the tow predict results above with actual data, calculate the prediction error as shown in Table 8.

Table 8: The forecast results and prediction error of single forecast model

Year	Actual Value	Grey Predict Value	Multiple Predict Value	Grey Error E(1)	Multiple Error E(2)	Rate of Grey Error	Rate of Multiple Error
1997	1143	1143	1132	0	-11	0.000	0.010
1998	1224	1197	1277	-27	53	0.022	0.045
1999	1506	1280	1485	-226	-21	0.150	0.017
2000	1364	1369	1319	5	-45	0.004	0.033
2001	1325	1464	1391	139	66	0.105	0.045
2002	1438	1566	1412	128	-26	0.089	0.017
2003	1673	1675	1618	2	-55	0.001	0.033
2004	1692	1791	1724	99	32	0.059	0.018
2005	1940	1916	1963	-24	23	0.012	0.012
2006	2178	2049	2165	-129	-13	0.059	0.006
Average error rate	—	—	—	—	—	0.050	0.023

(* G-results = The Grey model predictive results, M-results = The Multiple linear model predictive results)

By comparing the two kinds of model's average error rates, we can see that the gray forecast model's error is bigger than the multiple linear model, which reflects the advantages and disadvantages of two models in this Forecasts. In accordance with the calculation results (Table 8), we can get the total error of combined forecast E = 563. The error of the forecast model and its weight are as shown in Table 9.

Table 9: The error of the prediction model and its weight

The error of forecast model		The weight of forecast model	
E{1}	E{2}	W1	W2

Using the formula (10) to calculate combined forecast results of the future highway freight volume of Xiamen (Table 10).

Table 10: Combined forecast results (10,000 tons)

Year	2008	2009	2010	2011	2012
Transport volume	3086	3750	4582	5009	5457
Year	2013	2014	2015	2020	2030
Transport volume	5921	6389	6848	9330	20135

(2) The railway freight forecast of Xiamen City
Using the combined forecast model, we can get the future railway freight volume of Xiamen (Table 11).

Table 11: The combined forecast results of Xiamen's future railway freight (10,000 tons)

Year	2008	2009	2010	2011	2012
Freight volume	752	914	1114	1403	1754
Year	2013	2014	2015	2020	2030
Freight volume	2177	2686	3299	6429	19050

(3) The freight volume forecast of other cities in the domain of attraction
Using the combined forecast model, we can get the volume forecast results of other cities' freight, which is shown in Table12.

Table 12: The forecast results of 10 cities' highway freight volume

Years	**Highway freight volume (10,000 tons)**			
	Zhangzhou	**Quanzhou**	**Longyan**	**Sanming**
2010	3831	7598	6097	6483
2011	4061	8367	6964	7235
2012	4305	9201	7954	8074
2013	4563	10105	9085	9010
2014	4837	11085	10377	10055
2015	5127	12147	11852	11222
2020	5890	14921	23037	19424

4.3.3 The forecast of freight volume attracted by Qianchang logistics park in Xiamen
As Xiamen is the economic center and freight flow hub of its domain of attraction, part of the goods from other cities will also flow to Xiamen 's logistics nodes. According to the spot investigation, it is informed that annually about 30% of highway freight from Zhangzhou and Quanzhou is attracted to Xiamen in recent years, and the number from Longyan and Sanming is about 20%. We can use the formula:

$$Q^* = \alpha\beta Q \qquad (11)$$

to predict the freight volume that could be attracted to Qiangchang logistics park in target years. In the formula, the letter Q represents highway freight volume of Xiamen, α shows the proportion of the 3PL to the social logistics gross in target year, β shows the proportion of the 3PL logistics activity quantity happens in the logistics park to the quantity happens in social 3PL market. According to the experience and investigation, α , β can be evaluated as 0.7 and 0.8, then we can calculate the prediction of the logistics activity quantity happens in the logistics park, and the results (Table 13) shows freight volume attracted by Xiamen's logistics hub in target years.

Table 13: Freight volume attracted by Xiamen's logistics hub (10,000 tons)

Years	2009	2010	2011	2012	2013	2014	2015	2020
Total freight volume attracted by Xiamen	10174	11641	12980	14468	16117	17938	19944	30495

Years	2009	2010	2011	2012	2013	2014	2015	2020
Total freight volume attracted by logistics park	5697	6519	7269	8102	9026	10045	11169	17077

5. The Analysis and Forecast of Xiamen Qianchang Logistics Park's Suitable Terminal Capacity

This paper's section 4 and section 5 analyze and forecast the freight volume of each cities in the Xiamen's domain of attraction, and eventually get the prediction of freight volume attracted by Logistics Parks in Xiamen. This section will analyze the competition and cooperation among the logistics parks in Xiamen, study the forecasting methods on how a single logistics node could share the carrier city's freight, finally the paper will forecast suitable terminal capacity of Xiamen Qianchang Logistics Park.

According to the fuzzy and grey characters of logistics park comprehensive evaluation, this section uses the improved grey comprehensive evaluation to evaluate the composite indicator of the four major logistics park in Xiamen Urban Planning-modern logistics park (including Xiangyu logistics park, and the Hong Kong Air Logistics Park), Haicang Logistics Park, Xinglin logistics park, and the Liuwudian Logistics Park[9].

5.1 The summarization of grey comprehensive evaluation method

Grey comprehensive evaluation method is as follows:

(1)Set C_{ik} (i = 1,2,…n, k=1,2,…,m) as the original value of the kth index of the ith logistics park, and the original data matrix is:

$$C = (C_{ik})_{n\times m} \qquad (12)$$

Where, C is a $n \times m$ Matrix.

Set C_k^* as the optimal value of the kth indices in these logistics parks (high-priority indicators from the maximum and low-priority indicators from the minimum), C^* is the optimal index set of the system.

[9] Yiwen Zhang, Xinfa Gao. (2001): 'The Definition of the Attractived Region of the Main City in Hebei Province', *Journal of Hebei Normal University* (4). pp.533-536.

$$C^{*} = \{C_k^{*}\} = \{C_1^{*}, C_2^{*}, \ldots, \ C_{\mathrm{m}}^{*}\} \tag{13}$$

(2) Take the C^{*} as a reference data column, the formula

$$\left(C_{ik}\right) = \left(C_{i1}, C_{i2}, \ldots, C_{i\mathrm{m}}\right) (i = 1, 2, \ldots, n) \tag{14}$$

as the compared data column. Use the formula

$$\xi_{\mathrm{i}}\left(\mathrm{k}\right) = \frac{\min\limits_{\mathrm{i}}\left|\mathrm{c}_{\mathrm{k}}^{*} - \mathrm{c}_{ik}\right| + \rho \max\limits_{\mathrm{i}}\left|\mathrm{c}_{\mathrm{k}}^{*} - \mathrm{c}_{ik}\right|}{\left|\mathrm{c}_{\mathrm{k}}^{*} - \mathrm{c}_{ik}\right| + \rho \max\limits_{\mathrm{i}}\left|\mathrm{c}_{\mathrm{k}}^{*} - \mathrm{c}_{ik}\right|} \tag{15}$$

to solve the correlation coefficient——$\xi_{\mathrm{i}}\left(\mathrm{k}\right)$, which is between the *k*th index of the *i*th logistics park and the *k*th optimal index(i =1,2,…,n; k=1,2,…,m),and the discrimination coefficient $\rho \in (0,1)$, in the Evaluation Matrix:

$$\mathrm{E}=\left(\xi_{\mathrm{i}}\left(\mathrm{k}\right)\right)_{n\times m} \tag{16}$$

(3)Set

$$\mathrm{W}=\left(\varpi_1, \varpi_2, \ldots, \varpi_{\mathrm{m}}\right) \tag{17}$$

as the weight distribution matrix, and the ϖ_k (k=1,2,…,m) is the *k*th evaluation index's weight, it should be settled for:

$$\sum_{\mathrm{k}=1}^{\mathrm{m}} \varpi_{\mathrm{k}} = 1 \tag{18}$$

So the comprehensive evaluation matrix is

$$\mathrm{R}=\mathrm{W}\times\mathrm{E}^{\mathrm{T}} = \left(\mathrm{r}_1, \mathrm{r}_2, \ldots, \mathrm{r}_{\mathrm{n}}\right) \tag{19}$$

and it represents the comprehensive evaluation results of all the logistics centers.

(4)Finally, according to the formula

$$\mathrm{w}_{\mathrm{i}} = \frac{\mathrm{r}_{\mathrm{i}}}{\sum\limits_{\mathrm{i}\to\mathrm{n}} \mathrm{r}_{\mathrm{i}}} \tag{20}$$

we can calculate the weight of every logistics park in the Xiamen logistics system.

5.2 Calculation and prediction for transportation demand of Xiamen Qianchang logistics park

5.2.1 Main factors that affect the demands of logistics nodes

It relates to several factors influencing logistics parks' demands, mainly determined by serving area, product types, and city conditions, etc. Based on overseas experiences, combing domestic situation with the development of Xiamen's logistics nodes, this paper applies 5 comprehensive indices to evaluate Xiamen's main logistics nodes, which are planning acreage, spatial radiation range, expansibility of nodes, serving type and supporting industries.

(1.) Planned acreage of logistics nodes: planning acreage is the most influential factor for logistics nodes scale, and a basic guarantee for logistics nodes to provide logistics services. It has a positive correlation with logistics volume. Since most Xiamen logistics nodes are still in their infancy, this chapter uses nodes planned acreage to evaluate this criteria.

(2.) Spatial radiation scope: also called spatial serving scope, which reflects logistics node's serving capacity for functional area, which is positively related to single node's volume. Generally speaking, each single node's serving scope peripheral is not visually clear. Hence, this research adopts the qualitative analysis—Expert scoring method deciding on the value of individual logistics node. Each node's functional area consists of international, mainland, and appealing radiation area as well as serving Xiamen, Zhangzhou and Quanzhou. These areas are prioritized as mentioned sequence with scoring rank: 1, 0.75, 0.5, 0.25.

(3.) Serving type: generally speaking, logistics nodes have comprehensive service functions, while some logistics nodes stress on one or several kinds of logistics service function, such as the comprehensive logistics nodes equally providing all kinds of logistics service functions, the storage & distribution logistics nodes mainly providing storage and distribution services, the transportation logistics nodes mostly providing transportation, the circulation processing logistics nodes primarily providing circulation processing services. The comprehensive logistics nodes' logistics volume is relatively larger, the circulation processing logistics nodes' followed by, while the storage logistics nodes' is relatively smaller and the transportation logistics nodes' is smallest. These logistics nodes above are prioritized as mentioned sequence with scoring rank: 0.8, 0.6, 0.4, 0.2.

(4.) Extensibility of nodes: extensibility of nodes reflects logistics node location region's land utilization and space extensibility of nodes' development, having a positive correlation with logistics nodes' demand. The evaluating indicators are large, relatively larger, common, relatively small, and small, with scoring rank: 0.9, 0.7, 0.5, 0.3, 0.1.

(5.) Supporting industries index: according to highway's and railway's freight category and their volume of Xiamen in 2006, we analyze each logistics node's serving industry type, and define indices of supporting industries for logistics node and gives the value of corresponding indices. According to the principles above, the paper defines logistics park's logistics demand, the value of indices are shown in Table 14.

Table 14: The value of indicators about logistics park's logistics demand

	Service Area	Function Type	Extensibility	Planned Area （hektare）	Supporting Industry Indicators
Qianchang LP	0.75	0.8	0.85	387	0.46
Dongdu—Xiangyu LP	1	0.6	0.4	288	0.18
Haicang LP	0.9	0.4	0.6	144	0.21
Airport LP	0.75	0.7	0.4	22	0.19
Liuwudian LP	0.5	0.8	0.6	270	0.31

5.2.2 Identifying each affecting factor's weight

Different indices' weights influence evaluation effect, so identifying weight should connect with park's actual planning and operation situation. On the basis of considering each affecting factor how to influence logistics parks' logistics demand comprehensively, we organize experts try different methods to identify each affecting factor's weight, according to each index's characters, the weights are shown in Table 15.

Table 15: Affecting factors' weight about logistics park's freight demand

Affecting Factor	Service Area	Function Type	Extensibility	Planned Area	Supporting Industry Index
Weight	0.15	0.15	0.15	0.35	0.2

5.2.3 Forecasting the attract volume of Xiamen Qianchang logistics park

According to logistics park foundational evaluating indices, establishing evaluated index matrix C and identify most superior index set C^*=(0.9,0.8,0.85,5800,0.46).Taking most superior indicator set C^* =(0.9,0.8,0.85,5800,0.46)as a reference data sequence while $(C_{ik}) = (C_{i1}, C_{i2}, C_{i3}, C_{i4}, C_{i5})$ (i=1,2,…,5)as a comparison data sequence, choosing ρ =0.5, and changing matrix C to a judge matrix. According to six factors' weight affecting logistics park's freight demand W=(0.15,0.15,0.15,0.35,0.2), calculating comprehensive evaluating matrix of logistics park's freight demand R=(0.93,0.57,0.45,0.41,0.58). According to formula (20), get Xiamen Qianchang Logistics Park's proportion to all the freight volume of Xiamen: w=0.93/2.94=0.32. And connection with the value of forecasting the attract volume of Xiamen Qianchang logistics park market in 4.3.3, finally conclude the result of forecasting the attract volume of Qianchang logistics park, as shown in Table 16.

Table 16: the result of forecasting the attract volume of Xiamen Qianchang logistics park in the future year

Year	2009	2010	2011	2012	2013	2014	2015	2020
Suitable terminal capacity	1823	2086	2326	2593	2888	3214	3574	5465

References:

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Evaluation for Cargo Tracking Systems in Railroad Transportation

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Abstract

Cargo tracking issue on train transportation is challenging area because of long distance haulage, theft, terror attack and customer service. This paper aims at evaluating various cargo tracking systems in terms of cost and technology. The contents of this paper consist of the research trend of cargo tracking system in the railroad transportation and reviewing of technical alternatives in cost and service side. GNSS and RFID are reviewed as location tracking technology, Internet and Satellite technology like INMASAT and Low Earth Orbit are also reviewed as communication infrastructure. This paper selects cost and service factors in two alternatives of GNSS-Satellite and RFID-Internet, among GNSS-Internet, GNSS-Satellite, RFID-Internet, RFID-Satellite and evaluate each alternative in terms of cost and service. In a result, in terms of cost, RFID-Internet type is superior to GNSS-Satellite type, but in service GNSS-Satellite type is preferred to RFID-Internet in point of area coverage and service coverage.

Keywords: Location Based Service; Train Tracking; Position Measurement; GNSS; RFID

1. Introduction

The railroad transportation is suitable in long distance transport. Comparing with different transport, there is a strong point which is able to secure the timeliness of the freight transportation. However weakness of communication infrastructure, the charge of cargo tracking and trans-shipment to other train make difficulty in cargo tracking. There are many alternatives in cargo tracking system, which is composed of communication and position decision technology. This paper aims at evaluating various cargo tracking systems in terms of cost and technology. The contents of this paper consist of the research trend of cargo tracking system in the railroad transportation and reviewing of technical alternatives in cost and service side. GNSS and RFID are reviewed as location tracking technology, and Internet and Satellite communication technology like INMASAT and Low Earth Orbit are also reviewed as communication infrastructure. This paper selects cost and service factors in two alternatives of GNSS-Satellite and RFID-Internet, among GNSS-Internet, GNSS-Satellite, RFID-Internet, RFID-Satellite and evaluate each alternative in terms of cost and service.

2. Basic Study

2.1 Feature of rail transportation

Generally speaking, rail transportation has the advantage in price competition compared with other transportation modes under the condition of long haulage. Furthermore as rail transportation has not been affected by weather condition, it can guarantee reliable service to customer in terms of right time and right product. In comparison, rail transportation has also disadvantage in door to door service due to frequent transshipment because it has to operate on fixed rail.

2.2 Literature review in cargo tracking system

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Not so many papers about rail transportation tracking system have been found. H.S. Lee (2003) suggested that there are three type of positioning system, which are satellite based positioning system, mobile communication based positioning system and wireless based positioning system.

J.G. Lim *et al.* (2006) suggested that mobile positioning technology is classified into network based system and GPS receiver based system and hybrid system which combines two types.

Y.G. Lee (2003) analyzed cargo tracking system which applied in Korea business. His point is that car monitoring system mixing GPS and GIS technology is shown on high level utilizing mobile networks. In ocean area, vessel monitoring system is developed by MOMAF in order to track Korean flag vessel navigation in dangerous area using GPS and satellite communication technology

Y.S.Byun (2000) suggested that multi modal transportation requires cargo tracking system due to the complex structure of transportation in view ownership, position and transshipment. His point is that GPS technology is the popular alternative in tracking transportation object like rail, truck and vessel, but for cargo tracking, special database to link transportation object and cargo is required.

T.W. Kim (2007) suggested that RFID system is very useful tool to fix position because it make the related information such as identification, passing time and place and frequency of vehicle for related person.

3. Review of Alternatives for Railway Tracking

3.1 Scope of LBS review

In order to review the alternatives, first of all, we have to consider some aspects of rail transportation; that is a cargo train operates on fixed track and cross the border of many countries, and is supplied by electricity.

The tracking technology of moving object is composed of location positioning technology and communication technology for position data. GNSS, RFID, ultra sonic wave, infrared are main technology of positioning. In comparison, Internet, power line as wire communication, WMS (Wireless Mesh Network), VHF/UHF, Orbit satellite as wireless communication are main technology for communication.

3.2 Positioning technology

There are two kinds of technologies to catch position as reality alternatives among others. GNSS and RFID technology can be listed for rail transportation tracking system. RFID technology can be used as object identification technology and fixing position within closed space. In this review, RFID technology can be considered as fixing position tool utilizing identification technology different from RTLS (Real Time Location System).

3.2.1 GNSS

Global Navigation Satellite System is the tracing system which track object on earth using artificial satellite network. For example, GPS by USA, GLONASS by Russia, Galileo Project by EU, Beidou by China and QZSS by Japan can be listed.

In reviewing components of GPS, it has three parts which are composed of satellite division, a ground control center, user division. Satellite division had six orbits and twenty four satellites which go round earth on 20,200km height, 55 degree of inclination, 12 hour cycle period. The satellites are stationed in order to receive the signal from minimum five satellites.

A ground control center is composed of five control stations. The station tracks satellites by GPS receiver and stores distance into database of system. The collect data in the station sent to main ground control center processed for orbit decision and control of satellite. User division is composed of antenna and receiver. This user system calculates position, speed and time after receiving satellite signal. The positioning of GPS is dependent on triangulation method. There are five types of GPS positioning such as single positioning, DGPS, static survey, and RTK(real time kinematic) in accuracy as Table 1. Single receiver poisoning type has position error in 15~30meters, but low cost receiver evokes wide usage for navigation. DGPS is designed for improve accuracy limitation in single receiver type. The position accuracy of DGPS is within 1~5meters. Static survey positioning type is also designed for position accuracy combining two measurement GPS as well as DGPS, but it cannot get real time based position. RTK design style is very similar to Static survey type but it has real time based position. Figure 1 shows the block-diagram of GPS receiver.

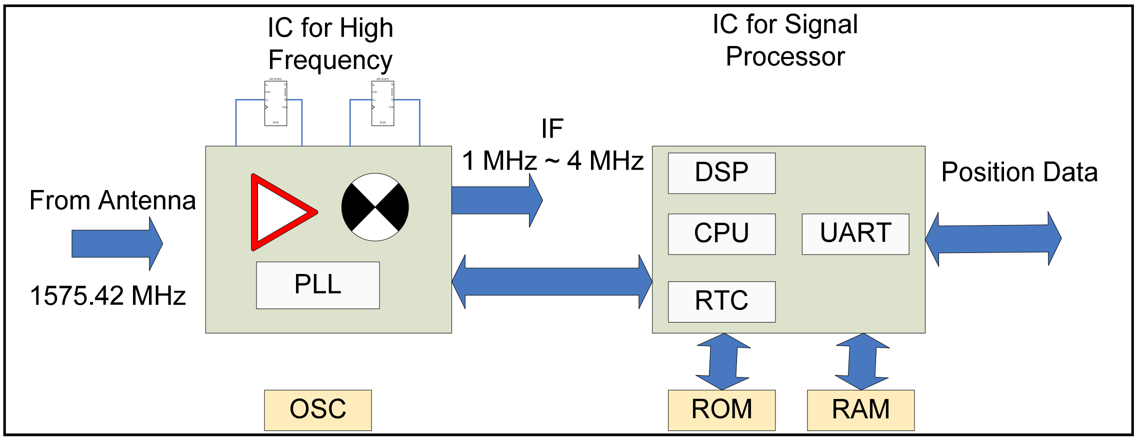

Figure 1: Block diagram of GPS receiver

Table 1: Types of GPS positioning

Type	Description	Accuracy	Remarks
Single Receiver Positioning	Positioning by single GPS receiver	15-30m 100 meter	Real time based position for navigation Low price receiver
DGPS (Differential GPS)	Combining measuring technology and navigation technology	1-5 meter	Requiring reference point and communication media for accurate positioning
Static Survey	Using more than two measurement GPS receiver for accurate positioning	1 ~ 5meter	Non real time positioning Requiring reference point High price receiver
RTK (Real Time Kinematic)	Using more than two measurement GPS receiver for accurate positioning in real time	1- 2meter	Requiring reference point and communication media for accurate positioning High price receiver

3.2.2 RFID

RFID is composed of four components such as RFID Tags, RFID readers, antenna and computer networks. The RFID tag is divided into passive type and active type. The main difference is that passive tag is activated by RF signal from reader and active tag has its own battery in tag for working. Active tag is more reliable to recognize the signal from distance in succession due to its power rather than passive tag. The signal of active tag with 915MHZ frequency reaches 30 meter, the signal of active tag with 2.4GHZ frequency reaches 90 meters for identification.

Meanwhile, the passive tag has advantage in the size, life cycle and tag cost in comparing with active tag. The tag is smaller and lighter and can be produced in lower cost and last in longer life.

3.3 Communication technology

3.3.1 Internet communication

There are many types of Internet communication which are LAN, WAN, MAN, High-Speed Backbone. In the research, PSTN(Public Switched Telephone Network) or ISP(Internet Service Provider) Network is applied for communication media as a type of WAN(Aide Area Network). There are some kinds of remote access of WAN which are optical cable, xDSL(i.e, VDSL, ADSL, RADSL), frame relay, ISDN, Cable Modem, satellite or cable modem. Among the above access type, cable modem type is preferred as a communication alternative because of lower rental cost and co operation with CATV. In addition, reviewing PSTN of ADSL or VDSL[2]as alternative, we dropped it because of unreliable quality from long distance[3].

3.3.2 Wireless Mesh Network

WMN operates just like a network of fixed routers, except that they are connected only by wireless links. WMNs are gaining significant momentum as an inexpensive way to provide last-mile broadband Internet access. In this application, some of the nodes in the WMN are connected to the Internet via physical wires, while the remaining nodes access the Internet through these wired gateways by forming a multi-hop WMN with them. As deployment and maintenance of physical wires is a major cost component in providing high-speed Internet access, use of WMN at the last hop significantly brings down the overall system cost and offers an attractive alternative to DSL/cable modem. This technology will be applied in further research to reduce communication fee occurring on each container to send position data to ground control center through satellite.

3.3.3 Satellite communication

A Stationary Orbit Satellite and LEO(Low Earth Orbit Satellite) provide communication channel between ground and satellite. A Stationary Orbit Satellite service is presented by INMARSAT and Low earth orbit is presented by Iridium, GLOBALSTAR, ORBCOMM and ICO. INMARSAT which was found by IMO(International Maritime Organization) is international maritime satellite communication system, whose role is to improve the communication service regarding to ship disaster, safety, maritime public communication, navigation information in anyplace including sea, air and land. Figure 2 shows the configuration of INMARSAT-C transceiver.

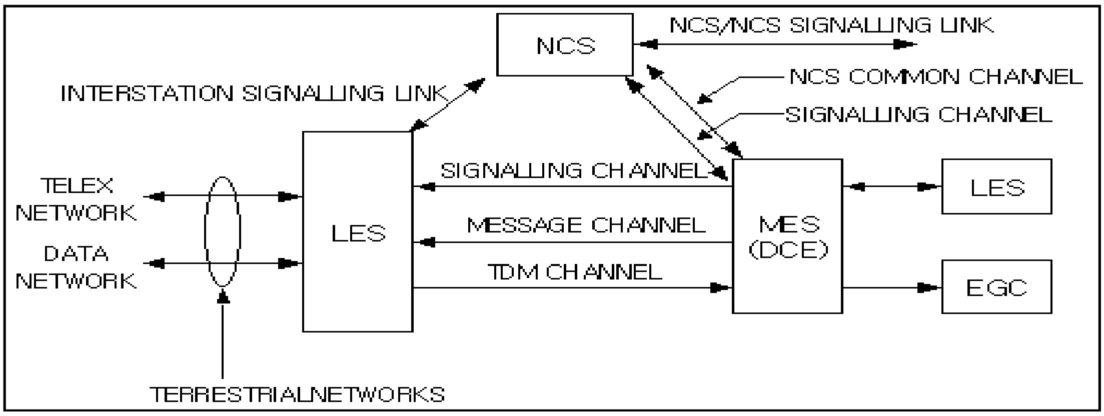

Figure 2: Configuration of INMARSAT-C Transceiver

LEO which is suggested by Motorola has some advantages in terms of lighter weight, smaller size, lower power for communication and lower launching cost. This advantage enables for customer to use LEO in field of mobile telecommunication, wireless call service and LBS.

[2] ADSL is an abbreviation for `asynchronous digital subscriber line'. COMPUTING ADSL is always on, which makes your PC much more vulnerable to hacking

[3] The speed is deteriorated in communication of 5 KM long distance

4. Evaluation Model for Railroad Transportation

In this section, the authors try to set up two types of evaluation model. The one is the combined type of GNSS and satellite communication (Figure 3), the other is the combined type of RFID and wire communication (Figure 4). Two suggested types here are based proven technology, the applicability reflecting on reality and the trend of technology development.

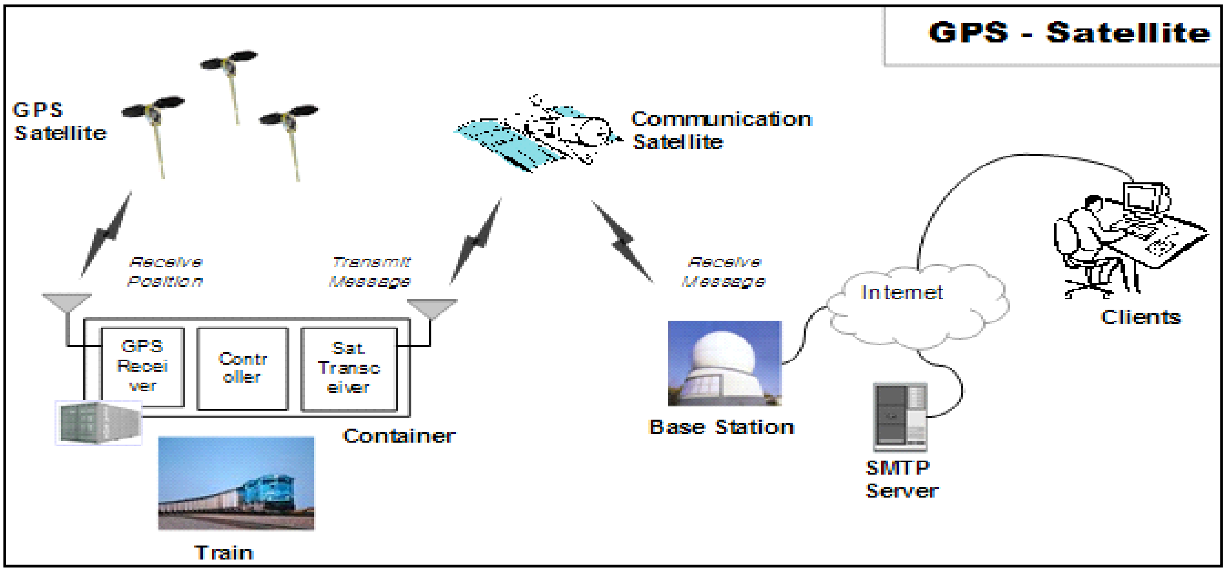

Figure 3: GNSS-Satellite System

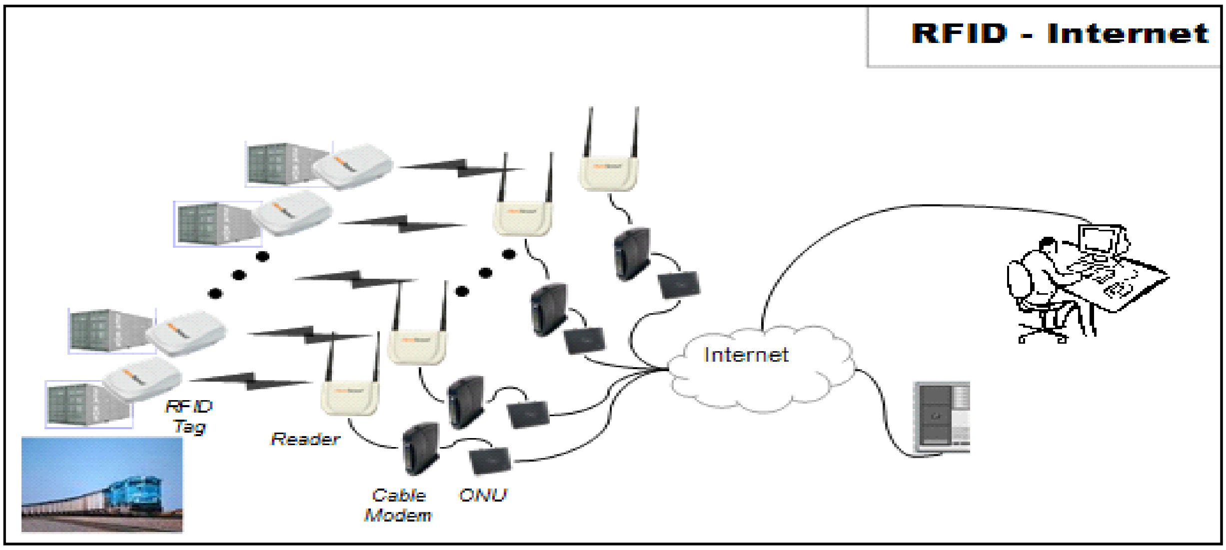

Figure 4: RFID-Internet System

4.1 Scenario for model evaluation

The authors set up railroad operation from Busan Jin station to Kyung-In ICD near Seoul as the scenario of model for evaluation of two type systems. The distance between origin and destination is estimated to be about 400 kilometers and a train moves average twenty three flat cars and the number of legs per day for Seoul is set to be 24 and for Busan is 22 on real operation[4]. Each container is loaded to be average 23 flat cars per one train and the ratio of 20 foot and 40 foot is set to be 3 to 7 and the full

[4] Source is drawn by internal report of Kyung-in ICD

loading ratio to be 80 percent. In case of loading 20 foot container on a flat car[5], two 20 foot containers can be loaded on one flat car. In order to catch location position of container, GNSS system or RFID system including communication system have to be installed on each container instead of train body. For smooth flow of trains on the track, the train control center is to be installed at O-Bong station near Seoul. The life cycle of control system is set be five years. For the calculation of total cost on two type model, the related data are summarized on Table 2.

Table 2: Basic data for evaluation

Number of trains movement per day	For Seoul	24
	For Busan	22
	Total	46
Number of flat cars per train		23
Full ratio per train		80%
Number of container movement per day		1,100 Van
Annually operation days		363 day
Annual container movement		399,300
Number of containers to be installed LBS	Reuse rate is 30%	119,790
Communication frequency	1 report per 2 hours	

4.2 Evaluation criteria

In order to evaluate two types system, the evaluation criteria has to be selected. Technology reliability, future trend, total cost and service can be listed as evaluation criteria. As the GNSS system and RFID system are proven technology used in practical business, it is reasonable to drop technology reliability as a criteria. After criteria on technology neglected, total cost and service factors remain as evaluation criteria. Considering cost estimation, it is necessary to decide who has responsible for cost, i.e. user or service provider. In this paper, cost estimation on service provider is selected in stead of user's cost. Generally speaking, total cost consists of initial investment and operation cost, but here some items for example personnel cost and overhead cost occurred on center operation which do not give a big difference would be dropped for convenient comparison of two types.

As service criteria, response time, service area, installation complexity, law issues like communication frequency allocation are selected, but accuracy of position is dropped as criteria because of train operation. In summary, Table 3 is presented as description of evaluation criteria.

Table 3: Description of evaluation criteria

Classification	Cost		Service	
	Initial Investment	Communication fee	Service Frequency	Coverage of Area
Definition	Hardware development cost including server and communication terminal Software development cost including middle ware and application Hardware	Initial register fee Annual rental fee	Service frequency in considering economy aspects and technology aspects	Service boundary
Unit	USD	USD	Hour	Km

5. Evaluation on Alternative

5.1 Data gathering

[5] Ibid.

The related data for cost calculation are collected from train operation company, satellite operation company and communication terminal maker through telephone interview on January 2008.

5.2 The result of calculation

5.2.1 GPS-LEO

Table 4 shows the result of calculation in GPS-LEO case. In this case, Early investment cost include hardware, software and satellite terminal. The cost of satellite terminal is not added because it is assumed as rent. but communication fee consist of registration fee and service cost including communication and terminal rent fee. As the result, Investment cost amount to USD 70,000 and communication fee to USD 56,741,090. Service frequency is real time and service coverage is all area.

Table 4: Evaluation on GPS-LEO (unit : US$)

Classification									
	Total cost							Service	
	H/W & S/W cost			Communication fee				Service frequency	Coverage
Items	Unit Price	Required Number	Total Cost	Items	Unit Price	Required Number	Total cost	Real time	All area
Server	10,000	2	20,000	Annual rental cost	38	119,790	54,624,240		
Application	50,000	1	50,000	Registered fee	15	119,790	1,796,850		
Satellite Terminal embedding GPS[6]	0	119,790	0						
Sub Total			70,000				56,421,090		
Grand Total							56,471,090		

5.2.2 RFID-Internet

Table 5 shows the result of calculation in RFID-Internet case. In this case, Early investment cost include hardware, software, RFID tag and reader. annual communication cost for internet is only included as communication cost. As the result, Investment cost amount to USD 6,083,500 and communication fee to USD 2,880. Service frequency and coverage is restricted within RFID reader boundary.

Table 5: Evaluation on RFID-Satellite

Classification									
	Total cost							Service	
	H/W & S/W cost			Communication fee				Service frequency	Coverage
Items	Unit Price	Required Number	Total Cost	Items	Unit Price	Required Number	Total Cost	Time difference between RFID Readers	Within 150 meters
Server	10,000	2	20,000	Annual Rental l cost	30	8	2,880		

[6] According to satellite service provider, satellite terminal manufacturing cost would be free and communication fee would be 50% discount if the number is over 100,000

Application	50,000	1	50,000	Registered fee	n.a	n.a	n.a
RFID tag	50	119,790	5,989,500				
RFID Reader[7]	3,000	8	24,000				
Sub Total			6,083,500				2,880
Grand Total							6,086,370

6. Conclusion

Cargo tracking issue on train transportation is challenging area because of long distance haulage, theft, terror attack and customer service. There are different set of technology to implement cargo tracking system. Positioning technology and communication technology is main technology part of cargo tracking system. In this paper we suggested two types of alternatives i.e. GPS-satellite and RFID-Internet reflecting on technology reliability and economy aspects. Furthermore, this paper tried to compare cost and service in order to give some guide for implementation.

In a result, in terms of cost, RFID-Internet type is superior to GNSS-satellite type, but in service GNSS-satellite type is preferred to RFID-Satellite in point of area coverage, service coverage.

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[7] For reliability, RFID reader is to be installed in dual mode.

Competitiveness of Indian Dry Ports and the Impacts of Government Policies: The Dualistic Approach of Policy-makers

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Abstract

Rapid economic growth in India demanded high quality logistical services, implying that dry ports, often characterized by inefficiency, would play pivotal roles. While the Indian government attempted to address this problem by introducing foreign private participation, at the same time, it had to uphold its social-democratic tradition where local operators and their interests should not be edged out by external competition. It is the endeavour of this paper to investigate how the Indian government had attempted to resolve these contradictory issues and provided insight on how political influences can shape an industry's competitive structure, especially in developing countries.

Keywords: Dry port; Competitiveness; Government; Dualistic policies; India

1. Introduction

Contemporary global economy is characterized by globalization which can be interpreted as the increasing universality and of consumption (Levitt, 1983; Dickens, 1998), production in separate locations (Brooks, 2000) and services, of which simultaneous technological progress has allowed services to be provided at a distant location, e.g., invoices, salary administration, marketing and promotion development, call centres, etc. Such development had also opened the global consumer markets to Indian industries which had direct implications on the Indian transport sector. In 2007, the Indian seaborne container trade has increased by nearly 14% to five million TEUs (Ministry of Shipping, 2008), while Indian ports are forecasted to handle 18 million TEUs by 2014 (Dayal, 2006). On the other hand, various duty free zones and special economic zones have been established in promoting exports with single window clearance system and no limits on sales and income tax exemption on profits made which could also be repatriated if the equity holder is a foreigner. Geographically, the northern states, notably Delhi, Punjab and Uttar Pradesh, were the home of which major agricultural and the manufacturing activities took place, e.g., textile, automotive components, etc., while international trade, including exports, was largely conducted through the gateway ports along the southern coast (Lall and Chakravorty, 2002). In 2007, for example, the two coastal ports of Mumbai, Jawaharlal Nehru Port Trust (JNPT) and Kandla (Mundra), had handled almost 80% of the country's containerized trade, of which the cargoes were almost entirely originated from these northern states (Indian Ports Association, 2008).

However, globalization would not be possible without the support of an efficient supply chain, with unimpeded flow of cargoes, of which when translated in colloquial terms implying integrated intermodal transportation network, with the need for high quality management of cargo flows with low inventory costs, more reliable delivery time and distribution. To ensure that Indian products can sustain their competitiveness in the global market, however, the shipment process of cargoes must be smooth and, perhaps more importantly, economical, which exerted substantial pressures to India's transport and supply chain development (Sahay and Mohan, 2003). Such requirement had become even more emphatic with the advent of containerization, and thus a well-developed transportation system would be pivotal in attracting foreign investments (Sachs *et al.*, 2000). For example, according to the World Bank's study interviewing 800 worldwide freight forwarders and logistics professionals, it was found

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that countries with the most predictable, efficient transport systems and trade procedures would most likely be able to take advantage of technological advances, economic liberalization and access to the international markets, while predictability, reliability and quality of services are even more important than the monetary cost of transportation (World Bank, 2005). Such results were supported by a later study conducted by the World Economic Forum where, rather than distance, the core factor in determining the quality of a supply chain should be connectivity, i.e., the ease with which trade can be transported (World Economic Forum, 2008). The same study also noted that, while distances account for 20% of variation in freight rates, competition and economies of scale have much stronger impact on transport costs, especially the transhipment costs incurred due to lack of direct connectivity.

Thus, it is clear that high delivery costs caused by fragmented supply chain, poor logistic service levels and connectivity would prevent developing countries from realizing their true potential, thus trapping them into sustained poverty. Under such situation, dry ports[2] is likely to play pivotal role in complementing the changing role of ocean carriers and other stakeholders within the intermodal supply chain (Heaver, 2002; Sánchez *et al.*, 2003; Notteboom and Rodrigue, 2005). Generally speaking, a dry port can be understood as an inland setting with cargo-handling facilities to allow several functions to carry out, for example, cargo consolidation and distribution, temporary storage of containers, custom clearance, connection between different transport modes, allowing agglomeration of institutions (both private and public) which facilitates the interactions between different stakeholders along the supply chain, etc. As inland logistics hubs, dry port plays significant roles in optimizing all activities to ensure the delivery of cargoes from one end to another in an efficient manner (Juhel, 1999). Usually located at strategic places near gateway seaports, industrial areas and/or along major transportation axes, a dry port attempts to support various needs along the supply chain, namely: (i) aggregation and unitization of cargoes; (ii) in-transit storage; (iii) custom clearance; (iv) issuance of bill of lading in advance; (v) relieving congestion in gateway seaports; (vi) assistance in inventory management; and (vii) deference of duty payment for imports stored in bonded warehouse (CONCOR, 2008). In many ways, a dry port conducts many functions similar to a modern seaport, especially its role as the distributional nodal points along intermodal supply chains (Meersman *et al.*, 2005). In India, many dry ports were also established within the hinterland regions with the perception that they would subsequently become catalysts of economic growth for their surrounding regions.

Until recently, however, dry ports in India, of which most of them were operated by state-owned corporations, with Container Corporation of India Ltd. (CONCOR) being the flagship operator, were characterized by mediocre performance, which could negatively affect the competitiveness of Indian manufactured products in the global market. While the Indian national government (hereafter called the 'Indian government') was fast to address this problem through the introduction of foreign participation within the sector, at the same time, the sector had fallen into the dilemma that the competitiveness of existing local state-owned operators would be in jeopardy, of which the consequence was not something that the government would be ready to bear. However, while previous works on seaports existed, e.g., Heaver (2002), Sánchez *et al.* (2003), Notteboom and Rodrigue (2005), etc., studies on dry ports remained very scarce, despite the fact that dry port is, in many ways, seaport's inland extension, where shippers can leave and/or collect cargoes as if directly at seaports (Woxenius *et al.*, 2004). Thus, it is the endeavour of this paper to fill in this gap by addressing how the Indian government attempted to play a dualistic game in balancing such contradictory interests.

This paper is structured as follows. Section 2 will introduce the theoretical background, while Section 3 will illustrate the research methodology. An introduction to Indian dry port industry will be given in Section 4, including the dilemmas and the rationale for dualism. The focus will turn to the Indian government's policies on dry port development in Section 5, with special emphasis on how the government's dualistic approach would impact on the competitive platform, finally followed by

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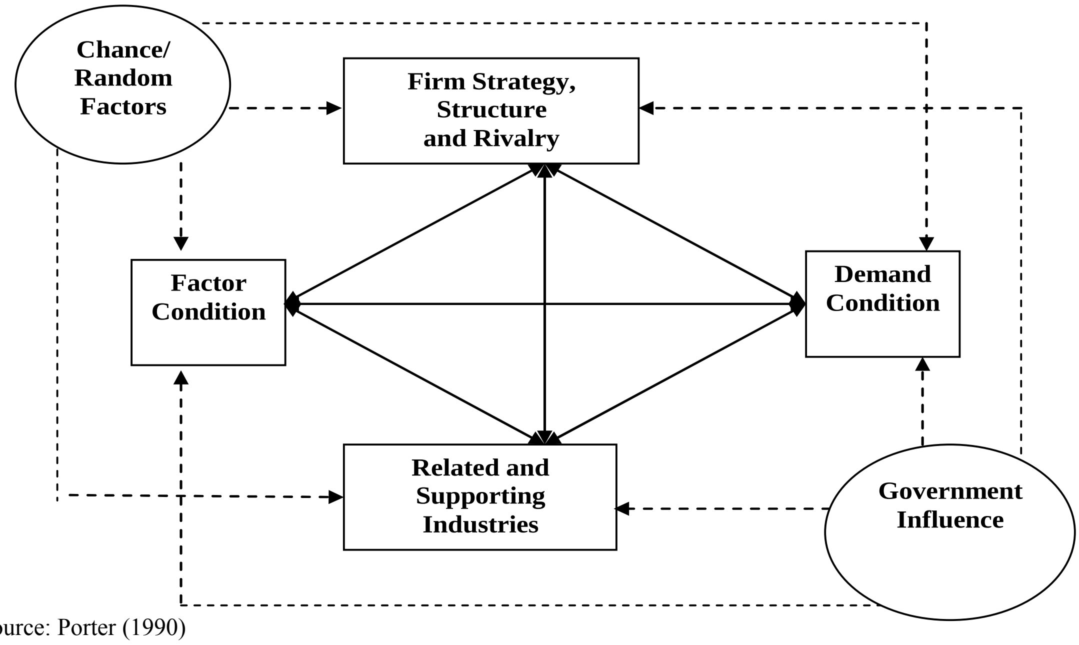
[2] In India, dry ports are usually known as Inland Container Depot (ICD) or Central Freight Station (CFS), which are common user customs bonded facility with public authority status, equipped with warehousing space, adequate handling equipments and IT infrastructure. ICD and CFS offer services for handling and temporary storage of Import and Export laden, as well as empty containers. Cargoes carried under custom control and other agencies competent to clear goods for home use, warehousing, temporary admission, re-export, temporary storage for onwards transit and outright export. The transhipment of cargo can also take place from such stations.

discussions and conclusions in Section 6. It is anticipated that this paper can shed light not only on the development of dry ports in India, but also on how the forces of globalization had its impacts on economic development, especially in newly developing countries.

2. Theoretical Background

Given the study nature which investigated the competitive structure of the Indian dry port industry, the authors had employed Porter's Competitive Diamond (hereafter called 'CD') as the theoretical framework for this study. CD was introduced by Porter in 1990, with the core objective in explaining how a firm could enhance its competitiveness through creating competitive advantages, as well as capturing the key elements of the major attributes which could influence a firm's position within the industry (Porter, 1990; Bowman and Faulker, 1997). The structure of CD can be found in Figure 1.



Source: Porter (1990)

Figure 1: Porter's Competitive Diamond

According to CD, firms, rather than countries, were the principal players in deciding the competitive structure of a particular industry, and the role of a country would be restricted to the provision of a home base for firms, which in turn affected their culture, characteristics and behaviours. Rather than static focus on cost minimization in relatively closed economies in previous competitiveness models, like the Five Forces Model (Porter, 1985), CD argued that competition in the contemporary world should be dynamic, based on innovation and strategic differences due to the increasing number of countries open to the international economy, and thus diminishing the factor intensities of competitions (Porter, 2000). Under such global economy, a firm's competitive position was dependent on two major attributes: (i) operational effectiveness (sought for the best operation practice); and (ii) strategies (sought to answer 'how to compete') (Porter, 2000). To enhance (and sustain) competitiveness, a firm should, on the one hand, ensure operational effectiveness while, on the other hand, create strategies which could self-distinguish from other (existing or potential) competitors.

The core components of CD included: (i) factor condition; (ii) demand condition; (iii) related and supporting industries; and (iv) firm strategy, structure and rivalry. For factor condition, although basic economic factors, i.e., labour, land natural resources and capital, could provide initial advantages, the existence of competition could exert pressures, and thus CD emphasized on creating advanced and specialized factors of production, e.g., technology, professional personnel, specialized facilities dedicated for the industry concerned, etc. Advanced factors were not only more critical in a global economy, but also more difficult to create and retain. Indeed, CD stressed that selective disadvantages in basic economic factors could pressurize firms to create new competitive edges because they needed to innovate so as to compensate their basic/inherited disadvantages. For example, the geographical disadvantage of a port could be compensated by higher cargo-handling facilities and more customer-oriented strategies.

For demand condition, it could be multi-folded, in terms of local, regional, national foreign and global. When the market for a particular product was larger locally than in foreign markets, local firms would devote more attention to that product than do foreign firms, leading to a competitive advantage when local firms began exporting the products (Porter, 1990). Demand characteristics played a highly important role, as sophisticated buyers might force the firm to meet higher standards, while special local circumstances might also complicate the demand characteristics. Indeed, this point was especially relevant for the transport sector, where the demand for transportation, especially freight, was largely derived in nature, thus demand characteristics was highly related to the demand of the surrounding regions, even the global economy, given the trend of gradual global division of labours (Dickens, 1998). Also, a strong and growing local market would offer a strong base for a firm when going global and, in case of maturity, local demand might also added incentives to firms to expand into foreign markets. On the other hand, related and supporting industries were critical to ensure that goods and services could be produced and offered effectively. It comprised of complementary products of which an organization could use and coordinate particular activities in the value chain together. In such case, dry port in India served as an excellent example being a supporting industry to the supply chain, especially given its role as an extension of the gateway seaports, and its performance would directly affect the competitive structures of Indian seaports, or even the Indian manufacturing industry.

Finally, for firm strategy, structure and rivalry, CD argued that there was no single common strategy which could explain all the behaviours of firms because different management ideologies existed. Rather than static, a firm was an evolutionary creature where past experience and personnel would direct impact strategies and development. In tackling competition, strategic decisions could be multi-faceted, e.g., revolutionary vs. conservative, expansionary vs. *status quo*, market consolidation vs. specialisation, etc. As argued by Porter (2000), in a competitive global economy, a firm should develop creative but effective strategies, including cross-border investments, cooperation between competitors so as to achieve win-win situation (Song, 2002), intensive marketing, etc. The market environment was not the only element in deciding strategies and competitiveness of a company, where competitiveness also depended on whether a firm could bent the market environments towards its favour, whether the management hierarchy preferred stability or adventures, or whether it accepted that change is necessary, as well as the availability and quality of resources available to the firm (Grant, 1991). Clearly, CD had included elements from the resource-based theory, where a firm could participate in deciding its own fate[3]. When facing threats (or, in other words, any 'imbalance' within CD of the industry concerned), existing firms could either drop out, or undertaking new strategies (including restructuring) in tackling the upcoming challenges, of which such decisions would be affected by the firm's culture, characteristics of decisions makers, the market environment, as well as the business objectives.

Empirical evidence suggested that the core factors as mentioned above were not the only attributes which could manipulate the direction of CD fully, and this had not unnoticed by Porter himself. Indeed, even within a market economy, the competitive structure could often be influenced by chances (i.e., random and/or unexpected factors) and, perhaps more importantly, the government. Rather than a core player, however, Porter argued that government should only take up a catalytic role, through creating a favourable economic environment for firms to compete at a fair platform, e.g., enforcing standards in service quality, encouraging competition, introducing and enforcing antitrust policies, providing necessary aid, etc., and would (and should) not participate in company's management and strategies because direct participation of government would lead to ineffectiveness and bureaucracy (Porter, 1990). According to Juhel (2001), in the port sector, government, with an established public sector with well-defined roles, should achieve three core missions, namely: (i) catalyst mission (like financing

[3] Resource-based theory argued that the best performing firm could make use of its best available resources into producing high quality products/services. The selection of competitive strategies should be based on sensible evaluation of available resources and strategic decisions which were constrained by past resource deployments, resulting in further reinforcement of the firm's profile. While Five Forces Model emphasised on industrial environment, resource-based theory focused on individual characteristics and believed that the competitive position of a firm mainly lied within its own hands. See Conner (1991) and Grant (1991).

transport assets which are unlikely to get access to private or alternative financing sources and creating regulatory enabling environment); (ii) statutory mission (like ensuring navigation safety and coastal management); and (iii) facilitation mission (like public governance, facilitating trade and initiating trade integration). His view was supported by Ng (2002) and Wang *et al.* (2004) who noted that public presence still mattered in affecting port efficiency. Indeed, governmental influence within port operation could still be widely found either in regional or national scales (World Bank, 2001). For example, state aids existed in many European ports (European Commission, 2005) while the public sector was also often involved in port projects, e.g., dredging, widening of river channels, etc. In North Europe, for example, the role of government in ports differed considerably even between countries within the European Union, where the Benelux countries, France, Germany and the UK all implemented diversified port policies. As a consequence, while CD had largely explained the competitive structure of an industry, with the roles of firms and market environment being clearly defined, its emphasis on the complementary role of the government/public sector within the market was an issue which was highly debatable. As will be discussed in the case of Indian dry ports in this paper, the role of government is not only being restricted to the backseat, but a pivotal role in deciding the 'balancing point' within the CD.

3. Methodology

Given the nature of the study, apart from desk research, the authors had conducted in-depth interviews with 26 companies which had invested, operated and/or managed dry ports in India[4]. Interviewees were chosen carefully by the authors, where all interviewees were assured to be the key persons in making strategic decisions for their respective dry ports when the interviews were conducted. Out of the 26 companies, 21 and 4 were state-owned and foreign companies respectively, while GTI Terminals was a joint venture between Maersk and CONCOR. The affiliations and positions of the interviewees can be found in Table 1.

Table 1: Positions and affiliations of interviewees during the interview period

Company	Position of interviewee	Nature of company
Ameya Logistics	Manager	Local
APL India	Director	Foreign
BML	General Manager	Local
CONCOR	Director	Local
Continental	CEO	Local
CWC Distripark	General Manager	Local
CWC Impex Park	Manager	Local
DRT CONCOR	General Manager	Local
Forbes	General Manager	Local
GDL	Vice-President	Foreign
GTI Terminals	CEO	Joint venture
HIND	Manager	Local
JNPT	Chief Manager	Local
JWC Logistics	General Manager	Local
Kalamboli CFS	Manager	Local
Maersk	Manager	Foreign
MICT	CEO	Foreign
MSWC	Manager	Local
Preeti Logistics	General Manager	Local
Punjab Conware	Manager	Local
SCI	Director	Local
Seabird	Vice-President	Local
South India Corp.	Managing Director	Local

4 Interviews were conducted between October and December 2007.

Speedy	Manager	Local
TransIndia	General Manager	Local
ULA	Manager	Local

In this paper, data, information and opinions obtained from these interviewees are referred as 'anecdotal information'.

4. Indian Ddry Ports: Dilemmas and the Rationale for Dualism

By 2006, 177 dry ports had been set up at several locations within India, of which 40 of them were proximate to the major gateway seaports, e.g., JNPT, Mundra, Chennai, etc., where 58% and 42% of the container traffic between the dry and gateway ports were handled by roads and rail respectively (Hariharan, 2004). Until recently, all of the major dry ports were under the public entity of the Indian government, i.e., state-owned corporations. However, the uneven distribution of dry ports within the country, with about 40%, 30% and 20% being located within the southern, western and northern regions respectively (the central and eastern regions are conspicuous by the almost negligible presence of dry ports) (Dayal, 2006) had led to congestion of facilities and breakdown of infrastructure on one hand, while capacity underutilisation on the other. Also, according to anecdotal information, given the scarcity in financial resources, technological and management know-how, dry ports in India had never been innovative, where long term efficiency-enhancing investments, research and development, e.g., RFID, GPS Systems, etc., were never considered, not helped by the Indian government's labour protective policies. Indeed, the almost complete monopoly of state-owned corporations, notably CONCOR and Central Warehousing Corporation (CWC), had contributed to the problems as mentioned above especially since, as government-approved monopolies, different dry ports often provided generic solutions to non-standardized demands between different regions, raising the question on whether dry port services were really customer-oriented (UNESCAP, 2005; Dayal, 2006).

The price of such problem was dismal performance, as typified by over regulation, poor quality service levels, under-investments in infrastructure development and under-utilization, which in turn affected the competitiveness of Indian manufactured products in the international market. According to the World Bank's Logistics Performance Index (LPI), of which ranking was based on the ability of the country/region concerned in transporting freight in a cost effective and reliable manner (including customs procedures, physical infrastructure, logistic competence, tracking and tracing of international shipments), India was ranked 39th and 46th in terms of overall performance and logistics costs. While the country performed better than most developing countries, such result was well below developed and major newly-industrializing countries, e.g., China, Malaysia, Thailand, etc. (World Bank, 2007). Such inefficiency had often resulted in the reluctance of dry port operators to offer time bound commitment to cargo owners and shipping lines, resulting in the inability of the latter in planning connection of the hinterland containers to specific ships. Indeed, these factors had also led to poor perception of dry ports (and logistics industry) by the general public. According to anecdotal information, working in the logistics industry, including dry ports, was often perceived in India as 'backward' and 'bleak', and thus the sector often found it difficult to attract necessary talents, nor has it been able to impart the necessary skills and vision, leading to sloth and inefficiency.

To address this problem, the Indian government had embarked upon a massive capacity enhancement program, as well as loosening the grip of its control on dry port operation through private participation (Ministry of Shipping, 2008), mainly through the sale and/or leasing of facilities, joint venture and/or Build-Operate-Transfer (BOT) arrangements. In other words, the process was actually duplicating the landlord concept of the gateway seaports in India where the government only sustained its regulatory functions while leaving the operational and management aspects to private operators (Haralambides and Behrens, 2000). Also, an inter-ministerial committee for approval of applications for dry ports had been established so as to facilitate single window mandatory clearances, payments, incentives, certifications, customs presence, etc. Responding to this initiative, together with the projected container trade growth of 15% per annum within the next decade in India (Investment Commission, 2006), a number of dry port users, including multinational logistics service providers (like Schenkers, Kuhne & Nagel and Prologis) and several major liner shipping companies (like APL and Maersk), had entered the Indian dry port sector[5]. Apart from enhancing the efficiency of the intermodal supply chain, increasing foreign incomes (like land rents and tax), the transfer of technology and know-how, the Indian government also anticipated that the participation of foreign firms in the operation and management of dry ports would alter the abysmal condition of India's transport infrastructure, as poor communication and transportation infrastructure could tarnish the country's image for potential investors (including different sectors) in a very tangible way (Sachs *et al.*, 2000a). The Indian dry ports and their operators can be found in Table 2, where state-owned corporations and CONCOR were still operating 61% and 31% of the country's dry ports respectively.

Table 2: Indian dry ports and their operators, 2006

Operator	No. of dry ports operating
Container Corporation of India Ltd. (CONCOR)	55
All other state-owned corporations	53
Total state-owned corporations	108
Private corporations	69
Total	177

Source: Dayal (2006)

Refer back to CD. The lack of competition within the dry port industry had inserted little pressure to improve the factor conditions, leading to mediocre performance. Nevertheless, given the close relation between transport and economic development, poor performance had affected the competitiveness Indian products overseas due to higher costs, causing a change in the demand conditions of the port industry's CD, causing an imbalance within the CD and thus creating a platform for changes. Indeed, the encouragement of private, especially foreign, investments was address such imbalance through enhancing the quality of the dry port industry's CD, so as to boost the quality of India's supply chain, and thus boosting the competitiveness of Indian manufactured products in the global market. On the other hand, however, foreign participation, often with superior technology, marketing strategies, management know-how and, more importantly, willingness to provide time-bounded guarantee to cargo owners and shipping lines, would pose significant threats to the survival of local, state-owned and operated, dry ports, especially if they had lost the advantages of government protection umbrella. Moreover, foreign investors which had entered the dry port industry usually have captive cargoes, and by controlling dry ports and cargo's inland transportation, these firms could potentially generate synergetic benefits leading to significant competitive advantages (enhancing factor conditions in the dry port industry's CD) of which local, state-owned, dry port operators could find it very difficult to match. Also, given the massive number of such dry ports established within the country (and the number of employees being employed), it would potentially be a political tragedy to the Indian government if their dry ports were knocked out of the industry by these new competitors. Indeed, being the world's largest democracy (in terms of population), the Indian government was often trapped in a dilemma, where they would like foreign investors to assist the country's development, especially improving transport infrastructure and efficiency, but at the same time protecting local interests from being exploited by these investors through abusing market power (Sachs *et al.*, 2000a). The need for dualism was, in fact, strictly following India's traditional socialist policy direction since gaining independence in 1947 in fighting poverty, inequality and deterring the exploitation of the non-privileged groups (Haralambides and Behrens, 2000).

The rest of this paper will review and analyze how the Indian government attempts to resolve this

[5] Another incentive for the participation of dry port users in dry port operation was related to the common practice in this trade, where most dry ports operators would charge their fees in advance from the users, mostly comprising of shipping lines and NVOCC operators. It was not uncommon for users to keep certain amounts of money with the operators and replenished the deposits at regular intervals. On the other hand, the dry port operators employed vendors for transportation and handling of cargoes and paid them at a later date. The surplus cash was often used by the operators as seed capital for expansion and servicing of debts. This served a reason why many users would like to enter into the business of inland logistics even though the profit margin was thin as cash flow would be steady and rather low risk.

contradictory issue through dualistic approach. Indeed, the core dilemma of the Indian government lied on how it could balance the dry port's CD, enhancing its efficiency on the one hand, while at the same time maintaining the survival of local non-foreign-invested dry ports before any fundamental but long term solutions could take place. The three major initiatives, both monetary and non-monetary, that the Indian government had taken in helping state-owned corporations in resisting the challenges posed from foreign dry port operators are: (i) land pricing and distribution; (ii) dry port operation; and (iii) dry port's connectivity. The details of these three initiatives will be discussed in the next section.

5. Dualistic Policies in Dry Port Development

5.1. Land pricing and distribution

The major component of the capital costs involved in the construction of a dry port was the cost of land and land pricing and distribution was probably the Indian government's most important policy in dry port development. State-owned corporations, notably CONCOR, were nearly always given preferential treatments so as to ensure that their new terminals could develop with minimum financial difficulties. According to anecdotal information, a dry port locating inside and outside the limits of major cities required a minimum of one and three acre(s) respectively (Revankar, 2006), while a typical dry port in India (with an annual throughput of 120 000 TEUs) would require a land area of about 30 acres. Although land cost varied based on several factors, e.g., geographical location, availability of usable land[6], economic environment, competition with other potential land users, proximity to market place or gateway ports, close affinity to road/rail network, etc., taking the above factors into consideration, by 2007, the land price would vary between US$ 25 000 to US$ 100 000 per acre, and thus a dry port with an annual throughput of 120 000 TEUs of throughout would typically need to spend US$ 1-3 million just only for the sake of acquiring the required land for building the terminals and installing the infra- and superstructures.

Being the biggest landowner within the country, the Indian government also had a major presence in the land's sale and lease. While charging market prices to foreign investors, Except areas around JNPT, lands had been leased out to state-owned corporations, especially CONCOR, for very long periods, usually 99 years, at very favourable rates significantly under market values. Rather than dictated by market forces, the Indian government itself was actually a price setter and implemented dual pricing on land sales or leases, despite that such actions were directly violating its own Competition Act (2002), Article 3, No. 1 (a), stating that no persons/associations should undertake actions which could determine prices (Government of India, 2003). According to the anecdotal information, in some cases, the US$ 1 – 3 million of investments on land could even be waived completely, as long as government officials were compromising alternative arrangements to ensure that their economic interests and policy objectives could be maintained. Such substantial differences in the costs of purchasing land had placed the foreign investors in a seriously disadvantaged position against state-owned corporations. In this way, the Indian government had actually been subsidising state-owned corporations through substantially reducing its initial capital costs when setting up dry ports, but *vice versa* for foreign operators.

Apart from financial factor, acquiring land for the construction of dry port, especially green-field projects, was subject to governmental permission in changing the land use purpose (as almost in all cases, the land was initially used for agricultural purposes), and land distribution policy was clearly offering preferential treatment to state-owned corporations which often enjoyed the privilege of obtaining the required land against other private operators. For example, in Mumbai, while most of the 17 dry ports surrounding JNPT were privately owned and operated, until now, the government had only granted land to the dry port operated by CONCOR in the construction of railhead, whereas leaving all others transporting their containers by trucks. Given that the typical cargo transportation rate between dry and gateway ports cost about US$0.15 per km US$ 0.25 per km by trains and trucks respectively (Ng and Gujar, 2008), it was clear that the government had imposed preferential policy so as to trigger

[6] For example, marshy land was not suitable for dry port construction, and would require substantial engineering expenditures to address such problem, e.g., filling, levelling, etc.

the attractiveness of state-owned corporation against its competitors.

Last but not least, the acquirement of land was complicated by the non-availability of proper land records, which often led to wastage of time and litigation. To resolve such problems, the Indian government, through local bodies like City Industrial Development Corporation (CIDCO) or other similar bodies, acquired land from users and developed it after which it was sold or leased to the interested parties. However this process was often riddled with corruption. According to anecdotal information, it was common practice that the promised road electricity, telecom infrastructures were never delivered or delayed due to the fact that government officials, especially local ones, were often waiting for extra 'credits' before taking the initiative in acquiring the required land. In this aspect, as mentioned earlier, the Indian government was the largest landowner within the country, with the Ministries of Railways and Defence and port trusts owning huge tracts of land across the country, thus possessing considerable strength in manipulating land distribution and its use.

5.2. Policies on dry port operation

Apart from land policy, the Indian government also carried out policies which allowed dry ports operated by state-owned corporation to grow, mature and compete. For example, state-owned dry ports were allowed to suffer a financial loss in the initial period of two years. During this period, on the one hand, the operator was expected to make every effort to keep its overheads low, while on the other hand canvassing for more businesses. Such scenario had largely benefited such state-owned corporations as it implied that a guarantee was offered by the government in absorbing any losses which had incurred during this period. In fact, even if the objective of balancing the books failed after the initial two years, the operator was able to cut its loss through selling off its equity holding, either partially or fully. Also, apart from such breathing space, the Indian government would also take the responsibility to partially cover revenue costs[7].

Given such substantial assistance in both capital and operational costs, state-owned dry ports were often able to make extensive use of discounts, preferential and predatory pricings to attract customers. For example, according to anecdotal information, users would often enjoy nearly 50% discounts in fuel costs in using state-owned dry ports. Such assistance had significantly enhanced its competitive positions, especially given the currently substantial increase in oil prices[8], while subsidizing policy simply implies that rail transportation can be employed, even if the minimum threshold had not been fulfilled[9]. For example, even though CONCOR had a published tariff on their official website (CONCOR, 2008), published information was merely for window-dressing purpose. According to anecdotal information, even CONCOR officials admitted that, except during the congested seasons, the actual prices was always flexible and usually significantly lower than what had been stated publicly, especially towards the major customers, where bulk discounts, extended credit periods and storage offered at subsidized rates were common. Indeed, the Indian government had so far *de facto* acknowledged such strategy. Despite the enactment of the Competition Act (2002), it had deliberately implemented measures to preserve the dominant position of state-owned corporations, especially CONCOR, within the industry. Finally, in certain cases where the cargoes involved was time sensitive or prone to pilferage, e.g., perishable products, garments and accessories, household products, leather products, pharmaceuticals, etc., the operators often demanded a premium above the published tariff simply for being extra diligent whilst handling such cargoes. Indeed, it was also not uncommon for the operator to rent out partially or sometimes entirely the storage space to a single customer for certain time periods against payment in advance which relieved its cash flow burden.

5.3. Policies on dry port's connectivity

[7] The revenue component mainly comprises of costs of transportation from the dry port to the gateway port and back.

[8] For example, between Jan 07 and Jan 08, oil prices have been doubled, while such figure had increased more than quadrupled since 2002 (BBC, 2008).

[9] In India, it is generally agreed that a minimum of 90 TEUs of containers is required for rail service to become economically feasible at the indicated rate of US$0.15 per km. See Ng and Gujar (2008).

On the other hand, interventionist policies also existed in affecting the connectivity to/from the dry ports and, in this aspect, the influence on rail operation served as the most important example reflecting the preferential policy of the Indian government. Until 2006, domestic container transport business was completely reserved to CONCOR, but the government decided to invite private participation into the container rail sector, after the publication of World Bank's report on India's future transport development (World Bank, 2002), for two main reasons. Firstly, the rapid annual growth rate in container trade in the next decade, as indicated earlier, implying an additional container transportation of almost 1 million TEUs, and it is perceived that CONCOR alone would not be able to handle. Also, the Indian government would also like to ease the stress on road by transferring some of the burden on the rail sector, of which currently nearly 60% of the containers throughout the country are transported by trucks. The result was the granting of licenses to 14 foreign private companies to operate container trains between dry ports and the gateway seaports through concession agreements envisaging two categories, namely: (i) pan-India basis, costing US$ 1 million (chosen by 10 operators); and (ii) the more expensive (but more lucrative) route-specific basis, costing US$ 2.5 million (chosen by 4 operators). Through the same agreement, private operators would deploy their own containers, wagons and handling equipment, building their own terminals, and marketing for customers. Under such arrangement, the participation of the private sector is expected not only to attract traffic from the road sector but is also expected to enhance rail transport capacity without burdening the government.

But after acquiring expensive licenses from the government, foreign operators often found it difficult to sustain operation as this had adversely affected their initial pricing structure, not to mention the substantial capital costs of purchasing land for building of terminals as discussed before. To make things worse, these operators also grudged the absence of service level guarantees in the model concession agreement which inhibited their ability to attract cargo from the road sector, given that the private operators often lacked their own terminals and shortage of container wagons[10] and that they often needed to pay CONCOR, the corporate limb of the Indian government, to use their terminals and container wagons, which put themselves in further disadvantageous competitive positions, as their supply of services was prone to government's manipulation. Finally, transport costs were also highly subsidized by the Indian government, usually in terms of fuel subsidies, as well as rail and road haulage between state-owned dry ports and the gateway seaports and production plants, as exemplified by the fact that the construction of CONCOR's railheads were heavily funded by public money. Under such situation, the private operators soon found that the carrot which attracted the private operators to this sector in the first place, i.e., the projected substantial container trade growth within the country, had soon evaporated, mainly due to the preferential polices of the Indian government to CONCOR.

6. Discussion and Conclusion

The case study in this paper served as a typical example illustrating the Indian government's dualism in tackling globalization while at the same time maintaining the *status quo*, i.e., the dominating control of dry ports (and their market shares) by the Indian government through their commercial limbs – the state-owned corporations. On the one hand, the Indian government would like to take advantages of globalization in assisting the country's economic and thus enhancing its global status and competitiveness (Dickens, 1998), while at the same time needed to absorb the shocks and minimized negative consequences posed by foreign direct investments (FDIs), especially potential market concentration and the abuse of market power, where it would be in direct loggerheads with the Indian Constitution (Article 39/b) stating that ownership and control of material resources of the community should be so distributed as to best sub serve common good and the operation of the economic system should not result in the concentration of wealth and means of production (Government of India, 1994).

[10] This problem was slightly relieved by the Indian government in permitting leasing companies to import container wagons increasing the capacity of wheel and axle plants. Nevertheless, the capital intensive nature of rail transport and the dominant position of CONCOR have ensured that this problem is unlikely to be completely addressed in the foreseeable future. Indeed, this has also reflected the dualistic nature of Indian policies in ensuring the survival of foreign investors, while at the same time restricting them to peripheral, rather than dominating, players.

Indeed, the competitive structure of the Indian dry port industry did not only have an economic perspective, but also a political perspective. Similar to port reform and governance, local/regional interests and political culture, were equally, if not more, important (Kingdon, 1995; Ng and Pallis, 2007), in deciding the competitive structure of Indian dry ports, especially where reservations to changes and foreign participation were still prevalent. While here is not trying to argue that the Indian government did nothing to assist foreign companies in establishing themselves in the industry[11], nor local dry port operators did nothing to enhance its competitiveness, as witnessed by CONCOR's attempts in providing value added services, e.g., packaging, container repairs, storage, etc., and even acting as 3PL service provider and handled cargo charges on behalf of the shippers by delivering it to the eventual consumers (Sahay and Mohan, 2003)[12], it was the Indian government which tolerated FDIs in dry ports in order to exert pressure to improve the industry's factor conditions so as to boost industrial competition while, at the same time, it was also the same government which intervened in order to slow down the need for state-owned corporations to improve their factor conditions, while also ensuring their (especially CONCOR's) dominant position in the foreseeable future, so that foreign investors would not be given any opportunities to create and abuse any market concentration power.

However, the Indian government's dualistic policies, with the objective of 'rebalancing' an 'imbalanced' CD through interventionism, has restricted the development of factor conditions (notably relieving the pressure of state-owned corporations in improving its efficiency and services) and limiting the strategic options of foreign investors. Similar to seaport reforms, the Indian government's rigid policy was clearly not following the rules of the global game (Haralambides and Behrens, 2000). Indeed, dry port operation is an excellent showcase illustrating the sustained policy direction of the Indian government to preserve India as a socialist democracy with 'mixed economy', as characterized its continuous desire to tolerate foreign investors while trying its best not overlook multiple political interests, and such attitude had not changed even after two decades of the 1991-92 major economic reforms, where it vowed to dismantle central economic control which had lasted for more than four decades (Sachs *et al.*, 2000b). According to anecdotal information, the main reason for foreign firms to continue their dry port operation, despite often operating at a loss due to Indian government's dualistic policies[13] was to reduce the risk posed by unreliable performance along the supply chain (as mentioned before, state-owned dry ports had been inefficient and unreliable), which was not dissimilar to these firms' strategy of acquiring dedicated seaport terminals (Heaver, 2002; Meersman *et al.*, 2005) and to ensure that they would not to be left out in reaping long term benefits from the country's projected rapid cargo growth (especially export). While looked okay in the short term, such approach would be unsustainable in the long term development of India, as such policy also backfired as it had implicitly affected the demand conditions of the CD, where foreign investors, in many cases, felt that the Indian government's interventionist approach had given an impression that foreign investors tried to take something away from India, despite the possibility of the other way round. As suggested by Sachs *et al.* (2000a), the FDI regime in India seemed to be restrictive where foreign investors were tolerated rather than welcomed, while its protective umbrella provided to state-owned corporations would prevent/slow down the overall quality of the dry port, and thus transportation and supply chain systems throughout the country.

Furthermore, analysis from this paper had posed a big question mark on the complementary nature of governmental influence on the competitive structure of an industry. Porter (1990) argued that the role of government was limited other than providing a favourable competitive platform for firms to compete.

[11] The Indian government would sometimes support foreign operators by providing aids similar to what had been provided to state-owned corporations. However, according the anecdotal information, the amount of such aids were by no means comparable to state-owned corporations. This policy had further reflected the dualistic nature of the Indian policy, where foreign investors would be tolerated (or even supported), but at the same time being suppressed from increasing market power.

[12] Apart from that, CONCOR had also developed its own gateway terminals in its dry port near JNCT in offering a single vendor service to meet the logistics requirements of customers and they are currently exploring the possibilities of entering into freight contracts with cargo interests directly to meet all the logistics needs of their customers.

[13] While unable to release concrete performance data here due to confidentiality issue, according to most interviewees, until now, few foreign-based dry port operators are making any real profits since starting dry port operations in India.

However, in the case of Indian dry ports, although a competitive platform had been created, rather than favouring all players, the platform was favouring those operated by state-owned corporations, of which the government also had significant interests in, and the market was severely influenced by (both explicit and implicit) subsidies, preferential policies and protection umbrella. Despite the enactment of various competition laws, including the Competition Act (2002) and its precursor, the Monopolies Restrictive and Trade Practices (MRTP) Act (1969), of which the Indian government should be responsible to eliminate practices which have adverse effect on fair competition, protecting consumer interests and ensuring freedom of trade by all participants within the Indian market (Government of India, 2003), in dry port operations, the government ironically took up the roles of both referee and player and actually employing its own market concentration power to halt the rise of alternative concentration, and thus ensuring that the balance point of Indian dry port's CD would be manipulated in line with the government's political objectives and economic interests, not helped by the continuing presence of relations and corruption, which further increased the government's rather contradictory policies in attracting foreign investments on the one hand, while continuing its reluctance in allowing the industry to decide its competitive structure freely.

Last but not least, the authors are confident this paper has provided some insight not only on the development of dry ports in India, but also shedding some light on how governmental influence could shape an industry's competitive structure in developing countries.

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An Appraisal of Motivation Principles in Shipping Companies

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Abstract

Ship managers have a number of challenges to face and successfully managing their people is certainly not the least of these challenges. The present paper will engage in a critical appraisal of motivation principles that can be applied in shipping firms. Within this context a case study involving shore-based staff in a shipping firm based in Taiwan is undertaken and the results of the analysis of primary data collected are discussed. The main findings of the study show that six motivating factors were found to be particularly important for shore-based shipping personnel, namely opportunity to learn new skills, receive higher pay, friendly working atmosphere, cash bonuses, personal growth and development and chance for promotion.

1. Introduction

As the human factor, either as a means to achieve competitiveness or as a cause of accidents, receives generally increasing attention in management practice, there is also a growing recognition within the shipping industry that people are not only a key element but perhaps even the most important part of the equation for an efficient, effective and safe ship operation. Nowadays, with regard to its employees, the shipping company is expected to go a bit further than just fulfilling the terms and conditions of the employment contract, by, for example, treating them fairly, providing them with safe working environment and quality of working life, giving security of employment, enhancing job satisfaction and respecting their needs. Apart from being competent and qualified to perform their jobs, shipping personnel need to be also motivated to achieve excellence, embrace corporate values and culture and exhibit company loyalty.

Against this background the aim of the present paper is to provide a critical appraisal of motivation principles that can be applied in shipping firms. This paper will initially engage in a discussion about the importance of motivation in the shipping industry. It will then set the context of the present study by providing an examination of the most prominent motivational theories. The paper will proceed to the presentation of an exploratory case study involving shore-based staff in a shipping company based in Taiwan and the critical analysis of findings of this research with the aim to shed light to the critical analysis of the motivational principles in ship-ping firms.

2. Motivation Principles in a Shipping Context

2.1 The role of motivation in shipping

The study of motivation is generally concerned with identifying the determinants of the human activity (Young, 1961, p.4). The why rather than the how is the main motivational question seeking to explain behaviour and actions. Motivation has been defined as a theoretical construct used to explain the initiation, direction, intensity, persistence and quality of behaviour and especially goal-directed behaviour (Maehr and Meyer 1997). In other words, it considers why behaviour gets started, is directed, for how long it is sustained, how hard the individual is working at that activity. Why is that of any interest to managers? Because employees' activities and efforts must be instigated and directed towards the accomplishment of organisational goals and their quality, intensity and continuation must be

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ensured. Principles of motivation applied in business organisations can direct behaviour toward particular goals, increase initiation of, and persistence in, activities, lead to increased effort and energy, determine what consequences are reinforcing, and thus result in improved performance.

Motivation has been characterised as being either intrinsic or extrinsic depending on whether the rewards to be gained by an activity are internal or external to the individual. For example, people are internally motivated to do something because it either brings them pleasure, or they think it is important, or morally significant. On the other hand, extrinsic motivation comes into play when a person acts in a certain way because of factors external to him or her, in order, for instance, to gain more money. Either way, whether internally or externally, motivation is associated with some sort of reward systems. And reward systems have been found to influence a number of human resource processes and practices. They have been found to affect recruitment and retention, corporate culture and even labour costs (Lawler 2000). In addition, therefore, to enhanced employees' performance, companies can benefit from the application of some kind of motivational practices in also other ways.

How is all that relevant to shipping? Shipping companies, as any other business organisation, are interested in all areas of improvements in organisational performance and of course the attainment of the company's goals. Shipping firms, however, due to their innate characteristics as service-sector organisations, and also due to the idiosyncrasies of the shipping business itself, rely even more on their people for successful and profitable ship operation. The special features of shipping with regard to its people mainly relate to the distinction between shore-based and ship-based personnel in the companies, the inherent complexity of ship operation which places capital intensive assets in the hands of very few people, and the social aspect of the staff's time on board. A shipping company is not a homogenous business entity in the sense that it is dispersed in two main functional units, the office and the main 'production' unit, the vessel. Among and between these two units employees must go to extra lengths to communicate information, coordinate activities, and cooperate with also external associates for the effective and efficient ship operation and service delivery. On top of that, the working conditions for the ship-based personnel is very distinct from any other business, as their place of work is also their place of living and socialising for extensive periods of time away from family, their social circle and every-thing else that life ashore has to offer. A shipping company is not a homogenous business entity also due to the fact that the people working in it come not only from diverse professional backgrounds but also, most of the times nowadays and referring basically to its ships, from differing national, cultural backgrounds with a so high turnover that is rarely found in other industries and organisations. All these of course can not but complicate work at shipping companies and perplex the employees themselves. Thus, employees need to be well-motivated in order to have the desired performance and avoid the risks of accidents and any kind of losses. Perhaps most importantly, the significance of keeping a pool of satisfied employees lies in their own power; this is so, because the real asset of a shipping company, in which huge capital investments have been made and from which the profits of the company are expected to derive, – the vessel – is in the hands of a very limited number of people, trading in various geographical areas, far away from the management office, in adverse weather conditions and under continuously changing formal jurisdictions. And this is a power that surely nobody wants to hand over to dissatisfied employees.

Obviously also, the point mentioned earlier about benefits arising from the establishment of reward systems can be applied in specific conditions of shipping firms. With the imminent shortage of appropriately skilled seafarers, already felt by many in the industry, established motivation systems can play their role in enhancing the reputation of the firm and attracting and retaining the much sought after personnel of high calibre. Incentives and rewarding conduct can also be conducive to creating and sustaining a corporate culture, whether this is a culture of safety and quality or simply a culture of loyalty to the firm. Lastly, investing in motivational systems, whether intrinsic or extrinsic, is an investment of well-spent resources, which might also result in reduced labour costs; as it has been observed, the cost of even paying higher wages may be more than offset by higher levels of performance (Pfeffer, 1998, pp.195-202).

2.2 Motivation principles reviewed

The focus on people in the discipline of management emerged primarily around the 1920s with the human relations movement introduced after the Hawthorne experiments. By the 1950s a number of early motivation theories had developed paying attention to either the traits or the fundamental needs of the people. Maslow's ascending hierarchy of needs approach to motivation is perhaps the most well-known such theory. The basic idea of his propositions is that there are five groups of human needs each of which when satisfied, ceases to act as an incentive for people (Maslow, 1987). These needs in ascending order are: physiological, safety, social, esteem and self-actualization, or else the lower-order needs usually satisfied externally (physiological and safety) and the higher-order needs basically satisfied within the person (social, esteem and self-actualization). The theory provided no empirical justification and received little empirical support in later years, too, but has remained influential mainly due to its intuitive logic and has given rise to expanded relevant need theories. McGregor (1987) talked about two different views of humans, one negative known as Theory X, encompassing assumptions about employees being lazy and uninterested in their work, and Theory Y, assuming that employees are dominated by higher-order needs and therefore can be motivated by greater responsibility, participation in decision-making and other. Herzberg's (1959) two-factor theory of motivation was particularly popular in the 1960s and investigated those areas at work that offer satisfaction and dissatisfaction to employees. He supported that these were not necessarily related and therefore it cannot be supposed that if workers do not feel dissatisfied this implies automatic satisfaction. He concluded that intrinsic factors were connected to job satisfaction and extrinsic factors to job dissatisfaction and further contributed to the vertical expansion of jobs so as to enhance greater planning and controlling on the part of the employees.

These three basic theories have provided the platform for many of the contemporary views on motivation but have also been criticized for the various weaknesses they exhibit on a number of aspects. Nowadays, for example, we tend to be believe more in the effects of the interaction between individuals and circumstances rather than in specific traits that make up for motivational discrepancies. On the other hand, there is no substantial research evidence of the existence of a universal hierarchy of needs. Noteworthy is the ERG (existence, relatedness and growth) theory of motivation (Alderfer 1969) and McClelland's theory of needs (McClelland, 1976). The ERG theory rejects Maslow's strict progression to higher needs suggesting that more than one group of needs may be operative at any given time and that people can regress to former levels of the hierarchy of needs when a higher one is not satisfied. Conversely, McClelland talked of three main needs, the need for achievement, for power and for affiliation and argued that they shape people's behaviour and can help explain motivation.

Practically the impact of the implications of the afore-mentioned theories has been, among others, the development of job redesign propositions. In essence, re-searchers have turned to the job itself to identify characteristics in it which might act as motivational factors. Hackman and Oldham (1980) suggested five job elements, namely, skill variety, task identity, task significance, autonomy and feedback, which when combined, will create internal rewards to the individual because he/she will know that he/she accomplishes an important task. The same notion of internal rewards and their positive effect on motivation is contained also in the cognitive evaluation theory. This theory, however, goes even further to purport that extrinsic rewards (Deci, 1975) might also have a negative impact and decrease motivation for a job which was previously intrinsically rewarding. Although such proposition might find applicability in a number of settings, it should not be expected to be always pertinent to work environments, as shipping companies, because there axiomatically exists the condition of extrinsic reward, i.e. employment payment, without which provision of employees' services are normally withdrawn. In any case, the significance of intrinsic motivation is once more underlined and ascertained.

Adopting a similar cognitive approach pointing to individuals' targets which condition their behaviour, the goal-setting theory suggests that the identification and establishment of specific goals can act as motivation factor and can lead to increased performance (Locke and Latham, 1990). The Management By Objectives principle echoes this belief, while the contemporary practice of providing financial rewards, in the form of bonuses, for example, after the attainment of specific company objectives is also linked to the same notion.

A review of motivation theories should also include a reference to the equity theory and the expectancy theory. Equity theory has been characteristically referred to as the “felt-fair” principle (Armstrong, 2002, p. 61). This basically implies that people have a sense of their inputs, outputs and the way these are assessed and re-warded in relation to others’ outcomes and they need to feel that they are fairly treated if they are to be motivated. On the other hand, the expectancy theory (Vroom, 1964) relies on certain expectations employees have with regard to: the performance a certain effort can exert, the results this performance will bring, and the attractiveness of these results in the light of their own purposes. It is argued that when the relationships ‘effort-performance’ and ‘performance-rewards’ are strong and when the financial and non-financial rewards satisfy employees, then personnel will be motivated. It refers, of course, to the psychological processes that are involved in motivation and considers the employees’ perception of the likelihood to achieve the desired out-come, their assessment of the attractiveness of the re-turns as well as the demonstrable ability and intention of the company to recognize and reward their performance. One of the strengths of this theory is perhaps exactly this process approach it adopts to motivation rather than seeking to establish a universal principle to explain it. The diversity of needs and values of people as well as of the organizations they work in can hardly be negated. By offering a pattern of mental process rather than a specific content to describe motivation, plenty of room is left for contingency factors to also play a role.

And contingency factors can play a role. Culture, for example, has more than once been found to condition the effect of motivation factors in different countries or cultural contexts (Robbins, S., 2005). The political and economic context can also to some extent channel, directly or indirectly, the concept and practice of motivation by shaping the strategic choices of companies (Marchington and Wilkinson, 2005). Motivation can further be affected by time; tastes, needs, values, priori-ties and attitudes do tend to change over time and managers have to be able to perceive and recognize the impact of these changes on their employees’ motivation. What should also be underlined in a discussion about motivation for improved performance is that the individuals must not only want to achieve high level of performance but they must also be able to do so (Hellriegel and Slocum, 2004). In other words, the issue of accounting for personal abilities comes to the fore as another contingency aspect. It is, therefore, evident that the study of motivation requires an insight into the range of existing motivation theories coupled with an understanding of the various contingency and other – subjective to employees – factors that inevitably come into play.

Having examined the most prominent motivation theories, in the next section the paper will discuss the choices made, for the purpose of the present study, in respect of the framework of issues to be investigated and of the methodological approaches used and it will present the results of the analysis of the relevant data.

3. Case study in Taiwan

3.1 Building a framework of study

The aim of the present research is to examine the concept and exercise of motivation of shore-based personnel in shipping companies and to explore the potential role and effect of individual factors in it. In order to achieve the aforementioned goal a number of more specific objectives have to be attained. Such objectives explicate the purpose of the study and in essence point directly to the kind of steps that need to be taken with regard to, for instance, the type of information that needs to be gathered as well as how it should be gathered. In accordance with the above, the main research objectives of the present study were:

- To explore the concept and practice of motivation in shipping companies
- To attempt to provide an answer to the question what the crucial motivating factors are for employees in shipping companies in Taiwan

- To examine whether various personal details of employees may have an impact on the perceived importance of motivating factors

- To investigate the relevance of perceived motivating factors in shipping firms to general motivational theories

Bearing in mind the diverse and sometimes even conflicting ideas expressed in the main motivation theories discussed before and given the exploratory nature of the present study and the time and resources constraints, a decision had to be made about which aspects of the motivation principles reviewed would become the focus of investigation. Instead of attempting to consider the applicability of a particular theory in the shipping industry, the effort was to widen the scope of the examination to a greater extent. Attention was, thus, drawn to discovering a common notion underlying the majority, if not the totality, of motivation theories which would serve as the overall framework of our research. The idea of 'returns', of 'rewards', of 'compensation' of some sort for the effort or the performance exerted appears to be present in one way or another and in one form or another in all the theories expressed. Whether extrinsic or intrinsic, whether related to personal traits, needs or contingencies, whether received for the input or the output of individuals, rewards are the tools in the mechanism of motivation provision. What is more, although "motives can only be inferred; they cannot be seen" (Hellriegel and Slocum, 2004, p.118), rewards are much more tangible and they are the practical way in which companies respond to motivation requirements. There is, of course, perhaps an large number of different rewards that can be introduced, all of which would be unfeasible to include in a single study. The direction of the present research with regard to the choice of organizational factors to be explored was taken from Steers and Porter (1991), who provided a relevant application of Maslow's need levels. The list was followed neither strictly nor comprehensively, as a number of other factors reflecting various theoretical points were included and as respondents were given the opportunity to add to these, too, prompted by open-ended questions.

Table 1: Steers and Porter's Rewards framework

Needs levels	General rewards	Organisational factors
Physiological	Food, water, sex, sleep	Pay Pleasant working conditions
Safety	Safety, security, stability, protection	Safe working conditions Company benefits Job security
Social	Love, attention, belongingness	Cohesive work group Friendly supervision Professional associations
Esteem	Self-esteem, self-respect, prestige, status	Social recognition Job title High status job Feedback from the job itself
Self-actualisation	Growth, advancement, creativity	Challenging job Opportunities for creativity Achievement in work Advancement in the organisation

Source: Steers and Porter, 1991, p. 35

The present study wishes to throw some light to the subject matter of motivation in shipping firms, gain insight into the pertinent reality of a specific cultural context, Taiwan, and increase familiarity with the concepts and issues concerned in the shipping industry. Under these circumstances, exploration is judged to be a perfectly legitimate objective for a research project (Churchill, 1991, pp.130-132) and the use of a case study also fully justified. Single case design is very well-matched with exploratory studies that serve as a first step to a later, more comprehensive study (Yin, 1994, pp.47-49). The company that served as the unit of analysis was a top containership carrier, public company listed on the Taiwan Stock Exchange, with a fleet of around one hundred vessels – the overwhelming majority of which containers – and with more that 1,000 people working in it. It represented typical case which provided the opportunity to investigate into the subject matter on the basis of easy access to it.

One hundred questionnaires were e-mailed to the shore-based staff of the shipping firm and of these 40 valid responses were received and analysed. Therefore, the results of the study reflect that attitudes and opinions of office staff only in the shipping company as access to shore-based staff was not possible.

3.2 Research results

In order to assess the relative importance of motivating factors, survey participants were asked to rate the importance of each of the listed motivating attributes using a five point scale where 1 = “very unimportant” and 5 = “very important”. Accordingly, a frequency analysis was conducted on the importance ratings reported by the respondents. Results of this analysis and the means for each factor are presented in Table 2.

As Table 2 indicates, the respondents perceive the importance of the motivating factors to be quite high. Most of the factors scored between very important and important (average is between 4 and 5). Only one of the factors is between unimportant and very unimportant (average is between 1 and 2). The two most important motivating factors to employees in the shipping companies are opportunity to learn new skills and receive higher pay, as both of their means are 4.45. The following factors are friendly working atmosphere, cash bonuses, personal growth/development and chance for promotion. Their means are 4.425, 4.4, and 4.325, respectively.

Table 2 also shows that at least half of the ten most important motivating factors refer to intrinsic motivations. This of course implies that the employees may be easier to motivate if they feel they could gain something such as skills, knowledge or experiences from their jobs rather than just receive material benefits.

Open ended questions included in the questionnaire elicited also interesting responses. Employees were asked to indicate any additional factors, apart from the ones appearing in the questionnaire, which could act as incentives for them at work. Seven out of forty respondents pointed out team work as a critical factor for their motivation. They suggested that through team work they share experiences, exchange ideas, learn to coordinate with people, and enjoy the friendly working atmosphere. Organisation of training courses is another factor that many respondents mentioned as contributing to their motivation. It further strengthens the argument that what employees want is not just money or material benefits but they also want to gain benefits of intangible value such as personal competence, ability and knowledge.

Fairness is another motivating factor that respondents put emphasis on. The suggestion points directly to the equity model of motivation referred to in the previous section and provides support to it. A number of other suggestions made by the employees pointed to additional motivating factors, such as the existence of a friendly leader, a convenient company location, parking place, job rotation, no overtime, allowances for pursuing further education, and family group travelling.

Table 2: Relative importance of motivating factors

Motivating Factors	Important Level		
	SD	Mean	Rank
Opportunity to learn new skills	0.545	4.450	1
Receive higher pay	0.589	4.450	1
Friendly working atmosphere	0.543	4.425	3
Cash bonuses	0.583	4.400	4
Personal growth/development	0.608	4.325	5
Chance for promotion	0.685	4.325	5
Good working conditions	0.689	4.225	7
Opportunity for more responsible work	0.628	4.175	8
Opportunity for more diverse work	0.572	4.150	9
Job security (e.g. long-term contract)	0.654	4.150	9

Praise (personally or in public)	0.685	4.075	11
Participation in decision making	0.705	4.050	12
Extra insurance package (life, health)	0.821	3.975	13
Greater autonomy in job planning	0.740	3.950	14
Chance for working abroad	0.773	3.950	14
Company shares	0.781	3.700	16
Social events organised by the company	0.620	3.625	17
Extra vacation time	0.768	3.600	18
Flexible working hours	0.803	3.425	19
Other Material benefits (e.g. shopping vouchers)	0.689	2.975	20

After determining the crucial motivating factors from the respondents' viewpoints, we examined whether various personal details of the respondents have any effect on the importance these motivating factors exhibit. The personal features we specifically looked into include age, gender, position in the company, and marital status. As shown in Table 3, respondents belonging to all different age groups consider the receipt of higher pay as an important motivating factor. It implies that money is always a strong incentive. People below the age of thirty exhibit a greater desire to work abroad, an observation which may point to their inclination for greater adventure or to the absence of any family duties. Employees above the age of forty put more emphasis on enhancing their personal ability, such as opportunity to learn new skills or chance for promotion. As for the least important factors, they do not show much difference among people of different age. Other material benefits is the least important motivating factor for all respondents. However, it is also characteristic that employees below the age of thirty think job security as an unimportant factor, alluding to both their young age and also perhaps to their few years of service in the company.

Table 3: Motivating factors by age group

Age (years old)	3 most important motivating factors and their average	2 least important motivating factors and their average
≥ 30	Receive higher pay (4.6) Personal growth (4.5) Chance for working abroad (4.5)	Other material benefits (3.0) Job security (3.6)
31-40	Receive higher pay (4.4) Cash bonuses (4.3) Job security (4.3)	Other material benefits (2.9) Flexible working hours (3.3)
41-50	Opportunity to learn new skills (4.5) Personal growth (4.5) Opportunity for more responsible work (4.5)	Other material benefits (3.1) Flexible working hours (3.6)
≤ 51	Receive higher pay (4.8) Chance for promotion (4.6) Opportunity to learn new skills (4.6)	Other material benefits (2.6) Flexible working hours (2.6)

From table 4 it is evident that there is no much difference between what men and women perceive as important or unimportant incentives. The receipt of higher pay and opportunity to learn new skills are in this case, too, the important factors for both genders; other material benefits and flexible working hours are the least critical factors. A note of interest, and perhaps a rather surprising one due to its contrast with social perceptions, is the fact that the dimension of friendly working atmosphere appears to be most important for men rather than for women. In addition, a female respondent noted that companies should have some women-specific policies, such as welfare for women during pregnancy.

Table 4: Motivating factors by gender

Gender	3 most important motivating factors and their average	2 least important motivating factors and their average
Male	Receive higher pay (4.5) Opportunity to learn new skills (4.5) Friendly working atmosphere (4.5)	Other material benefits (2.9) Flexible working hours (3.4)
Female	Opportunity to learn new skills (4.3) Cash bonuses (4.2) Receive higher pay (4.2)	Other material benefits (3.1) Flexible working hours (3.3)

Table 5 summarizes certain variations observed between people of different positions in the shipping companies. It is interesting to note that employees without any managerial responsibilities and those entrusted with the very basic ones are more oriented towards receiving some sort of extra pay as an incentive. As we move up the hierarchical ladder, however, the managers become more concerned with enhancing their personal competence and development in the company. A gradual increase in the importance of intrinsic incentives can clearly be seen with the gradual ascendance to managerial positions. It is also worth noting that the issue of higher pay comes back to the picture as a significant motivating factor in the 'executive managers' category having completely escaped the exact previous position category. This could be an indication of the fact that, as the post of 'executive managers' normally entails, both practically as well as symbolically, a sense of personal and professional accomplishment, the issue of higher pay becomes once again, and perhaps also as a differentiating factor among equals, critical. On the other hand, no job position category is particularly interested in the 'other material benefits' category, while again certain other differentiations occur. For example, lower rank personnel is especially concerned with increasing their income in the most concrete form of extra pay, that is, wages and bonuses but shows little interest in acquiring company shares. Conversely, for the higher two position categories, the issue of 'tampering' with their working time has hardly any significance, perhaps due to the expected and unavoidable workload and responsibilities that come with these posts.

Table 5: Motivating factors by position

Position	3 most important motivating factors and their average	2 least important motivating factors and their average
Employee	Friendly working atmosphere (4.8) Receive higher pay (4.6) Cash bonuses (4.6)	Other Material benefits (3.2) Company shares (3.8)
Assistant manager	Receive higher pay (4.6) Cash bonuses (4.4) Opportunity to learn new skills (4.3)	Other Material benefits (3.0) Participation in social events organised by the company (3.2)
Manager	Opportunity to learn new skills (4.4) Personal growth (4.4) Opportunity for more responsible work (4.4)	Other Material benefits (3.1) Extra vacation time (3.5)
Executive manager or above	Receive higher pay (4.8) Chance for promotion (4.8) Opportunity to learn new skills (4.8)	Other Material benefits (2.0) Flexible working hours (2.8)

From Table 6 it becomes clear that no major differences are to be found in the way personnel of diverse marital status perceive motivation. In respect of the most important motivating factors, they all include some sort of financial remuneration but greater emphasis overall appears to be given to the opportunities for greater personal and professional development. It is worth noting that, at a closer look, people with their own family and so with inevitably with increased responsibilities, seek greater stability and continuity in their jobs, in the form of job security and promotion prospects. One thing that is also of interest, however, and emerged contrary to expectations, is that extra time off work was judged as a least significant incentive for married people and people with children. This was a surprising observation and opposing to general beliefs, but could perhaps simply reflect the realism with which people regard their job obligations, especially if these coincide with duties of the higher raking managers.

Table 6: Motivating factors by marital status

Marital status	3 most important motivating factors and their average	2 least important motivating factors and their average
Single	Opportunity to learn new skills (4.5) Opportunity for more diverse work (4.4) Receive higher pay (4.4)	Other Material benefits (3.1) Company shares (3.4)
Married	Receive higher pay (4.5) Opportunity to learn new skills (4.5) Job security (4.4)	Other Material benefits (2.8) Extra vacation time (3.6)
Married with children	Chance for promotion (4.4) Personal growth (4.4) Cash bonuses (4.4)	Other Material benefits (3.1) Extra vacation time (3.4)

The analysis of the data and the discussion of the results of our research in the framework of the general motivation theories point to some interesting outcome. Clearly, for example, Maslow's theory of the ascending hierarchy of needs, is not substantiated by the findings of the present study. In our investigation physiological needs, for example, are related to factors such as receive higher pay and cash bonuses, while safety needs are more reflected to factors such as job security and extra insurance packages; social needs are represented by factors such as participation in social events and friendly working atmosphere; esteem needs by factors like praise and chance for promotion; lastly, self-actualisation needs correspond to factors such as opportunity to learn new skills and opportunity to engage in more responsible work. What has come out of this case study is that employees in the shipping company are concerned more about self-actualisation and physiological needs at the same time, while safety needs appear to be the least important factors to them. Thus, neither the priority nor the hierarchical order given to these categories of needs by Maslow's theory have found here application. The ERG theory is partly confirmed here in the sense that it is obvious that more than one group of needs can be simultaneously operative for employees in a shipping company's environment. The fundamental principles underlying the job redesign theory can also be reflected in the findings of the present research. Opportunity to learn new skills, opportunity for more responsible and diverse work, praise (i.e. feedback) are factors quite high in the importance ranking of employees and of course directly related to the values of the theory. On the other hand, it seems that the cognitive evaluation theory does not have a bearing in this case study. What is more, the issue of fair treatment – equity theory – has also been brought to the fore, despite the fact that no such attribute was included in the closed questions of the questionnaire. The "felt-fair" notion is apparently also at the back of the heads of employees in shipping companies. Lastly, worthy of note is also the fact that contingencies have appeared to play some, as well. Although, similarities across groups of employees in respect of the importance they attach to certain factors are certainly evident, discrepancies have also been observed especially in relation to different age groups and among employees of differing hierarchical status in the company.

4. Contribution, Limitations and Recommendations

The present study examined the significance of a number of crucial motivating factors for employees in shipping companies in Taiwan in an attempt to provide a general framework for motivation development in the shipping industry. The aim of the research was to explore an area of concern for ship managers, which, although extensively treated in the general management literature, has received little empirical investigation in the context of the shipping business environment. In this respect, the research results offer a useful platform for further theoretical reasoning and discussion on the provision of motivating incentives for shore-based staff in shipping companies and their critical appraisal.

However, given the complexity of the real world phenomena under investigation and the often limited re-sources available to researchers, empirical studies tend to suffer weaknesses and our study is not an exception. Within these realms, a number of limitations of the present research have been acknowledged.

The main weakness of a case study research approach, as already suggested, is that it precludes the development of any statistical theory, as it gives no basis for evaluating how closely the case studies' characteristics approximate the parameters of the population. There-fore, population inference or generalization of the theories or concepts discussed can not be made on the basis of statistical support. Having said that, recent years have seen the development of a redefined conception of generalizability According to these developments, generalizability does not only exist in a strictly statistical sense but it can assume other forms, too, equally important. For instance, it can be thought of as a matter of 'fit' between the situation studied and others to which one might be interested in applying the concepts and conclusions of that study (Schofield, 1990, pp.201-209), or it can be described by the term 'analytic generalization'. Analytic generalization does not rely on samples and populations as the investigator is striving to generalize a particular set of results to theoretical propositions, to a broader theory and not to populations or universes (Yin, 1994, p.10 & p.44). Generalising to a theory (analytic generalization) is different from generalising to a population and enumerating frequencies (statistical generalization) but both are perfectly legitimate in their own right. As a result, despite the admitted limitations of the chosen research strategy, reasonable deductions and discussions can be made from the present study about motivation aspects in shipping companies.

Another restriction of this study is the fact that only shore-based personnel of shipping companies was taken into account. Arguably, shipping relies fundamentally on its people on board vessels and their viewpoint and perceptions of motivation should not be overlooked or underestimated. Practical hindrances basically related to time constraints and the reality of work conditions on board which leave little time for participation in research projects prevented us from including responses from ship-based staff. Given the special working conditions on board vessels, the applicability of the research results should be examined only within the context of the office environment of a shipping firm.

Additionally, only a few dimensions with regard to motivation factors have been examined. The literature, as we have seen, is rich in motivation theories and offers a wide range of different aspects and attributes to be empirically investigated. This is especially true for an industry, such as shipping, which has practically not been considerably investigated within these realms. The exploratory nature of the present paper justifies the concentration on a few of the many diverse motivation features. In the same way, the choice of focus on a single country, Taiwan, limits the examination in a specific cultural context. As the literature review has shown, however, motivation factors can differ from one culture to another and this is something that should also be taken into account. Lastly, discrepancies based on the type of ship operation are not expected to be substantial in respect of motivation principles of different shipping firms; yet, it has to be acknowledged that other organisational characteristics could play a role. For example, employees in a family-owned bulk shipping company could be expected to have developed differing relation-ships with their company than employees of large, public shipping firms and this may well have an effect on the way these people can be motivated at work.

From the above it becomes clear that there is plenty of room for further research on this topic. For instance, future investigation in motivation in shipping companies can concentrate on the examination of a number of other motivating factors that stem from the general management theory; it can focus on different cultural contexts and provide the basis for comparisons to be made; it can employ different research strategies, such as surveys, to increase generalisability of findings; or it can consider the perceptions of ship-based personnel in addition to the shore-based staff. What is more, potential, future studies can undertake to examine the impact of organisational features of shipping companies, such as owner-ship type, size, culture, etc on the motivating factors considered as important by their employees.

5. Conclusion

The paper was concerned with a critical appraisal of motivation principles in shipping companies. Due regard was given to the idiosyncrasies of the shipping business which call for a motivation strategy on behalf of the shipping companies and the most prominent motivation theories were reviewed. The paper presented the results of a case study of a shipping firm in Taiwan regarding the degree of importance shore-based staff attached to a number of motivation factors. The findings of the research suggest that overall both extrinsic and intrinsic rewards motivate employees and that some discrepancies in employees' preferences should be expected based among others and on certain contingency factors.

Within twenty motivating factors in the questionnaire, the six most important factors from employees' view-points are opportunity to learn new skills, receive higher pay, friendly working atmosphere, cash bonuses, personal growth/development and chance for promotion. The average of each of these factors is above 4.3 for all of them. The three least important motivating factors according to the respondents are extra vacation time, flexible working hours and other material benefits. Added to the above, respondents suggested on their own also other motivating factors, like team work, organised training courses, and fairness.

The effect of various personal details on the importance level of motivating factors was examined. The results do not show great differences among the different contingencies such as age, gender, position in the company and marital status but some differentiation has been observed along specific parameters.

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World Maritime Cities:
From Which Cities do Maritime Decision-makers Operate?

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Abstract

In recent decades, many researchers have devoted themselves to the study of world cities. One of the most important contributions to world city research has come from the Globalisation and World Cities Study Group & Network (GaWC - Loughborough University). GaWC focuses on external relationships between world cities. It has analysed the world city network and the hierarchy between cities in various sectors, but primarily in advanced producer services (accountancy, advertising, banking/finance and law). Previous studies have identified London, New York, Paris and Tokyo as high-level global service centres, followed closely by Chicago, Frankfurt, Hong Kong, Los Angeles, Milan and Singapore. Thus far, however, the maritime sector has been neglected in the identification and analysis of global cities. The main purpose of the present article is to fill this void.

The first part of our analysis includes a study of the literature on world cities and an examination of the criteria and methods on which previous research has been based. In part two, we explore the world maritime city network by applying and interpreting the GaWC methods. For a city to be recognised as a world maritime city, it must have a presence of shipping companies and container terminal operators. As for the city's operational capacity, that is determined by the extent of linkages between those shipping companies and container terminal operators on the one hand and the rest of the world maritime market on the other. The collected empirical evidence shows that Hong Kong, Hamburg, Singapore, Shanghai, Tokyo, New Jersey/New York, Bangkok/Laem Chabang and London are the world's leading maritime cities. Furthermore, analysis of interrelations in these cities between shipping companies and container terminal has indicated Hong Kong, Hamburg and New York to be the main nodes in the world maritime city network.

Keywords: World cities; Maritime economics; Globalisation; Urban networks

1. Introduction

World cities and their networks have been well-researched. Yet, within this field of study, there is a noticeable void when it comes to world cities in the maritime sector. Indeed, there is precious little literature to be found on this subtopic: unlike other sectors of the economy, it has hitherto not been extensively studied. Yet Friedmann (1986), in his initial list of world cities, already suggests implicitly that seaports are significant. After all, he refers to Rotterdam Europort, not Amsterdam, as a world city. Hence, the purpose of the present paper is to fill the aforementioned lacuna.

This contribution consists of two main parts. Part I encompasses a survey of the literature on world cities. As we have previously pointed out, much research has already been conducted into global cities, albeit in relation to other industries than the maritime sector.

Part II consists mainly in empirical research whereby the world maritime cities are identified and the network that connects them is analysed. In this part we also consider the consequences of globalisation on the maritime networks and we ascertain what are the world's leading ports. Once the latter are

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identified, we are able compare the hierarchy of global ports with that of world maritime cities.

2. World Cities

In this section, we consider the work of a number of authors who put forward distinct perspectives on the subject of world cities. Our literature survey will provide insight into the foundations of other scholars' approach to world cities research and the various methodologies applied in this field.

2.1 Demographic versus functional approach

World cities research has been approached in different ways. A clear distinction can be made between the *demographic approach* and the *functional approach*. In the former, great significance is attributed to city size, while in the latter cities are considered more in the context of the network to which they belong. The functional approach focuses on cities' global capacity, i.e. the number of services offered or, if you will, the relative concentration of knowledge and expertise they represent (Beaverstock, Smith en Taylor, 1999). It is this approach that we shall take to determine from which cities the global maritime sector is commanded. After all, the scope and extent of maritime services provided in a city largely determine the position that it occupies within the network of world maritime cities.

2.2 The new international division of labour

The 1970s marked the beginning of a significant reorganisation of the world economy, a process commonly referred to as globalisation. Investment and production was no longer confined to national contexts, but became increasingly dispersed across the globe. The emergence of new information technologies and evolutions in the transport sector gave rise to a new international division of labour. It became possible for companies to decentralise production and yet retain central control. Moreover, transport was proceeding increasingly rapidly and/or efficiently. Production processes that did not require skilled workers were the first to be transferred to low-wage countries. According to Friedmann (1986), the general model of world cities is a response of those locations to the new international division of labour. The leading cities are, to all intents and purposes, the command and control centres of the world economy. They are important for the successful integration of the globally distributed production sites. Power relationships determine how they are connected with each other and the rest of the world. According to Friedmann, the most important world cities are London, New York and Tokyo (Beaverstock, *et al*., 1999; Beaverstock, *et al*., 2002; Knox *et al*., 1994).

Globalisation has also generated new goods flows and given rise to shifts within the maritime sector. Following Friedmann's hypothesis, we assume world maritime cities to be characterised by a dense concentration of leading corporate headquarters in the maritime industry.

2.3 The space of flows

According to Castells (2001), networks constitute the new social morphology of our societies. The many innovations that have occurred in communication science have been conducive to a structural change in the world and its economy. Today's societies are formed around networks of financial and information flows. In this context, Castells asserts that a passage has taken place from a "*space of places*" to a *"space of flows"*. Therefore, cities' hierarchical position is determined not only by their hinterland, but also by their status within networks of flows. These flows, argues Castells, exert a strong attractive force. The world cities function as large hubs within the space of flows: they are nodes where a multitude of economic sectors meet. Hence, these cities serve as information centres for companies from those different sectors (Bosworth, 1996; Taylor, 2004). The maritime sector, too, is organised as a network, built around maritime freight flows. Innovations in transport and logistics have fundamentally altered the classical networks of these flows. In the case of maritime services companies, it is paramount to their commercial success that they should be present in certain nodes within the network of maritime flows.

2.4 Advanced producer services

According to Sassen (1993), world cities are defined by the presence of not only headquarters of large multinational corporations, but also "*advanced producer services*". World cities, she argues, are essentially services centres. Advanced producer services consist mainly in specialised assistance (financing, market research, accountancy, insurance, advertising, public relations, legal counsel, management, consulting, etc) to both the private and the public sectors. Such specialised companies are necessary in order for the globalised world economy to function optimally (Beaverstock, *et al*., 2002; Knox, *et al*., 1994).

Sassen's work also includes a study of New York, London and Tokyo – her so-called "Global Trilogy" – in their capacity as global cities. According to Sassen, the evolution that has unfolded in telecommunication and information technology has led to two opposite yet complementary trends, namely decentralisation and concentration of economic activity. The dispersion of production has given rise to a need for new forms of control and organisation. These functions are now found in corporate headquarters in world cities, which in turn has resulted in increased demand for financial and business services. When multinationals – the principal customers of companies providing specialised services – began to operate more globally, service providers followed them to the leading cities. This way, world cities developed into clusters of specialised knowledge (Sassen, 1993; Knox, *et al*., 1994). Sassen's analysis is in line with previous definitions of world cities, though it represents a shift in emphasis. According to her, world cities are more than just command centres; they are, first and foremost, global service centres (Taylor, 2004). In the present study, we explore the role of the maritime services sector within these global service centres and vice versa.

Leading research in the field of world cities is conducted by the Globalisation and World Cities Study Group & Network, or GaWC. It has devised a general inventory of world cities using Sassen's criterion of the presence of companies offering advanced producer services (accountancy, advertising, banking / finance and law). For companies operating globally, it is important to locate in the most appropriate world cities. These firms disperse their professionals across the world, selecting cities where they feel they need to have an office in order to achieve their commercial ambitions. Hence, the presence of such companies provides us with a measure of a city's global capacity (Beaverstock, *et al*. 1999). Table 1 provides an overview of the GaWC inventory of world cities. At the highest level, we find New York, London, Paris and Tokyo. Importantly, the leading world cities (Alpha and Beta cities) are concentrated in three regions, namely North America, Western Europe and Asia-Pacific. It is no coincidence that these are also the world's most globalised regions (Beaverstock, *et al*., 1999).

Table 1: GaWC Inventory of World Cities

Alpha World Cities	
12 points:	London, New York, Paris, Tokyo
10 points:	Chicago, Frankfurt, Hong Kong, Los Angeles, Milan, Singapore
Beta World Cities	
9 points:	San Francisco, Sydney, Toronto, Zurich
8 points:	Brussels, Madrid, Mexico City, Sao Paulo
7 points:	Moscow, Seoul
Gamma World Cities	
6 points:	Amsterdam, Boston, Caracas, Dallas, Düsseldorf, Geneva, Houston, Jakarta, Johannesburg, Melbourne, Osaka, Prague, Santiago, Taipei, Washington D.C.
5 points:	Bangkok, Montreal, Beijing, Rome, Stockholm, Warsaw
4 points:	Atlanta, Barcelona, Berlin, Budapest, Buenos Aires, Hamburg, Istanbul, Copenhagen, Kuala Lumpur, Manila, Miami, Minneapolis, Munich, Shanghai
Evidence of World City formation	
3 points:	Athens, Auckland, Bombay, Dublin, Helsinki, Luxemburg, Lyon, New Delhi, Philadelphia, Rio de Janeiro, Tel Aviv, Vienna
2 points:	Abu Dhabi, Alma-Ata, Birmingham, Bucharest, Bogotá, Bratislava, Brisbane, Cairo, Cleveland, Den Haag, Detroit, Dubai, Ho Chi Minh City, Cologne, Kiev, Lima, Lisbon, Manchester, Montevideo, Oslo, Riyadh, Rotterdam, Seattle, Stuttgart, Vancouver

1 point:	Aarhus, Adelaide, Antwerp, Baltimore, Bangalore, Bologna, Brasilia, Calgary, Colombo, Columbus, Dresden, Edinburgh, Genoa, Glasgow, Gothenburg, Guanhzhou, Hanoi, Cape Town, Kansas City, Leeds, Marseilles, Richmond, Lille, St Petersburg, Tashkent, Tehran, Tijuana, Turin, Utrecht, Wellington

Source: GaWC: Globalisation and World Cities, 23 November 2005, Inventory of World Cities

2.5 World maritime cities

International world cities are pivotal in the ongoing globalisation process. According to Cartier (1999), nowhere is the impact of this evolution felt as profoundly as in port cities. As the globalisation trend took off in the final quarter of the previous century, the distances to be bridged became greater than ever before. Between 1960 and 1990, there was a fourfold expansion in the volume of maritime trade. Still according to Cartier, many of today's world cities grew out of coastal settlements. As a result of historical migratory patterns and maritime bartering, these locations became cities of great cultural diversity and economic power, which further enhanced their appeal to population groups who shaped global activity. In this manner, they were able to develop into large coastal conurbations. However, in the contemporary perception, maritime activity is not as central as it used to be, to the extent that it is not a condition for a city to be classified as a world city. Cities such as London and New York are important economic centres and they are indeed located near or on the coast, yet their role as ports is secondary to their function as services centres (Ducruet, 2004). In the mercantile era, maritime transportation was the only means of conducting trade across seas and oceans. In other words, the economic heart of a city was its port. More recently, however, air transport has arrived on the scene. While the bulk of freight is still transported by ship, air transport has become the choice mode in passenger transport, where travel time is obviously a crucial consideration. So even though freight continues to be transported mainly by sea because of the lower cost, the economic heart of the city has partly shifted from seaport to airport (Cartier, 1999).

In contrast to Cartier, Bosworth (1996) argues that a growing proportion of world cities are ports. He proposes that this is a consequence of ports' greater capacity to engage in global trade. Port cities, unlike continental cities, are able to attract such commodity flows as rice, coffee, oil, automobiles and textiles. Moreover, the rise of ports would appear to be a historical trend: by the year 2000, approximately 80% of the world's 25 largest cities were ports, compared to 60% in 1925 and 50% back in 1500. In other words, Bosworth feels that the world city network is becoming not only increasingly global, but also increasingly maritime in nature.

Table 2: The world's largest container ports in 1985 and 2005 (by total TEU handled)

	1985	Total TEU		2005	Total TEU
1	Rotterdam	2,654,906	1	Hong Kong	22,427,000
2	New York / New Jersey	2,367,000	2	Singapore	22,288,000
3	Hong Kong	2,288,953	3	Shanghai	18,084,000
4	Kobe	1,518,853	4	Shenzhen	16,197,173
5	Antwerp	1,350,000	5	Busan	11,840,445
6	Yokohama	1,327,352	6	Kaohsiung	9,470,000
7	Hamburg	1,158,776	7	Rotterdam	9,300,000
8	Keelung	1,157,840	8	Hamburg	8,050,000
9	Busan	1,148,000	9	Dubai	7,619,222
10	Long Beach	1,141,466	10	Los Angeles	7,484,624
11	Los Angeles	1,103,722	11	Long Beach	6,709,818
12	Tokyo	1,004,390	12	Antwerp	6,482,029
13	Bremen / Bremerhaven	986,265	13	Qingdao	6,310,000
14	San Juan	881,629	14	Port Klang	5,543,527
15	Oakland	855,642	15	Ningbo	5,191,000
16	Seattle	845,027	16	Tianjin	4,801,000
17	Bremerhaven	834,331	17	New York / New Jersey	4,800,000
18	Dunkirk	713,410	18	Guangzhou	4,684,000
19	Baltimore	706,479	19	Tanjung Pelepas	4,169,177
20	Jeddah	677,858	20	Laem Chabang	3,765,967

21	Le Havre	565,914	21	Xiamen	3,343,000
22	Melbourne	563,641	22	Tanjung Priok	3,281,580
23	Felixstowe	518,443	23	Gioia Tauro	3,160,981
24	Manila	505,351	24	Yokohama	2,900,000
25	Tacoma	504,807	25	Tokyo	2,802,846
26	Marseilles	487,796	26	Bremen / Bremerhaven	2,755,645
27	Montreal	481,525	27	Felixstowe	2,700,000
28	Leghorn	475,145	28	Dalian	2,651,000
29	Sydney	460,825	29	Manila	2,625,148
30	Savannah	452,298	30	Algeciras	2,611,969

Source: Ci-online: Containerisation International, 7 March 2006, Container Traffic

Table 2 presents the world's top 30 container ports for the years 1985 and 2005. The ports have been ranked by TEUs handled in those respective years. Comparing the two rankings, we notice that Rotterdam and New York have been overtaken primarily by Asian ports, with Hong Kong and Singapore now occupying the top two positions. The ports of China in particular have come to the fore: they feature hardly at all in the list for 1985, but twenty years on they are already among the leading ports. Most European and American ports also recorded growth over the period considered, but far less so than their Asian counterparts. The spectacular rise of Asia's ports is driven by the enormous increase in exports that the region has experienced in consequence of globalisation. In addition, China's economic development has made the country a large importer of raw materials, cargo which must of course pass through the country's seaports (YAP, *et al.*, 2006). If we compare the top 30 of world ports and the GaWC inventory of world cities (Table 1), we notice that a number of locations feature in both lists. Clearly, then, quite a number of world cities have a maritime focus. It should however also be noted that the study by GaWC dates from 1999, while the table of port cities pertains to 2005.

2.6 The consequences of globalisation for the maritime network

Globalisation has occasioned some important developments in the maritime sector. First and foremost, the volume of cargo has grown substantially. Moreover, the worldwide dispersion of production and consumption has resulted in the emergence of global supply chains. These changes have given rise to a need for improved maritime access of ports and greater efficiency in freight handling and hinterland transportation services. The advent of *containerisation and palletisation* signified a revolution in this respect: the transportation of general cargo in standard units has speeded up the entire distribution process. While in the past it may have taken months to ship cargo to its destination, it is now usually a matter of only days. The introduction of the container has also revolutionised both land-based transport and liner shipping, and it has had a profound impact on the traditional port hierarchy (Notteboom, *et al.*, 2005; Stopford, 2000).

Today, a shipping company will call at a particular port with a view to serving an extensive area beyond it and because that port constitutes a node in the global network of goods flows. Besides being transported to the hinterland, goods are also transshipped onto other vessels to be carried to ports further afield. Increasingly, ports are specialising in one or the other activity. Ports with a sizeable hinterland will tend to focus on improving their transport links with that area; ports that are optimally located to attract maritime container flows will tend to manifest themselves as transshipment hubs and concentrate on improving their links with the foreland. Hinterland ports, more so than transshipment hubs, tend to be located in the vicinity of urban centres. If this urban centre is large enough, one speaks of a port metropolis. Such port metropolises are internationally-oriented cities, with a strong presence of tertiary sector activities. They are the economic "cornerstones" of globalisation (Ducruet, 2004). Of great importance to the success of a port city is its connection to shipping lines operated by the leading maritime carriers. The greater the number of liner shipping networks a port belongs to, the more favourable its prospects for the future (Ducruet, 2004).

3. Identifying World Maritime Cities and Their Networks

We shall try to ascertain empirically which sites may be regarded as world maritime cities and how they are connected through networks. Our approach shall be based on an assessment of maritime services offered. The method applied in this study is the same as that used by Beaverstock, Smith and Taylor to construct their so-called "Roster of World Cities" and it is discussed extensively in various GaWC Research Bulletins. Research Bulletins 5, 23 and 43 in particular contain good methodological descriptions (Taylor, 2001; Taylor, *et al*., 2002; Beaverstock, *et al*., 1999).

3.1 Information gathering

Shipping companies are obviously important players in maritime transport. In today's market, we even observe a shift in the power balance away from port authorities and towards shipping companies. Port authorities will go to great lengths to be included in the network of an important shipping company or to ensure that a shipping company or terminal operator chooses to locate in their port. It is necessary for ports to adapt to shipping companies' strategies and to offer them the best locations (Ducruet, 2004). The starting point for our research consists in an extensive list of major firms in the maritime services sector (75 shipping companies and 19 container terminal operators). From this list, we select companies with a global locational strategy. According to Taylor *et al*, a company may be deemed to pursue a global locational strategy if it has offices in at least 15 different cities, including one or more cities in each of the prime globalisation arenas, i.e. Northern America, Western Europe and Asia-Pacific.

We must also take account of the fact that a number of shipping companies belong to larger groups or partnerships. Indeed, the maritime sector is characterised by increasing market concentration. On the one hand, takeovers have resulted in corporate structures consisting of a core firm and subsidiaries. On the other, medium-sized firms are increasingly entering into partnerships in order to be able to offer global services and compete with the largest players in the sector. Examples of such large groups are Maersk, CMA CGM, MOL, IRISL, COSCO CSAV and Hanjin. As a consequence, shipping companies such as Safmarine (Maersk Group), Norasia (CSAV Group), ITS (Evergreen Group) and Delmas (CMA CGM Group) do not appear in the list of companies considered, yet their offices are incorporated into the analysis, as they are part of a group network (Taylor, *et al*., 2002).

It is noticeable that container terminal operators are often far less globally-oriented. Moreover, many are part of a shipping company. Consequently, they are filtered out of the list. If we were to apply the same criteria for container terminal operators as we do for shipping companies, just two operators would be retained, and the two largest – Hutchison Port Holdings and PSA Corporation – would actually be disregarded. However, as these operators are the market leaders, they are included in our study nonetheless.

After an extensive study of the websites of 75 shipping companies and 19 container terminal operators, and taking due account of our selection criteria, a total of 35 firms were retained. The largest firms are represented in hundreds of different locations. Maersk Line, for example, has 325 offices distributed across more than a hundred countries. However, we restricted our study to the most important cities. These generally feature in the aforementioned Roster of World Cities (see Table 1) or in the list of major port cities (see Table 2). In addition, we have included a number of capital cities and other cities of economic importance in our study.

Subsequently, information was collected on the significance of a particular city to the global services provision of a particular firm. Two types of information are required in this respect. First, we need information relating to the size of a firm's presence in a given city. By this we mean the number offices and the number of professional staff that a firm has in that location. Second, information is needed on the so-called extra-locational functions of a firm's office in a given city. This is determined by the relative importance of an office in the overall corporate organisation. A distinction is made between headquarters, regional offices and subsidiary headquarters. This approach is in line not only with Sassen's advanced producer services theory, but also Friedmann's functional hypothesis. On the basis of all this information, one is able to determine a service value for each firm and city.

In order to convert this information into data, a "service value" was attributed to each city for each of the firms. To this end, we used a relatively simple scoring system, with an initial scale from 0 to 5. A city was obviously awarded score 0 if a firm was not present in that location. A score of 5 was awarded to a city if it hosted a firm's headquarters. It was far less straightforward to decide when to award scores 2, 3 or 4, as here we had to rely on available corporate information. Between the extreme scores of 0 and 5, three boundary lines needed to be defined: the boundaries between respectively 1 and 2, 2 and 3, and 3 and 4. We invariably started from the assumption that a city scores 2, i.e. that a firm has a regular office in that location. Whether or not that score needed adjusting depended entirely on external information on the office in question. If contact with the office is referred to an office in a different city, then a score of just 1 was awarded. A score of 1 was also awarded if the number of professional staff was very limited. Likewise, the boundary between scores 2 and 3 is based on size factors. A score of 3 was awarded to cities housing an office with an exceptionally large staff. Cities hosting a regional HQ score 4 points.

If a city hosted not only offices of a particular firm but also a container terminal operated by a subsidiary, which was considered to enhance the importance of being present in that location, its score was augmented by up to two points. In this manner, we were able to take adequate account of the presence of container terminals. We thus obtain a scale from 0 to 7 points. In this respect our approach differs from that applied by Taylor *et al* in other sectors of industry, where the maximum score is set at 5. Hence we arrive at a 35 x 130 matrix.

3.2 Methodology

3.2.1 Maritime service status of cities

In this paragraph, we draw from an early GaWC study, as reported in Research Bulletin 5 (Beaverstock, *et al*., 1999). We start from the basic matrix V with 35 rows representing firms and 130 columns representing cities. Each v_{ij}, where i represents a firm and j a city, may assume a value from 0 to 7. We can hence calculate the following aggregate:

$$C_j = \sum_i v_{ij}$$

C_j is the total score for city j. It is calculated by adding together the scores that city j is awarded for each of the firms i. The aggregate figure may be regarded as a measure of the city's global capacity. The Table 3 represents a ranking of the world's 50 most important maritime cities on the basis of their total score C_j. C_j is sometimes also referred to as the site service status. Relying on these research result, and following the approach proposed by the GaWC study group, we are now able to put forward a hierarchy of world maritime cities, as represented in Table 5. Cities categorised as level 1 have a C_j of 110 points or more, level 2 denotes a score between 80 and 110, level 3 a score between 70 and 80, level four a score between 60 and 70, level 5 a score between 50 and 60, and level 6 a score between 40 and 50 points.

Table 3: Overview of firms included in the study

1	Maersk Line
2	Mediterranean Shipping Company (MSC)
3	CMA CGM
4	Evergreen Marine Corporation
5	China Ocean Shipping (Group) Company (COSCO)
6	China Shipping Container Lines Co. (CSCL)
7	American President Lines (APL)
8	Hanjin Shipping
9	Mitsui O.S.K. Lines (MOL)
10	Nippon Yusen Kaisha (NYK Line)
11	Hapag-Lloyd Container Line (HLCL)
12	Orient Overseas Container Line Ltd. (OOCL)
13	Kawasaki, Kisen, Kaisha, Ltd. (K-Line)

14	Yang Ming
15	CP Ships
16	Zim Israel Navigation Company
17	Hamburg Sud
18	Hyundai Merchant Marine (HMM)
19	Pacific International Lines (PIL)
20	Compañía Sudamericana de Vapores (CSAV)
21	Wan Hai Lines
22	United Arab Shipping Co. (UASC)
23	Delmas
24	IRISL Group
25	Compañía Chilena de Navegación Interoceánica S.A. (CCNI)
26	MISC Berhad
27	Maruba
28	Sinotrans
29	Rickmers-Linie
30	Chipolbrok
31	TBS
32	Hutchison Port Holdings
33	PSA Corporation
34	APM Terminals
35	P&O Ports / Dubai Ports World

Table 4: The 50 most important world maritime cities

		10.1.1 C_j			10.1.2 C_j
1	Hong Kong	119	26	Beijing	52
2	Hamburg	111	27	Jakarta	52
3	Singapore	99	28	Kaohsiung	52
4	Shanghai	94	29	Vancouver	50
5	Tokyo	94	30	Le Havre	50
6	New Jersey / New York	89	31	Colombo	49
7	Bangkok / Laem Chabang	86	32	Bremen-Bremerhaven	49
8	London	84	33	Sydney	48
9	Seoul	77	34	Houston	48
10	Rotterdam	75	35	Barcelona	48
11	Antwerp	75	36	Los Angeles / Long Beach	47
12	Kuala Lumpur / Port Klang	73	37	Paris	47
13	Qingdao	71	38	Marseille	47
14	Genua	66	39	Sao Paulo	46
15	Tianjin	64	40	Osaka	45
16	Dongguan / Guangzhou	64	41	Buenos Aires	44
17	Mumbai (Bombay)	64	42	Melbourne	44
18	Dubai	64	43	Karachi	43
19	Taipei	62	44	Copenhagen	43
20	Shenzhen	61	45	Gothenburg	43
21	Ningbo	55	46	Helsinki	43
22	Xiamen	55	47	Bilbao	43
23	Dalian	54	48	Istanbul	43
24	Manila	54	49	Santiago	42
25	Ho Chi Minh City	53	50	Madrid	42

Table 5: Inventory of World Maritime Cities

	Alpha World Maritime Cities
Level 1:	Hong Kong, Hamburg
Level 2:	Singapore, Shanghai, Tokyo, New Jersey / New York, Bangkok / Laem Chabang, London
	Beta World Maritime Cities
Level 3:	Seoul, Rotterdam, Antwerp, Kuala Lumpur / Port Klang, Qingdao
Level 4:	Genoa, Tianjin, Guangzhou / Dongguan, Mumbai (Bombay), Dubai, Taipei, Shenzhen
	Gamma World Maritime Cities
Level 5:	Ningbo, Xiamen, Dalian, Manila, Ho Chi Minh City, Beijing, Jakarta, Kaohsiung, Vancouver, Le Havre
Level 6:	Colombo, Bremen-Bremerhaven, Sydney, Houston, Barcelona, Los Angeles / Long Beach, Paris, Marseilles, Sao Paulo, Osaka, Buenos Aires, Melbourne, Karachi, Copenhagen, Gothenburg, Helsinki, Bilbao, Istanbul, Santiago, Madrid

3.2.2 Analysis of the world maritime city network

Next, we analyse the network of world maritime cities. To this end, we consider the importance of the links that exist between the cities in that network. The more relationships that a city has with other cities, the greater its importance as a node within the network. The method applied in this analysis is described extensively in GaWC Research Bulletins 23 and 43. The starting point is the 35 x 130 matrix V. In the first instance, calculations are made for the top 5 firms in terms of quantity of service value and the Alpha (see 3.3.1) world maritime cities (limited 5 x 8 matrix). Subsequently, the analysis is repeated, but this time the Beta world maritime cities are also included (5 x 20 matrix).

(1.) Global connectivity of a city

First we consider the importance of the relationships between the world maritime cities. In other words, we ascertain to what extent the city functions as a services node within the network. For each pair of cities a and b, we can derive the relational element from matrix V:

$$r_{i,ab} = v_{ia} . v_{ib}$$

So for each firm i, we calculate the interlock link between cities a and b. We do so by multiplying the individual scores v_{ia} and v_{ib} of cities a and b. When we have made this calculation for every firm separately, the values obtained can be added up:

$$r_{ab} = \sum_{i} r_{i,ab}$$

On the basis of the resulting table, we can now make an *egocentric analysis* for each city separately. By this we mean that, for each city, the values of its relations with other cities are added up. This yields N_a, which may be regarded as a measure of the global situational status of a city within the network of world maritime cities:

$$N_a = \sum_{j} r_{aj} \qquad with\ a \neq j$$

(2.) Complete network specification

The egocentric approach is the simplest level of network analysis. In order to arrive at a model that considers all nodes and important linkages, we need to take our analysis one step further. We begin by creating a square (n x n) *elemental relational matrix* E. As we have 8 cities, in this instance it will be an (8 x 8) matrix. To create this matrix, we use the calculated interlock links between two cities, $r_{ab.}$ As r_{ab} equals r_{ba}, , E is a symmetrical matrix. All we need to do now is calculate the diagonal elements r_a:

$$r_a = \sum_i v_{ia}^{\;2}$$

r_a may be defined as the “self-relation” of a city a. To calculate this self-relation, we first select from matrix V the value of city a in respect of firm i and raise this value to the square. We repeat this procedure for each of the 5 firms, and subsequently we calculate the sum for city a for all firms combined.

The elemental relational matrix E is more readily interpretable if transformed into a *proportional relational matrix P*, where linkages are given as proportions of the maximum possible linkage. The elements of the proportional relational matrix P are obtained by means of the following formulas:

$$p_{ab} = r_{ab} / H \qquad \text{and} \qquad p_a = r_a / H$$

$$where \quad 0 \leq p_{ab} \leq 1 \qquad \text{and} \qquad H = \sum_i h_i^{\;2}$$

where h is the highest service value provided by firm i from across all cities. In other words, for each firm i, we select the highest service value from matrix V and square it. In the resulting proportional relational matrix P, p_{ab} defines the relative degree of quality of mutual services between cities a and b. So p_{ab} may be interpreted as the predicted relative quality of service a client can expect when doing business in a pair of cities a en b.

Relations in proportional relational matrix P can be converted into *social distances* by taking the complement of the proportional links in P:

$$d_{ab} = 1 - p_{ab} \qquad where \;\; a \neq b$$

In the resulting matrix D, relations between cities are defined in terms of the social distance to be bridged. Hence, the diagonal values of matrix D are obviously 0. Matrix D relates to the mix of firms in a given city. Pairings of cities with a similar mix of firms will have lower values in the matrix, as the “distance” between such cities is “shorter”.

As all the above matrices are symmetrical ($r_{ab} = r_{ba}$), they are not suitable for identifying hierarchical tendencies in the relations. We therefore need an *asymmetrical matrix A* where the relation between city a and city b can be different from that between city b and city a. For matrix P, the common total of all linkages was H. Now we apply an H that is specific to each link

$$H_{ab} = \sum_i h_i \;.\; v_{ia}$$

$$H_{ba} = \sum_i h_i \;.\; v_{ib}$$

In these equations, h_i still represents the highest service value for firm i, and v_{ia} and v_{ib} are the service values for firm i in cities a and b respectively. So to obtain the new denominator H, we first take the service value for firm i for the city that is first mentioned in the link. Next, we multiply this value by the highest service value for firm i. We repeat this procedure for all firms and calculate the aggregate. If we calculate H in this manner, it is characteristic for the city that is first mentioned in the inter-city link. Now we take values r_{ab} from the elemental relational matrix E and divide them by the corresponding H to obtain the values for the asymmetrical matrix:

$$q_{ab} = r_{ab} \ / \ H_{ab}$$

$$q_{ba} = r_{ab} \ / \ H_{ba}$$

The resulting q_{ab} may be interpreted as the level of service one may expect if one does business in city b from city a.

3.3 Results

3.3.1 Maritime site service status

It speaks for itself that offices, particularly important ones, are located most commonly in the most globalised regions (Northern America, Europe and Asia-Pacific), as is reflected in the table (Tables 4 and 5). The top two positions are occupied by Hong Kong and Hamburg, which emerge very clearly from our research as the two most important world maritime cities. Many shipping companies have their headquarters at Hamburg or Hong Kong. Hamburg owes its status as a leading maritime services centre primarily to a number of large German shipping concerns (e.g. Hapag-Lloyd, Hamburg Sud), which have made the city their home base. Hong Kong hosts the headquarters of a number of Asian shipping companies (including OOCL) and it is also the market leader among container terminal operators (e.g. Hutchison Port Holdings). Singapore, the third most important world maritime city, hosts the headquarters of, among others, PSA Corporation.

The top 5 is completed by Shanghai in the People's Republic of China and Tokyo in Japan. Clearly, then, Asia is strongly represented with 4 out of the 5 leading cities. The Alpha level of world maritime cities further includes New Jersey / New York, Bangkok / Laem Chabang and London. Further down the ranking, Rotterdam and Antwerp are tied in tenth place.

The top fifty of world maritime cities includes many Asian cities. China in particular is well represented. By contrast, there are few Northern American cities that make it into the ranking, which is largely attributable to the fact that New York occupies such a dominant position in the United States. We had already observed this in finance, and it now transpires also to hold for the maritime sector. Figure 1 provides an overview of all Alpha, Beta and Gamma world maritime cities. It shows strong concentrations of such locations in Europe and Southeast Asia.

Five Alpha world cities from the GaWC inventory also appear in our top 10: Hong Kong (1), Singapore (3) Tokyo (5), New York (6) and London (8). Los Angeles occupies place 36, with Paris down in 37th. Chicago, Frankfurt and Milan do not even make the top 50 of world maritime cities. Still, most Alpha world cities from the GaWC inventory also rank high in the hierarchy of world maritime cities. In other words, they are not only leading centre in finance, but also in maritime trade. Conversely, one could say that few of the truly high-ranking world maritime cities do not appear in the GaWC inventory. However, Hamburg, one of the truly important world maritime cities, has no more than Gamma status in the GaWC inventory. The "new" Chinese seaports (Qingdao, Tianjin, Guangzhou, Shenzhen,...) can rightly claim to be world maritime cities, but they do not feature in the list of world cities as far as finance is concerned. Another striking observation is that all Alpha cities are also global legal services centres (Beaverstock, *et al*., 1999).

Figure 1: Geographic Distribution of World Maritime Cities

If one subsequently compares the list of world maritime cities with the list of global ports, there are again a number of observations to be made. We may distinguish between three categories. First and foremost, there are the cities of Hong Kong, Singapore and Shanghai: they are the world's leading ports and, moreover, Alpha world maritime cities. Hamburg, too, may be regarded as belonging to this category. Second, there is a series of mostly Asian global ports that are not Alpha world maritime cities. Examples include Shenzhen, Busan and Kaohsiung. Third, there are cities that are not global ports, but which are nevertheless classed as Alpha world maritime cities, London being the prime example. New York, Bangkok / Laem Chabang and Tokyo are all in the global port top 30, but may also be considered to belong to this category.

Keeping in mind the above observations, it would appear that a city is able to become a leading world maritime centre if a number of conditions are fulfilled. First, the city must have a port, and second, it must also have a strong presence of financial and legal service providers. Maritime firms are attracted by the presence of a financial and legal services sectors. All enterprises require capital for investments. In global financial centres, potential clients and investors are never far away. Moreover, it would seem that maritime companies have a tendency to locate in cities where general maritime policy and regulations are given shape. As in the financial sector, the most important decisions in the maritime sector are taken in those cities where the most comprehensive information is available. Besides the financial and maritime sectors, the media and the legal services sector are, for example, also strongly represented in those locations.

Of course, there are some exceptions to this rule. London is a global financial and legal centre even though its port no longer ranks among the world's largest. London does, however, have a great tradition in shipping. After all, Britain was for centuries a true maritime nation that dominated the world's oceans. Moreover Hong Kong used to be governed from London. Hence, maritime firms deem it important to have offices in London, as well as in New York and Tokyo, the world's other leading financial centres. Should London have had a strategically important port alongside its strong financial sector, then it would most probably have ranked right at the top. The importance of London as a world maritime city is underscored by the presence of a number of important organisations. Both the International Maritime Organisation (IMO) and the Baltic Exchange are based in London. The International Maritime Organisation is a specialised United Nations agency that imposes a number of standards on the shipping industry. It is, in other words, concerned primarily with legal aspects of the industry. The Baltic Exchange is a membership organisation that maintains the global market for shipbrokers, charterers and shipowners. It provides daily freight market prices and maritime shipping cost indices, and a market for Forward Freight Agreements (FFAs). Forward Freight Agreements offer a means of protection against fluctuating freight rates. Clearly, then, legal and financial service providers in London cater specifically for the maritime sector. Hamburg, too, is in fact an exception to the rule. Financially and legally, Hamburg is by no means a leading global centre, yet in maritime affairs it most definitely is. Despite a less outspoken presence of financial and legal service providers, Hamburg does house a substantial number of HQs and regional HQs.

3.3.2 Network status of world maritime cities

The *egocentric analysis* is based on (5 x 8) matrix V (Table 6). Strikingly, there is not a single 0 value to be found in matrix V, implying that all firms incorporated into the matrix have offices in all Alpha world cities. We find that Hong Kong is the main node within the maritime network. Hong Kong, Hamburg and New York are, by some margin, the most important world maritime cities. Each of these top-3 cities lies in a different continent. In fact, they represent the world's three most globalised regions (Asia-Pacific, Europe and Northern America). Hong Kong is the central node of maritime information and goods flows in Asia, Hamburg fulfils that role in Europe, and New York does so in Northern America. When we compare with the general ranking in Table 5, we find that New York has climbed from position 6 to position 3 and that Singapore is no longer the third most important world maritime city. This implies that, despite its lower *maritime site service status* (because of the limited presence of firms), New York gains in importance within the network because of its greater connectivity.

Table 6: Total connectivity per city

Matrix V

		a Hong Kong	b Hamburg	c Singapore	d Shanghai	e Tokyo	f New York	g Bangkok	h London	F_i
1	Maersk Line	5	7	4	4	3	4	3	4	34
2	CMA CGM	5	2	2	3	2	2	2	2	20
3	MSC	5	2	4	3	3	4	3	2	26
4	Evergreen	3	3	2	2	3	3	4	3	23
5	CSAV	6	6	2	3	3	6	2	2	30
	C_j	24	20	14	15	14	19	14	13	133

Aggregated links r_{ab}

r_{ab}	Hong Kong	Hamburg	Singapore	Shanghai	Tokyo	New York	Bangkok	London
Hong Kong								
Hamburg	100							
Singapore	68	58						
Shanghai	74	64	44					
Tokyo	67	58	40	42				
New York	95	85	54	56	55			
Bangkok	64	55	40	41	40	52		
London	61	57	38	40	37	49	38	

Egocentric analysis

	N_a
Hong Kong	529
Hamburg	477
New York	446
Shanghai	361
Singapore	342

Tokyo	339
Bangkok	330
London	320
T	3144

When we repeat this analysis with Alpha as well as Beta world cities in the maritime sector, there are similar observations to be made, with certain Beta cities leapfrogging Alpha cities. Antwerp emerges as the fourth most important node. Likewise, Guangzhou and Rotterdam occupy a higher position in the rankings than one might have assumed. Despite being Beta world maritime cities, they are important nodes. Conversely, an Alpha world maritime city such as London drops down to seventeenth.

The three inter-city matrices each contain various specifications of the network of world maritime cities. Let us first consider the *proportional relational matrix P* (Table 7). In this matrix, p_{ab} provides an indication of the relative degree of quality of mutual services between cities a and b. In other words, p_{ab} may be interpreted as the predicted relative quality of service that a customer may expect when doing business in the pair of cities a and b. The highest non-diagonal value in matrix P is 0.66. It represents the pair of Hong Kong and Hamburg. The second (0.63) and third (0.56) highest values are found for the links Hong Kong / New York and Hamburg / New York. These three cities also emerged from the simple preliminary analysis as the three most important nodes within the network of world maritime cities.

Table 7: Global connectivity – proportional relational matrix (P)

matrix P	Hong Kong	Hamburg	Singapore	Shanghai	Tokyo	New York	Bangkok	London
Hong Kong	0.79	0.66	0.45	0.49	0.44	0.63	0.42	0.40
Hamburg	0.66	0.68	0.38	0.42	0.38	0.56	0.36	0.38
Singapore	0.45	0.38	0.29	0.29	0.26	0.36	0.26	0.25
Shanghai	0.49	0.42	0.29	0.31	0.28	0.37	0.27	0.26
Tokyo	0.44	0.38	0.26	0.28	0.26	0.36	0.26	0.25
New York	0.63	0.56	0.36	0.37	0.36	0.54	0.34	0.32
Bangkok	0.42	0.36	0.26	0.27	0.26	0.34	0.28	0.25
London	0.40	0.38	0.25	0.26	0.25	0.32	0.25	0.25

Subsequently, we consider the *social distance matrix D* (Table 8). This matrix relates to the comparative mix of firms in a given city. Pairings of cities with roughly the same mix of firms will exhibit lower values in the matrix, as the "distance" between such cities is "shorter". As far as the presence of offices is concerned, the sample shows an identical mix for all cities, as all firms are present in all cities. Nonetheless, there may be differences in terms of the size of those offices. In this respect, the lowest value (0.34) in matrix D represents the Hong Kong / Hamburg link. The second (0.37) and third (0.44) lowest values are, not surprisingly, found for the Hong Kong / New York and Hamburg / New York links. The fact that the picture to emerge from matrix D is the same as that emerging from matrix P is due to the nature of d_{ab}. To calculate d_{ab}, we have after all used the complement of p_{ab}.

Table 8: Global connectivity – social distances matrix (D)

matrix D	Hong Kong	Hamburg	Singapore	Shanghai	Tokyo	New York	Bangkok	London
Hong Kong	0.00	0.34	0.55	0.51	0.56	0.37	0.58	0.60
Hamburg	0.34	0.00	0.62	0.58	0.62	0.44	0.64	0.62
Singapore	0.55	0.62	0.00	0.71	0.74	0.64	0.74	0.75
Shanghai	0.51	0.58	0.71	0.00	0.72	0.63	0.73	0.74
Tokyo	0.56	0.62	0.74	0.72	0.00	0.64	0.74	0.75
New York	0.37	0.44	0.64	0.63	0.64	0.00	0.66	0.68

Bangkok	0.58	0.64	0.74	0.73	0.74	0.66	0.00	0.75
London	0.60	0.62	0.75	0.74	0.75	0.68	0.75	0.00

Finally, we look at the *asymmetrical relational matrix A* (Table 9). In this matrix, q_{ab} may be interpreted as the quality of service one may expect when doing business in city b from city a. When we look at the columns in matrix A, we find the highest values for Hong Kong, Hamburg and New York. These values represent the expected quality of service when doing business in these cities from a different city. Apparently, then, when doing business in Hong Kong, Hamburg or New York, one may always expect a high quality of service, irrespective of the city from where one is operating. All other cities are well-connected with Hong Kong, Hamburg and New York because of these three cities' importance in the network. By contrast, if one calls on an office in, say, Hong Kong, Hamburg or New York to do business in another world city, then the quality of service one may expect is lower. After all, many firms do not find it necessary to have an equally strong presence in the less important world maritime cities.

Table 9: Global connectivity – asymmetrical relational matrix (A)

matrix A	Hong Kong	Hamburg	Singapore	Shanghai	Tokyo	New York	Bangkok	London
Hong Kong	0.79	0.75	0.51	0.56	0.50	0.71	0.48	0.46
Hamburg	0.85	0.68	0.50	0.55	0.50	0.73	0.47	0.49
Singapore	0.87	0.74	0.29	0.56	0.51	0.69	0.51	0.49
Shanghai	0.88	0.76	0.52	0.31	0.50	0.69	0.49	0.48
Tokyo	0.88	0.76	0.53	0.55	0.26	0.72	0.53	0.49
New York	0.90	0.80	0.51	0.53	0.52	0.54	0.49	0.46
Bangkok	0.86	0.74	0.54	0.55	0.54	0.70	0.28	0.51
London	0.85	0.79	0.53	0.56	0.51	0.68	0.53	0.25

If we also include the Beta world maritime cities in our full network specification, we obtain more or less the same results. Matrix P then indicates the same top 3 of important linkages. Rather surprisingly, the fourth most important link is that between Hong Kong and Antwerp. The social distance matrix D again yields the same results as matrix P because of the calculation method. In the asymmetrical matrix A, the highest values are, not unexpectedly, found in the columns for Hong Kong, Hamburg and New York. One may also expect relatively good quality of service when conducting business in Shanghai and in the Beta cities of Antwerp, Guangzhou and Rotterdam, irrespective of the city from where one is operating.

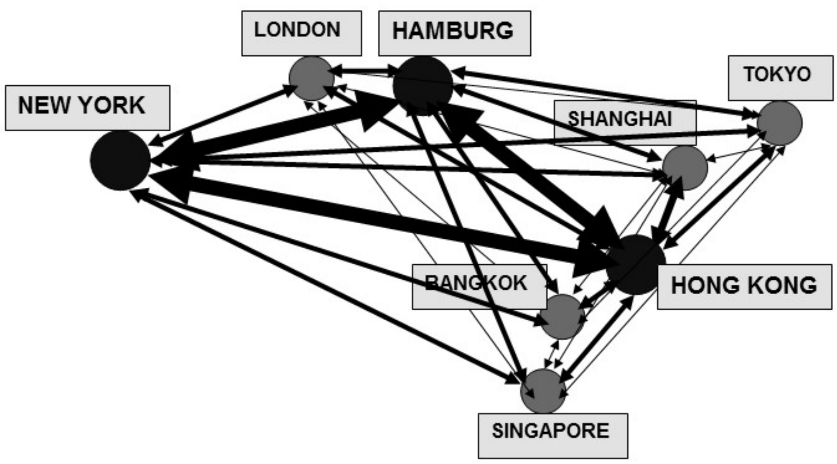

Figure 2: Map of the World Maritime Cities Network (Alpha level)

On the basis of this study, we may conclude that the three leading world maritime cities, in order of importance, are Hong Kong, Hamburg and New York. Figure 2 represents a map of the world maritime city network. It is based on our data regarding the network connections between the Alpha world maritime cities as represented in the proportional relational matrix P.

4. Conclusion

It transpired from our literature review that world cities research may be approached in different ways. The researchers of the Globalisation and World Cities Study Group & Network have developed a method for ranking world cities and for analysing the networks that connect them. On the basis of location strategies of firms from a number of service sectors, they arrive at an inventory of world cities. Hitherto, the method had not been applied to the maritime sector. Yet after some interpretation and minor adjustments, it can also provide insight into the network of world maritime cities, as has been demonstrated in the present study.

We have been able to ascertain that many world cities also have a maritime focus. This is due in part to the fact that globalisation processes tend first to manifest themselves in port cities and in part to these cities' long histories as pivotal transport nodes. Globalisation has also been conducive to a number of other important evolutions within the maritime sector. Volume of cargo has, for example, expanded very substantially. This has in turn created a need for greater efficiency and speed, resulting in, among other things, standardisation of loading units. Transport connections between ports and hinterlands have also come under greater pressure.

Our study has shown that the leading world maritime cities, in order of importance, are Hong Kong, Hamburg, Singapore, Shanghai, Tokyo, New Jersey / New York, Bangkok / Laem Chabang and London. In other words, a number of cities (London, New York, Tokyo, Hong Kong and Singapore) are not only absolute world cities, but also world maritime cities. Strikingly, London, which has no world port, still ranks among the world's leading maritime centres.

It emerges from our network analysis that Hong Kong, Hamburg and New York are the most important service nodes in the network of world maritime cities. Each of these three world cities is located in one of the three most globalised regions in the world Asia-Pacific, Europe and Northern America).

In the ranking of world maritime cities, Antwerp is tied in tenth place with Rotterdam. However, because of its central location, Antwerp is a strategically important maritime hub. Hence, most large maritime firms have offices in Antwerp, even though they are often small and of limited importance within the corporate structure of those companies. This is due to the relative absence of the financial and legal services sectors in Antwerp. In the leading world maritime cities, unlike in Antwerp, multisectoral clusters have emerged that represent vital sources of information for firms.

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The Added-Values and Motivations of Embarking on Postgraduate Maritime Studies

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Abstract

Recently, there has been massive growth of postgraduate professional studies in higher education, where academic institutions increasingly provide programmes on subjects which traditionally emphasize on non-academic/practical learning approach. The reasons behind such growth, however, remain under-researched. Focusing on the maritime industry, this paper focuses attempts to understand the added-values of such programmes. Is it mainly serving industrial growth – increased productivity and better equipped the practitioners, or a means for occupational groups to obtain their professional status? This paper use students-responded data to answer the above questions through analysis of their motivations enrolling on such programmes and their evaluation of the effectiveness of postgraduate education.

Keywords: Maritime education; Postgraduate professional programmes; Student motivations

1. Introduction

Since the 1980s, there had been a massive growth in the postgraduate sector in higher education. Substantial research on postgraduate programs and its development has been held in Western Societies. In the UK, for example, over the last decade, there has been 21% growth in new entrants (Sastry, 2004). New universities there have been skilled at exploiting the growth of student, particularly those from overseas. This development is partially explained by the universal trend of setting up postgraduate level education for professional studies (Burgess, 1997; Bourner *et al.*, 1999 & 2001). The best example is the introduction of 'practice-based' and 'professional' doctorates in both Old and New Universities in England (Bourner *et al.*, 2001). Professional education, which aims to bridge scientific acknowledge and practical performance, attracts considerable practitioners to become potential students of these courses, and it becomes a rather common view that professional competence was gained primarily, if not exclusively, through the application of scientific knowledge to practical problems (Tobias, 2003). As a result, apart from some well-established programs which successfully integrate professional practice and academic studies such as Law and Medicine, a new trend seems to be developing. Now academic institutions are increasingly providing professional education on subjects which traditionally emphasized on non-academic, apprentice-style learning approach.

Among these subjects, maritime education serves as a typical example. Since containerization and the increasingly emphasis on multimodal supply chain, the maritime sector has gradually transformed from a labour-intensive to a capital-intensive industry (Martin and Thomas, 2001), using state-of-the-art technology and modern ships and port equipment to transport goods. The major ancillary sectors that support this sector are usually made up of specialized and skilled, intelligent and trained people. Correspondingly, there has been significant emphasis on professional, dedicated knowledge and research (Moreby, 2004). In view of such requirements, employees of the highest caliber are needed as they need to respond effectively to the ongoing changes within the industry's business processes. The provision of postgraduate programs in maritime education is called to meet the requirement of 'more-than-monolithic' types of skills/knowledge from different stakeholders within the industry, as

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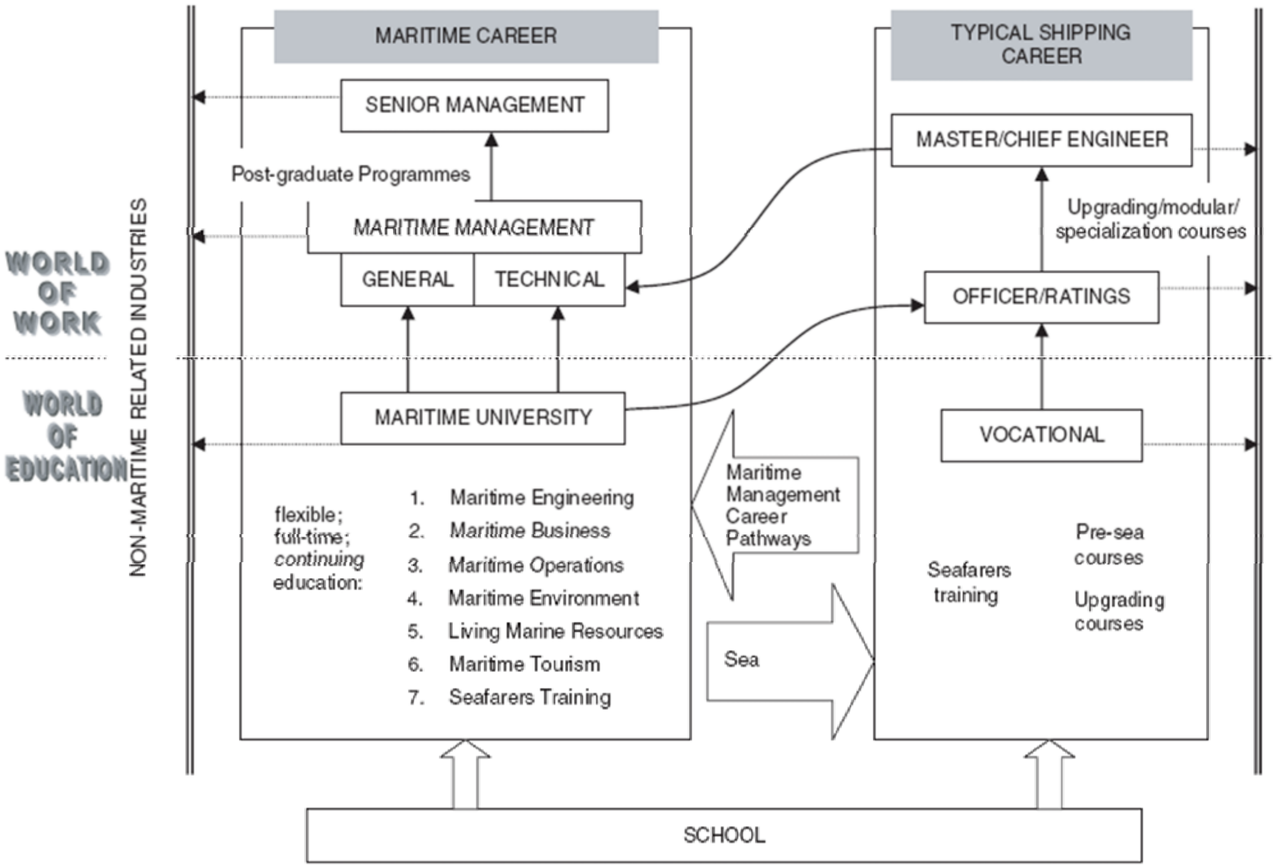
illustrated in Figure 1.



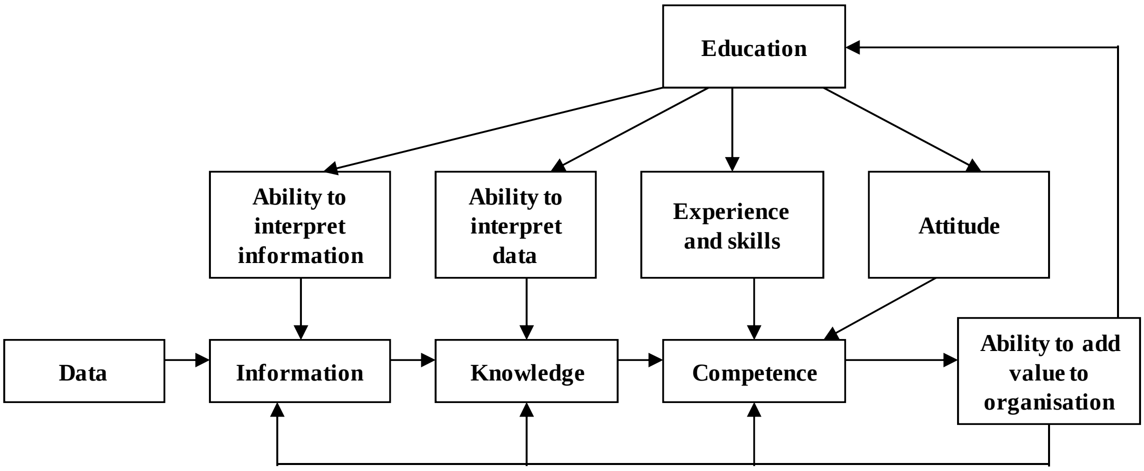
Dynamic personnel flow in shipping industry.

Source: Grewal (2005)

Figure 1: Different types of skills and knowledge required in pursuing a contemporary maritime career as well as different respective ways to achieve it

Setting against this canvass, the onus of responsibility for acquiring suitable qualifications has been shifted increasingly towards the individual, both in relation to training provision and university education (Dinwoodie, 2000). *Under such perception, the maritime industry had witnessed a growing number of academic institutions around the world offering postgraduate programs in maritime studies, notably in developed maritime economies. In Western Europe, various master programs with emphasis on the maritime management had been established since the turn of the century, e.g. Erasmus University Rotterdam (The Netherlands), University of Antwerp (Belgium), Cardiff University (UK), etc. In East Asia, a number of maritime-related master programs had also been introduced, e.g., The Hong Kong Polytechnic University, National University of Singapore, Korean Maritime University, etc. Although the details of these programs differ, all of them are stated to serve a common purpose: to allow graduates to become more competent, so as to enhance their ability in adding value to the organizations and/or society of which they are serving*[2]. As per Figure 2, it is believed that education can enhance the ability to interpret information and data, agglomerate experience and skills and create a good attitude, thus ultimately adding value to the institutions and/or society of which individuals are serving.

[2] This statement was concluded based on the listed programme objectives of their respective academic institutions, which can be found in respective official websites.



Source: Grewal and Haugstetter (2007)

Figure 2: The Role of Education

Despite such massive growth, however, the reasons behind such growth in professional education remain under-researched, especially on student's motivations pursuing such programmes and the effectiveness of postgraduate education, remain under-researched, and it is the endeavor of this paper to address such deficiency. Focusing on the maritime industry, this paper focuses attempts to understand the added-values of such programmes, investigating whether it is mainly serving industrial growth – increased productivity and better equipped the practitioners, or simply a means for occupational groups to obtain their professional status.

After this introductory section, Section 2 will provide the theoretical background for maritime education, with reference to traditional social science theories on education. In Section 3, the methodology and the empirical results will be provided, finally followed by discussions and conclusions in Sections 4 and 5 respectively.

2. Theoretical Background

The growth in postgraduate level of professional studies has not been confined to a few subjects but has encompassed a wide and growing range of subjects and fields (Bourner *et al*., 1999). This clearly demonstrates that there is an increased demand for postgraduate professional studies from various types of occupational groups. The phenomenon could be explained by at least two major reasons. First of all, increasing number of employers (ranging from business firms to the government) demand postgraduate educational credentials in hiring workers who take up higher ranking positions. They also want to secure workers who are more skilled and better motivated by sponsoring them to attend postgraduate professional education. Human capital theory posits that education directly increases productivity (Becker, 1993). Though its assumption is currently under hot debate (for example, see Marginson, 1997), the theory continues to underpin many investment decisions by governments and business firms. Many employers encourage or support their employees to prove higher level of professional education on human capital grounds (Carter and Lindsay, 1996).

Second, many occupations try to be professionalized. They raise their educational requirements as a means to increase their pay and prestige in society. According to Collins (1979) and Larson (1977), some occupational elites have increased educational requirements as a way of enhancing the prestige of their occupation. The more educated the members of an occupation, the more willing employers and the public are to accede to their demands for greater prestige, higher pay, and more control over their conditions of work. The introduction of the professional studies at postgraduate level that are related to their occupations becomes a crucial way to attain their professional status. Under this process of professionalization, the development of postgraduate education of these occupational groups takes up another very important role. It demonstrates that the industry and the occupational groups themselves are willing to become more selective and self-motivated, that they are willing to raise the quality and quantity of their work, and of course continue their work-related learning. In this sense, the development reflects the strong need to satisfy the expectations of professional associations. This is especially true for occupational groups which traditionally emphasize skills and apprenticeship rather than academic attainment (Tobias, 2003). In modern society, the professionalization journey of these occupations is generally seen as necessary and desirable. This leads to an upturn in demand for postgraduate professional education. However, the factors that motivate practitioners to enroll in postgraduate professional education and their evaluation on the effects of education are still unclear. There are few insights concerning student expectations when they enroll on such courses (except Gould *et al*., 1999).

With the case of maritime industry, two questions about the development of postgraduate professional education can be asked. The first question is: how important is the role of 'formal' tertiary education (vs. practical, apprentice-style of knowledge transfer) in helping learners to enhance their competence? While the role of academic education in pursuing traditional professional occupations, such as medical practitioner, lawyer, civil engineer, is beyond debate, the significance of academic education in traditionally practical subjects like maritime industry is open to discussions. Indeed, there have been diversified viewpoints regarding the importance of a postgraduate qualification in maritime education. On the one hand, the anecdotal information from the industry, it seemed that experience, rather than education, was still important.

On the other hand, Celik and Deha (2006), based on their research on ship managers, argue that technological development in the maritime sector has triggered the importance for managers to acquire office-based skills (i.e. financial and economic appraisal, human resource management, etc.) than just offshore skills like physical operation. *Indeed, maritime studies does not typically include only nautical studies, it encompasses other generic maritime disciplines such as, marine engineering; naval architecture; shipping finance, m*aritime economics and logistics; maritime business; marine policy, international shipping and transport; coastal management; maritime affairs and maritime law, etc. Thus, a planned and systematic management development program was pivotal as such programs were able to provide important management competencies like decision making skills, interpersonal skills, leadership skills and organizational knowledge. Their opinion is echoed by Melbrin (1997) and Grewal and Haugstetter (2007) who have noted that formal education would provide an opportunity for students to gain 'general' knowledge and understanding about the industrial environment, rather than narrow, specialized knowledge which was closely linked to their job responsibilities. Formal education also gives them significant 'fringe competency', such as networking and team works, which cannot be easily acquired otherwise. Indeed, in terms of networking, relationship is an important asset found in the international services, such as the maritime transport industry, due to the volume of human interactions and communications involved (Grewal and Haugstetter, 2007). More conventional avenues for networking include attending seminars, conferences, local events and training courses organised by relevant professional and sector-specific industry bodies which allows interaction between the students and industry players. One unique feature of the added value and benefit of networking is the strong link between the course structure and the global players in the shipping industry. Furthermore, every chance meeting can lead to work opportunities, which is why networking skills are a prerequisite for career development (Buggy, 2006), through encouraging the development of self-assertiveness and leadership qualities, which was a form of investment by itself. Finally, Dinwoodie (2000) examined the issue at a corporate level, and argued that rapid changes in globalization presented organizations with a pressing need to hire, advance and retain staff capable of working within a range of cultures and business environments. From the perspective of human resource management, such individuals must not only be empowered to achieve organizational objectives, but as the bitter experience of organizational learning has indicated, their personal development needs must also be met if they are to be retained. A specialized postgraduate education could be one feasible way of meeting such development needs. As a result, an interesting, but under-studied, hypothesis (H_1) has been developed:

H_1: *Postgraduate program in maritime studies, with well-managed program structure, relevant contents and qualified teaching staff, will enhance students'/ practitioners' ability to meet the needs of* *the latest development in maritime industry*

The second question is about the motivations of students in pursuing postgraduate maritime education. The general perception is that economic incentives provide the motivation for students to pursue postgraduate education. According to Becker (1993), individuals' demand for further education is an investment decision, the mechanism of which should be understood in terms of the costs and benefits involved. Given the fact that postgraduate maritime-related programs are often self-financed, the costs of students in enrolling in such programs are usually quite substantial, both as time and financial burden. See Table 1.

Table 1: Tuition fees for undertaking selected maritime business-related Master of Science (MSc) programs (self-financed) at selected institutions for academic year 2008-09

University	Centre/Department/School	Duration	Annual Fees (US$)*
Erasmus University (The Netherlands)	Maritime Economics and Logistics	1 year FT	31,000
University of Antwerp (Belgium)	Transport and Maritime Management	1 year	17,800
World Maritime University (Sweden)	----	1.5 year FT	35,300
London Metropolitan University (UK)	Economics, Finance and International Business	1 year FT	18,300
Hong Kong Polytechnic University (Hong Kong)	Logistics	2.5 years PT	11,200
Nanyang Technological University (Singapore)	Civil and Environmental Engineering	1 year FT	11,100

* It is assumed that a two-year PT programme is equivalent to a 1-year FT programme. *Sources*: Official websites of various universities/centres/departments/schools (2008).

Then, what are the possible benefits of gaining the credentials? Individuals probably hold out more open possibilities of occupational mobility. Research documented that *additional education and training was often perceived by students as a stepping stone in securing better promotion opportunities (Hesketh and Knight, 1999). Dinwoodie (2001) studied the motivations of logistics managers in pursuing a logistics master program in British universities and found that broadening knowledge, thus improving career opportunities and long-term career plans are core motivating factors. This seems to prove the economic argument.* Moreover, students would treat the earned credential as a way to divert them to the managerial ladder in their professional group. For students who enroll in maritime education, a postgraduate degree is often a necessity for a change of work nature. A good example involves seafarers who are seeking a change from a sea-going to onshore career, for whom such transition often intertwines with first obtaining a postgraduate qualification (Ketchum and Pourzanjani, 2005). Another possible motivation to enroll the postgraduate program is to secure more knowledge and skills to meet the increasing needs in the profession. Students might have a strong perception that the courses would help them to meet specific needs of their industries and client groups, in addition to their own requirements for professional and personal development. The recent development of the maritime industry has made composition of the industry becomes complicated. Nowadays, managing a maritime institution, e.g., a shipping company, requires not only technical knowledge and experience, but perhaps more importantly, professional knowledge in subjects like economics, finance and legal studies, which are traditionally more academic-related. Refer to figure 1 again.

However, we cannot ignore the fact that, for some students, *social aspiration could be the core motivational factor. Hesketh and Knight (1999) point out:*

'[Postgraduate] education in all its form serves the needs of individuals, it stimulates their minds, and enables them to learn new skills and acquire new knowledge, and to develop intellectual and cultural appreciation – and by all these means to enhance their chances of a rewarding and personally satisfying life'.

Indeed, some students who enroll to postgraduate professional education might look for their personal development. The motivation of students in pursuing postgraduate maritime education may not be purely economically inspired. Other social inspirations may also play equally, if not more, important role in their decisions to pursue postgraduate maritime education. Based on the above discussions, we can derive further hypotheses (H_{2a} to H_{2c}) for this project, as follows:

H_{2a}: The motivation of students in pursuing postgraduate maritime education is driven by the needs of professional group
H_{2b}: The motivation of students in pursuing postgraduate maritime education is purely economically inspired, in terms of forecasted increase in income and better prospect in the profession
H_{2c}: The motivation of students in pursuing postgraduate maritime education is for their own personal development

There exist various anecdotal evidence and ideas on the motivations and inspirations of students in pursuing postgraduate education in traditionally non-academic disciplines. However, the question remains whether such postgraduate courses could satisfy student's aspirations in enrolling and undertaking such programs (in some cases, as well as students' sponsors), are still very much under-studied and a systematic scientific investigation of such a question is still wanting. The current project is not denying the contribution of various research (e.g., Hara (2000), Lewarn (2002), Ruan (2002), Carp (2004), Cooper *et al.* (2004), Wu (2004), Bamett *et al.* (2006), Paine-Clemes (2006), etc., on maritime education. However, almost all these studies shared common shortcomings. Their contents are overwhelmingly factual and descriptive and do not have fundamental scientific methodologies, e.g., experimental, statistical, etc. (Lijphart, 1971), in addressing different empirical propositions within the topic. There is also a general lack of real linkages between empirical cases and general social science theories. We believe this project will provide a valuable contribution by bringing the issue of maritime education back to mainstream educational and social studies.

Last but not least, if postgraduate education is a 'real' need for the recent change and development of occupational groups, it should be demonstrated in practitioners' 'increase in productivity' or 'better performance' after obtaining the credentials. Otherwise, if postgraduate education is merely a 'means' for obtaining professional status, it should be reflected in students' aspiration or motivation in enrolling in related programs, even if effective results were found wanting.

3. Methodology and Empirical Results

Given the nature of the topic which requires data and information on opinions and experience-sharing, a questionnaire survey had been conducted from a service-user perspective, i.e., students who are enrolled in postgraduate professional courses (final year). The choice of service users as the targeted survey respondents is obvious as they are those who can immediately provide first-hand information in helping investigators to fulfill the project's objectives, i.e. the motivations of pursuing a postgraduate maritime program, as well as whether postgraduate maritime programs can significantly help them in their maritime career development. The academic institutions were chosen carefully and only those that are all widely acknowledged within the maritime industry as the leaders in providing postgraduate (taught master) maritime programs had been chosen. Surveys were conducted during the second half of 2007, collected from two universities in The Netherlands and Sweden which had been repetitive in providing postgraduate maritime education for at least a decade. The purpose of the research was targeted to segment students according to their motivations and added-values for pursuing higher degree in maritime studies. Survey participants were drawn from maritime programmes which were embedded within the education framework of maritime master's degree, with a scope from specialist emphases, including international shipping and logistics, through modally specific emphases to port, maritime economics and education. The details of the sample can be found in Table 2.

Table 2: The survey sample

Category	Figures
Sample size	32
Gender (in %)	
- Male	85
- Female	15
Age (in %)	
- 20 - 29	25
- 30 - 39	56
- 40 or above	19
Regional division (in %)	
- Europe	16
- Asia (incl. East, SE and Indian Subcontinent)	59
- Middle East	22
- Latin America	3

Even though the relevance of the targeted survey respondents are made up of postgraduate students at their final year of studies, 80% of the surveyed students are on sabbatical from their company to further their education with the prospect of gaining greater career advancement upon their graduation. More than 80% of the surveyed students claimed to have work experiences ranging from a minimum of 2 years up to 17 years working experiences in the maritime sector. Their maritime professions include former seafarers, maritime administrator, port managers, marine engineers and naval architects, human resources managers, as well as chartering and operation managers.

To realize the objectives of the study, the author acknowledge a similar questionnaire design in which survey questions with reference from Cerit *et al.* (2006) and Dinwoodie (2000) about teamwork, cooperative learning as well as management careers and education in shipping and logistics. A likert-style questionnaire was developed, and survey respondents were required to answer six questions[3], with the following scale: 5 = ‘strongly agree’; 4 = ‘agree’; 3 = ‘neither agree nor disagree’, 2 = ‘disagree’ and 1 = ‘strongly disagree’. The questions asked in the questionnaire, and the descriptive summaries of the mean scores[4], can be found in Table 3.

Table 3: Questions asked from the survey questionnaires and the descriptive summaries

Question	Mean Score
1. In your opinion, what are the added value and benefits to pursue maritime/shipping/logistics studies at postgraduate level?	
a) to broaden my horizon / knowledge	4.69
b) a change in career path	3.72
c) a potential career advancement in the management level	4.22
d) to specialize in the maritime industry as I want to find employment in this sector	3.87
e) to meet people/networking	3.97
f) to polish my human capital (communicative) and management skills	3.75
2. How important are the following reasons in making studying maritime business at postgraduate level at your university attractive? How important was each reason? I was attracted to study in this area because of	
a) my previous work experience	4.38
b) my interest in this area	4.63
c) more promising career prospects in the shipping industry	4.35
d) course reputation	3.38
e) peer/parental pressure	1.81

[3] The questions were decided by the authors based on detailed discussions with 10 various relevant personnel, e.g., academic scholars, industrial practitioners, maritime journalists, etc. Thus, it was believed that these questions were highly relevant in addressing this paper’s topic.

[4] The sensitivity of the mean scores has been tested statistically by applying ANOVA and *t*-tests.

3. What attracted you to choose your university as a centre to pursue your postgraduate studies? How important was each category below?	
a) global reputation	4.65
b) the only institution that I know which offers an MSc / Masters in international shipping and logistics	2.66
c) The programme fee is affordable	3.19
d) A group of experience and well qualified instructors/lecturers	4.03
e) The programme offers an ideal platform for networking	4.15
4. What are the best aspects of the postgraduate maritime studies you have undertaken at your university?	
a) It has all the elements with technical, practical and management characteristics of the global shipping industry	4.29
b) The ability to network and build my contacts	4.35
c) The course promotes innovative, cooperative learning and teamwork effectiveness	4.06
d) The course places emphasis on problem based learning, a method based on the principle of using problems as a starting point for the acquisition and integration of new knowledge	3.81
e) The course provides the desired skills (human capital, interpersonal, analytical skills) in preparing me to work in the shipping industry	4.03
5. Based on the selections you have made in Q4, in your opinion, do you think these factors are crucial to achieve the following?	
a) Preparing yourself for future managerial career in the global shipping industry	4.61
b) The stepping stone to gain entry into the global shipping industry	4.19
c) Entice me to consider a career in the global shipping industry	4.00
d) Developing your people management and networking skills	4.26
e) Providing you with a broad overview on the global shipping industry	4.68
6. At present, do you think your postgraduate courses which you will complete will prepare you well in the following career path in maritime business?	
a) Ship Broking	3.6
b) Shipping/Logistics/Supply Chain Management	4.13
c) Port Management	3.86
d) Marine Insurance	3.00
e) Ship Finance	3.21
f) Maritime Lawyer	2.67
g) Freight Forwarding	3.46
h) Marine Consulting	3.28

4. Discussion

Ratings in the above mentioned selected questions in the decision to undertake maritime studies at the Masters' level are being presented herein. All questions were related to students' motivations of taking the postgraduate maritime studies and their perceived added-values and managerial traits that a postgraduate maritime master's programme will provide.

<u>4.1. Motivation (H2)</u>

In students' answers of question 1 to 3, it is evident from that the demand for postgraduate maritime studies at the Master's level is not jaded. Makkar (2004) shared that the merchant navy is not for life but provides the platform for the ambitious who desire to gain experience and move on to other rewarding branches in the maritime industry. For certainty, ex-seafarers seeking an onshore career could choose the postgraduate pathway at the Master's level to acquire the necessary skills and qualifications for them, needed to step into the world of global shipping. For other aspiring graduates who either enrolled for a Master's course straight after their first degree or for personnel seeking to upgrade themselves after working for a couple of years in the maritime and related industries, a postgraduate maritime education offers a world of opportunity for them as well. These all shown in the overall high mean scores recorded in question 1. Moreover, from the respondents who were postulated, many display heightened motivations to broaden knowledge, gain networking opportunities, acquisition of specialize academic and human capital skills and long-term career plans such as potential advancement to the managerial level as essential factors to pursue maritime studies at the Master's level. Responses of question 2 and 3 revealed student perceptions of the courses held at the two European universities and their motivation of taking up the postgraduate programmes there. Obviously, the maritime master courses incorporate a diverse group of individuals, motivated in varying degrees either by employment and academic concerns. However, our results point out a common idea shared by students: quality maritime education is an important perquisite in career path mapping and in preparing aspirants for future managerial careers.

4.2. Needs (H1)

The collected data revealed limited information about the real needs of postgraduate education for the latest development in maritime industry. However, question 4 to 6 shed some lights on the expected increasing needs on practitioners' competence for the latest development in their work-related industry. It was shown in students' perception on the importance of education when they meet the challenge of the development of maritime industry. First of all, a strong need of creativity and innovation is revealed. The positive mean score of 3.81 on the provision of a problem-based learning (PBL) curriculum testifies that the structure and mode of delivery of the two university programmes is in tandem with industry needs; which is to harness the critical thinking skills of the students. Indeed, the expected benefits of postgraduate education go beyond the conventional classroom-teaching mode. Surveys results revealed that the ability to network to build social contacts coupled with the presence of cooperative learning and teamwork effectiveness, the acquisition of generic skills like interpersonal and analytical skills rank high in the surveyed outline. As reflected in Question 5, these are the crucial requirement for managerial roles in the global shipping industry.

Students' reposes also show that quality in maritime education was measured based on the course structure and mode of delivery. It is encouraging to note that relatively high mean ratings were recorded for cooperative learning and teamwork effectiveness as well as the emphasis on PBL. According to researchers, these learning techniques are touted by most academic institutions of higher learning as one revolutionary education paradigm used in a knowledge-based society and necessary for lifelong learning. These requirements are also fuelled by the recognition that the attainment of these skills is crucial in harnessing aspiring managers to succeed in the ever-changing maritime world. Acquiring such skills is part of the process of lifelong learning.

The modern maritime industry is global and dynamic. The surveyed results also brought to light that with regards to managerial competencies, mode of delivery and course structures which essentially include a combination of classroom lecture, field study and research group work, customary teaching tools taught in the postgraduate programme. The highly interactive nature of these modes of delivery is instrumental in allowing students to get the best out of many of the courses that are envisioned for their chosen postgraduate studies. Classroom lectures expose the students to contemporary issues and afford them the chance to draw on the experience and knowledge of not only the lecturer, but fellow students as well. Senior officers like Captains and Chief Engineers bring measurable amount of practical, technical expertise to the classroom as well. Field trips allow students to gain first hand knowledge and insight into various leaders in the industry. Research and problem-based learning affords the students the opportunity to demonstrate independent thought and understanding as well as serve as a basis for future analytical thinking that may be required during employment. These modes of delivery are particularly important for seafarers who are seeking employment ashore for possibly the first time. However, life at sea is an isolated one and officers may have had little opportunity to practice sound management, business and interpersonal skills on a corporate level. Henceforth, the route of graduate studies is regarded as the essential requirement for the way forward.

5. Conclusion

There are a growing number of universities and business schools that provides specialist maritime programmes at degree and post-experience level. On a personal note, we must not rule out the fact that greater opportunities for partnership collaboration between the academic institutions and the corporate sector in delivering and developing knowledge and learning in these areas could be an area of focus. There can be no doubting that the achievement of such initiatives will be the crux in harnessing greater generic and specialist skills necessary for the graduates to have a strong footing in the maritime industry and for those seeking to find a top spot in the boardroom.

The preliminary analysis of our study shows that the pressing needs of maritime personnel to acquire specialise skills to update their career profile and knowledge. Global shipping companies like Maersk and NOL are exemplary as both companies recognized the need for a more pro-active approach to attract the best and brightest, through careful and stringent selections of recruits to enroll in their own Management Associate Graduate Programme and other in house learning capabilities. Life-long learning call for the need that professional bodies to promote personal development and Master's qualifications, whilst monitoring the resource effectiveness of communication materials and media employed with different groups, predicated by an understanding of what attracts different groups to study (Dinwoodie, 2001). In this sense, the increasing change in globalisation and the internal demand on competent practitioners explains the motivation of aspiring professional to pursue postgraduate study. The demand for postgraduate maritime studies play pivotal role in preparing, retraining and refocusing maritime professionals' careers to ensure sustainable development and ongoing excellence in global shipping provision through meeting the changing demands for human capital management.

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A Study on Vietnamese Container Ports: Analysis, Evaluations, and Suggestions

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Abstract

Containerization has revolutionized cargo shipping. Nowadays, together with globalization and intermodalism, it has strongly affected to seaport's operations and development. In this paper, authors study about the situation of container ports in Vietnam. Accordingly, container volumes in the next few years are forecasted by using time series forecasting method. Based on current and expecting capacities and demands, ports are analyzed and evaluated. A SWOT analysis is then conducted to point out strengths, weaknesses, opportunities, and threats which are helpful and harmful to container port development. Based on them, suitable alternatives are suggested to support ports' future development to overcome harmful factors as well as improve their competitive ability, which are co-opetition, privatization, infrastructure development, regionalization, and specialization ones. Finally, some principal conclusions are drawn.

Keywords: Transportation; Containerization; Port management; Ports of Vietnam

1. Introduction

Containerization has revolutionized cargo handling and shipping. Since first 58 containers were carried by vessel in 1956, the annual container volume has been increased dramatically, which reached about 452 million TEUs in 2006 on the world scale (IAPH, 2006). This growth is direct consequences of the internationalization of almost all countries' economies, and of the intensive search for efficiency in freight handling and transport. Indeed, the introduction of containers had important impacts in operations and strategies of agents involved in containerization process. For instance, it has resulted vast improvements in port handling efficiency, thus lowering costs and helping lower freight charges and, in turn, boosting trade flows.

In Vietnam, this revolution came during the mid 1990s, quite late in comparison with other developed and developing countries. In the period 1995 – 2007, the container volume has increased more than 700 percent, which reached about 3.7 million TEUs. This figure is expected higher and higher in the next few years because of economic growth. Recently, more than ever, ports have been considered as a very important element for boosting national economy.

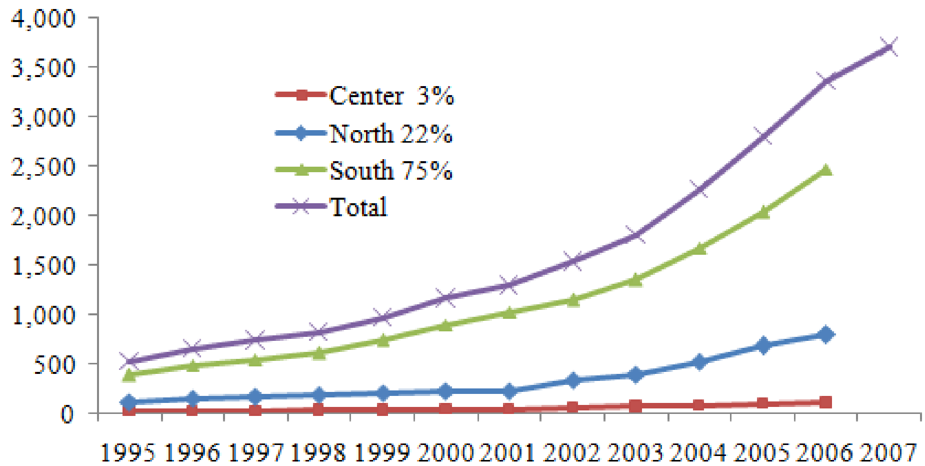
With geographical advantages, Vietnam has more than a hundred of ports along the country. There are eight major ports including two dedicated container ports and six conventional/multi-purpose ones, receiving container vessels regularly. Although there is a high demand in containerized cargo segment, number of dedicated container ports is diminutive in comparison with conventional/multi-purpose ones. In order to build a proper plan for the development of container ports in Vietnam, it is essential to study about the demand on container volume, as well as to analyze and evaluate container ports based on their strengths, weaknesses, opportunities, and threats.

Accordingly, future demand on container volume is forecasted by using time series forecasting method. Then based on current and expecting capacities and demands, ports are analyzed and evaluated. A SWOT analysis is then conducted to point out strengths, weaknesses, opportunities, and threats which are helpful and harmful to container port development. Based on them, suitable alternatives are suggested to support ports' development in the future and to improve their competitive ability, which are co-opetition, privatization, infrastructure development, regionalization, and specialization ones. Finally, some principal conclusions are drawn.

2. Container Volume Forecasting and Discussions

2.1 Container volume forecasting

The container volume via ports of Vietnam is illustrated in Figure 1. Obviously that it is increasing according to an upward and nonlinear trend. Besides, it is hard to collect data about some factors which might affect to container volume such as the yearly investment in infrastructure, the impact of government policies. Therefore, authors will establish the relationship between container volume and time in order to estimate or predict the future volume. According to Harnett and Horrell (1998), there are two basic approaches. The first one is to determine which type of nonlinear equation is appropriate for the investigated problem and find the exact form of that equation that gives the best fit. The second approach to fit an equation to nonlinear data is to transform the data so that they are linear, and then use the linear approach to forecast. In this paper, the first approach is applied.



Source: VINAMARINE.
** 2007: preliminary data*

Figure 1: Container Volume via Ports of Vietnam (1,000 TEUs)

Data are fit to four types of nonlinear equations, which are exponential equation, power equation, polynomial equation of degree 2 (quadratic form), and one of degree 3. For each equation, the multiple coefficient of determination, R^2, is calculated to measure how fit the equation is, following the rule that the higher R^2, the better fit equation. Then, MAPEs (Mean Absolute Percentage Errors) are calculated for each equation in order to find which type of nonlinear equation is best equation following the rule that the smaller MAPE, the better equation. The results are shown in Table 1.

Table 1: Trend equations and r^2 & mape values

Equation	R^2	MAPE
$y = 435.1Exp(0.164X)$	0.992	3.8591
$y = 356X^{0.779}$	0.862	29.041
$y = 25.12X^2 - 88.11X + 704.1$	0.991	6.404
$y = 1.028X^3 + 2.325 X^2 + 50.81 X + 505.5$	0.995	3.424

Y: Container volume; X: time variable, X = 1... n.

Both R^2 and MAPE values show that the last equation is the best fit. Therefore, this equation is used to forecast the future volume, as summarize in Figure 2.

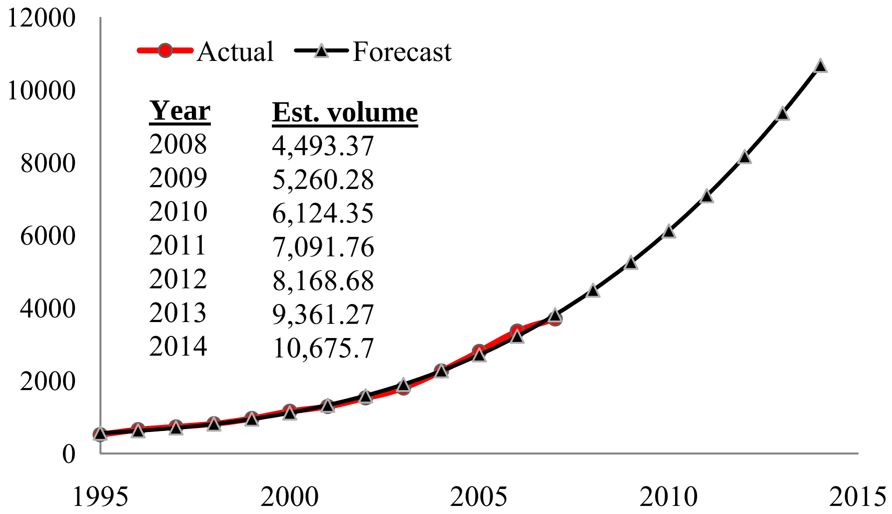


Figure 2: Forecast Result for Container Volume via Vietnam ports (1,000 TEUs)

However, among eight major ports receiving containers regularly, four, including the only two dedicated ports, are located in Hochiminh city area in the South, while other four ports are divided equally for Center and North of Vietnam. Ports in Hochiminh city occupy about 75 percent container volume of the total, while the percentages carried by ports in the Center and the North are 3 and 22 percent on average, respectively (see also Figure 1). Therefore, it is essential for conduct a forecast for the container volume via ports in the South of Vietnam in order to make an appropriate development plan.

A similar procedure is performed to find the best fit equation, and the following Equation is obtained.

$$y = 328.2e^{0.163X}$$

$$R^2 = 0.996,\ MAPE = 2.9502$$

The forecasted result is presented in Figure 3.

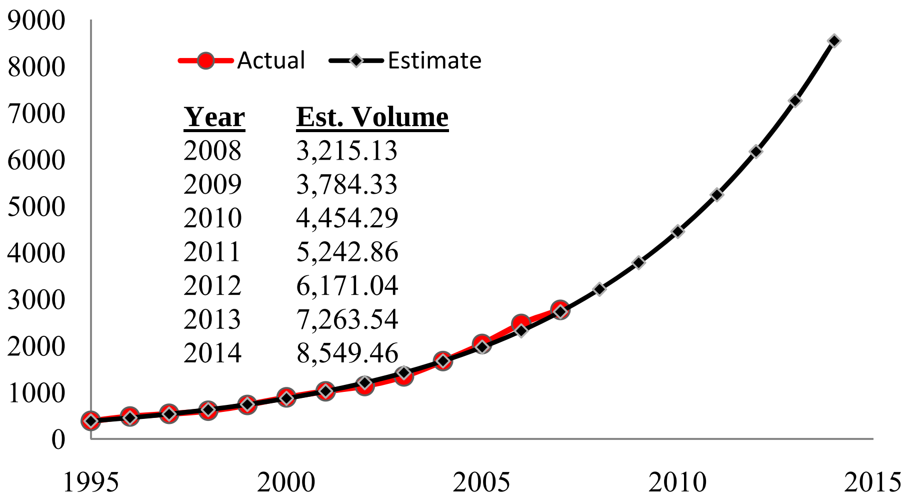


Figure 3: Forecast Result of Container Volume via Ports of South Vietnam (1,000 TEUs)

2.2. Discussions

As forecasted, the container volumes via Vietnam ports and Hochiminh city ports will be increased dramatically with the average growth rates of 15.8 and 17.7 percent respectively.

Currently, some dedicated container and conventional ports which can serve container vessels are constructing in order meet the market's increasing demand. The current and expecting capacities of exist and future major ports in the South of Vietnam are presented in Table 2.

Table 2: Current & expected capacities and expected surplus/deficit of south ports (1,000 teus)

Port	2006	2007	2008	2009	2010	2011	2012	2013	2014
Saigon	240	300	300	300	-	-	-	-	-
Saigon New	1,400	1,570	1,640	1,830	2,130	2,130	2,130	2,130	2,130
Ben Nghe	190	200	200	200	-	-	-	-	-
VICT	450	550	750	900	900	900	900	900	900
ICD Phuoc Long	250	250	250	250	-	-	-	-	-
Hiep Phuoc P&O Ports*			200	400	800	1,000	1,200	1,200	1,200
Cai Mep, ODA*						525	1,050	1,050	1,050
Cai Mep, SSA*					250	525	1,050	1,050	1,050
Cai Mep, APMT*					525	1,050	1,050	1,050	1,050
Cai Mep, New Port*				300	500	750	1,000	1,250	1,500
Cai Mep, PSA*					250	500	1,000	1,000	1,000
Cai Mep, Gemadept*							500	1,000	1,500
Total Capacity	**2,530**	**2,870**	**3,340**	**4,180**	**5,355**	**7,380**	**9,880**	**10,630**	**11,380**
Forecasted Volume	2,473 **	2,780**	**3,215.13**	**3,784.33**	**4,454.29**	**5,242.86**	**6,171.04**	**7,263.54**	**8,549.46**
Surplus/Deficit	57	90	**124.87**	**395.67**	**900.71**	**2,137.14**	**3,708.96**	**3,366.46**	**2,830.54**

'-'Ports will be removed.
'*' Ports are being constructed and expected to be operated at mentioned points of time
'**' Actual volume
Source: Capacities (Rasmussen, 2007)

According to this scenario, if the development plan of container ports is implemented and finished as expected, Vietnam ports can meet the growing demand on containerization cargo segment (see also Table 2).

3. SWOT Analysis of Container Ports

In this section, a SWOT analysis is performed in order to determine internal/external factors which are helpful and/or harmful to the container port development.

3.1 Strengths

Vietnam has an interlacing system of rivers and ditches of 40,998 km in length, and the coastline of 3,444 km (excluding islands), and it is nearly located at the important international marine lines, linking current eventful economic centers of the world. Distances from Vietnam ports to ports in North America, and Northeast Asia are shorter than those from ports in other Southeast Asian countries, as shown in Figure 4. Besides, many locations in Vietnam are suitable for building deep-sea ports, such as the 14 meter depth of Cai Mep area in South, 17 meter depth in Da Nang, and 25 meter depth in Van Phong areas in Center, and 14 meter depth in the North. Once built, ports can accommodate large and very large sized vessels, and also expanse Vietnamese ports' capacity.

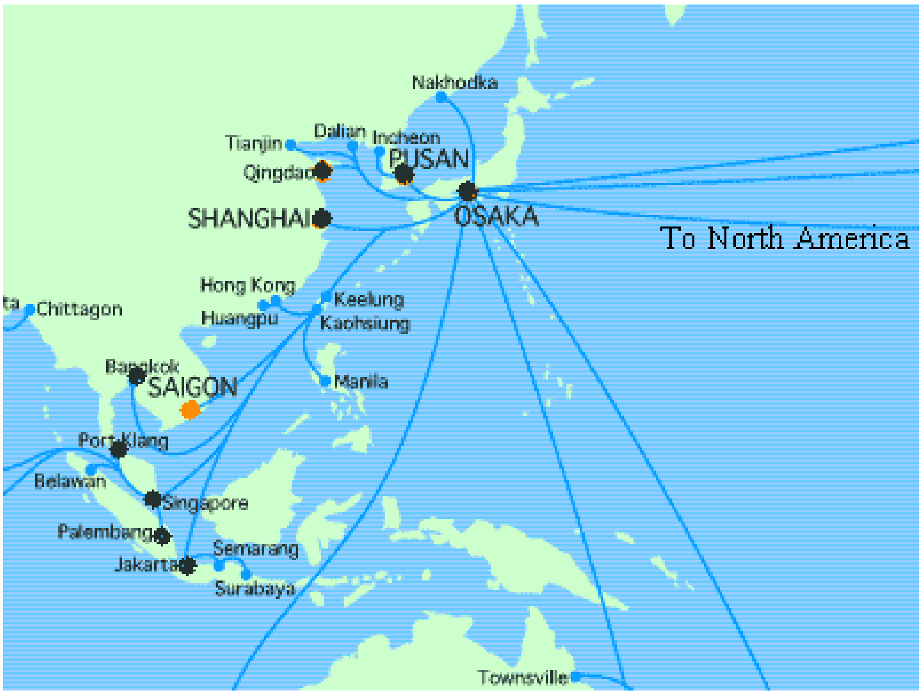


Figure 4.: Marine routes

It is very advantageous to transport goods and/or passengers among local areas inside Vietnam, and between Vietnam and other countries in the regions or in the world by waterways. Historical data show that approximately 90 percent of the import/export volume has been carried by waterways, and inland waterway transport accounts for about 34.5 percent of the domestic cargo transport volume in the past few years.

Besides, container volume via ports of Vietnam has increased continuously. As shown in Figure 1, the container volume has increased more than 700 percent over the period of 1995-2007. Currently, some ports are equipped with modern and specialized facilities, so that their handling capacities are improved to catch up with those of other development ports in region. For example, in normal condition, Vietnam International Container Terminal, VICT, can handle at the rate of 25 boxes per hour per crane.

3.2 Weaknesses

Although there are strengths as presented in previous section, Vietnamese ports system has many weaknesses. First, infrastructure and superstructure of most of port in Vietnam are very old and need to be improved. A few of Vietnam's major ports are equipped with the modern and specialized facilities and equipments, but still in limited quantity which leads to the low handling productivity as shown in the Table 3. For instance, although VICT has throughput rate of 25 boxes per hour per crane, its capacity is about 600,000 TEUs annually. Moreover, in most conventional ports, facilities are used for break bulk mixed with container cargo. In addition, the information technology and operating systems are also very old and inadequate.

Table 3: Productivities of vietnam major ports under normal conditions (boxes/crane/hour)

Port	Ben Nghe	Saigon	Saigon New	VICT	Hai Phong	Da Nang
Productivity	12	12	15	25	12	18

Source: Compiled from data collected from above ports.

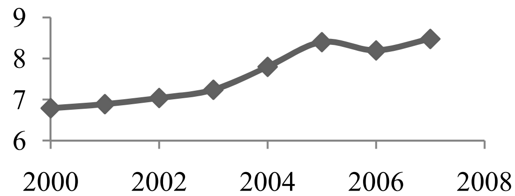
Second, while the containerized volume has increased rapidly, the development of dedicated container ports seems lagging behind. Ports in Hochiminh city are now run almost in full capacities, while capacity of other ports in the Center and North are expected to be adequate for short and medium market needs. For examples, in 2006 the container volume via ports in Hochiminh city reached 2.5 million TEUs while total capacity is 2.53 million TEUs, the figures in 2007 were 2.78 and 2.87 million TEUs for actual volume and capacity respectively (See also Table I).

Third, although the port costs of Vietnam ports have decreased continuously since the year 2001, it is still from 20 to 30 percent higher than those of other ports in the region according to some foreign shipping companies. For examples, the port cost of Hai Phong port is higher than those of similar ports in China and Thailand about 21 percent. The reasons are due to the obsolete of infrastructure and superstructure, and the inefficiency of the port management that leads to longer time to release vessels. For each day delayed, the ship owner will be fined USD 8,000. Moreover, the ports charge includes many types of fee that lead to the high total fee, while most ports in the region only charge port dues depending on the vessel's GRT (Gross Registered Tons) (Runkel, 2006).

Besides, most of the major ports of Vietnam are located along rivers and inner big cities, such as Saigon, Saigon New, Ben Nghe and VICT ports. This character used to be the ports' advantages such as utilized cities' infrastructure as well as close located to industrial and economic zones. However, it now shows weaknesses such as limitation of depth so that they cannot accommodate large sized vessels, limitation of hinterland, and terrible traffic tram problems at big cities. For instances, due to the shallow draft conditions, ports in the South can handle the small sized vessels of up to 1,500 TEUs, while this figure is about 600 – 800 TEUs for the ports in the North. However, as a matter of fact, large sized vessels will reduce cost. Therefore, ports have to receive more ships varying in sizes, especially the large ones.

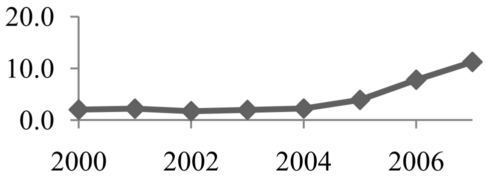
3.3 Opportunities

Vietnam's impressive and consistent growth over the last several years (second in Asia to China) has made Vietnam more and more visible on the global map, especially for those multinational corporations looking for an outsourcing and factory-relocating destination. The economic growth rate is shown in Figure 5. In the pursuing of lower cost and increased margin, many companies have looked to Asia for product outsourcing and Vietnam is one of preferable destinations. In order to compete for foreign investment with other developing countries, Vietnam has relied most on the strength of its abundant and low cost labor force, a highly educated young generations, inexpensive operation costs, and many other incentives signaling the government's warm welcome to investors and its determination to integrate into the global market. Therefore, the foreign investment continues increasing as shown in Figure 6. As consequence of economic development, the import/export is increased dramatically, as shown in Figure 7, which leads to the increase in port throughput.



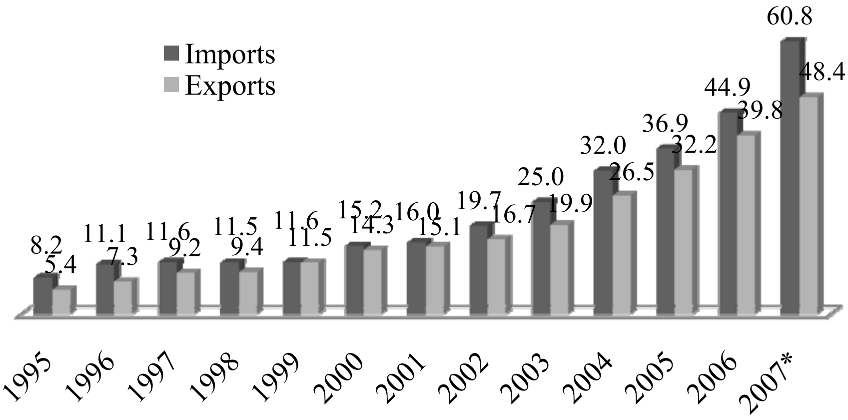
Source: Vietnam General Statistics Office

Figure 5: Vietnam economic growth rate (%)



* 2007: Only for first 10 months of 2007
Source: Vietnam General Statistics Office

Figure 6: Foreign Direct Investment (FDI) To Vietnam 1995 – 2007 (US$ billion)



Source: Vietnam General Statistics Office
* 2007: Preliminary data

Figure 7: Import/Export of Vietnam 1995 - 2007* (US$ billion)

Beside price, labor force, Vietnam also attracts investors by a safety investment environment with transparent and clear political policies. Becoming 150th member of WTO is an opportunity for Vietnam in general and Vietnam port system in particular. As the result of economic development, more and more import/export will go through ports.

In addition, many foreign investors are interested in ports. This will be a good chance for Vietnam to develop the container ports as well as enhance port's capacity.

3.4 Threats

Vietnam's transportation infrastructure relative to ports such as roads, and railways remains underdeveloped compared to those of other countries in the ASIAN, such as Singapore, Thailand, and Malaysia. Poor road conditions between main arteries and port hamper the development of ports. The rail system is even worse than the road system. Currently, railway system is very old and not connected to ports and not used for transporting container cargoes. Therefore, the development of transport infrastructure in step with port development is essential. In addition, industrial parks need to be strategically located near ports. The linkage of infrastructure, ports, and industrial parks will help to meet the Vietnamese Government's socio-economic development goals.

4. Proposed Alternatives

According to expected capacity and container volume, Vietnam port can meet the market requirement until 2014. However, as in SWOT analysis, there is very high demand for modern port facilities, especially dedicated container handling equipments in order to meet the demand for speed and safe cargo handling. Moreover, new investments in both ports and landside infrastructure and superstructure are critical. The soonest availability of port facilities to absorb new volumes and transport infrastructures are key to Vietnam's ability to meet growth targets and to ensure flow of foreign investments continues. In other words, the development of ports can boost the national economy.

In order to solve the capital problem on super- and infrastructures investment, as well as improve competitive power of Vietnam ports, it is essential to apply strategies of developed ports in the region as well as in the world. Most helpful strategies with respect to Vietnam conditions are presented as following.

4.1 Co-opetition

From the national point of view, port is regarded as a unit under a national level administration and competes or cooperates with other ports. Increase of horizontal and vertical integration is result of international logistics of manufactured goods. Integration of ports with inland transport is an alternative of organizations to enlarge their roles in logistics services. Based on effects of mergers and alliances on international shipping and port competition, which can control significant good flows on the major routes, container ports of Vietnam can share benefits from container traffic market. Levels of co-operation are adjusted through distance among ports and their potential to serve a common hinterland. Co-operation alternative can create efficiencies with neighbor facilities due to the economies of scale and scope. With terminal operations, mergers on the horizon provide high quality local service levels at very competitive prices while fitting into the global requirements of large lines and shipping alliances, immediate expansion and a stronger negotiating position, and greater flexibility in supplying.

Globalization and shipping alliances, larger size of vessels and intermodalism, and intense port competition are driving forces for port competition and co-operation. Song (2003) used a co-opetition concept, which is mixture of competition and co-operation strategy or win-win strategy, for port management. It searches new co-operation solutions via co-operation with the competitors, and is actually a collaborating alternative to compete. Most Vietnam ports have been operating separately, so natural competition among them is existed. To compete with other foreign ports, one of useful ways is the co-operation alternative. Belong to geography, groups of ports should be established, which operate in co-opetition principles. With specific geography, ports of Vietnam should focus in developing three groups of ports as clusters locating in the south, middle, and north of Vietnam. Besides, to broaden servicing capacities, ports of Vietnam can cooperate with others, such as port of Malaysia, Port of Singapore, and Port of South of Korea, to participate in transportation networks.

4.2 Privatization

Increase of private participation occurs in ports of most countries, but it is rare in full privatization. Although public sector has important roles, significance of role of private sector in seaports is enlarged. Among worlds' top-100 container ports, with port organization there are only 7 percent of ports which were private companies; with port assets there are 22 percent of ports with container cranes owned by private companies. Contribution of private sector mainly focuses in port operation (Baird, 2002). They mainly participate in port navigation services, stevedoring services, and added value services.

Most of ports of Vietnam have been administrated by public sectors. Although some advantages can be gotten under their management, inflexibility, inefficiency, high costs, and low service quality are disadvantages through this way, so container port of Vietnam can not compete with others. Privatization through terminal concessions and leasehold arrangements are common methods used by ports to facilitate private sector intervention (Baird, 2002). Other useful methods can be applied such as Build-Operate-Transfer (BOT), joint venture, outright sale of port land, and corporatization of port authority.

4.3 Regionalization

Inland distribution is a vital important dimension of globalization or maritime transportation. Port-hinterland relationships have to be paid special attention to develop port of Vietnam. Regionalization makes a stronger link, and higher geographical scale is its character. It encompasses the explicit integration of "off shore" hubs on island location. By this way, greater depth, land for future expansion, inland investment, and labor costs tending to be lower are its requirements. Ports in the south of Vietnam are planned to remove from Hochiminh City to Vungtau province which meets required conditions. Together with distributing freight, many operations to add value to the cargo should be considered. Constructing Free Trade Zone or logistics zone is one of alternatives. For instance, a suitable logistics network could be established among Vungtau province, Binhduong province, Hochiminh city, and Mekong River Delta area, which operates as logistics pole, in which Vungtau province can be considered as a primary logistics zone and others as secondary logistics zones.

Another expansion of port is incorporation of inland freight distribution centers and terminals as active nodes. Lack of available land, diseconomies as local road and rail systems, environmental constraints, and local opposition, which are local constraints, and global change through global production and consumption as well as distribution requirement are its reasons. Based on special Vietnam's geography, Hub-ports can be constructed. They do not only service for distribution freight to Vietnam and north-east area, but they also participate in transportation networks on the world.

4.4 Specialization

Most of ports of Vietnam are conventional ports which can serve many types but small ships, facilities are use for break bulks mixed with container cargoes, so they operate inefficiency. VICT port is the most efficient one, but it is still a small port. Actually, it can not compete with other neighboring ports in area. To improve competitive capacity of container ports of Vietnam, specialization container ports should be considered, which can service large sized container vessels. On the top five of container ports in the word, they can serve large and extra large sized container vessels. The relationship between efficiency and scale of a container port can summary shortly as the larger scale container port is the higher efficiency it has.

In addition, with specialization container ports, modernization in ports is more easily carried out. It is an important factor to compete. For example, Busan port is recorded a modest increase, and its productivity records were reported at one HPH-managed container terminal, which were 182 boxes per handled on a vessel using four cranes and twin-lifting devices in June in 2005 (UNCTAD, 2006), so it ranks the third container port traffic. Besides, by focusing on container ports, to improve port performance, optimization of container port systems can be reached through making optimizing scheduling plans for ships, and labor crews; optimizing inventory systems; and so on.

4.5 Infrastructures development

Considering neighboring countries, Singapore that has the world's largest container port has one of the largest cargo airports in the world. Thailand that has container port ranked on the top ten has road networks evaluated good, which connect to main industrial areas. Its new International Airport was equipped with modern technology, and rail network is extensive and connects with Malaysia's national system, providing direct linkages down to Singapore. Malaysia, one of the most efficient economies in the region, has Malaysia biggest airport, a transportation hub for all major rail transport networks, as well as well-maintained highways linking major centers to seaports and airports. All of them have good infrastructures, which are critical requirements to develop or support container ports.

The further development of transportation and logistics services is critical to Vietnam's continued economic expansion in general, and to improve competitive ability of container port of Vietnam in particularly. The non-existent or crumbling infrastructure threatens to put constraints on development. To ameliorate inland traffic, new airports for both domestic and international traffic have been built such as Long Thanh International Airport, the biggest airport in north-west area, located nearly Hochiminh city. Only approximately 19 percent of Vietnam's roads are paved (Source: Vietnam General Statistics Office), so constructing, maintaining, and improving the road networks are urgent requirements. Besides, rail systems are worst than roads and rarely used for shipping. To up-to-date, and expand rail networks has to be done.

A summary on benefits of each alternative is presented as in Table 4. Depending on existing situation of a particular port as well as suitable conditions such as timing, expecting objectives, one or more alternatives can be applied.

Table 4: A summary on benefits of alternatives

Alternative	Benefits
Co-opetition	Cost saving Shared investment, so risk sharing Port expansion, thus easily in geographical market penetrating Improved and utilized capacity Stronger bargaining power Enhancing customer services Increasing profits Contributing to welfare of the economy
Privatization	Lower port costs Sharing investment Reduce cost to public sector Increasing port efficiency Speed of development of new container terminals Expand trade Increasing revenue Management expertise
Regionalization	Enhancing logistics integration Reducing logistics costs Broadening hinterland Shorter transit time
Specialization	Increasing efficiency Easy to modernization Optimized ship schedule plan Optimized labor plan Optimized inventory and warehouse system
Infrastructure development	Ameliorating inland traffic Broadening hinterland Improving port competitive power

5. Conclusion

In the paper, authors have considered the increase of containerization in Vietnam. Although the revolution came quite late, it is very strong; after twelve years, 1995 - 2007, container volume has increased more than 700 percent. A SWOT analysis for development of container ports in Vietnam and a forecast of container volume for the next few years show that growth trend will continue with average rate of 15.8 and 17.7 percent for nation and Hochiminh city, respectively. Vietnam has very advantageous geographic conditions for development deep-sea ports to accommodate large sized vessels. Economic growing, clear, and transparent political environments are also opportunities. However, there are still many weaknesses and threats that hamper the development of Vietnam ports such as lack of dedicated container handling equipments, mixed use of facilities, old and inadequate facilities include IT and operating systems. Poor inland infrastructures are also obstacles for port development. The soonest availability of port facilities to absorb new volumes and transport infrastructures are key to Vietnam's ability to meet growth targets and to ensure flow of foreign investments continues. Consequently, some suitable alternatives are suggested to overcome weaknesses, threats, and to improve ports' competitive ability, which are co-opetition, privatization, infrastructure developing, regionalization, and specialization. The selection and application of alternatives depend on existing ports situations, their expecting objectives, and so on. The benefits of each alternative are also discussed in previous section.

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Is Container Liner Shipping an Oligopoly?

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Abstract

This paper focuses on the question whether or not the container liner shipping industry is an oligopoly. Although liner shipping literature has been occupied with this question, few authors have examined the market structure of the containerised liner shipping industry. Our empirical investigation uses the four-firm concentration ratio, the Herfindahl-Hirshman Index and the Lorenz curve to measure the degree of concentration. The results allow us to determine the degree of oligopoly and to attempt to position the liner shipping industry in the spectrum of oligopoly. The conclusion shows that the container liner shipping industry is more concentrated due to consolidation. This continuing process of concentration reveals that the containerised liner shipping industry operates in either a loose or a tight oligopolistic market, depending on the trade lane.

Keywords: Liner shipping industry; Oligopoly; Concentration measurement

1. Introduction

Over the last 15 years, the liner shipping industry, like many other sectors (financial, media, distribution, education, transportation in general, etc.), faced a period of restructuring and consolidation. An overview of the mergers and takeovers in the liner shipping industry is given in Appendix 1 (compiled with data from AXSliner, Containerisation International and Dynamar - various editions). Notice that, except for the liner operator Grimaldi (ranked 24), the 'buyers' are located in the Top 20 (Ranking based on 2008, January 1st).

As further consolidation is expected, the central research question becomes: 'What is the impact of this consolidation movement on the market structure of the container liner shipping industry?'

The market structure of the container liner shipping industry will be examined at the level of the industry, at the level of alliances descending to trade level by the following two hypotheses:
The (container) liner shipping industry is more concentrated due to consolidation.

The market structure in which the container liner shipping industry operates is an oligopolistic market.

These hypotheses will be studied from an industrial economic viewpoint. In empirical research, seller concentration is the indicator to analyse the merger impact on concentration, to determine the degree of oligopoly.

The paper is organised into four sections. The first section of this paper defines and outlines the container liner shipping industry. Section two focuses particularly on quantifying the degree of concentration in the container liner shipping industry. It also examines the concentration ratios at a disaggregated level, viz. the trade lane. This is followed by Section three in which the link with the degree of oligopoly is directly shown. The final section concludes and summarises the main theoretical and empirical findings.

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2. The (Container) Liner Shipping Industry

Before quantifying the degree of concentration, it is important to define and outline the (container) liner shipping industry.

2.1 Defining the (container) liner shipping industry

Defining the 'industry' is an essential first step on the road to concentration measures (see Section 2). Given the complexity of defining an industry (Stigler (1955), Kay (1990), Lipczynski, Wilson and Goddard (2005)), one can fall back on specific schemes for defining and classifying the industries. Although these classifications provide an interesting framework, in order to define the container liner shipping industry, they are not useful.

A scan of the literature yields the following definitions: In 1933 Fayle defined a liner service as a fleet of ships with common ownership or management, which provides a fixed service at regular intervals between named ports and offers transport to any goods in the catchment area served by these ports and ready for transit by their sailing dates. This definition was later on updated by Stopford. He added: "… A fixed itinerary, inclusion in a regular service and the obligation to accept cargo from all comers and to sail, whether filled or not, on a date fixed by published schedule are what distinguishes the liner from the tramp." (Stopford, 2004, p 343). Davies (1983) described the liner sector as that part of the ocean shipping (family of) industry (ies) which specialises in supplying scheduled cargo transport services on specified and fixed trade routes.

Bourne (2007, personal conversation) states that the liner shipping industry is best defined as those carriers of conventional general cargo (usually but not exclusively in containers these days) which carry cargo between defined ports on a regular basis.

Like the words 'industry' and 'market', the terms 'liner shipping industry' and 'container shipping industry' are - an observation after reviewing literature - sometimes loosely used. No definition of the container liner shipping industry was found.

Containerised liner shipping industry or container shipping industry can however be clearly distinguished from other industries in the water transport sector (see Figures 1a/b) and can therefore be defined as follows:

Container shipping industry, a major segment of the liner shipping industry, is a maritime industry, international if not global in scope. This industry operates vessels transporting containers with various but standardised dimensions/sizes, regardless of the contents. Whether filled or not, these (container) vessels are put into service on a regular basis and often according to a fixed sailing schedule, loading and discharging at specified ports.

2.2 Outline of the (container) liner shipping industry

First, we mark out the container liner shipping industry from the (liner) shipping industry. Combined with Stopford's market segmentation (Stopford, 2004, p. 390)[2] an analysis of data regarding the world fleet (incl. passenger ships) (ISL, 2006, own calculations) generates the following Figures showing the evolution.

[2] In terms of market segments, Stopford (2004) distinguishes the liner fleet, the bulk carrier fleet, the tanker fleet and the fleet of ships designed for a single cargo or the specialised fleet (e.g. cement carrier, heavy lift, car carrier, etc.).

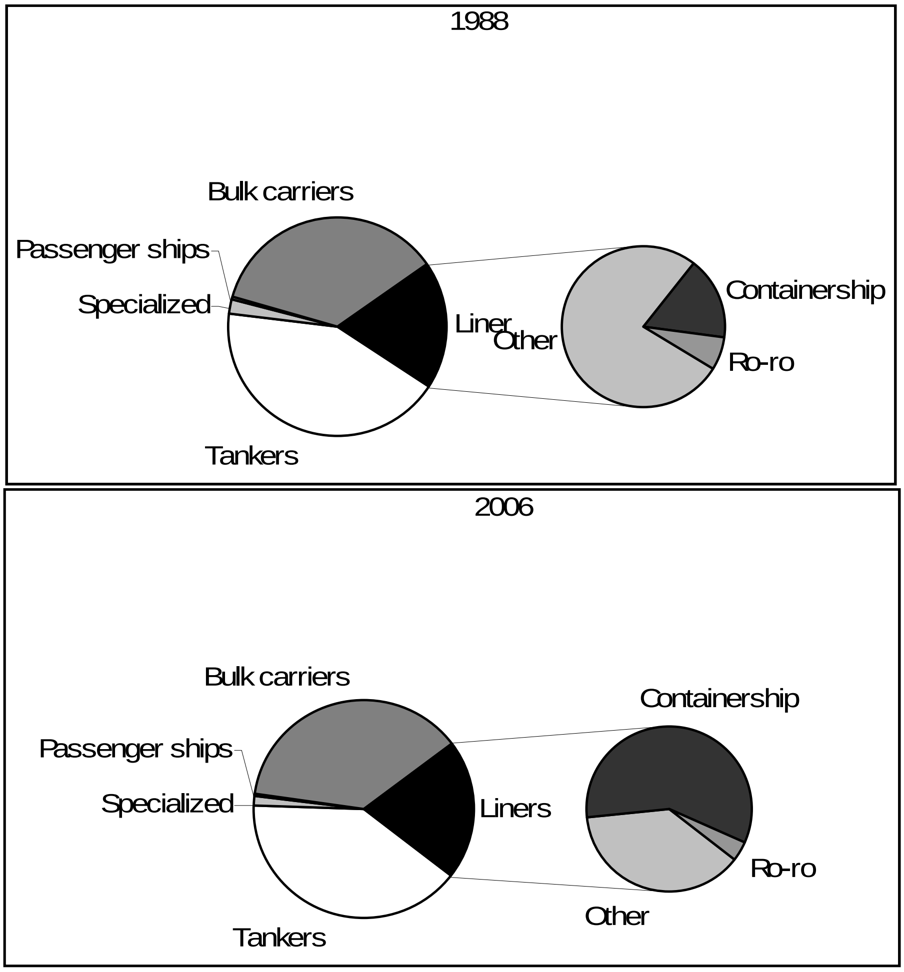

Figure 5 a/b: Liner Shipping versus Container Liner Shipping: Evolution 1988 - 2006

In 1988 the liner segment had a share of 18.44 per cent, compared with 42.41 % for the tanker segment, and 36.05% for the bulk segment. Over a time span of 18 years, the liner segment rose towards 21.46%. The specialized fleet (LPG tanker, heavy lift, refrigerated) diminished from 3.24% in 1988 to 1.88% in 2006. The share of the passengers segment rose from 0.42% in 1988 to 0.68% in 2006.

In detail the liner segment consists of three divisions, viz. containership (fully cellular), ro-ro and other (multipurpose, tweendecker, …). Figure 2 gives the percentages (measured in world total deadweight) per segment between 1988 and 2006 (ISL, 2006, own calculations). In 1988 the segment 'other' had a share of 14.14%, followed by 'containership' with an approximate 3% and 'ro-ro' with 1.21 per cent. Within 18 years the division 'containership' expanded its share to 12.57%. The shares of the divisions 'other' and 'ro-ro' have shrunk to 8.12% and 0.76% respectively.

	1988		1990		1995		2000		2001		2002		2003		2004		2005		2006	
containership	3,09%	17	4,02%	22	5,70%	31	8,31%	45	8,82%	48	9,52%	52	10,26%	56	10,74%	58	11,17%	61	12,57%	68
ro-ro	1,21%	7	1,20%	6	0,90%	5	0,94%	5	0,94%	5	0,92%	5	1,00%	5	0,97%	5	0,93%	5	0,76%	4
other	14,14%	77	11,72%	64	11,45%	62	9,99%	54	9,61%	52	9,00%	49	8,78%	48	8,35%	45	7,92%	43	8,12%	44
LINER	18,44%	100	16,94%	100	18,05%	100	19,24%	100	19,37%	100	19,44%	100	20,04%	100	20,06%	100	20,03%	100	21,46%	100

Figure 6: Share and index of the three liner divisions

Although the containerised liner shipping industry dominates the liner segment since 2003 (56 versus 53), the divisions 'ro-ro' and 'other' will always have a significant share (in 2006: 48). Due to the dimensions, weight, etc., wheeled cargo, break bulk, heavy equipment and project cargo will never be classified as containerised cargo. Secondly, we zoom in on the container segment. Figure 3 illustrates the ratio fully cellular container vessels versus non fully cellular container vessel. The share of all fully cellular container vessels equals 80,41% in 2005. In terms of tonnage, the share of fully cellular container vessels increased by 65,11 % over the period 1985-2005.

	nov/85		nov/95		nov/00		Oct 2005	
Fully cellular/converted	1160126	48,70%	2761312	62,65%	4716147	72,15%	7850513	80,41%
RoRo/container	90929	3,82%	144087	3,27%	415963	6,36%	386541	3,96%
Non cellular	1251055	52,51%	2905399	65,92%	1404731	21,49%	1526149	15,63%
Totals	2382399	100,00%	4407757	100,00%	6536841	100,00%	9763203	100,00%
Non cellular includes bulk-container/semi-container/multipurpose and LASH/barges								

Figure 7: Fully cellular vs. non fully cellular container vessels

In the continuation of the present paper, we will solely focus on fully cellular containerised liner shipping industry. Witlox (1993) summarises the studies of Lawrence (1972), Koike (1975) and Jansson and Shneerson (1987). These latter authors estimated that the proportion of liner cargo carried by containership measured in GT (or gross ton) would be resp. 50-60%, 41% and about 60% for the eighties.

	Ships			Gross ton (GT)			Deadweight (dwt)			TEU		
year	n°	index	% share of world total	1000 gt	index	% share of world total	1000 dwt	index	% share of world total	1000 TEU	index	% share of world total
1986	976	100	2,94%	17916	100	4,70%	19257	100	3,09%	1005	100	33,87%
1990	1147	118	3,46%	23001	128	6,04%	25026	130	4,02%	1435	143	48,37%
1995	1590	163	4,39%	34859	195	7,95%	38851	202	5,70%	2355	234	56,56%
2000	2437	250	6,26%	55101	308	10,88%	63296	329	8,31%	4273	425	67,56%
2001	2564	263	6,57%	59837	334	11,49%	68715	357	8,82%	4674	465	68,70%
2002	2726	279	6,97%	66402	371	12,36%	76131	395	9,52%	5288	526	71,36%
2003	2905	298	7,37%	72894	407	13,19%	83744	435	10,26%	5893	586	73,40%
2004	3036	311	7,65%	78176	436	13,71%	90214	468	10,74%	6424	639	74,72%
2005	3220	330	8,06%	85798	479	16,94%	99190	515	11,17%	7169	713	76,46%
2006	3514	360	8,80%	96231	537	19,00%	111663	580	12,57%	8139	810	86,81%

Figure 8: Evolution of the container segment

Figure 4 illustrates solely the evolution of the world fully cellular container fleet over the last two decades measured in number of ships, in gross ton, in deadweight and in twenty feet equivalent (TEU) (ISL, 2006). Anno 2006, the container fleet is assessed at 3,514 vessels with a total nominal capacity of 8,139,000 TEU. While the number of ships grew by a factor of 3.6, the capacity increased with a factor 5.37 regarding gross ton and a factor 5.80 based on deadweight, the carrying capacity (TEU) increased by a factor of 8.10 in the period 1986-2006.

3. The Degree of Concentration

Next to analysing the data, our empirical investigation uses the four-firm concentration ratio, the Herfindahl-Hirshman Index and the Lorenz curve to measure the degree of concentration.

3.1 Data description

The preferred method to calculate the size of distribution of liner operators is to examine the total annual TEU or slot capacity (Hoffman, 1998 and Notteboom, 2004). The concentration measurements are computed by using the Top 100 (www1.axsmarine.com). Although the container shipping industry accounts for about 400 liner operators, an omission of the lower-ranked carriers will have no significant impact on the conclusions, as the smallest liner operators in the container shipping industry have a market share of less than 1 % each (see Section 2.2.2, Herfindahl Hirshman Index).

As the trend in market shares gives useful preliminary information on the degree of concentration, a list of the 25 largest companies is included in Appendix 2. This Top 25 gives an overview of the market share of each carrier, the cumulative market share of the Top 25 and the market share in terms of the world's container fleet. In addition to the figures for 2007, the market share and cumulative market share of 2006 and 2003 are also presented (Figures refer to 1 January of each year) (www1.axsmarine.com). Notice that only one third of the Top 25 container service operators hold a share of more than 5 % (see Appendix 2). A closer look at the data reveals that only Maersk Line controls more than 15 % of the market share of the Top 25 and also of the world's total slot capacity. In general '15%' is indicated as a benchmark of the degree of market power.

3.2 Measurement of (increased) concentration

A prevailing method of analysing the industry is the measurement of concentration. In empirical research into industrial organisation, (seller) concentration, as a reference to the number and size distribution of firms, is an important indicator. (Seller) concentration can be measured at two levels: aggregate concentration[3] and *industry concentration* (Lipczynski *et al*, 2005). In this section we focus on the second level, which reflects the importance of the largest firms in some particular industry, in this case the container shipping industry[4]. Assuming that the product is homogeneous[5], the C4 ratio (2.2.1), the alternative Herfindahl-Hirschman Index (2.2.2) and the Lorenz curve (2.2.3) will be applied to the containerised liner shipping industry to study whether or not the container liner shipping industry is more concentrated due to consolidation.

3.2.1 C4 ratio

The first concentration measure is expressed by the term CRx, which stands for the cumulative share of the x largest liner operators in the market. The simplest measure of industrial concentration involves totalling up the market shares of the largest of so many firms (e.g. CR4, CR8, CR50, etc.). The four-firm concentration ratio, known as C4, is the most typical concentration ratio for judging the degree of concentration in an industry. Technically, the four-firm concentration ratio can be written as follows:

$CR4 = \sum_{i=1}^{n} s_i$ (Lipczynski *et al*., 2005, p.215).

Figure 5 summarises the evolution of the Top 100, 50, 25, 20 and 10 respectively compared to the total market, along with the C4 ratio, the Herfindahl-Hirschman Index (see 2.2.2) and the Gini coefficient (see 2.2.3).

Which conclusions can be derived from this? First, the Top 25 carriers currently have a market share (measured by share of total carrier capacity) of about 85% vs. 62% seven years ago. When considering the top-ten liner operators the market share accounts for 60 percent of the total TEU capacity. Of these, four are Europe-based companies with 39.37% of the total and three (corresponding the Top 3) account for 34.07% of the total share (see Appendix 2 - Liner operators in bold are Europe-based carriers. Carriers participating alliances are shaded.).

Furthermore, whereas most studies (Hoffman, 1998 and Notteboom, 2004) only measure concentration at the Top 20 level, in this paper the C4 ratio is repeatedly measured as the share of the 4 largest liner operators against the liner total, Top 100 and Top 25.

From these results one can conclude that the container liner shipping industry is becoming more

[3] This type of concentration reflects the importance of the largest firms in the economy as a whole.

[4] Concentration does not only occur on a horizontal level (between carriers). Carriers also engage in vertical integration activities that cover almost all stages of the transport chain. Abstraction is made of the latter in this paper, as well as of the profound effects of the process of concentration on port development.

[5] For lack of information, the product is assumed homogeneous (read: transport of a container/box). However, when service, transit time, etc. are taken into account, one evolves towards a heterogeneous product. Although market power can be measured at the industry level, taken into account the variation due to for instance service, the question regarding concentration becomes a firm-level expression (Martin, 2002).

concentrated. Regardless of the calculation basis, a remarkably higher concentration is noticeable between 1999/2000 and 2005/2006, not coincidentally corresponding with an intense wave of consolidation. Figure 6 lists the number of players in the container liner shipping industry making up 50% of total capacity in service (compiled with data from AXSliner and EU-report, 2005). In 1995 16 members accounted for 50%, whereas in 2008 only 7 carriers have this market power, clearly indicating the trend of growing concentration.

Focusing on the results at the Top 20 level, one can notice a decrease in the C4 ratio in the years preceding a consolidation wave. This observation indicates a stronger growth of lower-classified liner operators. Between 1996 and 1998 companies such as MSC (ranked 9 in 1996) and CMA (ranked 14 in 1996) increased their market share by 44.30% (solely by internal growth) and 45.17% respectively, whereas 3 of the 4 largest operators of 1996 found themselves facing a loss of market share two years later (Sea-Land (purchased by A.P. Møller (1999): -18.37%, Evergreen: -7.87% and Cosco: -4.54%).

		1980	...	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Top 100									77,93%	84,73%	79,47%	88,30%	93,59%	94,16%	94,79%	94,67%	95,38%
Top 50									71,49%	78,00%	73,66%	82,64%	88,18%	89,07%	90,51%	90,34%	91,33%
Top 25									62,17%	68,37%	65,25%	73,90%	79,55%	81,31%	83,71%	84,25%	85,41%
Top 20									57,21%	63,35%	60,55%	68,68%	74,23%	76,28%	80,85%	81,25%	82,38%
Top 10									38,85%	42,32%	40,28%	46,23%	52,10%	50,00%	56,66%	60,22%	60,55%
CR4	Liner total								23,66%	26,22%	24,66%	29,05%	31,00%	30,92%	37,60%	38,73%	39,37%
	Top 100				22,76%	25,28%		25,83%	30,37%	30,94%	31,03%	32,90%	33,21%	32,84%	39,67%	40,91%	41,27%
	Top 25				31,99%	32,13%	31,03%	32,91%	38,06%	38,35%	37,79%	39,31%	39,07%	38,03%	44,92%	45,96%	46,09%
	Top 20	38,60%		35,70%	34,99%	35,12%	33,50%	35,51%	41,36%	41,29%	40,72%	42,29%	41,87%	40,54%	46,51%	47,66%	47,79%
HHI	Liner total								252,21	306,96	269,87	351,87	404,91	420,13	598,33	579,16	582,27
	Top 100				273,92	332,53		336,20	415,34	427,54	427,37	451,34	462,24	473,91	565,93	646,22	640,00
	Top 25				511,55	514,50	529,55	545,81	640,21	645,80	624,77	636,75	633,87	630,60	350,51	813,12	795,56
Gini coefficient				0,5767				0,6466	0,6654	0,6717	0,6829	0,7001	0,7088	0,7199	0,7569	0,7607	0,7664
Δ									0,0188	0,0063	0,0112	0,0173	0,0087	0,0111	0,037	0,0039	0,0057

Figure 5: Measurement of concentration

	1995	2000	2003	2008
1	Maersk	Maersk-SL + SCL	Maersk-SL + Safmarine	APM-Maersk (*)
2	Evergreen Group	Evergreen Group	Mediterranean Shg Co	Mediterranean Shg Co
3	COSCO Container L.	P & O Nedlloyd	P & O Nedlloyd	CMA CGM Group
4	Sea-Land	Hanjin/DSR-Senator	Evergreen Group	Evergreen Group
5	NYK	Mediterranean Shg Co	Hanjin / Senator	Hapag-Lloyd (**)
6	P&O Nedlloyd	NOL / APL	APL	CSCL
7	Hanjin	COSCO Container L.	COSCO Container Lines	COSCO Container L.
8	P&O Containers	NYK	CMA-CGM Group	
9	MOL	CP Ships / Americana	NYK	
10	K Line	Mitsui-OSK L. (MOL)	CP Ships Group	
11	Zim	Zim		
12	Hapag-Lloyd			
13	NOL/APL			
14	DSR Senator			
15	MSC			(*) including P&O Nedlloyd
16	Yang Ming Line			(**) including CP Ships

Figure 9: Liner operators making up 50% of total capacity in service

After measuring concentration at the level of the liner operator, it is also interesting to analyse the market power of each alliance. Alliances group liner carriers operating on different routes around the world in order to offer a worldwide service to their clients. In addition, alliances offer a means to small and medium-sized carriers to pool vessels in order to create sufficient capacity providing strings to service trade route(s). The three largest alliances, viz. the Grand Alliance, the CHKY Alliance and the New World Alliance, are compared with number 1 Maersk Line over the years 2000, 2003, 2006 and 2008[6]. After the withdrawal of P&O Nedlloyd in February 2006, the 'new' Grand Alliance was formed by Hapag Lloyd (incl. CP Ships), MISC (still Europe-Asia only), NYK and OOCL. The members of the New World Alliance are APL, Huyndai and MOL. The CHKY Alliance consists of Coscon, Hanjin/Senator, K-line and Yang Ming.

Year	Alliance	TEU	% share /liner total
2000	GRAND ALLIANCE	692.551	13,45%
	CHKY ALLIANCE	649.709	12,62%
	Maersk/Sealand	620.324	12,05%
	TNWA	446.381	8,67%
	TOTAL	2.408.965	46,78%

Year	Alliance	TEU	% share /liner total
2003	GRAND ALLIANCE	957.019	13,97%
	CHKY ALLIANCE	846.251	12,35%
	Maersk/Sealand (incl. Safmarine)	818.850	11,95%
	TNWA	536.921	7,84%
	TOTAL	3.159.041	46,12%

Year	Alliance	TEU	% share /liner total
2006	Maersk Line	1.665.272	18,23%
	CHKY ALLIANCE	1.067.198	11,68%
	GRAND ALLIANCE	989.241	10,83%
	TNWA	720.708	7,89%
	TOTAL	4.442.419	48,62%

Year	Alliance	TEU	% share /liner total
2008	Maersk Line	1.878.943	16,06%
	CHKY ALLIANCE	1.349.452	11,54%
	GRAND ALLIANCE	1.296.557	11,08%
	TNWA	927.618	7,93%
	TOTAL	5.452.570	46,61%

Figure 10: Market share of the alliances

Figure 7 shows the share of the alliances versus the liner total over 4 different years, both in absolute figures (carrying capacity - TEU) and in percentages. Up to 2006 the Grand Alliance and the CHKY Alliance respectively took the first and second place. In 2007 the biggest strategic cooperation, in capacity terms, is the CHKY Alliance with a share of 11.54%. Since the takeover of Royal P&O Nedlloyd by Maersk Sealand (since known as Maersk Line), the 'new' Grand Alliance saw its share diminishes from 13.97% (2003) to 11.08% (2008).

After acquiring P&ONL the Maersk/Sealand alliance took over the first place. Its share rose from 11.95%

[6] For purposes of review, abstraction is made of the United Alliance (Hanjin and UASC). UASC, co-operating Hanjin/Senator is presently considered as an associate member of the CHKY Alliance.

(2003) up to 18.23% (2006). This concentration of market power illustrates that a liner operator can perfectly operate independently of alliances.

This leads us to trade level. Figure 8 lists the ranking of the largest deepsea liner operators on two different trades, viz. the Black Sea - Far East trade, a growing trade and the mature US trade[7]. For the three main Black Sea countries (Romania, Russia and Ukraine) the 2006 TEU volume of all trades (import and export but excluding transhipment) is reported as starting from 10,000 TEUs. On the right-hand side are the figures for the US full-container trade of all US ports (all destinations, all origins) over a time span of two years. Notice that these twenty lines carry more than 90% of the total US containerised import and export trade (www.dynamar.com).

A close analysis of these two trades reveals that the market power of each carrier differs on each trade lane. Two examples illustrates this:

In 2006 Maersk Line controls 18.23 % of the world's cellular fleet (see Appendix 2), while its share in the total US containerised import and export trade and in the Black Sea – Far East trade is 15.27 % and 20.33% respectively (see Figure 8) (compiled with data published by Dynamar). Secondly, a comparison with the market share of the second-biggest liner operator, MSC, shows that its market share differs more significantly: for the world's cellular fleet it equals 8.58% (see Appendix 2), for the US full-container trade it is only 7.20%, while this carrier is the biggest player in the Black Sea - Far East trade with a 23.15% share.

Black Sea - Far East		
Operator	2006	
	TEU	Share
MSC	181.000	23,15%
Maersk Line	159.000	20,33%
CMA-CGM	108.000	13,81%
Zim	106.000	13,55%
CSAV Norasia	91.000	11,64%
Hapag-Lloyd	39.000	4,99%
K Line	12.000	1,53%
Top 7	696.000	89,00%
Others	86.000	11,00%
Total	782.000	100,00%
C4		70,84%

US Trade					
Operator	2006		2005		growth
	TEU	Share	TEU	Share	
Maersk Line	4.179	15,27%	4.339	17,04%	-3,69%
Evergreen (incl. Hastu and Italia Marittima)	2.098	7,67%	2.098	8,24%	0,00%
Mediterranean Shg Co	1.970	7,20%	1.575	6,18%	25,08%
Hanjin	1.789	6,54%	1.561	6,13%	14,61%
APL	1.690	6,18%	1.629	6,40%	3,74%
Hapag-Lloyd	1.656	6,05%	1.690	6,64%	-2,01%
COSCO Container Lines	1.172	4,28%	1.146	4,50%	2,27%
OOCL	1.166	4,26%	1.112	4,37%	4,86%
NYK	1.105	4,04%	1.085	4,26%	1,84%
China Shg C.L. (CSCL)	1.067	3,90%	823	3,23%	29,65%
Hyundai	1.064	3,89%	1.048	4,11%	1,53%
Yang Ming Line	1.046	3,82%	924	3,63%	13,20%
CMA-CGM (incl. ANL and MacAndrews)	1.020	3,73%	753	2,96%	35,46%
K Line	993	3,63%	892	3,50%	11,32%
Mitsui-OSK Lines	797	2,91%	755	2,96%	5,56%
Zim	536	1,96%	478	1,88%	12,13%
CSAV (Libra Br/Libra Ur and CSAV Norasia)	429	1,57%	424	1,66%	1,18%
Hamburg-Süd (incl. Aliança)	421	1,54%	346	1,36%	21,68%
Seaboard	322	1,18%	305	1,20%	5,57%
Wan Hai Lines	280	1,02%	206	0,81%	35,92%
Top 20	24.800	90,63%	23.189	91,05%	
Others	2.564	9,37%	2.279	8,95%	
Top 100	27.364	100,00%	25.468	100,00%	
C4		36,68%		38,31%	

Figure 11: Trade analysis

In 2006 the four-firm concentration ratio for the US trade equals 36.68% (comparable with the C4 ratio of the total container shipping industry - see Figure 5), whereas the degree of concentration in the Black Sea - Far East trade (only seven liner operators) is significantly higher, viz. 70.84%. This will in turn influence the degree of oligopoly (see Section 3).

[7] For convenience of comparison the TEU totals (*1,000, rounded) of the (parent) companies mentioned have been stated as if they were in existence during the whole of all years indicated. US domestic trade has not been included in their figures. Analyses based on data sourced from *PIERS U.S. Global Container Report* (Dynamar, 0907).

Ultimately, two remarks can be made. First, the degree of concentration depends on how narrowly/broadly the industry/market is defined. The C4 ratio is higher when considering alliances rather than the industry in total. Conversely, this market concentration provides additional incentives for the smaller carriers to band together into operational agreements in order to compete against large carriers (EU-report, 2005, p.III-24). The study of the degree of concentration at trade level teaches us that it can differ significantly from trade to trade. Secondly, the C4-concentration ratio is limited in the sense that it only focuses on the top liner operators in the industry and does not take into account the distribution of the remaining firms[8].

3.2.2 Herfindahl-Hirschman index

The Herfindahl-Hirschman Index (HHI) is a far more precise tool for measuring concentration. HHI takes into account both the number of liner operators and the inequality of market shares. The HHI is calculated by squaring the market share of all liner operators in the industry, and then adding up those squares. Shepherd (1999) gives the following formula for the Herfindahl-Hirschman Index (HHI):

$$H = \sum_{i=1}^{n} s_i^2 \text{ x } 10.000$$

where n = the number of carriers and s_i = the share of the ith carrier. It gives added weight to the biggest operators.

The smallest liner operators in the container shipping industry have a market share of less than 1 % each. When squaring these very small market shares, the contribution each makes to the HHI is less than 1/1000 or affect the HHI at most in the fourth decimal place. As a result, where the container shipping industry is concerned, the lack of data on liner operators ranked in the segment 101-400 can be safely ignored without affecting the picture of industry concentration (as indicated under Section 2.1).

Figure 5 summarises also the calculations of the HHI value for the container shipping industry using the market share data published by AXSliner.

The principle is: the higher the index, the more concentration and (within limits) the less open market competition. The HHI approximates 0 for a perfectly competitive industry and equals 10,000 for a monopoly ($S1^2$ or 100^2, or 10,000). As a benchmark, a market with an HHI below 1,000 is considered to be unconcentrated and unlikely to be subject to any adverse competitive effects. A 1,000-1,800 value generally indicates moderate concentration. Anything over 1,800 is highly concentrated (Shepherd, 1999).

Over the years the HHI clearly increases, indicating a trend of growing concentration in the container shipping industry. Given the 1000-1800 limits, the containerised shipping industry must still be considered as an unconcentrated one. Regardless of the calculation basis, the HHI is never higher than 1000.

The decrease in the Herfindahl index noticeable in the Top 25 from the year 2003 to 2005 generally indicates a loss of market power and an increase in competition. Furthermore, the second consolidation round (2006) is again quite observable by a remarkably higher HHI (+ 35%).

3.2.3 Lorenz curve and gini coefficient

Although the Lorenz curve is often used to represent income distribution, this concept can easily be adapted to visualize information regarding industry concentration.

The Lorenz curve shows the variation in the cumulative size of the n largest firms in an industry, as *n* varies from 1 to N (i.c. N equals 100) (Lipczynski *et al*., 2005).
Figure 9 represents the Lorenz curve for the years 1996, 2003 (before the recent consolidation wave)

[8] It may be that a CR4 of 80 means that one company controls 50% of the market, while the others have 10% apiece. That is a very different market structure from one where every firm has a 20% share (Shepherd, 1999).

and 2007 (after the merger movement). The cumulative percentage of the total number of liner operators (smallest to largest) is plotted on the x-axis, the cumulative TEU percentage on the y-axis, as shown on the Figure below. A perfectly equal-sized industry can be depicted by the straight diagonal line y = x, called the line of perfect equality or the 45° line.

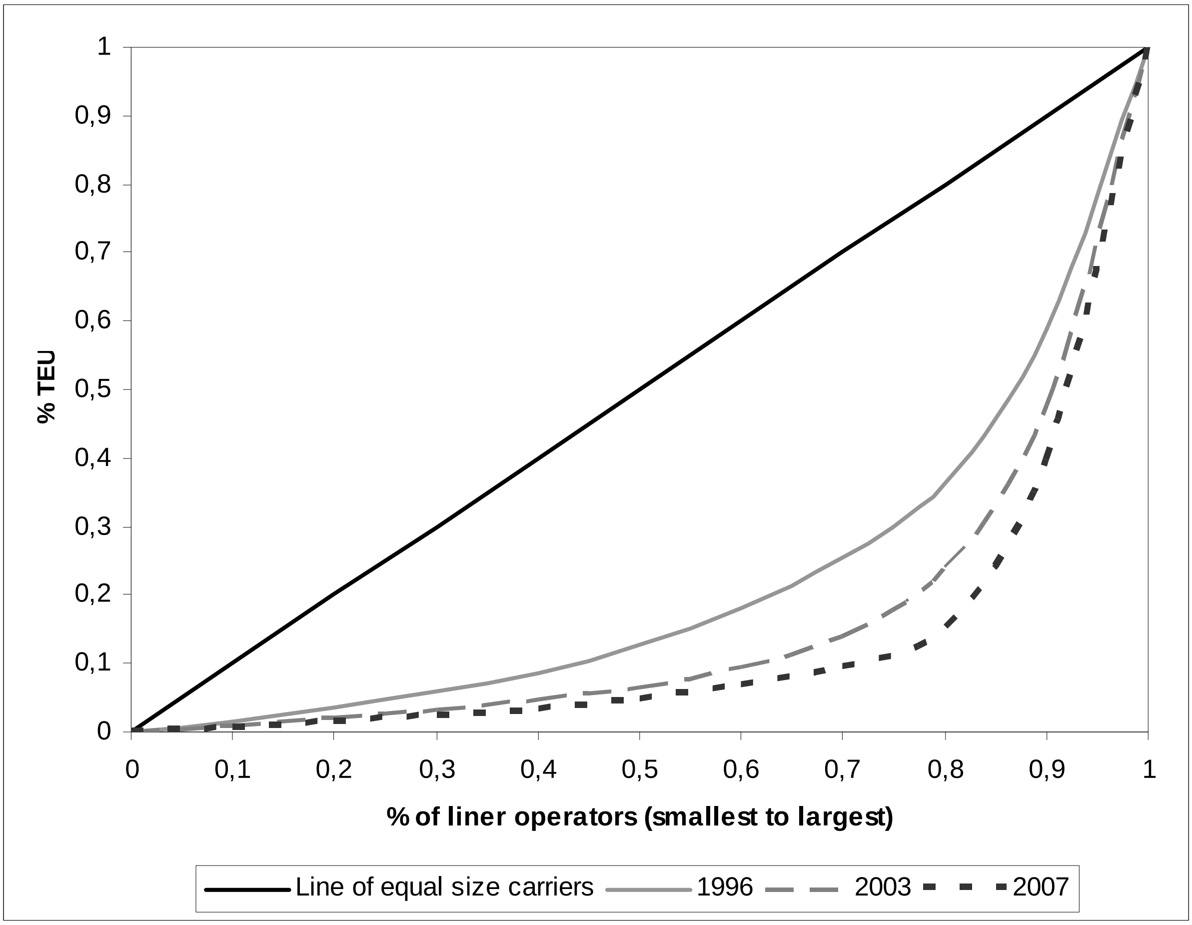

Figure 12: Lorenz curve

The perfect inequality line represents a distribution in which one carrier has the total cumulative TEU percentage whereas the others have none. In practice, the Lorenz curve will be situated below the 45° line (see Figure 9).

The Lorenz curve is quite useful for graphically presenting the change in concentration over time. Over a time span of 10 years the curve moved downwards away from the 45° line, suggesting a trend of growing concentration. To value this concentration, the Gini coefficient can be calculated. The formula definition for the Gini coefficient is as follows

$$G = \left\{ \frac{\sum_{n=1}^{N} \sum_{i=1}^{n} x_i}{0.5(N+1)\sum_{i=1} x_i} \right\} - 1$$

(Lipczynski, 2005, p. 224). The Gini coefficient is defined as a ratio with values between 0 and 1: the numerator is the area between the Lorenz curve and the line of perfect equality; the denominator is the area under the perfect equality line. Here 0 corresponds to the case of N equal-sized firms. The other extreme would be if the Gini coefficient value were equal to 1, which occurs when the entire market share is formed by the last firm on the horizontal axis (i.e. the Lorenz curve coincides with the horizontal axis as far as the last firm).

The result of the calculations are summarised in Figure 5. The value of G amounts to 0.7569 vs. 0.5767 a decade ago. A rise in the coefficient value suggests, here also, a higher market concentration. The variation (Δ) is also calculated. The merger movement (+ 0.037) is again observable in the results.

3.2.4 Increased concentration

After analysing the most important concentration measures, we can conclude that the containerised shipping industry is characterised by increased concentration. All three measurements back up this conclusion in the same way. Focusing on the variation of the Gini coefficient, no statement can be formulated with respect to the acceleration of this process (see Section 2.2.3).

In addition the first hypothesis, viz. *The (container) liner shipping industry is more concentrated due to consolidation* is confirmed. The impact of the consolidation waves on the degree of concentration is clearly observable in the calculations.

This concentration process, however, is not new. The introduction of the container resulted in a business consolidation and by consequence into fewer liner operators. Hundreds of liner companies disappeared and at that time the liner shipping became the most concentrated sector of the shipping business (Stopford, 2004). Furthermore, the process of concentration is likely to continue, as in the future the liner shipping industry is expected to face a continued consolidation process.

Nonetheless the container liner shipping industry is still a rather fragmented industry (cf. HHI values lower than 1000). In 2007 only 20 liner operators are holding a share of +1% (see Section 2.1 and Appendix 2). The calculated figures are modest when compared with the levels of concentration found in other sectors (e.g. telecommunication, air transport, …), as the (container) liner shipping industry is not the only industry undergoing a process of concentration[9].

A comparison of the container shipping industry with other maritime industries tells us that the latter are characterised by ever-fewer suppliers accounting for an increasing share of the world total (e.g. shipyard (Japan and Korea), car carrying, and specialised reefer shipping sectors) (Vanelslander, 2005).

Having calculated the concentration measurements, in Section 3 we will focus on another aspect of concentration, viz. its direct link to the degree of oligopoly. More specifically the hypothesis '*The market structure in which the container liner shipping industry operates is an oligopolistic market*' will be tested.

4. Market structure

Micro-economic theory traditionally divides industries into four categories, the two extremes of which are perfect competition and monopoly. The intermediate market structures are monopolistic competition and oligopoly. When the CR4 ratio is 40 per cent or more, according to Martin (2004), each player must be aware of the others. Such industries are oligopolies. An oligopoly is a market structure in which a small number of players constitute the entire industry and entry of new firms is restricted.

In literature, there is no consensus whether or not the liner shipping industry is an oligopolistic market or not[10]. In many studies the (container) liner shipping industry is intuitively presumed to be an

[9] The steel industry, for instance, is slowly consolidating. After the Arcelor-Mittal and Tata-Corus mergers, the steel industry remains much more fragmented than its suppliers, its customers and its rivals. The US$ 38.3 billion Arcelor-Mittal merger formed a global giant accounting for approximately 115 million tonnes or 10% of world production (www.issb.co.uk/steel_news). Here the C4 ratio equals 17,93%. In contrast, some industries (such as telecommunication, air transport, etc.) are dominated by far fewer players (e.g. Boeing and Airbus in aviation,…).

[10] Some examples illustrating this:

In 1998 Hoffman declares in his study that the first market structures in the majority of the shipping routes have become less oligopolistic in recent years. Secondly he states that "The tendency toward treating 'a box as a box as a box' also reflects the declining monopoly power of liner companies and their conferences".

example of oligopoly.

With the abolishment of the anti-monopoly immunity of freight conferences (starting as of Oct. 2008), the trend towards consolidation, etc. the question “Do we have an oligopoly in the container liner shipping industry?” is yet again of current interest. An important question because the market structure under which a carrier operates will determine its behaviour. This behaviour will in turn affect the liner operators’ performance: its price setting, profits, efficiency. Although liner shipping literature has been occupied with this question, few authors have examined the market structure of the containerised liner shipping industry.

According to Russel *et al*. (2006), the distinguishing characteristics of an oligopolistic market are [a] a small number of rival firms; [b] interdependence among the sellers, because each is large relative to the size of the market; [c] high barriers to the market; and [d] substantial economies of scale. Lipczynski, *et al*. (2005) adopt similar criteria, but add an extra characteristic to describe market structure, viz. the nature of the product (differentiated/undifferentiated).

The fewness of the firms is the key identifying characteristic of an oligopoly. ‘Fewness’ can be measured by the four-firm concentration ratio. Section 3 proceeds as follows: the link between CR4 en oligopoly will be examined at industry level (3.1) and at trade level (3.2).

4.1 Industry level

Looking again at the results in the previous section (Section 2 - Figure 5), the CR4 has exceeded the 40% limit since the year 2000, provided that the industry is restricted to the Top 20. However, if the C4 ratio is measured as the share of the 4 largest liner operators against liner total, Figure 5 reports a CR4 never higher than 40%. In the latter case, the container shipping industry would not to be an oligopolistic market.

Assuming that the container shipping industry is an oligopolistic market nonetheless, a more detailed analysis can determine what kind of an oligopoly it is or negate the assumption.
Various stages along the spectrum of oligopolistic behaviour can be distinguished (see Figure 10). Four viewpoints will be discussed.

In a paper prepared on behalf of the Ocean Common Carrier Coalition for submission to ACCOS, industry consultant Booz-Allen & Hamilton, Inc., asserts that “the liner industry is emerging as a network business” which “is almost universally regulated because their economic characteristics are such that they tend strongly to monopoly”.
In March 2003, the Japanese Shipowners' Association (JSA) stated that “A repeal of the immunity system would lead to destructive competition among carriers which may result in an oligopoly situation in liner shipping …”.
In November 2006, Chris Welsh (FTA) noted that due to the conference system the liner shipping industry is evolving from a monopolistic structure towards an oligopolistic market structure.

Types of markets			
		market type	market condition
gradients in concentration	Shepherd	pure monopoly	one liner operator holds 100%
		dominant liner operator	one liner operator holds 40% to 99%
		tight oligopoly	four liner operators hold over 60%
		loose oligopoly or effective competition	four liner operators holds 25 % to 60% + entry reasonably easy
variations in market share	Shepherd	symmetric	
		asymmetric	one dominant firm
variation in competition and collusion	Sloman	collusive oligopoly	
		formal collusive agreement (cartel)	freight conferences
		tacit collusion	operational agreements
		dominant firm price leader	
		barometric price leader	
	Markham	competitive type	
		monopolistic type	
		non-collusive oligopoly	
variations in interdepence	Machlup	pure collusion	
		uncoordinated oligopoly	
		fighting oligopoly	
		hyper-competitive oligopoly	
		chain oligopoly	
		guessing-game oligopoly	
		pure interdependent	

Figure 13: Types of markets

First, from the perspective 'gradients in concentration', a CR4 of over 60% is generally considered a *tight oligopoly*; CR4 between 25 % and 60 % is generally considered a *loose oligopoly*. A CR4 below 25 is no oligopoly at all. Furthermore, a CR_3 of over 90% or a CR_2 of over 80% should be considered a *supertight oligopoly* (Shepherd, 1999). The term 'tight oligopoly', is understood to mean oligopolies of which the market characteristics facilitate the realisation of supranormal profits for a substantial period of time and where significant barriers to entry exist.

Based on these more detailed limits, one can conclude that the container shipping industry is an oligopoly (regardless of the calculation method) and more specifically a loose oligopoly (25% < CR4 < 60% and a HHI < 1000) (see Figure 5). A rejection of this assumption would be incorrect.

Secondly, taking the variations in market share into account, the container shipping market can neither be denoted as a symmetric nor as an asymmetric market, but is rather located in the middle. Both viewpoints clearly show that one liner operator does not dominate the container shipping industry.

The third viewpoint focuses on variation in competition and collusion. Given the fact that in 2008 the conference system will be abolished (Regulation 4056/86), the impact of the growing concentration, etc., the container shipping industry will evolve from a more formal collusively orientated market towards a tacitly collusive market where operational agreements will probably become even more important.

There are two forms of tacit collusion: dominant firm price leadership and barometric firm leadership. At the level of the industry, the first form can be excluded, when we consider the market shares of the leading liner operators (see Appendix 2). A carrier can at most be taken as the barometer of the industry. If we focus on a specific trade, however, it is likely that our conclusion will alter (see 3.2).

At this point one can state that the containerised liner shipping industry is an example of a (loose) oligopolistic market.

Ultimately, the fourth viewpoint is about variation in interdependence. Machlup (1952) distinguishes four models of oligopoly (Lipczynski, 2005, p. 119). For the container liner shipping industry, we can exclude the first two categories, viz. fighting oligopoly and hyper-competitive oligopoly. Given the approaching post-conference era (Oct. 2008), the container liner shipping industry will most likely shift from a guessing-game oligopoly towards a chain oligopoly. Under 'guessing-game oligopoly, Machlup understands "a small group of firms might normally be expected to collude, were it not for the presence of a few headstrong characters who refuse to play the ball". The container liner shipping industry can be classified as a chain oligopoly if we define the industry as a competitive one and think of each liner carrier operating within an oligopolistic sub-group or trade.

4.2 Trade level

In Section 2 the four-firm concentration ratio was also calculated for two trades. Linking the degree of concentration with the degree of oligopoly, one can catalogue the US full-container trade as an example of a loose oligopoly, whereas the Black Sea-Far East trade is clearly an example of a tight oligopoly (CR4 > 60% - see Figure 8/11/12). Thus, at trade level, the containerised liner shipping industry remains an oligopolistic market (CR4 >25%) (compiled with data published by Dynamar (03/2007)).

Trade	2004	2005	2006
Black Sea - Far East	n/a	n/a	70,84%
US Trade	38,82%	38,31%	36,68%
Transatlantic	53,11%	53,03%	49,42%
Transpacific - eastbound	40,85%	41,14%	40,01%
Transpacific - westbound	43,87%	45,89%	43,72%

Figure 14: C4 ratio at trade level

For lack of data, the HHI can only be calculated by using the following formula. For a given m-firm concentration ratio the HHI must lie between

$$H_{min} = \frac{(CR_m)^2}{m} \text{ and } H_{max} = \begin{cases} (CRm)^2 \text{ when } CRm \geq 1/m \\ CRm/m \text{ when } CRm \leq 1/m \end{cases}$$

(Martin, 2002, p. 337). Only, in the case of the Black Sea - Far East trade, these liner carriers are no longer operating in an unconcentrated market structure, since the minimum HHI equals 1254.58 (> 1000). The C4 already indicated the higher degree of concentration here.

Subsequently is the container liner shipping industry evolving from a rather loose oligopoly towards a tight oligopolistic market?

Analysis of the two trades results in both types of oligopoly. Additional analysis of the largest trade lanes, for instance transatlantic and transpacific trade[11], is required. In the latter category, a distinction should be made between eastbound and westbound.

In 2006 the Top 10 liner operators accounted for about 73% of the total transatlantic trade (Northern Europe to US East Coast/Gulf). In this trade, the C4 is slightly declining from 53.11% to 49.42%. As for the transpacific trade, in the eastbound 2006 full-container liftings from Far East to US West Coast ports the Top-10 carriers achieved about 76% of the carrying capacity, whereas the containerised exports via the US West Coast to the Far East (westbound) account for a total of 81% (www.dynamar.com).

The calculations of the C4 show that the degree of concentration differs between east- and westbound

[11] In alphabetical order, the transpacific - eastbound trade consist out of the following carriers: APL, China Shipping, Coscon, Evergreen, Hanjin, HMM, K-line, Maersk Line, NYK and OOCL, while APL, Coscon, Evergreen, HMM, K-line, Maersk Line, MSC, NYK, OOCL and Yang Ming forms the Top 10 - league of the transpacific - westbound trade.

with the latter showing a slightly higher concentration degree (see Figure 12).

Turning back to our hypothesis: ultimately the second hypothesis, viz. *The market structure in which the containerised liner shipping industry operates is an oligopolistic market* is also confirmed. Whether the containerised liner shipping industry is loose or tight can differ from the studied trade lane.

5. Conclusion

The current competitive environment of the (container) liner shipping industry is more complex and changes at a faster pace than 10 years ago. This is due to a number of things such as rapidly changing customer requirements, the deployment of ever-larger container vessels, increasing competition, intense consolidation, etc.

This paper examined the degree of concentration linked to the degree of oligopoly. Using concentration measurements, we determined first the degree of concentration. From the results we can conclude that the container shipping industry is confronted with increased concentration. In addition, the results clearly show an increase in the degree of concentration in the years marked by mergers and acquisitions. Industry observers expect more consolidation. Therefore, the first hypothesis 'The container liner shipping industry is more concentrated due to consolidation' is confirmed. The trend of growing concentration will most likely continue. Nevertheless, the containerised liner shipping industry is still a fragmented industry.

Based upon the guidelines proposed by Martin (2004) and Shepherd (1999), the following conclusions may be drawn with regard to the second hypothesis viz. the market structure in which the container liner shipping industry operates is an oligopolistic market:

In general, the empirical part of the paper illustrates that the container shipping industry operates in an oligopolistic market structure.

Over the years we can clearly see that the Lorenz curve moves downwards, away from the 45° line, suggesting a trend of growing concentration. Regarding the pace of the concentration no clear trend can be determined. Consequently, as mergers and acquisitions continue to occur within the containerized liner shipping industry and the trend of concentration continues, the degree of oligopoly will increase.

In a more detailed study, we found that the degree of oligopoly depends on the studied trade lane.

In the spectrum of oligopoly, the containerised shipping industry moves from a formal collusively oriented market towards a tacitly collusive market. Linked with the degree of concentration, the container shipping industry is a loose oligopoly or a tight oligopoly depending on the trade lane.

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Appendix 1: Mergers and takeovers

Rank	Liner operator	Rank	Liner operator
1	A.P. Moller Maersk		
	Maersk Line (Takeover Aug. 2005) (Renamed Feb. 2006)		
	Maersk-Sealand (July 1999)		
	Maersk		
	Sealand		
	Torm Lines (Sept. 2002)		
	Royal P&O Nedlloyd (April 2004)		
	P&O Nedlloyd (Jan. 1997)		
	P&O Container Lines		
	Nedlloyd		
	Blue Star Line (Feb. 1998)		
	Farrell Line (2000)		
	Oceanica AGW (renamed Mercosul Line) (2000)		
	MCC Transport Singapore Pte Ltd		
	Norfolk Line Containers		
	Norse Merchant (July 2005)		
	Safmarine Contianer Lines (Jan. 1999)		
	Unicorn Lines (2002) (renamed Ocean Africa Container Line - 2004)		
	SCF Oriëntal Lines (2004)		
		2	Mediterranean Shg Co
3	CMA CGM		
	CMA CGM (1999)		
	CMA		
	CGM		
	CGM (1977)		
	MessMar		
	Transat		
	Australian National Lines (ANL) (1998)		
	Cagema		
	Cheng Lie Navigation Ltd. (2007)		
	CoMaNav (2007)		
	Delmas (2006)		
	Setramar (2001)		
	OTAL (2005)		
	Sudcargos (Sept. 2005)		
	United Baltic Corp. (Andrew Wier) (Dec. 2002)		
	MacAndrews & Ellerman Iberian (Andrew Wier) (Dec. 2002)		
	Delom SA (2002) (controlling interest - 80%)		
	Feeder Associate Systems (FAS)		
	Gemartrans		
4	Evergreen Line (2007)		
	Evergreen		
	Hatsu Marine Ltd. (2002)		
	Lloyd Triestino (July 1998) (renamed Italia Maritima)		
5	Hapag Lloyd (Oct. 2005)		
	Hapag Lloyd		
	CP Chips		
	Italia di Navigazione (May 2002)		
	TMM (2000)		
	Christensen Canada-Africa Line (2000)		
	ANZDL (Sept. 1998)		
	Ivarans ((May 1998)		
	Contship Container Lines (Oct. 1997)		
	Lykes Lines (July 1997)		
	Cast (Mar. 1995)		
6	CSCL		
	Shanghai Puhai Shipping Company (2005)		
	Universal Shipping		
		7	COSCO Container L.
8	APL/NOL (Nov. 1997)		
	APL		
	NOL		
		9	NYK
		10	OOCL
11	Hanjin/Senator (Feb. 1997)		
	Hanjin		
	DSR-Senator (renamed Senator Lines - 2002)		
12	MOL		
	P&O Neddlloyd (Nov. 2005) (SAECS trade)		
		13	K Line
		14	Zim
15	Hamburg Süd		
	Costa Container Lines (Dec. 2007)		
	Gilnavi srl di Navigazione (2004)		
	FOML (renamed FESCO Austrialia New Zealand Liner Services (FANZL)) (Mar. 2006)		
	Ybarra (renamed Ybarra Süd) (Jan. 2006)		
	Columbus Line (2004)		
	Kien Hung Line (April 2003).		
	Ellerman deep-sea services (Andrew Wier) (Dec. 2002)		
	Crowley American Transport (2000)		
	Aliança (1998)		
		16	Yang Ming Line
17	CSAV		
	Norsul container activities (2002)		
	Norasia (2000)		
		18	Hyundai M.M.
19	PIL		
	Advanced Container Lines (1994)		
	Pacific Direct Line (2006)		
	Pacific Eagle Lines		
20	Wan Hai		
	Interasia (July 2005)		
	Trans-Pacific Lines (Nov. 2002)		
		21	UASC
		22	MISC Berhad
		23	IRIS Lines
24	Grimaldi		
	Finnlines (June 2005)		
	Nordö Link (April 2002)		
	ACL (2002)		
		25	RCL (Regional Container L.)
		26	Sea Consortium
		27	CCNI
		28	Maruba + CLAN
		29	Swire Shipping
		30	TS Line

Appendix 2: Market share of the Top 25

2008 Rank	Company	2008 Total TEU	Market share (top 25)	Cumul. market share	Market share /world fleet	Cumul. market share/ world fleet	2006 Total TEU	Market share (top 25)	Cumul. market share	Market share /world fleet	Cumul. market share/ world fleet	2003 Total TEU	Market share (top 25)	Cumul. market share	Market share /world fleet	Cumul. market share/ world fleet
1	**APM-Maersk**	1.878.943	18,81%	18,81%	16,06%	16,06%	1.665.272	21,77%	21,77%	18,23%	18,23%	818.850	16,45%	16,45%	11,41%	11,41%
2	**Mediterranean Shg Co**	1.214.486	12,16%	30,96%	10,38%	26,45%	784.248	10,25%	32,03%	8,58%	26,81%	464.236	9,33%	25,78%	6,47%	17,88%
3	**CMA CGM Group**	891.803	8,93%	39,89%	7,62%	34,07%	507.954	6,64%	38,67%	5,56%	32,37%	464.236	9,33%	35,10%	6,47%	24,35%
4	Evergreen Line	619.462	6,20%	46,09%	5,30%	39,37%	477.911	6,25%	44,92%	5,23%	37,60%	394.468	7,92%	43,02%	5,50%	29,85%
5	**Hapag-Lloyd**	494.516	4,95%	51,04%	4,23%	43,59%	412.344	5,39%	50,31%	4,51%	42,11%	142.467	2,86%	45,89%	1,99%	31,84%
6	CSCL	432.251	4,33%	55,36%	3,70%	47,29%	346.493	4,53%	54,84%	3,79%	45,91%	152.923	3,07%	48,96%	2,13%	33,97%
7	COSCO Container L.	430.472	4,31%	59,67%	3,68%	50,97%	322.326	4,21%	59,05%	3,53%	49,43%	244.341	4,91%	53,87%	3,41%	37,37%
8	APL	401.625	4,02%	63,69%	3,43%	54,40%	331.437	4,33%	67,69%	3,63%	56,66%	239.844	4,82%	64,85%	3,34%	45,00%
9	NYK	375.925	3,76%	67,46%	3,21%	57,62%	302.213	3,95%	71,64%	3,31%	59,97%	207.040	4,16%	69,01%	2,89%	47,88%
10	OOCL	343.228	3,44%	70,89%	2,93%	60,55%	234.141	3,06%	74,70%	2,56%	62,53%	168.533	3,39%	72,40%	2,35%	50,23%
11	Hanjin / Senator	339.681	3,40%	74,29%	2,90%	63,45%	328.794	4,30%	63,35%	3,60%	53,03%	306.925	6,17%	60,03%	4,28%	41,65%
12	MOL	329.211	3,30%	77,59%	2,81%	66,27%	241.282	3,15%	77,85%	2,64%	65,17%	152.265	3,06%	75,45%	2,12%	52,35%
13	K Line	306.486	3,07%	80,65%	2,62%	68,89%	227.872	2,98%	80,83%	2,49%	67,66%	103.213	2,07%	77,53%	1,44%	53,79%
14	Zim	276.512	2,77%	83,42%	2,36%	71,25%	201.432	2,63%	85,93%	2,20%	71,93%	163.267	3,28%	84,44%	2,28%	58,59%
15	**Hamburg-Sud Group**	275.691	2,76%	86,18%	2,36%	73,61%	184.438	2,41%	91,40%	2,02%	76,51%	100.971	2,03%	88,85%	1,41%	61,65%
16	Yang Ming Line	272.813	2,73%	88,91%	2,33%	75,94%	188.206	2,46%	83,30%	2,06%	69,72%	180.715	3,63%	81,16%	2,52%	56,31%
17	CSAV Group	248.987	2,49%	91,40%	2,13%	78,07%	234.002	3,06%	88,99%	2,56%	74,49%	118.767	2,39%	86,82%	1,66%	60,24%
18	Hyundai M.M.	196.782	1,97%	93,37%	1,68%	79,75%	147.989	1,93%	93,34%	1,62%	78,13%	124.047	2,49%	91,34%	1,73%	63,38%
19	PIL (Pacific Int. Line)	169.444	1,70%	95,07%	1,45%	81,20%	134.362	1,76%	95,09%	1,47%	79,60%	103.213	2,07%	93,42%	1,44%	64,82%
20	Wan Hai Lines	137.656	1,38%	96,45%	1,18%	82,38%	114.346	1,50%	96,59%	1,25%	80,85%	82.053	1,65%	95,07%	1,14%	65,96%
21	UASC	95.516	0,96%	97,40%	0,82%	83,20%	74.004	0,97%	97,55%	0,81%	81,66%	71.161	1,43%	96,49%	0,99%	66,95%
22	MISC Berhad	82.888	0,83%	98,23%	0,71%	83,90%	40.543	0,53%	98,08%	0,44%	82,10%	40.454	0,81%	97,31%	0,56%	67,52%
23	IRIS Lines	73.921	0,74%	98,97%	0,63%	84,54%	53.512	0,70%	98,78%	0,59%	82,69%	36.162	0,73%	98,03%	0,50%	68,02%
24	**Grimaldi (Napoli)**	53.478	0,54%	99,51%	0,46%	84,99%	44.363	0,58%	99,36%	0,49%	83,18%	49.292	0,99%	99,02%	0,69%	68,71%
25	RCL (Regional Container L.)	49.198	0,49%	100,00%	0,42%	85,41%	48.604	0,64%	100,00%	0,53%	83,71%	48.580	0,98%	100,00%	0,68%	69,38%
	Top 25	9.990.975					7.648.088					4.978.023				
	Liner total	11.697.166					9.136.632					7.174.667				

Operational rules of container terminals:
An empirical study of mega operators in Hong Kong

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Abstract

Since 1975, container-shipping development has had a marked impact on the port industry. Terminal operators have not only had to handle increased container traffic, but at the same time maintain service quality to shipping lines, shippers, and consignees. Consequently, terminal operators have had to improve annual productivity of existing resources. However, without a preexisting model as a guide, they have had to adjust the implementation of their rules incrementally. Two Hong-Kong based mega-terminal operators, Hong Kong International Terminal and Modern Terminal Ltd., have been selected for this study to be examined. If these two operators have followed clear rules in terminal operations, information about these approaches should prove valuable to their counterparts.

Keywords: Terminal planning; Terminal operations; Container terminal.

1. Introduction

Major container-terminal operators have faced great pressures since the emergence of containerization. Although the capacity of containership has expanded—from around 1000 TEUs in the 1960s to more than 10,000 TEUs by 2007—the time allowed for container loading and unloading has remained unchanged or in some cases has even been reduced. In other words, operational efficiency in the container berth has not only had to be improved dramatically but also the handling capacity of the container yard has had to be expanded to accommodate the increased container traffic.

A number of strategies have been undertaken to improve operational efficiency: the deployment of additional terminal equipment, such as quay cranes and transtainers, and the construction of container berths. These strategies have both helped to ensure optimal operational efficiency. From the perspective of container-terminal planning, the key factors that need to be examined are quay length and the size of the container yard. From an operational viewpoint, the key factors that need to be studied are the number of quay cranes, transtainers and storage capacity. All of these factors have to be carefully considered by terminal operators in improving operational efficiency.

Long-term observations are required to examine the development of mega operators and to investigate, from both operational and planning perspectives, how additional container traffic can be handled. The Port of Hong Kong has been selected as the case study. Two major operators, Hong Kong International Terminal (HIT) and Modern Terminal Ltd (MTL), handled most of the container traffic during the time-frame studied. They are also the most productive mega-terminal operators in the world. This study expects to discover rules in terminal planning and operations, which may provide their counterparts with important insights.

2. Literature Review

In order to find out the factors influence the facilities planning in container terminals, related literatures have been collected and analyzed. Several related papers help to guide the understanding of concept of terminal productivity, a few papers are selected for reference to define productivity factors.

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First on the aspect of research method using model, the literature survey shown simulation model have been widely used. There are a few literatures using analytical modeling technique to analyze the factors that affect productivity in container terminal. Manuel Acosta *et al*. have analyzed the factors that affect port competitiveness actively in container traffic with a questionnaire and regression model. According to their findings, the variables, for example, infrastructure, superstructure, technology and communications systems, internal competition, and cooperation of the institutions and companies are the most contributed to the competitive advantage of the port. Nam-Kyu Park *et al*. (2003) aim at finding out the factors to enhance the productivity of container handling of quay crane, using simulation technique and statistical technique, and find out the main factors to improve problem. The results of the simulation and test shows that significant factors in productivity were the stacking height of container, block dispersion and distance in yard planning for loading. Kim *et al*. (1999) tried to solve the total travel time of straddle carrier to improve the productivity of container terminal by using integer programming technique. In addition, Kim *et al*. presented an efficient optimizing algorithm was also developed for solving routing problem of straddle carrier. Kim *et al*. suggested a decision support system to improve the efficient operation of port container terminal to enhance container terminal productivity.

CAI Yun *et al*, (2006) build a simulation and optimization model for minimizing the total stay time of ships, which aims at the problem of berth and quay crane scheduling. Arie Sachish (1996) has implemented in Israeli ports between 1966 and 1990, about cargo handling in ports. Research was undertaken with the goal of developing productivity functions that explain the changes in the productivity in Israeli ports by means of changes in various explanatory factors. A linear programming model is generated for developing productivity functions with an objective function of minimum deviations between calculated and actual productivity. The changes of volume, labour, capital, technology, management, and externalities had a great impact on productivity and on the effect of explanatory factors. The analysis of the relationship between the explanatory factors and actual productivity gives importance to the better understanding of organizational impact on productivity. This understanding can be used as a management tool through which a decision making process may be developed to arrive at decision on steps for raising productivity.

And on comparative analysis, we can find in many literatures that the authors take advantage of comparative analysis to research on port productivity. Peng Chuan-Sheng, (2007) collected and compared china and foreign mega-container terminal statistical data. The author, firstly, defined the concept of container terminal productivity, which has relationship between the port production output and input, and presented container terminal productivity depends on container yard establishment, equipment, capacity of workers, work efficiency, and tactics of organization. Moreover, the author presented the indexes of scaling container terminal productivity which are efficiency of length of berth utilizing, efficiency of quay crane utilizing, and efficiency of container yard utilizing. Chen Yang (2006), through Europe and Asia standard container berth production technology application comparative analysis, claimed that China modern container terminal should take advantage of the high-tech means, for instances, information technology, bigger-facilities, and automatic technology and facilities to enhance the container terminal productivity.

Besides, there are wide ranges of papers devoted to different aspects of productivity in container terminal. GU Mu (2006) introduced that for propose of enhancing the port productivity and throughput, Singapore port takes several measures: making use of the advantaged geographic location, and enhancing the management. For avoiding phenomenon of containers jam, Singapore port have expanded foundational establishment, added the deep water berth, enhanced the efficiency of loading and unloading, and also reduced turnaround time. Carlos and Nicolas (2007) aimed to extend the established literature on seaport productivity by applying the Luenberger indicator to estimate and decompose productivity change. A Luenberger productivity indicator is used to estimate and decompose productivity growth on observation of Italian and Portuguese seaports between 2002 and 2004. A key advantage of this method is that it allows for both input contraction and output expansion in determining relative efficiencies and productivity changes. The general conclusion is that there is productivity growth in the majority of seaports analyzed, which is driven more by improvements in technological change than improvement in technical efficiency. Possible explanation for this feature of the results is that investment is not matched by upgraded managerial practices. Prabir De, (2006) presented and defined total factor productivity (TFP) model which is a measure of technological change in industry. Furthermore, the authors collected data from 1980-1981 to 2002-2003 in India port, following the Perpetual Inventory Accumulation (PIA) method. By researching the results indicate that there are tremendous spurt in international research on the relationship between globalization and productivity. Prabir De, presented port should put both skilled workers and application of higher technology in operation to improve the productivity and keep competitive. According to CCDoTT (2000), The productivity of container terminal can be measured with terminal's sub-systems, which is terminal area, storage area, berth and man-hours, etc. and selection of output has to reflects limiting component and define the fact. It emphasizes continuously monitoring of productivity with comparing with another terminal when maximum practical capacity is calculated.

A conclusion could be drawn from literature review is the shortage of case studies and long term observation of the strategies that terminal operators adopted in response to the demand of increasing productivity. This study, therefore, could provide an in-depth insight to the terminal planning and strategies, not only to be referenced by academic research, but also to the industry implementation.

3. Terminal Operations and Research Design

A container terminal, which is the interface between sea and land transportation, comprises two major segments: the quay and the container yard (as shown in Figure 1). The combination of quay and yard area determines the container terminal's size. From an operational viewpoint, two types of equipment are required to handle the container traffic: quay cranes and transtainers[1]. The stacking height and internal span of the transtainer, along with the area assigned for container storage, determine the storage capacity of the terminal.

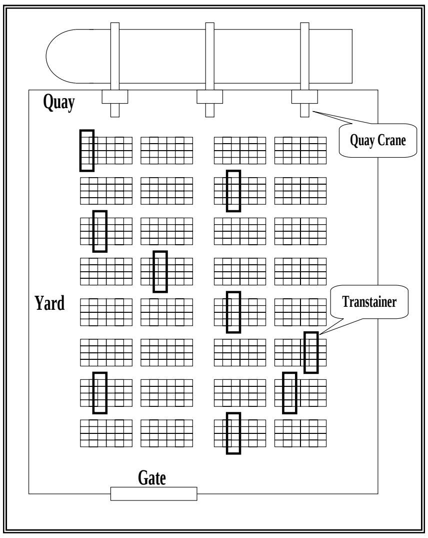

Figure 1: **Container berth and facilities**

Though terminal operators now handle much more container traffic than in the 1970s, the container berth's physical size has not changed significantly. In most terminals, the quay length assigned for each berth, for instance, has remained within the range of 300–330 meters. Meanwhile, the area of land occupied by terminal operators has been virtually unchanged because of the absence of land for expansion.

[1] There are three major types of transtainers, namely straddle carrier (S/C), rubber-tyred gantry (RTG) and rail-mounted gantry (RMG). Most Asian terminals use RTG and RMG in their yard operations.

Unlike land, the number and variety of yard equipment can be expanded when there is a pressing need. Have terminal operators deployed more equipment as one might expect? Data collected from terminal operators actually shows that the number of quay cranes deployed for terminal operations has been largely unchanged. Three quay cranes for a one-berth terminal and seven cranes for a two-berth terminal have been common up till present day.

The capacity of transtainers, however, has changed significantly during these years. Both the stacking height and internal span of transtainers have been expanded, which increases the storage capacity of the terminal. Meanwhile, terminal operators have deployed more transtainers for yard operations to handle the increased container traffic. But this begs the question: How many transtainers are needed?

4. Selection of case studies

A comprehensive study of the development of major container terminals in the long term is required here to discover what rules terminal operators have implemented to handle rising container traffic.

Hong Kong had the highest throughput of major container ports for years. Most of the container traffic is handled by two mega operators. As a consequence, these two mega operators with advanced management capacity, Hong Kong International Terminal (HIT) and Modern Terminal Ltd. (MTL), were selected for case studies. The data concerning the development of HIT and MTL was found in the Containerisation International Yearbook and their websites.

Container traffic handled by MTL increased more than eleven-fold, from around 360,000 TEUs in 1975 to 3.8 million TEUs in 2004. Simultaneously, the container traffic handled by HIT increased fifteen-fold, from 380,000 TEUs in 1975 to more than 6 million TEUs in 2004 (Figure 2).

Furthermore, because little land is available, there has been only one major land expansion since the 1970s. Therefore, the quay length of both HIT and MTL has remained unchanged for a long time (as shown in Figure 3). Thus, these terminal operators were forced to handle the increased traffic with existing container-terminal capacity.

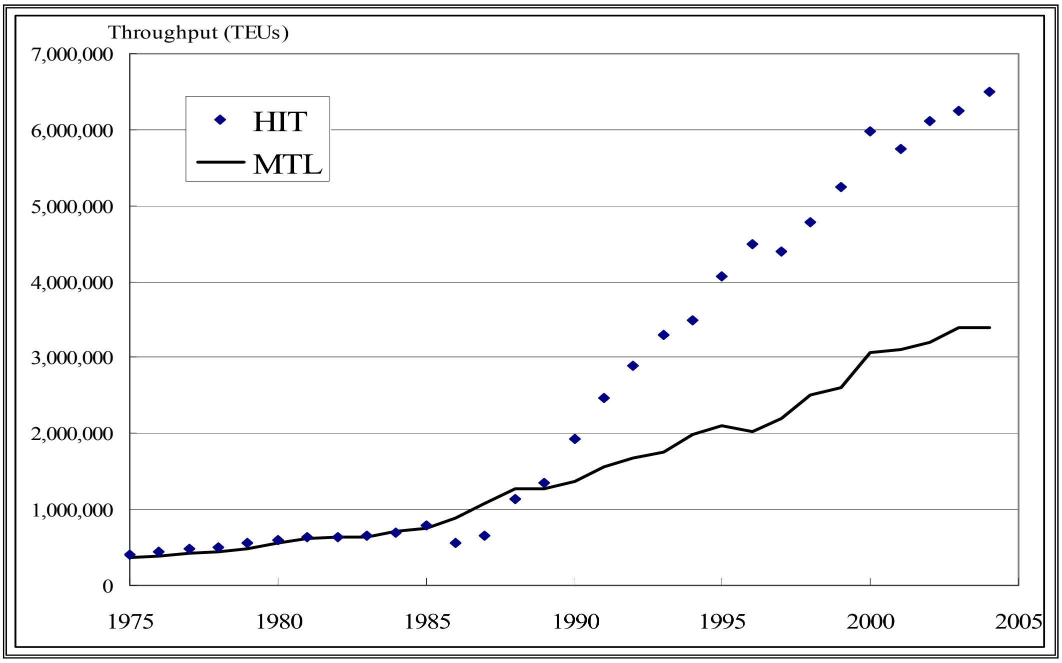

Figure 2: Container volume handled by HIT and MTL since 1975

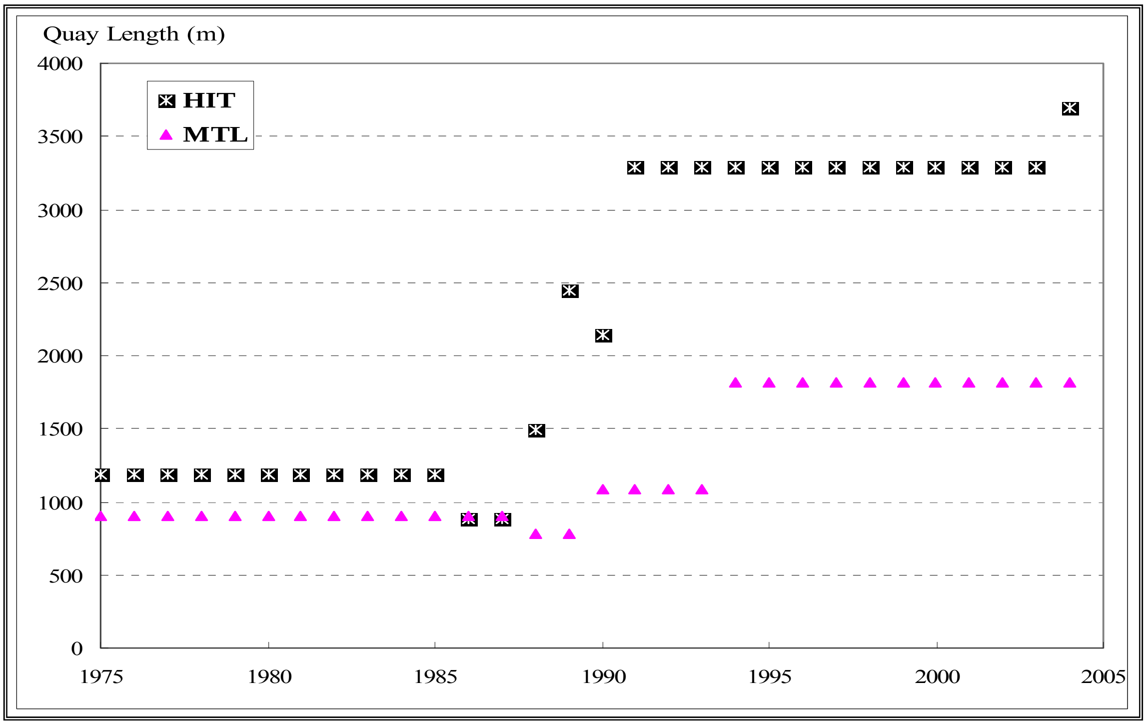

Figure 3: **Development of quay length of HIT and MTL from 1975**

5. Research design

In order to quantify the rules in terminal planning and operation, a comprehensive long-term study of the development of container terminals is required. The following information should be collected:
(1.) throughput of terminals, measured in TEUs per year;
(2.) quay length of the terminal, measured in meters;
(3.) number of quay cranes deployed, measures in QCs;
(4.) area occupied, measured in hectares;
(5.) number of transtainers used for terminal operation, measured in TTs;
(6.) storage capacity of the terminal, measured in TEUs.

In order to analyze the development of mega terminals from both planning and operational perspectives, the information collected needs to be reorganized to observe several performance indicators.

As terminals are compared on a single berth basis, their strategic development from both planning and operation viewpoints needs to be clearly identified. Quay length of a single container berth is assumed to be 300 meters, for the purpose of differentiating between performance indicators (as detailed in Table 1).

Table 2: Indicators on berth basis

	Performance Indicator	Content
1.	Berth Productivity (TEUs/300 m), which shows the annual productivity of one container berth.	Measured by dividing the annual throughput of the terminal by the length of the quay and multiplying by 300.
2.	Storage density (TEUs/ha), which shows how the yard is utilized for container storage.	Measured by dividing the storage capacity of the terminal by the area occupied.
3.	Berth land (ha/300 m), which shows the land assigned for each berth.	Measured by dividing the land occupied by the length of quay and multiplying by 300.
4.	Quay crane density (QCs/300 m), which shows the number of quay cranes deployed in each berth.	Measured by dividing the number of quay cranes by the length of the quay and multiplying by 300.

5.	Transtainer density (TTs/300 m), which shows the number of transtainers deployed in each berth.	Measured by dividing the number of transtainers by the length of quay and multiplying by 300.

Analysis of these indicators is expected to reveal the rules of terminal planning and operations adopted by both of the mega operators. For example, from the planning perspective, how many hectares of land are assigned to each berth and what is the storage density? From the operational viewpoint, how many quay cranes have been deployed for each berth and how many transtainers have been deployed?

To find out the rules between container traffic and the above indicators, this study uses the methodology of single regression to quantify the relationship between container traffic and each indicator. The indicators used covered both quay and yard system, and these systems operate independently; as a consequence, the methodology of multi-regression has not been selected.

6. Research Findings

6.1 General analysis

Data reflecting the development of both HIT and MTL was collected from 1975 to 2005, and double-checked with the information collected from their Web sites. Then the data was converted into performance indicators. Berth productivity has been used as the basis to examine the development of other indicators. Performance indicators were analyzed to find out their relationships with berth productivity.

From an operational perspective, both HIT and MTL reflect a strong positive correlation with quay crane density (as shown in Table 2), but data from only HIT exhibits a marked correlation with transtainer density. From a planning viewpoint, both HIT and MTL data record a significant correlation with storage density, but only MTL shows a strong correlation with berth area. These differences between HIT and MTL in terms of these indicators will be examined in detail.

Table 3: Analysis result of HIT and MTL

	Operator	R Square	Mth	b0	b1
Quay Crane Density	HIT	0.888	Lin	1.3541	0.0000032
QCs/300 m	MTL	0.798	S	1.4775	-133523
Storage Density	HIT	0.649	Lin	297.43	0.001
TEUs/ha	MTL	0.601	Pow	2.6624	0.4169
Berth Land	HIT	0.005	Lin	8.4402	0.0000014
ha/300 m	MTL	0.747	Pow	0.0577	0.4154
Transtainer Density	HIT	0.751	Lin	3.1419	0.000015
TTs/300 m	MTL	0.200	Log	-1.5955	1.4376

6.2 Quay crane density

As reflected in Figure 4, the berth productivities of both of HIT and MTL have increased several times since the 1970s, and the number of quay cranes deployed has not matched this change. Instead, the number of quay cranes has doubled to around three for each berth, with MTL using slightly more quay cranes than HIT. In 2004, the berth productivity of MTL was around 400,000 TEUs, with the corresponding figure for HIT at 500,000 TEUs. The comparison between berth productivity and quay-crane density reveals that both HIT and MTL have at least doubled the operational efficiency of their quay cranes to handle increased container traffic.

The curve of both mega terminals shows that if berth productivity achieves 700,000 TEUs, both HIT and MTL will deploy same number of quay cranes: 3.5 quay cranes for each berth or seven quay cranes for two berths. The number of quay cranes deployed is clearly less than expected. At present, it is difficult to explain why fewer quay cranes are deployed; possible explanations include the benefit of economies of scale and advanced container-terminal management systems.

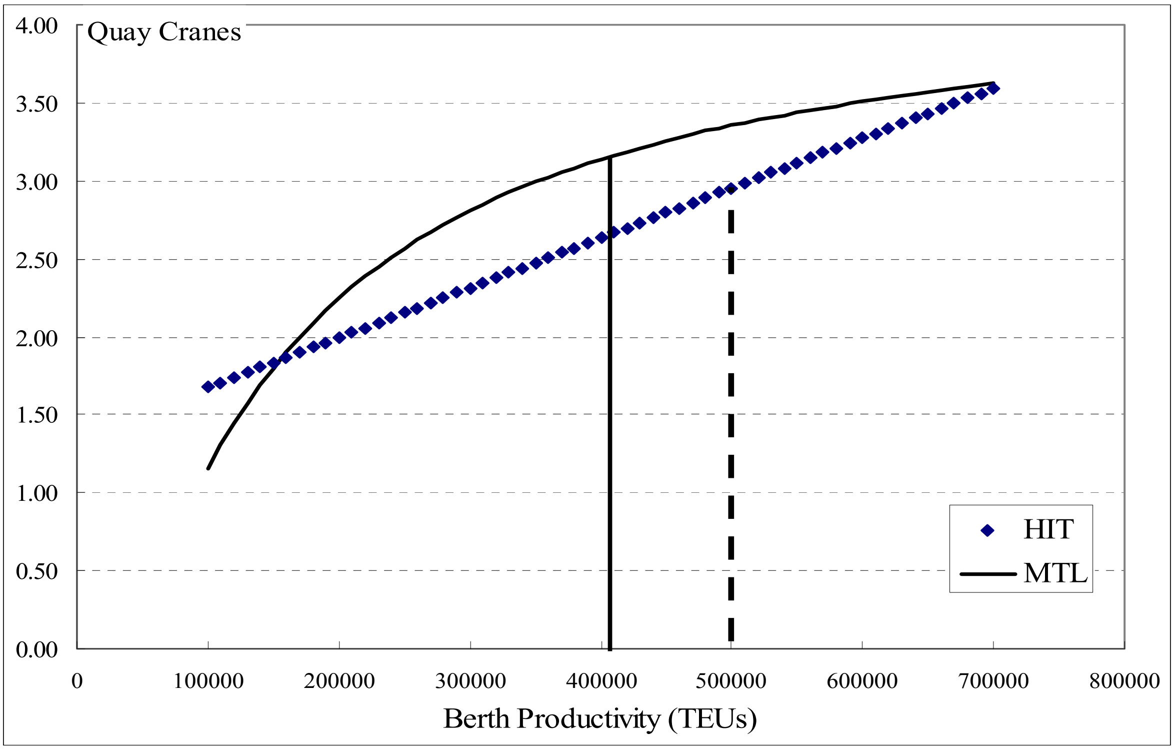

Figure 4: **Relationship between berth productivity and quay crane density**

<u>6.3 Storage density</u>

From the perspective of yard planning, storage density is used to measure how the land has been utilized. There are two ways to increase the storage density of a container yard: first, to use the terminal area for storage; and second, to deploy transtainers with a higher storage capacity. Also, terminal operators, for instance, may procure rubber-tyred gantry with a higher stacking ability. Terminal operators may also replace rubber tyred gantry (RTG) with rail-mounted gantry (RMG) or replace the straddle carrier (S/C) with rubber-tyred gantry.

Since 1975, HIT has implemented both strategies to increase storage capacity. Initially the stacking height of rubber-tyred gantry was modified, and in 1995, the rail-mounted gantry system has replaced the rubber-tyred gantry system.

MTL has adopted similar strategies. In 1996, to obtain higher storage capacity, MTL changed the straddle-carrier system to rubber-tyred gantry. This explains why the storage density of HIT is higher than MTL; the differential could be as high as 30 percent.

As shown in Figure 5, since the mid-1970s, berth productivity at MTL has increased at least fourfold, but the storage density has increased by only 50 percent. While the turnover rate of storage capacity has increased only twofold, MTL's berth area has only increased 50 percent, a factor that contributes most to increased berth productivity. In respect to HIT, the storage density has been doubled since the 1970s.

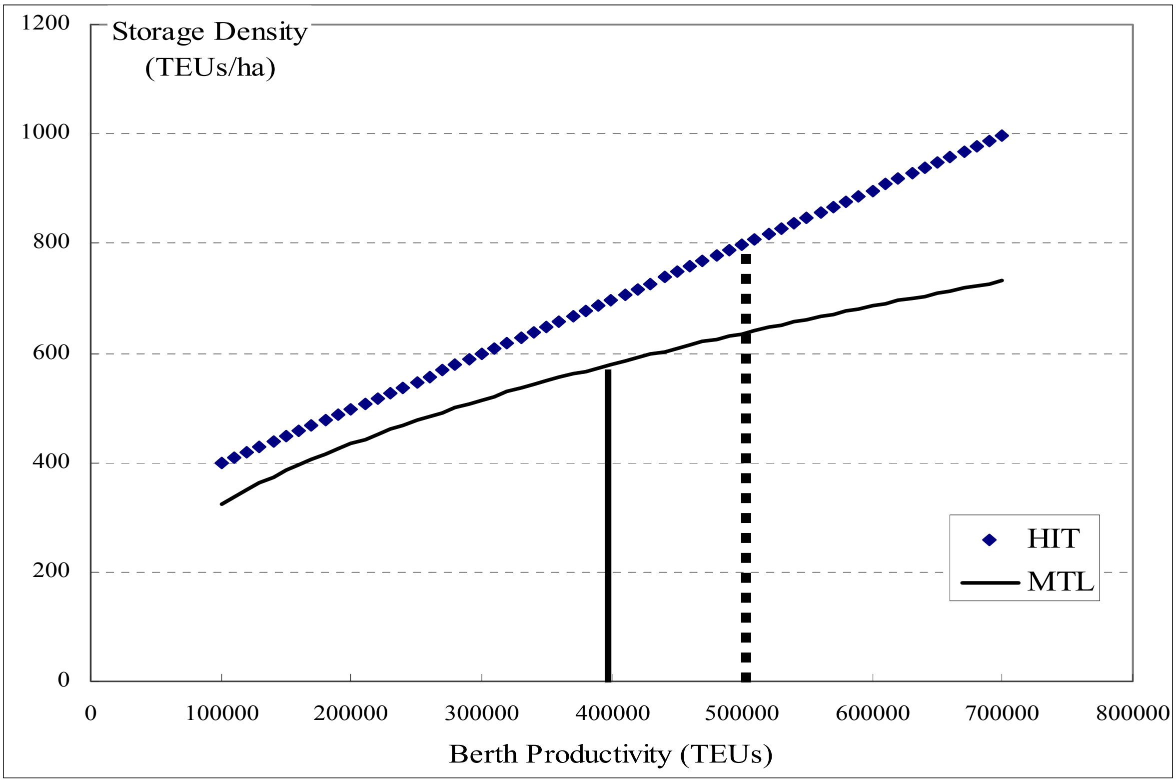

Figure 5: **Relationship between berth productivity and storage density**

6.4 Berth land

In the last thirty years, berth productivity of HIT and MTL has increased several times. However, the land available for expansion has remained restricted. Consequently, terminal operators have had to handle increased container traffic with existing resources (as shown in Figure 3).

Data in Figure 3 suggests that land and the length of quay assigned for each berth are constant. As expected, the HIT data shows that the area devoted to berth has no relationship with their productivity. On average, the land assigned to each berth has been around eight hectares, though HIT has expanded its footprint several times during the period under review.

The MTL data, however, presents a strong relationship between berth area and productivity. Unlike the case of HIT, the berth area has expanded from eight to twelve hectares for each berth. As shown in Figure 6, if berth productivity has reached around 700,000 TEUs, the berth area would be around fifteen hectares.

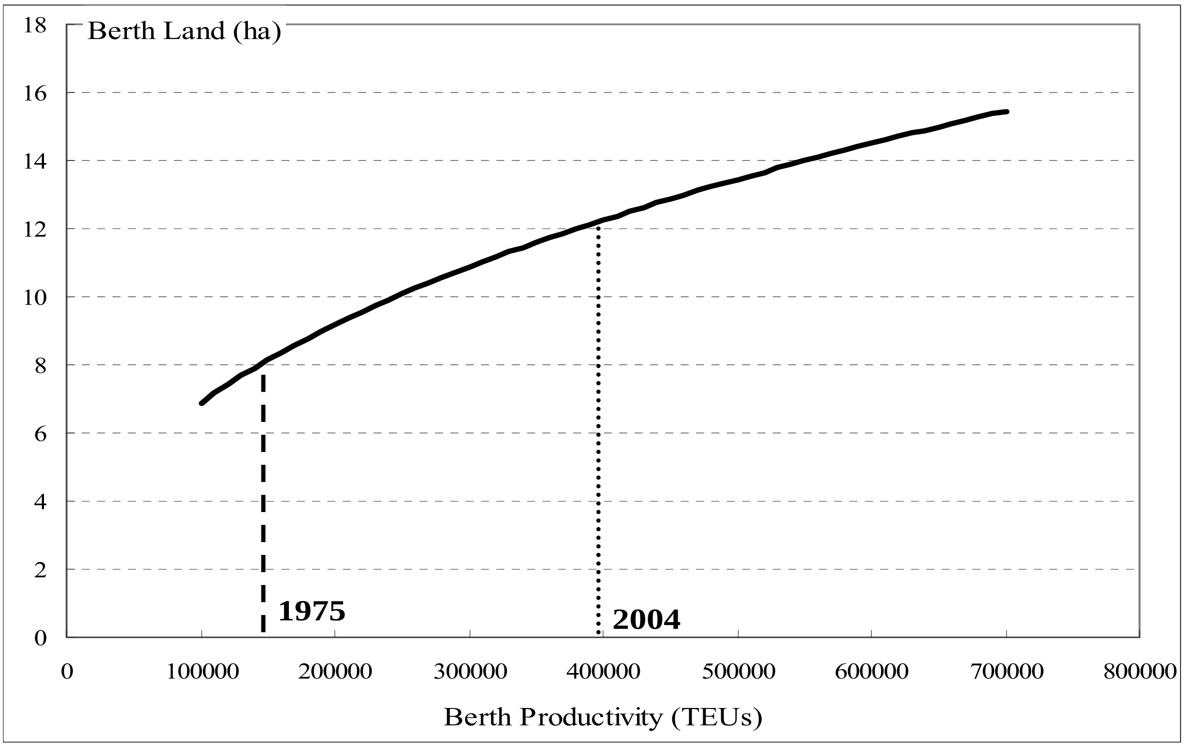

Figure 6: **Relationship between berth productivity and berth land of MTL**

6.5 Transtainer density

Transtainer density measures the number of transtainers deployed in each container berth. Although the HIT data reveals a strong relationship between berth productivity and transtainer density, the MTL data does not. One possible reason is that MTL changed its yard operating system from straddle carrier to RTG. Thus, the number of transtainers there dropped from 24 S/Cs per berth to 11 RTGs per berth. As the change in the number of transtainers was enormous – a decline of almost 50 percent - no relationship could be established. If MTL had maintained its straddle-carrier system longer, it may have been possible to find a relationship between berth productivity and transtainer density.

As shown in Figure 7, HIT has significantly increased transtainer density when berth productivity rose. Berth productivity has grown more than fourfold, and the number of transtainers deployed in berth has grown around two-and-a-half times. HIT has also doubled the operational efficiency of transtainers over these years.

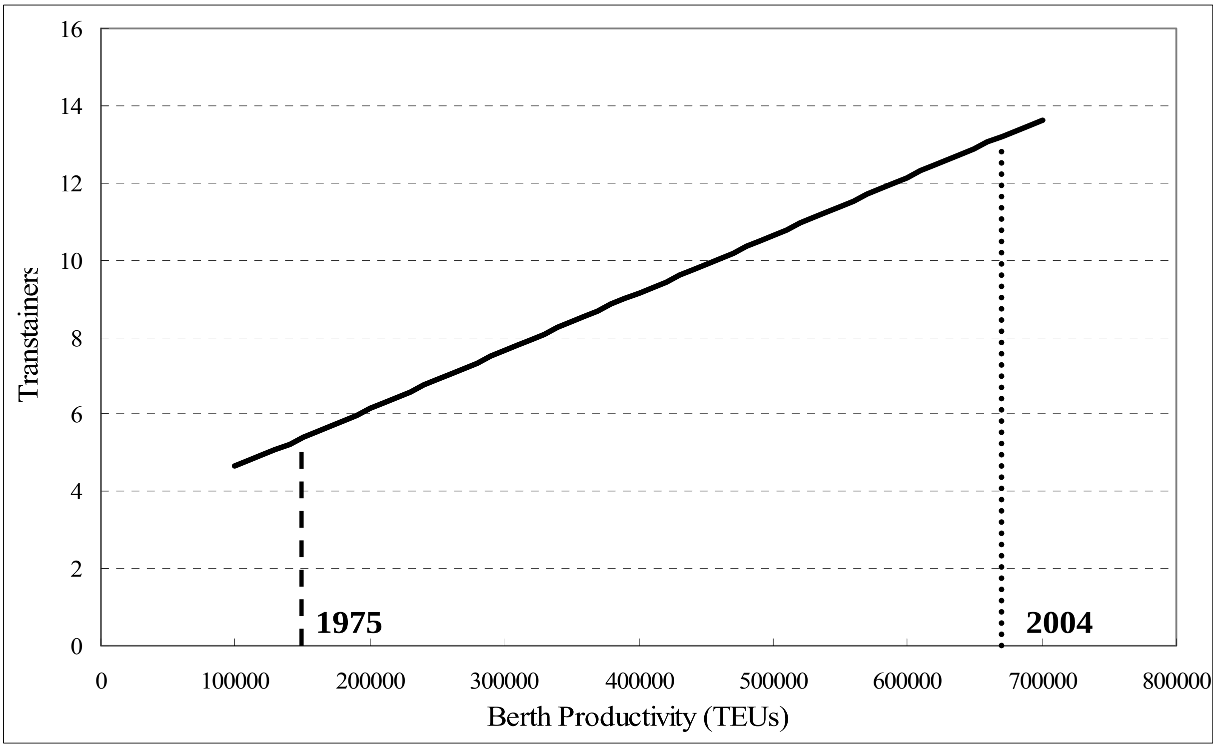

Figure 7: **Relationship between berth productivity and number of transtainers of HIT**

7. Conclusion

Terminal operators have faced dramatic challenges that have forced them to improve operational efficiency and productivity with limited resources. Such a challenge will not diminish in the future as the storage capacity of container ships will continue to grow while the time allowed for the loading and unloading of containerships will remain unchanged or grow even shorter, even as the land for expansion will still be restricted. Mega-terminal operators are expected to adopt similar strategies to handle the anticipated increase in traffic.

This study addressed a key issue in respect to how mega-terminal operators have handled increased container traffic. Research results have provided clear rules. Most terminal operators can learn from the experiences of HIT and MTL in respect to terminal planning and operations, with particular reference to land availability for berth, storage capacity, quay crane density, and transtainer density.

The other issue regarding how mega terminal operators handle increased container traffic involves improved management and operational efficiency, which has contributed to approximately 50 percent of increased productivity.

How containers transiting the terminal are processed, as well as the organization of the back-up systems and management-information systems are key issues which lie at the core of high operational efficiency and, consequently, will be significant areas for future research in this field.

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Perceptions and Assessment of Maritime Security Management - the Perspectives of Liner Shipping Companies

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Abstract

Since the 9/11 terrorist attacks, monitoring on container shipping transportation has been strengthened under the international measures. The shipping operators are required not only to pay more attention to the "safety operations and environmental protection" in their ship navigation and shipment transportation but also to well implement the "security management" at all times following the new regulations, such as the "International Ship and Port Facility Security Code" (ISPS Code), Container Security Initiative (CSI) and Customs-Trade Partnership Against Terrorism (C-TPAT) etc. The purpose of this research is to identify the perceived priority of essential dimensions in maritime security when formulate strategic response from international liner shipping companies' perspectives. This system approach consists of maritime security dimensions identification, maritime security measurement and assessment processes using three methods of In-depth interview, content analysis and fuzzy analytic hierarchy process. The results suggest that shipping companies identified four main dimensions of maritime security and perceive "people security," to be the most important dimension of conducting a maritime security strategic response, followed by "vessel security", "cargo security" and "environmental security". At last, theoretical and managerial implications of these findings are discussed.

Keywords: Maritime security; Liner shipping company; Content analysis; Fuzzy AHP

1. Intoduction

Since the September 11th 2001 terrorist attacks in the United States, the international community has acknowledge new security threats to maritime trading and transportation systems and the need for an improved regulatory regime (Bichou *et al*, 2007). The growing pressure from external regulatory sources has made it necessary for maritime industry players to fully integrate the security elements into both their strategic planning and daily operation procedures. This growing concern about moving goods and services across "economic" boundaries has arguably intensified, to the point where trading boundaries have become "security" boundaries (Suàrez de Vivero and Rodríguez Mateos, 2004).

To address the security issues, a number of international conventions and national regulations have promulgated to enhance regulatory coverage of safety and security within the whole-of-supply chain system, including changes to the Safety of Life at Sea (SOLAS) Convention that specifically address ship security and compliance with the International Code for the Security of Ships and Port Facilities (the ISPS Code). Besides, the United States has aggressively promoted several voluntary trade programmes aimed at enhancing security of inbound trade toward US seaports and other major trading countries. Different from the mandatory ones, there are two typical voluntary programmes the Container Security Initiative (CSI) and the Customers-Trade Partnership against Terrorism (C-TPAT) are intended to provide completive advantages to early voluntary adopters in the maritime industry

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(Barnes and Oloruntoba, 2005).

According to the United Nations Conference on Trade and Development (2004), Taiwan had controlled approximately 3% of the total shipping tonnage in the world, and the Ministry of Transportation and Communications indicated over 99% of Taiwan's annual foreign trade in tons is carried by sea on average (Department of Statistics, Ministry of Transportation and Communications, 2004). Among the largest 20 container carriers in the world, Evergreen Marine Corporate was ranked the fourth, while Yang Ming Lines and Wan Hai Line were ranked 16th and 20th, respectively in end of 2007. Further, as a result of foreign liners continuously established subsidiaries/branches in Taiwan, the liner shipping industry in Taiwan has become highly competitive. And the fierce competition forces liner shipping companies to realized the necessarily of searching the sources of competitive advantages to survive and grow in global maritime markets. Thus, recognizing the maritime security issues and taking appropriate strategic responses providing a source of competitive advantages and also incurring new challenges for liner shipping companies. Due to the complexity of maritime security issues, stakeholders and cost pressures, and regulation uncertainty, implementing maritime securities management practices is considered a thankless task that increase overall operation costs. Therefore, the major challenge in maritime securities management practices for liner shipping companies is to select suitable strategies in accordance with the regulations and stakeholders requirements in the shipping industry. To date, maritime securities management practices remained a new management paradigm that lacks sound and comprehensive theories and best practices. Although numerous studies have proposed various schemes for implementing maritime securities management practices (Suàrez de Vivero and Rodríguez Mateos, 2004;Bichou *et al*, 2007; Thai and Grewal, 2007), most of the extant researches are fragmented, the integration tasks are underdeveloped. Therefore, the main objectives of this study are to identify important dimensions associated with maritime security issues, and then to explore and assess which strategic responses liner shipping companies take will affect the management performance of maritime security issues.

The original analytical hierarchy process (AHP) method, introduced by Saaty (1980), got advantages in determining the priority of a set of alternatives and the relative importance of attributes in a multi-criteria decision-making (MCDM) problem (Saaty, 1980; Wei *et al*., 2005). However, Satty's AHP has been criticized for its several shortcomings such as only dealing with crisp decisions, does not take into account the uncertainty associated with the mapping of human judgment to a number; the ranking is rather imprecise; and subjective judgment, selection and preference of decision-makers have great influence on the results etc (Cheng, 1999).

For improving the conventional AHP method and recognize consistent strategies for implementing maritime security management practices, this study uses the fuzzy analytic hierarchy process (FAHP) (Erensal *et al*., 2006) and applies triangular fuzzy numbers to express comparative judgments of decision-makers. A systematic approach of FAHP to identify priority strategies for maritime security management practices implementation was adopted based on a complex and multi-criteria environment. As a result, the FAHP is developed to resolve alternative selection and justification problems. The main goal of this study is to establish a consistent and prior strategy for implementing maritime security management practices. Applying the FAHP to conduct the relative importance of different strategies is extremely crucial, for the results can be used by managers implementing and adopting their own maritime security management practices.

This remainder of this study is organized as follows. The following section briefly illustrated the changes of international maritime security regulations or initiatives and then synthesized the related studies on maritime security management practices. Section 3 presents the proposed methodology for establishing a consistent framework for the FAHP model. Section 4 discusses the priority weightings for different strategic responses of implementing maritime security management practices. Section 5 presents conclusion and future directions for research in maritime security management practices.

2. Literature Review on Maritime Security

2.1 International maritime security regulations and initiatives

Due to the size and scope of maritime shipping, an attack on the maritime supply chain would take a long time to solve the security issues, while stopping or slowing shipping interests around the world. Several International regulations and industry initiatives have been introduced in these years to improve the security of the maritime supply chain that deals with shipping containers that travel across the waterways of the world. The International Maritime Organization (IMO), International Maritime Bureau (IMB) and other groups such as the World Customs Organization (WCO) have jointly supported processes that enhance regulatory coverage of safety and security within the world trading system (Barnes & Oloruntoba, 2005).

Maritime security initiatives that concerning liner shipping containers to prevent maritime terrorists attacks including mandatory changes and voluntary programmes, the International Ship and Port Facility Security (ISPS) Code, Container Security Initiative (CSI) and Customs-Trade Partnership against Terrorism (C-TPAT) etc.

The common features of these programs are focused on prevention instead of post inspection. Here we briefly describe as follows,

2.1.1 Objectives and Functional Requirements of the ISPS Code

The main objective the ISPS is by the close cooperation and coordination between governments, the administrations, shipping companies and port authorities to detect security threat earlier and take preventive measures against security incidents affecting ships and port facilities[3]. In order to achieve the above objectives, the ISPS Code provides the following functional requirements[4]:

(1.) Gathering and assessing information with respect to security threats and exchanging such information with appropriate governments5;
(2.) Requiring the maintenance of communication protocols for ships and port facilities;
(3.) Preventing unauthorized access to ships, port facilities and their restricted areas;
(4.) Preventing the introduction of unauthorized weapons, incendiary devices or explosives to ships or port facilities;
(5.) Providing means for raising the alarm in reaction to security threats or security incidents;
(6.) Requiring ship and port facilities security plans based upon security assessments; and
(7.) Requiring training drills and exercises to ensure familiarity with security plans and procedures.

2.1.2 The Container Security Initiatives (CSI)

The mail purpose of the CSI programme is to secure what is believed to be the most vulnerable but indispensable link in the global supply chain: the ocean going container. CSI is a revolutionary programme to extend US zone of security by pre-screening containers posing a potential security risk before they leave foreign ports for US seaports. And the goal is to process 85 percent of all containers headed for the United States through CSI ports by 2007. There are four core elements consisted of CSI6:

(1.) To establish security criteria to identify high risk containers;
(2.) To pre-screen that ocean going containers identified as high risk before they arrive at US ports;
(3.) To use advance technology to quickly pre-screen high-risk containers;
(4.) To develop the use of smart and secure ocean going containers.

A critical element for the success of the CSI will be the availability of advance information in order to perform efficient pre-screening targeting. Risk assessments and trade analysis will form part of the decision-making process regarding the pre-screening of containers. The US Customs relationships with

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[3] See Section 1.2, Part A, the ISPS Code.
[4] See Section 1.3, Part A, the ISPS Code.
[5] See also Sections 4.14-4.17, Part B, the ISPS Code.
[6]US Customs Service Fact Sheet 8, August 8 2002.

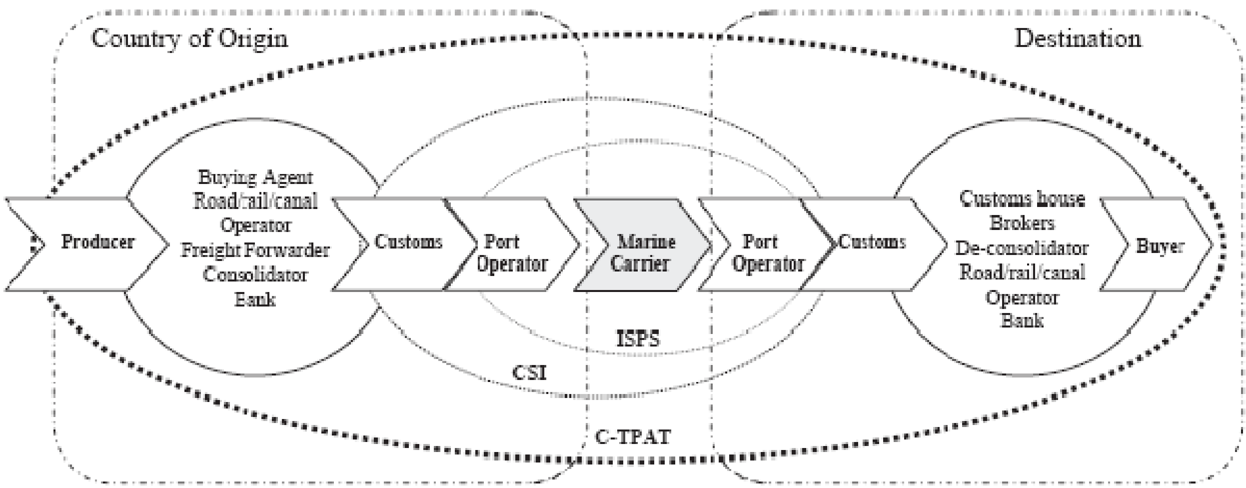
the so-called 'mega-ports' continue to be defined as these ports are very careful to minimize any resulting inefficiencies caused by the CSI. However, ports not specifically targeted by US Customs are concerned that those ports within the CSI may gain an unfair competitive advantage as pre-screened cargo will be given priority in terms of faster clearances through US ports of entry.

2.1.3 Customs-Trade Partnership against Terrorism (C-TPAT)

US Customs has also launched the Customs-Trade Partnership against Terrorism (C-TPAT) in April of 2002. The C-TPAT program seeks to enhance security measures across the entire supply chain by requiring close cooperation among its constituent entities, from importers, brokers, carriers and foreign manufacturers and suppliers. C-TPAT, a voluntary security program aimed at establishing uniform standards for secure facilities, assets and equipments, procedures and personnel for various parties throughout the supply chain. Membership of the program and compliance will mean avoiding unnecessary delays in cargo clearance by minimizing U.S. customs inspections and audits. Through this initiative, U.S. Customs and Border Protection (CBP) is asking businesses to ensure the integrity of their security practices and communicate and verify the security guidelines of their business partners within the supply chain. Since many US importers and their suppliers have been' advised' to join this initiative, eventually the scheme will cover the entire supply chain of the US importers, which includes foreign manufacturers, suppliers, suppliers' vendors, contractors and sub-contractors, warehouse providers, as well as air, sea and land carriers. Theoretically, the primary benefit of joining C-TPAT will be the expedited processing of cargo. Importers who are not C-TPAT members may, over time, find their shipments subjected to higher scrutiny and added examination with no guarantee of processing times. The compliance focuses of the C-TPAT program are seven elements,

- Procedural Security
- Physical Security
- Access Controls
- Personnel Security
- Education and Training Awareness
- Manifest Procedures
- Conveyance Security

At the moment the ISPS, CSI and C-TPAT programs are focused on reducing the likelihood of terrorist related incidents within maritime areas and not to strike a balance between efficiencies within the supply chain networks and requisite security assurances. The coverage of the ISPS, CSI and C-TPAT maritime security initiatives are shown in Figure 1.



Source: adopted from Barnes and Oloruntoba (2005)

Figure 1: Coverage of ISPS, CSI and C-TPAT Maritime Security Initiatives

2.2 Maritime security Management Practices

Reviewing the previous studies from literature, it is expected to provide valuable data and expertise for structuring the decision model on assessment strategic responses selection. Concerning about maritime security risk come out from the interaction of number of factors, that it cargo-being used to smuggle people and/or weapons, vessels-being used as a weapon or means to launch an attack, and people-fraudulent seafarer identity to support of terrorist activities (Barnes and Oloruntoba, 2005). Thai and Grewal (2007) discovered several essential elements in effective management of security in the maritime logistics operations, such as policy, people, process, communication, etc and a number of their combinations. As to the security of merchant shipping, King (2005) argued applying the human ingenuity might be able to keep away from the terrorism risks, out of several methods he proposed, the most outstanding one is to make good use of advanced information technology to monitor and identify anomalous with high risk, mitigate the malign impacts, and deal with emergency and recovery etc. Despite the varieties of researches on maritime security discussions, the numbers of paper investigating of adequate responses to maritime security issues with quantified methodologies are so rare in literature. Therefore, for identifying the relevant factors of maritime security management practices, we adopt the content analysis methods in the early stage to extract major constructs from both the contents of these three international regulations ISPS, CSI and C-TPAT and the in-depth interviews with maritime experts. With the increase in perception in international community regarding environmental concerns and corporate social responsibility, the forth main dimension recognized by maritime experts is "environment security". Here this study summarized and illustrated the main dimensions and corresponding strategies for implementing the maritime security management practices in Table 1,

Table 1: Dimension and Corresponding Indicators of Maritime Security Management Practices in response to International Maritime Regulation Changes

	Main Dimensions	Indicators of Maritime Security Management Practices
Maritime Security Management Practice	People Security (Seafarer)	Screening personnel with security-related certification, Conducting Security Training, Establishment of security culture, Aligning security management with evaluation system, Defining level of security on board, Building the security management system, Separating the authority and responsibility between ob board and shore-base activities
	Cargo Security	Adopting the new information technology (ex. RFID),Building the cargo tracing system, Cooperating with supply chain members, Monitoring and controlling the conditions of cargo, Establishing security standard in external operation processes, Adopting electronic-documents of inner operation processes, Classifying cargo based on the dangerous level
	Vessel Security	Using the security materials, Regularly repair and maintenance, purchase of safety equipments, Complying with international security regulations, Rewarding the implementation of security by authorities, Implementing port state control.
	Environment Security	Adopting environment protection equipments, Establishing the environmental culture, Setting up the department of Environmental preservation, Developing environmental management systems, Setting up the standard processes of environment protection, Complying with environmental laws and regulations, Conservation of resources

Source: compiled and adapted from Barnes and Oloruntoba (2005), OECD (2003), Thai and Grewal (2007), and content analysis of maritime experts conducted in this study.

3. Sampling and Content Analysis

Based on previous identifications from extant literature review, as well as synthesized from international regulations/initiatives, this study furthermore collected data from senior managers who have at least one year experience of working in charge of security affairs in liner shipping company. Then, we employ content analysis and fuzzy analytical hierarchical process to categorized and analyze the data.

3.1 Sample

The research uses purposive sampling to collect data. Nine validate questionnaire have been collected from nine senior managers from three different liner shipping companies. A general open-ended questionnaire used to ask interviewees about the maritime security management practice they use.

3.2 Content analysis method

The content analysis is one qualitative research technique that involves classifying textual units into conceptual categories that have particular meanings (Weber, 1990). The goal of content analysis research is to present a systematic and objective description of the attributes of communication. Some researchers have used the frequency with which a conceptual category is discussed in narratives as an indicator of the concept's importance (e.g., Abrahamson and Park, 1994; Wade, Porac, and Pollock, 1997), while others have used the mere presence of a conceptual category as an indication of its salience (e.g.,Westphal and Zajac, 1998). Since this study is only focus on the appropriateness of measurements, a simple binary code indicating agree or disagree was sufficient for our research purposes.

3.2.1 Main categories induced from content analysis

The researchers elicited some concepts from extant literature and combined the data from content method records of this study. This study developed four major dimensions to describe the conceptual framework of maritime security management practice depicted above in table 1. These four dimensions are: 1.people security, 2.cargo security, 3. vessel security, and 4. environment security. A detail descriptions of each dimension can be found in Table 1.

3.2.2 Degree of mutual agreement and reliability

The average mutual degree of this study by five coders is 0.88. So, the reliability of this study is 0.98 [8×0.88/ 1+(8-1)×(0.88)]=0.98. The reliability of these dimensions in this study proved to be acceptable.

4. Fuzzy Analytical Hierarchy Processes

The FAHP was applied to determine weight for the four dimensions and 27 indicators for implementing maritime security management practices, and provided the priority of those strategies for liner shipping companies to adopt and adjust their current maritime security management practices. Here we presented some essential calculation steps used in this study and explained as follows:

4.1 Step 1: Establishing the hierarchical structure

Construct the hierarchical structure with decision elements, decision-makers are requested to make pair-wise comparisons between decision alternatives and criteria using a nine-point scale. All matrices are developed and all pair-wises comparisons are obtained from each n decision-maker.
Step 2: Calculating the consistency

To ensure that the priority of elements is consistent, the maximum eigenvector or relative weights and $\lambda_{\max}$ is calculated. Then, compute the consistency index (CI) for each matrix order n using Eq. (1). Based on the CI and random index (RI), the consistency ratio (CR) is calculated using Eq. (2). The CI and CR are defined as follows (Saaty, 1980):

$$CI=\frac{\lambda_{\max}-n}{n-1} \quad (1); \qquad CR=\frac{CI}{RI} \quad (2),$$

where n is the number of items being compared in the matrix, $\lambda_{\max}$ is the largest eigenvalue, and RI is a random consistency index obtained from a large number of simulation runs and varies upon the order of matrix (see Table 2).

Table 2: Random index (Saaty, 1980)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	.58	.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

4.3 Step 3: Construct a fuzzy positive matrix

A decision-maker transforms the score of pair-wise comparison into linguistic variables via the positive triangular fuzzy number (PTFN). The fuzzy positive reciprocal matrix can be defined as (Buckly, 1985)

$$\tilde{A}^k = \left\lfloor \tilde{A}_{ij}^k \right\rfloor \quad (3),$$

where $\tilde{A}^k$: a fuzzy position reciprocal matrix of decision-maker k, $\tilde{A}_{ij}^k$: relative importance between i and j of decision elements, $\tilde{A}_{ij}^k = 1$, $\tilde{A}_{ij}^k = 1/A^k$, $\forall_{i,j} = 1,2,\ldots n$

4.4 Step 4: Calculate fuzzy weights value

In line with the Lambda-Max method proposed by Csutora and Buckley (2001), the fuzzy weights of the hierarchy can be calculated. The calculation process is described as follows.

- Let α=1 to get the positive matrix of decision-maker k, $\tilde{A}_m{}^k = \left[a_{ijm}\right]_{nxn}$, then apply the analytical hiererachical process(AHP) to calculate the weight matrix W_m^k,

$$W_m^k = \left[w_{im}^k\right],\ i = 1,2,\ldots,n \quad (4)$$

- Let α=0 to obtain the lower bound and upper bound of the positive matrix of decision-maker k, $\tilde{A}_l{}^k = \left[a_{ijl}\right]_{nxn}$ and $\tilde{A}_u{}^k = \left[a_{iju}\right]_{nxn}$,Then, apply the AHP to calculate the weight matrix, W_l^k and W_u^k,

$$W_l^k = \left[w_{il}^k\right],\ i = 1,2,\cdots,n \quad (5); \qquad W_u^k = \left[w_{iu}^k\right],\ i = 1,2,\ldots,n \quad (6)$$

- To ensure the fuzziness of weight, two modified constants,, are calculated as follows:

$$S_l^k = \min\left\{\frac{w_{im}^k}{w_{il}^k} \middle| 1 \le i \le n\right\} \quad (7); \qquad S_u^k = \max\left\{\frac{w_{im}^k}{w_{iu}^k} \middle| 1 \le i \le n\right\} \quad (8)$$

- Then use the modified constants to obtain the lower bound and higher bound of the weight matrix

$$W_l^{k*} = \left[w_{il}^{k*}\right],\ w_{il}^{k*} = S_l^k w_{il}^k,\ i = 1,2,\ldots,n \quad (9);$$

$$W_u^{k*} = \left[w_{iu}^{k*}\right],\ w_{iu}^{k*} = S_u^k w_{iu}^k,\ i = 1,2,\ldots,n \quad (10)$$

- Aggregating W_l^{k*}, W_m^k and W_u^k ,the fuzzy weight for decision-maker k can be obtained as follows:
  $\tilde{W}_i^k = \left(w_{il}^{k*}, w_{im}^k, w_{iu}^{k*}\right),\ i = 1,2,\ldots,n$, and through the geometric average method to incorporate the

opinions of decision-makers, calculated as follows,

$$\tilde{\tilde{W}}_i = \frac{1}{K}\left(\tilde{W}_i^1 \oplus \tilde{W}_i^2 \oplus \Lambda \oplus \tilde{W}_i^k\right) \quad (11)$$

Where, $\tilde{\tilde{W}}_i$: the fuzzy weight of decision-makers i is incorporated with K decision-makers.

$\tilde{W}_i^k$: the fuzzy weight of decision element i of k decision-maker.

K : number of decision-makers.

5. Results and Data Analysis

The problem discussed here is concerned with Liner shipping companies, searching the appropriate strategic responses to the challenges evoked by the changing international regulation environment. Through detailed analysis of the pertinent literature of maritime security management practices and in-depth interviews, the fuzzy AHP framework of implementing maritime security management practices is structured as a hierarchy which includes three levels: goal, dimensions (4 dimensions), and sub-dimensions (27 indicators) for determining the priority strategies.

A decision-making group is formed which consists of experts from Evergreen Marine Corporate, Yang Ming Lines and Wan Hai Line, the top three liner shipping companies in the largest 20 container carriers in the world.

The main dimensions and indicators of maritime security management practices identifying by fuzzy AHP processes summarized in Tables 3,

Table 3: priority weights of main dimensions of Maritime Security Management Practice

Dimensions	Priority Weights & ranking	Indicators	Priority weights
People Security (Seafarer)	Weight=0.44 Ranking=1	Screening personnel with security-related certification	Weight=0.073 Ranking=6
		Conducting Security-related Training	Weight=0.192 Ranking=2
		Establishment of security culture	Weight=0.178 Ranking=3
		Aligning security management with evaluation system	Weight=0.164 Ranking=4
		Defining level of security on board	Weight=0.109 Ranking=5
		Building the security management system	Weight=0.219 Ranking=1
		Separating the authority and responsibility between ob board and shore-base activities	Weight=0.066 Ranking=7
Cargo Security	Weight=0.18 Ranking=3	Adopting the new information technology (ex. RFID)	Weight=0.117 Ranking=4
		Building the cargo tracing system	Weight=0.24 Ranking=1
		Cooperating with supply chain members	Weight=0.112 Ranking=5
		Monitoring and controlling the conditions of cargo	Weight=0.085 Ranking=6
		Establishing security standard in external operation processes	Weight=0.194 Ranking=2
		Adopting electronic-documents of inner operation processes	Weight=0.174 Ranking=3

		Classifying cargo based on the dangerous level	Weight=0.078 Ranking=7
Vessel Security	Weight=0.28 Ranking=2	Using the security materials	Weight=0.127 Ranking=4
		Regularly repair and maintenance	Weight=0.314 Ranking=1
		Purchasing of safety equipments	Weight=0.114 Ranking=5
		Complying with international security regulations	Weight=0.218 Ranking=2
		Rewarding the implementation of security by government authorities	Weight=0.130 Ranking=3
		Implementing port state control.	Weight=0.097 Ranking=6
Environment Security	Weight=0.10 Ranking=4	Selecting environment protection equipments	Weight=0.09 Ranking=6
		Establishing the environmental culture	Weight=0.159 Ranking=4
		Setting up the department of Environmental preservation	Weight=0.088 Ranking=7
		Developing environmental management systems	Weight=0.171 Ranking=3
		Setting up the standard processes of environment protection	Weight=0.204 Ranking=1
		Complying with environmental laws and regulations	Weight=0.183 Ranking=2
		Conservation of resources	Weight=0.106 Ranking=5

* C.I. and C.R. values of above hierarchy < 0.1

Based on the analytical results, inconsistency index of every layer is below 0.1, it means the respondents are rational experts. The ranking of the main dimensions are people security, Vessel security, Cargo security, and Environment security and their priority weight are 0.44, 0.28, 0.18 and 0.10 respectively. Furthermore, priority weights of the sub-dimensions of maritime security management practice are depicted detail in table 3 shown as above.

6. Conclusion and Discussion

In this paper, the perception and assessment maritime security management practices which is a multiple criteria decision-making (MCDM) problem, is studied. A FAHP approach is used aiming at solving this kind of problem. In the approach, triangular fuzzy numbers is used to improve the degree of judgments of decision makers.

Analytical results demonstrate that 'people security' (0.4e) was the most important dimension, followed by 'cargo security' (0.28), 'vessel security' (0.18), and 'environment security' (0.10). As the maritime security management practice encompassed complicated matters and tasks related to people, the excellent effects of people/seafarer management should mitigate possible risks and costs derived mainly from human elements. Thus, many liner shipping have put lots resources on recruiting and training related personnel to handle the security issues and result in increased motivation for all members in the maritime supply chain to cooperate with each other for achieve whole secured objectives. For the sub-dimensions of 'people security', 'building the security management system' (0.219), 'Conducting security-related training' (0.192), 'Establishment of security culture' (0.178) and 'Aligning security management with evaluation system' (0.164) were the strategies with the highest priorities. Regarding the sub-dimensions of 'cargo security', 'Building the cargo tracing system' (0.24) was the most important item, followed by 'Establishing security standard in external operation processes'(0.194), 'Adopting electronic-documents of inner operation processes' (0.174), and 'Adopting the new information technology(ex. RFID)'etc. Within the sub-dimensions of 'vessel security, 'Regularly repair and maintenance' (0.314) was the first priority, followed by 'Complying with international security regulations' (0.218), and 'Rewarding the implementation of security by government authorities' (0.130) Etc. The dimension with the lowest weighting for implementing maritime security management practices was 'environment security' (0.10). As most liner shipping companies feel less pressures coming from their customers than manufacturing companies did.

Maritime security is closely connected with the maintenance of supply chains and thus significantly contributes to a country's economics. It may also directly or indirectly benefit marine transportation, port security, and public interests. For long-term success, it requires the all members of whole supply chain to work together to fight against terrorism and ensure higher quality security, especially the key players---the liner shipping companies. While applying maritime security management practices, due to the resources constraints, liner shipping companies need to consider the priority of implementing according to the expected goal---minimize costs and maximize security.

To achieve the above goal, it needs to develop strategic response plan, plan their better use of resources, establish assessment system, and improve the operations of those strategies step by steps in order to enhance the effectiveness and efficiency of the implementation of maritime security management security.

Although this study is merely an exploratory research, the empirical results may provide valuable findings, suggestion and implications to organizations regarding how they introduce the maritime security management practices. Since, our empirical study analyzed data collected from liner shipping companies in Taiwan; it would be interesting and valuable to conduct similar surveys in other countries or regions for comparative studies.

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The Optimal Fleet Capacity of a Container Shipping Line

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Abstract

This paper has developed an economic model to measure the optimal fleet capacity for a container shipping line. The model has also been applied to investigate the performance of fleet deployment by measuring the installation of fleet capacity. The finding suggests that the performances among the three Taiwanese shipping lines present a fairly steady trend toward the optimal level in the past decade, regardless of the patterns of fleet development being greatly different. Over all, regional container shipping line has a better performance on the deployment of fleet capacity. Meanwhile, the strategic behavior by holding excess capacity to deter entry and maintain market power may play a key role on the decision of containership fleet deployment.

Keywords: Container shipping; Optimal fleet capacity; Optimal ship size

1. Introduction

Over the past decade, the liner shipping has experienced an explosion in containership size. The driving force behind introducing big containerships was initially aimed at reaping greater economies of scale. In literature, Lim (1998), Gilman (1999), Cullinane and Khanna (1999, 2000), Ircha (2001), and Imai *et al*. (2006) have provided some discussions on the economies of scale achieved by big containership. Actually, the aggressive reactions from the major carriers to deliver bigger and much more containerships have greatly eroded the benefit of big containership due to the deterioration of loading factor. In addition, Lim (1998) have also shown that to add capacity in the form of big containership increase the risk of serious over-capacity, especially, when lots of carriers are making identical decision and delivering more containership capacity to the most competitive service routes.

As following the collective behaviors of delivering big containerships among major carriers, on the other hand, it is inevitable for a shipping line to reduce the calling frequency if the transportation demand is not increased enormously. Meanwhile, the huge capital cost and the operational and financial risk associated with the deployment of big containerships fleet have also driven the container shipping lines to cooperate with each other in the form of strategic alliance. In practice, the cooperative operations among the members of a given shipping alliance could provide more containership to serve more ports and routes with more calling frequency. In facing with more complicated shipping operations, a shipping line has to carefully decide not only what sizes of containership should be deployed, but also how much containerships should be allocated among the service routes. As a result, the prevailing operations of shipping alliance have raised a question for researchers: how big a containership fleet should be deployed for a shipping line to reach the target of operating containerships fleet efficiently and profitably?

Other than the study of optimal ship size, this paper has provided an economic model to measure the optimal fleet capacity for a container shipping line. In searching for the optimal fleet capacity, conceptually, it will involve to select the right ship size and the right number of containerships deployed for a container shipping line. In contrast, the studies of optimal ship size are developed to demonstrate the impacts by changing some operational conditions, such as the sailing distance, number of port calls and/or speed on the optimal size of ship deployed (Kendall, 1972, Jansson and Shneerson,

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1982, and Talley, 1990). As following the measure of optimal fleet capacity, in turn, the utilization of fleet capacity could be investigated to reveal the performance of fleet deployment and operation for a shipping line.

This paper is organized as follows. In section 2, an economic model is developed to find the optimal fleet capacity for a container shipping line. In section 3, an empirical application is performed to investigate the fleet utilization of the three container shipping lines in Taiwan. Finally, some conclusions are drawn in section 4.

2. The Model of Optimal Fleet Capacity for a Container Shipping Line

2.1 The economies of fleet

Regardless of the selection of ship size still playing a crucial role on shipping operation, the container shipping lines have greatly expanded their containerships fleet for improving their market competitiveness in the past decade. The decision of fleet deployment for a shipping line to deliver more and bigger containerships is not only to exploit the economies of scale of big containership, but also to reflect the consideration of strategically competitive behavior. In fact, the game of preemption by introducing mega-ships into market has been utilized to deter other competitors from some specific service routes. For the sake of keeping the cost advantage on ship operation, a shipping line may deliberately dispatch containerships with size larger than the optimal level while the competitors have introduced bigger containerships into market. As a result, the search for optimal ship size, which is based on some given operational conditions, becomes less applicable and practically unrealistic.

By introducing more containerships into market, operationally, it could bring more frequent sailing voyages in a given service route and more intensive routes network for a shipping line. Thus, it becomes a quite common practice for a major carrier to operate several service routes with deploying different number and size of containerships in a major trade route. For example, the leading container shipping lines have all delivered lots of containerships to provide many diversified service routes with different rotation and arrangement of port callings at the trans-Pacific trade routes. Usually, the sailing frequency, port calls and containership size among those diversified service routes are but not totally identical. On investigating the performance of containership fleet deployment for a shipping line, obviously, the model developed to measure the optimal fleet capacity will be a more appropriate approach to reflect the practical activities prevailing in the container shipping industry.

2.2 The model of optimal fleet capacity

Since the more containerships a shipping line has delivered, it implies that the more stock of capital should be invested. Conceptually, the action of selecting the fleet capacity for a container shipping line could be equivalently deemed as the action of determining a fixed stock of capital for a firm. In this paper, therefore, the properties of cost function will be borrowed to demonstrate how a container carrier to find an optimal fleet capacity.

To follow a cost function with U shape, if the actual output level is less than the output level with minimum cost (the output level at minimum efficient scale, MES), a firm could exploit more cost efficiency by raising the output level. In the practice of container shipping, it implies that a carrier could continuously enjoy more benefit by shipping more containers if the fleet capacity utilized is not reached to the MES level. In other words, if the invested fleet capacity is not efficiently utilized (under utilized), it will incur a huge cost burden to the carrier.

Furthermore, the relationship between the optimal output in short-run and in long run could be illustrated in Figure 1.With reference to the envelope theorem in economics, it has been shown that the long-run cost function is the loci of output associated with the lowest cost for different possible stock of capital invested. In theory, the long-run average cost curve is the envelope of short-run average cost curves with different levels of stock of capital. As following the implication of cost theory in economics, the output level at point A is neither an optimal point in the short-run case or in the long-run case. The optimal output level could be obtained by pushing the equilibrium point at either point B or C, as both represent points of tangency between the LARC and SRAC(K_1) curves in Figure 1. Actually, point B and C differ in that C is on a new short run cost curve, SRAC(K_2), which corresponds to the optimal stock of capital, K_2. In contrast, point B lies along the original short run cost curve, SRAC(K_1), with higher optimal output level than point A. In the process of adjustments from non-optimal point A to point B or C, the former one indicates the approach by varying the real output level and holding the existing fleet capacity constant, while the latter one represents how a container carrier to reach an optimal point by adjusting the fleet capacity with a given output level. Clearly, the way with changing the stock of capital could be utilized to find the optimal level of fleet capacity. Accordingly, an economic model for finding the optimal fleet capacity will be discussed below.

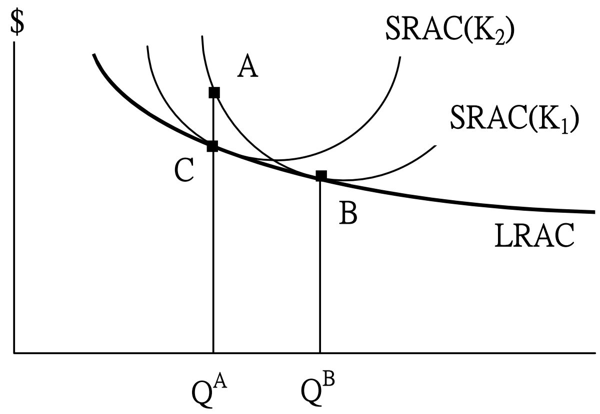

Figure 1: Long-run and short-run average cost curves with different level of capital input

Assume a shipping line possesses a production function as:

$$Q = f(L,\ F,\ M,\ K,\ T) \tag{1}$$

where L, F, M and K indicate the quantities of labor, fuel, intermediate materials input and capital, respectively, and T is an index of technology which is included to reflect the impacts of sailing distance on the output level, measured by TEUs shipped in a year. Following Lau (1976), if the shipping line minimizes the variable cost of producing a given output, subject to a given level of fleet capacity, there exists a variable cost function as:

$$VC = f(P,\ Q,\ K,\ T) \tag{2}$$

where P represents the price vector of factor inputs. This variable cost function represents the minimum variable cost of producing a given output, Q, conditional on a given set of input prices, a technological parameter, and a fleet capacity.

As to the specification of function form, Viton (1981) utilized the translog variable cost function to estimate the relevant capacity output level for investigating the cost efficiency of firms in the transportation industry. With reference to Christensen *et al*. (1975) and Christensen and Greene (1976), the translog variable cost function of equation (2) may be specified as:

$$
\begin{aligned}
\ln VC = {} & \alpha_0 + \sum_f \delta_f D_f + \sum_i \alpha_i \ln P_i + 0.5\sum_i \sum_j \alpha_{ij} \ln P_i \ln P_j \\
& + \beta_Q \ln Q + 0.5\beta_{QQ}(\ln Q)^2 + \sum_i \beta_{Qi} \ln Q \ln P_i + \gamma_K \ln K \\
& + 0.5\gamma_{KK}(\ln K)^2 + \sum_i \gamma_{Ki} \ln K \ln P_i + \gamma_{KQ} \ln K \ln Q + \delta_T T \\
& + 0.5\delta_{TT} T^2 + \sum_i \delta_{Ti} T \ln P_i + \delta_{TK} T \ln K + \delta_{TQ} T \ln Q
\end{aligned} \tag{3}
$$

where i, j = F, L, M. And, D_f appears in this variable cost equation to represent the dummy variables that are set to account for the unmeasurable attributes of a shipping line's operation that are constant over time. Given the translog variable cost as in equation (3), in addition, the condition of linearly homogeneous in input prices will be considered by imposing a set of parameter restrictions:

$$
\begin{array}{lll}
\sum_i \alpha_i = 1 & \sum_i \alpha_{ij} = \sum_j \alpha_{ij} = 0 & \sum_i \beta_{Qi} = 0 \\
\sum_i \delta_{Ti} = 0 & \sum_i \gamma_{Ki} = 0 &
\end{array}
$$

Further, the short-run total cost may be defined as:

$$
SRTC = VC + rK \tag{4}
$$

where r is the price of capital. To follow Klein (1960) definition, the potential output associated with optimal stock of capital is the point at which SRAC and LRAC are at a tangency. Thus, each point on LRAC has not only to be tangent to a specific SRAC, but also represents a minimized SRAC with respect to a given stock of capital. Mathematically, this statement can be expressed as:

$$
\frac{\partial SRAC}{\partial K} = \frac{\partial (SRTC/Q)}{\partial K} = \frac{\partial SRTC}{\partial K}\frac{1}{Q} = 0 \tag{5}
$$

In terms of short-run total cost (SRTC), the above result requires:

$$
\frac{\partial SRTC}{\partial K} = \frac{\partial VC}{\partial K} + r = 0 \tag{6}
$$

In order to measure the unobservable term, $\frac{\partial VC}{\partial K}$, the logarithmic derivative of VC with respect to K may be used to solve it. Thus, the term may be expressed as $\frac{\partial \ln VC}{\partial \ln K} = \frac{\partial VC}{\partial K} \times \frac{K}{VC}$, which implies that $\frac{\partial VC}{\partial K} = \frac{\partial \ln VC}{\partial \ln K} \times \frac{VC}{K}$ by using some simple mathematical manipulation. Accordingly, equation (6) can be rewritten as:

$$
\frac{\partial SRTC}{\partial K} = \frac{\partial VC}{\partial K} + r = \frac{\partial \ln VC}{\partial \ln K} \times \frac{VC}{K} + r = 0 \tag{7}
$$

Meanwhile, the estimate of $\frac{\partial \ln VC}{\partial \ln K}$ can be obtained by logarithmically differentiating equation (3) with respect to the stock of capital, K. In turn, multiplying $\frac{\partial \ln VC}{\partial \ln K}$ by the observable term, $\frac{VC}{K}$, and substituting the resulting expression into equation (7) yields the following result as:

$$\left(\beta_K + \beta_{KK} \ln K + \beta_{LK} \ln P_L + \beta_{FK} \ln P_F + \beta_{KT} \ln T + \beta_{KQ} \ln Q\right) \times \frac{VC}{K} + r = 0 \qquad (8)$$

Academically, the proper approach on estimating the parameters of a translog cost function is to apply the Zellner's seemingly unrelated regression (SUR) technique to simultaneously estimate the parameters of the translog function and the associated cost share equations (Christensen and Greene, (1976), Nelson (1989)). To follow with economics theory, the cost share equation for the variable inputs can be obtained by applying Shephard's Lemma. And, the factor demand may be derived from the cost function:

$$X_i = \frac{\partial VC}{\partial P_i} \qquad i = F,\ L,\ M \qquad (9)$$

where X_i is the demand of factor i. Thus, the cost share equation for factor i is given by:

$$S_i = \frac{X_i P_i}{VC} = \frac{\partial VC}{\partial P_i}\frac{P_i}{VC} = \frac{\partial \ln VC}{\partial \ln P_i} \qquad (10)$$

By taking derivative of equation (3) with respect to the price of factor i, the corresponding cost share equation could be calculated by:

$$S_i = \frac{X_i P_i}{VC} = \frac{\partial VC}{\partial P_i}\frac{P_i}{VC} = \frac{\partial \ln VC}{\partial \ln P_i} \qquad (11)$$

where i = F, L, M.

Once the parameters in equation (3) are estimated, the following task is to apply them into equation (8) to find the optimal K. Even though the estimated parameters in equation (3) can be borrowed to replace the parameters in equation (8), the optimal K may not to be obtained by using analytical methods, as K and lnK appear in equation (8) simultaneously. For this reason, an iterative method must be employed to solve for finding the optimal K. In addition, some required conditions, such as the starting point, ending condition and the interval of iteration in the iterative procedure should be also clearly defined before starting to seek the optimal K.

3. Empirical Application

3.1 Data description

The empirical study is performed to measure the optimal fleet capacity for the three container shipping lines in Taiwan. The data is spanned from 1992 to 2006. Generally, the variable cost of a shipping line will be defined as total operating cost and separated into two parts. One is incurred in sea and the other in port. Although the operating cost includes lots of cost items, such as cargo handling expense, port charges, fuel expense, container stevedoring charge, most of the items are all related to the expenditures of manpower, fuel consumption and some intermediate materials for supporting the sailing and stevedoring operations. For the sake of the availability of data collection, three categories of inputs are considered: labor, fuel, and intermediate materials input in this empirical study. The price of labor is measured by the average compensation per employee. The fuel price is obtained by dividing the total fuel expenditure by the amount of fuel consumed. Because the amount of fuel consumption is not reported in company's financial statement, some regression equations are created to estimate the fuel consumption for the three shipping lines. These regression equations are developed to incorporate the relationships among the actual fuel prices paid by carrier, the average fuel price in market, the fuel consumption, the sailing distance, and the freight level collected. The discussion in details is presented in the appendix A. Also, the required data for computing the three categories of inputs are all available from the carriers' annually financial statements.

In practice, it is quite normal behavior for a shipping line to charter in and/or out containerships to allow for the expected and unexpected variations of market. In order to exactly reveal the fleet capacity for a shipping line, it is more appropriate to utilize the slot capacity of the total containerships operated, instead of the owned containerships only, to measure it. Therefore, the total slots provided by owned and chartered-in containerships are borrowed to measure the variable of stock of capital in this study. The data about the total slot capacity of the operating containerships for each shipping line are collected from the Containerisation International Yearbook with different issues. Since the stock of capital in this empirical study is defined as the total slot capacity provided by a shipping line, the unit cost of capital is the corresponding capital cost per slot capacity invested. Due to the unavailability of the unit cost of capital, firstly, this study constructs the cost of capital by subtracting the book value of owned containerships from the accumulated depreciation. In turn, the derived net value is multiplied with the interest rate to measure the opportunity cost of holding the owned containerships. Because the deletion of ship has to be incurred in ship operation, the annual depreciation expense is used to approximately reflect the cost of deletion of operating the owned ships for a shipping line. In addition to the opportunity cost and depreciation expense of holding owned containerships, the annual hire expense paid by the shipping line has also been included in the calculation of the cost of capital. Eventually, the unit cost of capital could be computed by dividing the cost of capital by the slot capacity deployed.

Next, the cost of intermediate materials input is calculated by subtracting the labor, fuel cost from the total operating cost. Since the material cost includes the uncountable items and activities for shipping the total TEUs of containers, the price of intermediate materials is computed by dividing the total material cost by the total TEUs shipped in a year. As to the setting of the technology parameter in variable cost function, finally, it will involve the definition of output in this study. Due to the output level is defined as the total TEUs shipped in a year, obviously, the influence of sailing distance has been neglected completely. In order to recover the effect of sailing distance on the output level, an index of technology has been constructed by utilizing the derived oil consumption per TEU shipped in the process of finding fuel price. The details are discussed in appendix B.

3.2 Estimation of optimal fleet capacity

By following the theoretical derivation shown in the proceeding section, the estimate of parameters in equation (3) is a necessary condition to determine the optimal fleet capacity. There are three dummy variables included in the equation (3) to allow for the unmeasurable attributes of management and operation among the three container shipping lines. Since the cost share function should sum to unity by definition, there should only two equations be considered among the three cost share function in order to avoid introducing a linear dependence in the data. The annual cost shares of the three input categories for the three shipping lines are summarized in Table 1.

Table 1: The cost share of fuel and intermediate materials inputs for the three container shipping lines

	Carrier A		Carrier B		Carrier C	
	cost share of fuel input	cost share of intermdieae materials	cost share of fuel input	cost share of intermdieae materials	cost share of fuel input	cost share of intermdieae materials
1992	0.05	0.88	0.05	0.84	0.04	0.90
1993	0.04	0.87	0.05	0.86	0.03	0.91
1994	0.04	0.86	0.05	0.87	0.03	0.92
1995	0.05	0.85	0.06	0.87	0.04	0.92
1996	0.05	0.83	0.07	0.87	0.04	0.91
1997	0.05	0.81	0.07	0.87	0.05	0.90
1998	0.04	0.81	0.05	0.91	0.04	0.91
1999	0.06	0.76	0.05	0.92	0.05	0.89
2000	0.09	0.71	0.08	0.89	0.07	0.87
2001	0.10	0.68	0.07	0.89	0.08	0.87
2002	0.10	0.74	0.07	0.90	0.08	0.87
2003	0.10	0.81	0.08	0.88	0.10	0.85
2004	0.08	0.83	0.08	0.88	0.10	0.84
2005	0.11	0.80	0.11	0.82	0.12	0.82
2006	0.12	0.80	0.14	0.81	0.17	0.79
Average	0.07	0.80	0.07	0.87	0.07	0.88

Since 2004, not surprisingly, the cost shares of fuel input present significant increases to reflect the soaring price in the oil market. Obviously, it illustrates that the fuel expenditure has gradually shared a larger portion of the operational cost for a container shipping line. In addition, it also indicates that, at average, the summation of the cost shares of fuel and intermediate materials inputs over the period studied accounts for 87, 94 and 95% of total variable cost for Carrier A, B and C, respectively. Therefore, only the cost share function of fuel and intermediate materials inputs are considered in the following empirical study. For fuel and intermediate materials, accordingly, the corresponding cost share equation to equation (11) could be formulated as:

$$\begin{aligned} S_F = \frac{\partial \ln VC}{\partial \ln P_F} &= \beta_F + \beta_{FF} \ln P_F + \beta_{LF} \ln P_L \\ &+ \beta_{KF} \ln K + \beta_{TF} \ln T + \beta_{QF} \ln Q \end{aligned} \tag{12}$$

$$\begin{aligned} S_M = \frac{\partial \ln VC}{\partial \ln P_M} &= \beta_M + \beta_{MM} \ln P_M + \beta_{LM} \ln P_L \\ &+ \beta_{KM} \ln K + \beta_{TM} \ln T + \beta_{QM} \ln Q \end{aligned} \tag{13}$$

Econometrically, the equation (3), (12) and (13) should be jointly estimated to obtain the estimates of parameters of the variable cost function. With applying the Zellner's SUR technique, the sample size has reached to be 135 due to the stacked panel data by pooling equation (3), (12) and (13). Among the 30 parameters in the variable cost function, there are 18 estimated coefficients are statistically different from zero at the 10% significance level[2]. Meanwhile, among the each 7 estimated parameters of the fuel and intermediate material cost share functions, there are 7 and 6 parameters to be significant at 10% significant level, respectively. The R^2 for the variable cost function and cost share function of fuel and intermediate materials are 0.99, 0.94 and 0.62, respectively.

After the parameters in equation (3) being estimated, as the demonstration shown in above, the

[2] The 44 estimated coefficients of the variable cost and cost share functions are not provided in the paper. A copy of these coefficients is available from the author upon request.

corresponding parameters in equation (8) can be replaced with these estimated parameters to derive the optimal K. However, as both lnK and K appear in equation (8) simultaneously, it is not possible to find an equilibrium value of K by using analytical method. An iterative approach has been applied in this study to search for optimal K in equation (8). The initial value for K is set to be 2000 TEUs. The loop calculation is set up to the maximum at 800000 times with a interval of 2 TEUs each time. The iterative process will be truncated as the sign of objective function is changed. Finally, the truncated value of K will be defined as the optimal fleet capacity.

In addition, a ratio could be computed by dividing the actually invested fleet capacity by the derived optimal fleet capacity. In this study, the ratio is defined as the installation ratio of optimal fleet capacity to investigate the extent of fleet capacity deployment under or over the optimal level for a container shipping line. As the ratio is larger than one, it states that the shipping line has introduced a too big containership fleet capacity into the market for shipping the given amount of containers in the year. Under such a situation, the shipping line has confronted with an excess capacity situation in the deployment of fleet capacity. Conversely, as the ratio is less than one, it illustrates that the shipping line has met a shortage of fleet capacity for shipping the given amount of containers in the year. In other words, the shipping line should transpose less TEUs of containers for efficiently utilizing the fleet capacity introduced.

3.3 Results and discussion

The results obtained from the empirical application have been plotted in Figure 2. At first, it shows that the variations of the installation ratios are quite different among the three shipping lines. Carrier B has experienced a wider range of variation of installation ratios. Relatively, the variation for carrier C is more stable. Although there are considerable fluctuations over the period studied in the installation ratios, the trends present a fairly steady toward the optimal level, which has the ratio equal to one. Overall, it indicates that the performances of fleet capacity deployment among the three shipping lines do have been significantly improved in the past decade. Also, carrier C has presented the best performance on developing the containership fleet capacity among the three shipping lines. The finding seems to imply that a regional carrier will have a better performance on the deployment of fleet capacity.

Regardless of the improvements of installation ratio among the three container shipping lines, figure 1 also indicates that the two deep-sea shipping lines, carrier A and B have persistently kept over capacity situations in the long run. In contrast, the fleet capacity deployed by carrier C is still maintained under the optimal level before 2000. Since 2002, the installation ratio for carrier C has become higher than the optimal level. With reference to the development of service routes, carrier C has traditionally focused on trans-Asia market for almost 30 years and begun to penetrate into North America and Europe markets since 2002. According to the variations of installation ratios shown in figure 1, carrier C has been facing with the same situation as the other two deep-sea carriers to install an excess capacity containership fleet since 2002. Implicitly, the emergence of excess capacity situation for carrier C reveals that to install an excess capacity seems to be a required competitive strategy for the shipping line with worldwide service network to survive in the market.

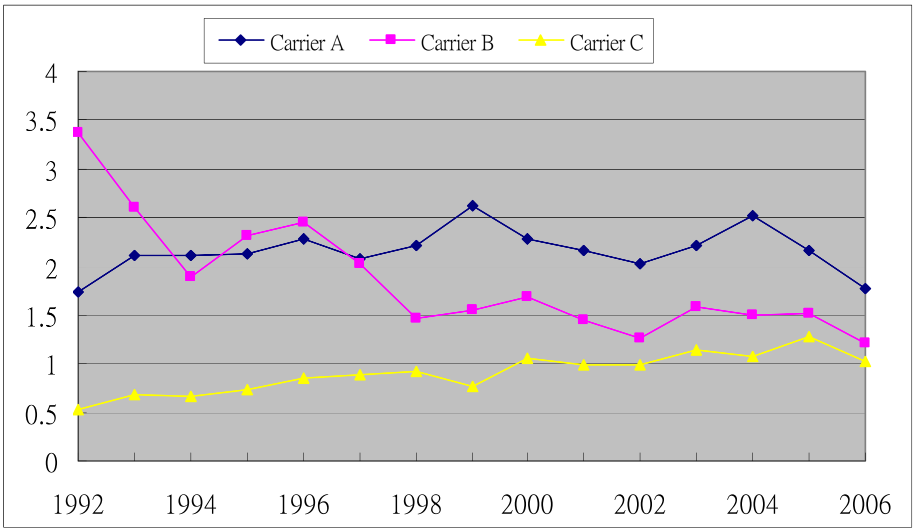

Figure 2: The installation ratios of optimal fleet capacity for the three container shipping lines in Taiwan

4. Conclusion

In this paper, I present an approach that allows us to estimate the optimal fleet capacity for a container shipping line. Conceptually, the search for the optimal ship size is an ex-ante approach to seek a cost-minimized ship size. Basically, it has only focused on the concern of the size under different operational conditions. In contrast, the concept for finding optimal fleet capacity has concerned with not only the size but also the number of ship deployed. During the past decade, the leading shipping lines have all aggressively expanded their containership fleet with larger and more containerships for increasing the sailing frequency and serving more intensive and wider service routes. Obviously, the concept of optimal fleet capacity seems to be a more appropriate approach to reflect the prevailing market activities and development.

According to the results of the empirical study, it suggests that the fleet developments among the three container shipping lines in Taiwan have been persistently improved in the past decade. Meanwhile, the patterns of fleet capacity development are quite different among the shipping lines with different scales of service network. By referring to the variations of installation ratios among the sample shipping lines, interestingly, it shows that the shipping lines with deep-sea service routes is likely to deliberately deploy an over-capacity containership fleet. Implicitly, the strategy by holding excess capacity to deter entry and maintain market power may have played a crucial role for a container shipping line on the decision of fleet capacity investment.

Since the concept of optimal fleet capacity has been modeled to reflect with the prevailing market activities, the measure of optimal fleet capacity could be regarded as a useful indication to monitor the performance of fleet capacity development for a shipping line. In the further study, the optimal fleet capacity could be decomposed into the two parts, optimal ship size and number of ships deployed. In turn, the optimal fleet combination could be found. And, the optimal adjustment path of fleet combination could be developed to provide a suggestion of fleet development for a shipping line. This paper has presented a technique to achieve these goals.

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Appendix A

Usually, the fuel price actually paid by a carrier is not exactly equal to the market price. The relationship between the two prices could be express as:

$$f_{it}^{a} = \bar{f}_{t} e^{\theta_{it}} \qquad \text{(A1)}$$

where f_{it}^{a} is the average fuel price actually paid by carrier i at time t. $\bar{f}_{t}$ is the average market fuel price at time t, and θ_{it} represents the deviations of the fuel price paid by carrier i from the market fuel price at time t. For a carrier, the total fuel expenditure per TEU shipped and the actual fuel price could be formulated as:

$$f_{it}^{a} O_{it} = F_{it} \qquad \text{(A2)}$$

where O_{it} and F_{it} is the average fuel consumption per TEU shipped and the fuel expenditure cost per TEU shipped for carrier i at time t, respectively. The equation (A1) and equation (A2) implies:

$$\bar{f}_{t} e^{\theta_{it}} O_{it} = F_{it} \qquad \text{(A3)}$$

Because the data of fuel consumption, O_{it} is unavailable, a fuel consumption equation, indicating the relationship between sailing distance and fuel consumption could be formulated as:

$$O_{it} = \alpha_{1} D_{it}^{\gamma_{1}} \qquad \text{(A4)}$$

where D_{it} is the average sailing distance per TEU shipped for carrier i at time t.

To take a logarithmical transformation for the resulting expression of substituting equation (A4) into equation (A3), it implies that:

$$\ln F_{it} = \ln \alpha_1 + \ln \bar{f}_{it} + \gamma_1 \ln D_{it} + \theta_{it} \qquad \text{(A5)}$$

Due to the unavailable data of distance variable, D_{it}, again, a freight function is created to express the relationship among freight level, fuel price and sailing distance per TEU shipped in a year. The freight function is formulated in logarithmical form as:

$$\ln P_{it} = \ln \alpha_2 + \beta \ln \bar{f}_{it} + \gamma_2 \ln D_{it} + \varepsilon_{it} \qquad \text{(A6)}$$

where P_{it} is the average freight level collected by carrier i at time t.

In order to cancel the unavailable term, D_{it} in equation (A5), the equation (A5) could be reformulated by substituting equation (A6) into equation (A5). After doing some mathematical manipulation, the θ_{it} term could be estimated by running the regression model:

$$\ln F_{it} = W_0 + W_1 \ln \bar{f}_{it} + W_2 \ln P_{it} + \theta_{it} \qquad \text{(A7)}$$

Once the θ_{it} term is estimated by equation (A7), the actual fuel price (f_{it}^a) could be computed by equation (A1).

Appendix B

Based on the derived actual fuel price in Appendix A, the total fuel consumption per TEU shipped (O_{it}) can be derived through equation (A2) because the data of the total fuel expenditure is available. In this study, the technology parameters are set for reflecting the impact of sailing distance on the measure of output level. Thus, an index called TEU-mile index has been constructed as the proxy of technology parameters. Since the sailing distance has a positive relationship with the fuel consumption per TEU shipped, in this study, the estimated O_{it} terms have been utilized to create the TEU-mile index.

The Law and Economics of Ship-Source Oil Pollution Damage

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Abstract

Private law plays an important and indispensable role in the effort of tackling ship-source oil pollution, in which the Civil Liability Convention (CLC) is the key regime that sets out the liability and compensation framework for oil spills. The paper carries out an analysis which focuses on the economic implications of strict liability which is a hallmark of the CLC together with certain defences. The issue of limitation of liability is then explored in detail. Both these are discussed based on the consideration of whether oil spills should be viewed as unilateral and/or bilateral accidents.

1. Introductory Remarks

Although most of the pollution at sea is from land based sources, tanker accidents always draw massive public attention. A whole spectrum of international conventions was developed in the last few decades addressing both the preventive measures as well as the remedial measures of ship-generated oil pollution, the periodic occurrences of major tanker disasters, such as the Erica and the Prestige, still make the public wonder whether the current legal regimes are adequate. Some questions then arise as to: On what basis should the law be evaluated? Should it be evaluated merely on the basis of its rigidity? What are the criteria that should be addressed to optimise the law's overall effectiveness? And, if the legal intervention is not optimal, how the law should be appropriately redesigned?

With an attempt to bring some insights into the above questions, this paper will take one of the most important marine pollution conventions, namely, the Civil Liability Convention (CLC) as an example to analyse its key features from a legal perspective in order to appreciate its significance in the context of law; and then to examine its rationale and implications from an economic perspective for the purpose of evaluating its desirability.

It is necessary at the outset to briefly present the background to the birth of the CLC. In March 1967, the Liberian tanker Torrey Canyon ran aground on the Seven Stones Reef off the coast of southwest England and some 80,000 tons of Kuwaiti crude oil spilled into the sea as a result of the grounding (British Government, 1967; Gold, 1971; Mukherjee and Lefevbre, 1984). The vessel was owned by Barracuda Tanker Corporation and bareboat chartered to Union Oil Company of California, U.S.A., a company that operated out of Bermuda. The master and crew were of Italian nationality (Nanda, 1967). The magnitude of the oil spill was unprecedented in maritime history and the incident was environmentally catastrophic. The positive side of the incident, nevertheless, is that it awakened the international maritime community and provided the impetus for decisive global action in relation to pollution damage from mega oil spills at sea (Mukherjee and Lefevbre, 1984).

International Maritime Organization (IMO) then known as the Inter-governmental Maritime Consultative Organization (IMCO) reacted without delay.[1] A legal dimension was first added to the Organization- which until then was predominantly technically orientated - by the creation of the Legal Committee. In 1969, under the auspices of IMCO, a diplomatic conference was convened in Brussels with a view to establishing an international regime for marine pollution casualties. Out of the deliberations at the conference emerged two important international conventions; one of these was the International Convention on Civil Liability for Oil Pollution Damage, otherwise known as the Civil

[1] The name of IMCO was changed to International Maritime Organization (IMO) in 1982. It is not merely a 'consultative' body but has powers to make law through conventions.

Liability Convention (CLC).[2]

The object and purpose of this convention was to establish an internationally uniform liability and compensation regime for victims of ship-source oil pollution damage. In essence, the Convention provides that the registered shipowner is liable for pollution damage caused by the discharge of persistent oil carried by tanker; the basis of liability is strict and the compensation to be paid by the owner may be limited to a certain amount calculated according the tonnage of the tanker. In 1992, a Protocol to the CLC1969 was adopted for the purpose of widening the scope of application of the Convention and increasing the compensation limit. The 'new' Convention is referred to as CLC1992.

In the following discussion, two salient features in relation to the liability regime of the Convention, namely, the basis of liability and limitation of liability will be examined. In order to obtain a comprehensive insight, the analysis will cover both the 1969 and 1992 CLC.

The approach employed in this paper falls within the combined discipline known as 'law and economics' or 'economic analysis of law'. Law and economics as a specialized compound discipline has been variously defined but in basic terms it is economic analysis which employs the application of the rational choice approach to law. The application of economic principles to legal issues is not new; but it has developed rapidly over the last few decades (Dnes, 1996). Economists and legal scholars have engaged in studies combining the two disciplines with the aim of gaining a clearer understanding of the law. Although this study has yielded many fruitful insights into various fields of law, the scholarly works carried out in the maritime law field are not many.

2. The CLC and Its Salient Features

There is little doubt that private law plays an important and indispensable role in the effort to tackle oil spills (Xu, 2006). The private law of marine pollution essentially involves liability for damage caused by pollution and the remedies available for such damage. Succinctly stated, the only remedy that is relevant to this discussion is damages, or compensation.[3]

Liability is a qualitative concept. In law, liability arises when the quality of conduct or standard of behaviour of a person is repugnant to the law because it causes damage or injury to others. In contrast, damages or compensation is a civil remedy, and one that is quantitative in character. It is the qualitative attribute of liability that dictates the quantum of damages that the wrong-doer must pay according to the law to the person who has suffered the damage or injury.

At the Brussels diplomatic conference mentioned above, the question regarding whether liability should be based on fault or whether it should be strict, or even absolute, engendered intense debate (Mukherjee and Lefevbre, 1984; M'Gonigle and Zacher, 1979; Özçayir, 1998; Wu, 1996.). In traditional tort or delict law, liability can only be imposed on the defendant polluter if the plaintiff claimant successfully proves on a balance of probabilities that the damage or injury suffered by him was proximately caused by the fault or negligence of the defendant (Mukherjee and Lefevbre, 1984; Rogers, 2002). By contrast, in the strict liability regime, which in terms of English law derives its origin from the law of nuisance, the plaintiff need only prove damage (Gauci, 1997; Rogers, 2002). Once that is done, the defendant is liable regardless of the presence or absence of fault, be it in the form of negligence, nuisance or any other tort.

After some hard negotiations between the delegations from different countries, it was finally agreed at the conference that a strict liability regime would be employed in the Convention. The CLC1992 retains

[2] The other one is the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969.

[3] It is to be noted that the term damages is not the plural of 'damage' in terms of common law understanding, but is a legal term that has virtually the same meaning as compensation. The term compensation is the one that is more familiar to the continental civil law system and is also used in international conventions dealing with pollution damage.

this regime in its Article 3(1) which reads as follows:

Except as provided in paragraphs 2 and 3 of this Article, the owner of a ship at the time of an incident, or, where the incident consists of a series of occurrences, at the time of the first such occurrence, shall be liable for any pollution damage caused by oil which has escaped or been discharged from ship as a result of the incident.

It is notable that in the strict liability regime, even though it is relatively rigorous, certain exceptions are afforded which enable the defendant to escape liability in prescribed circumstances. Usually, these are extraordinary circumstances beyond the control of the defendant to which the pollution damage is attributable. Article 3(2) of the CLC1969 (the same in the CLC1992) provides that -

No liability for pollution damage shall attach to the owner if he proves that the damage:

(1.) resulted from an act of war, hostilities, civil war, insurrection or a natural phenomenon of an exceptional, inevitable and irresistible character, or
(2.) was wholly caused by an act or omission done with intent to cause damage by a third party, or
(3.) was wholly caused by the negligence or other wrongful act of any Government or other authority responsible for the maintenance of lights or other navigational aids in the exercise of that function.

Article 3(3) of the CLC1969 (the same in the CLC1992) provides a fourth exception –

If the owner proves that the pollution damage resulted wholly or partially either from an act or omission done with intent to cause damage by the person who suffered the damage or from the negligence of that person, the owner may be exonerated wholly or partially from his liability to such person [emphasis added].

It is worth mentioning that there are certain types of damage, e.g. nuclear damage, that attract absolute liability.[4] In an absolute liability regime the polluter is liable notwithstanding the circumstances. There are virtually no exceptions and therefore no defences. As such, from the defendant's viewpoint absolute liability is the most rigorous.

Another subject of intense debate among the delegations at the Brussels conference was regarding whether liability, or rather, the amount of compensation, should be limited by law. The notion of limitation of liability, which was at one time unique to maritime law and is still a distinctive feature of shipping, is deeply rooted in maritime practice.[5]

Where there is limitation of liability, the unsuccessful defendant shipowner is not obliged to pay the whole amount of the damages. He need only pay up to a stipulated amount usually calculated according to the tonnage of the ship; so the plaintiff himself bears the balance of his loss or damage. The practice stems from the original notion that a shipowner should only be liable for the amount that represents the value of his ship regardless of the damages assessed against him. Limitation according to tonnage is based on the premise that the larger the ship, the higher is its value. In modern times that premise is no longer entirely valid; the type and use of a vessel is largely determinative of its value, but size in terms of tonnage is nevertheless a decisive criterion. The concept of limitation of liability evolved historically as a privilege accorded to shipowners. Its object is to support and sustain shipping, commercial trade being a nation's economic lifeline. It also manifests public recognition of the entrepreneurial and daring spirit of maritime adventurers. Thus, traditionally, it has been granted pursuant to public policy rather than by virtue of a legal right (Lord Denning in The Bramley Moore, 1963).

[4] In the Civil Liability Convention, 1992 and the Hazardous and Noxious Substances Convention, 1996, the regimes are of strict liability. In the Convention on the Liability of Operators of Nuclear Ships, 1962 (Article II, paragraph 1), the regime is one of absolute liability.
[5] The term 'limitation of liability' is somewhat of a misnomer. The limitation is not in respect of liability which is qualitative, but rather, in respect of the amount of compensation payable which is quantitative. It is the quantum of damages that is limited according to law.

At the conference the question still remained as to whether the limit of liability should be the same as in the prevailing international regime of global limitation or should those limits be raised; or whether a new and separate limitation regime should be created given the sensitivity of environmental concerns profusely aggravated by the Torrey Canyon disaster (O.R. 1969, LEG/CONF/4).

Some delegations such as the United Kingdom were against high limits fearing that funds available in the insurance market would be depleted (Özçayir, 1998); others such as the United States preferred higher limits consistent with their own national experiences (M'Gonigle and Zacher, 1979). Eventually, the parties did arrive at a compromise that led to the adoption of the limitation regime which is found in Article 5 of the CLC1969. The limitation was increased significantly by the 1992 amendment; and the amendment adopted in 2000, which entered into force in 2003, further increased the figure.

The limitation amounts provided by the CLC1992 and the 2000 Amendment are summarised below:

- For a ship not exceeding 5,000 gross tonnage -
  - for an incident occurring before 2003, liability is limited to 3 million SDR
  - for an incident occurring after 2003, liability is limited to 4.51 million SDR

- For a ship of 5,000 to 140,000 gross tonnage -
  - for an incident occurring before 2003, liability is limited to 3 million SDR plus 420 SDR for each additional gross tonne over 5,000
  - for an incident occurring after 2003, liability is limited to 4.51 million SDR plus 631 SDR for each additional gross tonne over 5,000

- For a ship over 140,000 gross tonnage -
  - for an incident occurring before 2003, liability is limited to 59.7 million SDR
  - for an incident occurring after 2003, liability is limited to 89.77 million SDR

It must be noted that the shipowner may lose his right to limit liability in certain circumstances. Article 5(2) of the CLC1992 provides as follows:

The owner shall not be entitled to limit his liability under this Convention if it is proved that the pollution damage resulted from his personal act or omission, committed with the intent to cause such damage, or recklessly and with knowledge that such damage would probably result [emphasis added].

Admittedly, it would be quite difficult, if not impossible, for victims to prove 'intent' or that the act was committed 'with knowledge'.

3. The Economic Analysis

In the following economic analysis, a general theoretical framework provided by the economic analysis of accident law will be first presented; and then the relevant principles and theories will be applied to oil spills to examine the economic implications of the two key features of the liability regime of the CLC.

3.1 Theoretical Framework of Economic Analysis of Liability

From legal perspective, a liability regime has various functions, including among other things, provision of compensation to victims who have suffered harm (Sands, 2003). In economics, it is argued that providing compensation is no longer the primary purpose of private law because accident insurance is generally available in modern societies; instead, creation of incentives to reduce risk is the real purpose (Shavell, 2004).

Viewed by economists, the social goal of accident law is to maximize social welfare; that is the utility derived from risky activities less total social costs. The total social costs refer to the sum of costs involved in taking care and the expected accident losses. Thus, the legal regime should be established to provide injurers with the incentive to take optimal level of care which refers to the level of care where the total social costs are minimized (Shavell, 2004; Calabresi, 1970). The law should also encourage parties to carry out optimal level of activity because a higher activity level, while increasing the injurer's utility, may increase the number of accidents and consequently the expected accident losses. The socially optimal level of activity refers to the activity level where the utility derived from the additional unit of activity equals the costs of care plus expected accident losses caused by that unit of risky activity. At this level, the total net utility, that is, social welfare is maximized.

Economic analysis of liability is generally carried out by comparing strict liability and fault-based liability, which is often referred to as negligence rules in economic studies. For a clearer insight, a distinction is normally made between unilateral accidents and bilateral accidents, based on the contribution of the behaviour of injurers and victims towards the accident risks. Unilateral accidents refer to those where only the injurer's behaviour affects the level of accident risk, and the victim's care or precaution does not reduce risk or only has slight effects on accident risk (Shavell, 2004). In bilateral accidents, not only injurers but also victims can take precautions to reduce accident risk.

3.1.1 Unilateral accidents

Economists argue that in unilateral accidents both strict liability[6] and negligence rules can lead the injurer to take optimal level of care but only strict liability can lead to optimal level of activity.[7] Under strict liability, in basic terms, once the accident occurs the injurer will be found to be liable and will be required to pay for all the damage done in the form of compensation.[8] Threatened by the payment of compensation, the injurer will be induced not only to pursue the level of care where his total expenses are the lowest – so the socially optimal level of care is achieved, but also to limit his activity to the socially optimal level to maximize his utility. By contrast, where negligence rules are engaged, the injurer is liable for the losses caused by his activity only if he is found negligent; in other words, only if the level of care exercised by him is lower than the due care defined by courts. He will, of course, take due care so that he can escape paying compensation and his total costs will only be the costs of taking care. However, his activity level will exceed the socially desirable level (Shavell, 2004).

It is worth pointing out that, although both strict liability and negligent rules can provide enough incentive for injurers to take due care, courts face different tasks in achieving such result. Under strict liability, courts need to closely evaluate the accident losses in order to determine the amount of compensation. However, under a negligence regime, in addition to the magnitude of damage, courts have to be able to define due care at the socially optimal level and acknowledge the actual level of care exercised by the injurer in an accident. In order to determine the level of due care, courts must be aware of the costs and the probability of having an accident under different levels of care (Shavell, 2004; Landes and Posner, 1987).

In the context of oil transportation, the care taken by shipowners normally includes various forms of precaution such as employing competent masters and crew, safety and pollution combat training and avoiding the use of substandard ships. The measure of activity level includes two elements; one is the distance that cargo is transported; the other is the amount of cargo carried on board ships.[9] The distance element may have more influence on the number of accident occurrences; while the amount of cargo affects more the potential damage once the accident occurs. It is not difficult to envisage that the more oil loaded on a ship or the longer the distance that the tanker navigates it is more likely to increase pollution damage even though the tanker owner takes the optimal level of care in each voyage.

When oil spills are viewed as unilateral accidents, based on the above analysis, it would appear that

[6] It must be noted that this 'strict liability' is different from the strict liability in the context of law. More discussion in this regard will be carried out later in this paper.

[7] In the analysis in this paper, it is assumed that parties involved in accidents are risk neutral.

[8] It is assumed here that the injurer is capable of paying for all the accident losses with no limitation or judgement-proof protection.

[9] The result of multiplying these two elements is used to measure the production of marine transportation, which is referred to as 'ton-mile'.

strict liability is more appropriate than negligence rules in terms of both the optimal level of care as well as the optimal level of activity.[10]

3.1.2 Bilateral Accidents

The analysis for bilateral accidents does not only take into account the response of the parties towards different liability rules but also to consider the dependence of one party's reaction upon the other's behaviour. Generally, the optimal level of care in bilateral accidents exists when both the victim and injurer take care (Shavell, 2004).

Economists argue that strict liability alone will not lead to an optimal level of care but strict liability with the defence of contributory negligence and various negligence rules, including negligence, negligence rule with the defence of contributory negligence and comparative negligence rule, can result in an optimal outcome. Under these rules, both the injurer as well as the victim will be induced to take care either to avoid being found liable or for the purpose of reducing expected accident losses. It should be noted, however, that in order to achieve the optimum result, courts must define due care at the socially optimal level (Shavell, 2004).

In terms of the overall socially optimal activity level, none of the above mentioned regimes are perfect. Under strict liability with the defence of contributory negligence regime, the victim may engage in excessive activity to maximize his own utility because he will be compensated for his losses if he takes due care. However, under negligence rules, the injurer will not have the incentive to exercise the optimal level of activity because he does not have to pay compensation if he takes due care; while the victim will have to choose the correct activity level in order to reduce expected accident losses in case the injurer is not found liable. Since neither of these regimes is perfect in this regard, the choice between the regimes should be made depending on which party's activity is more important to be controlled. If, for example, the excessive activity of the injurer is more harmful to society than that of the victim, negligence rules should be avoided and strict liability with the defence of contributory negligence is then preferable (Shavell, 2004; Landes and Posner, 1987).

It could be argued that a tanker owner's excessive activity is more harmful than that of victims such as fishermen or hotel owners in terms of environmental damage. Thus, when oil spills are viewed as bilateral accidents, negligence rules should be avoided. It may thus be concluded, on a theoretical basis, that strict liability with the defence of contributory negligence appears to be a better choice for the private law regime governing oil spills. In practical terms, however, such a regime may not be perfect. The problem concerned is simple but crucial; that is, the costs involved in establishing a victim's due care and finding his actual care. These costs mainly comprise legal and other expenses, such as time and effort spent by the concerned parties and the courts. For maritime cases, those costs are likely to be prohibitively high. As a matter of fact, the complexity and mobility of oil pollution accidents make such task well nigh impossible to be carried out, at least with the current technology.

Following the above consideration, this author submits that strict liability with certain defences provided by the CLC is the most suitable private law regime to deal with oil spills. The argument will be stated in the following section in which the basic characteristics of oil spills and some significant differences between the theoretical economic analysis and the practice of law governing oil pollution will be examined and taken into account while applying economic theories in the maritime context.

3.2 The Economic Implications of the Liability Regime Governing Ship-source Oil Pollution

The theories developed in the economic analysis of law discussed above outline the general issues; however, they may not perfectly fit the issues of marine pollution due to differences between the theoretical framework and the practice. Consequently, several points need to be considered when

[10] Oil spill accidents may be viewed as bilateral accidents under some circumstances. The discussion on whether or not strict liability is desirable for oil spills when they are viewed as bilateral accidents will be carried out in later sections. The perception with regard to whether oil spills should be viewed as unilateral or bilateral accidents will also be explored.

applying economic analysis of accident law to oil spills. Some modifications should be made based on those considerations in the context of maritime practice.

3.2.1 Oil Spills - Unilateral or Bilateral Accidents?

The underlying basis for the application of economic theories to oil pollution concerns the question of whether oil spills are unilateral or bilateral accidents. One may argue that oil spills are typically unilateral accidents because the victims such as fishermen and hotel owners have no control over the accident risks. The issue is not as straightforward as it may appear. This author submits that the issue should be approached from the perspective that is associated with the type of damage, i.e., environmental damage versus non-environmental damage; and thus a single oil spill accident can be viewed as having both unilateral and bilateral features.

If one considers the damage where the victim is able to take care in one way or another, oil spills can be viewed as bilateral accidents. Such damage may include, for example, property damage suffered by hotels, clean-up costs in respect of the same and reduced tourism income, etc. The victims involved may be individuals, firms and local or national governments. In any sense, it is not the environment or natural resources. For convenience, these kinds of damage will be referred to as non-environmental damage in the following analysis.[11] Being investors and controllers of their activity, these victims can take certain precautions to reduce potential damage.

At this juncture, it is necessary to point out that where accident risks are concerned, two elements need to be considered, namely, the probability of accident and the magnitude of damage once the accident occurs. With regard to oil spills, although the victim may not have control over the possibility of an accident occurring, his behaviour may have an impact on the extent of damage or accident losses from his side. An obvious example is the investment of a seaside resort or a hotel. If the investor does not have to bear any risk of oil pollution, he would invest to the extent where his own utility is maximized without taking into account the expected accident losses. He may invest in a beach where he anticipates receiving maximum income whether or not a tanker route is nearby. Thus, if an oil spill accident occurs, more damage will be caused than if his investment decision had taken in the element of spill risk. However, if he invests less or chooses a location away from busy tanker routes, the damage would be less; or, it could even be avoided. In this sense, the shipowner who caused the harm, by being strictly liable for the damage, in effect partly loses his control over the amount of damage. Since both the shipowner and the victim can reduce pollution risks in terms of probability and the amount of damage, an oil spill should be viewed as a bilateral accident.

Of course, damage caused by oil spills does not only include non-environmental damage or losses mentioned above, but also damage to the environment and natural resources with or without property rights. For convenience, this will be referred to as environmental damage in contradistinction to non-environmental damage. In terms of environmental damage, basically the victim is the environment and the natural resources.[12] Undoubtedly, in this case precaution can only be taken by the shipowner but not by the environment per se or governments as custodians of the environment. This therefore furnishes oil spills with unilateral accident features.

Based on the above considerations, it can be concluded that one oil spill accident may consist of both unilateral and bilateral characteristics depending on the type of damage concerned. Due to such complexity, the available theories in the economic analysis of accident law are not tailor-made to suit marine pollution issues. Therefore, while applying the theories to oil spill problems, some modifications must be made. In addition, the features of both unilateral and bilateral accidents must be

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[11] The reason of employing this term is to avoid the overlap between property damage and damage to the natural environment and natural resources, as some beaches and islands may be attached to property rights.

[12] Of course when beaches and islands with property rights are concerned, the victims treated by law are the property owners but not necessarily owners of the environment. However, for the purposes of this analysis, a distinction is made between damage to the lands *per se* and the damage to the resources situated on the lands, as things situated on the land could be located elsewhere to reduce potential damage but the land itself cannot be moved away to avoid being contaminated. Thus, damage to beaches and islands is also treated as environmental damage in this analysis although the victim in law is not the environment.

taken into account in designing legal regimes for oil spills.

3.2.2 Strict Liability in Oil Pollution

The term 'strict liability' used in economic analysis is not the same as it is understood in the legal context. In economic analysis the term resembles the concept of 'absolute liability' in law, under which, as mentioned earlier, injurer has no defence for escaping liability. In law, strict liability is not as 'strict' as it pertains in economic analysis where injurer is conclusively liable once the accident occurs. By contrast, in the law of oil spill damage, the shipowner's strict liability is subject to certain exceptions which can be invoked as defences. If he succeeds in bringing himself within any of those exceptions, he can escape liability.

The economic implications of strict liability in law and in the theoretical parameters of economic analysis are therefore different. In terms of economic analysis, victims have no incentive to take precaution whereas in law, the availability of specified defences for injurer will induce potential victims to exercise certain level of care because if injurer successfully invokes an exception, the victim will have to bear his own losses. By taking care, he can decrease the possibility of those losses.

In considering victim's level of care for reducing accident risk and his level of activity, the economic analysis should extend to a comparison of four different regimes, namely, (1) absolute liability, (2) strict liability with defences other than contributory negligence – it will be referred to as 'strict liability' in the following text, (3) strict liability with contributory negligence, and (4) various negligence rules. Notably, in the CLC, the shipowner's defences include victims' negligence and some extraordinary circumstances that are beyond the shipowner's control, such as act of God, etc; in other words, both (2) and (3) are included in the Convention.

Victim's incentive for taking care under strict liability is more than that under absolute liability. The economic implications of strict liability, in terms of level of care, are closer to strict liability with the defence of contributory negligence. Under both regimes, the victim will have to face the risk of bearing his own losses even if the basis of liability is strict. In terms of activity level, under the regime of strict liability with defence of contributory negligence, injurer will exercise optimal level of activity but victim will not because so long as he is not negligent he will receive compensation for his losses. However, under strict liability, victim's activity level may be reduced because even if he is not negligent he may still have to bear his accident losses in certain circumstances where injurer is not found liable. On the other hand, injurer's activity level may not differ much from the optimal level because if he could not be protected by the defences he will still be governed by strict liability.

Where oil spills are viewed as bilateral accidents, flowing from the above analysis, it is submitted that strict liability so designed in the CLC is more plausible than other liability regimes - at least in principle - as it can encourage both injurer and victim to take care and reduce their activity level. It should be pointed out, however, that in practical terms the defences are in effect rather difficult for shipowner to invoke. For example, one of the defences requires that the 'natural phenomenon' which has caused the incident must be 'of an exceptional, inevitable and irresistible character' [emphasis added]. It is not difficult to envisage that the task for the shipowner to prove that a typhoon or a hurricane bears all the three characters would not be easy. Another defence requires that the incident is 'wholly caused by an act or omission done with intent to cause damage by a third party' [emphasis added]. Apparently, the restrictions 'wholly' and 'with intent' would considerably reduce the possibility of shipowner being exonerated from liability. Taking into account the above mentioned issues, this liability regime may have its limit in terms of providing sufficient incentive to victims to reduce their activity level especially when they are well aware that shipowner is unlikely to be protected by the defences.

It is worth mentioning that although negligence rules also encourage both parties to take care, the costs involved in determining the optimal level of care and the actual care taken by injurer will be too high to be socially desirable (Landes and Posner, 1987; Shavell, 2004). As stated by Dr. Gauci (1997, p.19), '[S]trict liability bypasses problems relating to proof of negligence and issues relating to vicarious responsibility. The ultimate result of this should be more expeditious compensation, and hence less expensive litigation procedures'.

3.2.3 Limitation of Liability

The concept of limitation of liability is a well-established feature of maritime law and is germane to the private law of marine pollution (Gauci, 1997). The viewpoints of legal scholars on limitation of liability vary (Gauci, 1995). Some argue that it should be retained; others are of the view that it does not 'fulfil the [economic] incentive functions' (Sands, 2003, p165). Judges also have diversified attitudes. Lord Denning (1963, p.437) stated the following in The Bramley Moore:

I agree that there is not much room for justice in this rule; but limitation of liability is not a matter of justice. It is a rule of public policy which has its origin in history and its justification in convenience.

Similarly, Griffiths, L.J. (1984, p.44) states that limitation of liability is 'a right given to promote the general health of trade and in truth is no more than a way of distributing the insurance risk'. A contrary view was expressed by an American judge who opined that limitation of liability 'at this date seems especially inappropriate' (Black J., 1954, p.859).

In economic studies, it is believed that limitation of damages or the injurer being judgement-proof reduces his incentive to take care (Shavell, 2004). As mentioned earlier, in marine pollution, the limitation regime is established largely through international conventions. Obviously, even if limitation was not provided, victims could possibly face the problem of the shipowner being judgement-proof. Even with limitation, in many cases it could be beyond an individual shipowner's financial capability, especially in the case of a single-ship company, to pay full damages. Thus, the problem of the shipowner being judgement-proof is still there.

The right to limit liability dilutes shipowner's incentive to take precaution and arguably, is a deviation from the object of protecting the marine environment. It may, however, have different implications when oil spills are viewed as unilateral or as bilateral accidents. If oil spills are viewed as bilateral accidents, limitation of liability can provide some incentive for potential victims to take precaution. This becomes significant when the defences mentioned above do not provide sufficient incentive for victims to take precaution or to control their activity to the optimal level. In the hotel investment example mentioned previously, if the investor was subjected to receiving limited compensation, he would be induced to limit his investment to a certain extent so that it would be fully covered by remedies available in the case of an accident, even if he is uncertain how likely the shipowner would be successful in invoking the defences.

However, where environmental damage is concerned, oil spills should be viewed as having the feature of unilateral accidents. The victim here being the natural environment, it would not be possible for any precaution to be taken and the significance of limitation as in the case of the bilateral accident view disappears. It is therefore desirable that shipowner takes full care without any reduction of liability. It is thus submitted that liability in respect of damage to the natural environment and natural resources should be unlimited.[13]

In addition, it should also be born in mind that if the injurer's incentive to take due care is diluted by not paying the full damages, regulations can be jointly used to control the injurer's behaviour (Shavell, 2004; Shavell, 1984; Kolstad *et al*., 1990; Burrows, 1999). MARPOL is the main international

[13] A question may arise as to whether or not limitation of liability should be retained with respect to non-environmental damage suffered by fishermen. Theoretically, liability for such damage should be limited because oil spills in this case could be viewed as bilateral accidents in the sense that fishermen could fish in different location or change their occupation. However, some realistic factors need to be considered and although the damage suffered by fishermen is not environmental, it should be unlimited. This is justifiable on the ground that compared with the hotel investor the fisherman has far less control over oil spill risks, both in terms of the number of occurrences and potential damage. His livelihood is not detachable from the natural resources and once they are contaminated his interests will suffer. It is well nigh impossible for him to take any precautionary measure to reduce his risk and damage. Due to the nature of fishing activity, a free choice of location for him to carry out his livelihood away from an area of oil spill risk may not be attainable. Thus, it would not be justified to require fishermen to take care. For these reasons, damage suffered by fishermen should be viewed as caused by a unilateral accident and liability should be imposed on the same basis as for environmental damage, which should be unlimited.

convention containing preventive measures for oil spills (Xu, 2007). There are also other conventions, e.g., SOLAS Convention, STCW, addressing issues such as safety management, crew training and certification, etc. Regulatory preventive measures for oil spills have been prescribed from various perspectives. There is little reason to doubt that the preventive measures in oil shipping are not sufficient. Although it is not possible to quantify the optimal level of care for oil spills in this study, there is hardly any doubt that if liability is always unlimited, oil pollution will be over-regulated when it is also under the governance of a sound regulatory regime.
It is thus submitted that limitation of liability should not only focus on whether or not the regime should be retained; instead, it should be considered in relation to different kinds of damage. It is therefore proposed that a two-fold liability regime be established for marine oil spills. Generally, for non-environmental damage limitation of liability may be necessary and useful as a supplement to the defences in terms of providing incentive to victims; for environmental damage, liability should be unlimited.

Actually, there is existing precedent for a combined liability regime consisting of both limited and unlimited liability is employed to address different kinds of oil spill damage although the structure is not the same as what is proposed here. In the state of Florida in the United States, limited liability is imposed in respect of cleanup and abatement costs and unlimited liability is imposed for damage to natural resources (West Florida Statutes Annotated, 1997 Supplementary Pamphlet).

4. Concluding Remarks

The scope of this paper does not allow an inclusive analysis of all the salient features of the CLC. However, a focused analysis with great detail on the two key features of the liability regime, namely, strict liability and limitation of liability, should be able to provide some useful insights into the rationale and desirability of the law; especially when the differences between the legal concepts and the theoretical framework used in economic analyses are pointed out and taken into account in the discussion.

Generally, economic analysis of accident law is approached by first identifying whether the accident in question is unilateral or bilateral. Although the same analytical methodology is employed, the economic implications of legal regimes for different versions of accident may not be the same. The question of whether oil spills are unilateral or bilateral is not straightforward; in short, oil spill accidents can be viewed as to having both unilateral and bilateral features. Thus, the examination of the desirability of the private law regime on various aspects must be made based on this conceptual foundation.

According to the economic analysis, strict liability with certain defences as set out by the CLC is desirable for dealing with oil spills; and limitation of liability may be necessary as a supplementary method to provide incentive for the victim to take care only when oil spills are viewed as bilateral accidents. However, when oil spills are viewed as unilateral accidents, it may be desirable to employ unlimited liability.

It would indeed be desirable to have the analysis supported by empirical studies. However, in carrying out a quantitative analysis one is likely to encounter some insurmountable difficulties such as estimating risk caused by the infrequency of certain types of accidents. It is also not easy to predict generally the consequences of accidents because each accident is likely to have its own cause and characteristics. More importantly, it is extremely hard to attribute reduction of risk or increased level of care to a particular provision. This, of course, poses a formidable challenge to the conduct of any economic study on this subject. Nevertheless, the qualitative analysis is by all means important and necessary, and the analytical framework is of great significance in guiding the understanding and formulation of the law.

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Effectiveness of an Empty Container Repositioning Policy with Flexible Destination Ports

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Abstract

Empty container repositioning is an important issue in shipping industry. The majority of previous studies followed the same mechanism as moving laden containers, i.e. destination ports have to be specified before being lifted on vessels. An interesting practice that we observed from interviewing industrial experts is that empty containers may be lifted on a vessel with no determined destination ports, but will be lifted off the vessel when necessary. This paper aims to formulate a repositioning policy with flexible destination ports. The policy only specifies the direction of the empty flows, whereas ports of destinations are not determined in advance and empty containers are unloaded as needed. The effectiveness of this policy is evaluated using a simulation model. Numerical experiments demonstrate that the new policy is more appropriate than a conventional policy in situations with more severely imbalanced trade patterns or with relatively smaller container fleet sizes.

Keywords: Container shipping; Empty container repositioning; Threshold control policy; Stochastic; Simulation

1. Introduction

Repositioning empty containers has become one of the major issues for many shipping companies. It has been estimated that since 1993 about 20% of all ocean container movements have involved the repositioning of empty boxes. (The ROI Container Cargo Alliance, 2002). A variety of factors could contribute to the requirement for empty container movements, e.g. trade imbalance, dynamic behaviour, uncertainty in demands / handling / transportation, types of equipment, blind spots in the transport chain, and a carrier's operational and strategic practices (Song and Carter, 2008). Among those factors, trade imbalance is the most fundamental cause. Taking the Trans-Pacific route as an example, the east-borne trade is about three times of the volume in the opposite direction, which results in a large number of empty containers required to be repositioned from America to Asia.

Moving empty containers is a huge burden to ocean carriers due to the difficulty to redeem the incurred costs in the competitive market (Song *et al*. 2005). Therefore, effectively repositioning empties has become one of the key strategies for ocean carriers to gain competitive advantage. A lot of research has been carried out to improve the efficiency of empty container management.

Much of the work has taken a deterministic approach, which is essentially dynamic in time and uses classical linear programming formulations (e.g. Dejax and Crainic 1987, White 1972, Bourbeau *et al*. 2000, Erera *et al*. 2005, Olivo *et al*. 2005, Cheang and Lim 2005).

The stochastic/ uncertainty factor of the problem has attracted much attention since 1990s. Crainic (1993a) considered inland transportation of empty containers between ports, depots and customers. The work was further extended to multi-commodity inland transportation network (Crainic *et al*. 1993b). Many other researchers focused on empty container repositioning between sea ports. For example, Shen and Khoong (1995) developed a decision support system to facilitate empty container distribution in a

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hierarchical structure. Lai *et al*. (1995) used a simulation model to examine empty container allocation policies from ports in the Middle East to ports in the Far East. Cheung and Chen (1998) proposed a two-stage stochastic network model for the dynamic empty container allocation problem. The mathematical models often successfully capture the stochastic and dynamic nature of the problem, but give rise to the following two concerns. The first is the selection of planning horizon, e.g. Choong *et al*. (2002) reported that a longer planning horizon could encourage the use of inexpensive slow transportation modes to reposition empties. The second is the computational complexity and implementation, e.g. Du and Hall (1997) pointed out that mathematical models require intensive realtime informaiton exchange and are difficult to implement in reality because its logic is hidden from the shipping opreator.

Another interesting development is the examination of the qualitative characteristics of the optimal empty repositioning policies in shipping networks with specific topological structure. Du and Hall (1997) developed a single threshold policy to redistribute empties in a hub-and-spoke system. Li *et al*. (2004) studied the structure of empty container allocation in a single port and presented a two-threshold policy. Li *et al*. (2007) extended the two-threshold policy to a multi-port system. Song (2005, 2007) demonstrated that the optimal empty repositioning policy for two-depot service systems has the threshold structure, in which the threshold parameters can be obtained analytically. Those threshold-type policies have advantages of easy-to-operate and easy-to-understand. For example, the empty containers may be retained at a port up to one month in search for meeting customer demands before being repositioned out of the area.

Almost all of the above research took a perspective that the destination ports of empty containers have to be determined before they are loaded onto vessels. Through interviews with some ocean carriers and inland railway transportation companies, the authors have observed an interesting practice in redistributing empty containers and empty railcars. That is, the empty containers or railcars may be loaded on vessels / trains without determined destinations. Intuitively, this type of practices tends to be more flexible to handle the uncertain and dynamic environment since the repositioning decisions can be done when more reliable information becomes available. However, to the best of our knowledge, there is no research reported on the effectiveness of such practice compared with conventional policies.

In this paper, we will first mathematically formulate the empty container repositioning problem with flexible destination ports formulate. The repositioning policy consists of two parts. The first part concerns when and how many empty containers should be lifted onto a vessel. The second part concerns where and how many empty containers should be lifted off a vessel. Secondly, we present a threshold-type flexible destination policy, and compare it with a conventional policy in which destination ports are determined before empty containers are loaded onto vessels. The comparison is done using a simulation method.

2 Problem Formulation

Consider a shipping system that is composed of a fleet of vessels, a fleet of containers and a set of ports. Vessels make repetitive cycle trips along the ports based on predefined timetable. When a vessel arrives at a port, it will unload laden/ empty containers first, and then collect laden/empty containers from the current port and continue its journey. In practice, the operation of the shipping system differs in many details. We make the following assumptions:

Assumption 1: The container fleet is fixed and no short-term leasing is allowed.
Assumption 2: Vessels follow the pre-specified service routes and schedules.
Assumption 3: Decisions on unloading empty containers from a vessel are made when the vessel arrives at a port. Decisions on meeting customer demands and repositioning out empty containers are made when a vessel departs from a port.
Assumption 4: Unloaded laden/ empty containers from a vessel can be used to meet customer demands in the current port when the vessel departs from the port.
Assumption 5: After a vessel departs from a port, unmet customer demands at the current port due to

insufficient vessel capacity or empty containers will be lost and incur lost sale costs.

The problem can be formulated in an event-driven way. The state of the system is only updated when a vessel arrival or departure event happens. These events naturally divide the planning horizon into a series of stages. In the paper, a stage is defined as the time interval between two consecutive events.

2.1 Notation

To describe the system, we introduce the following notation.

System variables:

- k: the k^{th} stage (event), which could be either a vessel arrival event or departure event.
- t_k: the k^{th} event occurring time.
- $\xi_{ij}^{u}(n)$: the customer demands (in TEU) received by the shipping company on the n^{th} day from port i to port j in the service route u, which is a random variable.
- c_i^h: the inventory holding cost per TEU per day at port i.
- c_i^o: the lifting-on cost per TEU at port i.
- c_i^f: the lifting-off cost per TEU at port i.
- c_{ij}: the transportation cost per TEU from port i to port j.
- N_c: the container fleet size in TEU.
- r^v: the vessel capacity in TEU.

State variables:

- $d_{ij}^{u}(k)$: the cumulative demands for service u from port i port j, which are accumulated from the time that the last vessel departed from the port i to the beginning of stage k.
- $s_i(k)$: the inventory level of empty containers at port i at the beginning of stage k, and $s_i(0)$ represents the initial distribution of the empty container fleet.
- $s^v(k)$: the number of empty containers on vessel v at the beginning of stage k.
- $y_{ij}^{v}(k)$: the number of laden containers shipped from port i to port j on the vessel v in stage k.

Decision variables:

- $x_i^v(k)$: if k is a vessel arrival event (to port i), it represents the number of empty containers lifted off from the vessel v to port i; if k is a vessel departure event (from port i), it represents the number of empty containers lifted onto the vessel v from port i.
- $Y_i^v(k)$: the number of laden containers lifted onto vessel v from port i in stage k.

Identification function

In order to facilitate the formulation of the system in an event-driven way, the following identification functions are introduced.

- $p(v,u,k,A) = i$: if vessel v deployed on the service route u arrives at port i in stage k, i.e. k is a arrival event corresponding to vessel v in service route u.
- $p(v,u,k,D) = i$: if vessel v deployed on the service route u departs from port i in stage k, i.e. k is a departure event corresponding to vessel v in service route u.
- $I\{\cdot\}$: the indicator function. If the condition in the braces is true, then $I\{\cdot\} = 1$, otherwise 0.

2.2 State transition

If k is a vessel arrival event, e.g. a vessel v in the service route u arriving at port i at time t_k and this is the only event occurring at the time epoch t_k, then,

$d_{lj}^u(k) = d_{lj}^u(k-1) + \xi_{lj}^u(t_{k-1}+1) + \ldots + \xi_{lj}^u(t_k)$;

$s_i(k) = s_i(k-1) + x_i^v(k) + \sum_l y_{li}^v(k-1)$;

$s_j(k) = s_j(k-1)$ for any $j \neq i$;

$s^v(k) = s^v(k-1) - x_i^v(k)$;

$y_{li}^v(k) = 0$ for any l;

$y_{lj}^v(k) = y_{lj}^v(k-1)$ for any $j \neq i$.

On the other hand, if k is a vessel departure event, e.g. a vessel v in the service route u departing from port i at time t_k and this is the only event occurring at the time epoch t_k, the state transition is a bit more complicated. As for the customer demand variables at port i, they are updated in two phases: receiving the customer demands from the previous event epoch, and meeting those demands. Firstly

$d_{ij}^u(k) = d_{ij}^u(k-1) + \xi_{ij}^u(t_{k-1}+1) + \ldots + \xi_{ij}^u(t_k)$,

which represents the volume after receiving customer demands. Taking into account the availability of empty containers and the vessel capacity, the maximum customer demands to be met at port i is given by

$Y_i^v(k) =: \min\{s_i(k-1), r^v - s^v(k-1) - \sum_l \sum_j y_{lj}^v(k-1), d_{ij}^u(k)\}$;

It should be pointed out that which customer demand, i.e. $d_{ij}^v(k)$, should be satisfied first depends on the company's priority rule. Other variables are updated as follows:

$s_i(k) = s_i(k-1) – Y_i^v(k) – x_i^v(k)$;

$s_j(k) = s_j(k-1)$ for any $j \neq i$;

$s^v(k) = s^v(k-1) + x_i^v(k)$;

$\sum_l y_{il}^v(k) = Y_i^v(k)$, which represents the laden containers loaded on the vessel v after satisfying customer demands;
$y_{lj}^v(k) = y_{lj}^v(k-1)$ for any $l \neq i$.

After meeting customer demands, it is assumed that unmet demands will be lost. Therefore, at the second phase of this event, we have

$d_{ij}^u(k) = 0$, representing the volume after meeting demands.

2.3 Objective function

The objective of the problem is to minimize the total costs including inventory holding costs, lost-sale penalty costs, lift-on costs, lift-off costs, and laden/empty container transportation costs. The total cost in stage k is given as follows:

$$J_k = \sum_i c_i^h \cdot s_i(k-1) \cdot (t_k - t_{k-1})$$

$$+\sum_i c_i^p \cdot \sum_u \sum_v \left(\sum_{j \neq i} d_{ij}^u(k) - Y_i^v(k) \right) \cdot I\{p(v,u,k,D) = i\}$$

$$+\sum_i c_i^o \cdot \sum_u \sum_v \left(x_i^v(k) + Y_i^v(k) \right) \cdot I\{p(v,u,k,D) = i\}$$

$$+\sum_i c_i^f \cdot \sum_u \sum_v \left(x_i^v(k) + \sum_j y_{ji}^v(k-1) \right) \cdot I\{p(v,u,k,A) = i\}$$

$$+\sum_i \sum_u \sum_v c_{i-1,i} \cdot \left(x^v(k-1) + \sum_{i \neq j} y_{ji}^v(k-1) \right) \cdot I\{p(v,u,k,A) = i\}$$

The first term on the right hand side of the above equation represents the empty container holding costs at port, which is related to the inventory level and the storage time. The second term represents the penalty costs incurred by losing unmet customer demands due to insufficient vessel capacity or unavailable empty containers. The third term represents the lift-on costs for both laden and empty containers. The fourth term represents the lift-off costs for laden and empty containers. Finally, the fifth term represents the container transportation costs. Where, $c_{i-1,i}$ reprents the transportation costs per TEU moved from the last port to the current port i.The transportation costs are only calculated for the vessel arrival events.

The objective function is the following expected total cost in the whole planning horizon:

$$J = E \sum_k J_k$$

The evolution of the system is subject to a set of constraints. Firstly, the vessel capacity constraint, i.e. the total number of containers on board should not exceed the vessel capacity.

$$r^v - s^v(k-1) - \sum_l \sum_j y_{lj}^v(k-1) \geq 0$$

Secondly, the inventory level of empty containers at each port should be nonnegative. That is

$$s_i(k) \geq 0$$

Thirdly, at any given stage k, all the containers at ports and on board must equal the container fleet size.

$$\sum_i s_i(k) + \sum_v \left(s^v(k) + \sum_i \sum_j y_{ij}^v(k) \right) = N_c$$

In this paper, we assume that customer demands should be satisfied as much as possible in order to maximize the revenue and also assume that the customers with the largest volume will have priority to be satisfied (if ties, the FCFS rule will be applied). Therefore, the laden container generation and loading onto vessels are implicit. In other words, the decision variable $Y_i^v(k)$ is implied. We only need focus on the decision variable $x_i^v(k)$. For the empty container management, our main concerns are two aspects:

- Loading empty containers: when and how many empty containers should be repositioned out of a port?
- Unloading empty containers: where and how many empty containers should be unloaded from a vessel?

In the circumstance of dynamic operations and uncertain behaviour, it is difficult to find the optimal solutions to the above questions mathematically. The aim of the paper is to present an easy-to-operate threshold-type policy with flexible destination ports, and investigate its effectiveness by comparing it with a conventional empty repositioning policy.

3. Flexible Destination Port Policy (FDP)

3.1 Loading empty container decisions

Suppose there is a dominant ocean leg that can separate the ports on the shipping route into two sets. For example, in a trans-Pacific route, the ports on the American side can be a set, and the ports on the Asian set can be the other set. Normally, due to the trade imbalance, one set consists of deficit ports, i.e. export volume is more than import volume; while the other set consists of surplus ports, i.e. import volume is more than export volume. Clearly, empty containers should be repositioned from the surplus set to the deficit set. Based on this observation, we can determine the direction of empty container repositioning between two sets.

It is reasonable to assume that empty containers at a port in the surplus set can be repositioned to any other ports; whereas empty containers at a port in the deficit set can only be repositioned to the ports within the deficit set. Take the trans-pacific shipping route as an example, empty containers at the ports on the American side can be repositioned to other ports on both sides, but those at Asian ports can only be repositioned to other Asian ports.

Note that the loading empty decisions will only be made when a vessel departure event occurs. The empty container loading decisions consist of the following four steps:

(1.) Identify direction of repositioning empty containers at the beginning of the planning horizon. Denote the deficit set as A, which is composed of deficit ports, and the surplus set as B, which is composed of surplus ports, i.e. $\sum_{u} \sum_{i \in A, j \in B} d_{ij}^{u} > \sum_{u} \sum_{i \in A, j \in B} d_{ji}^{u}$. The direction of repositioning empty containers is from the surplus set to the deficit set, i.e. from B to A.
(2.) Initialize the threshold values of empty container inventory for each port at the beginning of the planning horizon.

Suppose that port i has a pair of threshold values $\{D_i, U_i\}(U_i \geq D_i \geq 0)$ to control its empty container inventory. The empty repositioning requirements can be described as follows. If the empty container inventory is greater than the upper bound U_i, then empty containers should be moved out of the current port and bring the inventory level back to U_i; if it is less than the lower bound D_i, then empty containers should be moved into the current port from other ports and bring the inventory level up to D_i; otherwise, no repositioning is required.

The threshold values D_i, U_i are determined by net demands Δd_i at port i, which equals the difference of total exporting demands and total importing demands in a specific time period, e.g.,

$$\begin{cases} U_i = max\{0, \overline{\Delta d_i} + sd_i\} \\ D_i = max\{0, \overline{\Delta d_i} - sd_i\} \end{cases}$$

Where, $\overline{\Delta d_i}$ is the average net demand between two consecutive departure events at port i, and sd_i is the corresponding standard deviation.

(3.) Compute the estimated number of empty containers to be exported or imported for each port at stage k.

When vessel v is going to depart from port i in stage k, the number of empty containers left at the port after meeting customer demands is

$$s_i^{'}(k) = s_i(k-1) - \sum_{v} Y_i^v(k)$$

If there are no vessels calling at port i, $s_i^{'}(k) = s_i(k-1)$. The number of empty containers to be exported or imported is calculated as follows

$$\begin{cases} EO_i^v(k) = s_i^{'}(k) - U_i, EI_i^v(k) = 0 & , s_i^{'}(k) \geq U_i \\ EI_i^v(k) = D_i - s_i^{'}(k), EO_i^v(k) = 0 & , s_i^{'}(k) \leq D_i \\ EO_i^v(k) = EI_i^v(k) = 0 & , D_i \leq s_i^{'}(k) \leq U_i \end{cases}$$

(4.) Determine the actual number of empty containers to be exported from the current port.

For port i, if $i \in A$, i.e. it belongs to the deficit set, then the number of empty containers to be loaded onto vessel v is given as follows:

$$x_i^v(k) = min\left(EO_i^v(k), \sum_{j \neq i, j \in A} EI_j^v(k) \right)$$

If $i \in B$, i.e. it belongs to the surplus set, then,

$$x_i^v(k) = min\left(EO_i^v(k), \sum_{j \neq i, j \in A, j \in B} EI_j^v(k) \right)$$

3.2 Unloading empty container decisions

The unloading decisions will be made when a vessel arrival event occurs. In principle, the empty containers on board can be unloaded at any port that the vessel calls at. In reality, it is reasonable to assume that they will be unloaded from the vessel if the current port is short of empty containers or it is the last port that belongs to the deficit set in the service route. This is reasonable since we do not want to move empties across the ocean from the deficit region to the surplus region. The number of empty containers to be unloaded at port i is given as follows:

$$x_i^v(k) = \min\left(max\left(0, \sum_u \sum_{j \neq i} d_{ij}^u(k) - s_i(k-1) - \sum_j y_{ji}^v(k-1)\right), s^v(k-1)\right).$$

The above equation implies that if vessel v arrives at port i in the stage k, the number of empty containers to be unloaded from the vessel is the number of empty containers required for meeting the customer demands at port i subject to empty containers on board. However, if it is the last port that belongs to the deficit set in the service route, then $x_i^v(k) = s^v(k-1)$.

4. Determined Destination Port Policy (DDP)

In order to evaluate whether or in what conditions the flexible destination port policy (FDP) is effective, we introduce a conventional policy, termed determined destination port policy (DDP), to make a comparison.

The DDP has the same threshold structure as the FDP policy. The only difference is that under DDP, the destination ports of empty containers have to be explicitly specified before they were loaded onto a vessel. More specifically, it consists of the following steps:

(1.) Initialize the threshold values of empty container inventory for each port at the beginning of the planning horizon (Same as FDP)
(2.) Compute the estimated number of empty containers to be exported or imported at stage k (Same as FDP).
(3.) Determine the destination ports for empty containers based on the following equation.

$$x_{ij}^{v}(k) = \frac{EI_j^v(k)}{\sum_j EI_j^v(k)} \cdot min\,\{EO_i^v(k), \sum_j EI_j^v(k)\}$$

With a slight abuse of the notation, we let $x_{ij}^{v}(k)$ denote the number of empty containers to be repositioned from port i to port j via vessel v at stage k. Basically, the destination port for empty containers is determined by splitting those empties over deficit ports in proportion to its degree of the requirements for empty containers. The min in the above formula implies that the estimated exporting empties from the current port are capacitated by the total requirements of other ports.

It should be noted that the decision on unloading empty containers is not necessary under the DDP policy because all the empty containers on board have explicit destination ports, and they will be unloaded at pre-specified destination ports.

5. Numerical Experiments

In this section, we will evaluate and compare the performance of FDP and DDP using a simulation software ConSim developed by ourselves. To facilitate the comparison, we introduce another simple control policy, denoted as no repositioning policy (NRP), as a base, in which only laden containers will be loaded onto (unloaded from) vessels, and no empty containers will be repositioned explicitly.

5.1 System setting

The experiments were designed based on the real operational data in a Chinese shipping company (Qu, 2004). The service route is composed of six ports including Southampton (GBSOU), Le Havre (FRHAV), Rotterdam (NLROT), Hamburg(DEHAM), Charleston(USCHA), and Houston(USHOU) (See Figure 15). There are five container vessels deployed in the shipping route to provide weekly services. The capacity of each vessel is 5250, 5600, 5200, 5000 and 5000 TEUs respectively. From Europe to American, each vessel calls at all six ports one by one; from American to Europe, all vessels skip the port Le Havre (Figure 1).

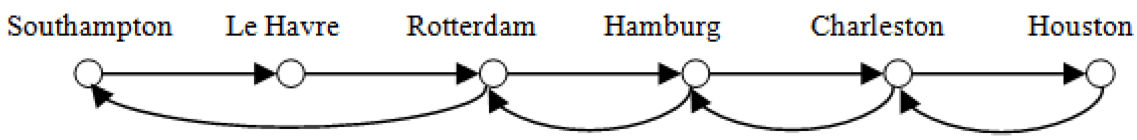

Figure 15: A Trans-Atlantic shipping service route

The journey time on one round trip for each vessel is 35 days. Part of the time-table for five vessels is shown in Table 1. The planning horizon in the simulation experiment is from Sept. 1st 2007 to Feb. 20th 2009. The unit costs of inventory and lifting cost are given in Table 4 and the transportation cost per unit between two ports is given in Table 5. Initially, the empty containers are allocated over ports according to the proportions shown in Table 6.

Table 4: Part of vessel schedules in the experiments

VSL NAME	GBSOU	FRHAV		NLROT		DEHAM		USCHA		USHOU
	ETD	ETA	ETD	ETA	ETD	ETA	ETD	ETA	ETD	ETA
101	9-1	9-2	9-2	9-3	9-4	9-5	9-6	9-15	9-16	9-19
102	9-8	9-9	9-9	9-10	9-11	9-12	9-13	9-22	9-23	9-26
103	9-15	9-16	9-16	9-17	9-18	9-19	9-20	9-29	9-30	10-3
104	9-22	9-23	9-23	9-24	9-25	9-26	9-27	10-6	10-7	10-10
105	9-29	9-30	9-30	10-1	10-2	10-3	10-4	10-13	10-14	10-17

VSL NAME	USHOU	USCHA		DEHAM		NLROT		GBSOU
	ETD	ETA	ETD	ETA	ETD	ETA	ETD	ETA
101	9-19	9-22	9-22	10-1	10-2	10-3	10-3	10-5
102	9-26	9-29	9-29	10-8	10-9	10-10	10-10	10-12
103	10-3	10-6	10-6	10-15	10-16	10-17	10-17	10-19
104	10-10	10-13	10-13	10-22	10-23	10-24	10-24	10-26
105	10-17	10-20	10-20	10-29	10-30	10-31	10-31	11-2

Table 5: Unit inventory and lifting costs at ports

Port	Unit inventory cost	Unit lift-on or lift-off cost
Southampton	0.30	30
Le Havre	0.28	29
Rotterdam	0.32	32
Hamburg	0.30	34
Charleston	0.30	32
Houston	0.29	28

Table 6: Unit transport cost between two neighbourhood ports in the route

NO.	From	To	Unit Cost per TEU
1	Southampton	Le Havre	3
2	Le Havre	Rotterdam	2
3	Rotterdam	Hamburg	7
4	Hamburg	Charleston	18
5	Charleston	Houston	5
6	Houston	Charleston	5
7	Charleston	Hamburg	18
8	Hamburg	Rotterdam	7
9	Rotterdam	Southampton	5

Table 7: Initial allocation of empty containers over ports

Port	Southampton	Le Havre	Rotterdam	Hamburg	Charleston	Houston
Empty containers	12.50%	12.50%	12.50%	18.75%	18.75%	25.00%

The uncertainty of customer demands can be represented by probability distributions. We assume that the daily demand from an origin port i to a destination port j (an OD pair) follows a uniform distribution $U(0, 2\mu_{ij})$, where μ_{ij} represents the average daily customer demands. Many factors may influence the effectiveness of an empty container repositioning policy. Two of the most important factors are the demand pattern and the container fleet size. The demand pattern determines the degree of trade imbalance, which is the root cause of empty repositioning. The container fleet size represents the physical container capacity, which has a direct impact on the empty repositioning decision. In the rest of this section, we will compare the performance of three policies, FDP, DDP, NRP, in a range of scenarios with different demand patterns or different container fleet sizes.

5.2 Scenarios with different demand patterns

Two kinds of demand patterns will be considered. The first has a moderate level of trade imbalance like the Trans-Atlantic pattern. The second is more severely imbalanced like the Europe/Asia or Trans-Pacific pattern. The average volumes of daily demands from port to port for two demand patterns are in Table 7 and Table 8 respectively. In Table 7, the ratio of the demands from Europe to American to those from American to Europe is 1.39. In Table 8, the ratio is 2.07.

Table 8: Average daily demands for the moderate imbalanced demand pattern

	Southampton	Le Havre	Rotterdam	Hamburg	Charleston	Houston
Southampton	0	20	17	37	36	42
Le Havre	0	0	14	43	50	27
Rotterdam	88	0	0	28	43	47
Hamburg	43	0	42	0	49	45
Charleston	17	0	25	37	0	50
Houston	43	0	52	70	36	0

Table 9: Average daily demands for the severely imbalanced demand pattern

	Southampton	Le Havre	Rotterdam	Hamburg	Charleston	Houston
Southampton	0	20	17	37	43	50
Le Havre	0	0	14	43	60	32
Rotterdam	88	0	0	28	52	56
Hamburg	43	0	42	0	59	54
Charleston	14	0	20	30	0	50
Houston	34	0	42	56	36	0

Let the container fleet size be fixed as 20,000 TEU in both scenarios. They are initially allocated over six ports according to the proportions in
Table 7. The total costs under different control policies for each demand pattern are shown in Table 10.

Table 10: Performance comparisons in scenarios with different demand patterns

Control policy	Moderate imbalanced demand pattern	Severely imbalanced demand pattern
FDP	137.7	173.2
DDP	137.5	181.7
NRP	176.7	196.7

It can be observed from Table 10 that: 1) the performance of FDP and DDP is better than NRP, which indicates that empty repositioning does reduce the total costs; 2) FDP is worse than DDP in the first scenario, while FDP outperforms DDP in the second scenario. Therefore, it appears that the FDP policy is probably more suitable for the service routes where customer demands are severely imbalanced (e.g. trans-Pacific route), while the DDP policy is more suitable for less imbalanced trade routes.

5.3 Scenarios with different fleet sizes

In this section, nine scenarios were designed to investigate the sensitivity of FDP and DDP to the container fleet size. In all scenarios, we assume that the customer demand pattern is fixed as given in Table 9. From scenario 1 to scenario 9, the container fleet size varies from 10,000 TEU to 90,000 TEU. The total costs under different control policies in 9 scenarios are shown in Table 11.

Table 11: Performance comparisons in scenarios with different container fleet sizes

	10000	20000	30000	40000	50000	60000	70000	80000	90000
FDP	174.7	173.2	140.1	135.5	131.3	201.2	210.5	222.3	234.1
DDP	182.5	181.7	145.6	137.9	133.4	203.6	212.6	221.7	230.8
NRP	194.1	196.7	161.6	155.2	151.9	225.1	235.5	246.2	256.8

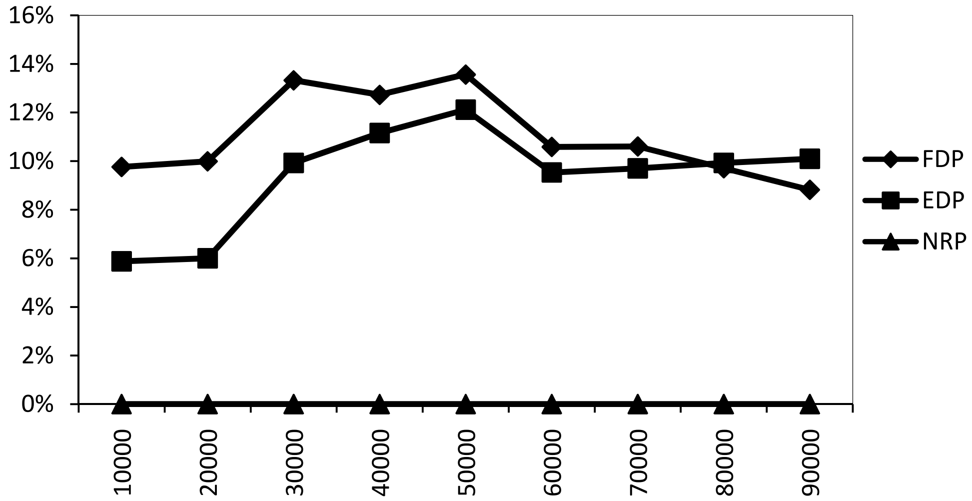

Figure 16: Cost reduction percentages in scenarios with different container fleet sizes

To have a clearer view of the relative performance of FDP and DDP, we use NRP as a base. The cost reduction percentages achieved by FDP and DDP from the base case are shown in Figure 16. It can be seen from Table 11 and Figure 16 that: 1) the FDP policy is better than the DDP policy for the scenarios in which container fleet size is less than 80,000; 2) the performance of FDP is worse than DDP when container fleet size is greater than 80,000; 3) both FDP and DDP policies are significant better than the NRP policy, and 4) the total costs are convex with respect to the fleet size for the given empty repositioning policy and the demand pattern. A shipping company usually owns a container fleet that is less than 3 times of its vessel fleet capacity. Note that the total vessel fleet capacity in our experiment is 26,050 TEU, which gives an upper bound of container fleet size 78,150 TEU. Therefore, in most scenarios of fleet sizes, the empty repositioning policy with flexible destination is more appropriate than the repositioning policy with determined destination ports, particularly in the situations when the container fleet size is relatively small.

6. Conclusion

Motivated by industrial practices, this paper formulates the empty container repositioning problem in a dynamic and stochastic environment in such a way that the empty repositioning decisions are divided into two parts: empty loading decisions and empty unloading decisions. A new repositioning policy with flexible destination ports is presented. Under this policy, the decisions on where and how many empties should be repositioned to can be made at the latest point when more accurate and timely information become available. The flexible destination port policy (FDP) is evaluated and compared with a conventional determined destination port policy (DDP) in a range of scenarios using a simulation tool. The experimental results demonstrate that FDP is more effective than DDP when the trade demands crossing the longest ocean leg are more severely imbalanced. It is also observed that FDP outperforms DDP more significantly as the container fleet size decreases. The interpretation of the above results is that if the shipping system requires more empty movements, the FDP policy appears to be more effective than the DDP policy. However, more intensive experiments are needed to confirm and generalize the above findings.

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Factors Driving Shipping Companies to IT Outsourcing

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Abstract

Outsourcing, in the recent past, has emerged as business strategy to gain competitive advantage. Various industries ranging from manufacturing banking, finance, marketing and education to a plethora of other successfully use this strategy. Despite the ongoing debate over its business benefits and risks, information systems (IS) outsourcing has become so pervasive that shipping companies cannot ignore it. In spite of concerns about decreased control more and more shipping companies today are moving toward outsourcing IT functions to save time and money. This paper tries to identify the factors which drives the shipping companies to IT outsourcing. In particular it employs the Analytical Hierarchy Process (A.H.P) as analysis method for IT outsourcing decision, which is used as a decision tool from shipping companies. The factors that affect IT outsourcing decision were recorded from the state of the art review in several IT sectors and a field research study in international level i.e. (interviews, focus groups from IT professional experts, academics and shipping professionals). The criteria and subcriteria for IT outsourcing in shipping and their weight ranking were provided from the above interviews. Finally, an IT outsourcing decision framework is provided that can be implemented in shipping companies.

1. Introduction

The Information systems outsourcing began in 1954 by General Electric Corp. so it is not a new phenomenon (Yang-Huang 2000). It began in 1960's and 70's with the data management in financial operations. In 1960's the use of external providers was confined to time sharing or processing services. In 70's created for the first time application packages. In 80's the development of low cost microcomputers and later personal computers influenced the IT services.

By the time the focus shifted to IT supported vertical integration in the 1980's, the outsourcing trend of the 1970's had lost its steam (Lee –Huynh-Wai-Ming Pi, 2003). Interest in outsourcing resurfaced in the early 1990's, not for contract programming and specific processing services, but for network and telecommunication management, distributed system integration, application development and systems operations. The outsourcing vendors of 1990's aggressively targeted in facilities management. IT personnel were shifted from the customer to the vendor, with some the vendors purchasing customers' hardware and managing client services onsite. System integration was another popular outsourcing segment in the 1990's and involved complex technology, including network management and telecommunications, along with associated education and training.

Lohn and Venkatraman (1992) defined outsourcing as: "the significant contribution by external vendors in the physical and /or human resources associated with entire specific components of the IT infrastructure in the user's organization" Gonzalez-Llopis (2005) gave definition of IS outsourcing : "Information systems outsourcing means that the physical and /human resources related to an organization's information technology (IT) are going to be provided and/or managed by an external supplier.Willcocks, Lacity, Fitzerald (1995) defined it as "handing over to third party management for required result, some or all of an organizations IT information system and related service". Competence, increased IS department flexibility, improved IS quality, improved communication

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problems, increased ability of management and control of IS department.

The main reasons for IS outsourcing are the following: focus on core t, share risks, increased access to new technologies, access to specialized supplier who has specialized personnel, staff and technology costs savings, decrease of investment, change fixed costs into variable costs and procure higher reliability and performance of IS (Yang- Huang 2000; M.Greaver 1998; Domberger 1998; Lankford-Parsa 1999; Gilley-Rasheed 2000; Gonzalez-Gasco-Llopis 2005; Rodriguez-Padilla 2005).

IT services which are usually outsourced: Technical support, networking, systems infrastructure, development environment, applications, content, process support, process execution

Shipping industry is a sector of economy that is affected from the global economic, social, political and technological changes.

The shipping companies which manage a large number of ships prefer integrated solutions through successful communications ship and office, while small ones use isolated applications. Large companies have in house IT department while small companies use external provider for hardware and software

This paper tries to identify the factors which drives the shipping companies to IT outsourcing. In particular it employs the Analytical Hierarchy Process (A.H.P) as analysis method for IT outsourcing decision, which is used as a decision tool from shipping companies. Finally it is developed a new IT outsourcing decision model in shipping. Section 2 examines the implementation of IT outsourcing in shipping industry and the nature of the IT activities. Section 3 presents a conceptual model .Section 4. Presents the Analytic Hierarchy Process that is a multicriteria method for decision making and the implementation of this method to IT outsourcing decision making a new outsourcing framework in shipping. Section 5 presents the hierarchical structure of IT outsourcing decision model. In section 5.2 is presented the research results and the implementation of IT outsourcing decision model in ship management companies. Finally conclusions are given in Section 6.

2. ICT Outsourcing in Shipping

The IT in Shipping Industry and especially IT in shipping companies includes hardware and software. IT outsourcing in shipping mainly refer to software.

The role of communications in shipping is very significant because the communications infrastructure of ship is necessary for emergency situations. Software for communication ship to shore that is used in shipping companies depends on departments that exist in company. Electronic Maritime Services has been divided into 10 categories according to their use .A ship management company is an IT oriented when its departments cover all the categories by using EMS and are the following :

(1.) Communication software/Teleconference.
(2.) Quality and Safety management ISM, ISPS.
(3.) a. Planned/Periodic Maintenance System/Ship performance/Repairs
b. Monitoring hull &Machinery Maintenance.
c. Dry docking.
(4.) Inventory control (provisions/stores/spares)
(5.) Electronic Procurement (provisions/stores/spares)
(6.) Operation/Voyage management.
(7.) Chartering and sales & purchase
(8.) Human resource management/crew, training.
(9.) Financial applications accounting/MGA/Payroll.
(10.) Maritime Electronic Marketplaces.

The communication needs of ships are mainly electronic data interchange between ship –company and others such as shipbrokers, agents, authorities, suppliers, shippers, insurers etc.

Recently have developed new communications technologies in shipping companies. The use of these technologies in communications between ship and office has driven in a large capacity of data interchange which requires specific software.

In the telecommunications market a variety of alternative satellite communication services are offered by new providers to ocean shipping industry, in a market that leading role was played for many years by Inmarsat. Iridium and Globalstar present competitive products in voice services, whereas VSAT systems provide broadband connections to the vessel.

Large shipping companies developed specific software in house.

It was created companies specialized in shipping software. There are two categories of shipping software companies, the first includes companies which provide integrated solutions through successful communications between ship and office. The second category includes companies which produce software for the basic needs of shipping companies. Large Greekowned shipping companies use integrated IS which connect maritime operations with chartering and accounting, while small ones use isolated software applications.

Large companies have in house IT department while small companies use external provider for hardware and software. In 2006 was carried out a research in 13 Greekowned shipping companies (Stratakos, Nikitakos, Lambrou 2006). The results of above research are the following: The 77% of Greekowned shipping companies engage IT department experts and 23%of them do not have IT department or an expert but they outsource the IT support to third parties. Also decisions for investments in IT and communications made 38% from IT managers and 62% from general managers. The technical support of hardware and software (operating systems and general applications) made in house by 46%, outsourced 23% and the 31% of companies use a combination both in house and outsourced support. The technical support of specialized maritime applications (software) made both in house and outsourced 31% and 69% outsourced. The technical support of enterprise network is supervised by IT departments of the companies 62%.A smaller percentage 23% is outsourced due to high technical knowledge required for the maintenance of the network support and 15% is combining both solutions. The technical support of web applications are developed in house 31%, outsourced 31% and not applicable 38%.

The shipping companies use specific shipping software in large scale. Today there are faster connections so many solutions are offered. The choice of solution depends on users' needs, the cost of first establishment and the cost of use.

3. Developing a Model of IT Outsourcing in Shipping

Yang- Hang (2000) proposes five factors that affect IS outsourcing decision which are management, strategy, technology, economics and quality. They propose a decision model for IS outsourcing using analytical hierarchy process which is based on above factors. Wang – Yang (2006), suggest a hybrid multicriteria decision model for IS outsourcing, which includes six factors that affect outsourcing decision, which are economics, recourses, strategy, risk, management and quality. In our paper it is proposed a new conceptual model for IT outsourcing in shipping (Figure 1) which is based on the model for IT outsourcing of Tamimi, 2006 and an adaptation in shipping is performed.

According to the model, outsourcing decision is affected from three factors: motives, risks and satisfaction from outsourcing.The satisfaction from outsourcing implementation is affected from cost, reliability, performance and security. The motives and risks of IT outsourcing are divided in five main categories:strategic, managerial, technological, economics and qualitative and are analyzed in details in this paragraph (Yang- Huang 2000; Tammimi, 2006; M.Greaver 1998; Domberger 1998; Lankford-Parsa 1999; Gilley-Rasheed 2000; Gonzalez-Gasco-Llopis 2005; Rodriguez-Padilla 2005).

Table 1: Motives and risks of IT outsourcing

Motivation
Strategic
1. Focus on core competence,
2. Share risks.
Managerial
1. Improve communication problems,
2. Increase the ability of management,
3. Increased flexibility.
Technological
1. Access to new technologies,
2. Access to specialized providers.
Economics
1. Staff cost savings,
2. Technology cost savings,
3. Financial flexibility.
Qualitative
1. High performance of IS,
2. Higher service level.

Risks
Strategic
1. Loss of core competence,
2. Loss of internal technical knowledge .
Managerial
1. Dependence on providers,
2. Loss of control over providers,
3. Problems with vendors
Technological
1. Damaging the firm's innovating capability.
Economics
1. Poor cost benefit ratio .
Qualitative
1. Do not exist specialized providers.

After outsourcing decision making the next step is the vendor(s) selection which is based on vendors' selection and vendors' evaluation criteria. The vendors selection criteria in higher education IT according to Tammimi (2006) are: price, capability, outsourcing experience and experience in higher education .Parsasuraman, Zeithaml, Berry (1985), Gronross (1990) and Panayides (2002) suggest a list of vendors' selection and vendors' evaluation criteria.

The results of the study of above literature related on vendors selection and evaluation criteria are presented in Figure 1. In the future, we are scheduling to make an initial investigation in order to find the factors which affect the IT outsourcing decision in greekowned and international shipping.

This paper is a part of a bigger study about IT outsourcing in Shipping. This conceptual model for IT outsourcing in Shipping can be improved and it will become a decision making tool or ICT outsourcing in Ship management companies. In this study will be created a decision model for the choice of the type of ICT sourcing and a decision model for ICT vendor selection in Shipping industry. According to the IT outsourcing models of Tammimi (2006) and Yang-Huang (2000) which we based, outsourcing decision is affected from three factors (criteria) : motives ,risks and satisfaction from outsourcing . These three factors are affected from other (subcriteria) .Finally taking in to account the above criteria and sub-criteria we will decide which alternative type of ICT sourcing we will choice. The outsourcing decision should consider various factors, including tangible (cost) and intangible (quality,strategy etc) factors.

The decision process should include clear, coherent analytic steps and can generate numerical results to convince those who involved accepting the result. Saaty (1980) developed a method namely Analytic Hierarchy Process (AHP) to solve decision problems with uncertainty and with multiple criteria characteristics .AHP is a method that collect expertise of decision makers and uses hierarchy structure to present a complex decision problems by decomposing into several sub-problems (Forman-Selly ,2002).The first level of hierarchy is the goal we want to reach and the elements of lower levels are criteria ,sub-criteria ,sub-sub-criteria and in the lowest level are the alternatives, so there are five hierarchical levels (see Table 1 and Figure 1). The criteria, sub-criteria and sub-sub- criteria are used to evaluate the alternatives .The AHP method encompasses three steps: First constructing the hierarchy; second, computing the weight of criteria and sub-criteria; and third, computing the weight of alternatives, evaluation the alternatives and decision making (Yang-Huang, 2000).

After the completed adaptation of this model in shipping, it will be used the Analytic Hierarchy Process method in IT outsourcing decision making, in order to be refined.

4. The Analytic Hierarchy Process

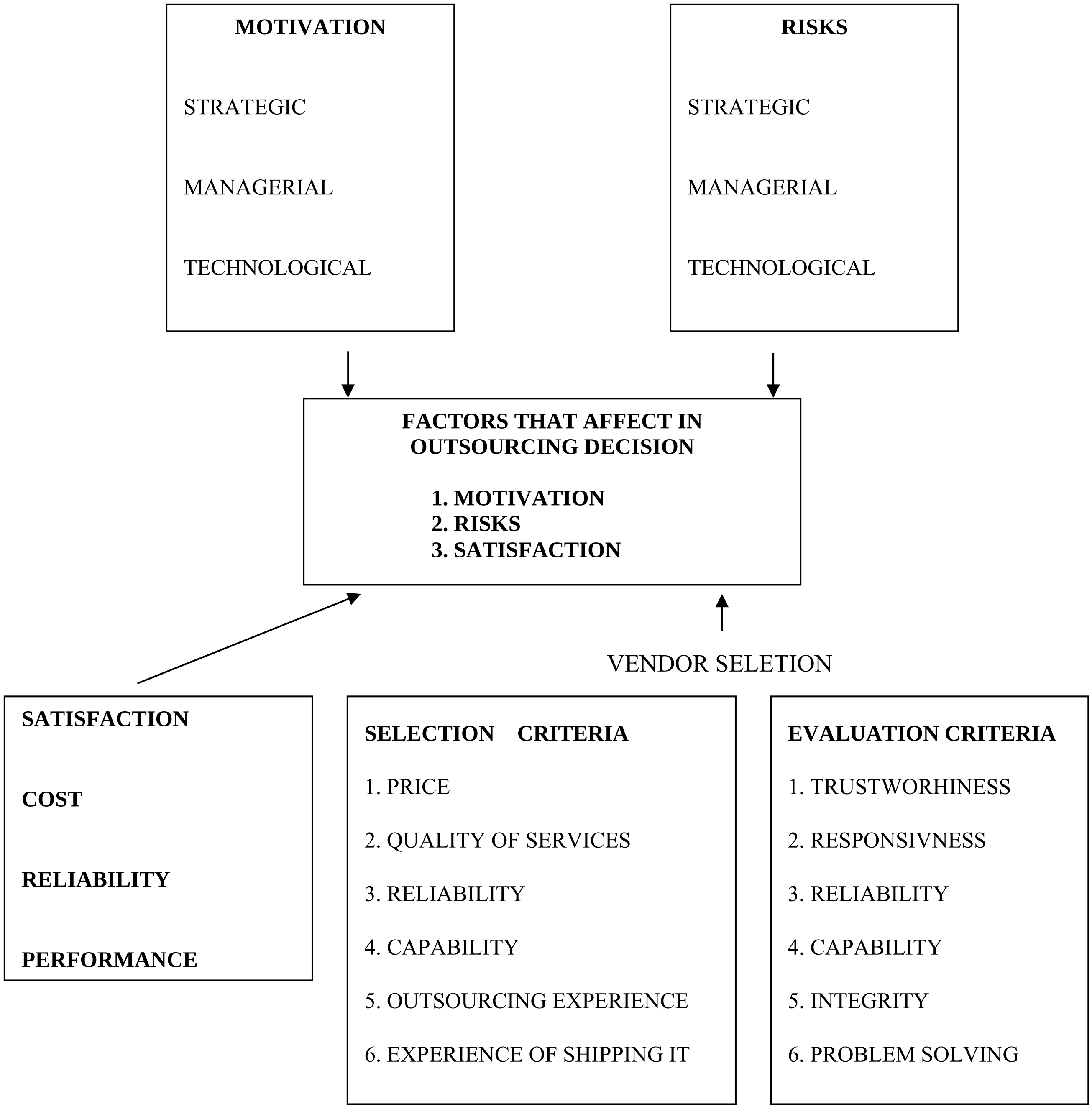
4.1 Method description

AHP is a multicriteria method for decision making and priorities ranking developed by Saaty (1971; 1980; 1990) this method collects expertise of decision makers and uses a hierarchic structure to present a complex decision problem by decomposing it into sub problems. AHP is a method which combines subjective and objective estimations or perceptions in an integrated framework which is based on scale ratios from pair comparisons (Saaty 1980).The AHP algorithm is based on matrix algebra. The judgments from the pair comparisons are made by experts or decisions makers and in combination with use of the AHP algorithm are the tools which produce the final combination. This is the ranking priorities of each element or alternative regarding the ultimate goal according to their specific gravity, which is expressed in percentile form. Before proceed further to the discussion of the method.

It is worth defining the term “experts who are the responders of the AHP questionnaires .There are three types of AHP applications (Saaty 1994).These are: (a) the AHP which based on the distributive relative measurement approach, (b) this which use the ideal relative measurement approach and (c) the one which use the absolute measurement mode.

The AHP method encompasses three steps, first constructing the hierarchy; second computing the weight of the elements each level; and third computing the weight of alternatives (Yang- Huang 2000)

(1.) The construction of a hierarchy. A complex problem can be dealt with by decomposing it into sub problems within hierarchy. The elements in a level of hierarchy would not exceed seven because it is difficult for human beings to deal with more than seven things simultaneously. The highest level with only one element is the goal we want to reach and the elements in the lowest level are the alternatives. Elements in the middle levels are the criteria or attributes for evaluating alternatives.
(2.) Compute the weight of the elements in each level. Three steps can be describe this phase: Paired comparisons, computing a vector priorities and measuring consistency. The paired comparisons can be based on preference, probability or importance and usually are based on expert’s estimations ,usually on 9 point scale. The number of comparison is n(n-1)/2 where n= number of criteria.
(3.) The synthesis of the priorities and the measurement of the alternatives (if there exist) which will give outcome of the whole process. There are four ways for the calculations of priorities:
    (a.) The consensus;
    (b.) The vote compromise;
    (c.) The geometric mean of personal judgments; and
    (d.) The weighted arithmetic mean.



Source: Adapted by Tammimi (2006)

Figure 1: Conceptual model for IT outsourcing in shipping.

AHP has four axioms which are vital importance for its application and the extraction of reliable results. These are (Forman Selly 2002):

- The reciprocal axiom. If Pc(Ea, Eb)is a pair comparison of the subcriteria a, b regarding the criterion c ,thenPc(Eb , Ea)= 1/Pc (Ea, Eb)
- Homogeneity axiom .The importance of criteria or sucriteria is equal (Saaty 1990)
- Independence axiom .The elements in the hierarchy are not dependent fom the elements in the lower level of the hierarchy
- The proper use of AHP. In order to have reliable results from the application of AHP, except from improper use of judgments in pair comparisons must be consistent. In order to trace the inconsistency, there is an inconsistency ratio (IR). This ratio must be IR< 0,1 in order to have reliable judgments and out comes (Saaty 1980).

4.2 Use of analytic hierarchy process in IT outsourcing decision making

Yang-Kim-Nam-Min (2006) exams the factors that affect the BPO decision and structures a decision model using AHP method. They suggest a decision model for BPO adoption for management and hot it may applied in a real decision process for BPO .Determinants affecting BPO adoption were investigated in multiple dimensions including expectation, risk and environment .

Finally a total of eight factors in three criteria were chosen. The three criteria is expectation, risk and environment. The subciteria for expectation are cost savings ,focus on core competence and flexibility ,for risk are information security loss of management control, labor union, morale problem, for environment is vendor's service quality. The possible alternatives are :A. outsourcing business process, B. maintaining current business and C. modifying and maintaining current business process. They did two surveys; the first survey is verifying the reasonable of the chosen determinants (questionnaire in experts) while the second survey is for computing the weight of settled factors through the first survey using AHP methodology (interviews of CEO's).

Yang Huang (2000) was created a decision model for IS outsourcing take into account the factors that affect that decision.

A careful examination of those factors mentioned above concludes that five dimensions or factors, management, strategy, technology, economics and quality should be employed. Distinct attribute of these factors exist as shown in Table 2.

The proposed model included five steps.

(1.) Establish the expert team
(2.) Choose the factors and attributes
(3.) Construct the analytical hierarchy
(4.) Compute the alternatives
(5.) Make decision

The candidate systems for outsourcing (alternatives) are facilities management, maintenance of management Information System and new development.

Table 2: The factors and attributes of outsourcing

Management
- Stimulate IS department to improve their performance and enhance morale
- Improve communication problems and selfishness between IS department and operational department
- Solve the floating and scarcity of employee
- Increase the ability of management and control of IS department
- Keep the flexibility to adjust department, including consolidation or decentralization

Strategy
- Focus on core competence
- Make strategic alliance with vendor to make up the shortages of resources or technology
- Form a new company by concatenating core competencies of this strategic alliances to develop new product and sell
- Share the risks
- Time to market

Technology
- Get new technology
- Learn new technology of software management

Economics
- Reduce the developing and maintaining cost of information systems
- Make the fixed costs to become variable costs
- Increase the flexibility in finance

Quality
- Produce higher reliability and performance of IS
- Reach higher service level

G.Udo (2000) proposed the used of Analytic Hierarchy Process to analyze the information technology outsourcing decision. The main criteria for IT outsourcing decision that evaluate and rank IT function for outsourcing decision are: strategic importance, stakeholder's interest, vendor's issues, cost operation, industry environment.

Wang-Yang (2006) used a hybrid multicriteria decision aid method for information systems outsourcing. They proposed six factors (criteria) including economics, resource, strategy, risk, management and quality, should be considered for outsourcing decision. The above factors in details are:

(1.) Economics, means, reduce costs of information systems, economic scale of vendors and financial flexibility.
(2.) Resource includes new technologies at professional workers.
(3.) Strategy firms need to focus on their core activities and outsource non core activities.
(4.) Risk includes, loss of core competence, loss of internal technical knowledge, loss of flexibility, damaging the firm's innovative capability increasing information services management complexity, etc.
(5.) Management includes problem as: improving communication problems, improve performance of IS department, increasing the ability of management and control of IS department, solving the floating and scarcity of employee, keeping the flexibility to adjust department.
(6.) Quality because vendor's may have access to more resources, have more qualified or more motivated personnel, provide a greater breath of services etc.

The Analytic Hierarchy Process is used to analyze the structure of the outsourcing problem and determine of weights of the criteria and PROMETHEE method is used for final ranking, together with changing weights for a sensitivity analysis.

5. Research Framework for Applying AHP in ICT Outsourcing in Shipping.

5.1 The construction of hierarchy model

The research framework aims at the choice of ICT sourcing type that can be used by a shipping company using the AHP. This decision is based in 3 criteria and 5or 4 sub-criteria for each criterion, also each sub-criterion is affected from 1to 3 sub-sub-criteria.

The study applies AHP as a decision making tool. Following the three processes approach ,the first step in research is the construction of hierarchy .The choice of ICT sourcing type designated as the ultimate goal(upper level).In the middle levels of hierarchy there are 3criteria :motivation, risks ,satisfaction and 5 sub-criteria for motivation and risks: strategic, managerial, technological, economic qualitative, also 4 sub-criteria for satisfaction :cost ,reliability, performance and security .For each sub criterion there 1 to 3 sub-sub-criteria which are referred above in Table 1.In the lowest level there are the alternatives :in house, total outsourcing, selective outsourcing

5.2 Interviews development and sample selection

The criteria, sub criteria that can be taken into account for decision making of which type of IT sourcing can be used by Ship management companies, defined by interviews with ICT experts in Shipping (ICT managers in Ship management companies). The next step in the research framework has been the development of structured interview based on AHP model. Based on AHP theory we were received interviews by experts and decision makers.

A total sample of 20 experts was developed, they are ICT managers in Greek owned shipping companies. The second stage contains the computation the weight of the elements in each level, paired comparisons, computing a vector priorities and measuring consistency The third stage of research contains the synthesis of the priorities and the measurement of the alternatives

5.2.1 Research Results

The third step of the research is the data process and synthesis of the results. The data from structured interviews were processed using the Expert Choice 2000 PC software

The research focus is the assessment of critical factors which driving Ship management companies to IT outsourcing. For the proposes of this study a structured interview was created to be answered by ICT managers of Greek owned shipping companies endeavoring the ocean going market.

This study is the part of a larger research of IT outsourcing in Shipping and the interviews are the pilot research.

Briefly the questions asked included the size of company (number, type and size of fleet), the number of IT personnel of ship management companies , which IT functions are outsourced ,in sourced and partial outsourced, the reasons which driving to IT outsourcing ,the risks of IT outsourcing and the satisfaction from IT outsourcing.

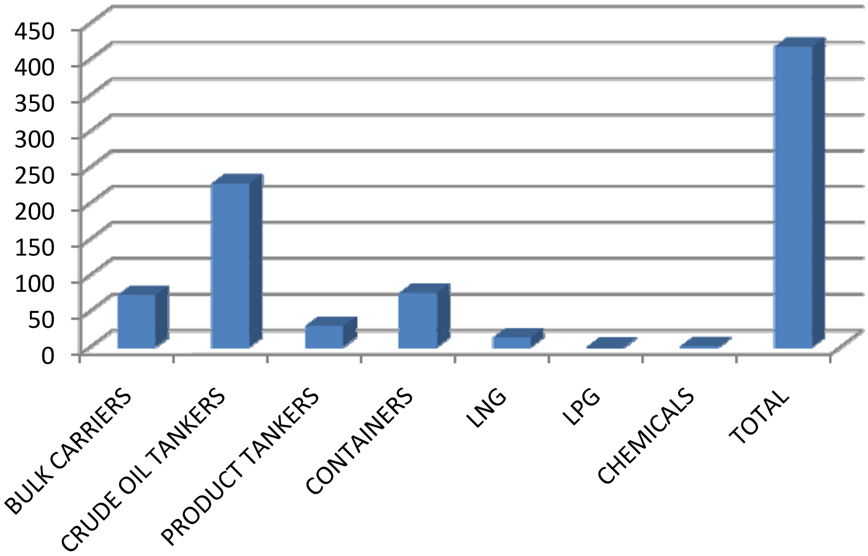
5.2.2 Size of Fleet

According to the given answers by the ICT managers of 20 Greek owned shipping companies, the number and types of vessels are the following:

Table 3: Fleet size/type

Type of Vessels	No vessels	%
- Bulk carriers	72	17,3
- Crude oil tankers	227	54,4
- Product tankers	29	6,95
- Container ship	75	18
- LNG	13	3,12
- LPG	0	0
- Chemical	1	0,24
TOTAL	417	100

Total DWT: 23685000



5.2.3 IT department in Greek owned shipping companies

The 100 % of Greekowned shipping companies engage in the IT departments experts. The number of IT personnel in shipping companies are **from 1 to 9** employees and the **average is 2**, **8 employees**, 15 companies have 1-3 employees in IT department.

5.2.4 ICT Functions which are outsourced, in-house or combination of both

According to the given answers the ICT Functions sourcing presented in the following table.

Table 4: ICT functions which are outsourced, in-house or combination of both

ICT functions in house , outsourced, or combination of both	In house	In house %	Outsourced	Outsourced %	Inhouse/outsourced	Inhouse/outsourced %
- Technical support of hardware	4	20	6	30	10	50
- Software support	4	20	14	70	2	10
- Technical support of enterprise network	10	50	6	30	4	20
- Development software applications	2	10	14	70	4	20
- Network management	20	100	0	0	0	0
- Communication software	1	5	18	90	1	5
- Support of communication software	1	5	18	90	1	5

The 30% of Greekowned shipping companies outsource the technical support of hardware, 20% do support in house and 50% have this support in combination in house and outsource. The 70% of Greekowned shipping companies are outsourced the software support, 20% do this support in house and

10% have this support in combination in house and outsource. The 30% of Greekowned shipping companies are outsourced the technical support of enterprise network, 50% do this support in house and 20% have this support in combination in house and outsource. The 70% of Greekowned shipping companies are outsourced the development software applications, 10% do this applications in house and 20% do this applications in combination in house and outsource. The 100% of Greekowned shipping companies have in house network management. The 90% of Greekowned shipping companies are outsourced the communications software and the support of this, 5% do this software and support in house and 5% do this software and support in combination in house and outsource.

5.2.5 The motives of IT outsourcing in Greekowned Ship management companies

The study present the ranking of the motivations of IT outsourcing in Greekowned Ship management companies which are ranked below according to importance given by responders. The main motives according to responders are: Procure reliability and performance of IS and higher service level (75%), access to new technologies and staff cost savings (65%), focus on core competence and access to specialized providers (60%).

Table 5: IT outsourcing motives

Motivation	%	No comp.
Strategic:		
Focus on core competence	60%	12
Share risks	45%	9
Managerial:		
Ability of management	55%	11
Increased IS department flexibility	55%	11
Improve communication problems	20%	4
Technological :		
Access to new technologies	65%	13
Access to specialized providers	60%	12
Economics:		
Staff cost savings	65%	13
Technology cost savings	45%	9
Financial flexibility	45%	9
Qualitative:		
Procure reliability and performance of IS	75%	15
Higher service level	75%	15

5.2.6 The risks of IT outsourcing in Greekowned Ship management companies

The study presents the ranking of the risks of IT outsourcing in Greekowned Ship management companies which ranked below according to importance given by responders. The main risks according to responders are: Loss of core competence 75%, loss of internal technical knowledge 70%, dependence on providers and problems with vendor 60%.

Table 6: Risks of IT outsourcing

Risks	%	No comp.
Strategic:		
Loss of core competence	75%	15
loss of internal technical knowledge .	70%	14
Managerial:		
Dependence on providers	60%	12
loss of control over providers	55%	11
problems with vendor	60%	12
Technological:		
Damaging the firm's innovating capability.	45%	9
Economic:		
Poor cost benefit ratio	25%	5
Qualitative:		
Superior providers to the existing internal unit do not exist.	40%	8

5.2.7 The satisfaction from IT outsourcing in Greekowned Ship management companies

The study presents the ranking of the satisfaction of IT outsourcing in Greekowned Ship management companies which ranked below according to importance given by responders. The main factors of satisfaction according to responders are: performance 80%, reliability 75%, cost and security 70%.

Table 7: The satisfaction from IT outsourcing

Satisfaction	%	No comp.
Cost	70%	14
Reliability	75%	15
Performance	80%	16
Security	70%	14

6. Conclusion

In this study it is proposed a new conceptual model for IT outsourcing in shipping which is based on the model for IT outsourcing of Tamimi, 2006 and an adaptation in shipping is performed .According to this model ,outsourcing decision is affected from three factors : motives, risks and satisfaction from outsourcing. After the outsourcing decision the vendor's selection is examined based on specific selection and evaluation criteria(Panayides 2002;Parsasuraman 1985;Gronross 1990; Tammimi 2006).

In according to field research the ICT functions which are outsourced from Greek owned shipping companies in large scale ,are Communication software and Support of communication software (90%) , also development of software applications and software support (70%).

This study tries to identify the factors which drives the shipping companies to IT outsourcing. In particular it employs the Analytical Hierarchy Process (A.H.P) as analysis method for IT outsourcing decision, which is used as a decision tool from shipping companies.

The factors that affect IT outsourcing decision were recorded from the state of the art review in several IT sectors and a field research study. (Interviews focus groups from IT professional experts, and shipping professionals).

The criteria and subcriteria for IT outsourcing in shipping and their weight ranking were provided from the interviews. Finally, an IT outsourcing decision model is provided that can be implemented in shipping companies.

In the future, this model after its pilot implementation in shipping ,it will be used for vendor's selection which will be based on specific selection and evaluation criteria (Panayides 2002) and an IT vendor selection model will be developed .

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Assessing the Natural and Socio-Economic Environments caused by Routine Maritime Activities: a New Perspective and its Applications to North Europe

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Abstract

Environmental impacts had been well-recognized as an increasingly significant problem within contemporary maritime industry. Routine pollution, like oil spills and emissions from maritime operation, does not only generate negative externalities within the industry, but also supply chains and the surrounding environment. This problem, however, is often under-researched, mainly due to its invisibility and unnoticeable character. Understanding such deficiency, this paper proposes a new perspective in assessing the natural and social-economic costs caused by routine maritime activities and applies it to the case of Port of Rotterdam, The Netherlands. Based on the analytical results, measures for improvements will also be provided.

Keywords: Maritime pollution; Environmental impact; Social-economic; Port of Rotterdam; MARPOL 73/78

1. Introduction

Scientific knowledge on the dimension of the societal, environmental problems and external costs associated with transport has grown over the time (Button, 1999) and various tools in measuring the impacts posed by externalities have developed, with the most appropriate approaches being widely documented within the economic literature, e.g. Baumol and Oates (1988); Helm (1991); Pearce (1995); Button (1993a); INFRAS/IWW (2000), etc. As one of the most important components of the negative externality, environmental impacts had been taken high attention within the transport industry and studies which specifically targeted on evaluating the maritime-generated environmental impacts had appeared within the scientific field. However, while the introduction of evaluation methodologies specifically for accidental incidents during commercial maritime activities causing significant pollutions (such as large-scale oil spills from ship collisions) had been immense, e.g., Rawson *et al.* (1998); Etkin (2003); Garza-Gil and Prada-Blanco (2006); Liu and Wirtz (2006); Bigano and Sheehan (2006), etc., such major shipping incidental pollution, while often catching public attention due to its spectacular scale and easy visibility (Kingdon, 1995), did not necessarily make them the most important source of oil pollution at sea (Etkin 1999; Etkin *et al.*, 1999; GESAMP 2001), and incidental pollution was merely a tip of the iceberg within the maritime industry's environmental impacts as a whole. Indeed, chronic pollutions from routine maritime activities often shadowed constant threats to coastal environmental and socio-economic welfare, leading to far greater impacts over time. For example, in the European Union (EU) alone, the annual chronic oiling amounts to eight times the spills of the *Exxon Valdez* disaster, and a small amount of illegally dumped oil in a crucial seabird habitat could be far more deadly than a large, incidental oil spill elsewhere (IFAW, 2007).

Despite IFAW's efforts in providing a thorough investigation on the impacted seabirds suffered from chronic maritime oil spills, however, it had not gone any further involving other possible maritime-generated pollution sources, e.g., chemical wash water, sewage, etc., not to mention the lack

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of consideration of the socio-economic impacts caused by shipping and port operations. Understanding this deficiency, the endeavour of this paper is to evaluate the chronic negative impacts on the natural and socio-economic environments caused by routine maritime activities. After this introductory section, Section 2 consists of the literature review where existing works, as well as their deficiencies, will be reviewed. This is followed by Section 3 where the authors will introduce a new perspective in assessing the natural and socio-economic impacts caused by routine maritime activities, including response and research costs. In Section 4, an empirical study on the Port of Rotterdam (PoR), The Netherlands, will be undertaken to illustrate the model's application, where a forecast for the long-term impacts on PoR will also be discussed, finally followed by the conclusions in Section 5. By shedding light on an important but under-researched issue, the authors are confident that this paper has played its role in contributing to the progress of achieving blue oceans in the foreseeable future.

2. Literature Review

A review of past literature indicated that different methodologies of evaluating the transport-related environmental impacts had been introduced. For example, the INFRAS/IWW report, entitled *External Costs of Transport: Accident, Environmental and Congestion Costs in Western Europe*, with the objective to improve the empirical basis of external costs of transport based on the actual state-of-the-art of cost estimation methodologies and identified a general approach (INFRSA/IWW, 2000), introduced a methodology to evaluate broad external costs generated by all kinds of transport modes. The broad costs categories covered not only the various environmental impact costs, e.g., nature damages, noise, air pollution, climate change, etc., but also other costs triggered by accidents and congestion within the transport sector. Here the most significant methodology was the 'resource' approach, or the so-called 'damage cost' approach, which was introduced to estimate the opportunity costs in damaged natural resources or social welfares. If one could not properly estimate the damage costs, the second best approach, called the 'prevention' approach, aiming to estimate the costs spent on avoiding the potential environmental impact, would be introduced, especially on climate change aspect (INFRAS/IWW, 2000; Daniels and Adamowicz, 2000).

Later in 2005, based on the INFRAS/IWW (2000) study, the EU updated the methodology in their research project entitled *ExternE*. Similar to the INFRAS/IWW report in 2000, this study concentrated on external costs evaluation, of which the environmental impact was one category. *ExternE* was not designed specifically for maritime transport sector, but a more general purpose to quantify all the energy-related external costs from electricity and heat production as well as transportation. It had developed an original methodology, namely the 'impact pathway' approach, which was useful especially in the quantification of the impacts by emission through providing a framework in transforming impacts, which were originally expressed in different units, into a common monetary value (European Commission, 2005). The study divided the methodology into three principal steps, namely: (i) defining the target to be studied, as well as the important pollutants and injured parties; (ii) estimating the impacts with a "dose-response function" and transformed these impact costs into monetary values; and finally (iii) assessing the uncertainties, analyzing the results and drawing conclusions. However, while the introduction of approaches could potentially measure environmental impact costs effectively, its generality was jeopardized by since the fact that the results overviewed by INFRAS/IWW (2000) were obtained only through EU research projects, e.g. TRENDS, *ExternE*, PETS and TRENEN, and similar data could be hard to obtain in regions outside the EU, thus limiting its general applicability. Furthermore, since the INFRAS/IWW (2000) study was not specifically for maritime transport sector, there had also been no detailed discussion and models on maritime-generated environmental impact evaluation being introduced.

On the other hand, Etkin (2003) provided a more straightforward methodology in evaluating oil spill impacts of shipping activities. In her work, both natural environmental and socio-economic losses were considered and she claimed that her model possessed the ability in quantifying relative damage and cost for different spill types for regulatory impact evaluation, contingency planning, as well as assessing the value of spill prevention and reduction measures (Etkin, 2003). In her paper, all the models were based on 'quantity of the pollutant' as the main variables in her formulations, and the easy-look-up tables made the models simple and handy estimation. Factors such as spill amount; oil type; response methodology and effectiveness; impacted medium; location-specific socio-economic value, freshwater vulnerability, habitat/wildlife sensitivity and location type were identified as spill-specific factors have the influences on oil-spill impact costs (Etkin, 2003). These spill-specific factors were incorporated to provide a more accurate oil spill impact assessment. Unfortunately, until recently, there had been no empirical evidence indicating that her approach could be soundly applied into the maritime industry outside the US, as the parameters in the models were highly specific to the American situation, including geographical, environmental and socio-economic conditions around and thus the methodology might be *ad hoc* to one specific country, although in theory the parameters could be adjusted in order to correspond with different situations, although Etkin herself made no attempts in generalizing the applicability of her work.

Recently, Liu and Wirtz (2006) had also developed a series of economic evaluating models in calculating the impacts of incidental oil spills. Their model consisted of two principal steps, namely: (i) measuring the lost services of injured natural resource; and (ii) integrating the lost services with a unit value of injured natural resource, which was either measured by economic valuation methods or transferred from existing valuation studies. In their paper, they introduced the 'service recovery function' into the model, and defined a broader concept of 'environmental impact cost', which covered 'natural environmental', 'social-economic', 'responding', and 'research' costs and the unit values of 'injured party' in their model accordingly. Both the natural environmental damages and socio-economic losses were deemed as the sum-up of opportunity costs in a non-market or market. For 'responding cost' evaluation, they entirely used the clean-up model introduced by Etkin (2003), of which the expenditures for natural resource damage assessment and the costs for investigating and monitoring affected areas were classified as parts of the 'research costs' of the total environmental impact cost package (Liu and Wirtz, 2006). On the other hand, Garza-Gil and Prada-Blanco (2006) introduced the similar models as Liu and Wirtz (2006). However, their work was limited to 'socio-economic losses' and 'response costs' due to accidental (rather than routine) maritime pollutions. Also, although their model was based on historical observed data analysis, they did not include a 'service recovery function' of the injured parties, thus making their model failed to forecast future path of recovery pattern, as well as the future impact costs.

Finally, IFAW (2007) concentrated their recent studies on the chronic oil pollutions from routine maritime activities along Northeast European coast, and examined the impacts to the population of seabirds. IFAW gave detailed measures and information from their "beached-bird surveys" and other monitoring methods. However, their study was only limited to the environmental impacts from maritime oil spills, i.e., MARPOL Annex I category. Impacts due to other maritime-generated pollutions (in MARPOL annex II-VI) were not considered, even although such impact might not be as significant. Similar to other European studies, the IFAW (2007) report was based on thorough pollutant data from EU projects, such as EGEMP and OCEANIDES conduced by EC Joint Research Center. Thus, IFAW's methodology might not be able to apply to other countries/regions, since such similar detailed information might not be available.

Despite the existence of the above mentioned studies in providing general environmental impact estimation concepts and methodologies within the transport sector, these studies shared common deficiencies. Firstly, most of them had only concentrated on assessing the costs of major pollution incidents within maritime operations only, where pollution from routine operations was often overlooked, despite its potential in causing even more environmental and socio-economic impacts as mentioned before. For example, the works of Hoc Panel (1997), Liu and Wirtz (2006), and Garza-Gil and Prada-Blanco (2006) put all their attentions on large-scale accidental oil spills (notably *Exxon Valdez* and *Prestige*) rather than routine minor oil spills (like spills from engine room or oily ballast water discharging in routine shipping and port activities). Indeed, large-scale of pollutants from major shipping incidents did not make them as the main source of sea pollution (Etkin, 1999; Etkin *et al.*, 1999; GESAMP 2001). As an attempt to address this deficiency, Bigano and Sheehan (2006) and GESAMP (2007) calculated small and large-scale accidental oil spills separately using different models. Unfortunately, still, both studies did not extend to other maritime pollution source or providing the any further detailed evaluation of environmental impacts along the coastal areas.

Secondly, as indicated in the works by INFRAS/IWW (2000), Etkin (2003) and IFAW (2007), even when some types of generalization had taken place, it was highly restricted within a regional perspective, of which useful data (or the categories set by the studies) was usually available only within a particular region, e.g., the EU, US, etc. Finally, although a number of existing works considered the chronic environmental impact from routine shipping operations, they had not extended their work any further to a broader pollution source category, such as air emissions and chemical disposals, as characterized by the works of Bigano and Sheehan (2006), GESAMP (2007) and IFAW (2007). Clearly, further works are required to tackle this issue more comprehensively.

3. The New Perspective

Based on the literature review, here the authors introduce a new model to evaluate the environmental impacts which are specifically generated from maritime industry. Different from previous literature as discussed before, this paper's models have various specific features, namely: (i) chronic environmental impacts from routine maritime activities in seaport area, not for incidental pollutions, because incidental pollutions cannot be well-forecasted; (ii) the main variable – quantity of pollutants – is from the port's routine records which are based on MARPOL73/78 Annex[3]; a broader types of pollutants can be examined by using the model and such kind of data is comparatively easier to obtain[4]; and (iii) the concepts of 'service recovery year' and 'service recovery function' are being introduced, based on (and improved) from the existing literature; and (iv) broader costs categories are to be considered, which do not only include the costs of natural environmental damage, but also the socio-economic losses, as well as response and research costs. Before going on, however, it is noted that the proposed model here is used to assess the environmental impacts on port and coastal areas, not open oceans and seas.

3.1 The formulation

Long-term pollution from routine maritime activities, especially within the port areas, does not only impact the natural environment, but also the socio-economic welfare, with seabirds and coastal fishery being respective illustrative examples on different categories of the injured parties. The proposed model with broader costs categories can be found in the following formulation:

$$TC = \sum_{p} (N_p, S_p, R_p, x_p) - c \tag{1}$$

where *TC* represents the total cost of maritime-related negative environmental impact; *p* represents the pollution sources found in MARPOL73/78; *N* represents the total natural environmental damages; *S* represents the total socio-economic losses directly related to *p* (such as lost in commercial fishery due to ship oil spills); *R* represents the summed costs of response (like clean-up and removal costs) and research to the pollution (which is usually a constant with little correlation with *p*); *x* represents other possible costs due to pollution impact from maritime activities; and *c* represents the coefficient costs of either combination impacts from MARPOL Annex I-VI. Note that, however, *c* is the potential overlapping costs that from some joint maritime pollutants' impacts. For example, the lost population of certain marine specie might be the result of both vessel oil-spills and chemical washed-water discharges. In practice, during data collecting and processing, breaking up such overlapping costs into independent cost data could be difficult, partly because that the majority of the data are the 'package data', on which several kinds of pollutants might have the impacts. As a consequence, in some cases, some impact costs may be double-counted, and this also implies that there are still rooms of

3 MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships) is the international treaty regulating disposal of wastes generated by normal operation of vessels. It was released in 1973 and was modified by IMO's Protocol of 1978. The Convention includes regulations aimed at preventing and minimizing pollution from ships – both accidental pollution and that from routine operations – and currently includes six technical annexes: oil spills, noxious liquid substances, harmful substances, sewage, garbage and air pollutions.

4 For example, unlike many other sources, data obtained from MARPOL 73/78 does not involve significant monetary costs or confidentiality issues.

improvements for MARPOL 73/78.

3.2 Natural environmental and socio-economic costs

Impacted by certain type of maritime-related pollution source *p*, the total natural environmental damages (*N*) can be expressed as the function of unit value and quantity of injured natural resources, as well as the years spent on recovering their lost service (or value), as expressed in the following formulation:

$$N_p = \sum_i V_N * Q_i * Y_i = \sum_i V_N * g(Q_p) * Y_i \tag{2}$$

Similarly, socio-economic loss (*S*) can be expressed in the following formulation:

$$S_p = \sum_i V_S * Q_i * Y_i = \sum_i V_S * g(Q_p) * Y_i \tag{3}$$

where *i* denotes the injured party that is impacted by pollutant *p*, which can be the injured party in either the natural environmental or socio-economic categories; *V* is the unit value of *i*; Q_i is the quantity of *i*, while Q_p is the quantity of *p*; $g(Q_p) = Q_i$ is the relation function between quantity of pollutant and quantity of injured party; *Y* is the service recovery years of *i*, or to say, the real time spent on injured party in order to let recover its lost value or service.

Here is to note that, although *V* is the unit value of *i*, V_N and V_S represent the different value of *i* on natural environmental (non-market) and socio-economic (market) aspects; the calculations of V_N and V_S, therefore, are different. Calculating V_N can be one of the most difficult steps in maritime environmental impact estimation as V_N is extracted from environmental common resources which the unit value cannot be evaluated via examining the market-driven price, it should therefore base on the approximate average 'willingness to pay' (WTP) method, through applying the Contingent Valuation Method (CVM). On the other hand, all the socio-economic goods are traded within marketplace and have their market values, estimating V_S is comparatively easier and thus during V_S's estimating process, it does not need to calculate the rough average WTP through complicated CVM (like V_N does). The only thing that should be done in estimating V_S is to examine the price in existing or future market place, e.g., the potential unit income from fishery for certain fish *i*, the potential average revenue from certain coastal tourism, etc.

3.3 Response and research costs

Response and research costs can be expressed in the following formulation:

$$R_p = \alpha * Q_p + \beta \,, \;\; Q_p > 0 \tag{4}$$

where α is the unit response cost; β is the research costs. As discussed, response cost response includes all the costs directly related to addressing maritime-related pollutants, but not the treatments to the injured parties, for instance, rescuing contaminated marine mammals. The function of *R* has two sections, in which the response cost has a linear relationship with pollutant amount while the research costs are deemed as constant. *R* has no relationship with recovery function of injured parties; but is the direct function of pollution amount Q_p. The unit response cost α, which the value is determined by current market. During a certain period, R_p has a linear function with Q_p due to the routine small-scale pollutions, the unit response cost α can be constant. However, in practice, there is hardly any maritime pollutant can be instantly 'cleaned up' within a rather short period of time, especially for the case of large-scaled illegal pollutions; some pollutant residues (like sticky vessel sewages) might require months, or even years and decades, to be completely removed, if possible at all. Therefore, all the forecasted future α should be discounted by certain discount rate, such as interest rate, to the present until the years when the discharged pollutant is fully removed, namely Q_p. For the long-term, chronic environmental impacts from routine maritime activities, research costs β does not have significant quantitative relationship with either Q_p or Q_i. Indeed, β represents the expense of a general marine environment research which considers all the pollutants in MARPOL 73/78 Annex, and thus should be regarded as a constant.

Other costs, which may cover the expenses on rescuing the contaminated animals, or on the indirect research aimed to promote technical innovations for maritime environment improvement, e.g., improving the anti-fouling components, new-tech filtering systems, etc., have little relationship with collected variables (Q_p and Q_i) and thus will be deemed as constant in equation (1).

3.4 Service recovery function

As for equations (2) and (3), only a few injured parties from maritime-related environmental impact can be fully recovered within short-time period. To evaluate the maritime environmental costs over years, it is essential to introduce the 'service recovery years' *Y* of the injured party *i*. Since the numbers of years spent on service recovery are equal to the years when partial service is lost, *Y* can be also explained as the 'lost service years' of *i*. The authors made revisions and improvements on previous literatures and introduce *Y* with more accuracy. As indicated in equations (2) and (3), the impacts can be due to natural resource's degradation and socio-economic welfare losses and, as a consequence, a decrease of the service of *i* after the maritime-related pollution took place. Figure 1 illustrates the service recovery path which is presented as the function of *Y*.

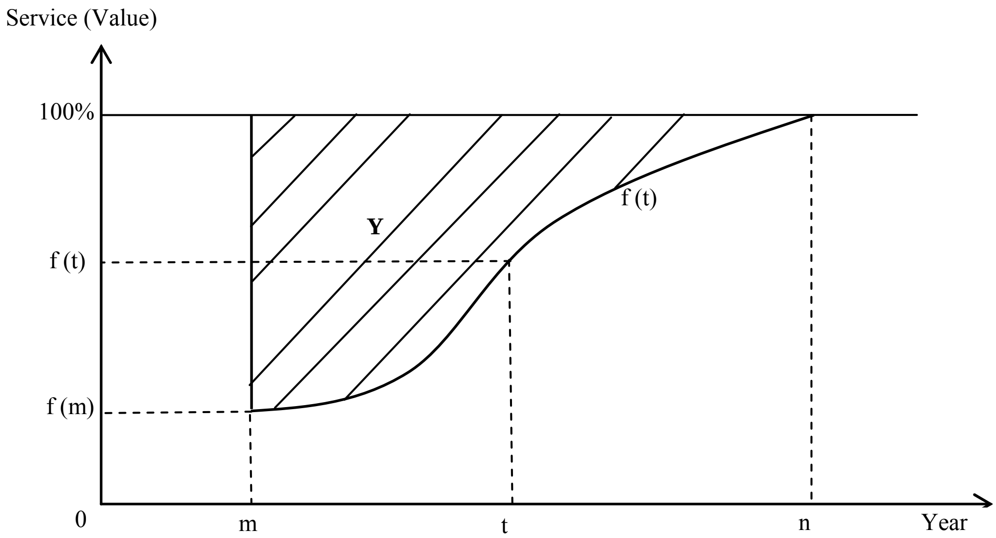


Figure 1: Service recovery function of an injured party

In Figure 1, *f(t)* is the service recovery function of the injured party *i* on year *t*, while the path of *f(t)* shows the recovery course of a unit injured party over time. *m* is year when injury begins, as years gone by, such loss will be recovered and finally reach zero, of which the service will be fully recovered, or when the recovery course has finally stopped (year *n*). Here is to note that, in some situations, *n* can be also defined as infinite (∞), or having a trend to 'permanently close' to zero losses. This is because not all the damages or losses of injured party can be fully compensated after a finite recovery time and some services (or values) might be lost forever after serious environmental impact from accidental large-scale vessel pollutions like the *Exxon Valdez* spills. However, given the focus of this paper which is on small routine maritime pollutions, it is assumed that *n* equals to zero. The service recovery years, *Y*, is illustrated in the shadowed area as indicated in Figure 1. The function between *f(t)* and area *Y* of unit *i* can be expressed in the following formulation:

$$Y_i = \int_m^n (1 - f(t_i))dt_i \,, \quad m \le t_i \le n \,, \quad 0 \le f(t_i) \le 1 \tag{5}$$

where *f(t)* (no unit) denotes the remaining service as the percentage to the full service value which is before injured. Therefore, *(1-f(t))* is the percentage lost service at year *t*. *Y* (in years) is the integrated area of small fractions of the real service recovery years.

3.5 Social discount rate

In order to estimate the present value of the lost services over the injury years, the lost services of *i* have to be discounted into present with appropriate discount rate. When considering the discount rate, the equations (2) (3) and (5) can be combined, forming the following formulations:

$$N_p = \sum_i V_N * Q_i * Y_i = \sum_i V_N * g(Q_p) * Y_i$$
$$= \sum_i \int_m^n V_N * g(Q_p) * (1 - f(t_i)) * \left(\frac{1}{1+r}\right)^{t_i - m} dt_i \qquad (6)$$

$$S_p = \sum_i V_S * Q_i * Y_i = \sum_i V_S * g(Q_p) * Y_i$$
$$= \sum_i \int_m^n V_S * g(Q_p) * (1 - f(t_i)) * \left(\frac{1}{1+r}\right)^{t_i - m} dt_i \qquad (7)$$

where *r* is the annual discount rate. Just like *V* and $g(Q_p)$, *r* may be different in equations (6) and (7). In equation (6), which evaluates the impact costs of natural environmental damages, *r* is the 'social discount rate'. On the other hand, in equation (7), which evaluates the impact costs of socio-economic losses, *r* can be the current market interest rate (or any other suitable discount rate). With the market-based character, it is relatively easy to obtain *r* in equation (7) by examining the current and historical market. On the other hand, since equation (6) possesses a non-market character, calculating *r* is more difficult, although based on NOAA's estimation, the number of social discount rate *r* is defined as 0.03, which would also be used by this paper.

4. Case study: Port of Rotterdam, The Netherlands (PoR)

This section illustrates the model's practicality by applying it into PoR. This section is divided into two parts. Section 4.1 discusses the modeling assumptions and data collection, while Section 4.2 illustrates the results and discussions.

4.1 Data collection and assumptions

Given that The Netherlands is a member of the MAPROL 73/78, every year, Rotterdam Port Authority (RPA)[5] would prepare detailed statistics on daily pollutants being discharged into PoR's premises, and such data would be significant enough to represent the general environmental impacts to PoR and its surrounding areas caused by routine maritime activities, and so data could be found in PoR's reported pollutions published in the MARPOL 73/78's Annex providing a clear clue to track the routine small-scale pollution sources from port area's maritime activities with various categories. Thus, based on the evaluation model, the authors collected required data of Q_p from PoR. RPA recorded data regularly on the quantity of pollutants (Q_p) generated from seagoing vessels within their port area through the years. This unit of Q_p of this empirical study is in cubic meters (m^3). On the other hand, the data of quantity of injured party (Q_i) was collected from OSPAR's recent costal survey along the North

5 Since 2004, a new public corporation had been established in PoR which undertook all the major responsibilities related to the operation and management of PoR, namely Havenbedrijf Rotterdam N.V. Since then, the collection of data on maritime pollutants was carried out by the Harbour Master's office under this newly-established corporation.

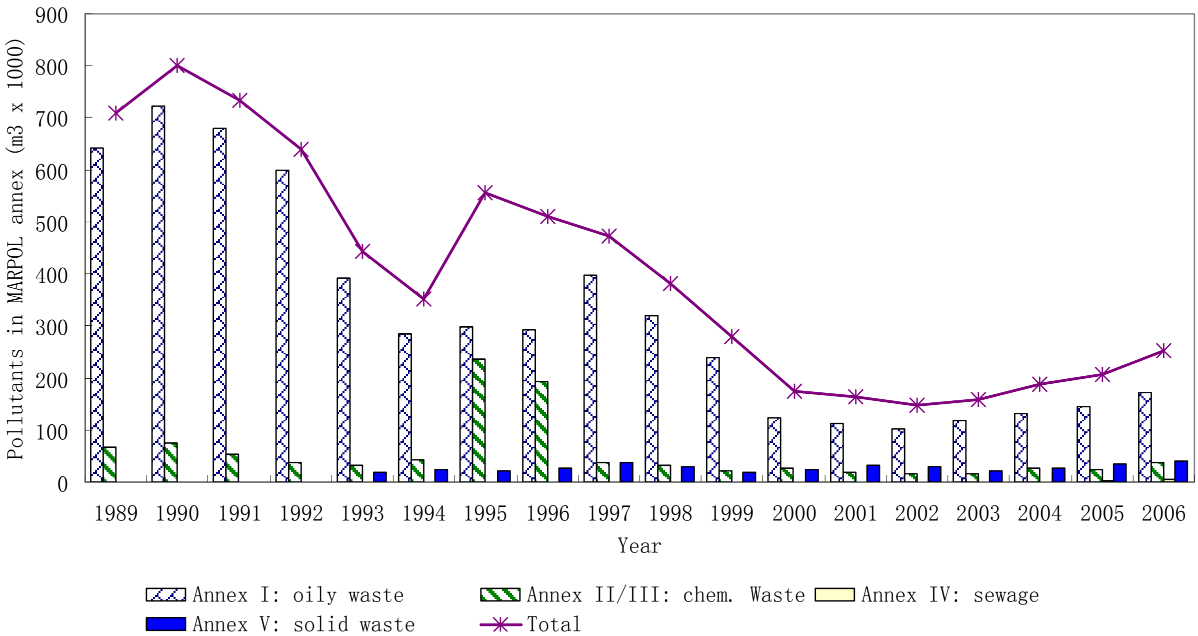
European coastal areas. The definition of the pollutants was based on MARPOL 73/78 Annex which categorized the pollution sources into five categories (Annex I-V), which can be found in Table 1.

Table 1: Maritime pollution sources based on MARPOL 73/78 Annex I-V

MARPOL 73/78 Annex	Pollution sources	Type of waste
I	Fuel oil residues (sludge)	Ship-generated
	Used engine oil (UEO)	Ship-generated
	Bilge water (BIW)	Ship-generated
	Wash water oil (WWO)	Cargo residue
	Ballast water oil (BTW)	Cargo residue
II and III	Wash water chemical 1	Cargo residue
	Others	Cargo residue
IV	Sewage	Ship-generated
V	Domestic waste	Ship-generated
	Food waste	Ship-generated
	Plastics	Ship-generated
	Dry cargo residue	Cargo residue
	Maintenance waste	Ship-generated
	Cargo associated waste	Ship-generated

Source: MARPOL 73/78 Annex; PoR (2006)

Based on the classification of Table 1, Figure 2 illustrates the maritime pollutants discharged into PoR's premises between 1989 and 2006.



Source: PoR (2006)

Figure 2: Maritime pollutants discharged into Rotterdam port area, 1989-2006

From Figure 2, it is not difficult to found that, throughout the last two decades, oily waste spills (MARPOL – Annex I) had the dominating source of maritime pollutant to PoR. However, one should note an interesting phenomenon happened, where the gap between oil waste and other pollution sources had been continuously shrinking throughout this period, especially since 2000. As a consequence, it is clear that a comprehensive consideration of all polluting categories in the MARPOL Annex is necessary in this case, as other pollutants might get more equal impacts to PoR's port community than simply to oil spills.

During the data collection process, a number of assumptions had been made. Firstly, while OSPAR (2006) reviewed 21 ecological quality objectives in their North Sea pilot project which covered major possible natural communities impacted by coastal maritime activities, the authors had chosen 'commercial fish species' (expressed in tons) and 'seabirds' (expressed in tons) as the two injured parities (i) within PoR's premises. With this assumed i, the commercial fish species represented the socio-economic category which was fixed in equation (7); while the seabirds represented the natural environmental category fixed in equation (6). The unit values (V) of both natural communities were assumed to be constant throughout the 10 years of services recovery and, based on existing information on market fishery stock and seabirds along the North West European coast, the authors assumed that the average values for commercial fish and seabirds would be 300 USD per ton 100 USD per unit respectively.

Also, although the service recovery function, $f(t)$ could be any shapes depending on the characteristics of the injured parities, after examining the recovery pattern throughout the years on different injured services, Liu and Wirtz (2006) found that the lost service estimation was not sensitive to the choice of recovery function, as long as the recovery time did not exceed one decade, of which it would be specifically useful for the chronic pollution impacts from routine maritime activities. With such understanding, it was assumed that $f(t)$ was in linear function for both injured seabirds and commercial fishery values. With the assumed linearity, the initial injured (m) and recovery-ending (n) years would be 0 and 10 respectively; For social discount rate (r), the authors followed NOAA's estimation (see last section) and the r which was equal to market-base interest rate in equation (7) was assumed to be no different to the social discount rate in equation (6). For response and research costs, the average unit response costs (α) in equation (4) was assumed to be 1.5 USD/m^3 of all kinds of MARPOL 73/78 Annex pollutants, and was also assumed as constant through the recovery years. According to anecdotal information from the industry, the research cost (β) was assumed as annual inputs for maritime environment research and pollution prevention projects. β was assumed to be constant, at 700 000 USD per year regardless of Q_p and Q_i, while the coefficient effects of research to the Q_p and total costs would not be considered. Finally, it was assumed that no other costs (c) would be triggered from other maritime-related environmental impacts.

4.2 Results and discussions

By applying the models that are discussed above with the relevant assumptions and data, the total costs (TC), natural environmental costs (N), socio-economic losses (S) and response/research costs (R) can be found in Figure 3.

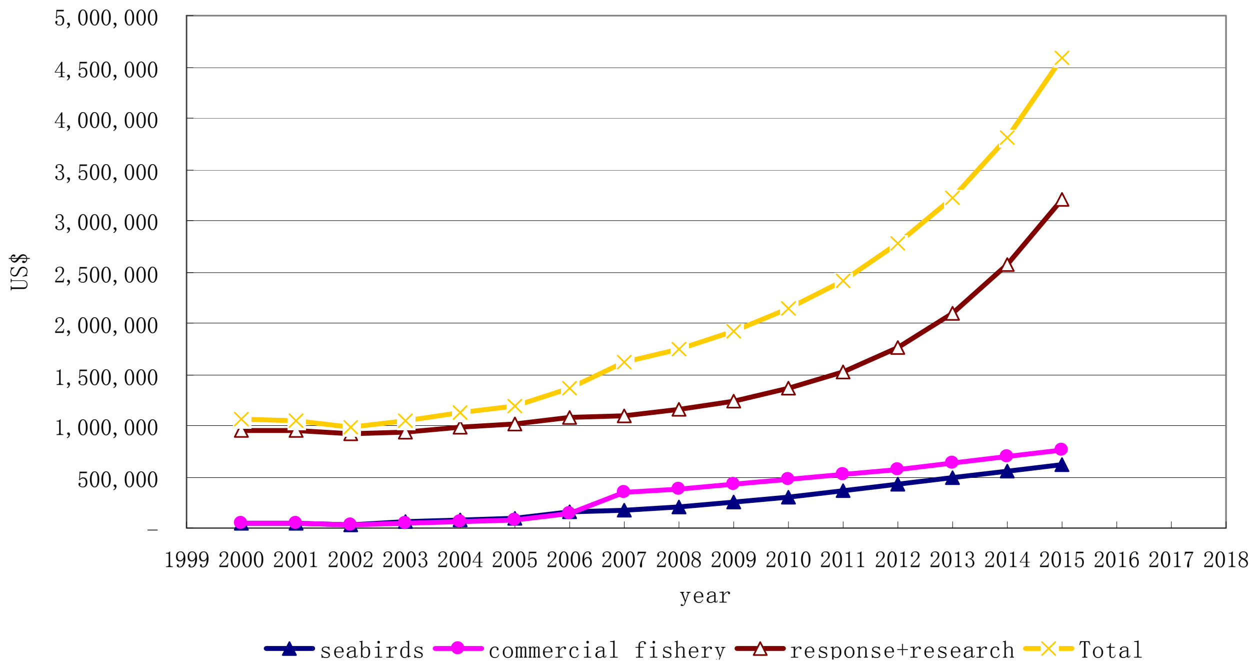


Figure 3: The projected costs of environmental impacts caused by Rotterdam port area maritime activities, 2000-2015

Figure 3 displays an increasing pattern of environmental impacts caused by maritime activities within PoR's premises, which is projected from 2007 until 2015. Through regression analysis, it was found that both the natural environmental damages (represented by injured seabirds) and socio-economic losses (represented by commercial fishery lost) would be significantly sensitive to the pollutants categorized in MARPOL Annex I, i.e., oil residues discharged from routine shipping operations, where the correlations between Annex I (oil spill) and injured parties are over 90% compared with other pollutants (Table 2).

Table 2: The correlations between different injured parties and polluting categories within PoR's premises

Category	Annex I	Annex II/III	Annex IV	Annex V
Seabirds	0.96	0.75	0.93	0.58
Commercial fish	0.92	0.80	0.71	0.38

On the other hand, however, the costs spent on response (mainly the disposal of oil spills) and researches, however, were huge (Figure 1) and they may, in the long-term, decelerate the trend of the negative impacts caused by routine maritime activities. With the consideration of long-term time span, usually over the 10 years, research may help ships to improve their cleaning technologies, controlling their residues within a reasonable range during the shipping process within the port area or along the coastal, and finally relieving the increasing impacts to the overall natural environment and social welfares. This means that the research costs should have a negative relationship with the increase rate of pollution amount (Q_p), and therefore reducing some impacts costs of maritime pollutions. Although this paper does not formulize such relationship, mainly due to the complexity in quantifying the effects of research (namely, the amount of *TC* increase rate reduced due to relevant researches results, especially the R&D of the green-technology innovation) (where further research is required), Figure 4 gives an initial readjusted estimation on the trends of the maritime environmental impacts with the consideration of coefficient effects of research.

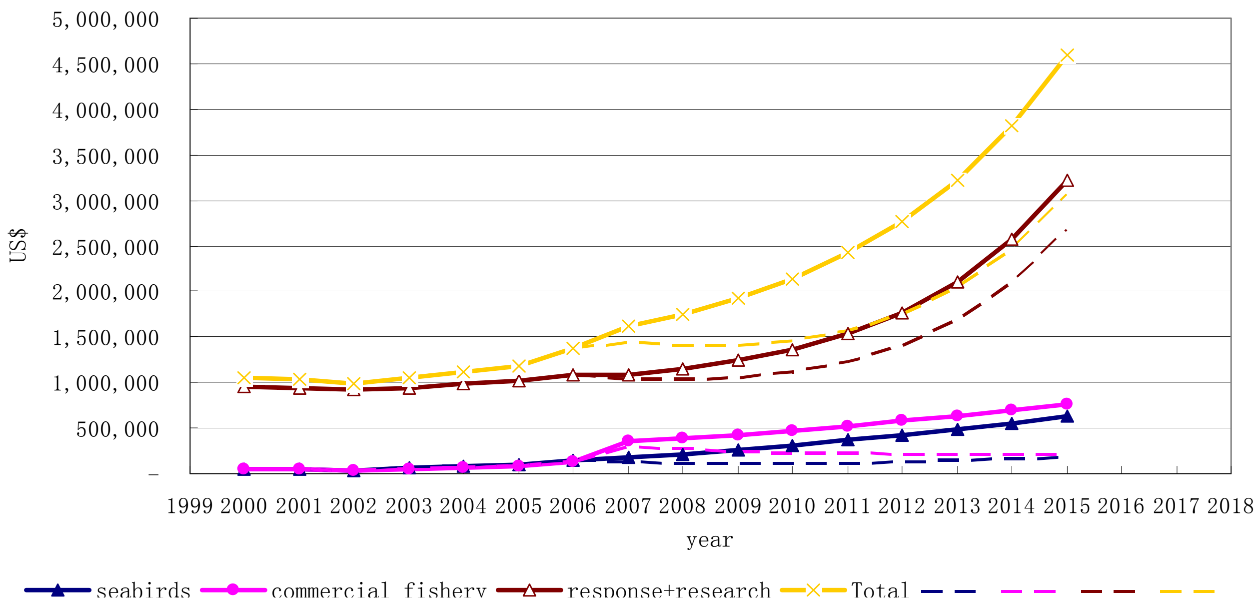


Figure 4: The projected costs of environmental impacts caused by PoR's maritime activities with the consideration of coefficient effect of researches, 2000-2015

Both Figures 3 and 4 illustrate an increasing trend of general environmental impacts from maritime activities of PoR's premises between 2000 and 2015. It should be noted that the rate of such impacts has also been increasing throughout the years. Scientific researches or actions with the aims on clean technology improvement and regular pollutions preventions in maritime industry can actually reduce the total environmental impact costs by approximately 10% to 30% in a long term context.
With the understanding that the routine oil residues (MARPOL Annex I) could have significant impacts

on PoR coastal environment and society welfare, a recommendation to PoR and other similar ports is to put their main environmental considerations on oil spills within or around port area. Based on empirical results in this paper, the authors would recommend a number of policy measures to RPA and/or similar national authorities and enforcement agencies of other states, as well as the international authorities. First of all, it is important to implement OSPAR's Ecological Quality Objectives (EcoQO) or other similar monitoring tools to injured parties in other coastal or seaport areas. Local authorities should cooperate with and support local NGOs or other institutes to conduct survey schemes of oil-contaminated parties, especially in the 'natural environmental' category. That will be very helpful to estimate the current and future environmental impact from maritime activities.

Also, although the collection of pollutant data is comparatively easy to the port authority, PoR should go on put their main concern on monitoring and recording oil residues in the MARPOL Annex I. This also requires the close cooperation between port authorities and shipping companies. To strengthen the existing legislation and measures in order to put stricter limitations on future chronic oil pollutions, port state control should be improved and makes sure all ships within their port areas would comply with the international anti-pollution standards and facilitate the use of port reception facilities. Some economic incentive policies should be applied properly to reduce shipping oil spills, e.g., discount on the purchase of fuel upon delivery of waste waters to reception facilities, smaller port access fees, etc. (IFAW, 2007). Besides, port authorities should also encourage onboard oily waste disposal, and monitor the disposal and handling procedure by using the transponders.

At an international level, the IMO should consider amending the MAROPL Annex I, where the speeding up of replacing Oil Record Book by the Electronic Oil Discharge Monitoring System (EODMS) is required and made compulsory in the MARPOL Annex I. Shipping companies and other marine stakeholders should be encouraged to facilitate this transformation process so as to comply with the MARPOL Annex I's oil discharge requirements. If possible, placing the "places of refuge" for distressed ships may minimize the risk for the impacts to seabirds and other parties. Finally, in order to make the unified database and international regulations, other port states are urged to join the MARPOL 73/78. Indeed, the proposed model in this paper can potentially develop to become a global generalized model in assessing the environmental footprints due to routine maritime activities, but this requires port states around the world to join MARPOL 73/78, as well as providing relevant and internationally comparable data and information.

5. Conclusion

Long-term chronic pollution from routine maritime activities casts a shadow to coastal natural environment and socio-economic welfare, often leading to far more negative externalities over time than large, incidental ones. However, due to various reasons, notably the lack of public attention due to their routine small dose, invisibility and thus comparatively unnoticeable character, they are always overlooked within environment shipping's research field. Compared with many existing studies, which limited to large-scale incidental maritime pollutions aspect, this paper concentrates on routine maritime-generated pollution and introduces a new simulation perspective in assessing its impacts on the natural and socio-economic environments.

Also, when compared with previous similar studies that were restricted within particular regions, this paper has provided a more general evaluation method based on easily-available database and makes the future impact trend more predictable. The calculation of maritime pollution impacts depends highly on coastal surveys on injured parities amounts and pollutants records, which are based on MARPOL 78/78 annex. As long as the port state is a member state of MARPOL 73/78, unified and stable routine pollutant records will be rather easy to obtain and the evaluation results will likely be comparatively accurate. This will also greatly help researchers to compare the coastal environmental impacts among different ports. Also, different from large incidental maritime pollution, the chronic future environmental impact from routine maritime activities can be well forecasted by applying the models in this paper, especially for the small amount pollutants discharged from vessels within or around port premises and coastal areas. While not attempting to argue that this new perspective does not need any improvements, notably further research is required to improve the make the assumptions on social discount rate and research cost more concrete, it has offered an ideal platform in creating a global, generally-accepted method in assessing the impacts of maritime activities.

The variables and the model itself can be readjusted in case of port regions' specific situations, which might be various greatly. The calculations performed in this paper provide approaches for the crucial factors should be considered in the maritime environmental protection issue. Based on the findings of this paper, reducing the routine small oil spill (in MARPOL Annex I), in the long-term, will have much significant effects for the coastal environment and society compared with other maritime pollutants. Through addressing the deficiencies of previous works and its reliance on MARPOL's data source (which is, basically, the generally-accepted international standards), the new perspective introduced in this paper can potentially become a global generalized model in assessing and benchmarking the negative impacts of routine maritime activities on port and coastal areas, especially when more port states are joining MARPOL 73/78 in the near future, thus allowing more detailed data to be collected from other impacted parties. Last but not least, by shedding light on an important, but often under-researched, issue, the authors are confident that this paper has played its role in contributing to the progress of achieving blue oceans for future generations.

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The Relation between Port Competition and Hinterland Connections
The Case of the 'Iron Rhine' and the 'Betuweroute'

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Abstract

This paper discusses the relationship between port competition and hinterland connections. The analysis presented is based on expected trends in maritime transport and the likely consequences for seaports. The inauguration of the Betuweroute in 2007 offered the port of Rotterdam additional rail capacity to Germany. The port of Antwerp, meanwhile, is pressing for the reactivation of the Iron Rhine, a direct rail link to that same German hinterland. Research has shown capacity to be the key to success, both in maritime throughput and in hinterland transportation services.

Keywords: Port competition; Hinterland connection; Capacity; Iron Rhine; Betuweroute

1. Introduction

Within the Hamburg-Le Havre range, the ports of Antwerp and Rotterdam are engaged in a competitive struggle involving two railway lines to the German hinterland. In 2007, the Netherlands inaugurated the so-called Betuweroute, connecting Rotterdam with the Ruhr Area in Germany. Belgium, for its part, intends to reactivate the Iron Rhine, an existing line between Antwerp and the Ruhr. So here we have two transport projects to the same destination zone: a perfect illustration of how port competition can manifest itself on the battlefield of hinterland transportation.

In this paper, we take a closer look at two hinterland projects, more specifically in the context of inter-port competition. From a transport economic perspective, the Iron Rhine and the Betuweroute are also very much port projects, in the sense that it will achieve two things that will inevitably affect hinterland transport services:

- Additional capacity shall be created for goods flows to and from Antwerp and Rotterdam;
- In comparison with the existing and operational railway lines the new lines will cut transport-related expenses, through lower out-of-pocket and time costs; in principle, a comparatively lower cost for rail transport should impact on the modal split.

Hence, it is important that forecasting in the field of hinterland transportation services should take due account of the aspect of 'port competition'. The relationship referred to is twofold. First, the reactivation of the Iron Rhine may improve the relative competitive strength of the directly affected ports of Antwerp and Zeebrugge, and, to a lesser extent, Rotterdam as well. Second, the appeal of those ports shall inevitably impact on the utilisation rate of available rail transport capacity, including on the Iron Rhine.

In this paper, we attempt to gain better insight into some of the principal aspects affecting port competition. To this end, four elements are put forward:

(1.) An outline of the competitive environment from the perspective of the ports of Antwerp and Rotterdam. Which factors affect port competition, both within the Hamburg-Le Havre range

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and between different ranges? How may we expect inter-port competition to evolve in the future? What is the nature of the mutual power balance between the various actors involved in the choice of both port and hinterland connection, in terms of both mode and route?

(2.) An evaluation of which goods flows are likely to be affected. More specifically, we are concerned with flows between between the Ruhr region in Germany and the ports of Antwerp and Rotterdam respectively.

(3.) An analysis of the growth perspectives, as well as an assessment of the likely limits to growth (e.g. in terms of available terminal and throughput capacity).

(4.) An assessment of how port competition may be affected by the reactivation of the Iron Rhine and how this would impact on the choice of port.

2. Survey of Port Competition

Global ports are often regarded as engines of economic growth, and with good reason. At the same time, though, they lie embedded in a highly competitive environment. Hence, insight is required into the factors that affect port competition and competitiveness.

The ports of the Hamburg-Le Havre range have, in recent decades, generally performed well. Huge growth has been recorded in terms of not only throughput but also employment and added value. For a long time, this growth was taken for granted: it was seen to be the logical consequence of the location of these seaports and the presence of knowledge and skilled workers, which is translated into high productivity.

In more recent years, however, this self-evidence has evaporated. While some ports have continued to grow in absolute terms, they have suffered a decline in market share in container throughput, a crucial subsector in freight logistics. Other ports have seen a significant downturn in specific market niches, such as break bulk.

In what follows, we take a closer look at the competitive environment in which ports operate. We deal consecutively with forecast trends in maritime transport and the likely consequences for ports, future focal points for the maritime sector, and the relationship between port competition and hinterland transport services.

2.1 Trends in the maritime logistics chain and their consequences for ports

First and foremost, it should be noted that the world economy has changed in a quite fundamental way, as international trade (and hence maritime transport services) has expanded enormously in a trend characterised by a worldwide redistribution of labour and capital and an integration or globalisation of markets. It should be noted that this altered world economy continues to drive the maritime sector today (Meersman and Van de Voorde, 2001; Meersman and Van de Voorde, 2006).

Ever-larger shipping companies are increasingly manifesting themselves as strategic customers of ports. On the one hand they attract traffic and industrial activity to the port, while on the other they are attracted by such industrial activity. Freight passes through the ports, after which drayage may be taken care of either by the ocean carrier (i.e. ‘carrier haulage’) or the shipper (i.e. ‘merchant haulage’). We have also witnessed substantial scale increases on the part of shipping companies in recent times. This has been achieved first and foremost through horizontal cooperation and/or mergers and takeovers. Additionally, shipping companies have set their sights on terminal operators and hinterland transport services, as operations are increasingly approached from the perspective of complex logistics chains, whereby each link must contribute to the constant optimisation of the entire chain. This has altered the competitive balance in the market, as shipping companies have acquired greater overall strength through their control of logistics chains.

Within the ports themselves, we have also witnessed an important structural evolution: traditional stevedoring firms are increasingly developing into more complex terminal operating companies, as a lack of working capital induces mergers, takeovers and externally funded expansion projects. External capital is sometimes also provided by shipping companies. Port authorities, for their part, initially chose to watch rather passively from the sideline as these evolutions unfolded.

In view of the above, the question arises which scenarios are likely to play out in the future. Will economic growth persist? And if it does, will it continue to translate into greater demand for maritime transport? Or will economic growth manifest itself in services rather than in industrial output? And will the previously described scale increases on the basis of horizontal and vertical integration also continue? What are the likely consequences of the deployment of ever-larger vessels, particularly in the container business? What kind of timeframe may shipping companies be looking at in their search for new partnerships? And which strategies may the other market players deploy in response? Put differently, will shipping companies become the dominant players and thus be able to impose their will upon other parties, including port authorities and terminal operators?

Each of these essential issues is shrouded in uncertainty. Moreover, the market in which they present themselves is an extremely dynamic environment. One may reasonably assume all parties involved in it to proceed proactively and to anticipate on moves by other players.

Quite enlightening in this respect is the work of Heaver *et al*. (2001), in which the various forms of cooperation and concentration in the maritime sector are examined. The observed configuration still exists today, with some parties engaging more actively than others in the search for partnerships. Table 1 provides an overview of the various forms of cooperation that characterise the sector. We restrict ourselves to shipping companies, terminal operators and port authorities.

Table 1: Types of strategic partnerships in the maritime sector

Market players	Shipping companies	Terminal operators	Port authorities
Shipping companies	▪ Vessel sharing agreements ▪ Joint-ventures ▪ Consortia ▪ Alliances ▪ Mergers and take-overs ▪ Conferences		
Terminal operators	▪ Joint-ventures ▪ Dedicated terminals ▪ Capital share ▪ Consortia	▪ Mergers and take-overs ▪ Joint-ventures	
Port authorities	▪ Concessions for dedicated terminals	▪ Concessions ▪ Joint-ventures	▪ Alliances

Source: own processing of data from various shipping companies, terminal operators and port authorities and Heaver *et al*. (2001)

<u>2.2 Focal points for the future maritime sector</u>

In order to understand how port competition may evolve further, greater insight is required into the maritime context as a whole. In which direction will the maritime sector move in the foreseeable future? Which position should port authorities adopt? Will players presently acting within the port perimeter, such as terminal operating companies, be able to survive independently? Again, these are questions shrouded in much uncertainty. We shall deal consecutively with the rationalisation trend among shipping companies, land-side developments, and the new role of the port authorities. On this basis, we shall try to outline an emerging framework that is bound to impact on the specific significance of hinterland transport.

2.2.1 Shipping companies: rationalisation, mergers and scale increases

The greatest amount of movement is observed in the container transport business. And it is precisely in this dynamic subsector that we make a peculiar observation: while shipping companies complain about relatively low freight rates as a consequence of overcapacity, they nevertheless continue to invest heavily in even more capacity. Table 2 provides an overview of container vessels (existing fleet and orders) in 2007 and 2008.

Table 2: Overview of container vessels (existing fleet and orders) in 2007 and 2008

	Existing fleet (number)	TEU x 1 000	Orders (number)	Orders (TEU)
1/1/2007	5,695	10,464	1,310	4,374
1/1/2008	5,915	11,730	1,447	6,885

Source: Dynamar B.V. (2008)

The underlying strategy of these shipping companies is clear to see: in response to already low freight rates, they are attempting to deploy additional capacity at a lower operational cost per slot. Moreover, they consider a mixed fleet as a means of spreading risks. Additional cost control can be achieved through mergers and takeovers, and the capacity reduction this would entail. Strategic and financial considerations by the holdings that control the shipping companies will keep capacity further in check, through strategic alliances, new partnerships, the rerouting of vessels (cf. Table 1). These evolutions may / will give rise to changes in direct port calls, which may in turn have significant implications for hinterland transport projects such as the Iron Rhine between the port of Antwerp and the industrial Ruhr region in Germany. Moreover, rerouting may also imply shifts in freight volumes to be transported to and from the hinterland. On the other hand, it is perfectly conceivable that a port may compensate largely or even wholly for a drop in direct port calls through additional (maritime) feeder services.

There is little doubt what impact the above developments will have on the maritime logistics chain in its entirety. In the short to medium term, these kinds of rationalisations are bound to result in a radical reorganisation of services. We shall witness the emergence of new alliances, within which further mergers and takeovers will occur. On the side of the shipping companies, the market will stabilise, though there will of course be fewer players following the inevitable rationalisation and concentration drive.

An issue of concern to port and public authorities is where the increase in container vessel size will stop. Will we see a further evolution towards 10,000 to 12,000 TEU, or even up to Malaccamax-sized vessels of 18,000 TEU? The answer no doubt depends on the exact context. However, there is no denying that some of Maersk's more recent fleet additions represent another step in that direction (e.g. Emma Maersk).

On the other hand, this new generation of larger vessels will serve as a laboratory for knowledge acquisition in the technological as well as the economic field. The present state of science suggests that increasing vessel size will lead to a different cost function, among other things because of the necessity of a second engine (for further details, see for example Stopford, 2002). Moreover, shipping companies have had some unpleasant experiences with scale increases in tanker shipping, including the imposition of higher port dues. The expectation is therefore that they will not allow themselves to be manoeuvred into a situation where they have no alternative seaport, i.e. where port authorities are all too aware that ship owners' price elasticity is extremely low. Finally, benefits of scale achieved at sea may be lost through higher terminal and hinterland transportation costs due to the greater freight volumes involved. Let us consider this point in further detail.

2.2.2 Land-side developments

It is important to the maritime logistics chain that the economic benefits shipping companies seek through far-reaching scale increases and the corresponding cost reduction should not be wasted through time and cost bottlenecks on the quay, in the terminal or during hinterland transport.

Many Northern European ports intend to further expand in the short to medium term, albeit almost entirely in terms of container throughput capacity. Table 3 provides an overview of these expansion plans. The result is again quite predictable: any substantial growth in capacity will further aggravate the existing problem of overcapacity in the world market and at certain European ports. Examples that come to mind are Amsterdam, Cagliari, Zeebruges and Sines.

Besides these plans for additional capacity, there is also the issue of the manner in which freight handling at terminals is organised. Here too, we notice a concentration movement, inspired in part by the growing need for investment capital, which the original owners are often no longer able to supply themselves. This concentration movement, coupled with the market entries of such players as PSA, Hutchison Whampoa and DP World have also created a buffer against any attempt at vertical integration on the initiative of the shipping companies.

Table 3: Planned expansion of container capacity in a number of Northern European ports

Port	Terminal	Unused capacity / Planned introduction
Amsterdam	CERES Paragon Containerterminal	2006: 1,000,000 TEU extra
Antwerp	Deurganckdock terminals	2005: 7,000,000 TEU extra
Bremen	CT 4	4 new berths between 2006 and 2008
Vlissingen	Westerschelde Container Terminal	2,000,000 TEU, no date specified
Hamburg	Eurogate Container Terminal Hamburg CTH	2010: 1,900,000 TEU extra
	HHLA Container Terminal Burchardkai CTB	2010: 2,400,000 TEU extra
	HHLA Container Terminal Altenwerder CTA	2010: 600,000 TEU extra
	HHLA Container Terminal Tollerort GmbH CTT	2010: 1,050,000 TEU extra
Le Havre	Port 2000	Phase 1: 4 quayside berths (2005-2006)
		Phase 2: 2 quayside berths (2008-2009)
		Phase 3: 6 quayside berths
Rotterdam	EUROMAX terminal	2008: 3,000,000 TEU
	Maasvlakte 2	2013: 17,000,000 TEU
Zeebrugge	Albert II dock	1,000,000 TEU, no date specified

Source: own processing of data from various port authorities

Obviously, the prospect of even further concentration among terminal operators poses an economic threat to shipping companies, as reduced competition may lead to lower productivity growth, longer vessel-handling times and, perhaps most importantly of all, higher rates. The latter evolution is primarily a consequence of the fact that shipping companies no longer have a choice between any number of rival terminal operators, but are increasingly dependent upon large players who operate in different locations and are therefore able to negotiate longer-term package deals for services in those different ports. This way, the focus of port competition will gradually shift from the level of individual port authorities to that of terminal operators, i.e. large groups that are able to offer regional networks of services.

We may assume with a high degree of certainty that shipping companies will not be prepared to (continue to) undergo this evolution. As their relative market power is at stake, it seems logical that they should put greater effort into acquiring so-called dedicated terminals, be it under joint ventures with local terminal operators or otherwise. This need not be detrimental to the port authorities' cause, as it will at least make shipping companies less footloose, in the sense that a long-term relationship is thus forged that makes them less likely to relocate (Heaver *et al*., 2001). In the short term, such dedicated terminals may however lead to lower utilisation rates of available capacity.

2.2.3 Port authorities in a new role

Based on the foregoing, we conclude that the involvement of port authorities in commercial activities within the logistics chain is declining. Consequently, the market power of those port authorities and, as the case may be, the public authorities that control them is also decreasing. In the debate on port competition, the aspect of a port's competitive strength is, for that matter, no longer regarded separately, in comparison with that of other, rival ports. Henceforth, ports are considered to perform well insofar as they are part of competitively strong logistics chains. Control over those logistics chains, however, lies only in part with the port authorities and the undertakings located in that port.

The question of where market power actually resides cannot be answered unequivocally, as the situation varies from port to port. In the case of such mainports as Rotterdam and Antwerp, it is already the case that terminals are given in concession, albeit mostly under a joint venture between a shipping company and a terminal operator. From this, we draw the following conclusions:

(1.) The shipping companies and terminal operators involved appear to adhere to the saying 'If you can't beat them, join them'. Rather than engaging in an all-consuming competitive struggle, they prefer to collaborate. The immediate effect is, however, a new decline in the relative power of port and public authorities;

(2.) Revenues from a dedicated terminal may be higher, but now they need to be divided. In the case of a 50/50 terminal, the operator must, unlike in the past, give up 50% of profits to the shipping company. On the other hand, terminal operators thus acquire greater certainty that freight flows will be retained or may even increase in the future.

The strategy proposed is, in any case, more pure than that previously pursued by some port authorities in trying to gain influence in the port debate. A typical example is the port authority of Rotterdam, which in 1999 acquired a 35% stake in the capital of terminal operator ECT. Such moves, be they temporary or not, raise concerns over possible conflicts of interest, especially as the port authority will subsequently have to decide on whether or not to grant concessions to what are, to all intents and purposes, its competitors.

In the current negotiation game between shipping companies and terminal operators, the port authorities hold one strong trump card: they have the power to grant concessions and to determine their duration. Once a long-term concession has been awarded, they lose much of their market power, though. It has, for example, hitherto proven very hard to penalise concession holders who fail to achieve the objectives of their business plan. Consequently, there is an economic incentive for port authorities to award long-term concessions (e.g. 30 years), but in conjunction with mandatory interim objectives agreed upon beforehand with the concession holder.

2.3 The relationship between port competition and hinterland transport

So what does the above analysis, whereby port competition was approached from the perspective of maritime logistics chains, tell us about the aspect of hinterland transport?

Logistics in general, and the maritime and port industry in particular, are evolving very rapidly. Port authorities and enterprises are always confronted with new technologies. From a business economics perspective, strategies are constantly adapted with a view to increasing market share and, more importantly still, profits. All of this translates into an altered market structure. For hinterland transport services, which depend entirely on volumes of freight to be carried to and from ports, this is extremely important.

The short-, medium- and long-term future of the seaports in the Hamburg-Le Havre range is fraught with uncertainty too. However, the previously outlined trends point at certain elements that can help us reduce this uncertainty to some extent. We summarise them as follows:

- We may reasonably assume that the economy and international trade will continue to grow substantially in the future. This trend will also manifest itself in maritime trade. Throughput in the Hamburg-Le Havre may be expected to grow proportionately, and so too may demand for hinterland transport services. Any shifts in the competitive balance between ports may however result in relative shifts in freight flows between those ports. Hence, an improvement of hinterland transport services has direct relevance, not only to ports' capacity for growth, but also to shifts in the competitive balance.

- There are no indications of increasing profit margins in maritime transport. This is in itself rather surprising, as ocean carriage involves a risk for which investors may reasonably expect a premium.

Consequently, at the level of individual shipping companies, shareholders will exert constant pressure on management to improve business results. Management will in turn continue to pressurise other links in the logistics chain, including hinterland transport services, thereby occasioning further vertical integration.

- Some shipping companies have, in recent years, taken a number of important long-term decisions, including in relation to fleet expansion. At aggregate level, this holds a real danger of overcapacity, which would inevitably lead to further rationalisation and cost reduction through partnerships, takeovers and mergers. Such movements may, or will, result in changes in terms of shipping companies' ports of call, loops and frequency of service. Obviously this will have a knock-on effect for hinterland transport services.

- In the short to medium term, overcapacity will result in lower freight rates and lower ROI, putting additional pressure on market players elsewhere along the logistics chain. Over a slightly longer time horizon, a lack of working capital may give rise to cooperation agreements that go beyond the level of dedicated terminals. Hinterland transport services will then become potential participants in an integrated logistics chain.

So how do the above insights translate into recommendations regarding the forecasting of future freight flows to ports and, subsequently, taking into account the modal distribution, regarding potential hinterland freight flows?

(1.) In the first instance, one could make aggregate forecasts of future maritime transport. Preferably, one should distinguish between the general goods categories (coupled with the type of transport and vessel, e.g. containers versus break bulk) and the different shipping areas. By applying growth figures to current flows and modal shares, one obtains an initial indication of future demand.

(2.) Much will depend on the behaviour of the shipping companies, who are, after all, ports' largest and most influential customers. They may determine their behaviour individually or under so-called strategic alliances. Carriers may even go so far as to reduce or end their footloose behaviour if they are allocated a dedicated terminal in a particular port. In order to gain insight into such strategies, a detailed analysis is required at the level of individual shipping companies.

(3.) A decisive factor in individual shipping companies' behaviour is their aversion to any potential time loss. They will opt first and foremost for seaports and terminals that are free of bottlenecks. Hence the importance of having enough free and directly available capacity. Available (theoretical) container capacity, multiplied by a realistic capacity utilisation factor, is therefore a useful indicator of future throughput.

We have thus far focused primarily on container traffic and throughput. However, the ports of Antwerp and Rotterdam attract not only containers, but just about any unit load, liquid as well dry bulk, and virtually any goods category on virtually any geographical relation. And each of these submarkets is characterised by different degrees of freedom.

Moreover, a detailed analysis ought also to take account of all actors present within a particular port. Major shipping companies are approached differently than minor ones, if only because they possess different market power; terminal operators are approached differently than shipping companies, etc. In the once much praised port cluster analysis, very divergent subsectors are combined into a single measure. However, while an adequate policy does require an awareness of cluster effects, one should not neglect the singularity of individual enterprises and sectors. It would therefore appear to make sense also to look within the port perimeter at the production capacity and capacity utilisation of industrial companies and sectors (e.g. the petrochemical industry), in conjunction with existing investment plans.

The most likely scenarios, which therefore deserve to be studied in depth, are more or less known.

However, the speed at which the various market players within the maritime logistics chain will take specific initiatives shall depend on a battery of exogenous and endogenous variables. As is the case with pricing in the maritime sector, and with successfully covering oneself against price fluctuations and other risks, timing is what ultimately determines who will emerge a winner. In this sense, it should be very clear that hinterland transport is largely dependent upon the strategic decisions and the success of other market players, but that it can also contribute to the success of specific maritime logistics chains.

3. Analysis of Maritime Freight Flows from Antwerp and Rotterdam

The potential of the Iron Rhine and the Betuweroute lies in the substantial volumes of (container) traffic between the Ruhr region in Germany and the ports of Antwerp and Rotterdam respectively. In the present chapter, we provide a brief analysis of incoming and outgoing maritime freight in the two ports, i.e. the loading and unloading of ships. In the next chapter, we focus more closely on the hinterland freight flows. Evolutions in these flows shall serve as a backdrop in the interpretation of simulation results regarding future traffic in the context of the Iron Rhine and the Betuweroute.

3.1. Port of Antwerp

The port of Antwerp is an inland seaport spread out over a surface area of 13,057 ha. At the moment, tide-independent shipping is guaranteed to a draught of 11.85 metres. Further deepening works will increase the permissible draught to 13.10 metres. The port extends over both riverbanks, with the Left Bank, or *Linkeroever*, presently undergoing a phased expansion (cf. Deurganck Dock). The port's total usable quay length, before and behind the locks, amounts to 150 km. (Gemeentelijk Havenbedrijf Antwerpen, 2008 and Kabinet van Kris Peeters, 2007)

Table 4 provides an overview of the general trend in Antwerp's tonnage throughput in the period 1998-2007. Over the past 10 years, an average annual growth of 4.91% has been realised in terms of tonnage unloaded. The corresponding annual average for tonnage loaded is 5.54%. In 2007, total maritime cargo handled amounted to 183 million tonnes, comprised of 100 million tonnes unloaded and 83 millions tonnes loaded.

Table 4: Maritime cargo in the port of Antwerp: tonnage loaded and unloaded (percentage changes), 1998-2007

Year	Unloaded	Loaded	Total
1998	13.84	-1.70	7.05
1999	-7.86	3.14	-3.45
2000	13.70	11.75	12.86
2001	-1.31	0.91	-0.37
2002	-2.20	5.75	1.21
2003	6.89	10.58	8.54
2004	7.10	6.03	6.62
2005	4.77	5.43	5.07
2006	5.62	3.32	4.57
2007	8.54	10.17	9.28
Minimum	-7.86	-1.70	-3.45
Maximum	13.84	11.75	12.86
Average	4.91	5.54	5.14
Standard deviation	6.92	4.35	4.88

Source: Gemeentelijk Havenbedrijf Antwerpen (2008)

Container traffic has grown more rapidly than overall traffic in the port, with a recorded annual increase of approximately 11% in both loading and unloading of vessels (see Table 5). The year 2005 saw the inauguration of Deurganck Dock, whose terminals represent an additional annual capacity of approximately 7 million TEU (Gemeentelijk Havenbedrijf Antwerpen, 2006d). If the growth rates presented in Table 5 are indicative of future trends, then total TEU in Antwerp is set to increase from 6.482 million in 2005 to 14.938 million by 2013. In other words, supposing that all of this additional future container traffic is accommodated at Deurganck Dock, the new goods-handling facility will have reached full capacity by 2013. A further expansion of the port’s capacity, with the addition of Saeftinghe Dock, is therefore under consideration.

Table 5: Container traffic in the port of Antwerp: freight loaded and unloaded, in TEU (percentage changes), 1998-2007

Year	Unloaded	Loaded	Total
1998	11.60	8.43	9.99
1999	9.96	11.38	10.67
2000	11.82	14.06	12.95
2001	3.95	2.73	3.33
2002	12.44	14.04	13.25
2003	12.74	15.19	13.99
2004	11.50	11.21	11.35
2005	6.93	6.87	6.90
2006	9.05	7.55	8.28
2007	16.13	16.85	16.50
Minimum	3.95	2.73	3.33
Maximum	16.13	16.85	16.50
Average	10.61	10.83	10.72
Standard deviation	3.37	4.40	3.82

Source: Gemeentelijk Havenbedrijf Antwerpen (2008)

One may reasonably assume that, in the short to medium term, maritime throughput at Antwerp will continue to increase. Without additional investment in port throughput capacity (i.e. terminals), the port is in danger of reaching its upper throughput limit.

3.2. Port of Rotterdam

The port of Rotterdam is accessed directly from the North Sea. The permissible draught is 24 metres. Unlike in Antwerp, there are no locks. The port area extends over 10 000 ha, and total quay length adds up to 74 km. Preparations are underway for the construction of Maasvlakte 2, a new port area that will include 1 000 ha of industrial terrain with direct deep water access. (Haven van Rotterdam, 2008)

In absolute terms, Rotterdam handles a greater volume of cargo than Antwerp does. In 2007, total volume handled amounted to 407 million tonnes, comprised of 299 million tonnes unloaded and 107 million loaded. Rotterdam’s and Antwerp’s unloaded-to-loaded ratios amount to 2.79 and 1.20 respectively. Rotterdam records an average annual growth of 2.93%, which is lower than the figure reported for Antwerp.

Table 6: Maritime cargo in the port of Rotterdam: tonnage unloaded and loaded (percentage changes), 1998-2007

Year	Unloaded	Loaded	Total
1998	2.14	-2.72	1.10
1999	-5.84	6.61	-3.28
2000	7.56	7.53	7.56
2001	-0.88	-7.57	-2.40
2002	0.52	8.67	2.27
2003	2.96	-1.42	1.96
2004	6.01	12.53	7.45
2005	3.78	9.08	5.00
2006	2.18	6.06	3.11
2007	4.14	13.97	6.56
Minimum	-5.84	-7.57	-3.28
Maximum	7.56	13.97	7.56
Average	2.26	5.27	2.93
Standard deviation	3.76	6.95	3.82

Source: Nationale Havenraad (2008)

Table 7: Container traffic in the port of Rotterdam: TEU loaded and unload (percentage changes), 1998-2007

Year	Unloaded	Loaded	Total
1998	9.35	8.87	9.11
1999	5.39	6.58	5.98
2000	-2.01	0.01	-1.01
2001	-0.89	-4.52	-2.70
2002	5.63	7.95	6.77
2003	10.60	8.06	9.34
2004	16.88	15.23	16.07
2005	12.78	11.22	12.02
2006	3.40	4.50	3.93
2007	11.39	12.20	11.78
Minimum	-2.01	-4.52	-2.70
Maximum	16.88	15.23	16.07
Average	7.25	7.01	7.13
Standard deviation	6.05	5.83	5.86

Source: Haven van Rotterdam (2008)

As in the port of Antwerp, growth in container traffic outpaces overall growth in the port. It amounts to approximately 7%, compared to Antwerp's 11%. As in the case of Antwerp, growth in maritime throughput may be assumed to continue. So Rotterdam, too, requires additional capacity, which is to be achieved first and foremost through the construction of Maasvlakte 2.

4. Analysis of Hinterland Freight Flows in the Context of the Iron Rhine and Betuweroute

The significance of the Iron Rhine and Betuweroute rail links extends beyond the ports of Antwerp and Rotterdam. In this section, we provide a general overview of which other freight flows may experience an impact from a shift in traffic to the Iron Rhine and the Betuweroute (i.e. which freight on these rail links may free capacity on other connections). Domestic traffic, as well as import, export and transit freight may all be affected. So, in the case of the Iron Rhine, it can be argued that the competitive advantages for the port of Antwerp will also lead to advantages for other (Belgian) ports. However, we ought to point out straight away that routing choices are ultimately operational decisions.

In order to be able to arrive at a number of (quantitative) assertions, we must first acquire insight into the modal split in the Belgian and Dutch infrastructure networks on the basis of relevant available material.

We shall first consider evolutions in hinterland transport to and from the ports of Antwerp and Rotterdam. After all, it is here that the main potential of the Iron Rhine and the Betuweroute lies. Hinterland traffic to and from other ports and regions may nevertheless benefit from any capacity that may subsequently become available on other connections.

In the first instance, we provide a general analysis of land-based transport in Belgium and the Netherlands (i.e. road, rail and inland navigation) and indicate the relative importance of rail transport (sections 4.1. and 4.2.). Subsequently, we consider the implications as far as the ports of Antwerp and Rotterdam are concerned (sections 4.3. and 4.4.).

4.1 General analysis of land-based transport (road, rail and inland waterways) in Belgium

In 2006, the modal split in freight transport (by tonnage) on the Belgian infrastructure network was as follows: 68% by road, 23% by inland waterways and 9% by rail. These general shares have remained more or less unchanged in recent years. Obviously there are substantial differences to be observed if one breaks the figures down further. In imported freight, for example, the three modes' respective shares are 46%, 45% and 9%, while in exports they are estimated at 56%, 31% and 13%. (FOD Economie, 2008)

Also in 2006, total rail freight in Belgium, by operator B-Cargo, amounted to 62,189 tonnes (x 1 000). About 40% of this was domestic transport, 23% consisted in imports, 33% in exports and 4% was transit without reloading. (FOD Economie, 2008)

Table 8 provides an overview of goods categories transported by rail in 2006, broken down into domestic, export, import and transit freight. The most important freight categories are "Products from the metal industry" and "Machinery, transport equipment, manufactured articles and miscellaneous articles".

Table 8: Belgian rail freight by goods category, in %, 2006 (broken down into domestic, export, import and transit freight)

Type of transport	0	1	2	3	4	5	6	7	8	9
Domestic	0.95	0.57	2.09	0.67	14.51	37.49	6.33	0.00	2.71	34.68
Imports	3.45	8.42	0.00	0.34	4.80	41.25	0.51	0.00	4.97	36.28
Exports	1.35	0.35	10.74	9.04	1.35	25.47	10.33	0.94	8.10	32.34
Transit	6.85	2.74	0.00	6.85	0.00	36.53	1.37	4.57	27.40	13.70
Total	1.90	2.38	4.35	3.59	7.39	34.38	6.10	0.50	6.02	33.40

Source: Own processing of data from FOD Economie (2007), with 0=Agricultural products and live animals, 1=Foodstuffs and animal fodder, 2=Solid mineral fuels, 3=Petroleum products, 4=Ores and metal waste, 5=Metal products, 6=Crude and manufactured minerals, building materials, 7= Fertilizers, 8=Chemicals, 9=Machinery, transport equipment, manufactured articles and miscellaneous articles

We have selected a number of import and export countries whose transport infrastructure may be affected by the reactivation of the Iron Rhine, be it directly or indirectly. In the former case, certain goods flows may be transported along the Iron Rhine itself. In the latter, the reactivation of the rail link will free capacity on other relations. The data we have at our disposal is country-level data. We repeat that, ultimately though, the choice of rail route is an operational decision. Tables 9 and 10 provide an overview of respectively imports to and exports from Germany, the Netherlands, Luxembourg, Denmark, Sweden, Poland and the Czech Republic (for the period 2003-2006), as well as a ranking in declining order of volume. One notices immediately how very important the relationship with Germany is.

Table 9: Belgian imports by rail: absolute figures in tonnes (x 1 000) and ranking, 2003-2006

Country	Absolute figures per year				Rankings per year			
	2003	2004	2005	2006	2003	2004	2005	2006
Germany	2,273	2,165	1,968	2,324	1	1	1	1
The Netherlands	1,295	1,260	942	791	2	2	2	3
Luxembourg	705	792	792	1,171	3	3	3	2
Denmark	1	2	1	0	7	7	7	7
Sweden	199	257	239	250	4	4	5	4
Poland	141	153	139	122	5	5	6	5
Czech Republic	112	80	314	85	6	6	4	6

Source: own processing of data from the Federal Public Service for Economics, Small and Medium-size Firms and Energy, Statistics and Economic Information, Transport Statistics

Table 10: Belgian exports by rail: absolute figures in tonnes (x 1 000) and ranking, 2003-2006

Country	Absolute figures per year				Rankings per year			
	2003	2004	2005	2006	2003	2004	2005	2006
Germany	3,407	3,948	4,198	4,573	1	1	1	1
The Netherlands	2,381	2,222	1,498	1,415	2	2	3	3
Luxembourg	1,968	1,890	1,659	1,839	3	3	2	2
Denmark	25	35	33	22	7	7	6	7
Sweden	189	228	242	261	4	4	4	4
Poland	114	138	159	147	5	5	5	5
Czech Republic	51	41	33	95	6	6	7	6

Source: own processing of data from the Federal Public Service for Economics, Small and Medium-size Firms and Energy, Statistics and Economic Information, Transport Statistics

4.2 General analysis of land-based transport (road, rail and inland waterways) in the Netherlands

On the basis of data from NEA (2007), we calculate that, in 2005, the modal split in Dutch land-based transport infrastructure was as follows: 67% by road, 30% by inland waterways and 4% by rail. The main difference with Belgium lies in the share of rail transport (9% in Belgium). In imports, the shares of the respective modes are 59%, 36% and 5% in the year 2003. In exports, they amounted to 38%, 54% and 8%. (CBS, 2008) Inland navigation is more strongly represented in exports than is the case in Belgium (31% in Belgium compared to 54% in the Netherlands).

Total Dutch rail freight in 2005 is estimated to have amounted to 38,000 tonnes (x 1 000) in 2005. (NEA, 2007) The respective shares of domestic freight, imports and exports were 19%, 21% and 61%. (Eurostat, 2008) Exports by rail are proportionally more substantial in the Netherlands than in Belgium.

If we break down rail freight by goods category (see Table 11), we notice that, as in Belgium, category 9 (which includes containers) is the most important. The second most important category is “products from the metal industry”.

Table 11. Total rail freight in the Netherlands by goods category, in %, 2005

	0	1	2	3	4	5	6	7	8	9
Total	2.38	1.68	15.48	1.86	18.83	8.37	6.49	0.52	11.02	33.37

Source: own processing of data from Eurostat (2008), with 0=Agricultural products and live animals, 1=Foodstuffs and animal fodder, 2=Solid mineral fuels, 3=Petroleum products, 4=Ores and metal waste, 5=Metal products, 6=Crude and manufactured minerals, building materials, 7= Fertilizers, 8=Chemicals, 9=Machinery, transport equipment, manufactured articles and miscellaneous articles

The same import and export countries were considered as in the analysis of Belgian rail freight. Again, the relation with Germany emerges as the most significant, especially in exports. Exports to Germany (14,614 tonnes x 1 000) represented 75% of total Dutch exports by rail.

Table 12: Dutch imports from selected countries (freight transport), 2003-2006

Country	Absolute figures per year				Rankings per year			
	2003	2004	2005	2006	2003	2004	2005	2006
Germany	2,244	2,257	1,977	2,115	1	1	1	1
Belgium	2,188	1,764	1,429	1,301	2	2	2	2
Luxembourg	70	31	30	n.a.	5	6	6	n.a.
Denmark	7	4	2	n.a.	7	7	7	n.a.
Sweden	63	58	32	11	6	5	5	3
Poland	83	106	102	n.a.	4	4	4	n.a.
Czech Republic	236	229	459	n.a.	3	3	3	n.a.

Source: Eurostat (2008) and CBS (2008)

Table 13: Dutch exports to selected countries (freight transport), 2003-2006

Country	Absolute figures per year				Rankings per year			
	2003	2004	2005	2006	2003	2004	2005	2006
Germany	11,323	13,345	12,863	14,614	1	1	1	1
Belgium	1,285	1,265	912	766	2	2	2	2
Luxembourg	23	0	n.a.	n.a.	7	7	n.a.	n.a.
Denmark	26	23	18	n.a.	6	6	6	n.a.
Sweden	71	68	63	53	5	5	5	3
Poland	190	212	217	n.a.	4	4	4	n.a.
Czech Republic	261	316	226	n.a.	3	3	3	n.a.

Source: Eurostat (2008) and CBS (2008)

4.3. Analysis of the port of Antwerp in relation to the Iron Rhine

In the previous two paragraphs, we have provided a general picture of rail transport in Belgium and the Netherlands, in order to offer an initial insight into freight flows that may be influenced. The figures show how very important the two countries' relation with Germany is. In the present section, we take a closer look at data relating to the port of Antwerp. Our analysis focuses specifically on traffic to and from Germany. It is our purpose to gain insight into the modal split in relation to the port of Antwerp and to put forward a number of possible evolutions.

Rail transport in the port of Antwerp is operating close to maximum capacity. The reactivation of the Iron Rhine is one of three railway projects that are crucial to the port's future, the other two being a new railway tunnel under the river Scheldt and an improved rail access to the port on the Right Bank. The Iron Rhine is a disused railway line of 160 km connecting the port of Antwerp with Germany. The main stumbling block for its reactivation was a stretch of railway across Dutch territory. However, an international legal ruling gives Belgium the right also to reactivate that part of the rail link. Belgium, the Netherlands and Germany are presently engaged in negotiations over the issue. (Gemeentelijk Havenbedrijf Antwerpen, 2008) Traffic forecasts predict that, by 2020, between 9.4 million and 12.3 million tonnes will be transported annually along the Iron Rhine. Depending on which scenario pans out, the number of freight trains on the line would amount to between 62 and 82 per day by that same year. (Duijnisveld *et al*., 2007)

Total rail freight to and from the port of Antwerp amounted to 24,854 tonnes (x 1 000) in 2006. This represented 40% of the total volume of freight transported by rail in Belgium.

Tables 14 and 15 show the evolution of total imports from and exports to Germany by rail and inland waterways. The port of Antwerp accounts for 41% of Belgian imports from Germany by rail (see Table 9) and 40% of Belgian exports to Germany by rail (see Table 10). Again, Germany emerges as a very important partner, especially to the port of Antwerp.

Table 14: Port of Antwerp: imports and exports (in tonnes x 1 000) by rail and inland waterways, 2002-2007

	Year					
	2002	2003	2004	2005	2006	2007
Imports from Germany						
▪ Rail	879	1,162	1,051	972	954	n.a.
▪ Inland navigation	8,912	9,820	10,393	10,661	10,301	11,198
Exports to Germany						
▪ Rail	1,060	1,332	1,492	1,548	1,838	n.a.
▪ Inland navigation	9,982	9,752	9,884	10,499	10,531	10,325

Source: Gemeentelijk Havenbedrijf Antwerpen (2006a, 2006b and 2008)

The figures above demonstrate the importance of rail transport to the port of Antwerp and the strong growth that has occurred between 2002 and 2006 in rail traffic between Belgium and Germany. Hence, the need for additional rail capacity.

No official data are available regarding road haulage between Antwerp and Germany. However, the Antwerp Port Authority has calculated the modal split in total freight flows to and from the port. For 2002, the split was found to be 41% for road haulage, 42% for inland navigation, and 17% for rail transport. No distinction was made between incoming and outgoing freight. (Gemeentelijk Havenbedrijf Antwerpen, 2008) The port assumes these proportions still to have been valid in the year 2007.

A distinction can also be made between maritime freight and industrial freight. Maritime freight concerns the loading and unloading of sea ships, while industrial freight refers to the supply and removal of goods (without loading or unloading of a sea ship) before and after processing in the port area. In maritime freight, the respective shares of road, rail and inland waterways are 49%, 21% and 30%. The corresponding proportions in industrial freight are 19%, 7% and 74%. The aforementioned data takes no account of reloading of freight from one vessel onto another, nor of pipeline traffic. Clearly, then, the proportions vary depending on the transport segment under consideration.

On the basis of the 2006 annual report of the Antwerp Port Authority, we conclude that the modal split was virtually unchanged in that year. Approximately 60% of all containers passing through the port were transported by road. Inland navigation accounts for over 31% of containers carried to and from the port. The Antwerp Port Authority's longer-term objective is for the shares of inland navigation and rail haulage in the transportation of containers to be increased to respectively 40 and 20 per cent. (Gemeentelijk Havenbedrijf Antwerpen, 2007)

Figures from NEA (2004) provide an indication of hinterland transport to and from the port of Antwerp. Table 15 presents an overview of the shares of the various hinterland modes in 2002. The flows referred to are maritime freight (i.e. goods that are imported or exported without industrial processing in the port area; cf. the concept of transit ports).

Table 15: Hinterland transport to and from the port of Antwerp (maritime freight), in millions of tonnes, 2002

	Maritime import	%	Maritime export	%	Total	%
Road	18.48	54	16.38	70	34.86	60
Rail	6.07	18	3.30	14	9.37	16
Inland navigation	9.91	29	3.84	16	13.75	24
Total	34.46	100	23.52	100	57.98	100

Source: own processing of NEA data (2004)

In 2002, the modal split in the hinterland transportation out of the port (i.e. imports by sea) was 54% for road haulage, 18% for rail transport and 29% for inland navigation. In the case of hinterland transportation into the port (i.e. exports by sea), the respective shares are 70%, 14% and 16%. Note that the hinterland flows referred to do not have an origin or destination in the so-called port region.

The above data demonstrate there is still a potential for growth for the various transport modes if economic growth persists. Simulation models can provide a more detailed picture in this respect. Suffice it for now to say that these growth scenarios should always be considered in conjunction with available capacity in road haulage, inland navigation and rail transport. The issue of the reactivation of the Iron Rhine should therefore also be approached from this angle. If one ignores capacity, there is a danger that the port of Antwerp will reach its limits, so that it will become less interesting as an import and export hub.

4.4. Analysis of the port of Rotterdam in relation to the Betuweroute

The Betuweroute is one of thirty transnational priority projects in the European Union (TEN-T). This new 160-km freight rail line connects the port of Rotterdam with the German rail network. Inaugurated in 2007, it was designed for an annual capacity of 74 million tonnes (European Union, 2005). In theory, it can manage ten freight trains per hour. (Betuweroute, 2008) In the first two months of 2008, the rail link was used by 615 trains. (Nieuwsblad Transport, 2008)

Rail freight to and from the port of Rotterdam amounted to 15,553 tonnes (x 1 000) in 2006, which corresponded to approximately 40% of total rail freight in the Netherlands, a similar proportion as in the case of Antwerp and Belgium.

Table 16 provides an overview of total imports from and exports to Germany by rail, inland waterways and road with Dutch trucks. The port of Rotterdam represents 22% of total Dutch imports from Germany by rail (see Table 12) and 72% of total Dutch exports to Germany by rail (see Table 13). As was the case for Belgium, these figures show just how important the rail connection with Germany is.

Table 16: Port of Rotterdam: imports and exports (in tonnes x 1 000) by rail and inland waterways, 2006

	Year 2006
Imports from Germany	
▪ Rail	473
▪ Inland navigation	11,835
▪ Dutch trucks	2,559
Exports to Germany	
▪ Rail	10,575
▪ Inland navigation	54,893
▪ Dutch trucks	3,686

Source: Haven van Rotterdam (2008)

On the basis of the data from Table 16, complemented with data from CBS (2008) regarding the ratio of Dutch to foreign vehicles, we are able to make an estimation of the modal split in hinterland transport in 2006 (Table 17). On the basis of these data, it is estimated that 7% of freight arrives in the port of Rotterdam by rail and 12% is removed by rail. These figures are slightly higher than the Dutch average, but lower than the corresponding figures for Belgium. The substantial share of inland navigation in the Netherlands is quite striking.

Table 17: Hinterland transportation to and from the port of Rotterdam: modal split estimate for 2006

Hinterland transportation	Tonnes x 1 000	%
To port of Rotterdam:		
▪ Dutch trucks	5,118	14
▪ Foreign trucks	3,122	9
▪ Inland waterways	25,359	70
▪ Rail	2,389	7
▪ Total	35,988	100
From port of Rotterdam:		
▪ Dutch trucks	7,816	7
▪ Foreign trucks	3,752	4
▪ Inland waterways	81,997	77
▪ Rail	13,164	12
▪ Total	106,729	100

Source: Haven van Rotterdam (2008), supplemented with an estimation on the basis of CBS data (2008)

According to calculations by the Port of Rotterdam, the modal split in container transport in 2006 was as follows: 58.6% by road, 30.5% by inland waterways and 10.9% by rail. (Port of Rotterdam, 2008) These proportions are similar to those for container transport to and from the port of Antwerp.

Table 18 offers an overview of hinterland transport in the Rhine and Meuse estuary. This region extends beyond the port of Rotterdam, but the figures still provide a good indication. Again, we notice that inland navigation accounts for a much more substantial share than is the case in Antwerp.

Table 18: Indication of hinterland transport to and from the port of Rotterdam (maritime freight), in million tonnes, 2002 (based on the Rhine and Meuse estuary)

	Maritime import	%	Maritime export	%	Total	%
Road	33.51	27	20.46	45	53.97	32
Rail	11.08	9	4.19	9	15.27	9
Inland navigation	80.14	64	20.87	46	101.01	59
Total	124.73	100	45.52	100	170.25	100

Source: own processing of NEA data (2004), with Rhine and Meuse estuary referring to Rotterdam, Schiedam, Vlaardingen, Maassluis, Dordrecht, Moerdijk and Scheveningen

What can we conclude now from the figures in the previous parts? It is clear that the Iron Rhine and the Betuweroute provide additional rail capacity to and from Germany. This is an important signal to the users of the ports of Antwerp and Rotterdam. The new lines free also capacity on other routes, so other destinations and origins gain extra capacity. New member states to the European Union will also lead to a further increase in demand for hinterland transport services (East European countries).

5. Conclusion

Our analysis of the effects of port competition on hinterland transport services has shown capacity to be the keyword. It is a critical factor that comes into play at different levels.

In port competition (particularly in the context of container traffic), available capacity is an important factor in a port's ability, not only to attract new cargo flows, but also to retain current flows. Shipping companies tend to opt for ports where operations are not hampered by congestion and bottlenecks. They like to think ahead, and are therefore likely to choose for open space and locations offering potential for growth. This means that loading and unloading of goods must proceed smoothly, and that available hinterland transport services (or the modal choice) is also an important factor.

In this instance, rail transport must therefore be regarded in the broader context of (control over) the total logistics chain. Ports must offer adequate (reserve) capacity to maritime traffic, both in terms of goods-handling facilities and hinterland transport options. They must, in other words, be able to guarantee that no bottlenecks will occur in the transportation process.

We observe that, in 2006, some 40% of total rail freight in Belgium was either destined for or originated from the port of Antwerp. Similar figures emerge for the port of Rotterdam and its share in total Dutch rail freight. In other words, these two ports are not only engines of economic growth, but they also hold a considerable potential insofar as rail transport is concerned.

Seen from the perspective of the port of Antwerp, the Iron Rhine is, first and foremost, a valuable addition to available transport capacity, which will allow the port to continue to grow. Container traffic in Antwerp has, over the past ten years, expanded by an average 11% per annum. This would seem to suggest that hinterland connections (road, rail and inland waterways) ought to prepare for further growth. If one ignores this prospect, there is a real longer-term danger of maritime cargo flows shifting to other ports, including Rotterdam.

The inauguration of the Betuweroute represents additional hinterland transport capacity to the port of Rotterdam. The rail link has a potential of 74 million tonnes annually. In this sense, it is important that the port of Antwerp should also extend available hinterland transport services, particularly in view of its current capacity problems in rail transport.

In the first instance, the Iron Rhine and the Betuweroute provide additional rail capacity to and from Germany. These new lines will also free capacity on other routes. Moreover, the accession of new member states to the European Union may also lead to a further increase in demand for hinterland transport services.

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Footnotes

1. In recent years, most port and higher public authorities have concentrated mainly on the container business. The question arises whether this is or has been a wise strategy. After all, not all cargo can be containerised. Moreover, the added value and profits realised in, say, project cargo are usually significantly higher than in containerised cargo.

   Consider the following two (related) examples:

   - The petrochemical industry is extremely important to the ports of Rotterdam and Antwerp: it provides significant employment and represents substantial added value. It is, moreover, a non-footloose industry that also fulfils an important supply function to other companies and sectors. At the same time, however, it is sensitive to changes in environmental legislation and industrial policy.

- The revenue realised by the major ports usually consists in a cyclical and a non-cyclical component. Revenue from concessions (to both industrial concerns and terminal operating companies) are relatively stable in the short to medium term, i.e. they are less sensitive to cyclical fluctuations.

2. The question arises how far one can / should go in order to achieve economies of scale and scope. Consider the following example: in the deployment of 8,000-plus TEU vessels, the number of calls is restricted to ports handling large volumes (in the order of 1,000 to 2,000 movements). However, the system still relies on 'hubs', implying additional handling costs. One may reasonably assume that it will then become interesting for non-mainports to attract smaller ships (e.g. in the order of 1,500 to 2,000 TEU) offering direct origin-to-destination services, without hubbing and associated additional handling and storage costs.

3. The countries selected all belong to the top right quadrant from Belgium's perspective.

4. For the purpose of our analysis, we set out in search of readily comparable Belgian and Dutch data. As it turns out, however, Dutch public rail data are far less detailed than the corresponding Belgian data.

5. No data available with regard to transit freight.

Evaluating Container Developing Strategies for the Port of Kaohsiung: An Exploratory Analysis

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Abstract

This paper empirically evaluates crucial container developing strategies for the Port of Kaohsiung from the perspectives of port authorities, shipping academics and maritime firms. In terms of the level of effectiveness, the findings suggest that approval of direct shipping between Mainland and Taiwan is perceived as the most important strategic attribute to increase container cargo volume for the Port of Kaohsiung, followed by establishing integrated port information system, long term berth leasing agreement with carriers, simplified customs procedures, prompt response to carriers' needs, pricing flexibility, simplified port administration procedures, etc. Based on a factor analysis, four strategic dimensions are identified, namely, port administration and operational efficiency, services and marketing, pricing flexibility and incentive, and logistics. Theoretical and strategic implications of the research findings for the port authorities are discussed.

Keywords: Container; Port; Competitive strategies; Factor analysis

1. Introduction

The Port of Kaohsiung is located in the prosperous trade routes - East Asian coastal, Far East/Europe and Transpacific service lines. Among the seven leading ports in the Asia Pacific region (Kaohsiung, Singapore, Hong Kong, Manila, Shanghai, Shenzhen, Tokyo), the Port of Kaohsiung is one of best placed as a marine transport hub. Its links are closer to the other ports by 53 hours of navigation time on average. Due to the advantage of geographic location, the growth of volume of cargoes handled and container throughput has significantly increased over the last decades.

Figure 1 gives the latest available figures on reported at world container port traffic for the period from 2001 to 2006. The growth rate of container port throughput (number of movements measured in TEUs) is displayed in Figure 2. Singapore regained the top position with a 6.9 per cent growth rate, while Hong Kong was displaced into second position on account of its modest 3.6 per cent growth rate increase in 2006. As can be seen in Table 1, Mainland Chinese ports continued to record particularly good results: Shanghai and Shenzhen recorded outstanding increases of 20.1 and 14.0 per cent respectively. In particular, other Chinese Ports, of the 10 remaining ports, Qingdao, Ningbo recorded advances of two places each, while Guangzhou and Tianjin ports moved upward by three and one places respectively. According to the Containerisation International Yearbook (1996-2006) report, the Port of Kaohsiung has been ranked the world's third largest container port before 1993. However, in

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2007, the container throughput of the Port of Kaohsiung was 1.025 million TEU with a 4.6 per cent growth rate increase compared with previous year. Dubai and Rotterdam overtook Kaohsiung, which moved from 6th in 2006 to 8th position in 2007. From the 1990s, the gradual shift in the gravity of economic growth and trade from Japan to China led to the emergence of new transshipment and gateway hub ports, which include Shanghai and Shenzhen. The Port of Kaohsiung faces the prospect of intensifying competition from the emerging ports in East Asia. Thus, the Kaohsiung Port Authority needs to re-think their strategies to response carriers' requirements and changes of competitive environment.

Table 1: The throughput of top 20 container ports between 2005 and 2006 (Unit: TEUs)

Rank	2005 top ports		2006 top ports	
1	Singapore	23,192,200	Singapore	24,792,400
2	Hong Kong	22,427,000	Hong Kong	23,230,000
3	Shanghai	18,084,000	Shanghai	21,710,000
4	Shenzhen	16,197,173	Shenzhen	18,468,900
5	Busan	11,843,151	Busan	12,030,000
6	Kaohsiung	9,471,056	Kaohsiung	9,774,670
7	Rotterdam	9,300,000	Rotterdam	9,600,482
8	Hamburg	8,087,545	Dubai	8,923,465
9	Duba	7,619,222	Hamburg	8,861,545
10	Los Angeles	7,484,624	Los Angeles	8,469,853
11	Long Beach	6,709,818	Qingdao	7,702,000
12	Antwerp	6,482,061	Long Beach	7,290,365
13	Qingdao	6,307,000	Ningbo	7,068,000
14	Port Klang	5,543,527	Antwerp	7,018,799
15	Ningbo	5,208,000	Guangzhou	6,600,000
16	Tianjin	4,801,000	Port Klang	6,320,000
17	New York	4,792,922	Tianjin	5,900,000
18	Guangzhou	4,685,000	New York	5,128,430
19	Tanjung Pelepas	4,177,121	Tanjung Pelepas	4,770,000
20	Laem Chabang	3,765,967	Bremerhaven	4,450,000

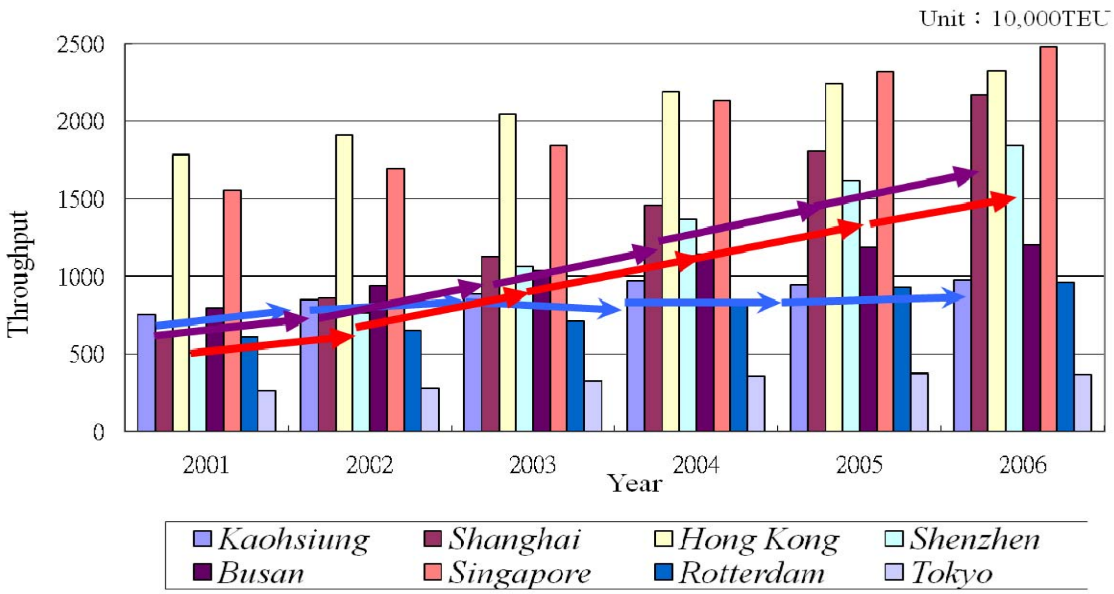

Figure 1: Container throughput at main ports, 2001-2006

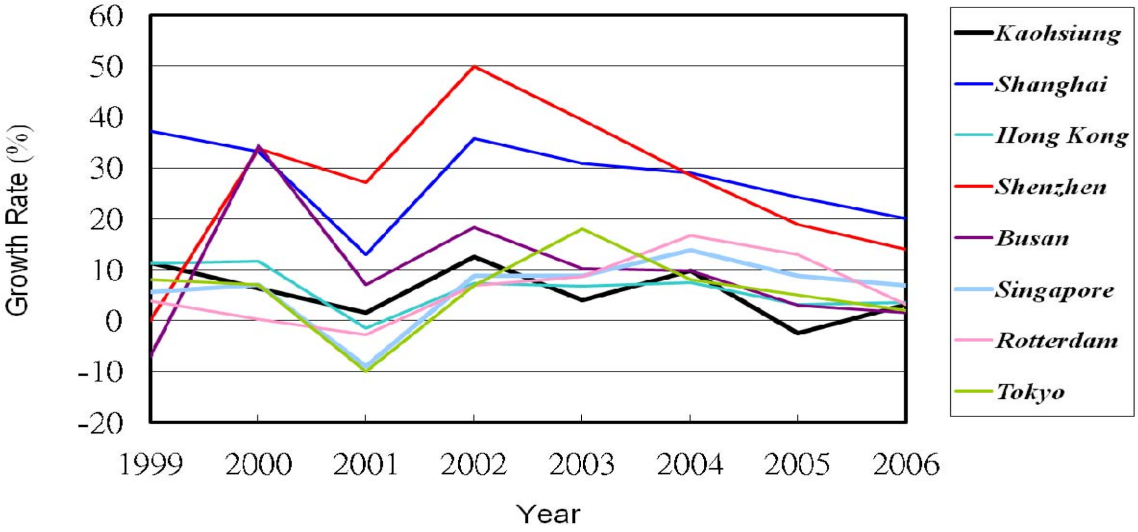

Figure 2: Growth rate of container throughput at main ports, 1999-2006

A number of previous studies have addressed the issue of the importance port selection (Slack, 1985; Tongzon, 2002; Tiwari *et al*, 2003; Ha, 2003; Malchow and Kanafani, 2004; Lirn, 2004; Delangen, 2007) and port competitiveness (Monie, 1987; Carbone and Martino, 2003; Barros and Athanassiou, 2004; Bichou and Gray, 2004; Lam, 2005; Brooks and Pallis, 2007; Karatas and Cerit, 2008). Notteboom and Winkelmans (2001) reflected efficiency oriented ports can achieve competitive advantage by either cost leadership or differentiation. Key factors in obtaining a competitive advantage were (1) flexibility to adapt quickly to changing opportunities, and (2) an integral approach to logistics issues in transport chains. However, there is a lack of empirical studies investigating the competitive strategies in the context of container ports. Although there are many studies exploring the different aspects of competitive strategies, there is no consistent focus on the identification of competitive strategic dimensions. Hence, this paper aims to use an exploratory analysis to evaluate container developing strategies in the Port of Kaohsiung.

There are four sections in this study. Following this introduction the next section discusses the research methodology, including measures of the surrey, sampling technique, and research methods. Section 3 presents the analytical results of descriptive analysis and exploratory factor analysis from the perspectives of port authorities, shipping academics, and government. Conclusions drawn from the research findings and their implications are discussed in the final section.

2. Methodology

2.1 Sampling technique

The samples for this study focus on shipping academics, employees of port authorities, and container shipping managers and executives. The questionnaire survey was sent to 62 shipping academics, 66 employees of port authorities and 106 executives at the mid of October 2007. The container shipping managers' samples were selected from the Directory of the National Association of Shipping Agencies and Companies, whereas the shipping academics were selected based on those who had taught in shipping departments at the university in Taiwan. The total useable responses were 89 out of 234, of which 33 were from shipping academics, 33 were from employees of port authorities, and 23 were from shipping managers and executives. The overall response rate for this study was 38.0 percent.

2.2 Profile of Respondents

Results indicted that nearly 79% of shipping academics survey participants had worked in their universities for more than 5 years, whereas only 21.2 percent of them had worked for less than 5 years. Over 90 percent of the shipping academics respondents had Ph.D. degree. Twenty one percent of shipping academic respondents had job title professor, whereas 33.3 percent and 45.5 were associate professor and assistant professor, respectively. For the port authority respondents, 15.2 percent of respondents are director or deputy director and 18.2 percent of respondents are harbor master/ chief secretary/ chief engineer. The remaining respondents are team leader/director (21.2%), supervisor (18.2%), and general employee (27.2%) respectively. On the other hand, for the shipping manager respondents, nearly 87 percent of participants in the survey were 'president or above' and 'manager/assistant manager'. This finding is important since managers are involved in and anchor strategy development in their businesses. Thus, the high percentage of responses from managers or above confirmed the reliability of the survey's findings. Results also indicated that nearly 78 per cent of respondents had worked in the container shipping industry for more than 10 years, suggesting that respondents had abundant practical experience to answer questions. Over half of shipping manager respondents (52.2%) was from shipping agencies. Remaining respondents were from container shipping companies (43.5%) and others (4.3%). The results also shows 43.4 percent of shipping responding firms had employees between 51 and 500 employees, while 34.8% of them had over 501 employees. Around 74% had been in business for more than 15 years. Shipping manager respondents were also asked to provide information concerning their firms' annual revenues in 2006. The results indicated that 39.1% of respondents reported annual revenues between NT $ 10 million and NT $ 1 billion, 25.4% revealed annual revenues between NT $ 5 billion and NT $ 30 billion, and 21.7% had annual revenues of NT $ 30 billion or more.

3. Results of Empirical Analyses

3.1 Importance of container developing strategies according to respondents

This survey also sought to identify the most important container developing strategy of Kaohsiung Port. Responses' assessment of each of the container developing strategy used in the questionnaire was determined using a five-point Likert scale, anchored by the level of importance '1 = very unimportant' to '5 = very important'. Table 2 shows the importance of each container developing strategic attributes as perceived by respondents in descending order. Results indicated that eight developing strategies stood out as being very important to all respondents (their mean scores were over 3.99): to remove the restriction of direct shipping between Mainland China and Taiwan, improving port information systems, encouraging a long term berth leasing agreement with carriers, simplified customs procedures, prompt response to carriers' complaints, flexible rate to response market change, and simplified administrative procedures. In contrast, the least important developing strategies attribute to respondents were: encouraging carriers to establish container positioning center in Kaohsiung, free trade zones marketing and promotion, and enhancing human resource management (their mean scores were below 3.55).

Table 2: Importance of container developing strategic attributes in Kaohsiung Port

Container developing strategic attributes	Mean	S.D.	Rank
To remove the restriction of direct shipping between Mainland China and Taiwan	4.22	1.07	1
Improving port information systems	4.13	0.76	2
Encouraging a long term berth leasing agreement with carriers	4.12	0.85	3
Simplified administrative procedures	4.11	0.80	4
Prompt response to carriers' complaints	4.04	0.81	5
Flexible rate to response market change	4.00	0.90	6
Simplified customs procedures	3.99	0.90	7
Developing transshipment services	3.92	0.93	8
Establishing international distribution centers	3.88	0.93	9
Encouraging private sector invest in port operations	3.85	0.83	10
Providing incentives for cargo growth	3.81	0.96	11
Enhancing the functions of free port zones	3.76	0.99	12
Management reorganization	3.73	0.96	13
Enhancing employee training and knowledge	3.72	0.83	14
Strengthening the intermodal connection with road, air, and inland water transport	3.71	0.91	15
Encouraging private-sector equity participation in port	3.69	0.90	16
Providing one stop shopping services for carriers	3.66	0.80	17
Dredging channel and berths draft	3.65	1.08	18
Strengthening port sales and promotion	3.64	1.02	19
Encouraging carriers to establish container positioning center in Kaohsiung	3.55	0.95	20
Free trade zones marketing and promotion	3.53	0.98	21
Enhancing human resource management	3.49	0.93	22

Note: The mean scores are based on a 5-point Linkert scale (1=very unimportant 5= very important); S.D.=standard deviation

In addition, the perceived implemented time for container developing strategic attributes for the Kaohsiung Port was also investigated in the questionnaire, anchored by 1=below one year, 2= one to three years, 3= three to five years, and 4=over 5 years. Table 3 shows the perceived implemented time for each container developing strategic attributes as perceived by respondents in descending order. Results indicated that seven developing strategies stood out as being short-term need to perform to all respondents (their mean scores were below 1.67). They were prompt response to carriers' complaints, strengthening port sales and promotion, providing one stop shopping services for carriers, enhancing employee training and knowledge, flexible rate to response market change, providing incentives for cargo growth, and developing transshipment services. In contrast, the long term developing strategies (their mean scores were over 2.17) attribute to respondents were: simplified customs procedures, enhancing human resource management, establishing international distribution centers, encouraging private-sector equity participation in port, strengthening the intermodal connection with road, air, and inland water transport, to remove the restriction of direct shipping between Mainland China and Taiwan, management reorganization, management reorganization, and dredging channel and berths draft.

Table 3: The perceived implemented period of container developing strategic attributes in Kaohsiung Port

Container developing strategic attributes	Mean	S.D.	Ranking
Prompt response to carriers' complaints	1.22	0.58	1
Strengthening port sales and promotion	1.43	0.56	2
Providing one stop shopping services for carriers	1.45	0.78	3
Enhancing employee training and knowledge	1.51	0.68	4
Flexible rate to response market change	1.51	0.77	4
Providing incentives for cargo growth	1.56	0.67	5
Developing transshipment services	1.67	0.71	6
Encouraging carriers to establish container positioning center in Kaohsiung	1.85	0.82	7
Encouraging private sector invest in port operations	1.90	0.78	8
Free trade zones marketing and promotion	1.93	0.85	9
Enhancing the functions of free port zones	1.96	0.72	10
Simplified administrative procedures	1.97	0.88	11
Encouraging a long term berth leasing agreement with carriers	1.97	0.83	11
Improving port information systems	1.98	0.69	12
Simplified customs procedures	2.17	0.99	13
Enhancing human resource management	2.18	0.94	14
Establishing international distribution centers	2.20	0.94	15
Encouraging private-sector equity participation in port	2.22	0.82	16
Strengthening the intermodal connection with road, air, and inland water transport	2.28	0.82	17
To remove the restriction of direct shipping between Mainland China and Taiwan	2.39	1.08	18
Management reorganization	2.40	0.90	19
Dredging channel and berths draft	2.52	0.87	20

Note: Mean 1 represents below one year; 2 represents between one and three years; 3 represents between three to five years; 4 represents over 5 years; S.D.=standard deviation

3.2 One-way analysis of variance (ANOVA) results

To evaluate the relationships between the importance of container developing strategy and respondents' characteristics, an ANOVA was performed in this study. As can be seen in Table 4, the result of ANOVA analysis indicated that five container developing strategic attributes differed significantly in terms of importance at the 0.05 statistical level. These are: to remove the restriction of direct shipping between Mainland China and Taiwan, encouraging a long term berth leasing agreement with carriers, encouraging carriers to establish container positioning center in Kaohsiung, management reorganization, and dredging channel and berth draft. Notably, the largest mean difference between port authority employee and shipping managers was related to remove the restriction of direct shipping between Mainland China and Taiwan (4.36 and 3.70, respectively). Port authority rated encouraging a long term berth leasing agreement with carriers as the most important container developing strategic attribute, where shipping academics and shipping managers rated it as fourth.

Table 4: Importance of container developing strategic attributes according to shipping academics, port authorities, and shipping managers

Container developing strategic attributes	Respondents: Shipping academics N=33 Mean	Ranking	port authorities N=33 Mean	Mean	Shipping managers N=23 Ranking	Mean	F value
To remove the restriction of direct shipping between Mainland China and Taiwan	4.45	1	4.36	2	3.70	11	4.09*
Simplified customs procedures	4.06	2	4.24	4	4.00	5	0.72
Improving port information systems	4.00	3	4.27	3	4.13	3	1.07
Encouraging a long term berth leasing agreement with carriers	3.88	4	4.39	1	4.09	4	3.21*
Prompt response to carriers' complaints	3.85	5	4.15	6	4.17	2	1.57
Establishing international distribution centers	3.85	5	4.00	8	3.74	10	0.56
Enhancing the functions of free port zones	3.82	6	3.70	12	3.78	9	0.13
Developing transshipment services	3.79	7	4.21	5	3.70	11	2.72
Simplified administrative procedures	3.79	7	4.09	7	4.13	3	1.34
Flexible rate to response market change	3.76	8	4.00	8	4.35	1	3.02
Free trade zones marketing and promotion	3.73	9	3.56	15	3.22	16	1.89
Encouraging private-sector equity participation in port	3.73	9	3.64	13	3.70	11	0.09
Encouraging private sector invest in port operations	3.67	10	3.97	9	3.96	6	1.34
Strengthening the intermodal connection with road, air, and inland water transport	3.64	11	3.64	13	3.91	7	0.79
Providing one stop shopping services for carriers	3.61	12	3.79	11	3.57	15	0.66
Enhancing employee training and knowledge	3.58	13	3.79	11	3.83	8	0.80
Encouraging carriers to establish container positioning center in Kaohsiung	3.52	14	3.85	10	3.17	17	3.63*
Providing incentives for cargo growth	3.52	14	4.00	8	3.96	6	2.54
Strengthening port sales and promotion	3.48	15	3.79	11	3.64	13	0.73
Management reorganization	3.42	16	4.00	8	3.78	9	3.14*
Enhancing human resource management	3.30	17	3.58	14	3.65	12	1.16
Dredging channel and berths draft	3.24	18	4.09	7	3.61	14	5.69**

Note: The mean scores are based on a five-point scale (1=very unimportant to 5=very important)
* represents significance level $p < 0.05$
** represents significance level $p < 0.01$

Table 5 shows the results of perceived implemented period of container developing strategic attributes. With the exception of enhancing human resource management, management reorganization, and simplified administrative procedures, other strategic attributes did not differed significantly at the 0.05 statistical level. In general, they perceived that prompt response to carriers' complaints and strengthening port sales and promotion could be implemented within one and half year. In contrast, port authority perceived that management reorganization (mean = 2.64) was the longest period to implement of strategic attribute, where shipping academics and shipping managers perceived to remove the restriction of direct shipping between Mainland China and Taiwan as well as dredging channel and berths draft, respectively.

Table 5: Perceived implemented period of container developing strategic attributes

Container developing strategic attributes	Respondents Shipping academics N=33		Port authorities N=33		Shipping managers N=23		F value
	Mean	Ranking	Mean	Mean	Ranking	Mean	
Prompt response to carriers' complaints	1.27	1	1.09	1	1.30	1	1.15
Strengthening port sales and promotion	1.45	2	1.45	6	1.35	2	0.30
Providing one stop shopping services for carriers	1.58	3	1.21	2	1.61	5	2.50
Enhancing employee training and knowledge	1.58	3	1.39	4	1.57	4	0.71
Flexible rate to response market change	1.61	4	1.36	3	1.57	4	0.91
Developing transshipment services	1.75	5	1.63	7	1.61	5	0.38
Providing incentives for cargo growth	1.76	6	1.42	5	1.48	3	2.33
Encouraging carriers to establish container positioning center in Kaohsiung	1.88	7	1.79	10	1.91	10	0.17
Encouraging a long term berth leasing agreement with carriers	1.94	8	1.94	12	2.04	12	0.13
Free trade zones marketing and promotion	2.03	9	1.73	9	2.09	13	1.58
Improving port information systems	2.03	9	2.03	13	1.83	8	0.74
Simplified customs procedures	2.06	10	2.03	13	1.74	7	1.03
Encouraging private-sector equity participation in port	2.09	11	1.67	8	1.96	11	2.59
Enhancing the functions of free port zones	2.09	11	1.85	11	1.91	10	0.98
Establishing international distribution centers	2.15	12	2.27	17	2.17	16	0.15
Strengthening the intermodal connection with road, air, and inland water transport	2.27	13	2.39	19	2.14	15	0.66
Encouraging private sector invest in port operations	2.30	14	2.21	15	2.13	14	0.30
Enhancing human resource management	2.39	15	2.33	18	1.65	6	5.46**
Management reorganization	2.55	16	2.64	21	1.87	9	6.21**
Simplified administrative procedures	2.55	16	2.15	14	1.65	6	6.16**
Dredging channel and berths draft	2.64	17	2.58	20	2.26	17	1.40
To remove the restriction of direct shipping between Mainland China and Taiwan	2.70	18	2.24	16	2.14	15	2.33

Note: 1. mean 1 represents below one year; 2 represents between one and three years; 3 represents between three to five years; 4 represents over 5 years
2. ** represents significance level p < 0.01

3.3 Factor analysis

Factor analysis was used to reduce the container developing strategy attributes to a smaller, manageable set of underlying factors. This was helpful for detecting the presence of meaningful patterns among the original variables and extracting the main service factors. Principal components analysis with VARIMAX rotation was employed to identify key strategic dimensions. In order to aid interpretation, only variables with factor loadings greater than 0.5 were extracted, a conservative criterion based on Hair, Anderson, Tatham, and Black (1995). In addition, variables with two factor loading scores greater than 0.50 were eliminated (Kim and Muller, 1978). An examination of Table 6 shows three items was eliminated in this research. Six factors were found to underlie the various sets of container developing strategies for the port of Kaohsiung based on responses to the survey. They were labeled and are described below:

(1.) Factor 1 is an administrative management efficiency strategic dimension, comprising eight attributes, namely, enhancing employee training and knowledge, simplified administrative procedures, management reorganization, enhancing human resource management, improving port information systems, simplified customs procedures, encouraging private sector invest in port operations, and strengthening the intermodal connection with road, air, and inland water transport. This factor accounted for 47.82% of the total variance. Enhancing employee training and knowledge had the highest factor loading on this factor.

(2.) Factor 2 is a carrier services related strategic dimension. This dimension consists of six items, namely, encouraging a long term berth leasing agreement with carriers, developing transshipment services, dredging channel and berth draft, providing one stop shopping services for carriers, encouraging carriers to establish container positioning center in Kaohsiung, and strengthening port sales and promotion. Encouraging a long term berth leasing agreement with carriers had the highest factor loading on this factor. Factor 2 accounted for 8.455% of the total variance.

(3.) Factor 3, a price and incentive strategic dimension, comprises four items, namely, providing incentives for cargo growth, flexible rate to response market change, encouraging private sector invest in port operations, and prompt response to carriers' complaints. Providing incentives for cargo growth had the highest factor loading on this factor. Factor 3 accounted for 6.16% of the total variance.

(4.) Factor 4 is a logistics services strategic dimension. It consisted of three attributes, namely, enhancing the functions of free port zones, establishing international distribution centers, and free trade zones marketing and promotion. This factor accounted for 5.791% of the total variance. Enhancing the functions of free port zones had the highest factor loading on this factor.

(5.) Factor 5 consisted of one attribute, namely, to remove the restriction of direct shipping between Mainland China and Taiwan. This factor accounted for 4.63% of the total variance. Thus, the factor is labeled as direct shipping strategic dimension.

A reliability test based on a Cronbach Alpha statistics was used to determine whether the five factors were consistent and reliable. Cronbach Alpha values for all factors are also shown in Table 6. With the exception of the fifth factor (direct shipping strategic dimension) was not available for reliability test because only one attribute, the values of the other four factors are well above 0.80, considered a satisfactory level of reliability in basic research (Nunnally, 1978; Carmines and Zeller, 1979; Sekaran, 1992; Churchill, 1991; Litwin, 1995).

Table 6 also showed the importance of the factors as judged by respondents. Results showed they perceived the most important container developing strategic dimension is direct shipping between Mainland China and Taiwan (mean=4.220), followed by price and incentive (mean=3.925), administrative management efficiency (mean=3.821), carrier service (mean=3.756), and logistics services strategic dimensions (mean=3.723).

Table 6: Factor analysis for container developing strategic attributes

Container developing strategic attributes	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Enhancing employee training and knowledge	0.792	0.246	0.059	0.189	0.087
Simplified administrative procedures	0.777	0.277	0.191	0.277	-0.048
Management reorganization	0.731	0.394	0.192	0.074	-0.058
Enhancing human resource management	0.727	0.018	0.368	0.235	0.028
Improving port information systems	0.696	0.346	0.166	0.279	0.035
Simplified customs procedures	0.649	0.133	0.311	0.055	0.356
Encouraging private sector invest in port operations	0.638	0.422	0.197	0.049	0.054
Strengthening the intermodal connection with road, air, and inland water transport	0.608	0.008	0.266	0.456	0.145
Encouraging a long term berth leasing agreement with carriers	0.190	0.806	0.136	0.130	0.011
Developing transshipment services	0.074	0.798	0.090	0.382	0.085
Dredging channel and berths draft	0.359	0.711	0.338	0.033	0.053
Providing one stop shopping services for carriers	0.414	0.674	0.216	0.065	-0.04
Strengthening port sales and promotion	0.380	0.656	0.212	0.240	0.053
Encouraging carriers to establish container positioning center in Kaohsiung	0.106	0.608	0.171	0.239	0.246
Providing incentives for cargo growth	0.083	0.188	0.888	0.135	-0.020
Flexible rate to response market change	0.342	0.236	0.694	0.205	0.044
Encouraging private-sector equity participation in port	0.385	0.200	0.661	0.122	-0.019
Prompt response to carriers' complaints	0.494	0.292	0.595	0.076	0.104
Enhancing the functions of free port zones	0.262	0.188	0.272	0.836	-0.010
Establishing international distribution centers	0.290	0.261	0.314	0.735	0.176
Free trade zones marketing and promotion	0.175	0.443	-0.091	0.693	0.021
Mean	3.821	3.757	3.925	3.723	4.220
Eigenvalues	10.522	1.860	1.355	1.274	1.021
Percentage variance	47.826	56.281	62.441	68.232	72.872
Cronbach Alpha	0.9178	0.8909	0.8565	0.8601	-

4. Conclusion and Discussion

Previous studies have explored the importance of competitive strategies in the context of port operations. However, to identify a competitive strategy based on a empirical studies was lacking. This study used an exploratory analysis to evaluate container developing strategies from the perspectives of port authority, shipping managers, and shipping academics. This study has provided a framework for examining the key container development strategies specifically in the Port of Kaohsiung. This study's main findings, derived from a survey conducted in Taiwan, are summarized below.

The six most important strategic attributes from the all respondents perceptions are to remove the restriction of direct shipping between Mainland China and Taiwan, improving port information systems, encouraging a long term berth leasing agreement with carriers, simplified customs procedures, prompt response to carriers' complaints, flexible rate to response market change, and simplified administrative procedures. The present research suggests that port authorities need to be especially concerned with these attributes when developing their competitive strategies.

It should be noted that the strategic attributes used to identify critical dimensions in the previous research have significant variations. This study provides a fundamental concept for port authorities to identify and assess their key container developing strategic dimensions. Based on a factor analysis, the findings reflect that direct shipping between Mainland China and Taiwan was the most important strategic dimension, followed by price and incentive dimension, administrative management efficiency, carrier services, and logistics services strategic dimensions. In particular importance, strategic dimensions not only involved one strategy (direct shipping strategic dimension) but also covered other key strategic dimensions such as price and incentive related, information management related, organizational related, human resource management related, and logistics and so forth. This implies that port authorities need to consider an overall integrated strategy before they implement any strategic decisions. Hopefully, an understanding of competitive ports' behavior and strategies based on the concept of capability and resources should enable port operators to compete effectively in a competitive market.

However, there are some limitations to this research, and there exists wide scope for future research. First, this research was limited to examining the crucial container developing strategies based on an exploratory analysis. Further studies could be conducted to ascertain antecedent and consequent relationships between performance and competitive advantage. Another worthwhile direction for future research could be use of the concept of strategic groups to identify strategic differentiation and competitive advantages in a competitive environment based on resource based view. Strategic groups mapping is beneficial for understanding the situation in a particular industry. Such an approach could investigate strategic and operating differences among various firms within an industry. Additionally, strategic group analysis is a helpful tool for informing companies about significant differences in competitors' approach to the market-place.

The analysis used in this study was static, i.e. the evaluation of respondents' perceptions was conducted at one point in time. Longitudinal research could be employed to examine how perceptions of key strategic dimensions change over time. In addition, this research was conducted in the Port of Kaohsiung. Future research could undertake the same scope of investigation in other international ports context.

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Analyze the Risks of Biological Invasion: An agent based simulation model for introducing non-native oysters in Chesapeake Bay, USA

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Abstract

Introducing non-native specie into the coastal and marine environment, both intentionally and accidentally, could have significant ecological and environmental consequences. Analyzing the possible consequences of nonnative species is vitally important in preventing invasive species, as well as challenging due to the complexity of the marine ecosystem and the interactions among the existing species. This paper presents a Spatial-Explicit Agent Based Simulation (SEABS) model and its application on risk analysis of a non-native oyster in Chesapeake Bay, USA. The result shows that the risks for the introduced species to become dominant species depend on its initial stocking location and level.

Keywords: Marine environmental risks; Biological competition; ABM simulation; Non-native species

1. Introduction

Invasive species are a rapidly growing economic and environmental problem worldwide. It has been identified as one of the leading factors causing tremendous, irreversible environmental changes at ecosystem level (GISP, 2003; UDSA, 1999). Many countries have suffered from huge damage caused by invasive species. For example, in China, one third of the endangered species are the result of invasion of foreign species. United States, for example, has been invaded by approximately 50,000 alien species. One study estimated that the environmental and economic cost of invasive species amount to $120 billion per year (Pimentel *et al*, 2005).

The term "invasive" is applied to nonnative species that cause or are likely to cause economic losses, harm to the environment and/or adverse impacts on human health which are disproportionate to any associated social benefit (e.g., National Invasive Species Council, 2002). Majority of nonnative species are introduced through human activities, either intentionally or unintentionally (National Research Council, 2002), especially with the increase of international trade. Since human actions are largely responsible for introduction, and it is also the pathway that can be managed effectively, many of the management efforts are focusing on this issue.

One example in preventing unintentional introduction of invasive species in international trade is the effort in controlling the discharge of ballast water in maritime transportation. Ballast water is necessary during the ship loading/unloading process for stabilization. With the increase intensity and extensiveness of international trade, this pathway has been identified as the main vector for the introduction of nonnative species. It is estimated that some 3000 species are transported in ships' body or on ships hulls each day (Firestone and Corbett, 2005).

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To control the risk of spreading invasive species from shipping activity, International Maritime Organization (IMO) adopted International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Convention) on 13 February, 2004, which requires ships to develop ballast water management plans, maintain a ballast water record book, undertake certain ballast water management measures, and eventually comply with concentration-based discharge limits.

Intentional introduction of nonnative species for commercial reasons may also result in invasive species either because the introduced species could become invasive in the new environment, or there may be "hitch hikers" that become invasive. Not all nonnative species are invasive. Many nonnative species support highly valued commercial activities and improve our quality of life, such as many introduced agricultural crops, livestock species, ornamental plants and household pets. Thus, it is not desirable to base invasive species control policies based on a wholesale prohibition on the introduction of all nonnative species. This is recognized in extant policy guidance such as Executive Order 13112 and the associated National Invasive Species Management Plan (National Invasive Species Council, 2001), which forbid actions to introduce or enhance nonnative species unless "… the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

Estimating the risks accompanied with the accidental and intentional introduce of invasive species present a challenge due to the complex, yet most of the time unknown biological and ecological adaptation of the introduced species in the environment. However, it is also one of important elements in the decision-making process of controlling the incidents of invasive species from non-intentional introduction, and the permission to intentionally introduce some non-native species into the environment, to provide the satisfaction of our human being.

This paper presents an Agent-based Simulation model for assessing the risks of non-native species to become invasive species, using a case study on the introduction of non-native Suminoe oyster species (*Crassostrea ariakensis*) in the Chesapeake Bay area where the oyster industry is under threat because of the declining population of the native eastern oyster (*Crassostrea virginica*). We will first briefly introduce the oyster industry in Chesapeake Bay and issues in the introduction of the Suminoe oyster. It will be followed by the description of the simulation model, and data used in the simulation process. The simulation result will be presented at the end as a conclusion.

2. Background

Chesapeake Bay is located in the middle lower part of US East Coast, across the State of Maryland and Virginia. Oyster industry there has been decreased dramatically in the past centaury from a billion-dollar industry in the 1880s to less than 1% of that value today, due to the effects of over-fishing, channel dredging, pollutants, sediments runoff, and diseases (Gottlieb and Schweighofer, 1996), and especially, the diseases called MSX and Dermo, caused by an invasive protozoan parasite, *Haplosporidium nelsoni*, which was introduced to the East Coast from Asia (Burreson, Stokes and Friedman. 2000).

A recent initiation on introducing non-productive nonnative Suminoe oyster into the Chesapeake Bay area is under debate because it presents risks in both undermining the ongoing recovery effort of native species, and the risks that the introduced species may become invasive. The hatchery raised triploid Suminoe oyster is supposed to be non-productive, but some of the triploid oysters will revert to diploids, which is capable of reproduction. In addition, some diploid oysters may also be mixed with the triploid oysters and get into the environment accidentally. Hence, introducing triploid oysters reduces the probability that the species will become invasive, but does not completely eliminate the risk.

Therefore, one main task of this research is to find out if the introduced species can generate a sustainable population mass in the bay area under different condition, whether it is diverted diploid oyster, or the oysters accidentally mixed with the diploids. If there is no hope that the introduced species can form a sustainable population, then it can be considered as "low risk" for the introduction of non-native species. However, if the introduced species can form a sustainable population, then we have to be more cautious in deciding to introduce the species into the environment.

Many existing papers have studied the biological property of Suminoe oyster and how it is interacting with the environment. Langdon and Robinson (1996), for example, discussed the aquaculture potential of non-reproductive Suminoe oyster in the West Coast of USA. It presented many life history parameters of Suminoe oysters, spawning environment and period, and its environmental tolerances. Similar research including Nell (2002) who discussed the possibility to use triploids for oyster farming activity in France, and Calvo *et al* (2000) which studied the environmental requirement for oyster growth.

Dew *et al* (2003) built a simulation model for assessing the Likelihood of self-sustaining populations resulting from commercial production of triploid Suminoe Oysters in Chesapeake Bay. The life-history parameters of this simulation draw heavily from a previous research by Mann and Evans (1998), which estimated the standing stock for the native eastern oyster in the James River. The variables in the simulation include salinity, stocking density, reversion rate from triploids to diploids, reproduction potential, natural and harvest mortality. The spatial interaction and the competition are not considered in the model. Similar modeling effort using oyster population dynamics could also be found for Pacific oyster (Crassostrea gigas) in Mediterranean coastal lagoon at Thau, France (Gangnery *et al*, 2004), at Port Stephens, Australia (Honkoop and Bayne, 2002).

A recent report on the background economic analysis for the environmental impact statement regarding the introduction of non-native Suminoe oyster in Chesapeake Bay (Lipton *et al*, 2006) presents an extensive economic analysis for the benefits and costs with the introduction of Suminoe oyster. However, in estimating the future benefits from the introduced oyster growth, the limitation and spatial distribution of the oyster habitat on the population growth of the introduced species were not included.

Large scale simulation analysis for modeling the spatial biological interaction between species and with environment using agent based modeling approach is not frequently seen in the publications. One of such paper is addressing the ecological system in the Coastal lagoons ecosystem where human being (like oyster farmer) is involved in the complex decision-making process (Pereira *et al*, 2004). One of the example provided in the paper simulates the anthropogenic environmental pressure resulted from the tourism and shellfish/fish farming in Sungo Bay, People's Republic of China. It was modeled as a 2D model including the hydrodynamic process and biochemical process in the region, based on a finite difference bathymetric staggered grid with 1120 cells and a spatial resolution of 500m (side length of rectangular cell). This grid configuration is not optimal in modeling the homogeneous diffusion in all direction.

Our focus in this research is to simulate the spatial growth of the introduced oyster in the Chesapeake Bay, taking into consideration many realistic factors such as the spatial distribution of oyster habitat, species competition between native and non-native species, in addition to the population dynamics and life history parameter of the native and non-native oysters. It also allows the analysis of different management policies, such as selecting the level and site of initial stocking, setting policies on Total Allowable Catch and initial non-harvesting period, etc.

We use Agent Based Model [ABM] in simulating the oyster population dynamics and spatial diffusion over the oyster habitats in the Chesapeake Bay. ABM is a relatively new computational modeling paradigm, originally derived from the Computer Science and refers to the modeling of various phenomena as dynamical systems of interacting software agents. The outstanding feature of ABM is its ability to derive the intricate behavior of the whole system based on the simple, local behavior of each individual agent. Because of this, it has been applied in the study of collective economic behavior (Tesfatsion, 2006), biology (Politopoulos, 2007), and complex social, economic, and biological system (Bobashev *et al*, 2007). As it is rather complex to model the result from the interaction of oysters in different area of the bay, we design a virtual oyster population agent to manage the population dynamics and spatial diffusion of oyster within each cell.

3. Population Dynamics for Oysters

This research simulates the behavior of oysters using a detailed model of survival, growth, reproduction and transport of oyster populations. The model described in this section, including all life history parameters of oysters closely follows Mann and Evans (1998) and Dew *et al* (2003), with two significant departures. First, we include detailed modeling of larval transport. The population dynamics specified in this section are for each specific oyster habitat "cell". The specification of the cell will be explained in next section. Secondly, we examine interactions between the native species and the introduced species. In locations where the two stocks co-exist, they compete for food and habitat space. Also, we model stock interactions though reproduction, as discussed below.

Once oysters set, they are secured to hard surface (including other oysters), so that transportation of adult oysters is minimal. Rather, transport of oysters occurs almost exclusively during reproduction and the larval life stages. Various means of controlling the spread of nonnative oyster involve management actions that effectively reduce the production of gametes (sperm and eggs), such as introducing non-reproductive triploid oysters, and actions that reduce the viability of larvae, thereby reducing the production of juvenile nonnative oysters. For example, planting of non-native oysters could be restricted to isolated habitat locations, where larvae are unlikely to spread. Or since larvae are far more sensitive to salinity levels than adults, the risk of uncontrolled spread of non-native oysters could be reduced by introducing non-native oysters in locations where salinity is unfavorable for survival of larvae.

In order to model policies that control potential spread of nonnative oysters, we need to carry out detailed modeling of various stages of the process from spawning through survival of young-of-the-year. For these reasons, our model focuses more extensively on modeling the details of the early life stages of oysters than is typical for bioeconomic models. Our model includes separate equations for production of gametes, fertilization into zygotes, and setting of spat on hard substrate.

At present, we utilize identical life history parameters for the two species of oysters, with the important exception of susceptibility to disease. The primary rationale for introducing *C. ariakensis* is its resistance to disease. Therefore, we adopt available estimates for susceptibility of the native species, *C. virginica*, but assume that the introduced species is not affected by disease.

3.1 Modeling the oyster fecundity with the environmental condition

First we model fecundity or the production of gametes. The number of gametes produced depends upon the number of oysters and the size of oysters, where gamete production increases at an increasing rate with size. Also, in the case of introducing non-reproductive triploid oysters, the reproductive potential is determined by the fraction of introduced oysters that revert from triploid to diploid and the fraction of diploids that are accidentally introduced. The equation for fecundity is:

$$\mathrm{F}_{\mathrm{tj}} = 39.06\left[0.000423 L_{\mathrm{tj}}^{1.17475}\right]^{2.36} N_{\mathrm{tj}}(R_{\mathrm{tj}} + T_{\mathrm{tj}})$$

where F_{tj} is total potential fecundity (in millions of eggs) at time t for age class j, L_{tj} is the length at time t for age class j, N_{tj} is the number of adults at time t for age class j, R_{tj} is the percentage rate of revision from triploid to diploid, and T_{tj} is the percentage of diploids accidentally released into the environment. Note that for native oysters and nonnative oysters are stocked as reproductive diploids, R_{tj}=0 and T_{tj}=1. Salinity is used to relate potential fecundity to actual fecundity. Although adult oysters are relatively unaffected by salinity, reproductive effects can be important. This suggests a spatially explicit policy to reduce risk of invasion by planting nonnative oysters in areas where reproduction is limited by salinity, or in areas where nonnative oysters are confined by salinity. For example, the risk of spread of the nonnative species can be controlled by limiting planting to inlets that are isolated from the rest of Chesapeake Bay by an area with salinity that is unfavorable to survival of larvae, thereby reducing the likelihood of geographic dispersal of nonnative oysters.

The fecundity adjustment factor accounting for salinity, F_S, is zero for salinity less than 8 ppt, reaches a maximum at salinity of 13.5 ppt, then declines back to zero when salinity reaches 35 ppt. We specify the relationship between fecundity and salinity as a piecewise linear function of the level of salinity.

Salinity (S)	S<8	8≤S<13.5	13.5≤S<35	for S≥35
F_S	0	(S-8)/5.5	(35-S)/21.5	0

where F_S is the salinity factor that relates potential to actual fecundity, and S is salinity measured in parts per thousand.

We introduce a disease factor to account for the effect that various diseases can have on reproductive success. The disease factor goes from 0 to 1, where zero indicates no reproductive success, and 1 indicates no disease-related mortality. Although nonnative oysters have proven to be resistant to diseases that are prevalent on the east coast, they may be affected by other diseases. Also, the disease factor will be important when the model is used to analyze decision with within a multi-species framework, with both native and nonnative oysters.

Oysters tend to congregate in highly concentrated communities, called oyster bars. Indeed, oyster bars were significant hazards to shipping in Chesapeake Bay when oyster populations were at historic high levels. Oysters benefit from high concentrations in at least two ways. First, oysters require hard surface to attach to, including other oysters. Therefore, oysters provide their own habitat. Also since oysters are broadcast spawners, fertilization success increases with concentration of oysters. We specify an equation for fertilization success as:

$$F_{ft,i} = 0.0049 D_{t,i}^{0.72}$$

where $D_{t,j} = \dfrac{N_{t,j}(R_{t,j} + T_{t,j})}{A}$

and $F_{ft,j}$ is fertilization efficiency, $D_{t,i}$ is the density of reproductive oysters, and A is the area in square meters. For hexagon with side length 500 meters, A is equal to 649519.05 square meters.

Total zygote production is the sum over all age classes of potential production, corrected for salinity (F_s), the sex ratio (F_{qi}), the fraction not lost to disease (F_d) and the fertilization rate ($F_{ft,i}$)

$$F_{total,t} = \sum_i \left(F_{revert\,t,i} * Fs * F_{qi} * F_d * F_{ft,i} \right)$$

3.2 Dynamic population of oyster population

Spat are zygotes that have successfully metamorphosed, settled and attached to hard substrate. The total number of zygotes is sum of the number of reproduced from the population net of the emigrated zygotes (E percent), plus the number of population from all other cells. Spat are then produced by metamorphosis of the zygotes and setting onto hard structure. The number of spat is determined by multiplying the number of zygotes by the probability of successful completion of metamorphosis (P_{met}), corrected for larval mortality through the time of settlement. The daily larval mortality rate is L_{mort}, and it takes approximately 21 days from metamorphosis to finish. Finally, the number of one-year-old oysters is the number of spat times the total mortality rate for oysters less than one year old (m_0). The equation relating the number of zygotes to the number of one-year-old oysters is:

$$N_1 = \left(F_{total}(1-E) + \sum_{n=1}^{N} \alpha_n F_{total}^n \right) P_{met}(1-L_{mort})^{21}(1-m_0) \quad \text{for } l \neq n$$

where N_1 is the number of individuals at age class one in one cell, F_{total}^{k} is the total larvae from the k^{th} cell, α_n is the percentage of the larvae moved from n^{th} cell to this cell, N is total number of cells that have larvae being transported to this cell. When working in the multi-species framework, this will be extended to include a fraction of non-viable zygotes that result from hybridization between the native and nonnative species. More discussion of this issue is contained below.

Numbers of individuals at various age classes then progress through the equation:

$$N_{t+1,j+1} = N_{tj}(1 - M_j)(1 - H_{tj})$$

where H_{tj} is the harvest rate for age class j at time t, and M_{tj} is the natural mortality rate at time t for age class j. Harvest also varies by time to account for changes in the different management policies over time. The total number of individuals in the population is simply the sum over all age classes:

$$N_t = \sum_{j=1}^{M} N_{tj}$$

3.3 Competition of habitat space through biomass Capacity

In real environment, the oyster population cannot grow over certain limit. In the simulation model, we specify the upper limit for the total weight of oyster per square meters (C). If the total weight of the oysters in one cell is larger than its capacity, the population of the oysters in all the age class will be reduced proportionally, so that the total weight will below the capacity limit.

When two species resides in the same cell, they will compete for available limited space. For example, if the total weight of native oysters in cell i at time t (W_{it}^{n}) and non-native oysters (W_{it}^{o}), $W_{it}^{n} + W_{it}^{o}$ is larger than C, then it is necessary to limit the number of oysters for each species. The upper limits for each species will be:

$C_{it}^{o} = \delta C$ and $C_{it}^{n} = (1 - \delta)C$

where $\delta = \dfrac{W_{it}^{o}}{W_{it}^{o} + W_{it}^{n}}$ is the percentage of the non-native oyster weight in total weight of the oyster in the cell. C_{it}^{o} and C_{it}^{n} are the capacity limited of the non-native oyster and native oyster, respectively. Thus the species with higher growth rate will eventually become dominate in the cell, if all other factors not changed.

3.4 The effect of gamete sink on oyster population

Another potentially important issue associated with co-existence of two oyster species in the same area is the gamete sink (e.g., Meritt *et al*, 2005, Bushek *et al*, 2007). Oysters of all species are broadcast spawners, and fertilization occurs when sperm and egg join in the environment. This raises the potentially important issue of the extent to which gametes of the two species interact. If the two species of oysters synchronize spawning, then a fraction of eggs from one species will join with a sperm from the other. This results in a hybrid that is not viable, which adversely affects reproduction of both species. Therefore, whenever non-native species happen at the same cell as the native species, we compute the result of gamete sink on both species. Assume the number of gametes for native species is N_A and that for non-native N_B, then $N_A^{'} = p_A N_A$, and $N_B^{'} = (1 - p_A) N_B$ are the number of gametes for native and non-native species, respectively, after the gamete sink effect, where

$$p_A = \frac{N_A}{N_A + N_B}$$

is the ratio of the gametes of native species in the total gametes number in this cell.

This specification shows that the effect on the less numerous species may be far more devastating from a reproductive viewpoint. For example, suppose that the gametes (eggs and sperm) of one species outnumber those of the other by a ratio of 3 to 1. In this case, ¼ of the gametes from the more numerous species will join with gametes from the less numerous species, and become hybrid. Since these hybrids are not viable, they die. However, ¾ of the gametes from the less numerous species will join with gametes from the more numerous species, producing hybrids which subsequently perish. This means that less numerous species in an even worse competitive position in each future generation, and their gametes will become outnumbered by an even larger ratio in the future. Hence, even in cases where the population of less numerous species is viable in the absence of the more numerous species, the potential for the gamete sink could make the species reproductively non-viable. This notion of the gamete sink is incorporated in calculating the viability of zygotes in the multi-species version of our simulation model, as discussed above.

The effect of the gamete sink could be advantageous or disadvantageous when considering potential risks of invasion by intentionally introduced species. If the gametes from the introduced species significantly outnumber those of the native species, the native species could be driven out (assuming synchronized spawning), and attempts to restore the native species could be futile if a large population of reproductive nonnative species is established. However, if the number of gametes from the introduced species is kept sufficiently below those of the native species, then the gamete sink effect could reduce the risk of invasion by the introduced species, and the number of gametes of the introduced species could be kept low by introducing non-reproductive triploids. Thus, even if the population of the introduced species is significantly larger than that of the native species, the number of gametes from the introduced species could be kept low by introducing non-reproductive triploids. The gamete sink effect could reduce the probability of successful reproductive by mosaics and accidentally introduced diploids.

However, it would be advised not to become too reliant upon the gamete sink notion to control the risks of invasion by the introduced oysters. If spawning is not well synchronized across the two species, then the gamete sink notion is not relevant. And even if the populations start out synchronized, one might expect evolutionary pressures to disrupt the synchronization of spawning: oysters whose reproduction is not synchronized with the competing species might become relatively more successful, and the two populations might naturally move out of synchronization.

4. Simulation the Spatial Movement of Oysters

We developed a spatially explicit agent-based model that simulates the growth, transport and harvest of the native and nonnative oyster species in Chesapeake Bay. The agent-based framework extends Recursive Porous Agent Simulation Toolkit (RePast), which supports general simulation activities, such as GUI for starting and stopping simulation, controlling time steps, change simulation parameters, and coordinating with basic simulation functions. Simulation procedures specific to this project are started with oyster model, which read in the data necessary and simulation parameters, create oyster habitat space for oyster population agent, a display for oyster habitat and the population agents, and a data recorder to take down the numerical simulation results. A general structure of the simulation model is in Figure 1.

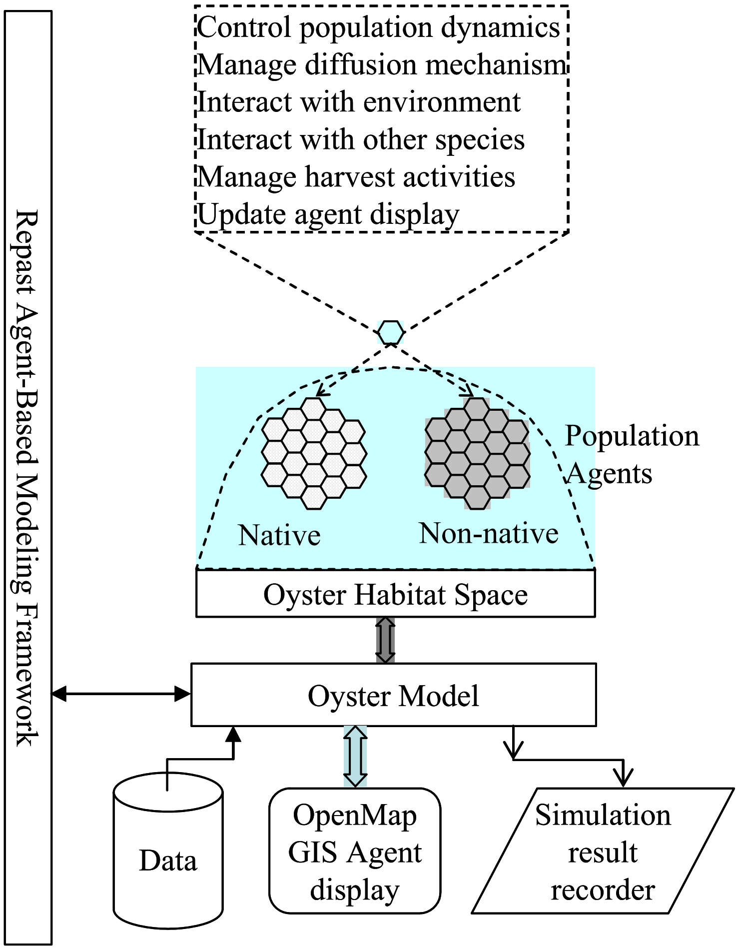

Figure 1: Depiction of the modeling system architecture

The oyster model also creates the initial oyster population agent at the initial stocking cell for each species, and let them grow and spread in the simulation process in the virtual habitat space. Model results are passed back to OpenMap to create a dynamic visual representation of oyster population on electronic maps. The OpenMap depiction of simulation area in Chesapeake Bay and an illustrative view of a spatial distribution of oyster population are presented in Figure 2, as they would be seen by the model user. More detailed simulation results, such as the quantitative levels of oyster populations over time and space, harvest, etc. are stored for later analysis. Next we will explain more on the configuration of the habitat space and the simulation environment.

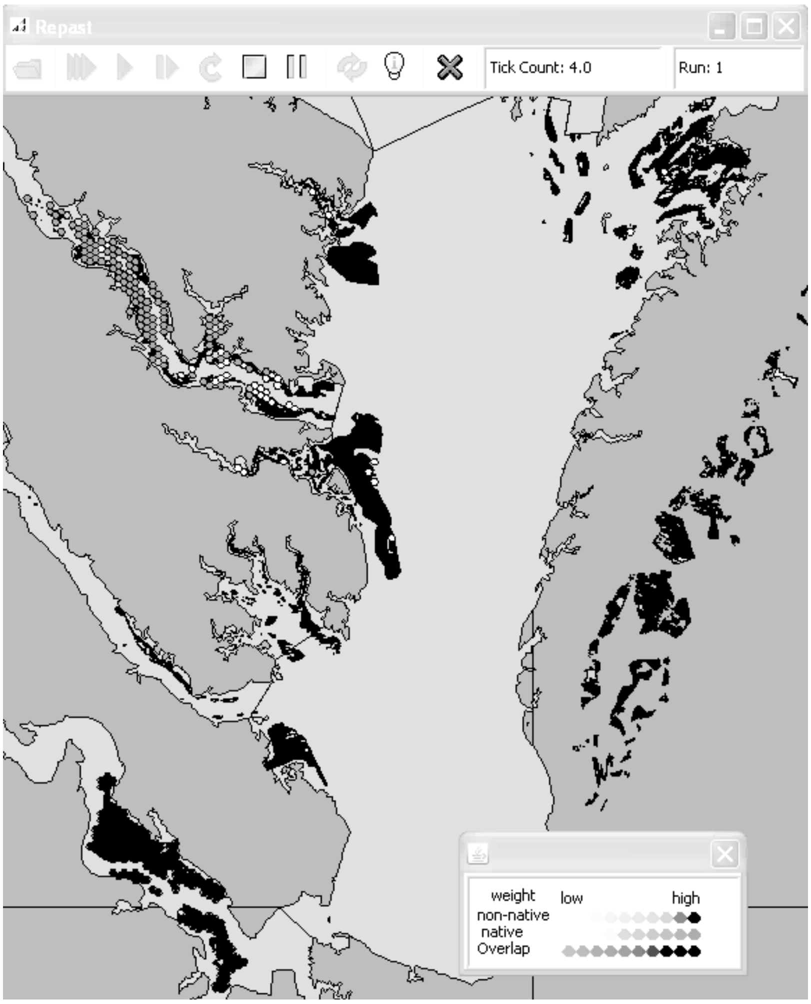

Figure 2: Illustrative output from the simulation model

<u>4.1 Spatial configuration of oyster habitats</u>

The oyster habitats in Chesapeake Bay are scattered in different tributaries, and cover only a small part of the bay area. To enable the simulation of the spatial diffusion of oyster larva as well as the harvest activities for adult oysters, we divided the habitat space into many small hexagonal cells, 500 meters on each side. The whole simulation area, as shown in Figure 3, could be divided into 200 by 200 such cells if all the area were oyster habitat. This grid configuration could be changed before each simulation to accommodate the need of different research purpose. In addition, we only included cells with hard bottom type (oyster rock, shell mud, and shell sand), as oyster can only fix and grow on hard surface.

With this arrangement of cells, each cell is identified by its coordinates x and y, with the origin being the upper left corner of the simulation area (Figure 3). This specification will greatly facilitate the conversion of coordinates system with the longitude and latitude, and calculate the distance between the any two cells. Further, it facilitates the diffusion mechanism by simplify the algorithm in finding out the neighboring cells at specific range measured by the number of rings.

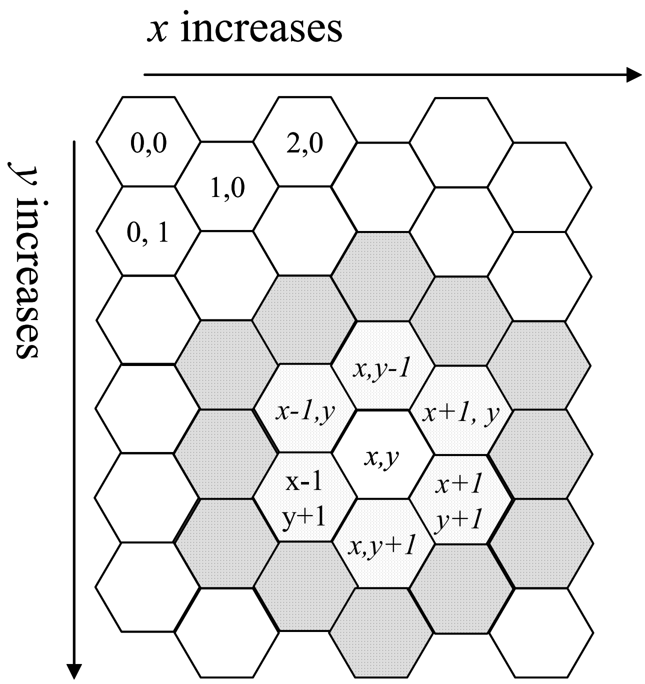

Figure 3: Illustration of the coordinate system of oyster habitat space

Residing in each cell is one population agent that manages the population dynamics from each species. It is identified by its specie name and its coordinates, has information about the life-history parameter of the specie (such as age, length, growth mechanism, mortality rate, reproductive capability, etc), and can access to the environmental information such as location, bottom type, the tributary information, and information about whether there is other specie resides in the same cell.

4.2 Spatial diffusion of oyster

Agent in one cell interacts with the agents in the neighboring cells through spreading oyster larvae into other cells within certain range, and accepting larvae drifted from other cells. This is the main mechanism for oyster to diffuse over the bay area.

Many of the environmental factors participated in the movement of the oyster larvae in the water column, such as the geographical condition, hydrodynamic characteristics of the bay, tidal and water current, etc. To simplify the simulation process, for each species (*s*), we used the actual observations on the transportation distance d_i^s at each tributary (*i*)(Table 1), and the connectivity among tributaries (ρ_{ij}^s) (Table 2) to model the zygotes movement within the same tributary (*i*=*j*), and the movements to other tributaries (*i*≠*j*).

Table 12: Oyster larval transport distance and estimated standard error and max. distance (Km)

Tributaries	C. Virginica			C. Ariakensis		
	distance	Std	Max.Dist*	distance	Std	Max. Dist*
Rappahannock R.	10.9	16.16	26.58	7.2	10.67	17.56
Piankatank River	6.2	9.19	15.12	3.9	5.78	9.51
York River	9.2	13.64	22.44	7.1	10.53	17.31
VA Mainstem	20.7	30.69	50.48	16.7	24.76	40.73
Mobjack Bay	6.4	9.49	15.61	5.9	8.75	14.39
James River	9.3	13.79	22.68	7	10.38	17.07

* Max. Distance: the distance where the cumulative distribution is equal to 95%.
Source: North *et al* (2006)

Table 13: Oyster diffusion rate within and across tributaries

			Destinations (V.: C. Virginica; A: C. Ariakensis)					
			Rappa-hannock	Plana-tank	York	Virginia Mainstem	Mobjack Bay	James
Source	Rappahan-nock	V	92.10%	2.00%	0.40%	5.30%	0.30%	
		A	99.60%	0.20%		0.30%		
	Planatank	V	3.40%	69.40%	0.50%	26.30%	0.40%	
		A	7.70%	86.50%		5.70%		
	York	V			93.70%	0.70%	5.50%	0.05%
		A			97.90%	0.30%	1.30%	0.50%
	Virginia Mainstem	V	8.80%	4.00%	6.10%	72.70%	6.20%	1.60%
		A	11.30%	2.10%	1.70%	62.30%	1.10%	19.30%
	Mobjack Bay	V			5.90%	1.80%	92.30%	0.03%
		A			8.80%	0.60%	90.60%	0.01%
	James	V				1.60%		98.40%
		A			0.001%	0.020%	0.001%	100.0%

Source: North *et al* (2006).

To model the zygotes movements within same tributary, we first assume the transportation distance of zygotes follows positive portion of normal distribution. Since we don't have the negative part, and d_i^s is the mean value of zygotes transport distance, we can find the standard deviations (σ_i^s) that make the cumulative probability from origin to the mean distance (d_i^s) equal to 25%:

$$\frac{1}{\sigma_i^s\sqrt{2\pi}}\int_0^{d_i^s} e^{\frac{-t^2}{2\sigma_i^s}}\,dt = 25\%$$

The standard deviations that satisfy above condition are shown in Table 1 (std.). They are used to calculate the percentage of larvae that will be transported into cells at different distance. Figure 4 illustrates an example of half-normal distribution when standard deviation equaling to 2, and percentages of larvae remain in the initial cell and that transported to each ring. As the cell length is 500 meters, and its center is the starting point of the half-normal distribution, the first ring starts at 500 meters, then each of next ring will start 1 km away from the previous one, until the cumulative probability is larger than 95%. Table 1 also includes the computed maximum distance ($d^s_{i,\max}$). As the cell diameter is 1 km, $d^s_{i,\max}$-0.5 is actually the number of rings for species *s* in tributary *i*. Using Φ^s_{ik} for the cumulative probability at the k^{th} ring, if all of the cells at that ring are oyster habitat, then the percentage of larvae (λ^s_{ik}) moved to any one cell at that ring is:

$$\lambda_{ik}^{s}=\frac{\rho_{ii}^{s}\Phi_{ik}^{s}}{6k}$$

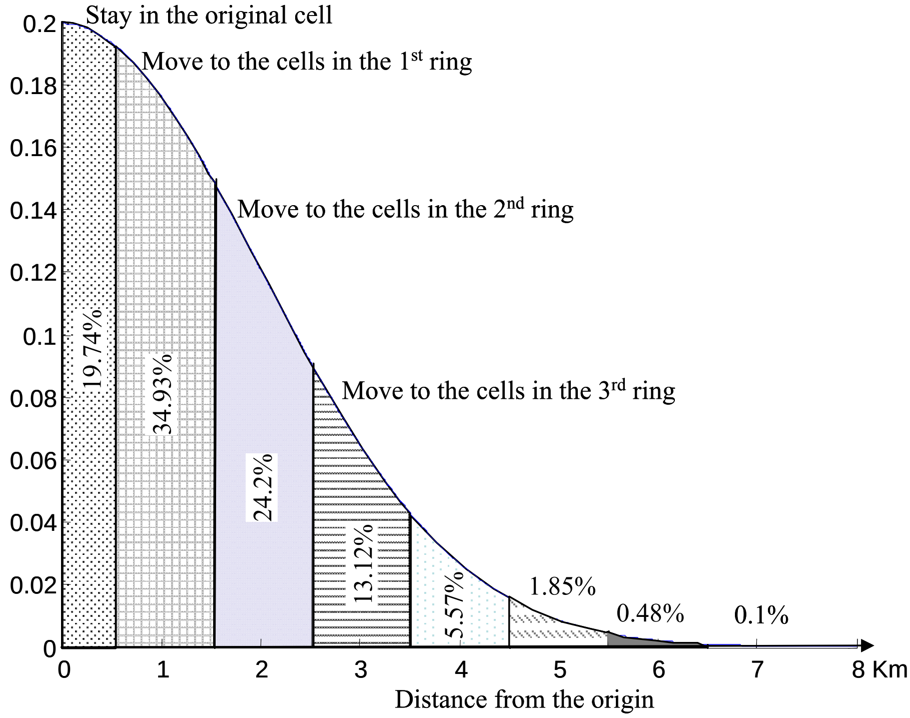

Figure 4: Percentage of zygotes transported to different rings for standard deviation=2

The diffusion to the cells not in the same tributary is done by randomly pickup one cell from the tributary where $\rho_{ij}^{s}\neq 0$ in table 2, and assume all that friction of the zygotes are transported to the chosen cell. If the cell is an oyster habitat, it can survive; otherwise, they will just disappear.

In either case, the new population agent will be created if the cell that accept new larva does not have a population agent in it. Then the agent will manage the oyster population dynamics, and interaction with the other agents and with the environment. If the oyster population in a cell becomes zero, the population agent will be deleted.

4.3 Data used in the Agent-Based Simulation Model

Data used in this simulation model include the actual larvae movement data for native and non-native species in the Chesapeake Bay (Table 1 and Table 2), the GIS database for different bottom types in the Virginia part of the Chesapeake Bay (Figure 5), and the life-history parameters and economic price of the native and non-native species (Table 3).

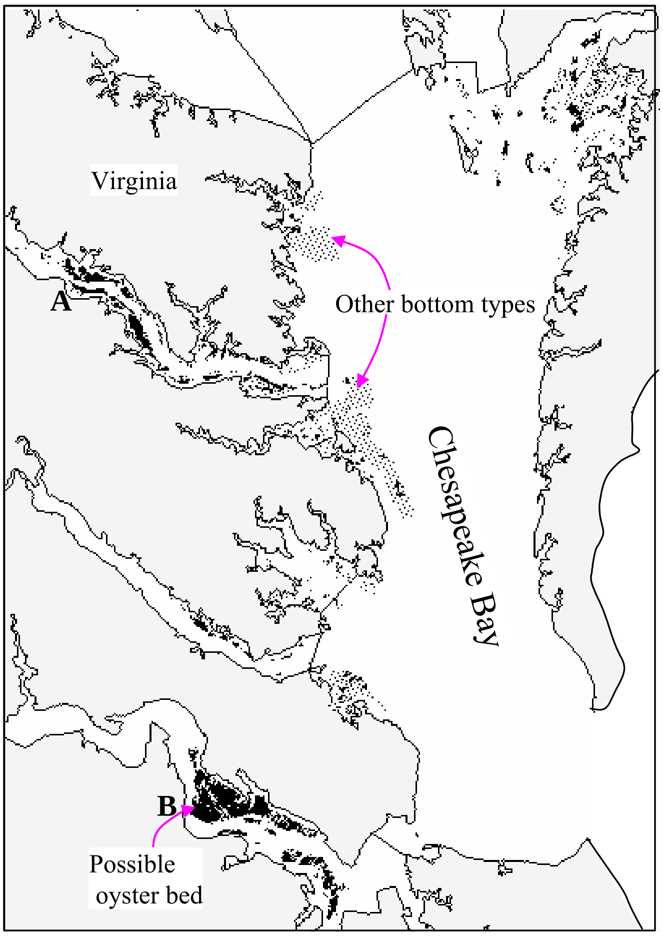

Figure 5: Oyster bed and other bottom types in Virginia part of the Chesapeake Bay (Dark spots in the figure (A, B) indicates oyster bed. Other bottom types are currently not suitable for oyster to grow, but possible oyster beds.)

Table 14: Life-history parameters and economic price for native and non-native oysters

Year		0	1	2	3	4	5	6
Length (mm)		0	54.5	96.9	124.2	151.5	178.7	196.9
R		0	0	0	0.049	0.009	0.014	0.019
T		0	0.001	0.001	0.001	0.001	0.001	0.001
Fq		0	0.28	0.66	0.8	0.9	0.95	0.95
M	Native	0.98	0.7	0.6	0.5	0.4	0.3	0.2
	Non-native	0.98	0.5	0.4	0.3	0.3	0.2	0.2
H		0	1	1	1	1	1	1
Price	Native	0	0.2	0.65	0.55	0.55	0.55	0.1
(P*)	Non-native	0	0.2	0.25	0.3	0.25	0.2	0.1

* US Dollar per piece.

Figure 5 shows that there are not so many areas in the Virginia part of the Chesapeake Bay suitable oyster to settle down and grow. The black areas in the map are either oyster rocks, shell mud and shell sand area, which are scattered in different tributaries, separated by place not suitable for oyster to grow. The other bottom types, such as buried shell, sand, sand mud, clay, etc, cannot be used as oyster habitat.

Owing to lack of data for non-native Suminoe oyster, most of the parameters used in this simulation are actually from native Easter species. We assume that nonnative oyster, *C. arikansis*, has very similar life history parameters as the native one. The only differences are their susceptibility to disease. Nonnative species' mortality is 80% higher than the nonnative one. Besides, due to the preference of the local people, the market price of native oyster is higher than the non-native one.

For each simulation trail, we specify initial settings for the oyster model to build the habitat space and start the simulation. They include the simulation area, grid specification (side length of hexagon), initial stocking level and position, biomass capacity, TAC, and certainty of catch. Certainty of catch is the probability of harvest for legal-size oyster in a cell. It actually reduces the catchibility, for both native and non-native species. For native species, it will increase the probability for restoring native oyster population. For non-native species, it increases the risk of forming a self-sustaining population.

5. Simulation Result

The concern for the introduction of the non-native species including whether the introduced species can become a self-sustaining species in the Chesapeake Bay, and whether it will out-compete with the native species, become the only species in the Bay. The risk for the non-native species to become self-sustaining population depends on many factors. We will address the quantity and place of stocking, the whether there are native species competing with them. The major part of the simulation result is a dynamic, visual display of the spatial oyster population agents in the simulation process. A snapshot of such dynamic visual display is shown in Figure 2. Because of the data availability in the bottom types, we only simulate the area in the Virginia part of the Chesapeake Bay.

5.1 Simulation scenarios

We use several scenarios to demonstrate the simulation results with respect to different locations and initial quantities of the native and non-native species, with or without harvest activities. To illustrate the different outcomes with or without specie competition, we will first present the result for the introduced species only. Then we will specify the scenario for two species. Two places considered for stocking oyster spats in the simulation are A, in Rappahannock River, and B, in James River, as shown in figure 2.

5.2 Scenarios with single species

We start with the simulation with only non-native species in the Chesapeake Bay, to show the survivability of introduce non-native triploids with respect to the place of stocking.

5.2.1 Scenario 1: non-native Triploids at James River

In this scenario, we specify initial stocking population 150 million spats at the one oyster cell in James River, which equals to $230/m^2$ in spat density. In the first some years, the oyster will just stay at its original place, as spats are fixed to the oyster bed. New larvae will only appear when the undetected/reverted diploids become mature. These larvae will quickly spread over the oyster beds within the same tributary in the first 5 years. From the 10^{th} year, it begins to spread over the oyster habitats in other tributaries. However, due to limited density, oyster population starts to decrease at the 20^{th} year. At the 45^{th} year, only the oyster bed in James River still has some oyster left. At the year 48, all oyster disappeared from Chesapeake Bay.

This scenario indicates that the risk for the introduced species to be dominating species in the Chesapeake Bay is low if the initial stocking site is in James River. The nonnative oyster will not be sustainable in the Chesapeake Bay. It will disappear even without harvest activity.

5.2.2 Scenario 2: non-native Triploids in Rappahannock River

With the same amount of initial spat, the simulation result shows that the non-native species will be able to exist perpetually in the Chesapeake Bay, if the initial stocking place is in Rappahannock River. Because of the position of Rappahannock River, the oyster species stocked in this river is easy to spread, and hence have high possibility to sustain itself.

The difference between these two scenarios may be partly attributable to the water current movement in the Chesapeake Bay area. In Rappahannock River, the water flow enables the spreading of the oyster larvae into other parts of the bay area, while in James river, as it is at the downstream of the water flow, it larvae diffusion is not as efficient as that in Rappahannock river area. This can be represented by the diffusion rate among the tributaries in the bay area (Table 2).

5.2.3 Scenario 3: Non-native triploids in Rappahannock River with harvest

With the same initial spat number and the place of stocking for non-native oyster as in Scenario 2, the simulation result shows that the species will also become not sustainable if we allow harvest 10 years after stocking. The harvest is so arranged that only 20% of the oysters in the total simulation area can be harvested, i.e., the Total Allowable Catch (TAC) is 20%. Also, as the oyster is fixed at the oyster bed and easy to catch, it is assumed that the certainty of catch is 95%. Thus 5% of the legal size oysters will be available for reproduction in each cell.

The simulation result of introducing non-native species when there is no competition species in the bay area can be illustrated by the population dynamics in the initial cell (Figure 6). It shows that the initial growth period in scenario 1 is just not enough to sustain future growth. The difference between scenario 2 and 3 is the starting of harvest after year 10. This shows the possibility to introduce non-native triploids, get the economic benefit from such introduction, and at the same time prevent the risk having an invasive species.

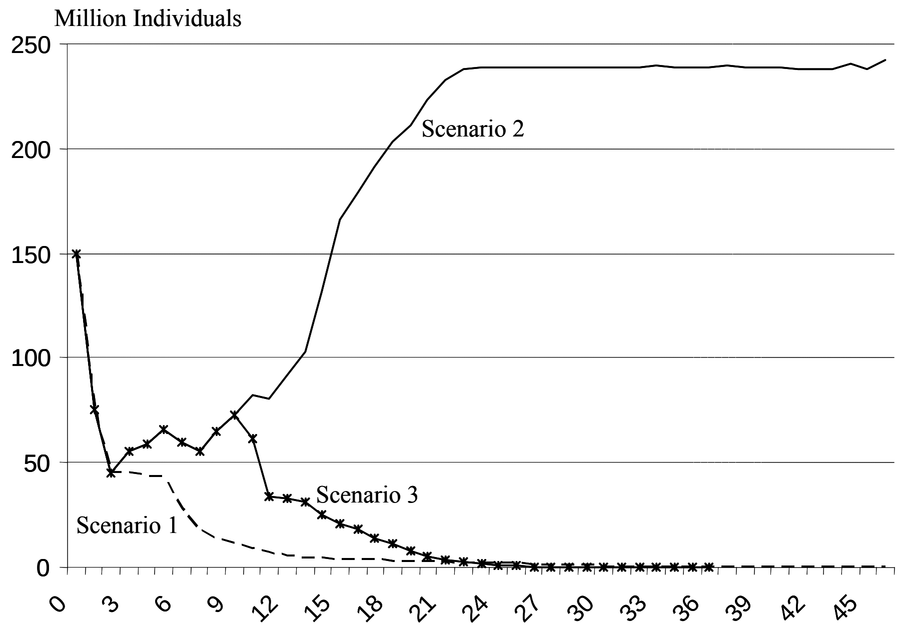

Figure 6: Simulated population dynamics at the initial cell for scenarios 1 to 3

5.3 Scenarios with competing species

With two species in the same bay area, they will interaction with each other through competing for limited spaces and possible gamete behavior during the spawning time. Next several scenarios will demonstrate the simulation result for such interaction. In both scenarios, the initial stocking number is set to 200 million spats (307/m^2), to allow for this mutual impact.

5.3.1 Scenario 4: native oyster in Rappahannock River, and non-native specie in James River

Although the number of initial spat number increased to 200 million, the oyster population still cannot support itself if we allow harvesting 20% of the total oysters in the Bay area from the 10th year of the simulation. Although native specie has better location, it still can not compete with the non-native species, because it its high market price, and high mortality rate. Therefore, the non-native species will beginning to spread over in the Rappahannock River at 20th year, and will become dominant after that. However, as the population size is not sufficient to support reproduction, the non-native will start to diminish and disappear in the bay area.

The simulation result for the total population of native and native species in the whole simulation area is shown in Figure 7. At the very beginning, the number of native oysters is higher than the nonnative one, because only a very small percent of the introduced species is reproductive. However, once the introduced oyster is generated from the reverted triploids, they all become reproductive, so it will have higher growth rate.   It also shows that the harvest activity after the 10th year is the main factor for the diminishing of non-native oyster population. The value of the harvest could be around 75 million dollars at the peak time of the harvest.

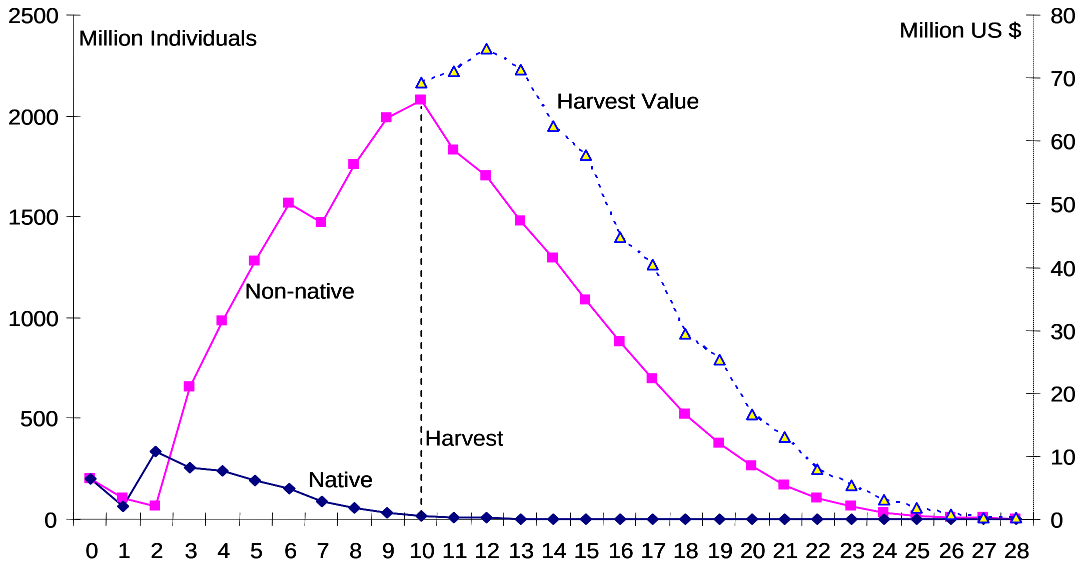

Figure 7: Simulated population dynamics for scenario 4 for the whole simulation area

5.3.2 Scenario 5: native in James River and Non-native in Rappahannock River

With native oyster in James River, non-native oyster will dominate the simulation area, able to sustain harvesting 20% of the total oyster, and still exist perpetually in the bay area. Because of that, the value of the harvest could also last forever (Figure 8). However, this scenario does not consider any possible negative impacts from the over-dominating population of non-native oyster species in the Bay area. The main concerns for the negative impact includes: clogs the waterway, eradicate the native oyster species, compete with other living organisms for space and food, change the bio-diversity of the local environment, and the biological structure of the ecosystem. These are actually the main concerns for the introduction of the non-native species.

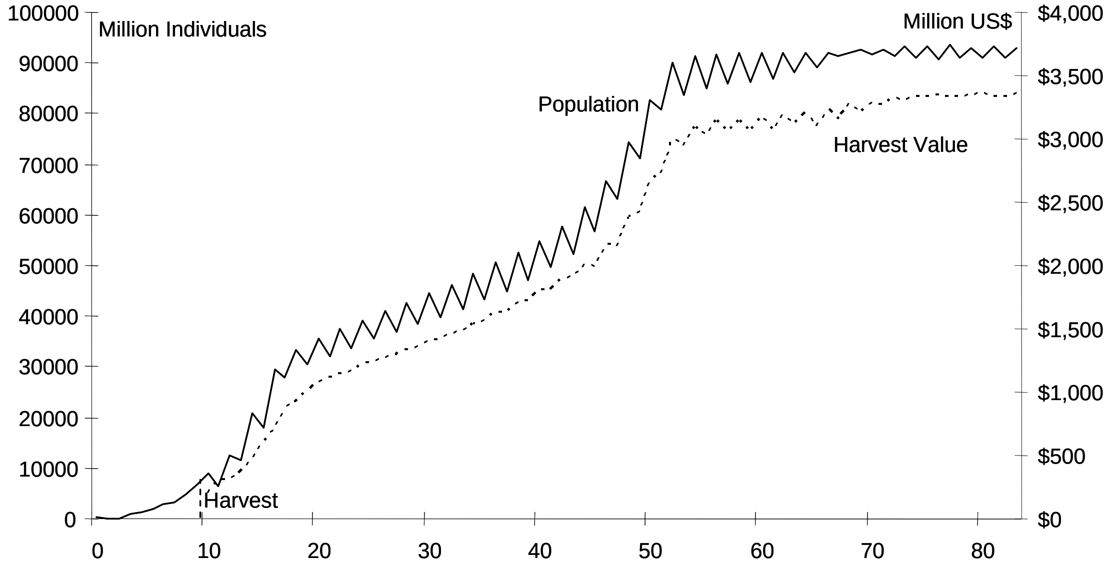

Figure 8: Simulated population growth and harvest for scenario 5

These five scenarios demonstrate the different outcomes with different initial stocking levels at different tributaries of the bay area, with or without the interactions of the native species. For both cases (single specie and two species), it reveals that non-native species will be more easily spread and fill in all the oyster beds when they are stocked in the Rappahannock River. In scenario 2, the non-native oyster will spread all over the oyster bed in the simulated area and grow to the capacity level without harvest. The risk exists for the non-native species to become invasive. As the purpose of introducing non-native species is for its economic value, scenario 3 show that the oyster population will not last forever with harvest after 10 years. This minimizes the risk for the introduced species to become invasive, and at the same time, meet the market demand for oysters. It is not an issue for the disappearing of the non-native species, as it can be re-stocked again if it is diminishing. Scenario 5 illustrates a case where the oyster population become perpetual even with 20% TAC, which illustrate higher catching rate or lower initial stocking level should be adopted, to eliminate the risks for the introduced species to become invasive.

Scenario 4 and 5 also demonstrate the concerns on how to protect the native species that is under threat due to both over harvest and the impact of diseases. With the introduction of non-native species with lower mortality rate, the native species are under unfavorable position in the specie competition. In both scenarios, the native species will be replaced by the non-native species. If the management decision is to protect the native species, then it is necessary to adopt a more conservative policy in introducing the non-native species.

6. Summary

This paper introduced the Agent Based Simulation Model for spatial population growth and species competition, and applied it to the risk analysis for the intentional introduction of the non-native oyster species into the Virginia part of the Chesapeake Bay. It integrates the bio-economic model of Oyster population dynamics with the spatial spreading and movement of the oyster larvae over the actual distribution of the existing oyster habitats in the real environment.

Compare with Dew's results, the simulation results from this research indicate that it should be more cautious when considering introducing non-native triploids into the bay area. With the similar stocking density, the non-native oyster would become self-sustaining with 30 years' stocking period in Dew's simulation, while in our simulation only one year is necessary. This means that the simulation without consider the distribution of the oyster bed and spatial interaction may under-estimate the risks for the non-native species to become invasive.

There a couple of limitation to this research, which may require further studies. First, the position and level of existing stock of the native oyster is not known. To enable the restoration of the native species, it is necessary to survey the existing status of the native species, so as to decide the location and level of non-native species, to make it not replace the native species. Second, the simulation model only included the Virginia part of the Chesapeake Bay, due to the fact that the bottom type data is not available in upper part of the bay.

Nonetheless, this simulation model reveals some important issues regarding the policy of introducing non-native species in the marine environment. Effective measures for reducing the risks of invasive species could be employed, so that economic benefits could be obtained at the same time preserve the local ecological environment. This could also be employed to analyze the invasive species problems in the maritime transportation sector, so as to allow the economic benefits from shipping and port activity, and protect the local environment from the negative impact of invasive species.

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Ship Traffic in Container Port: Modelling Methodology and Performance Evaluation

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Abstract

This paper gives modeling methodology of ship traffic in container port and performance evaluation. The basic approach used mathematical and simulation models. These models are developed for impact analysis of the ship traffic and patterns of arrival ships at terminal performance. The results, analysis and conclusions given in this paper also addresses issues such as the performance criteria and the models parameters to propose an operational method that reduces average cost per ship served and increases the terminal efficiency. We present effect on capacity performance with numerical results and computational experiments which are reported to evaluate the efficiency of Pusan East Container Terminal (PECT).

1. Introduction

This paper gives a ship-berth-yard link modeling methodology based on statistical analysis of container ship traffic data obtained from the PECT. Implementation of the presented procedure leads to the creation of a simulation algorithm and analytical methodology that captures ship-berth-yard link performance well. All the main performances of the ship-berth-yard link are given. As a ship-berth-yard link at a container terminal is the large and complex system, a performance model has to be developed. In this paper, we propose two models based on simulation and queueing theory, respectively, in order to determine the performance evaluation of ship-berth link in port. The analytical model has fewer inputs and requires less computational times, whilst the simulation model can handle more practical situations with more manipulated variables and less constraints.

This paper describes the criteria for the combined evaluation of important parameters of the total port cost function such as: ship service and waiting time, the number of berths and related average container ship cost in port and the optimal combination of berths/terminal and quay cranes/berth. These parameters are the basis of simulation and analytical approaches used in this paper. Furthermore, the advantage of simulation modeling over analytical modeling of ship-berth link is that it allows a higher level of detail and avoids too many simplifications. In analytical models, the level of detail is often restricted by the limited expressiveness of the analytical method, while for simulation models it is only restricted by the available time and resources.

The rest of this paper is organized as follows. In the next section we provide an overview of the

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literature related to port simulation and analytical modeling. The following section presents a brief description of ship-berth-yard link modeling procedure. Also, this section is concerned with the evaluation of functional estimation models in container port. This is followed by the next section which gives model validation and simulation and analytical results for PECT. Finally, we conclude by summarizing the results and contributions of this paper.

2. Related Literature

Most studies and papers focus their attention on the strategic and tactical problems in the applications of the simulation and analytical models. The determination of optimum number and capacity of berths have been treated both theoretically and practically in many studies.

Numerous studies have been conducted regarding the improvement of the efficiency of ship operations or berth and quay crane (QC) scheduling and planning problem in port. Nicolaou (1967, 1969) has defined the port performance measures as "degree of occupancy" and "degree of congestion", "percentage occupancy" and "percentage congestion". Noritake and Kimura (1983) extended the application of queueing models to the ship-berth link in relation with the researches of Nicolaou (1967). Noritake (1985) has considered the port congestion in relation with the cost and the optimal berth utilization. Schonfeld and Sharafeldien (1985) were the first who discussed the problem of optimal berth and crane combinations in containerports. In the same context, Huang *et al.* (1995, 1997) assumed a similar form of equations to measure the transfer time a ship spends in a port. Furthermore, Chu and Huang (2002) discussed the degrees of interferences for multiple cranes that work simultaneously in the port of Kaohsiung.

Moreover, simulation models have been used extensively in the planning and analysis of ship-berth-yard link in port. Ballis and Abacoumkin (1996) developed a simulation with animation to simulate the operational activities of a container terminal with straddle carriers. Merkuryeva *et al.* (2000) considered simulation of containers processed at the Baltic Container Terminal in Riga as a basic simulation research, and then its complementing by a metamodelling study is discussed. Yun and Choi (1999) proposed a container terminal simulation model using an object-oriented approach. Key issues of the application of modeling and simulation for the management of the Malaysian Kelang container terminal are discussed in paper by Tahar and Hussain (2000). Gambradela *et al.* (2001) presented a solution to the problems of resource allocation and scheduling of loading and unloading operations in a container terminal. Legato and Mazza (2001) focused on the berth and allocation of berths to arriving ships with queueing network based on the model which is simulated by Visual SLAM software in various scenarios. Nam *et al.* (2002) examined the optimal size of the Gamman Container Terminal in Pusan, in terms of berths and quay cranes using the simulation analyses which were performed in four scenarios, representing different operational patterns. Shabayek and Yeung developed simulation model employing the Witness program to analyze the Hong Kong's Kwai Chung container terminal performance. Pachakis and Kiremidjian (2003) presented a ship traffic modeling methodology based on statistical analysis of container ship traffic and cargo data obtained from a port in the United States. Demirici (2003) developed simulation model to analyze port operations and was run especially for investment planning. Dragović *et al.* (2005) developed simulation models of ship-berth link with priority service in container port. Bielli *et al.* (2006) proposed simulation model which can improve ports efficiency and they gave the architecture components that are implemented with Java. Ng and Wong (2006) developed a simulation model for studying the impact of the vessel-traffic interference in Hong Kong's terminal basin on its container terminals' capacities.

In addition, Kozan (1997) gives a review on analytical and simulation models. Yamada *et al.* (2003) presented a mathematical model with the queuing theory for determining optimal container handling systems so that the total cost incurred in a container terminal is minimized. A simulation model was also developed to investigate the performance of the mathematical model. In order to determine the performance evaluation of ship-berth link in port Dragović *et al.* (2006a,b) proposed two models based on simulation and queueing theory, respectively. It should also be pointed out, that there are three overview concepts of container port operation literature given by Vis and Koster (2003), Steenken *et al.*

(2004) and Stahlbock, and Voß (2008).

3. Problem Description and Modeling Procedure

Container port system is complex owing to the different interarrival times of ships, different dimensions of ships, multiple quays and berths, different capabilities of QCs and QCs productivity and so on. Therefore, simulation and analytical models are used to describe this system.

The analytical modeling of container terminal consists of setting up mathematical models and equations which describe certain stages in the functioning of the system. Specifically, the probabilistic models are, often, used to describe the evolution of these systems in the process of their modeling. Simulation modeling is better than analytical one in representing random and complex environment of container terminal.

3.1 Simulation Model Structure

The different types of simulation languages that have been used for modeling of the processes at the ship-berth-yard link include MODSIM III, AweSim, EXTEND, SIMAN, SLAM, Taylor II, ARENA, Witness, GPSS/H. The simulation models are used to analyze queuing and bottleneck problems, container handling techniques, truck and vessel scheduling (departure and arrival rates), equipment utilization, and port throughput and operational efficiency (yard, gate and berth). Most container terminal systems are sufficiently complex to warrant simulation analysis to determine systems performance. Simulation is recommended for analyzing ship-berth-yard link performance. The GPSS/H simulation language, specifically designed for the simulation of manufacturing and queueing systems, has been used in this paper (Schriber, 1991).

In order to present the ship-berth-yard link processes as accurate as possible, the following phases need to be included into simulation model (Dragović *et al.*, 2005 and 2006a,b):

- **Model structure:** ship-berth-yard link is complex due to different interarrival times of ships, different dimensions of ships, multiple quays and berths, different capabilities of QCs and so on. The modeling of these systems must be divided into several segments, each of which has its own specific input parameters. These segments are closely connected with the stages of ship service.

- **Data collection:** All input values of parameters within each segment are based on data collected in the context of this research. The main input data consists of ship interarrival times, lifts per ship, number of allocated QCs per ship call, and QC productivity. Existing input data are subsequently aggregated and analyzed so that an accurate simulation algorithm is created in order to evaluate ship-berth-yard link parameters.

- **Inter-arrival times of ships:** The inter-arrival time distribution is a basic input parameter that has to be assumed or inferred from observed data. The most commonly assumed distributions in literature are the exponential distribution (Demirci, 2003; Pachakis and Kiremidjian, 2003; Dragović, *et al.* 2006a,b); the negative exponential distribution (Shabayek and Yeung, 2002) or the Weibull distribution (Tahar and Hussain, 2000; Dragović *et al.* 2005).

- **Loading and unloading stage:** Accurate representation of number of lifts per ship call is one of the basic tasks of ship-berth-yard link modeling procedure. It means that, in accordance with the division of ships in different classes, the distribution corresponding to those classes has to be determined.

- **Number of QCs per ship:** The data available on the use of QCs in ship-berth-yard link operations have to be considered too, as this is another significant issue in the service of ships. This is especially important as total ship service time depends not only on the number of lifts but also on the number of QCs allocated per ship. Different rules and relationships can be used in order to determinate adequate number of QCs per ship. On the other hand, in simulation models, it is enough to determine the probability distribution of various numbers of QCs assigned per ship.

- **Flowchart:** Upon arrival, a ship needs to be assigned a berth along the quay. The objective of berth allocation is to assign the ship to an optimum position, while minimizing costs, such as berth resources (Frankel, 1987). After the input parameter is read, simulation starts by generating ship arrivals according to the stipulated distribution. Next, the ship size is determined from an empirical distribution. Then, the priority of the ship is assigned depending on its size. The ship size is important for making the ship service priority strategies. For the assumed number of lifts per ship to be processed, the number of QCs to be requested is chosen from empirical distribution. If there is no ship in the queue, the available berths are allocated to each arriving ship. In other cases ships are put in queue. The first come first served principle is employed for the ships without priority and ships from the same class with priority. After berthing, a ship is assigned the requested number of QCs. In case all QCs are busy, the ship is put in queue for QCs. Finally, after completion of the loading and unloading process, the ship leaves the port. This procedure is presented in the algorithms shown in Figure 1.

In order to calculate the ship-berth-yard performance, it is essential to have a through understanding of the most important elements in a port system including ship berthing/unberthing, crane allocation per ship, yard tractor allocation to a container and crane allocation in stacking area. As described in Figure 2 - process flow diagram of the terminal transport operations, the scope of simulation, strategy and initial value and performance measure will have to be defined. In addition, the operational aspect such as machine failures having a direct impact on ship, crane and vehicle will have to be considered. To move containers from apron to stacking area, four tractors are provided for each container crane.

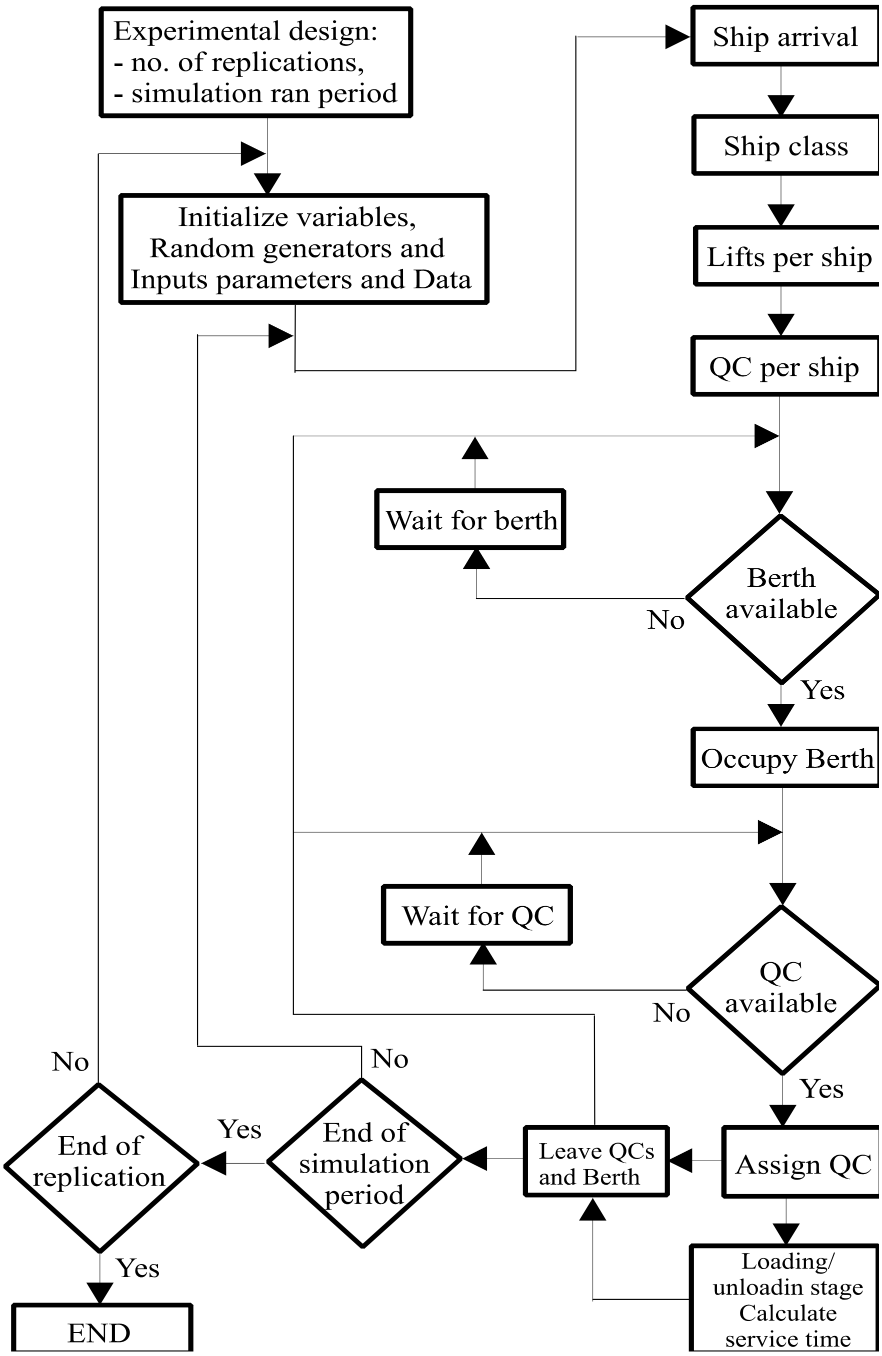

Figure 1: Flowchart for a ship arrival/departure

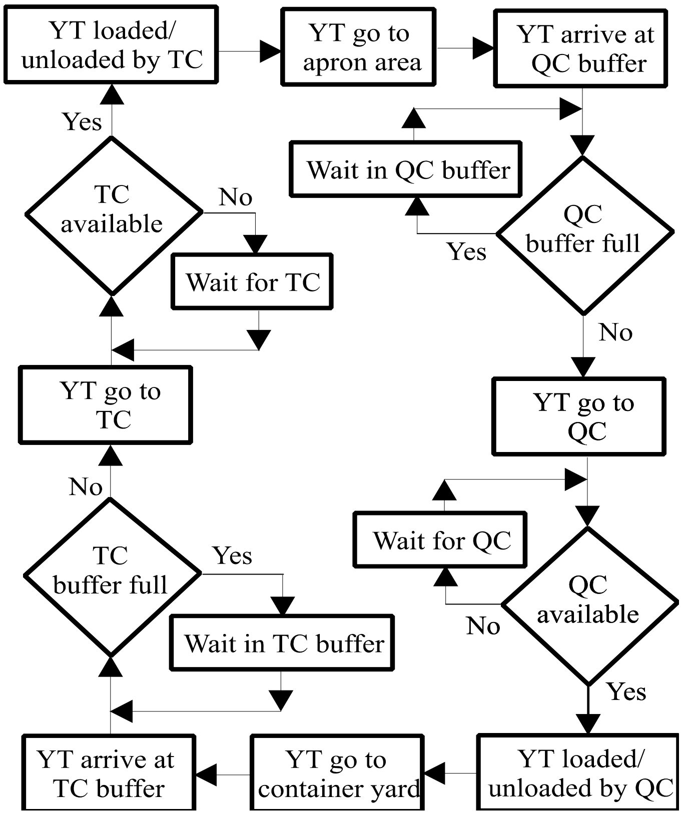

Figure 2: Flowchart of the terminal transport operations

3.2. Analytical Model Structure

Queueing theory (QT) models for analyzing traffic of ships in port is proposed and shown in Figure 1, which indicates that each symbol has the following meaning: λ – average ship arrival rate in ships/hour; μ – average ship service rate in ships/hour; n_b – number of berths per terminal; n_c – number of quay cranes (QCs) per berths; n_s – number of ships present in port; t_w – average waiting time in hours/ship; t_s – average service time in hours/ship; t_{ws} – average time that ships spend in port in hours/ship; t_{du} – maneuvering time (berthing/unberthing) = const. in hours; n_{con} – number of containers loading/unloading per container ship; r_{con} – QC move time in hours/container; t_c – ships' loading/unloading time in hours/container ship; k_c – QC interference exponent and θ – ship traffic intensity.

The average service time, t_s, $t_s = 1/\mu$, where $\mu = (t_c + t_{du})^{-1}$, includes ships loading/unloading time t_c, in hours per container ship, expressed as

$$t_c = (n_{con} \cdot r_{con})/(n_c)^{k_c} \quad (1)$$

where $k_c = (\ln(n_{con} r_{con}) - \ln(t_c))/\ln(n_c)$ (2)

It follows that

$$n_c = \left(\frac{\lambda n_{con} r_{con}}{\theta - \lambda t_{du}}\right)^{1/k_c} \quad (3)$$

Further, it can be shown that

$$t_{ws} = t_w + t_s \tag{4}$$

where $$t_w(\theta) = \frac{\theta^{n_b}}{(n_b-1)!\,\mu(n_b-\theta)^2\left(\sum_{n_s=0}^{n_b-1}\frac{\theta^{n_s}}{n_s!}\right) + \theta^{n_b}(n_b-\theta)\mu} \tag{5}$$

for the ($M/M/n_b$) model. Accordingly, this parameter with the notation θ, is equal $\theta = \lambda \cdot t_s = \lambda / \mu$.

In this study, formulae due to Lee and Longton (1959) and Cosmetatos (1975, 1976) have been adapted concerning the average port waiting time of ships (Noritake 1985, Radmilović 1992). Accordingly with it, when the ships service time has an Erlang distribution with k phases, the following equations are obtained

$$t_{ws} = t_w V_c + t_s \tag{6}$$

for the ($M/E_k/n_b$) model, where $V_c = \frac{1}{2}\left(\frac{1}{k}+1\right)$ - the coefficient of variation of ships service time distribution and k is the number of phases of an Erlang distribution;

$$t_{ws} = t_w \cdot \left[\frac{1}{2}\left(\frac{1}{k}+1\right) + \left(1-\frac{1}{k}\right)\left(1-\frac{\theta}{n_b}\right)(n_b-1)\frac{(4+5n_b)^{\frac{1}{2}}-2}{32\theta}\right] + \frac{1}{\mu} \tag{7}$$

for the ($M/E_k/n_b$) model.

3.3. Ship traffic

A queueing theory model for analyzing traffic of $N \geq 1$ ships in port is proposed at interval $(0,T)$. Suppose that interarrival times of ships are random variables determined by the distribution function $A(t)$ with $A(+0) < 1$, and the expectation value $\alpha = \int_0^\infty t dA(t) < +\infty$. The function $A(t)$ is used below to determine the probability distribution for the number $p_i(t)$, $i = 0,1,..., N$ of ships that arrive in port at an interval $(0,t)$, so that $\sum_{i=0}^{N} p_i(t) = 1$.

Such introduced random flow, determined for $0 \leq t < +\propto$ is called limited recurrent flow. The probability $p_i(t)$ can be determined (Cox and Smith, 1961) as

$$\begin{aligned} p_i(t) &= A_*^{(i)}(t) - A_*^{(i+1)}(t), \quad i = 0,1,..., N-1; \\ p_N(t) &= 1 - \sum_{i=0}^{N-1}\left(A_*^{(i)}(t) - A_*^{(i+1)}(t)\right) = A_*^{(N)}(t), \end{aligned} \tag{8}$$

where $A_*^{(i)}(t)$ is a i'th convolution of the function $A(t)$ with itself; $A_*^{(0)}(t) \equiv 1$.

Suppose that ships arrive according to a limited Poisson process, so that

$$A(t)=\begin{cases}1-e^{-\lambda t} & for \quad t\ge 0\\ 0 & for \quad t<0\end{cases} \tag{9}$$

Then (8) (Cox and Smith, 1961) implies

$$p_i(t)=\frac{(\lambda t)^i}{i!}e^{-\lambda t},\ \ 0\le i<N \tag{10}$$

$$p_N(t)=1-\sum_{i=0}^{N-1}\frac{(\lambda t)^i}{i!}e^{-\lambda t} \tag{11}$$

It is well known that a flow composed from finite number $m>1$ of simple mutually independent flows with rates $\lambda_1,...,\lambda_m$, is also a simple flow with rate $\lambda_1+...+\lambda_m$. The same property is also true for the limited Poisson process described above.

Suppose that on the interval $(0,T)$ is planed arrival of $N_1+N_2+N_3$ ships, where the number N_i related to i'th flow, $1\le i\le 3$, and $N_1\le N_2\le N_3$. Next suppose that mean interarrival time of ships in i'th flow, $1\le i\le 3$, is λ_i^{-1}. Denote by $p_n(t)$, $0\le n\le N_1+N_2+N_3$, the probability $p_n(t)$ at the interval $(0,t)$ arrive n ships from described flow. Then since the above three flows are mutually independent, we have

$$p_n(t)=\sum_{\substack{n_1+n_2+n_3=n\\ 0\le n_i\le N_i\\ 1\le i\le 3}} p_{n_1}^{(1)}(t)p_{n_2}^{(2)}(t)p_{n_3}^{(3)}(t) \tag{12}$$

where the probabilities $p_{n_i}^{i}(t)$, $1\le i\le 3$, can be computed by the Eqs. (10) and (11).

by changing λ with λ_i and N with N_i.

In order to determine the sum on the right hand side of the Eq. (12), we consider the following cases:
Case 1, $n_i\ne N_i$ for all $1\le i\le 3$. Then by Eq. (10) the corresponding term in the sum given by Eq. (12) is

$$\prod_{j=1}^{3}\frac{(\lambda_j t)^{n_j}}{n_j!}e^{-\lambda_j t}=\left(\prod_{j=1}^{3}\frac{(\lambda_j)^{n_j}}{n_j!}\right)t^n e^{-\sum_{j=1}^{3}\lambda_j t} \tag{13}$$

Case 2, $n_i=N_i$ for exactly one i, $1\le i\le 3$. Then for such an i by Eqs. (10) and (11) we have the corresponding term in the sum expressed by Eq. (12) is

$$\begin{aligned}&\left(1-\sum_{k=0}^{N_i-1}\frac{(\lambda_i t)^k}{k!}e^{-\lambda_i t}\right)\prod_{\substack{j=1\\ j\ne i}}^{3}\frac{(\lambda_j t)^{n_j}}{n_j!}e^{-\lambda_j t}\\ &=\left(1-\sum_{k=0}^{N_i-1}\frac{(\lambda_i t)^k}{k!}e^{-\lambda_i t}\right)\left(\prod_{\substack{j=1\\ j\ne i}}^{3}\frac{\lambda_j^{n_j}}{n_j!}\right)t^{\sum_{j=1}^{3}n_j-n_i}e^{-\sum_{j=1}^{3}\lambda_j t-\lambda_i t}\end{aligned} \tag{14}$$

Because of $\sum_{j=1}^{3} n_j - n_i = n - n_i = n - N_i$, the above sum is

$$\left(1-\sum_{k=0}^{N_i-1}\frac{(\lambda_i t)^k}{k!}e^{-\lambda_i t}\right)\left(\prod_{\substack{j=1\\ j\neq i}}^{3}\frac{\lambda_j^{\,n_j}}{n_j!}\right)t^{n-N_i}e^{-\sum_{j=1}^{3}\lambda_j t-\lambda_i t} \qquad (15)$$

Case 3, $n_i = N_i$ and $n_l = N_l$ for exactly two values *i* and *l* with $1 \le i < l \le 3$. Then for such i and l by (10) and (11) we obtain that the corresponding term in the sum given by (12) is

$$\left(1-\sum_{k=0}^{N_i-1}\frac{(\lambda_i t)^k}{k!}e^{-\lambda_i t}\right)\left(1-\sum_{k=0}^{N_l-1}\frac{(\lambda_l t)^k}{k!}e^{-\lambda_l t}\right)\frac{(\lambda_r t)^{n_r}}{n_r!}e^{-\lambda_r t} \qquad (16)$$

where $1 \le i < l \le 3$ and *r* is the element from $\{1,2,3\}$ distinct of i and l.

Case 4, $n_i = N_i$ for all $1 \le i \le 3$. Then $n = N_1 + N_2 + N_3$ and by Eq. (11) we obtain that the corresponding term in the sum expressed by Eq. (12) is

$$\prod_{i=1}^{3}\left(1-\sum_{k=0}^{N_i-1}\frac{(\lambda_i t)^k}{k!}e^{-\lambda_i t}\right) \qquad (17)$$

Finally, it is obvious that $p_n(t)$ determined by (12), can be expressed as a sum of three subsums whose general terms are given by (13), (15), (16) and (17), respectively. Recall that in the whole sum given by (12) the second mentioned subsum must be written for any i with $1 \le i \le 3$, and the third mentioned subsum must be written for any pair i,l with $1 \le i < l \le 3$.

3.4. Modeling of ship loading/unloading operations

The basic tasks in container port management are berth and QC allocation, container yard and storage planning, dock labour, controlling container and cargo flows, and the logistics planning of container operations. In this way the port management would be acting jointly in its own best interests and those of the shipping lines using the container port. On the other hand, the objective cost function of the formulation is to minimize total port costs, which includes ship traffic intensity, waiting time before berthing, length of queue, time spent in the queue and ship turnaround time.

In general, this model integrates main actual operations of the container terminal by simplifying complex activities, and these operations are defined according to ship class. In this section, various objects were observed in the real terminal and model elements. Model elements of the container terminal can be separated into following group: berth cost in \$ per hour, $c_1 = n_b c_{n_b}$; QCs cost in \$ per hour, $c_2 = n_b n_c c_{n_c}$; storage yards cost in \$ per hour, $c_3 = \theta\mu n_{con} t_{t_{con}} a_{con_{cy}} c_{cy}$; transportation cost by yard transport equipment between quayside and storage yard in \$ per hour, $c_4 = \theta\mu n_c t_c n_{cyc} c_t$; labor cost for QC gangs in \$ per hour, $c_5 = \theta\mu n_c t_l c_l$; ships cost in port in \$ per hour, $c_6 = \theta\mu t_{ws} c_s$; and containers cost and its contents in \$ per hour, $c_7 = \theta\mu t_{ws} n_{r_{con}} c_w$. The total cost function, would be concerned with the combined terminals and containerships cost as $TC = \sum_{i=1}^{7} c_i$.

It is necessary to know that only the total port cost function computes the number of berths/terminal and QCs/berth that would satisfy the basic premise that the service port cost plus the cost of ships in port should be at a minimum. This function was introduced by Schonfeld and Sharafeldien (1985). We point out that their solutions may not be as good as ours because we have simulation approach to determine key parameters t_w, t_s, λ, μ, θ and especially k_c. Therefore, to find the optimal solution, their function can be obtained in the following form

$$TC = f(\theta) = n_b\left(c_{n_b} + n_c c_{n_c}\right) + \\ + \theta\mu\left(n_{con} t_{t_{con}} a_{con_{cy}} c_{cy} + n_c t_l\left(c_l + n_{cyc} c_t\right) + t_{ws}(\theta)\left(c_s + n_{r_{con}} c_w\right)\right) \tag{18}$$

where TC - total port system costs in \$/hour; c_{n_b} - hourly berth cost in \$, ($c_{n_{b1}}$ - the initial berth cost, i - interest rate, n_y - economic lifetime in years, $c_{n_{bm}}$ - annual maintenance cost per berth), $c_{n_b} = \left(c_{n_{b1}}\left(i(1+i)^{n_y} / (1+i)^{n_y} - 1\right) + c_{n_{bm}}\right) / (365 \cdot 24)$; c_{n_c} - crane cost in \$/QC hour; $t_{t_{con}}$ - average yard container dwell time, in hours; $a_{con_{cy}}$ - number of m^2 of storage yard per container; c_{cy} - storage yard cost in \$/m^2 hour; n_{cyc} - hourly average number of cycle by yard transport equipment between quay side and container yard; c_t - transportation cost between quay side and container yard per cycle in \$; t_l - paid labor time in hour per gang per ship, $t_l = \max\{t_c\}$; c_l - labor cost in \$/gang hour; c_s - ship cost in port in \$/ship hour; $n_{r_{con}}$ - average payload in containers/ship; c_w - average waiting cost of a container and its contents in \$/container hour.

By substituting Eq. (3) into Eq. (18) we obtain

$$TC = f(\theta) = n_b c_{n_b} + \lambda n_{con} t_{t_{con}} a_{con_{cy}} c_{cy} + \left(\frac{\lambda n_{con} r_{con}}{\theta - \lambda t_{du}}\right)^{1/k_c} \times \\ \left(n_b c_{n_c} + \lambda t_l\left(c_l + n_{cyc} c_t\right)\right) + \lambda t_{ws}(\theta)\left(c_s + n_{r_{con}} c_w\right) \tag{19}$$

where $t_{ws}(\theta)$ is defined by the Eq. (6) or Eq. (7) or by a result of simulation modeling.

From the total port cost function per average arrival rate, we can obtain

$$AC = \frac{f(\theta)}{\lambda} = \frac{f(\theta)}{\theta\mu} \tag{20}$$

Eq. (20) shows the average container ship cost in \$/ship, AC. In this study, the trade-off will be simulative and analytically resolved by minimizing the sum of the relevant cost components associated with the number of berths/terminal and QCs/berth, and average arrival rate. These three parameters are key to the analysis of facility utilization and achieving major improvements in container port efficiency, increasing terminal throughput, minimizing terminal traffic congestion and reducing re-handling time. A reduction in operating cost can be achieved by jointly optimizing these parameters. In solving the berths/terminal and QCs/berth, analysts and planners are concerned primarily with the average time that ships spend in port and the average cost per ship serviced.

4. Computational Results

This section gives a ship-berth-yard link modeling methodology based on statistical analysis of container ship traffic data obtained from the PECT. The efficiency of operations and processes on the ship-berth link has been analyzed through the basic operating parameters such as traffic intensity, average number of ships in waiting line, average time that ships spend in waiting line, average service time, average total time in port, average QC productivity and average number of QCs per ship.
PECT is big container terminals with a capacity of 2,075,895 twenty foot equivalent units (TEU) in

2006. There are five berths with total quay length of 1,500 m and draft around 14-15 m, Figs. 3 and 4 (PECT website). Ships of each class can be serviced at each berth.

4.1. Parameters Involved

An important part of the model implementation is the correct choice of the values of the simulation parameters. The input data for the both simulation and analytical models are based on the actual ship arrivals at the PECT for the ten months period from January 1, 2005 to October 31, 2005 (Figure 3) and January 1, 2006 to October 31, 2006 (Figure 4), respectively (PECT website, PECT *Management reports*). This involved approximately 1,225 ship calls in 2005 and 1,285 in 2006. The ship arrival rate was 0.168 ships/hour in 2005 and 0.176 in 2006. Total throughput during the considering period was 1,704,173 TEU in 2005 and 1,703,662 TEU in 2006. Also, the berthing/unberthing time of ships was assumed to be 1 hour. The ships were categorized into the following three classes according to the number of lifts: under 500 lifts; 501 – 1,000 lifts; and over 1,000 lifts per ship. Ship arrival probabilities were as follows: 23.8% for first class, 40.8% for second and 35.4% for third class of ships in 2005 and 29.9% for first class, 37.7% for second and 32.4% for third class of ships in 2006.

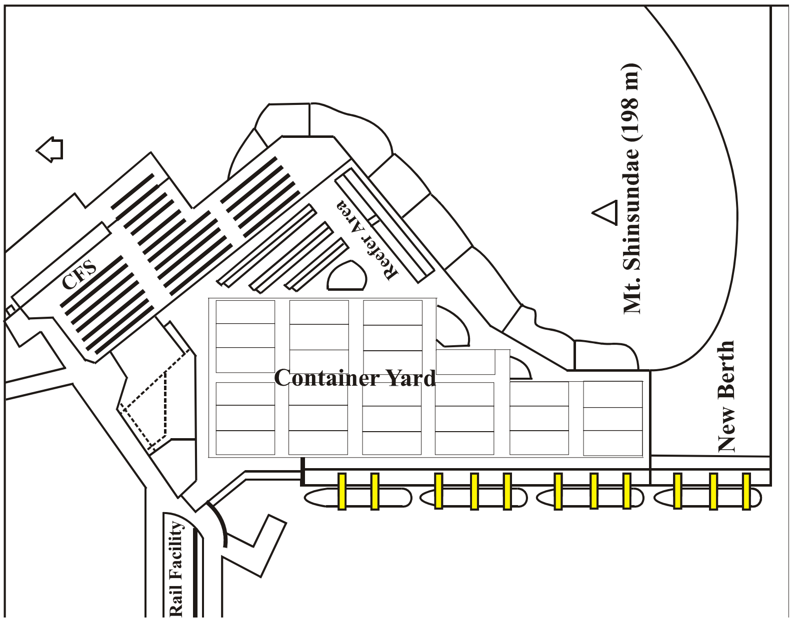

Figure 3: PECT layout, 2005

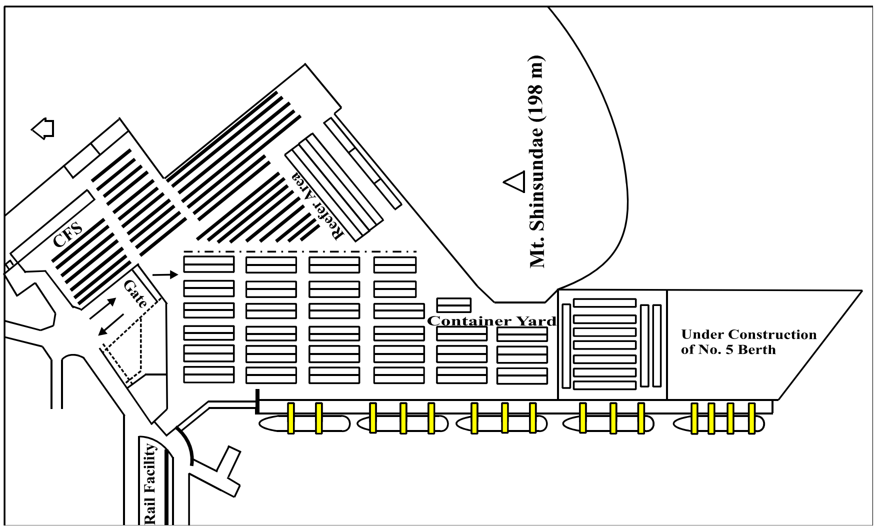

Figure 4: PECT layout, 2006

Suppose that on the interval $(0,T)$ is planed the arrival of $N_1+N_2+N_3$ ships, where the number N_i related to i'th flow (class), $1 \le i \le 3$, and $N_1 \le N_2 \le N_3$. Next suppose that mean inter-arrival time of ships in i'th flow, $1 \le i \le 3$, is λ_i^{-1}. Since numbers of ships in each of three ship classes given in the Table 1, we can assume that $\lambda_1 : \lambda_2 : \lambda_3 = N_1 : N_2 : N_3$. In particular, for $T = 1$ hour we obtain $\lambda_1 = 0.0399$, $\lambda_2 = 0.0685$ and $\lambda_3 = 0.0594$ for 2005. Similarly, by using the same notation for 2006 from Table 1 we have $\lambda_1 = 0.0526$, $\lambda_2 = 0.0663$ and $\lambda_3 = 0.0570$. By using these values from Eqs. (12) and (13), we can compute the probabilities $p_n(t)$ for small values of n. The analogous results may be obtained for arbitrary times less than 10 months.

Table 1: Actual ship arrivals at the PECT in 2005 and 2006

Class of ships	Number of ships		Average lifts per ship		Total lifts	
	2005	2006	2005	2006	2005	2006
< 500 lifts	292	384	313	305	91,394	117,405
501 – 1000 lifts	500	485	782	741	364,100	359,401
> 1000 lifts	433	416	1,444	1,413	625,371	587,983
All classes	1,225	1,285	882	829	1,080,865	1,064,789

The interarrival time distribution (IATD) is plotted in the Figures 5a and 6a. Interestingly, even though ship arrivals of the ships are scheduled and not random, the distribution of interarrival times fitted very well the exponential distribution.

Service times were calculated by using the Erlang distribution with different phases. To obtain accurate data, we have first fitted the empirical distribution of service times of ships to the appropriate theoretical distribution. Service time distributions are given in Figure 5b-e for 2005 and in Figure 6b-e for 2006.

a)

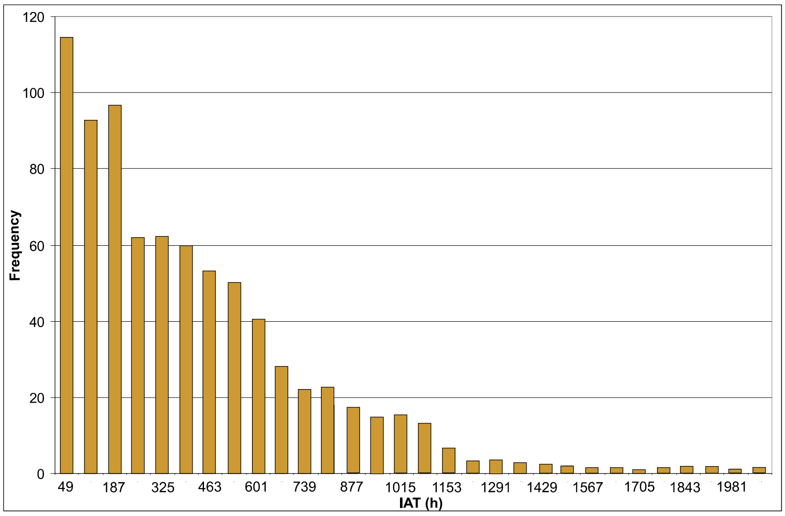

Figure 5(a): IATD of ships at PECT in 2005

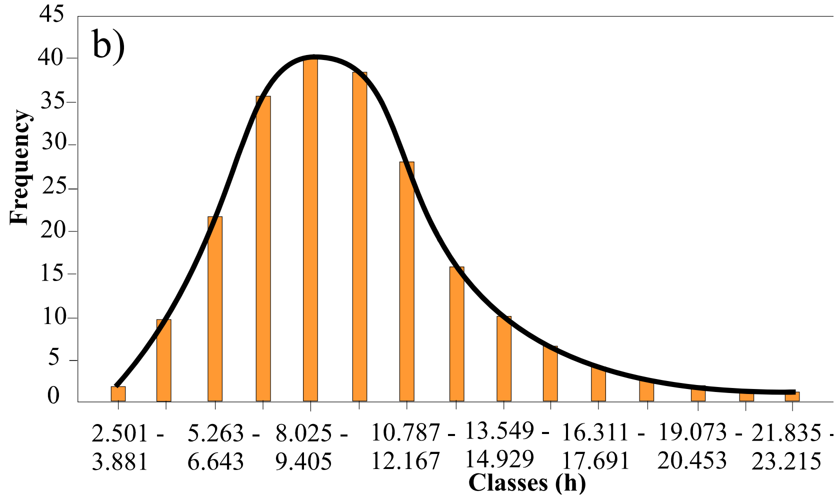

Figure 5(b): Service distribution (SD) of first class of ships, the 4-phase Erlang distribution, (E4)

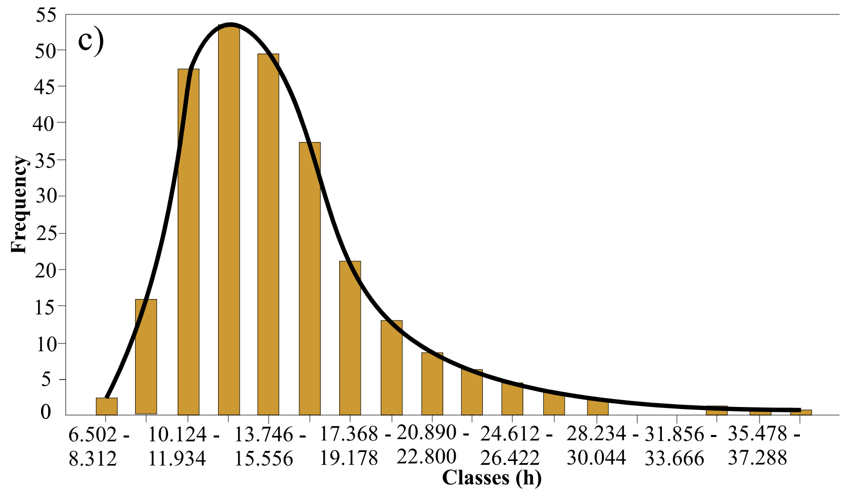

Figure 5(c): SD of second class of ships, (E4)

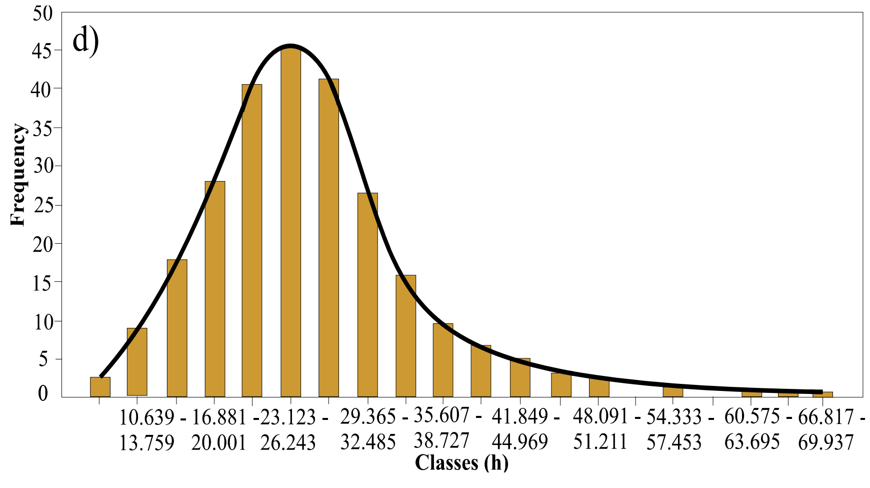

Figure 5(d): SD of third class of ships, (E5)

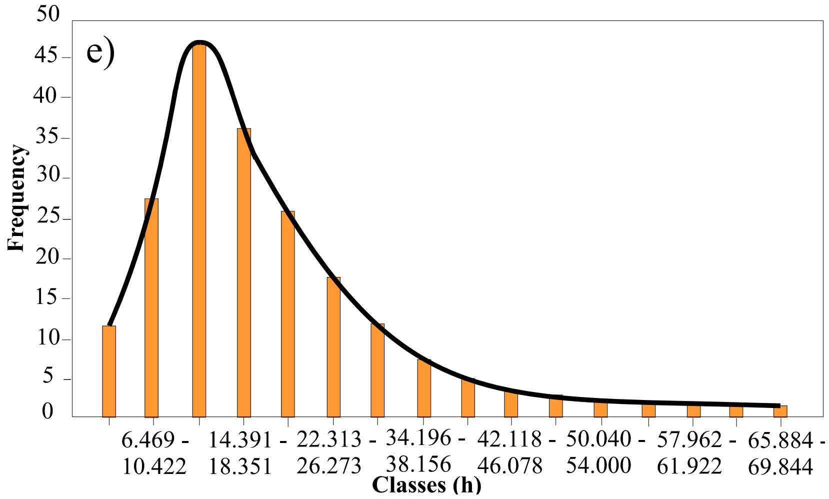

Figure 5(e): SD of all classes of ships, (E3)

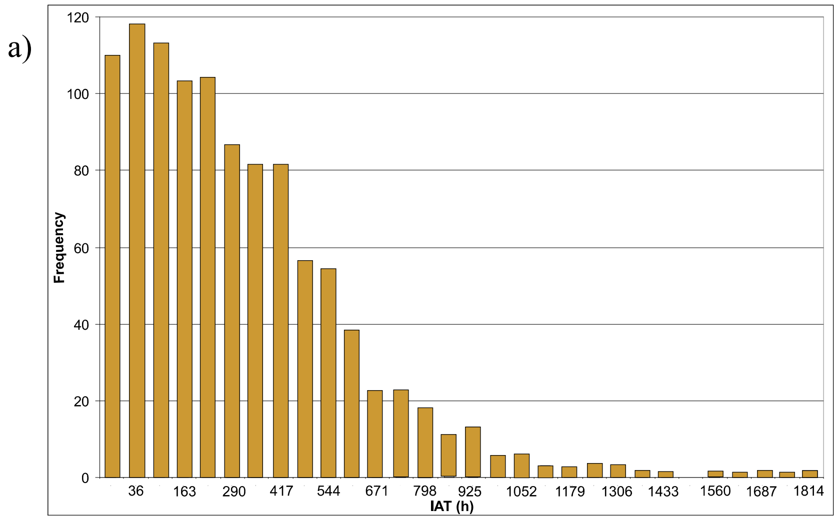

Figure 6(a): IATD of ships at PECT in 2006

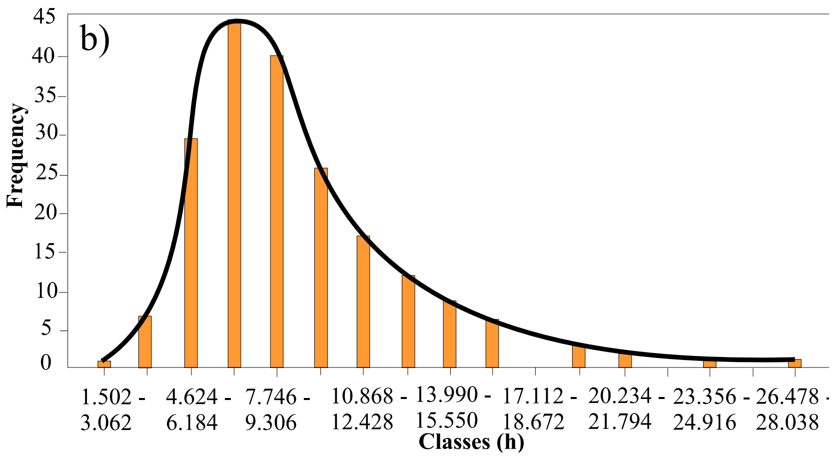

Figure 6(b): Service distribution (SD) of first class of ships, (E5)

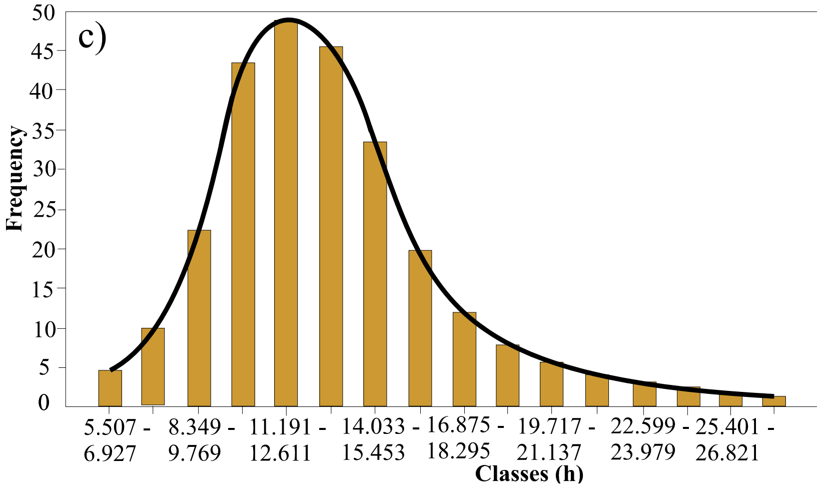

Figure 6(c): SD of second class of ships, (E6)

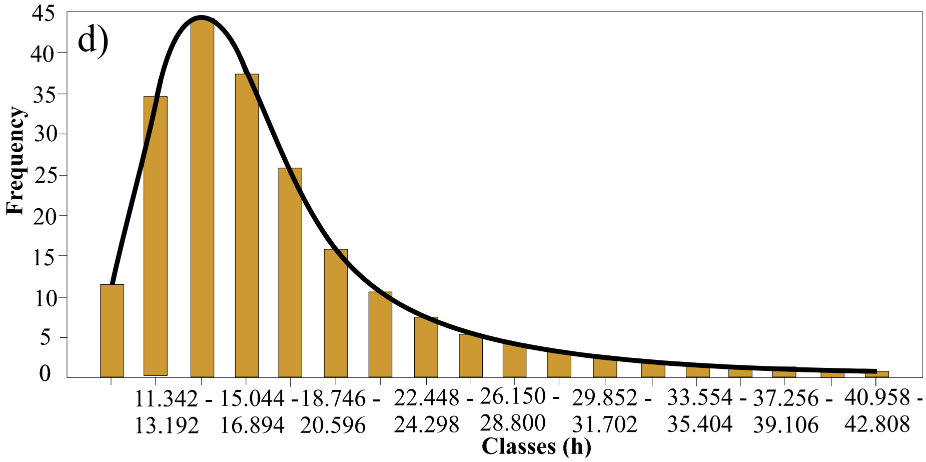

Figure 6(d): SD of third class of ships, (E2)

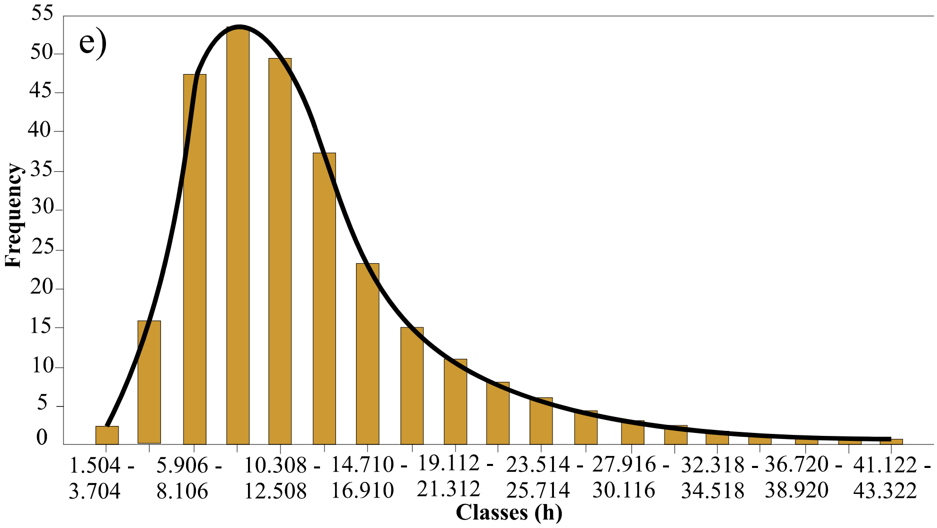

Figure 6(d): SD of third class of ships, (E2); (e) SD of all classes of ships, (E4)

Goodness-of-fit was evaluated, for all tested data, by both chi-square and Kolmogorov-Smirnov tests at a 5 % significance level.

We have carried out extensive numerical work for high/low values of the PECT model characteristics. Our numerical experiments are based on different parameters of various PECT characteristics such as: number of containers loading/unloading from container ship, the QC move time, hourly berth cost, average yard container dwell time, transportation cost by yard transport equipment between quayside and storage yard, number of m^2 of storage yard per container, storage yard cost, paid labor time, labor cost, ship cost in port and average payload of containers, presented in Table 2 (PECT *Management reports,* Korea Maritime Institute 1996). The described and tested numerical experiments contain four segments in relation to the input variables.

Table 2: Input data – Terminal characteristics

Class of ships	Input data n_{con} (no. of containers)		r_{con} (hours per container)		t_l (hours/ gang/ship)		c_s (\$/ship hour)		n_c^*		k_c	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
I class	313	305	0.055	0.053	8.87	7.15	745	739	1.76	1.93	0.89	0.90
II class	782	741	0.051	0.050	13.91	12.71	1098	1081	2.55	2.68	0.931	0.925
III class	1444	1413	0.038	0.036	20.29	17.80	1354	1365	3.14	3.39	0.979	0.965
All classes	862	829	0.044	0.042	14.35	12.95	1164	1155	2.50	2.67	0.918	0.911

n_c^* - average number of QCs assigned per ship (Real data and Simulation results); $c_{n_{b1}}$ = 62 million \$; i = .0663; n_y - 40, $c_{n_{bm}}$ = 6.2 million \$; c_{n_b} = 1215 \$; c_{n_c} = 38.8 \$/QC hour; $t_{t_{con}}$ = 188 hours; $a_{con_{cy}}$ = 63.9 m^2/container; c_{cy} = 0.000292 \$/m^2 hour; n_{cyc} = 9; c_t = 5 \$/cycle; c_l = 357 \$/gang hour; $n_{r_{con}}$ (601 for I class, 1085 for II class, 1312 for III class, 999 for all classes in 2005; and 642 for I class, 1114 for II class, 1371 for III class, 1042 for all classes in 2006; c_w =1.4 \$/container hour. To move containers from apron to stacking area, four tractors are provided for each QC. It takes average 10 minutes from apron to stacking area including unloading/loading time by transfer crane. The average distance between apron and stacking area is assumed to be 850 meters.

4.2. Model Validation

For purposes of validation of simulation model and verification of simulation computer program, the results of simulation model were compared with the actual measurement. Three statistics were used as a comparison between simulation output and real data: traffic intensity, average service time and average number of serviced ships. The simulation model was run for 44 statistically independent replications. The average results were recorded and used in comparisons. After analysis of the port data, it was determined that traffic intensity is about 2.55 in 2005 and 2.25 in 2006, while the simulation output shows the value of 2.61 in 2005 and 2.28 in 2006, respectively.

Average service time shows very little difference between the simulation results and actual data, that is, 14.07 h and 14.35 h in 2005 and 12.60 h and 12.88 in 2006, respectively. The simulation results of the number of serviced ships completely correspond with the real data (i.e. the simulation result of the total number of ships are 1224.1 in 2005 and 1285.88 in 2006, and the real data are 1225 and 1285; the first class of ships: 291.11 in 2005 and 383.3 in 2006, and 291 and 384; the second class: 502.16 in 2005 and 486,01 in 2006, and 501 and 485; and third class: 434,17 in 2005 and 415.02 in 2006, and 433 and 416). All the above shows that simulation results are in agreement with real data.

The attained agreement of the results obtained by using simulation model with real parameters has also been used for validation and verification of applied analytical model. In accordance with it, the correspondence between simulation and analytical results gives, in full, the validity to the applied analytical model to be used for the optimization of servicing ships processes at PECT, i.e., at the considered ship-berth link, see Tables 3 and 4.

Table 3: Average service time of ships

Results	Average service time of ships in hours							
	(All classes)		(I class)		(II class)		(III class)	
	2005	2006	2005	2006	2005	2006	2005	2006
Real data	14.07	12.60	8.71	7.85	13.47	12.52	20.05	17.48
Simulation resluts	14.35	12.88	8.87	8.15	13.91	12.71	20.29	17.80
Analytical results	14.51	12.95	9.06	8.17	13.67	12.91	20.78	17.75

Table 4: Average waiting time of ships

Results	Average waiting time of ships in hours							
	(All classes)		(I class)		(II class)		(III class)	
	2005	2006	2005	2006	2005	2006	2005	2006
Simulation resluts	2.429	1.156	2.459	1.291	2.431	1.159	2.398	1.018
Analytical results, AM I	3.191	1.854	3.254	1.210	3.247	2.141	3.076	2.213
Analytical results, AM II	2.632	1.295	3.151	1.413	2.711	1.322	2.045	1.152

4.3. Simulation and Analytical Results for PECT

The impact of the different models is determined by comparing the key performance measures of simulation and analytical approaches to those of the real data of PECT. Table 3 presents average service time of ships (all classes, I class, II class and III class), while Table 4 shows average average waiting time of ships (all classes, I class, II class and III class). In addition, Table 5 gives average time that ships spend in port. According to this, judging from the computational results for some numerical examples of the ($M/E_k/n_b$) – using average waiting time, t_w from Eq. (6) (for brevity analytical model I (AM I)) and ($M/E_k/n_b$) – using average waiting time, t_w from Eq. (7) (for brevity analytical model II (AM II)) models, it can be confirmed that Eq. (6) is inclined to estimate the values of average time that container ships spend in port, i.e. average waiting time of ships.

Table 5: Average time that ships spend in port

Results	Average time that ships spends in port in hours							
	(All classes)		(I class)		(II class)		(III class)	
	2005	2006	2005	2006	2005	2006	2005	2006
Simulation resluts	17.799	15.036	12.329	10.441	17.341	14.869	23.688	19.818
Analytical results, AM I	18.701	15.804	13.314	10.380	17.917	16.051	24.856	20.963
Analytical results, AM II	18.142	15.245	13.211	10.583	17.381	15.232	23.825	20.270

The average time that ships spend in port for simulation model (SM) is 15.036 h for all classes of ships in 2006. This is about 15% shorter than that of SM, 17.799 h in 2005 and about 1.5% shorter than that of AM II, 15.245 h in 2006. For first class of ships, the average time that ships spend in port is 10.380 h for AM II in 2006, about 0.6% shorter than SM, 10.441. This time is 15.232 h for second class of ships (AM II) in 2006, about 12% shorter than AM II in 2005. Finally, the average time that ships spend in port for third class of ships is 19.818 h (SM) in 2006, about 16% shorter than SM in 2005 or 2% shorter than AM II, 20.270 h in 2006.

The results presented here support the argument that average cost per ship or container served, can be easily obtained by the use of the average cost curves in function of traffic intensity and QCs/berth. The described and tested numerical experiments contain more segments in relation to the input variables. All numerical results presented in Figure 7 are obtained by using the input data from Table 2. Simulation testing (Simulation model (SM)) was than carried out by using the GPSS/H. The solution procedure for AM I and AM II models was programmed using the MATLAB program.

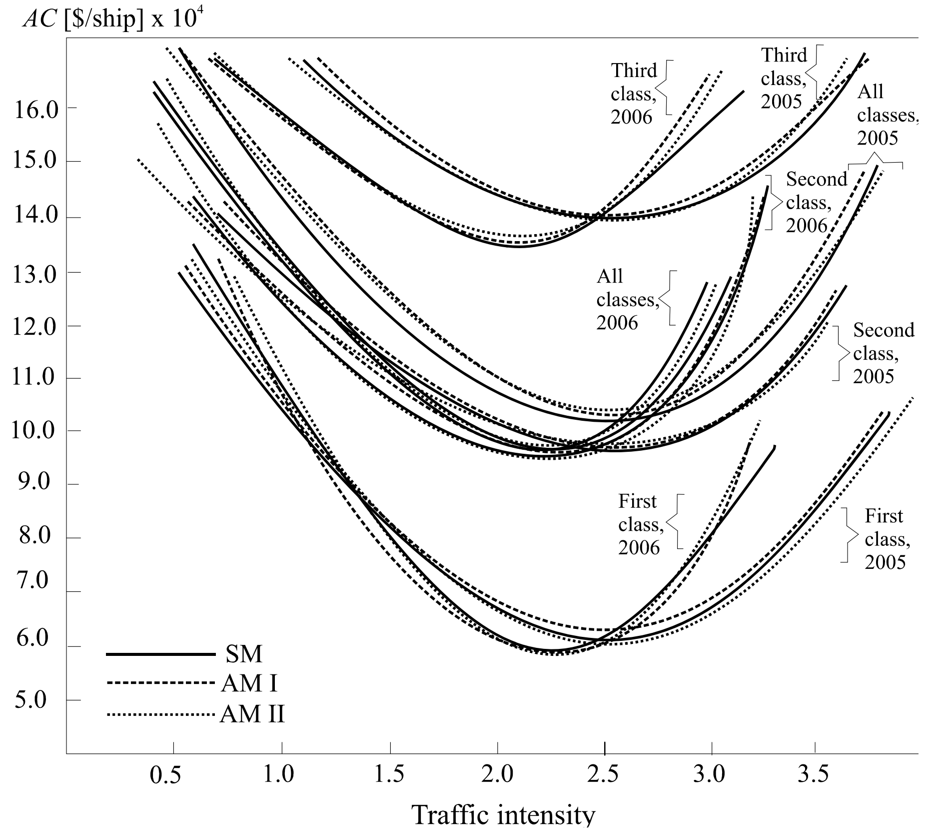

Figure 7: Average container ship costs for various traffic intensity (θ = 0.5–3.5) – (1) Minimum AC in 2005 are: $101,094 (SM) for all classes of ships; $62,955 (AM II) for first class of ships; $98,632 (SM) for second class of ships and $141,697 (AM II) for third class of ships; (2) Minimum AC in 2006 are: 97,749 (SM) for all classes of ships; $58,507 (AM II) for first class of ships; $96,721 (AM II) for second class of ships and $138,019 (SM) for third class of ships

Figure 7 compares the average ship costs of different ship classes taken by SM, AM I and AM II models at a PECT in 2005 and 2006. They graphically show the sensitivity of the average ship costs to the various values of θ. In curve SM for all classes of ships in 2006, the minimum cost per ship served decreases by about 3.3% in 2006 with respect to 2005. However, the average costs per first class of ships served decrease in 2006 by about 7% than the minimum cost in 2005, see curve AM II. This decrease for second class of ships is about 2% in 2006 with respect to the minimum cost in 2005 for curve AM II. Finally, in curve SM for third class of ships, the minimum cost per ship served decreases by about 2.6% ($138,019) than the minimum cost in 2005 ($141,697).

Accordingly, it will be useful to graphically show the range of container capacity which can be optimally handled with the specific number of berths, i.e. optimal range of traffic intensity. For the reason already stated in the numerical experiments, the average container ship cost in $/ship, *AC*, has been adopted as a measure to determine the average traffic intensity and the optimal number of cranes/berth n_c (n_c =1 - 7) for the constant number of berths/terminal in this study.

5. Conclusion

A simulation model employing the GPSS/H has been developed to ship-berth-yard link performance evaluation of PECT. It is shown to provide good results in predicting the actual ship-berth-yard link operations system of the PECT. The attained agreement of the results obtained by using simulation model with real parameters has been also used for validation and verification of applied analytical model. In accordance with that, the correspondence between simulation and analytical results gives, in full, the validity to the applied analytical model to be used for optimization of processes of servicing ships at PECT. Finally, these models also address the issues such as the performance criteria and the model parameters to propose an operational method that reduces average cost per ship served and increases the terminal efficiency.

However, presented simulation and analytical methodology and results are convenient for different analyses, planning and development of port system, for example, increasing the number of berths or traffic intensity depending on the optimum berth capacity and average ship cost. The optimum number of berths, optimum traffic intensity, optimum berth capacity and associated average terminal and ship costs could be extensively used in different analyses of port system in real world.

Container terminals in Busan Port, especially PECT, are trying to expand capacity and increase performance at a maximum of investments. Often the container terminal operations are changing to meet increased customer demands as well as to adapt to new technologies. Reasons for the decrease of the average cost per ship served with the introduction of new container berth, QCs, container yard area and automated stacking cranes (ASC) include that waiting time of ships and the average time that ships spend in port decrease with the advanced handling systems improving the operations procedures.

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Port and Maritime Security:
Is there a Distinctive European Approach?

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Abstract

Following major transport related security incidents, public policies aiming to enhance the competitiveness of port systems and their integration in supply chains and multimodal systems have been complemented by regulatory and voluntary initiatives aiming to increase the security and operational reliability of the sector. The adoption of international rules has been followed be the emergence of regional regimes. This study focuses on transport security public policies in Europe vis-à-vis the ones that take place in the US. This study demonstrates that while the European Union (EU) initially acted mostly as the 'follower' of the US security related initiatives, stakeholders and policy-makers in Europe have progressively thinking of a more flexible (or less restricted) approach. The study provides a comparative assessment of the scope and content of the relevant endorsed US and EU security related (maritime) transport and port policies, as well as the initiatives currently in discussion, in the light of the stakeholders approaches vis-à-vis these and other potential policies. It also compares the resulting policy-making and implementation regimes that are in place. The findings of these comparisons suggest that the characteristics of the European industries and of the involved transport systems and, not least, the attitudes of the stakeholders differ from those observed in the US, with this differentiation leading to the emergence of an adjusted European maritime and port security approach.

1. Introduction

In the beginning of the 21st century the formation of transport policies, at almost every international, peripheral, national or local level, focused mainly on the competitiveness and the effectiveness of transport systems and modes. It was only sporadically that security related initiatives, i.e. measures indenting to minimize the possibility of successful unlawful acts against transportation means and nodes were part of the policy agendas.[2] A series of events, foremost the 9/11 attacks in New York, fostered an increasing awareness on security issues. Incidents such as the attacks to the Madrid commuter trains (2004) and to the London public transport system (2005) have increased public unease and maintain security concerns at the centre of contemporary transport policies. Security awareness has expanded with the aim being to minimize relevant risks in every transport system and mode and supply-chain operations.

Maritime transportation and ports, in particular container ports and terminals, are among the sectors that have drawn most of the attention. Port infrastructures constitute industrial complexes with high economic values and areas where the larger part of the international trade takes place. Vessels and unitized (containerized) cargoes can be used as weapons, or be used to carry weapons (Johnston, 2004). A maritime related security incident could might not only cause human casualties, but also produce an economic shock, by interrupting trade and resulting in an economic lose for the entire society. The attack to the M/V Limburg resulted in a short-term collapse of shipping businesses in Aden, a tripling of war risk premiums levied on vessels calling at the Aden, the Yemeni economy losing an estimated $3,8 million in port revenues per month, and an increase in crude oil price by $0,48 per barrel

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[2] Other incidents include the attacks on the battle ship USS Cole (October 2000), and the incident ate the M/V Limburg (October, 2002).

(Greenberg *et al*, 2006).

Due to the characteristics of system, maritime trans(port) security enhancement cannot however be addressed by minimizing the risk in isolated port facilities only. The extensive use of combined transport results in the integration of ports in supply-chains. The consequent spatial and functional regionalization of ports (Notteboom & Rodrigue, 2005) expands the port related hinterland and requires an appropriate security policy that covers a broader geographical area. This hinterland expansion also increases the number of stakeholders involved in transport chains. Apart from the needs of this complex trans(port) system, security policies ought to recognize the specialized needs of the different participants in the maritime transportation system as well (cf. Button & Brooks, 2007). The costs for securing transportation increase, along with the number of interactions between stakeholders with vested interests. All these demand a holistic approach which takes into account the entire system, i.e. facilities, broader entities like ports, and entire supply-chains.

Several international organizations have strived to develop initiatives that respond to this need. The major ones are the International Ship and Port facility Security (ISPS) Code that was endorsed by the IMO and the Code of Practice on Security in Ports as collectively agreed by the IMO & ILO (2003). Other major policies have been the new port related ISO standards, like the ISO 20858 and the ISO 28000 (ISO, 2004; 2005), the ILO's (2003) Revised Seafarer's Identity Documents and the 2004 World Customs Organization's (WCO, 2004) Resolution on security and facilitation measures concerning the international trade supply chain. These measures have different degrees of enforceability and target multiple security related specific goals.

The adoption of international rules has been followed be the emergence of regional regimes. The United States (US) has led this trend, by endorsing national-level initiatives, with a global impact, aiming to safeguard the entire transport process, including maritime transport, ports and supply chains. It was also among those advocating the need of endorsing such measures within the international maritime rule-making organizations, and exercised their capacity to influence these organizations to move towards this direction. The European Union (EU), as well as other regions (i.e. Asia) and/or countries of the world, mostly acted as the *followers*. Progressively, however there have been indications that European policy-makers and stakeholders became unease with the US initiatives and think of a more flexible (or less restricted) approach.

This study provides a comparative assessment of the EU and US maritime and port security policies, the initiatives in discussion, the stakeholders' approaches vis-à-vis these and potential other policies, It also compares the relevant schemes of policy making, and implementation processes that are in place in both sides of the Atlantic. This analysis indicates this progressive divergence of attitudes and concludes on the reasons that motivate the search for a distinctive European approach in addressing the different security issues.

Section 2 presents the major US security initiatives, while Section 3 analyses the EU security policies. This section also examines the justifications for a distinctive EU security policy, taking into account the reactions of major EU trans(port) stakeholders. Section 4 makes a comparative assessment of the US and EU security initiatives, while Section 5 summarizes the conclusions of this paper.

2. The US Approach

Following the 9/11 attacks, the US government moved decisively towards filling what was assessed to be a 'security policy gap'. It developed relevant policies that cover an extensive range of activities throughout the transport system. In the case of the maritime related transport systems, these policies focus mainly on the transportation of containers, including vessels, containers, terminals and facilities hosting containers, without however ignoring cargoes *per se* and passengers. Initially, the US government adopted measures largely supplementary to the ISPS Code, as had agreed within the IMO, with an emphasis on the most extended application possible. Then, in response to its own analysis of the vulnerabilities of the maritime transport system, the US regime gradually expanded well beyond the scope of the IMO initiatives.

2,1 The '96 hours' rule

Chronologically, the first major maritime security related US policy has been the so-called '96 hours' rule. Few weeks after the 9/11 attacks, the US developed a temporary rule which requires that every vessel indenting to enter the US territorial waters sends an advanced notice of arrival to the US Coast Guard (USCG), 96 hours prior to her arrival. The notice includes detailed information on the crew, the passengers or/and the cargo and the vessel herself. In its early implementation days the rule was thought to be a temporary reaction to the events that had taken place. It turned however to a permanent regime enforced by the USCG, which comes under the Department of Homeland Security (DHS).

2.2 The coast guard and Maritime Transportation Act (MTSA)

The major US security policy has been the Coast Guard and Maritime Transportation Security Act (MTSA; adopted November 2002), which is the US equivalent to the ISPS Code. This act, which was developed by the DHS and the Maritime Administration (MARAD), and enforced by the USCG requests the development of a security plan by all the US ports and US flagged vessels as well as the implementation of all the requirements of the ISPS Code. The latter is applied not only in the international trade to or from the US, as the IMO decision requests, but has been expanded to cover the transactions between those participating in intra-US trade as well.

2.3 The 24-hour advance vessel manifest rule

The third major US initiative is the so-called '24-hour rule'. Adopted in 2002 and being in force since February 2003, this rule obliges all ocean carriers or non-vessel operating common carrier (NVOCC) departing from a foreign port with the aim being to reach the US, to send cargo manifest information to the US Customs and Border Protection (CBP) 24 hours before the loading of the cargo onto the vessel heading directly to a US port. The enforcement of the 24-hour rule is a responsibility of the CBP which operates under the Department of Homeland Security.

2.4 Container Security Initiative (CSI)

The Container Security Initiative (CSI; adopted in 2002; in force since February 2003) focuses explicitly on security gaps in port facilities and has a major global impact. This is because it aims to increase the security of the US trade by broadening the US borders far away from the actual ones. The target is fulfilled by carrying out inspection controls in foreign ports to containers which bound to US in foreign ports. These inspections are carried out by assigned personnel of the CBP which is the responsible agent for the application of the CSI, in cooperation with the custom authorities of the foreign countries.

Most importantly, the implementation of the CSI is based on a risk management approach as the US officials inspecting only the high risk containers. The program is implemented on a reciprocal basis so that custom personnel from foreign countries can also perform security controls in the US ports and in containers bounding to their country (CBP, 2007). Until now, 58 foreign ports participate in the CSI, accounting for 85% of container traffic bound for the USA. The geographical distribution of the ports is 13 ports in the Americas, 23 ports in Europe, 20 ports in Asia and the Middle East and 2 ports in Africa.[3] The long-term target of the CSI is to progressively include all foreign ports which load containers to be transported to the US. Notably, the importance of the CSI on the US-EU trade impelled the two trade partners to sign a bilateral agreement (CEU, 2004) which defines a joint customs cooperation framework.

2.5 Security and Accountability For Every (SAFE) Port Act

[3] Source:http://www.dhs.gov. Accessed: March 10, 2008.

The Security and Accountability For Every (SAFE) Port Act, (endorsed in 2006; implemented since August 2007; fully in force in 2012) is part of the broader framework defined by the MTSA of 2002, and (as described in latter sections) one of the most controversial US policy developments. This act requires from the DHS to develop operational standards for scanning systems that will be used to conduct scanning for nuclear and radiological materials in all the containers (100%) departing from foreign ports with destination to the US.

This program differs from the CSI rules and the C-TPAT (Customs- Trade Partnership Against Terrorism), as scanning should take place regardless the prior assessed risk of each container (GAO, 2007a). If a container does not pass through this scanning process then it is not allowed to be transported to the US. Another major difference between this rule and the CSI is that the latter works on a reciprocal base, while the former is a unilateral policy that is not based on the cooperation between US and other countries.

2.6 Transportation Worker Identification Credential (TWIC)

The Transportation Worker Identification Credential (TWIC), furthers the MTSA of 2002 and the SAFE Port Act of 2006. The provisions of this, quite sensitive in terms of data demanded, proposal demand that every trans(port) worker who has access to security sensitive areas of vessels and port facilities should provide biometric information (such as fingerprints) to the US government. An estimated one million individuals were required to obtain a TWIC. This includes Coast Guard-credentialed merchant mariners, port facility employees, longshoremen, truck drivers, and others requiring unescorted access to secure areas of maritime facilities and vessels regulated by MTSA. Facility and vessel owners/operators are required to inform employees of their responsibility to possess a TWIC and what parts of the facility and vessel will require a TWIC for unescorted access. The aim of the final rule is to enhance the security of ports by requiring such security threat assessments of persons in secure areas and by improving access control measures to prevent those who may pose a security threat from gaining unescorted access to secure areas of ports. Currently, there are no regulatory requirements pertaining to the use of TWIC readers. However, TWIC enrolment began in October 2007 and will be phased in at both small and large ports over the course of 2007 and 2008.

2.7 Customs-Trade Partnership Against Terrorism (C-TPAT)

All the described measures are part of the holistic US approach to safeguard the entire supply chain In direct response to 9/11, the U.S. Customs Service, now CBP, challenged the trade community to partner with CBP to design a new approach to supply chain security focused on protecting the US against unlawful acts by improving security while simultaneously speeding the flow of compliant cargo and conveyances. The result was the voluntary Customs-Trade Partnership Against Terrorism (C-TPAT). Launched by the CBP in April 2002, C-TPAT aims to secure the landside part of the supply chain via a risk management approach. In particular, it calls US exporters and importers to develop security requirements on themselves and their partners. By participating in this voluntary program, participants obtain benefits, with the most important one being the Green Lane award. Those participants that develop a well defined security framework receive the Green Lane award and experience fewer customs inspections.

2.8 Complementary rules and programs

Apart from the preceded major rules in place or under discussion, a number of programs deal with specific maritime issues and situations as well. The National Infrastructure Protection Plan (NIPP) of 2006 is the major one. The NIPP aims at securing every public or private infrastructure in the US that is assessed as *crucial by* providing sectoral plans for a coordinated approach by the public and private actors involved in each sector. That plan will be used to establish national priorities, goals, and requirements for infrastructure protection so that funding and resources are effectively applied, and every state is leading, integrating and coordinating the security of its critical infrastructures in the most effective manner. The program explicitly mentions 17 such crucial infrastructures and key resources, with transportation systems being one of them. Once more, this is an initiative based on a risk

assessment management strategy, including the setting and prioritising of security goals and an assessment of risks on critical (transportation) assets, systems, networks, and functions.
Illustrative examples of programs are the pilot project Operation Safe Commerce (developed by the Transportation Security Administration (TSA) and the CBP), and Megaport (developed by the Department of Energy). The former project intents to verify the contents of containers at the port of loading, ensuring the physical integrity of containers in transit, and track their movement through the transport chain from the origin to the final destination (see: Frittelli, 2005). Megaport, in progress since 2003, facilitates the scanning of containers in foreign ports for radioactive materials. For this reason, radiation detection equipment has been placed in some foreign ports[4] as well as in US border crossings (rail crossings, vehicle crossing, and small seaports).

Following the adoption of the SAFE Port Act, CBP and the Department of Energy launched another pilot program, the Secure Freight Initiative (SFI) in order to determine the feasibility of the 100% scanning procedure. Based on the experience of the Megaport and CSI programs, SFI has led to the installation of relevant equipment in six foreign ports[5]. This pilot implementation will report in mid-2008 and, if a success, then it will be expand to every CSI port.

3. The European Path Towards Maritime Security

The EU reacted to the new 'securitized' trans(port) environment by formatting its own legislative framework. Reversing a period of inertia in the specific policy sub-field (cf. Power, 1992; Pallis, 2002) the EU developed a rather comprehensive regional regulatory framework aiming to secure the about 9500 flagged vessels (over 500 GT) 4300 maritime companies, 1250 ports and over 4100 port facilities that exist in the 27 EU member-states (Dupont, 2007). This has been done via an evolutionary process reflecting the concept that the realities of the market make a big-bang approach unrealistic.

Coincidentally, the European Commission published a White Paper detailing the EU transport policy to 2010 (CEU, 2001) only one day after the events of 9/11. This report had a broad reference on the security of passengers onboard cruise vessels and ferries as well as on the transportation of nuclear goods. Concerns leading to these general observations have been fuelled by the combination of an increasing global awareness regarding security, and an assessed need to be in line with relevant initiatives either endorsed by the international fora or developed by one of the region's geopolitical allies and trading partner, the US. The latter acted as the locomotive for such developments, with researchers observing that the first prepared ever EU security legislations rely primarily on (existing or already published) rules that had been developed elsewhere (Schilk *et al*, 2007).

3.1 Ship and port facility security

In fact, the first endorsed EU maritime transport security initiative had a reference to international rule making. Regulation 725/2004 (in force since 2004) targets the enhancement of ship and port facilities security, via the enforcement of the major IMO relevant decision, the ISPS Code.[6] By transforming the latter to EU legislation, the Regulation demands that ship security plans (SSPs) and port facility security plans (PFSPs) specify a range of security measures to be maintained by ships and port facilities respectively. Ports have to identify restricted areas and monitor them in order to prevent unauthorised access, and implement measures to prevent weapons, dangerous substances and devices being taken onto ships or into port facilities.

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[4] The list of foreign ports that participate in the Megaport program include the ports of Algeciras, Bahamas, Colombo, Rotterdam, Singapore, and Piraeus.

[5] Port Qasim (Pakistan), Puerto Cortes (Honduras) and Southampton (UK) deploying scanning equipment to capture data on all containers bound to USA. Port Salalah (Oman), Port of Singapore and Busan – Gamman terminal (South Korea) have an initial limited deployment in order to learn how to integrate the new technology with port operations and commerce flow. Data from DHS: http://www.dhs.gov/xprevprot/programs/gc_1166037389664.shtm. Accessed on 10 March 2008.

[6] Regulation 725/2004, of 31 March 2004, on enhancing ship and port facility security, OJ L. 129/6, 29.4.2004.

The rule requires that EU member-states identify and evaluate the transport assets and infrastructures that are important to protect, and develop practices that minimize risks of unlawful acts. The primary concern of this process is the avoidance of human casualties. The secondary concern is to figure out how the port facility, structure, or installation can rapidly re-establish a normal functioning following the threat or occurrence of a security incident. Member-states are also responsible for enforcing this policy in their national territory, while they might also determine security measures for the vessels and ports that are not covered by it.

Via this rule, the EU introduced stricter security measures, than those of the IMO decision. While the ISPS Code covers ships engaged in international voyages and those ports that accommodate them, the EU rule includes provisions that extend these measures to the ships engaged in national voyages within the EU, as well as the related port facilities that serve them. The application of the Regulation goes beyond the international extra-EU trade to cover intra-EU (between EU member states) trade and transport as well. It has also introduced a different agenda, by extending the application of the rule to those ports that might only occasionally serve inter-national transport.

3.2 Enhancing port security

Following the adoption of a rule dealing with European port facilities but only the port area where an interaction between the port and maritime carriers takes place, the EU moved towards an integrated security framework for the European port industry. It did so by endorsing Directive 65/2005 (in force since June 2007) that applies in every port in which Regulation 725/2004 applies and enacts security practices in the port area that is not covered by the latter Regulation.[7]

This non 'ship/port interface' port area is designated by the member-states. On its behalf, the Directive designates three security level (normal, heightened, and exceptional) reflecting differences in the risk profile of different sub-areas in the port, and demanding different measures. Such measures are the creation of a port security plan that contains the necessary procedures and actions to be undertaken in the event of a security incident, and the designation of a port security officer. The enforcement of the Directive is a responsibility of the port authority and the monitoring of the compliance (for all ports in a member-state territory) lies in a national lever port security authority. The port security officer acts as the contact person between the port authority and the port security authority. The whole process is periodically under review, while member-states ensure the presence of a focal point for port security as the contact point between them and the European Commission.

The implementation of the Directive in the different member-states is well-underway with the actual implementation, currently being left to both a national authority and the port authorities. Reported difficulties suggest that additional work for port authorities in relation to the Port Security Directive mainly occurs in those ports which have no clear natural borders. Especially for those ports which have areas characterized by a far reaching integration of direct maritime activities and more industrial activities, the implementation of the Directive seems to cause a lot of additional work. The same can be mentioned for ports which are stretched out over a wide area and have a mixture of other activities than directly maritime related uses within the port area. Especially for the latter, European port authorities argue that the Directive entails a lot of assessments whilst additional security measures might seem rather abundant.

3.3 Establishing a community customs code

These two rules are part of a broader EU move towards a policy framework that minimizes security risks throughout the entire transport chain. A first step towards this direction has been the endorsement of a revised Community Customs Code, which will be fully in force in 2009. The relevant Regulation 648/2005 sets up a common EU secure custom system based on the electronic exchange of advance information between traders and customs authorities on all goods entering or leaving the EU.[8]

[7] Directive 2005/65, of October 26, on enhancing port security, OJ L. 310/28, 25.11.2005.
[8] Regulation 648/2005, of 13 April 2005, amending Council Regulation 2913/92 establishing the Community

The most important provision of this measure is the introduction of the Authorized Economic Operator (AEO) status. The latter is a core element in the EU effort to secure the supply chain. According to this concept a transport operator can enjoy the AEO status when it fulfils four interrelated: (a) an appropriate record of compliance with customs requirements; (b) a satisfactory system of managing commercial records; (c) proven financial solvency (where appropriate); and (d) appropriate security and safety standards (where applicable). The incentive for the operator to reach this status is the benefit of experiencing fewer custom controls in the future. The AEO status is operational since the beginning of 2008 and reportedly that there is a big interesting from the operators.[9]

3.4 The European critical infrastructure program

In June 2004 the European Council asked the Commission to prepare an overall strategy to protect critical infrastructure. In response, the Commission put forward the concepts of introducing a European Program for Critical Infrastructure Protection (EPCIP) and establishing a Critical Infrastructure Warning Information Network (CIWIN).[10] Two years latter the Commission proposed a Directive that provides the main foundations for a EPCIP (CEU, 2006a) and a communication that contains non-binding measures designed to facilitate the implementation of the concept (CEU, 2006b). The scope is to protect those European infrastructures (i.e. physical resources, services and information technology facilities, networks and infrastructure assets or parts thereof) that if disrupted, or destroyed, would have a serious impact on socially critical functions (including the supply chain, health, safety, security, economic or social well-being) of two or more member-states, or a single member-state if the critical infrastructure is located in another member state (DG-TREN, 2006). Such critical infrastructures can be found in 11 sectors, one of them being transport.[11] Their operator is expected to develop an operator security plan, describing the security measures that have been taken, as well as a security action plan.

This development has been a turning point as regards the inclusion of port infrastructures in the broader context of the EU general or sectoral security related measures. Port infrastructures have been excluded from the program, with the rationale being that in the case of European ports relevant issues are already covered by the Directive 65/2005 on port security. The heterogeneity of the structural and operational conditions in different member-states was a key issue for this decision. The reason is that a common framework can only be effective if there is a uniform approach of determining critical infrastructure. In the absence of identical traditions, the EPCIP would have a distorting effect on the market whenever member-states define different protection regimes for identical infrastructure. This decision was also taken in the light of the strong reaction by port authorities (see: ESPO, 2006a) and other stakeholders, who emphasized the potential of unnecessary financial burden and the formation of an overregulated market.

Yet, it has to be noted that member-states will establish a critical infrastructure protection authority to monitor the implementation of an action plan, the mobilisation of expert groups at EU level, information sharing processes, and finally a broader discussion towards the identification and analysis of interdependencies of the various European transport (and other) infrastructures. Taken into account that past decisions to exclude ports from transport related measures were reversed due to the complementarities of transport modes (for the case of the trans-European networks: Chlomoudis & Pallis, 2002), this situation might not be seen as irreversible.

3.5 Supply chain security

Along with security related measures that explicitly address the maritime transportation, and the port

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Customs Code. OJ L 117, 13 –19, 4.11.2005.

[9] Lloyd's List, EU inundated by early rush for the AEO status, by J. Stares, 19 February 2008.

[10] For a definition of the Critical Infrastructure see DG-TREN (2006).

[11] The other nine identified sectors are: energy, nuclear industry, information and communication technologies, water, food, health, financial, chemical industry, space, and research facilities.

sector, the EU has moved towards measures to secure the landside part of the transport chain. The Commission proposed a regulation on enhancing supply chain security (CEU, 2006c) via the introduction of the *secure operator* status. The suggested pattern is not a new one: fulfilling specific security requirements operators would be awarded a quality status and thus experience less security controls within the EU members-states.

With some port areas being embedded in supply chains and several operators interacting within these areas, the endorsement of the regulation would affect ports. Especially as it would imply that every individual business actor in the European transport markets (including shippers, transportation companies, forwarders, and value-added - warehouse, storage facility or inland terminal - operation) would have to fulfil proper security management requirements, which comprise aspects of physical security, access controls, procedural security: personnel security, documentation procedure, information security and education and training awareness.

The essence of the proposed regulation produced reactions by various stakeholders (cf. IRU, 2006). In its own position paper, ESPO (2006b), the interest group representing all the European port authorities, welcomed the widening of the scope of EU security measures to all forms of transport but argued for the reduction of security checks along with clarity on how existing security legislation is applicable. ESPO stressed the importance of an appropriate minimum, basic security standard applicable to all operators in the supply chain rather than a voluntary scheme which does not force weaker parts of the chain to participate. Besides, port authorities and other stakeholders advocated that with the AEO standards expanded on the security component, the application of the AEO security status for both, international and intra-EU trade, could and should offer sufficient possibilities for internal market application and securing supply chains in Europe.

As the European transport sector refused this security approach due to its potential negative effects in their businesses and the society advocate that its implementation would increase costs, cripple small businesses, creation of an overregulated transport market, while bringing minor security benefits (Schilk *et al*, 2007), the EU decided to put on hold the proposed regulation. In particular, the Commission has decided to re-evaluate the need for further action within 2008 based on the experience of the implementation of the recently reviewed Customs Code introducing the AEO concept. This development, which implies that seaports will be affected by the implementation of the Community Customs Code, means that the EU institutions will examine if the implementation of the latter rule provides sufficient tools to protect the intra-EU transport supply chain against unlawful acts.

4. Is There a European Approach?

4.1 The initial 'following the same path' approach

A comparison between the content and the main provisions of the reviewed US and EU security related transport initiatives suggests that in the early days decision-makers in these two regions endorsed similar strategies. Turning to their date of initiation and/or endorsement, the fact the EU measures were adopted in a more recent chronological point might from those adopted in the US leads to the conclusion that in these days the EU followed the path designed by its geopolitical ally and trading partner.

The first target for both the US and the EU was to implement the international decisions in the strictest way possible. Having consent to (or even pioneering) the endorsement of the ISPS Code in the IMO context, both the US and the EU adjusted the respective policy regimes in order to transform the ISPS Code to a mandatory national regulation framework. The fact that the US had adopted the MTSA 16 months before the EU adopted the relevant regulation, might not be a clear sign of US leadership, as it can attributed to the presence of a more complex European policy-making regime. Yet this sign is further enhanced that both of them have expanded this international rule implementation in the same way, i.e. by expanding it in coastal trade.

Similar trans-Atlantic strategies are also identified when comparing the US C-TPAT and the EU Revised Customs Code which was launched two years later. As Table 1 illustrates, both policies aim at securing the landside of the transport chain, via a rewarding voluntary scheme that provide similar benefits to the qualified operators.

The early adopted policies dealing explicitly with port security provide further strategy similarities, as well as further indications of a US leadership. The US moved first via an initiative with a global effect (CSI) and the EU followed in various ways. Not only it signed a bilateral agreement with the US but two and a half years later it endorsed its first policy on enhancing port security, beyond the ISPS Code and Regulation 65/2005 provisions. Although this regulation does not have many common provisions with the US policies, it can be characterized as the European reaction to the USA initiatives.

Table 1: Comparing US C-TPAT and the EU revised customs code

	C-TPAT	Revised Customs Code
Launched	April 2003	April 2005
Aim	Securing the landside leg of the transport chain	Securing the landside leg of the transport chain
Applies to	US exporters, importers and their partners	Land transport operators
Scheme	Voluntary	Voluntary
Rewarding Operators	Green Lane Award	Authorized Economic Operator (AEO) Status
Requirements	Minimum security criteria based on the nature of the transport operation (air /sea /rail /highway /long haul carrier, foreign manufacturer, custom broker, Port Authorities)	a) Appropriate record of compliance b) System of managing commercial records c) Financial solvency d) Security and safety standards
Benefits	Fewer custom controls	Fewer custom controls

Similarly, the publication of the endorsed NIPP has been chronologically followed by the EU EPCIP, with the two rules sharing many common features. Both initiatives concentrate on the protection of infrastructures of vital importance in a wide variety of economic sectors putting the transport sector central stage. However, as US initiative is in place since June 2006, while decisions regarding the EU initiative have been (temporarily?) halted due to the presence of several stakeholders' reactions (see: Pallis & Vaggelas, 2007), these cases are also an example of the fact that the relevant domestic scenes and policy-makers capacities to move towards the same direction are rather different in the case of each side of the Atlantic.

4.2 Towards a distinctive approach

In recent times there are clear signs that the EU approach has shifted towards a different path. While in the US further rule making in order to enhance maritime transport and supply chain security is considered essential, policy-makers and several stakeholders in Europe, have indicated their discontent with the introduction of further, frequently overlapping, rules.

Progressing the application of the EPCIP initiative has not been a smooth process, with the latter resulting in the exclusion of ports from the rule. The critical reactions of many trans(port) stakeholders to the proposed policy aiming at enhancing supply chain security concluded in a stalemate. This proposal was simply trying to adopt security measures similar to those of the respective voluntary US C-TPAT program. Stakeholders, including port authorities and freight forwards (see ESPO, 2006b; CLECAT, 2006), suggested that the proposed regulation correspond neither to the peculiar characteristics of the European port market, nor to the needs of the landside part of European supply-chains. Many transport companies in the EU are small and medium enterprises, thus the cost of implementing the proposed regulation would force many of them to exit the market, due to competitiveness deterioration.

The most recent indication for the existence of a new EU approach on trans(port) security is the explicit criticism of stakeholders (including port authorities (ESPO, 2007) forwarders (CLECAT, 2006) and shipowners) member-states (i.e. Belgium, France, Germany, Greece Italy, UK, Netherlands, Spain) and the European Commission on the US SAFE Port Act. Apart from the reciprocity issue, the SAFE Port Act requires from every foreign port with US-bound containers to install the appropriate scanning equipment. The main point of criticism relates to the many problems in the application procedure and mainly the need for ports to separate out US-bound containers in order to go through the scan procedure. This impels for extra surface areas in many port sections, such as terminals, storage areas etc, extra personnel, and investments in new scanning equipment.

Other application related criticism refers to the lack of scanning effectiveness or guarantees in order to handle the 100% container scanning There is also the question of who will pay for the cost of implementing the rule (i.e. governments, port authorities, operators, or users?). The common denominator of these issues is the advocacy that the rule is imposing an unnecessary burden in the port industry. There is also confusion regarding the data that will produce from the scanning process. The SAFE Port Act does not determine who collects, maintains, disseminates and analyzes the apparently sensitive data.

All these would impose a discrimination barrier with biggest ports being the one that could bear the relevant costs dominate container trade with the US. Estimations suggest that the cost of the scanning equipment will be $100 million for every European port,[12] Foremost, with the law being a unilateral one, US exporters are not required to scan their cargoes, thus posing a discrimination against the non US exporters. With estimates being that the new law affects the $500 billion US commerce and about 600 foreign ports (WSC, 2007), a number of reactions and skeptical views regarding the SAFE Port Act are expressed by stakeholders and decision makers within the US (see: GAO, 2007b), and other countries worldwide (i.e. China, Singapore, and Canada).[13] In the European case the new US security law is expected to affect negatively the trade with the EU so the stakeholders' fierce opposition not only limits the potential of a similar EU rule, but resulted in a campaign to get the US authorities to re-think the law that they have been singed.[14]

Having endorsed the international rules to the best extended application possible, and having provided a core security relevant policy framework, the EU seems to be reluctant, of endorsing further, occasionally overlapping, rules. Further signs of this EU approach on trans(port) security is provided by the absence of any EU rules corresponding to US initiatives like the '96 hour rule' and the '24 hour rule'. In the case of the latter opposition by stakeholders is explicit, with European shippers arguing that this is 'another unnecessary bureaucratic burden' demanding the exchange of commercially very sensitive information with trading partner, and thus seeking their exemption from the scheme.[15]

Apart from the variance regarding the willingness to endorse information-sharing, a major issue is the substantial costs for implementing these efforts to strengthen trans(port) security. Developing new security policies demands the mobilization the appropriate financing sources to implement them. A recent study by UNCTAD (2007) provides a global survey of the costs of meeting security in ports. Based on survey responses, UNCTAD estimated the port related expenditures of the ISPS Code to range between about $1.1 billion and $2.3 billion initially and $400 million and $900 million annually. These expenditures would be equivalent to increases in international maritime freight payments of 1% and 0,5% respectively.

This is not so important in the case of shipping companies which face a small implementation cost comparing to the overall investments required for operating a vessel (Rotterdam Maritime Group, 2005). The scene in the port industry is quite complex. Security costs differentiate due to the size of the EU

[12] The Wall Street Journal, New shipping law makes big waves in foreign ports, October 26, 2007.
[13] Lloyd's List, China backs Europe on US box scanning, by J, Stares, February 4, 2008.
[14] Lloyd's List. Europe takes box Scanning fight to US Congress, by J. Stares, February 18, 2008.
[15] Lloyd's List, EU shippers seek '10+2' scheme waiver, by J. Stares, January 10, 2008.

ports (small ports, large ports etc) as well as the type of cargo they facilitate (container ports, dry cargo ports etc). The port industry endorses various approaches to finance those costs, ranging from full funding by port authority through to market driven solutions such as security surcharge levied on port users. In general, mechanisms might include an increase in port tariffs, and/or a security charge to every port user and/or government assistance.

In the US, the overall annual cost (i.e. enrolment, issuance, threat assessments, IDMS, card production and program support) of the TWIC final rule is estimated to be $189 million. The SAFE Port Act requires $400 million every year in order to apply its provisions. Public funds are available to be used by the port sector, even though the 2009 US budget provisions for port security financing were reduced comparing with the respective provisions of the 2008 US budget.[16] In the EU, the security financing regime is different. While the first two of the mentioned financial mechanism are in line with the EU internal market rules, government support is not an option; as such support is considered a distortion of competition in the case of a remarkable heterogeneous industry (see: Pallis, 2007). Even though some might consider security as a public good, the potential of the EU allowing the public financing of the security measures, seems remote.

4.3 Comparing policy-making and implementation regimes

Figure 1, presents the main US security policies and the authorities which are responsible for each of them. While DHS supervises the major security related public authorities and also manages the majority of the US security policies and programs, this figure illustrates the complex US security scheme in place providing the base for comparisons with the respective non-US security schemes. Figure 2 presents the EU policy making regime and the responsible authorities for their enforcement and monitoring the regulations and programs that constitute the backbone of the EU security policy framework.

[16] Lloyd's List, Port short-changes in US security budget, by R. Josh, February 7, 2008.

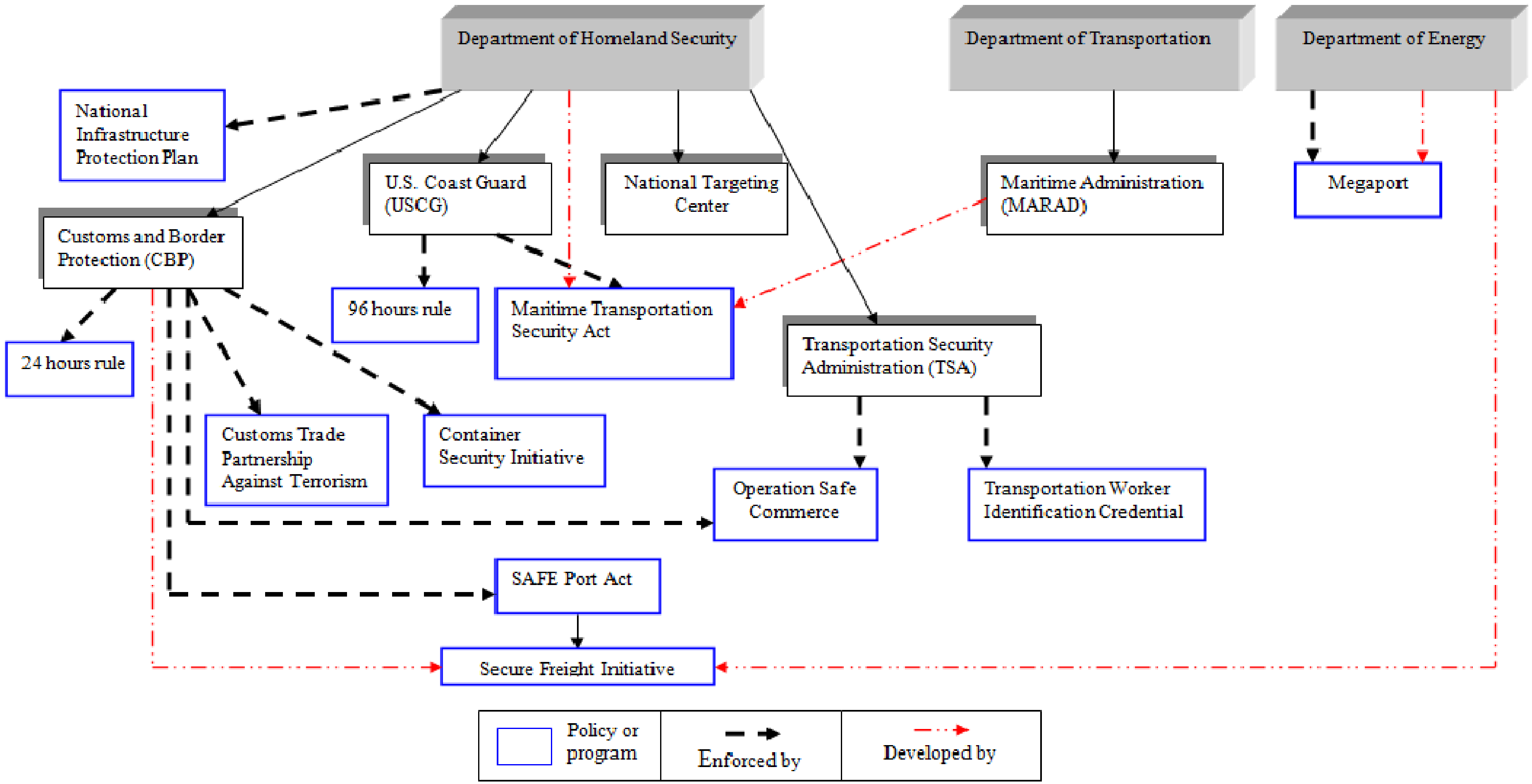

Figure 1: The US Maritime Transport related Security Regime

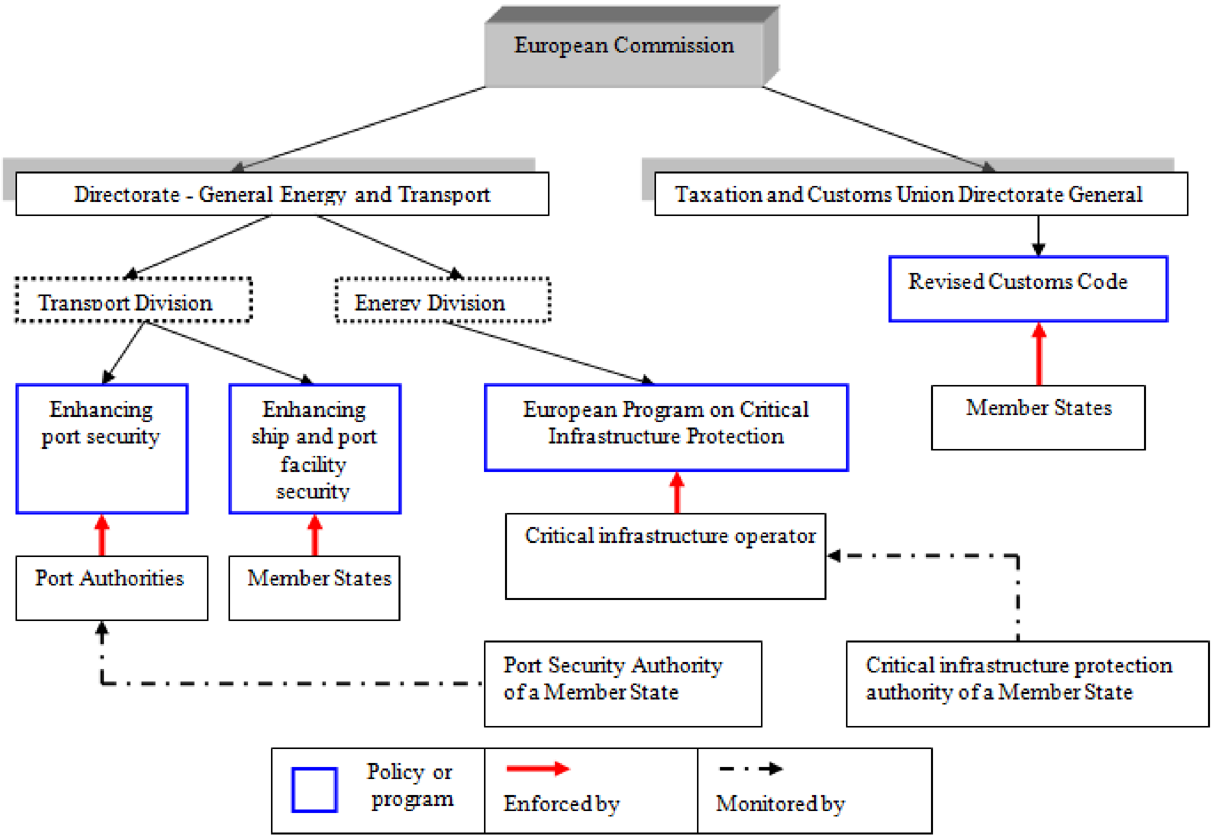

Figure 2: The EU security policy framework

Comparing with the relevant USA regime, the EU security policy framework is a more compact and a more centralized one. Two Directorate Generals (DGs) of the European Commission are responsible for proposing all the security related transport policies, to be then decided according to the standard EU legislative process (i.e. involving consultation with the stakeholders, the participation of the European Parliament in a co-decision process, and the final decision of the Council of (Transport) ministers). The enforcement of some of the EU policies is a responsibility of the Member States. In the case of the rest of the security policies the operators of the transport infrastructures, i.e. port authorities, terminal operators, etc, are responsible for applying the provisions of the security policies, while national member-states administrations maintain the role of monitoring the application.

5. Conclusion

The paper examined the EU regime dealing with the enhancement of maritime and port security, comparing this regime with respective policy developments in the US. In recent times, especially since the events of 9/11, EU policies aiming to minimize risk and increase the security and operational reliability of the sector have been central stage. Some of these initiatives have been transformed to EU laws, regulations and administrative provisions while others are still under discussion.

EU security related maritime (trans)port policies were initially developed as a result of major security incidents which occurred worldwide and the subsequent security initiatives undertaken at international (IMO, ILO, etc), and peripheral levels. The findings of study suggest that the US led this trend, with the EU following a similar strategy and, to a certain extent, copying the actions of it geopolitical ally and trading-partner. Both US and EU adopted the broader possible application of the ISPS Code, and then brought in security initiatives aiming to safeguard the entire transport process.
The study indicated that progressively policy-makers and stakeholders in Europe became unease with this strategy. First, a number of further rules that have been recently discussed in the European context have been challenged by stakeholders, with policy-proposals failing to transform to EU legislation. The

latter advocate that the established EU regime does not need any additional rules that would prove to be unnecessary bureaucratic burdens frequently overlapping with security policies in place. Reason contributing further to this discontent with the US approach, are the huge implementation costs involved, the difficulties to finance the implementation of security related policies in a remarkably heterogeneous European port industry, and, not least, the different levels of willingness to share commercially (or else) sensitive information for security reasons. This discontent is so extensive that has resulted even in demands by European stakeholders for the US overturning its own recent policy initiatives (i.e. containers' scanning in foreign ports).

The presence of different schemes of policy-making regimes and implementation processes in each side of the Atlantic emphasize further the emerging *sui generis* European approach. Yet, the themes of these two distinctive approaches remain interlinked, as none of them can ignore the global structures of the (trans)port industry, and the security demands of these structures.

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Valuing Costs and Benefits of Shipbuilder's Sales' Incentives

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Abstract

A technical advancement in ship technology does not automatically result in vessel sales, profitability and longevity in the industry. Shipbuilders and marine suppliers often face the daunting task of turning highly innovative designs and processes into hard cash by convincing conservative shipowners and operators of their invention's superiority, due to the perceived multifaceted risks associated with new technology. To compound the problem, shipbuilders operate in a competitive environment (as do shipowners and ship operators) and that in order to "close a deal", particularly involving new technology, a package of goods or services or concessions ie "sweeteners" may need to be offered by the sales/marketing divisions. These sweeteners, by encouraging sales, facilitate the commercialisation of the technology. From the buyer's point of view, there is no doubt that sales incentives are attractive and may add significant value to the shipowner's project, often turning a marginal project into an attractive investment. The shipbuilder needs to measure the advantages and costs of this strategy in order to calculate whether the benefit is to the builders advantage. A decision tree methodology is introduced to do this by assessing firstly the benefits gained by offering a sweetener and then measuring the net gain of speeding up the likelihood of acceptance by the market of new technology. The components of value are identified and their contribution calculated. The methodology provides decision makers with valuable information to determine the appropriate investment strategy.

Keywords: Ship technology; Shipbuilding; Sales incentives; Sweeteners; Real option; Contingent liabilities

1. Introduction

A technical advance or invention in ship technology does not automatically result in vessel sales, profitability and longevity in the industry. Inventions fall into two classes: Those that are evolutionary in nature and those that are revolutionary and involve a radical change. Owners/investors are comfortable with incremental change to basic hull design or propulsion and this Darwinian evolutionary process can be traced through time to most vessels of today. However, the industry's history is littered with cases where a technical breakthrough was shunned by investors or took years, sometimes decades, to gain acceptance.

For an example, over the last ten years there has been a tremendous shakeout of yards specialising in the high tech fast ship sector. Of the seventy six shipyards in 1997 which had built at least one vessel capable of speeds in excess of 30 knots, only sixteen remain in the business in 2006 [Baird 2006]. This is a drop of 80%. A few years ago at the high end, sixteen shipyards were building ro-pax vessels of 70 metres or more but only four are currently operational and attracting worthwhile orders [Lowrie 2006].

Some of the collapse of the industry can be explained by macroeconomic factors such as the Asian financial crisis, rising fuel prices as well as the cyclical correction to oversupply. Claims were made by some shipbuilders and designers about prospective vessel capability which could not be met. Poorly built vessels did nothing to enhance confidence in the sector. Many yards were forced to "spec build" in order to keep their skilled workforce, often with disastrous financial consequences.

Thus shipbuilders specialising in new technology face both technical and market uncertainty. Not only do they have to prove their technological advances and convince conservative investors of the merits of their designs, market uncertainty may encourage the builder to offer various concessions (sweeteners) which impact on the bottom line. Some concessions can be priced directly but others, at the outset, may be difficult to value and prove in the future to be a significant contingent liability for the builder along with considerable risk exposure.

Most builders' strategies converge along the same basic dimensions of competition as they focus on matching or beating their rivals by incremental improvements. Innovative companies on the other hand break free from the competitive pack by staking out fundamentally new market space – that is, by creating products or services for which there are no direct competitors (Kim and Mauborgne, 2001). Innovative builders have to prove that their invention not only works but face the daunting task of turning the innovative product into a bottom line profit and then to a long term commercial success[1].

The reliability of all the components of the propulsion systems, hotel systems etc may be a source of uncertainty for the shipbuilder, even if guarantees are in place from equipment suppliers[2]. A new vessel which proves unreliable under normal operating conditions will result in negative publicity from disgruntled operators and create difficulties for further sales, despite the fact that the actual fault was not created by the shipbuilder.

This paper will be of interest to financial officers evaluating investments in new shipping technology, however the approach may be applicable in a more general setting. The paper provides a methodology to model and value both the resolution of technical uncertainty associated with innovative technology and commercial uncertainty associated with winning repeat orders in a very competitive business environment. To ascertain the net benefit of offering a sales incentive to win an initial order, the potential value drivers are identified in section 2 and the costs of various sweeteners discussed in section3. A decision tree methodology is used in section 4 as it is an effective decision support tool to model investor's strategies and their possible consequences, including chance events. Although decision trees have been used in a variety of maritime applications (Frenkel, 1989, White et al, 1999, Ashar, 2001, Ambrosino, 2002, Roumboutsos et al, 2005, Mateus, 2007), in this paper the decision tree approach differs. Here it is used to model the shipbuilder's technical and commercialisation phases of new technology and to estimate the marginal costs and benefits of different strategies and their contingent outcomes. A sensitivity analysis is performed. Section 5 summaries the findings and concludes the paper.

2. Gains from Offering Sales Incentives, "Sweeteners"

"*With an industry which tends to be radical innovation- averse ….it is not for want of innovation….it is the incentive to adopt innovation that is the problem*" (Taylor, 2006. p 128). Shipbuilders need sales to generate cash flow and ensure longevity in the industry, Sweeteners may be viewed as the incentive necessary to achieve the desired sales. Shipbuilding is a low volume, lumpy financing proposition with high overhead costs and a skilled labour force to be maintained. Since contract negotiations for specific vessels can take months or years, the builder is under pressure to lock in a sale. Cash flow pressures may lead builders into offering "deals" and other concessions during the heat of negotiations. These concessions effectively reduce profitability but may be seen as a necessary evil if the new design is to be proven and become a commercial success.

From the shipbuilder's perspective, the prospect of an earlier sale enhances the value of the project by resolving success/failure uncertainties more quickly. The quicker resolution of uncertainty adds considerable value to the project by bringing forward the positive cash flows from future sales if successful, or alternately, to the faster abandonment of the project[3] and the aborting of high overhead costs, maintenance of skilled labour and future payouts of capital. The shipbuilder cannot wait for technical and commercial certainty before ramping up infrastructure, otherwise the yard risks that there

[1] The risk to commercial survival is demonstrated by the 80+% drop in HSC shipbuilders between 1997 and 2006.

[2] SEMT Pielstick, the French Engine Manufacturer agreed to a $10 million compensation package with Maritime Company of Lesvos, or NEL lines whose fleet of Corsaire fast ferries have been plagued with breakdowns. *Lloyds List* 18 September 2006.

[3] For abandonment options, see Bendall, 2002, Bendall and Stent, 2002, Adner and Levinthal, 2004.

will be insufficient capacity to fulfil multiple orders. However this capital expenditure would cease should the technology prove unsuccessful and the project abandoned. Thus the quicker the resolution of the project's uncertainty, the less unnecessary expenditure would need to be made. These gains generated from positive future cash flows or savings will be incorporated in the modelling.

3. Costs of Offering Sales Incentives

There are numerous examples of "sweeteners" forced upon the industry by competitive pressures and these sales incentives impose direct and/or indirect costs on the shipbuilder. "Throw-ins", negotiated as part of the purchase price such as additional equipment, spares or even the new owner's yacht, have a known monetary value and are relatively easy to incorporate into the investment evaluation analysis, while others are more difficult to value. Some owners seek shipyard finance in various forms such as direct loans or require the shipbuilder to take an equity position in the venture. Although both debt and equity finance have a known and calculable monetary value they also have indirect or opportunity costs. Capital tied up in loans or equity will restrict future funding or borrowing ability of the builder. Other concessions may seem minor in comparison at the time of granting but also impact indirectly on day-to-day operations. Training is generally provided by the builder but sometimes shipowners demand specialised personnel to be on hand for an extended period creating an opportunity cost, as those with special skills are unavailable to the shipyard. These costs are often difficult to estimate at the outset.

It is usual practice in contract negotiations to offer set delivery dates and performance guarantees during acceptance trials such as minimum speed, maximum noise, smooth ride etc before the vessel is handed over to the owners. With new technology and/or first builds of new designs unforeseen problems may arise. The penalties for failure to meet the specifications and/or delivery dates may have onerous financial consequences for the shipbuilder, particularly if any problems are not resolved quickly. If the delivery dates are not met shipowners may have the right to cancel the contract or charter-in a vessel (if available) at the shipbuilder's cost. Yards may be forced to accept financial penalties in the form of price reductions or offer other concessions. If guarantees are for an extended period the risks to the shipbuilder increase as the builder may be exposed to possible unbounded liabilities.

Some incentives may create contingent liabilities, increasing uncertainty until costs are known and any negotiated warranties have passed unexercised. Sales may be easier if new technology vessels can be shown in operational mode rather than just as a brilliant concept being spruiked around by enthusiastic designers. To win the sale, shipbuilders may be tempted to offer a*" try before you buy*" or a "*safety net*" deal. In a try before you buy deal the shipowner may charter for a given period and then offered an option to buy the vessel at the end of the charter period[4]. In the alternate, the shipowner buys the vessel but is offered an opportunity to sell the vessel back to the shipbuilder at specified date and price, following successful trials[5], should the investor's commercial venture fail or the vessel prove unsuitable for the trade. In both of these cases the shipbuilder is offering the investor an attractive real option, reducing the technical, operational and financial uncertainty for the investor.

In this paper we will be analysing the "safety-net" case. With a buyback guarantee, shipbuilders are granting a European put option which gives the owner the right but not the obligation to sell the vessel back to the shipbuilder at a pre-determined exercise price[6] at a pre-set expiry date, following technical acceptance. The flexibility given to the shipowner through the option allows him not only to minimise

[4] The shipowner would hold a European call option on the vessel. An option is called a European option if the option can be exercised only on a pre-set date. A call option grants the owner the right but not the obligation to buy the vessel at a pre-determined price.

[5] If the technology fails at the acceptance trials, ie the vessel does not meet specifications, then the uncertainty associated with technical risk, is resolved from both the buyer and builder's perspective. Monies already paid are returned or other monetary concessions made. There is an unknown cost of negative publicity and a slowing of the commercialisation of the technology.

[6] The buy-back price is pre-set, generally on a sliding scale, at rates commensurate with depreciation and the time value of money.

downside risk of loss by adopting new technology, but also to retain relatively unlimited upside potential should the vessel prove to be a financial success. To the shipowner this flexibility (real option) is extremely valuable but to the shipbuilder, the granting the option, has created a contingent liability until the option lapses. Although the shipbuilder is exposed, the shipbuilder is punting that the option will not be exercised if the vessel has passed trials and been accepted by the owner.

However there may be a number of reasons for the option being exercised even if the technology has been proven[7]. Technical and design problems may arise which were not evident at the time of handover but emerge under operating conditions. For example, excessive vibration in specific operating conditions may lead to high maintenance costs or sea state conditions and ride may force an unacceptable number of scheduled voyage cancellations, squeezing profitability for the owner. The vessel may be too big or too small for the particular trade, making the venture financially unattractive. The shipowner may be exposed to excessive and restrictive regulation, unforseen competition and/or a discouraging macroeconomic environment may turn out to be critical factors. The owners may be poor managers or indeed entered into the negotiations in "bad faith" with the intention of handing the vessel back.

If the buy-back eventuates, the shipbuilder's contingent liability resolves into disposing of a second-hand vessel, with negative implications for the owner's new build sales

In summary, granting a buy-back option speeds up the resolution of technical uncertainty and accelerates commercialisation of an innovative new build. Despite the contingent liability, without this first sale, the project may fail. 'Sweeteners" increase value by bringing forward opportunities for positive cash flows generated by successful commercialisation or by an earlier abandonment of the project, if the project should prove to be neither technically feasible nor commercially viability. However, if the shipbuilder grants a "buy-back" option, as grantor of an option, the builder faces a contingent liability until the option lapses. An exercised option will add to the shipbuilder's cost and dampen opportunities for further sales. The strategy of offering "sweeteners" should only be initiated if the marginal cost of the granted option is less than the marginal benefit achieved by making the sale.

4. Valuation of Technical and Commercialisation Phases

Technical uncertainty…."can only be resolved by undertaking and completing the project" (Dixit and Pindyck, 1994 p 47). The modelling recognises two uncertainties associated with the innovation process of new technology; technical and commercial uncertainty The model is explained first for the case when no "sweeteners" are offered, The incorporation of a "sweetener" follows in section 4.6. The put option is valued using risk neutral valuation.

4.1 The First Order For A New Technology

The development of the new technology requires a first vessel's order. The explanation of the model starts at the point when this first order has been signed. The modelling of the timing of the first order itself is taken up below. Given the first order, the subsequent outcomes are modelled in two phases, shown in Figure 1. The first phase incorporates the new technology in the building of the first ship. It culminates in sea trials that are either satisfactory or unsatisfactory. Only in the former "satisfactory" case is the ship accepted by the buyer and the second phase entered. The outcome of this second phase will depend upon the experiences of the first user, but crucially upon whether further orders are received. This second phase is labelled the commercialisation phase in Figure 1 and is also modelled as culminating in two outcomes: successful, meaning a viable flow of orders is received, or unsuccessful. Each of the building and commercialisation phases is assumed to be one one-year long below in the development of the model, though either period could be readily changed in an application.

[7] However the option is unlikely to be exercised if the owner could obtain a higher value for the vessel in the market.

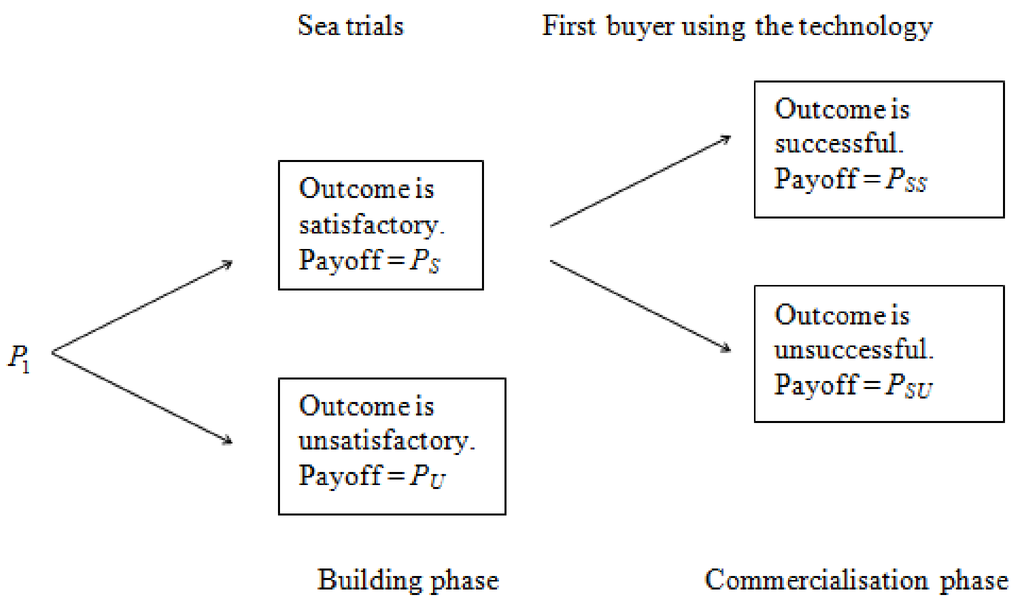

Figure 1: Building and commercialisation phases of a new technology.

4.2 Valuing A Successful Technology

The new technology is successful if both sea trials are satisfactory and a viable flow of orders ensues. If both conditions are met the shipbuilder has a project that can be valued as the discounted sum of its expected cash flows. Denoting the expected value of the cash flow in year *t* by $\mathrm{E}(C_t)$ and the cost of capital by *k*, the discounted sum, P_{SS}, is

$$P_{SS} = \sum \mathrm{E}(C_t)/(1+k)^t \qquad (1)$$

The cash flow in year *t* will be the sum of revenues received during the year from payments for vessels less building costs paid during the year. There may be down periods between the completions of orders when there are no cash inflows. Such periods will be of a random nature and will incur a different level of costs. The random nature of the cash flows can be modelled by simulation. The assumptions and parameters used in the example are summarised in Table 1.

Table 1: The simulation of a successful technology

Ship building time	1 year
Minimum time between commencing orders	6 months
Average number of orders per year	1 ship
Cash inflow from sale of ship	$40 million
Received at time of order	20%
Received at time of delivery, one year later	80%
Ship costs (distributed evenly over building time)	77.5%
Profit	22.5%
Costs per month during down times	$0.5 million
Cost of capital	10% per year
Estimate of P_{SS}	$71.51 million

Orders and cash flows are modelled on a monthly basis. Orders are modelled as independent events with a constant probability over time, back-ordered if necessary to ensure a minimum period of six-months between commencements of building ships. It is assumed that the shipbuilder keeps operations intact during down periods and that this policy carries a fixed monthly cost during such periods. The unit of currency is the US dollar. All of these assumptions of course could be varied. The simulation requires an assumption about the number of orders in the system at the start. Since the discounted sum P_{SS} applies to the period following successful ship trials there could already be orders in the system. For this reason the simulation was run with a "warm-up'' period of three years, with the measurement of annual cash flows starting from the fourth year (t=1). The following 20 years were simulated, and the average cash flow over the last three of these 20 years used as a perpetuity to obtain a terminal value. The simulated outcomes were insensitive to alternative procedures to estimate terminal values. The simulation was run with 5000 iterations. The estimate of the discounted sum P_{SS} is \$71.51 million which is the payoff for the top right box in Figure 1.

4.3 Valuing An Unsuccessful Technology

Given the first order for a ship, the model recognises two times when the technology can be unsuccessful. The first is when the ship does not pass sea trials. This is the lower node in Figure 1 with payoff denoted by P_U and is considered first. Having failed, the venture is terminated. The buyer does not accept the ship. There is a positive cash flow from any scrap value of the ship and terminal values of the yard and equipment, but a negative cash flow from the refund of the ship buyer's initial deposit. These calculations are summarised in Table 2 for the present assumptions giving a net payoff $P_U = -\$4$ million. Other costs such as the cost of building the ship belong to earlier nodes and are modelled there.

Table 2: The payoff with unsuccessful sea trials

	$ Millions
Refund of ship deposit, 20% of $40 million as per Table 1	–8.00
Scrap value of ship, 5% of ship value as per Table 1	2.00
Market value of yard and equipment	2.00
	–4.00

The second time that the technology can be unsuccessful is when the trials are successful but the technology does not attract a viable flow of orders. This path in Figure 1 branches up in the building phase and then down in the commercialisation phase, ending at the node with payoff denoted by P_{SU}. Although the commercialisation phase is modelled as a known period of time, this is a modelling simplification. In practice the period might be protracted with, perhaps, one or two orders before it becomes clear that the venture is not going to be profitable in the long term. While the assets may have some terminal value there will be costs incurred keeping the order book open until the decision is made to terminate the venture. For this reason the present model assumes that the expected payoff P_{SU} is zero.

4.4 Valuing the First Order

The model folds back to the starting node in Figure 1 to obtain the values at the remaining nodes, culminating in the value of the first order, P_1. The payoff P_S at the node for the satisfactory sea trials outcome is calculated first. Equation (2) models this value and is explained below.

$$P_S = (p_{SS} \times P_{SS} + p_{SU} \times P_{SU})/(1+k_C) + R_S - C_S \qquad (2)$$

The first term on the right side is the discounted expected payoff from the two possible outcomes that follow satisfactory sea trials. Using lower case p to denote probabilities, the probability of a successful outcome to the commercialisation phase is written p_{SS}, and the probability of an unsuccessful outcome written $p_{SU} = 1 - p_{SS}$. In the example followed through it is assumed that there is a 60% chance of a successful outcome making p_{SS} and p_{SU} 0.6 and 0.4 respectively. The expected payoff at the end of the commercialisation phase is then calculated and discounted back to the start of the phase to obtain the first term in Equation (2). The discount rate used for this phase is denoted by k_C. Since commercialisation uncertainty is to do with the suitability of the new technology for ship buyers' purposes rather than their need for shipping per se, the beta of the project over this phase will be less than the average. The discount rate k_C is therefore modelled as a weighted average of the cost of capital for a successful technology (k=10% from Table 1) and the risk free rate (estimated to be r_f= 7%) with the weights being the probabilities p_{SS} and p_{SU} respectively:

$$k_C = p_{SS} \times k + p_{SU} \times r_f = 8.8\% \qquad (3)$$

The value of the first term in Equation (2) is calculated for the example to be $39.44 million.

The resolution of commercialisation uncertainty has been modelled with two possible outcomes, successful and unsuccessful. An interesting alternative approach would model this phase as a continuous phenomenon over time and use the principle of risk neutral valuation to value management's flexibility to abandon or expand the project. Several issues arise such as the need to model volatility. As time progresses the uncertainty in question would diminish as the acceptance of the technology or otherwise becomes clear.

The two remaining variables to explain in Equation (2) are R_S and C_S. These are the revenue received and costs incurred respectively for the building of the ship at this time. In the present example the revenue received following successful sea trials is the balance of the payment for the ship, that is 80% of $40 million, or R_S= $32 million. It is assumed that no further ship building costs are incurred in the commercialisation phase, that is C_S = $0. In summary, the value for P_S used for the example, from Equation (2) is $39.44 + $32 = $71.44 million.

The model next folds back the values P_S and P_U at the end of the first branch in Figure 1, to obtain the value of the first order, P_1. An equation similar to (2) is used:

$$P_1 = (p_S \times P_S + p_U \times P_U)/(1 + k_B) + R_1 - C_1 \qquad (4)$$

The probabilities of the outcome of the sea trials being satisfactory and unsatisfactory are denoted by p_S and $p_U = 1 - p_S$ respectively. In the example being followed through the values used for p_S is 0.8 and the value used for p_U is 0.2. The overall success of the project, $p_{SS} \times p_U$, is then 0.6×0.8 or just less than 50%. The expected value of the payoffs for the two outcomes is discounted back the 12-month length of the building phase using the rate k_B. This rate should be that appropriate for a new technology. Since technological uncertainty bears little relationship with market uncertainty a risk-free rate of 7% is used. The cash receipt at the time of the first ship order, denoted by R_1, is the deposit received at the time of the order. The value used in the example is, using the figures in Table 1, 20% of $40 million, or $8 million. The cash payments at this time, denoted C_1, are the costs of building the ship. Using Table 1 figures again for the example, C_1 is 77.5% of $40 million, or $31 million. The value for P_1 is calculated from Equation (4) to be $29.66.

4.5 Modelling the Total Value of the Project

The project is modelled in a time line, illustrated in Figure 2. The first month either results in the first order (up branch) or in no order, in which case the sequence proceeds to the second month. The second month either results in the first order (up branch) or proceeds to the third month. The sequence continues until a first order is placed. Once this occurs (an up branch) the sequence passes to that in Figure 1 above, with value in that month being $P_1 = \$29.66$ million. Each month that passes until the first order is received incurs a cost. There are two components to this cost. They are explained below.

The value of the project is denoted by P_0 and is the following discounted sum:

$$P_0 = \sum \left[\frac{p_t P_1}{(1+r_m)^t} + \frac{(1-p_{(t)})F + (1-p_{(t-12)}P_U)G}{(1+r_m)^{t-1}} \right] \qquad (5)$$

where p_t is the probability that the first order is received in month *t*, $p_{(t)}$ denotes the cumulative probability that the first order is received in a prior month $p_{(t)} = p_1 + ... + p_{t-1}$ ($p_{(t)}$ is zero if $t \le 1$), *F* and *G* are the two cost components to be explained below, and r_m is the discount rate per month. While the payoffs P_1 apply at the end of months, costs are assumed to occur at the start of months. This accounts for the discount factor for the cost component in Equation (5) being smaller by one period. To calculate p_t it is assumed that the conditional probability of an order being received in month *t*, given that an order has not been placed in a prior month, is a constant *p*. Successive values of p_t are calculated:

$$p_1 = p, \; p_2 = (1-p)p, ..., \; p_t = (1-p)^{t-1} p \qquad (6)$$

The summation in Equation (5) runs over months *t* =1, 2, … . In theory there is no upper limit to the summation, though the terms quickly become small. Ten years, which is 120 months, were used in the calculations below where it was assumed that if an order had not been received during that time one was received in the 121st month.

The first component of cost, denoted by *F* in Equation (5) is a fixed monthly cost assumed to be incurred until the first order is received. It models the ongoing costs of the builder to keep operations intact. These are similar to the monthly costs incurred with a successful technology during down times, between orders. The second cost component, *G*, represents capital costs per month incurred at the start of the project in ramping up for production. Such costs are assumed to continue for a fixed period of time, the first two years of the project, but to terminate if sea trials for a first order are conducted within this period and the technology found to be unsuccessful. In this case there would be no purpose in completing plans for production. One advantage of an early first order is to terminate these costs should the technology be destined to fail. The component $(1-p_{(t-12)}P_U)G$ is an expected cost. The earliest time that technology can fail is month 13, which is twelve months after the time of the first possible order. Thus, for the first twelve months the cost is a deterministic quantity *G*. After the twelfth month the cost is weighted by the probability that the technology has not failed to date. The weight is calculated as the complement of the probability that it has failed to date, or $1-p_{(t-12)}p_U$ using the notation outlined previously

The parameters used to calculate the value of the project using Equation (5), in the absence of sweeteners, are presented in Figure 2. The resulting value of Equation (5) is P_0 = \$10.95 million. This value happens to be \$24.76 million if an order is received with certainty in the first month (found by recalculating Equation (5) with *p* = 1). The difference, \$13.81 ($= 24.76 - 10.95$) million sets an upper bound on the value of sweeteners to the builder.

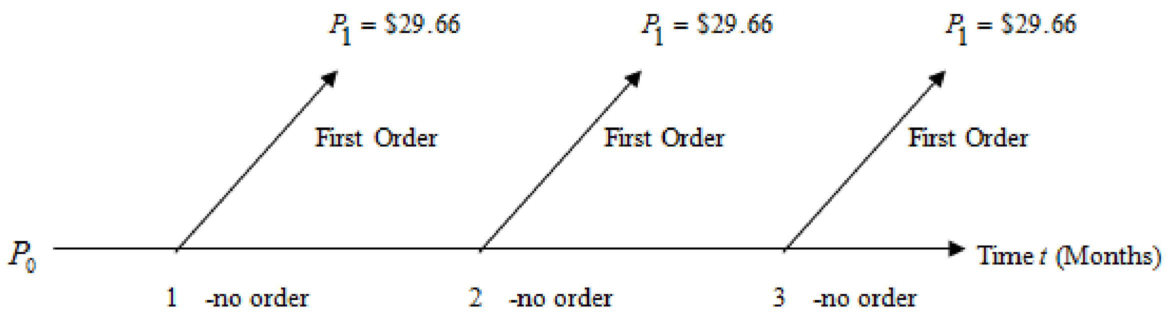

Figure 2: The project along a time line

4.6 The Valuation of Sweeteners

The value of sweeteners to the ship builder comes from a quicker resolution of uncertainty. In Equation (5) the gain comes from the conditional probability of an order, p, assuming a higher value. Say by offering a sweetener, p is increased from $1/24$ to $4/24$. The implications for the likelihood of an order over time are illustrated in Table 3.

Table 3: The probability of a first order

Probability of an order	No Sweetener $p = 1/24$	Sweetener $p = 4/24$	Limit $p = 24/24$
Within first month	0.042	0.167	1.00
Within six months	0.225	0.665	
Within one year	0.400	0.888	
Within two years	0.640	0.987	
Value of project ($ million), from Equation (5) before any cost of sweetener	10.95	21.36	24.76

The bottom line of Table 3 shows the value of the project calculated according to Equation (5), for the various possible values of p. The limiting case with p=1 is shown in the right-most column. It is interesting that with the parameters underpinning Table 3, much of the increase in value comes from the relatively small increase in the monthly probability of an order from 1/24 to 4/24.

However, if a sweetener is offered to hasten the likelihood of an early order then its cost must be deducted from the increase in the project's value. A specific example of a sweetener is followed through. It is where the ship builder gives the first buyer the option to sell back the ship for its depreciated value calculated by straight-line depreciation based on a 15-year ship life, two years following its delivery. The first of these two years covers the commercialisation phase of the new technology. Here, it is assumed that if there is an *unsuccessful* outcome to the commercialisation phase then the buyer will exercise the option at that time and 14/15ths of the $40 million price of the ship must be refunded. This is a cost to the builder attributable to the sweetener, but it would be offset by whatever value could be obtained for the returned ship. Since the commercialisation of the technology has been unsuccessful the second-hand value of the ship would be low. It is assumed that the ship merely has scrap value and that the same figures would apply that followed unsuccessful sea trials. These are the figures in Table 2 above, except that 14/15ths of $40 million is now refunded and not just the initial deposit on the ship. The value for P_{SU} in Figure 1 is –$33.33 million.

In the case of a *successful* outcome to the commercialisation phase the ship builder still faces a contingent claim and must buy back the ship if the buyer exercises the option. The builder has effectively underwritten a put on the value of the ship to the buyer. The ship buyer will exercise the option if the value of the *buyer's* project, which the possession of the ship enables, falls below the depreciated ship-value. The cost of the option is valued in the model as a European-style put using risk-neutral valuation and the parameters in Table 4.

Table 4: Valuation of the put

S_0, the initial market value of the ship buyer's project	$37.33 million
Volatility of the underlying	20% per annum
Strike price, 13/15ths of $40 million	$34.67 million
Risk-free rate of interest	7%
Time to maturity	1 year
Further costs to the builder if the option is exercised	$5 million
D, the value of the put	$2.26 million

Table 4 values the option at the time of the successful outcome of the commercialisation phase. The ship is one year old at this time. The purchase of the ship is assumed to be a marginal, zero net-present-value project for the ship buyer which makes its market value equal to the value of the ship at this time[8]. Straight-line depreciation and a 15-year ship-life are used to estimate the initial value of the buyer's project to be 14/15ths of the full price of the ship. The model allows for further costs [9]to the builder in reselling the ship should the option be exercised, here estimated to be $5 million. These costs make the valuation of the option slightly different from the usual valuation of a put. The option was valued using a binomial tree and is *D* = $2.26 million. This cost becomes a component of $C_S$in Equation (2) above.

The value of the project with the sweetener is calculated from Equation (5) to be $11.60 million, assuming that the sweetener increases the monthly probability of an order to 4/24. The value $11.60 million can be compared to the project's value with no sweetener of $10.95 calculated previously. The value of the increased likelihood of an order offsets the cost marginally by $0.65 million (11.60–10.95).

Table 5: Value of the project with sweetener under different scenarios

Probability of an order	Worst case (No improvement) $p=1/24$	$p=4/24$	Best Case $p=8/24$	Limit (Certainty) $p=1$
Volatility of underlying per annum				
Worst case: 30%	1.54	11.03	12.87	14.14
	*–9.41**	*+0.08*	*+1.92*	*+3.19*
20%	2.06	11.60	13.44	14.72
	–8.89	*+0.65*	*+2.49*	*+3.77*
Best case: 10%	2.71	12.32	14.17	15.46
	–8.24	*+1.37*	*+3.22*	*+4.51*

All values are in $ million.

* The change in value from the no-sweetener case (10.95) is shown in italics.

A sensitivity analysis is contained in Table 6 and demonstrates the impact of varying the probabilities of a sale with the volatility of the shipowner's cash flows. A pattern stands out with the present parameters. Firstly, if the monthly probability of an order does not increase to about 4/24, offering the sweetener is not a good decision; it subtracts value. At that value for *p*, offering the sweetener adds marginal value. If the sweetener increases the monthly probability of an order to about 8/24, it is a value-adding proposition. However the gains are not large relative to the value that is destroyed should *p* not increase. Further, rather than increasing exponentially, the increase is flat as the limiting case of *p*=1 (certainty) is approached. Using the most-likely case for the volatility of the buyer's underlying project value, 20%, the potential gain from offering the sweetener is just $3.77 million. The present value of the shipbuilder's project increases by 34.4% from $10.95 to $14.72 million with certainty, compared with a decrease of $8.89 million should the likelihood of an order remain unchanged.

5. Conclusion

There are considerable risks associated with the introduction of new technology. Developers are keen to commercialise their technology but need to demonstrate their design's technical advances and service reliability. To do this they need sales and so during negotiations may entice potential investors by offering incentives or "sweeteners", packaged with the sale of the vessel, so as to speed up the resolution of the uncertainty surrounding the new technology. This paper provided a methodology to model the

[8] Should the buyer's project yield a negative NPV, ie without the "sweetener" a unprofitable venture, the cost of underwriting the "sweetener" would be far more to the shipbuilder than the cost in the example explored and demonstrates the importance of undertaking an analysis of the buyer's operating environment before offering a buy-back option so as to minimise the chance of the offer of a "sweetener" being abused.

resolution of this uncertainty and demonstrated how to value the project's "sweetener". The modelling recognised two uncertainties associated with the innovative process; technical uncertainty, resolved by the vessel meeting technical specifications at acceptance trials and commercialisation uncertainty, resolved by winning broader market acceptance. A buy-back option was chosen as the sales incentive and although the buyback option increased the likelihood of an order, the shipbuilder, as grantor, faced a contingent liability until the option lapses.

The analysis showed that "sweeteners" can add or subtract value, demonstrating the importance of valuing the project with and without a particular sweetener. The value of the sweetener comes from increasing the likelihood of an order. As the probability of an order is a subjective parameter it is important to conduct a sensitivity analysis to find the point of indifference. The sensitivity analysis in this paper demonstrated that even if the monthly probability of an order increased from 1/24 to 4/24 using the most likely case for the volatility of the buyer's underlying project value, the offering of a "sweetener" is a marginal proposition. Even doubling the likelihood to a probability of 8/24 the potential gains are not large relative to the value destroyed, should p not increase. As the limiting case of $p = 1$ (certainty) is approached further gains are marginal. Because of the relevance of the ship buyer's market to the outcome, the shipbuilder should undertake an analysis of the buyer's market to ascertain the likely profitability and volatility of the venture to ensure that if "sweeteners" are granted in negotiations then the benefit (value) gained outweighs the costs associated with granting the option.

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Creating Value-driven Port Logistics in Free Trade Zones

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Abstract

Global logistics integration in the port and their related industries has redefined the functional role of ports in value-driven chains. This role change brings about the new thinking of port logistics in recently established free ports/free trade zones particularly in Asian area. While ports are vigorously setting up free trade zones, what are the core industries most beneficial to a certain port becomes an important issue. This paper first compares the key features of free ports/free trade zones in Netherlands, Hong Kong, Singapore, Japan, Korea, China and Taiwan. It then explores the new paradigm of port logistics in free trade zone. Finally, this paper employs three indicators of value-added, market share and forward and backward linkages to measure and select core industries in free trade zone so that the appropriate enterprises could be attracted into free trade zone to meet the value-driven goal.

Keywords: Value-driven chains, Core industry, Logistics, Input-output analysis, Market share, Free Trade Zone (FTZ)

1. Introduction

The world currently has over 600 freeports and Free Trade Zones (FTZs). Governments in Europe and the Americas, and in nearby Singapore and Hong Kong, are using free ports to offer commercial trade, industrial processing, technology development and logistics services in a single place. The names of these special zones can vary according to purpose and function, and include: foreign trade zone, free port, transit zone, free perimeter, export processing zone, special customs privilege zone, special economic zone, etc. The goals of all of these zones are to promote free flow of goods, attract foreign investment, and stimulate economic development. Most FTZs are located within ports/airports.

With the growth of global business, international trade is increasingly eliminating national boundaries. Firms are increasingly utilizing the value-driven global logistics management model. This model means the raw material, technology development, manufacturing, warehousing, and distribution can be arranged in different countries but still contact closely in order to obtain the cheapest and most efficient production and optimal resource allocation. Ports and airports are the major nodes of international trade. Panayides and So (2005) have discussed value-added logistics with the concept of maritime/port logistics.

This study discusses FTZ activities from port logistics perspective and uses the value-chain concept of Porter to explore the competitiveness advantage of FTZ and key successful factors of FTZ. Furthermore, this study analyzes how to select core industries to be included in FTZ.

The remainder of this study comprises four main sections. Section 1 reviews the literature, addressing the meaning and concept of FTZ and comparing Taiwan with other countries. Section 2 then discusses the key successful factors for FTZ from the perspective of port logistics. Next, section 3 defines the core industries of FTZs, and attempts to identify the core industries of FTZs in Taiwan. Finally, the findings are discussed and conclusions are drawn.

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2. The Meaning and Concept of Free Trade Zone

UNCTAD (1994) defined a freeport as a designated area within a port or airport where goods can be imported, stored or processed and re-exported, free of all customs duties. Firoz *et al.* (2003) defined FTZs as enclosed and policies areas in seaport, airport, or some other inland point where goods of foreign origin may be brought in for re-export by land, water, or air without the payment of customs duty. The name varies according to purpose and function, and can include foreign trade zone, free port, transit zone, free perimeter, export processing zone, special customs privilege zone, special economic zone, etc. All such zones are designed to create a situation in which goods could flow freely, attract foreign investment, and boost economic development.

Originally, FTZs were used for storage and trade, but recently the focus has shifted to manufacturing, processing and assembly. Merchandise entering FTZs is free of customs duties and quotas, and can be stored without time constraint. According to the definition of United States International Trade Commission (ITC), FTZ is an independent, bonded area in which merchandise for re-export is treated differently from that in ordinary customs territory, and merchandise may be admitted to the zone, without being subject to customs duties, unless and until the merchandise enters the domestic market. Mathur and Ajami (1995) observed that enterprises can pursue high value-adding processing and enjoy preferential treatment, though these benefits are offset by higher rent and administrative expenses. Following the value-adding process, goods can be efficiently exported from nearby ports through simpler custom clearance. Firoz *et al.* (2003) argued that trade restrictions have minimal effects on FTZs. According to Tansuhaj and Jackson (1989), the benefits of FTZs include: (1) no customs for goods entering FTZs; (2) preferential tariff treatment for parts assembled into finished products in FTZ and then entering the domestic market; (3) free and safe flow of goods in FTZs; and (4) permissible transport of goods among different FTZs.

Additionally, Firoz *et al.* (2003) describe FTZs as providing transportation, insurance, finance, and communication services. Tansuhaj and Gentry (1987) found significant differences between users and non-users of foreign trade zones. Furthermore, users rated the benefits as being more important in facilitating their global marketing and logistics functions. Therefore, FTZ can be created with several functions, including trade, finance, warehousing, logistics, value-added service, transshipment and manufacturing. FTZs in Taiwan offer all of these functions. Enterprises of FTZ in Taiwan are divided into FTZ and non-FTZ-enterprises according to their logistics activities, and offer different taxation rates and fee schedules.

FTZs in different countries have different content and fulfill different functions. All FTZs aim to provide a liberal logistics center facilitating convenient trade of goods, as shown in Table 1. With the location, Hong Kong and Netherlands are the most special cases. The whole of Hong Kong is a single economic trade entity. The bonded area of the Netherlands could be located with approval in all parts of the country, if it follows and maintains accordance with customs clearance regulations. Most other countries have placed their FTZs in special locations, generally inside or nearby port/airport control areas or in industrial park. Taiwan has five FTZs, all of which are in port or airport control areas. However, according to Taiwanese law, FTZ could be located in an adjacent and controlled area or in an area with goods tracking system which connects with controlled districts of international ports/airports through technological facilities.

Table 1: Difference of FTZs between Taiwan and other countries

Factors	Country/Characteristic
Location	Hong Kong: All area is free port. Singapore: Within port/airport Japan: In Okinawa, near port Korea: Within port/airport China: Near port/airport or manufacturing site (bonded area) Philippine: An isolated policed area adjacent to a port and/or airport. Netherlands: Distribution center, permitted in whole country.

	America: Near port/airport. Taiwan: An area near or within port / airport
Legal	Hong Kong: The Basic Law Singapore: Free Trade Zone Act Japan: Okinawa Promotional Special Measures Law China: Administration Order (bonded area) Philippine: The Special Economic Zones Act(ECOZONES) Korea: Free Economic Zone Act (FEZ) and Comprehensive Investment Initiatives Netherlands: Community provision of and National provisions of the Netherlands America: Foreign Trade Zone Act Taiwan: The Free Trade Zone Act
Preferential Taxes	Hong Kong: 1. No VAT 2. No customs duty 3. Only profit tax. Singapore: 1. No customs duty or Customs permit. 2. No GST 3. No excise duty. 4. Adopt Major Exporter Scheme (MES) Japan: Reduce corporate tax China: Exemption from customs duty for most imported goods. Income tax of 15% throughout the whole country No corporate tax for production companies during their first two years and 50% tax rebate during their 3rd to 5th years of operations. Philippine: 1. Exemption from national and local taxes. 2. Member of ASEAN, with preferential tariffs 3. Exemption of 98% customs tariffs before 2010. 4. Preferential access to developed markets such as the U.S. Korea: 1. Reduction of corporate tax 2. Reduction of individual income tax and five-year tax exemption for foreign engineers. Netherlands: No customs duty No VAT Income tax based on the level of activity. America: 1. Customs duty: maybe deferral, elimination of duty, tariff relief, or ad valorem, 2. Income tax: most states exempt all FTZ merchandise from inventory taxes. Taiwan: 1. Exempt from customs duties, commodity tax, tobacco and wine tax, tobacco health and welfare surcharge, trade promotion service charge, and port dues. 2. Zero-rated business tax on sale of services within FTZ. 3. Zero-rated business tax for domestic procurement 4. Zero-rated business tax for operator outside FTZ transporting goods and storing therein under instructions of foreign customer and obtaining foreign exchange.
Adminstrative	Hong Kong: 1. Using risk management, customs checking classified by origin country. 2. 24hrs customs services provided by EDI Singapore: 24 hrs service, clearance by TradeNet System, and no clearance within zones Japan: Reduction of land cost. China: No customs control, clearance data provided to supervise. 24hrs customs clearance No customs inspection, all goods finish customs Philippine: One stop shop center for registration Netherlands: 1. 24hrs services provided by EDI. 2. Different type of bonded warehouse: e-type , c-bac etc. Different type of bonded warehouse:

	e-type , c-bac etc. America: 1. Form 214 must be completed for all cargo and permission must be given by the port authority. 2. Direct delivery permited before 30 days. 3. No time constraints on storage Taiwan: “Inside national territory but outside customs” for flow of goods, commerce and people. Single-window administrative services.

Source:
1. Republic of the Philippine Congress of the Philippines Metro Manila Third Regular Session.
2. Free Trade Zones Act, The Statutes of the Public of Singapore.
3. Welcome to a Business Paradise: Industrial Site Promotion Guide, Okinawa Special Free Trade Zone, http://www.pref.okinawa.jp/zone
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5. Council for Economic Planning and Development (2000), Free Port Planning in Taiwan and related analysis and research in other countries.
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With regard to scale, scale is generally not a major factor, but most FTZs exceed 30 hectares in size. The FTZ of Okinawa in Japan has an area of 122 hectares, while Waigaqiao, a bonded zone in China has an area exceeding 1600 hectares.

Regarding legal issues, with the exception of Hong Kong, where the FTZ is regulated simply by the general law, most FTZs are regulated by various special laws providing different customs clearance benefits, personnel entry and exit requirements, and tax incentives.

With regard to goods flow and processing, most countries focus on re-export and simple value-added processing (labeling, repacking and assembling). Korea and Taiwan also focus on multi-stage value-added processing and manufacturing. Taiwan emphasizes that adding value via a multi-stage approach creates unique competitive advantage for FTZs in Taiwan. A report (IOT, 1999) revealed that a single transshipped container of cargo generates US$1,625 in added value. In comparison, a transshipped container of cargo that undergoes simple processing generates US$4,750 in added value. Moreover, a transshipped container of cargo that undergoes multi-stage value-added processing creates US$18,500 in added value. Taiwan can use its advantage in high value-added manufacturing and design with convenient logistics and least trade limitation in FTZs to create new international trade opportunities between Taiwan and Mainland China in the future.

Regarding tax preferences, the waiving of customs duty for re-export products is a basic incentive. Just as Firoz (2003) describe when goods enter FTZ, duty is free so long as goods stay there. Both Hong Kong and boned areas in China have no customs duty. Hong Kong has the most attractive incentives, with no customs duty, VAT, or profit taxes (also call income taxes in other country). Meanwhile, FTZs in Japan, the Philippines, the United States and Korea eliminate custom duty. Finally, the Philippines, Korea, China and Japan eliminate income tax.

Regarding management, the operation of ports or airports in Hong Kong, Singapore and Netherlands have high administrative efficiency. Hong Kong, Singapore and Netherlands all offer 24 hours customs clearance and provide convenient entry for people. Additionally, some countries provide single-window administrative services and special promotional mechanisms.

3. New Paradigm of Port / Airport Logistics

The above countries differ in terms of FTZ type and content, but all are intended to improve the competitive advantage of their respective regions. Porter (1990) observed that value chain could be used to analyze the resource of enterprise competitiveness. Value chain analysis can be applied to divide industries according to whether they are engaged in primary or support activities. Primary activities are the main source of profit for enterprises. Primary activities are what Hafreez *et al.* (2002) termed core-competences or core businesses. From a value-chain point of view, the competitiveness of FTZ lies in selecting the most suitable core business for transshipping and maximizing added value. Therefore, it is necessary to redefine port activities for ports that FTZs located from a value-chain perspective.

Bichou and Gray (2005) observed that today the port role exceeds the simple function of services to ships and cargoes. In addition to its traditional role as a sea/land interface, a port is also a good location for value-added logistics and for other related services including industrial, trade, financial, and even leisure and property development activities. Therefore, the definition of the core business of ports is multifaceted. Generally, ports are involved with both port and non-port business activities. Although some studies, for example, Haralambides and Veenstra (2002), limit the core business of ports to cargo handling only, the World Bank broadens port activities to include a range of value-added services (including both value-added logistics and value-added facilities).

Additionally, different scholars have considered the concept of port value chain (such as Robinson, 2002; Bichou and Gray, 2004; 2005) and maritime /port logistics (Panayides and So, 2005; Panayides, 2006). The concept of value networks in port environments argues that competition takes place among value chains as opposed to among individual ports. Port value chains thus are not limited on logistics channels, but can also be divided according to transportation system into route, forwarder of transportation and customer clearance, loading/unloading etc. All functions are integrated with deliverer (Bichou and Gray, 2005). Ports play an important role in integrating all three types of channel. Many organizations are involved or potentially involved in logistics and supply chain integration within and around ports, in the role of logistics channel facilitators (ocean carriers, land-based carriers, port operators, freight forwarders, port agents, etc.), trade channel members(shippers), and supply channel associates (manufacturers and retailers). Therefore, Bichou and Gray (2004; 2005) indicate that ports can provide more roles and perspective from integration within the role of logistics, trade and supply channel. These roles could be described as follows:

(1.) From a logistics channel standpoint, ports are very important node since they service as an intermodal/multimodal transport intersection and operate as a logistics center for the flow of goods (cargo) and people (passengers).
(2.) From a trade channel perspective, ports are a key location whereby channel control and ownership can be identified.
(3.) From a supply channel approach, ports not only link outside flows and processes but also create patterns and processes of their own. At this level, ports are one of the few networking sites that can bring together various members in the supply channel.

This new approach extends the traditional port system to an "integrated channel management system" where the port stands as a key location linking different flow and channels with their members
Another concept in maritime /port logistics is that maritime transport concerns the transportation of goods and /or passengers between two sea ports. A supply chain consists of the series of activities and organizations that materials (raw materials and information) move through on their journey from initial supplier to final customer. Notably, maritime logistics is the concept of integration of physical (intermodal), economic/strategic (vertical integration, governance structure) and organizational (relational, people and process integration across organizations) (Panayides, 2006). It is crucial that logistics and other added value services be provided at the right time and place to enhance production and delivery efficiency. The FTZ simply can serve this purpose.

Generally, the enterprises on FDI determinants or location choice are concerned with the establishment of FTZ. For example, Woodward and Rolif (1993) analyzed export-led companies and found that numbers of FTZ influence their choice of location when investing in the Caribbean. Head et al (1999) gathered data on Japanese enterprises investing in America between 1980 and 1992 and found a positive correlation between enterprise in investing and the location of FTZ. Mathur, Ajami (1995) and Breners *et al.* (1997) also indicated that firms seeking to locate their operations in FTZ should take several factors into account, including the quality of available manufacturing and warehousing facilities, access to air and sea ports, available transportation modes, onsite customs offices to expedite and simplify imported raw material clearing, and infrastructure quality. According to Yang (2003) and Lu and Yang (2006), research indicates that the five criteria respondents considered most important are political stability, corporate tax incentives, government administration efficiency, labor and energy costs. Hu and Chen (1998) assessed investment in the Okinawa FTZ. They think both FTZ and new industry park need science research and government support, lower electricity, water and labor cost, incentive of tax and finance and construction with complete infrastructure. However, these key successful factors are the most important factors for productivity, the issue of which industries are suitable for stationing themselves in FTZ has not yet been considered. Feng and Hsieh (2008) note from a logistics point of view that FTZ competitiveness should depend on selecting the optimal core industries in terms of transshipping and adding value. Just as Robinson（2006）observes, the larger the number of value pools, the more sets of functions are migrated via landside logistics operations. Thus the management strategies used for FTZ should first decide the core industries to make advantage of resources, location and trading activity of FTZs.

4. Selection of core industry

The goal of Free Trade Zones is to maximize the value of transshipment in the value chain process. But which industry could create the maximum value and should be given incentives is the key issue of this study. Feng and Hsieh (2008) sets the following selection principles based on FTZ's goals (See Figure 1): increase transshipment added value of FTZ industries, benefit domestic industry development and enlarge the market share of FTZ industries among the competition ports. Based on these principles, four selection criteria of core industries in FTZ are described as follows:

(1.) industries that can process high transshipment value added operations within FTZ.
(2.) industries that are closely interrelated with down-stream and up-stream industries, and could enhance the domestic industry developments.
(3.) industries that can bring about large positive impacts on international trades.
(4.) industries with effective land use, such as second and tertiary industries.

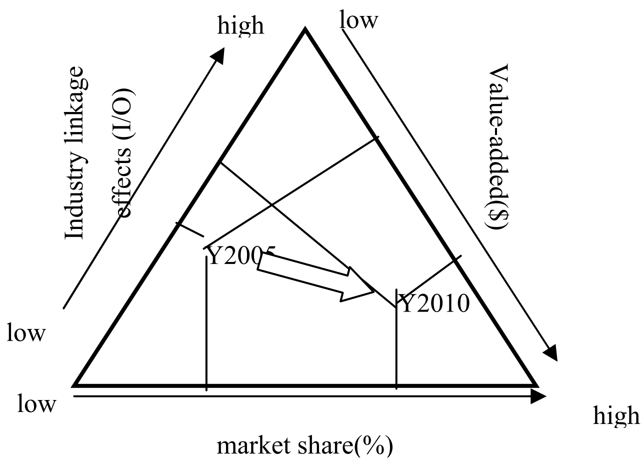

Figure 1: The selection indicators of core industry

Based on the above principles, the core industries for FTZ could be defined as the union set of high value-added industries, high forward and backward linkage industries and high market share industries (as shown in Figure 2). Following the selection principles and definition of core industry, three selection indicators of transshipment value-added, the backward and forward linkage, and market share are proposed and measured as follows:

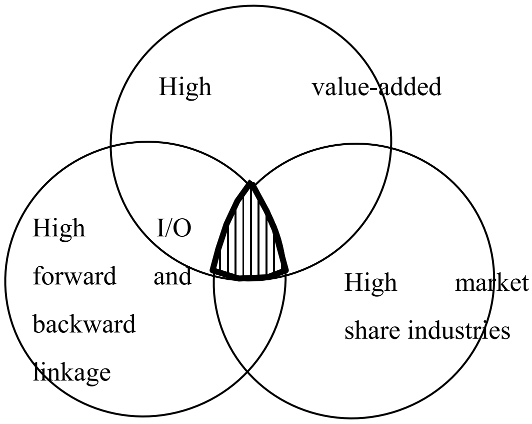

Figure 2: Union set of core industries in three indicators

(1) Transshipment added value:
Since industries in FTZ involve with international trade, this study uses the rate of added value based on the definition of IMF (2005) to measure "added value" of industries. The rate of added value is defined as follows:

Rate of added value= $(CIF_j / FOB_j) - 1$ (1)

where CIF_j = import shipping costs, including cost, insurance, and freight for industries j
FOB_j =merchandize value= value of free on board for industries j

(2) Forward and backward linkage
The backward linkage（also know as index of power of dispersion） is defined as : $b_j = \sum_{i=1}^{n} r_{ij}$, where r_{ij} is the element of the Leontief inverse matrix $(\mathrm{I}-\mathrm{A})^{-1}$ in input-output analysis. A is the matrix of input coefficients or technical coefficients, while $(\mathrm{I}-\mathrm{A})^{-1}$ is the matrix of interindustry interdependent coefficients. b_j represents the output multiplier frequently used in input-output analysis. The backward industries mean those industries have strong linkage with other local industries that is dominates. The forward linkage（also know as index of sensitivity of dispersion） f_j is defined as $f_j = \sum_{j=1}^{n} r*_{ij}$, where r_{ij}^* is the element of inverse matrix $(I - A*)^{-1}$ and where the elements of A^* are output coefficients. A forward-linkage industry will have a high ratio of intermediate sales to final demand and thus be dependent on other industries for its growth. Hirschman (1958) defines key industries as those for which both indices are greater than the average linkage for the whole economy since these industries dominate through their forward and backward linkages (Harris and Liu, 1998). Industries could be divided into four categories and the core industries in term of the forward and backward linkage in this study belong to the category I in Table 2.

Table 2: Inter-industry interdependency linkage

Category	Backward Linkage Impact (index of power of dispersion X）	Forward Linkage Impact (index of sensitivity dispersion Y)
Ⅰ	high	high
Ⅱ	low	high
Ⅲ	low	low
Ⅳ	high	low

Source: Hirschman (1958)

(3) Market share
Industries which could have the potential of creating a higher market share among competition ports in Asia will be selected as the possible core industries in FTZ. The market share is measured as follows:

$$S_{ij} = F_{ij} / (\sum_{j=1}^{n} F_{ij}) * 100\% \qquad (2)$$

S_{ij} in equation (2) denotes the market share of industry j in port i, F_{ij} denotes the cargo volume for industry j in port i. The target competition ports in Mainland China are selected to measure the market share in this study includes ports of Ningbo, Shanghai, Guangzhou, Shenzhen and Xiamen.

Table 3: The core industry of each indicator

Indicator	Value-added (>15%)	Forward and Backward Linkage (The index of sensitivity dispersion and index of power of dispersion are all greater than the mean value of overall industries)	Market Share (>40%)
Core industry	products of the chemical or its relevant industries(16%) leather and its product(17%) footwear, headgear; umbrellas; feather and their products(16%) base metals and its products(16%) machinery and electronic component (15%) precision instruments and equipments(20%) miscellaneous (toys, games and sports requisites)(16%)	products of the chemical or its relevant industries plastic and its products base metals and its products machinery and electronic component	products of the chemical or its relevant industries (45%) base metals and its products(50%) machinery and electronic component precision(50%) precision instruments and equipments (60%)

The selected core industries based on three indicators of transshipment added value, forward and backward linkage and market share are shown in Table 3. The threshold of transshipment added value is set up to 15% based on the study Liou (2007). According to categories of merchandise for re-export in 2005, the industry categories of "products of the chemical or its relevant industries", "leather and its products", "base mental and its products" , "footwear, headgear, umbrellas, feathers and their products", "precision instruments and equipments", "machinery and electronic component equipments", and "miscellaneous products" have their higher transshipment added value exceeding the threshold of 15%. The empirical findings of this study are similar to those industry categories existing in the Taiwan bonded area or export processing zone, and also to those high value-added industries in the Pearl River Delta (Gui et.al, 2006). Liou (2007) found that re-export schemes offered in Hong Kong provide some peripheral services and raise the transportation trade prices (i.e. price markup), therefore even the Hong Kong's re-export price markups are lower than 35% and their mean value is around 22%, still, the price markup is higher than that for Taiwan's added value. Thus, transshipment value-added operation in Taiwan still has room for growth.

The forward and backward linkage result of Input/Output analysis is computed from figures published by the Department of Budget, Accounting and Statistics, Executive Yuan, which has categories of 49 sectors and subcategories of 161 sectors. This study computes the interindustry interdependency coefficient values in 2004. The industries with forward linkage and backward linkage both exceeding the mean value of these two indexes over all industries are selected as the potential core industries. In other words, the industries belonging to the category I (high backward and forward linkage) in Table 2 are classified as the core industries in term of backward and forward linkage indicator. The selected core industries are " products of the chemical or its relevant industries", "plastic and its products", "base metals and its products", and "machinery and electronic components and its products". In terms of market share, the industries with a market share exceeding 50% in Taiwan include "base metals its products", "machinery and electronic component precision", and "precision instruments and equipment". Besides, the industries with the market share exceeding 40% include "products of the chemical or its relevant industries", "base metals and its products", "machinery and electronic components", etc. This study uses 40% as a threshold of market share because other market shares are below 30%. Taiwan is competitive in all of these industry categories, and the findings regarding market share are consistent with what is generally recognized industry categories of primary exports in Taiwan.

Summarizing the above industries selected from transshipment added value, forward and backward linkage and market share, it is found that "products of the chemical or its relevant industries ", "based metals and its products" ,and "machinery and electronic components" have all passed the threshold of three indicators. These three industries thus are selected as the most competitive and valuable core industries. Since the data for the industry of precision instruments and equipment such as photography and optics of precision machinery is not available in input-output analysis, this industry is thus not on the list of forward and backward linkage. However, this industry has shown its high market share (60%) and high added value (20%), we still consider it as one of the core industries.

From the union set of industries based on three indicators, four industry categories, namely "products of the chemical or its relevant industries", "base metals and its products", "machinery and electronic component precision", and "instruments and equipment" are selected as core industry in FTZ and worth to give incentives by government.

5. Conclusions and Suggestions

Different functions including trading, finance, logistics, warehousing, processing and manufacturing in FTZ may be performed within different FTZ types. No matter FTZs are set by special law or not, all provide more preferential strategies such as convenient flow of goods and people, preferential tax treatment, etc. than other areas. Hong Kong and Netherlands are the most special cases. The whole of Hong Kong is a single economic trade entity. The Netherlands contains bonded area comprising all parts of the country that can follow and accord with the customs clearance regulations. Most nations establish FTZ in special locations, mostly either within or near port/airport control area or in industrial park. In Taiwan, FTZs are located in port or airport control area or in an adjacent and isolated area. One of the special features of Taiwan FTZ is to allow the multi-stage value added than other countries which focus on re-exporting.

Facing a competitive environment, FTZ around the world are no longer limiting themselves to traditional port activities. Instead, such FTZ are reconsidering value-chain processes to enhance FTZ competitiveness. That is, the role of ports has been transferred from providing simple straightforward shipping/cargo service to a rather good and pivotal masterminding role with added values. Following port logistics with the concept of value-chain, it is better to select suitable core industries to locate in limited FTZ area. Three indicators of transshipment added value, forward and backward linkage and market share are used to select core industries for FTZ. The empirical results show that "products of the chemical or its relevant industries", "base metals and its products", " machinery and electronic component precision", and "instruments and equipments" are selected as the most suitable core industries for FTZ in Taiwan. The appropriate enterprises in these industries are worth to be given more incentives by government to meet the value-driven goal of FTZ.

Due to the data limitation, this study could not include more competition ports in Asia, analyze more detail in industry category. It is suggested that when the government wants to give preferential incentives to some specific industries, it is better to realize which industries are worth to be given more incentives. The study of selecting core industry could be a reference for government to achieve this purpose.

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A Comparative Assessment of Service Quality Perspectives and Satisfaction in Ports: Evidence from Nigeria.

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Abstract

The study presents the findings on the effect of service quality on port users' satisfaction from two distinct methodological perspectives. The study utilized a sample of Nigerian shippers wherein service quality is operational via two distinct measures – SERVQUAL and Technical/Functional Quality. These two service quality measures are compared and contrasted as to their ability in predicting port users' satisfaction in Nigerian ports. To assess the validity of these findings, two moderators of the service-quality/port user's satisfaction relationship are introduced and evaluated. Finally, we examine the potential utility of employing separate measures for port users' satisfaction from the perspectives of both technical and functional aspects of the service delivery process. Overall, our findings are of importance to port managers as they strive to identify efficient and effective approaches for improving quality.

Keywords: Service Quality; Port Users' Satisfaction; Nigerian Ports

1. Introduction

Delivering quality service to port users' is a must for success and survival in today's competitive port industry (Heaver *et al*., 2001; Lobo and Jain, 2002; 2003; Ugboma *et a*l., 2004; Pantouvakis, 2006). Among others, provision of high quality services enhances customer retention rates, helps attract new customers through word of mouth advertising, increases productivity, leads to higher market shares, lower staff turnover and operating costs, and improves employee morale, financial performance and profitability (Julian and Ramaseshan, 1994; Lewis, 1989; 1993). Practitioners and academics alike are keen on accurately measuring service quality in order to better understand its essential antecedents and consequences, and ultimately, establish methods for improving quality to achieve competitive advantage and build customer loyalty (Zahorik and Rust, 1992; Palmer and Cole, 1995). Service quality is commonly noted as critical prerequisite for establishing and sustaining satisfying relationships with valued customers. In this way, the association between service quality and customer satisfaction has emerged as a topic of strategic concern (Cronin and Taylor, 1992; Taylor and Baker, 1994). In general, research in this area suggests that service quality is an important indicator of customer satisfaction (Spreng and Mackoy, 1996; Ugboma *et al*., 2007).

Two of the most prevalent and widely accepted perspectives on service quality include the SERVQUAL model (Parasuraman *et al.,* 1988) and the Technical/Functional Quality framework (Gronroos, 1983; 1990). Each of these perspectives posits various components or antecedents of service quality.

The demand for port service is a derived demand and ports must follow service quality trends otherwise they will be left behind, especially if there are alternative transport systems that provide quality services

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which do not require cargo to pass through ports, as is the case of Europe and North America (Marlow and Paixao, 2001).

Within this context, evaluating service quality offered to customers in ports becomes very essential in the Nigerian port industry. The Nigerian economy has witnessed exponential rise in importation of goods in recent times thus leading to acute cases of port congestion at its ports. These congestions have been, partly, attributed to favourable business environment, occasioned by liberalization of trade in the country and stable political situation.

Evidence in the literature indicates that service quality has become a major strategy for ports at improving its performance.

2. Research Objectives and Hypothesis

The main thrust of this research is to compare and contrast the SERVQUAL and Technical/Functional Quality based approaches in the port industry, taking Nigerian ports as the case study. The objective is to assess the relative strength and weaknesses of each model with regard to their ability in predicting port users' satisfaction. By comparing and contrasting these models to one another, researchers and practitioners alike will be provided a more comprehensive understanding of the relative strengths and weaknesses of each approach. If, for example the approaches are found to perform differently in the port industry, it would be beneficial for port managers to investigate the circumstances as to when and why the measure differs. Another objective of this study is to examine the utility of separately measuring port users' satisfaction from the perspectives of both technical and functional aspects of port service delivery process. By individually examining these interpretations of satisfaction, we hope to determine whether satisfaction is more appropriately conceptualized as a general effect or rather as a multidimensional construct. Since service quality has been previously demonstrated to have a variety of distinct elements, it might therefore be expected that port users' satisfaction (as directly impacted by various components of service quality} also comprises multiple components. Based on this reasoning, our hypothesis is that port users' satisfaction is a multidimensional construct, and these dimensions will be differently impacted by the various components of service quality.

3. Literature Review on Port Service Quality

Customer satisfaction is related to the service offering. In ports, the convenience and competitiveness of the port's offerings can be expected to affect a customer's overall satisfaction and ongoing patronage.

Research has shown that location is a major determinant of port choice (Tongzon, 2002; Ugboma, 2004). Conventional notions of port choice by users have focused on geographical location as one of the main determinants of a port's attractiveness. Underlying location are the customer benefits of convenience and accessibility which are enabling factors that make it easy for the customer to do business with the port.. The port's ability to deliver these benefits on an ongoing basis to its existing clientele will probably impact on customer satisfaction. However, the choice of a port is not merely a function of proximate convenience but derives considerable implications as well from the overall transit costs of cargo tracking, for example, the distance between the port and the shipper's premises has a major impact on inland transportation cost (Tongzon, 2002). Another determinant of port choice is port charges (Tongzon, 2002; Foster, 1978). While differences exist in port charges, patronage is likely to be minimal between competing ports, customers are concerned that they are getting competitive charges because of the impact on their profit situation. Murphy *et al*., (1991, 1992) have shown that some port users are actually willing to accept higher port costs in return for superior and more efficient service. Again, customer satisfaction is likely to be influenced by the perceived competitiveness of the port's charges.

Another determinant of port choice is frequency of ship visits. Greater frequency of ship visits translates into more choices for cargo owners in scheduling their shipments and selecting a shipping service for the transportation of their cargoes, and hence resulting in more competitive carrier costs. Further, greater frequency of ship calls allows for greater flexibility and lower transit time. Thus, the more ship visits a port has, the more attractive it is to shippers.

The most important aspect of service offerings in a port is the port's efficiency. Although frequency of ship calls is a significant factor for shippers in port choice, ports can also attract shippers due to their high levels of efficiency. Port efficiency often means speed and reliability of port services. UNCTAD (1992) cited 'on-time delivery' as a major concern by most shippers. In fast-paced industries where products must be moved to the markets on time, terminal operators as vital nodes in the logistic chain must be in a position to guarantee shippers a very reliable and quick service.

Port efficiency can be reflected in the freight rates charged by shipping companies, in the turnaround time of ships and cargo dwelling time. Ceteris paribus, the longer a ship stays at berth, the higher is the cost that a ship will have to pay. This higher cost can be passed on to shippers in terms of higher freight charges and longer cargo dwelling time. The ability of the shipping lines to pass on the costs to shippers would depend largely on the elasticity of demand and the proportion of total costs attributable to these costs.

Tongzon and Ganesalingam (1994) identified several indicators of port efficiency and categorized them into two broad groups; namely operational efficiency measures and customer-oriented measures. The first set of measures deals with capital and labour productivity as well as asset utilization rates. The second set includes direct charges, ship's waiting time, minimization of delays in inland transport and reliability.

Port infrastructure is another determinant of a port by users. Port infrastructure in its widest context refers not simply to the number of container berths, cranes, tugs and terminal area, but also to the quality of cranes, quality and effectiveness of information systems, availability of inter-modal transport (such as roads and railways), the approach channel provided and the preparedness or otherwise of the port management (Tongzon and Ganesalingam, 1994). If the volumes handled far exceed a port's cargo-handling capacity, this will result in port congestion and inefficiency, and thus can turn off port users. Furthermore, limited access to current information about shipment arrivals due to lack of adequate information system will slow the documentation process and thus the smooth functioning of a port. Without adequate inter-modal links, shipper cannot easily move cargo to and from the port, which could lead to congestion, delays and higher costs.

Ports are also expected to respond quickly to port users' needs. This means that ports would have to constantly monitor and understand the needs of port users in order to devise the quickest way to respond to them. Regular dialogues and social interactions between the port's public relations staff and the port users are quite useful in this regard.

Port's reputation for cargo damage is another factor of port choice by port users. Perception of cargo safety can be more powerful and important than the actual safety. If a port has a reputation that the handling of cargoes is unsafe, this could drive away potential clients and discourage existing clients. Thus, marketing and promotional efforts by port authorities to highlight the port's positive characteristics and accomplishments could improve the port's reputation. A record of accomplishments and achievements gives assurance to customers in terms of quality and reliability. The latter is eminent for influencing carrier's choice of port as it is often the relative perception of customers that supersedes the actual port performance.

4. Research Foundation

4.1 SERVQUAL Model

The SERVQUAL scale is a principal instrument in the services marketing literature for assessing quality (Parasuraman *et al.*, 1988; Parasuraman *et al.*, 1991). Parasuraman *et al's.*, (1988) conceptualization of service quality, the original SERVQUAL instrument included two 22 item sections that intended to measure (a) customer expectations for various aspects of service quality, and (b) customer perceptions of the service they actually received from the focal service organization (Parasuraman *et al*., 1988). In short, the SERVQUAL instrument is based on the gap theory (Parasuraman *et al*., 1985) and suggests that a consumer's perception of service quality is a function of the difference between his/her expectations about the performance of a general class of service providers and his/her assessment of the actual performance of a specific firm within that class (Cronin and Taylor, 1992).

Parasuraman *et al*., (1988) posit that there are five dimensions of service quality across a variety of services. These dimensions include tangibles, reliability, responsiveness, assurance, and empathy. *Tangibles* are the physical evidence of the service (e.g. physical facilities, appearance of personnel, equipment or tools used to provide the service), *reliability* involves consistency of performance and dependability (i.e. a firm performs the service right the first time and honors its promises), *responsiveness* concerns the willingness or readiness of employees to provide service (e.g. timeliness of service), *assurance* corresponds to the knowledge and courtesy of employees and their ability to inspire trust and confidence, and, finally, *empathy* pertains to caring, individualized attention that a firm provides its customers.

4.1.1 The Functional/Technical Model of Service Quality

As originally conceptualized by Gronroos (1983), technical quality involves *what* is provided, and functional quality considers *how* it is provided. Examples of technical quality might include the quality and effectiveness of a cargo handling equipment, the effectiveness of a car repair, or the cleanliness of a room in a hotel. Functional quality, on the other hand, comprises the care and/or manners of the personnel involved in the delivery of service product.

There exist numerous empirical works to test Technical/Functional Quality model. Measuring service quality in the area of architectural design, Baker and Lamb (1993) suggest that, for evaluative purposes, customers tend to rely primarily on functional based dimensions of service quality, as they may not have the knowledge and/or skill to evaluate more technical based dimensions. Likewise, Higgins and Ferguson (1991) report that, although clients of an accountancy service evaluated both functional and technical dimensions of service quality, the functional dimensions seemed to be very important and carry the most weight.

4.1.2 The relationship between service quality and satisfaction.

Numerous empirical works that support the quality/satisfaction causal order exist. Cronin and Taylor (1992) tested, among other things, the causal relationship between service quality and customer satisfaction. They found that perceived service quality leads to satisfaction. A study by Spreng and Mackoy (1996) tested a model developed by Oliver (1993). Oliver's model integrates the two constructs, and suggests, among other things, that perceived service quality is an antecedent to satisfaction. Spreng and Mackoy's (1996) results indicate that, as predicted, service quality leads to satisfaction.

Although the direction of the quality/satisfaction relationship (i.e. quality leads to satisfaction) is fairly well understood for services, the question of whether or not (and how) this relationship varies depending on particular settings and/or situations is not. Next, we explore this issue and propose plausible moderators of the quality/satisfaction relationship for services.

4.1.3 Moderators of the quality/satisfaction relationship in services

In order to explicate clearly and accurately the premise of our tests, we use an established model in organizational economics, the Structure-Conduct (Process) Performance (i.e. S-P-P) model, as a theoretical backdrop. The S-P-P model suggests that market performance (originally measured by profits, efficiency, and the like) is dependent on the conduct of sellers and buyers in the matters pertaining to pricing, interfirm cooperation, and the types of strategic or process functions (Scherer, 1980; Thorelli, 1977). This conduct, in turn, depends on the structure of the relevant market, which originally included such features as the level of vertical integration, the relative size and power of buyers and sellers, and the differentiability of the product.

In our study, the S-P-P framework serves as a backdrop for the tests of moderation i.e. the present moderation test can be subsumed under the S-P-P perspective such that this organizational economics framework serves as a theoretical foundation to both clarify and validate the current moderation analyses. The proposed tests of moderation essentially involve three types of variables: a moderating variable - *structure*, a predictor variable -*process*, and a criterion variable - performance. Some pre-existing aspect of the service environment and/or relationship (structure), for instance, influences the effect that service quality (process) has on satisfaction with the service (performance). Conceptually, we can conceive of these relationships as a three-stage, causal-like procedure wherein the moderating variables affects the predictor variable (service quality), which in turn, affects the criterion variable (satisfaction). The moderating variable can be thought of as the structure of the service setting, which, in turn, affects the extent to which the process of service quality influences service performance (i.e. service satisfaction).

To understand whether or not there is a weak or inconsistent relation between the predictor or process variable – service quality – and the criterion or performance variable – satisfaction – given a particular setting and/ or situation inherent in the service environment (the moderating or structure variable), we ask the question; what variable (or variables) – in addition to level of service contact – moderates the quality/satisfaction relationship? Based on the services marketing literature, we test two straightforward moderator variables: a service failure variable and a communication variable.

4.1.4 Communication Moderator
We postulate that the ability (or lack thereof) of a customer to communicate freely and easily with the service firm will moderate the quality/satisfaction relationship. We base this conjecture on the theoretical model of marketing communication proposed by Mohr and Nevin (1996). Their model suggests, among other things, that communication serves to moderate the effects of various circumstances and conditions associated with exchange on the outcomes of the exchange. For instance, communication (or lack thereof) between buyers and sellers is thought to moderate the impact that organizational climate exerts on buyer-seller satisfaction. Communication between buyers and sellers is considered to be an important process such that the link between exchange conditions and outcomes is explicated more fully by modeling the role of communication (Mohr and Nevin, 1996).

In the services literature, communication is thought to play an important role in the service delivery process. For instance, the GAP theory of service quality suggests that ignorance regarding customers' expectations is one of the root causes of failure to satisfy these expectations (Zeithaml *et al*., 1990). Also, ignorance of customer expectations likely results from a lack of direct interaction and communication with customers.

4.1.5 Service Failure Moderator
Service failure is known to have a potentially powerful effect on consumers (Zeithaml *et al*., 1990; 1994). For instance, Bitner *et al*., (1990) used the critical incident methodology to uncover what are often referred to as critical service encounters, or moments of interaction between customers and service firms (Lovelock, 1988). Briefly, Bitner *et al*., (1990) categorized critical service encounters (or incidents) in order to isolate those particular events and related behaviours of contact employees that cause customers to distinguish very satisfactory service encounters from very dissatisfactory ones. In a similar study investigating service provider behaviours that cause consumers to switch firms, Keaveney (1995) found that switching behaviour was associated with service failure. Not unlike communication, service failure appears to be a significant variable in terms of understanding the service delivery process.

5. Methodology

5.1 Design of Sample Size and Data Collection

In Nigeria, shippers are grouped into three types: those who have long-term contracts with shipping lines, those who are using freight forwarders and those that are independent shippers. The first category of shippers are committed to a particular carrier for a number of years and are therefore dependent on the shipping lines' chosen port of call, while the second group of shippers delegate their responsibilities to freight forwarders who act on their behalf. Thus, only the freight forwarders and the independent shippers are engaged in regular port use.

Therefore, the sample for this study consisted of operations and marketing managers of freight forwarding companies, importers and exporters who use the services of the busiest ports in Nigeria; Lagos (Lagos Port Complex, Tincan Island Port, and RoRo Port) and Port Harcourt (Port Harcourt Port Complex) and senior personnel of the ports under survey.

Service quality was operationalized according to both the SERVQUAL and Technical/Functional Quality models. Following Cronin and Taylor (1992), we used the 22 item SERVPERF scale (a performance only version of the original SERVQUAL scale) to represent the five SERVQUAL dimensions. The Technical/Functional Quality perspective of service quality, on the other hand, was measured via a 16-item, five point Likert type scale developed by the authors based on Gronroos (1983) inceptive conceptualization. In the main, seven items measured the functional aspect of service quality, and nine items measured the technical aspect. Data for this survey were collected through the use of questionnaires. The questionnaire was constructed from information gathered from the focus group interviewed and the literature.

To obtain data, the service quality model (SERVQUAL) model developed by Parasuraman *et al*. (1988) was modified to reflect port activities and adopted. The questionnaire form was developed to test the ratings of expectations and perceptions of the port users' on service attributions and pilot tested. Assuming that customers' proposals for better quality service and satisfaction can be used as a way of customer-focus services, their solution proposals were requested.

Having validated the questionnaire through expert validation and pilot testing, a sample of 100 registered licensed clearing agents registered with the Nigerian Customs were randomly selected from their directory published by the Customs Department and mailed the questionnaire. The full survey, through the mailed questionnaire, was carried out within three months. Although the response rate was initially not encouraging, various techniques were used to improve the response rate including the provision of stamped self- address envelope, and a personalization (a hand-written note) on the covering letter in the follow-up stage. After discarding five incomplete questionnaires, the survey yielded 45 usable responses.

To accomplish the research objectives, we used ordinary least squares (OLS) regression to test six models of customer service (see Figures 1 and 2). The models specify the dimensions of both the SERVQUAL and the Functional/Technical Quality based perspectives of service quality to predict three different measures of customer satisfaction.

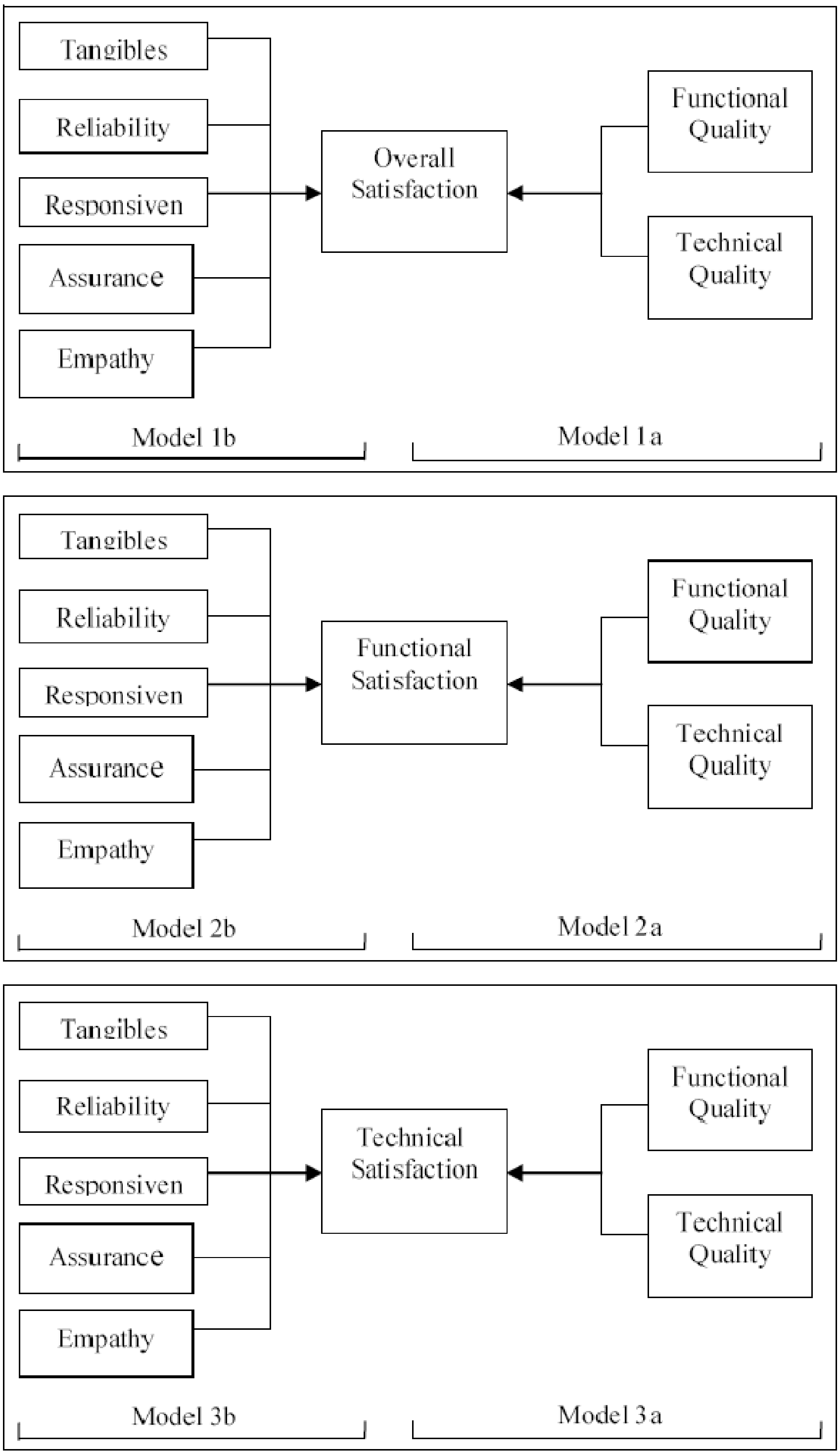

Figure 1: SERVQUAL vs Functional/Technical Quality based impact on Satisfaction.

From Figure 2, each moderator model included three independent variables and a dependent variable for a total of 14 models. The set of independent variables for each model comprised a predictor variable (one of significant quality dimensions), a moderator variable (either the communication or the service failure variable), and an interaction term (predictor *moderator). The dependent variable for each model is one of the three satisfaction measures (overall satisfaction, functional satisfaction, technical satisfaction).

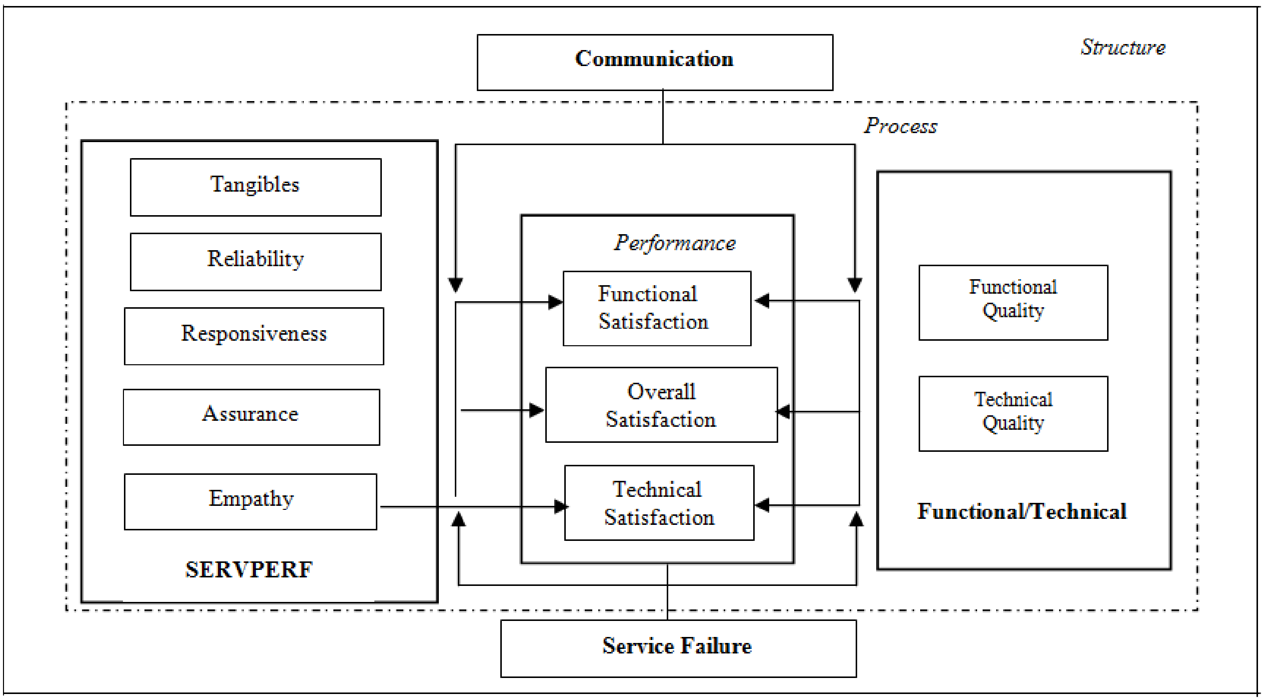

Figure 2: Moderation Effect of Communication Levels and Service Failure on Satisfaction – An S-P-P Framework Perspective.

5.2 Measures

We used port users' satisfaction as the dependent variable in this study. This was measured using a nine-item index that reflects port activities, developed by the authors. The index is based on the satisfaction literature as well as interviews with senior port management personnel, and was adequately pilot tested via port users' interviews to insure that the items addressed the entirety of the satisfaction construct.

During the pretest port users' interviews it became apparent that, similar to Gronroos' conceptualization of quality, it is possible to distinguish items as corresponding to either a functional or technical aspect of satisfaction. In other words, not unlike the service quality construct, service satisfaction may be a multi-dimensional construct. Following discussions with the ports' management team, it was decided a priori to formulate the dependent variable such that three satisfaction index (consisting of all nine items), a functional-satisfaction sub-index (consisting of three items), and a technical-satisfaction sub-index (consisting of six items). In this way, we tested six unique quality/satisfaction models – one for each of the three satisfaction measures across the two service quality perspectives (SERVQUAL and Technical/Functional Quality).

We use two single items to measure the moderating variables – one each for communication and service failure. The first question asked port users' if the ports' emphasize customer satisfaction, and was dichotomously (i.e. 0 == no and 1 = yes). The second question asked port users' whether or not they had ever experienced a situation wherein the ports' performance did not meet their expectations (i.e. service failure).

6. Results and Findings

6.1 Assessment of Measures

6.1.1 Measures of Port Users' Satisfaction
The satisfaction measure was treated as an index rather than as a scale because not all port users use the

same set of port services. In an effort to include all randomly chosen port users and not to create response bias by excluding certain less frequented services, we chose to develop an index. Port users were asked to indicate their level of satisfaction on three functional and six technical satisfaction characteristics. For services they did not utilize, port users were given the choice to mark the measurement item as not applicable.

Cronbach's alpha for the five dimensions of service quality based on the SERVQUAL framework range from 0.94 to 0.90. For the two service quality dimensions of Gronroos conceptualization the α's are 0.95 for functional and 0.90 for technical quality. The values of Cronbach's alpha show that these measures are reliable (see Table 1).

Table 1(a): reliability of independent measures

Scale	Number of items	Coefficient alpha
Tangibility (Tng)	4	0.96
Reliability (Rli)	5	0.93
Responsiveness (RSP)	4	0.95
Assurance (Asu)	4	0.94
Empathy (Emp)	5	0.93
Functional quality (FQu)	7	0.95
Technical quality (TQu)	9	0.90

Table 1(b): factor analysis of functional and technical quality scales

Constructs/items	Factor 1 Functional Quality	Factor 2 Technical Quality
Functional quality (FQu)		
Delivers on promise	90	16
Employees always ready to serve	84	16
Employees posses skill/knowledge	84	16
Efficient in handling complaints	86	35
Effectiveness of tracking system	80	25
Keeps client information confidential	79	21
Pleasant interactions with employees	76	50
Technical quality (TQu)		
Provides good values for money	22	81
Free storage days	9	78
Terminal contact	25	72
Gives correct/proper information	15	70
Give cost saving ideas	24	60
Cut-off time for cargo	30	60
Credit terms	33	51
Storage Costs	16	48
Offers freight consolidation services	9	27
Eigenvalues	5.5	4.3

We conducted an explanatory factor analysis to further assess the discriminant validity of the measures. Utilizing principal component analysis with varimax rotation, we found that the measurement variables did load according to the two dimensions of functional and technical quality. While all variables aligned with their respective factors, three technical quality items did not show significant loadings. This result is partly owing to the fact that the response rate for these three items was significantly lower than for others. Eigenvalues for the dimensions of functional and technical quality were 5.5 and 4.3 respectively. The results are encouraging and appear to demonstrate satisfactory levels of reliability and validity.

6.1.2 Correlations

A correlation matrix of both the independent and dependent variables is shown in Table 2.

Also included in the table are two combined measures of service quality: one combining the five SERVQUAL dimensions – a Total Quality Measure for SERVQUAL (TGS) and another combining Gronroos two dimensions – a Total Quality Measure for Gronroos (TQG). These two combined for overall measures of service quality were created primarily for the purpose of psychometric assessment. That is, although the research objectives and predictions relate primarily to the individual dimensions of the two service quality perspectives, the newly created combined measures are used to test validity and further assess reliability.

Two fundamental facts emerged from Table two; that the correlations between TQS and the overall satisfaction measure, and between TQG and the overall satisfaction measure, are both strong and significant and that the two overall measures of service quality – TQS and TQG- were significantly correlated.

Table 2: Pearsons correlation coefficients and variable means

Var	Osa	Fsa	Tsa	Tng	Rli	RSp	Asu	Emp	FQu	TQu	TQs	TQg
Osa	8.57											
Fsa	0.90	8.94										
Tsa	0.96	0.70	8.21									
Tng	0.60	0.52	0.55	7.91								
Rli	0.51	0.48	0.47	0.90	8.19							
Rsp	0.57	0.50	0.56	0.80	0.96	8.13						
Asu	0.50	0.44	0.47	0.91	0.89	0.90	8.44					
Emp	0.55	0.48	0.49	0.88	0.75	0.77	0.80	8.19				
FQu	0.80	0.81	0.74	0.40	0.40	0.45	0.47	0.46	8.21			
Tqu	0.61	0.41	0.52	0.32	0.47	0.33	0.38	0.30	0.57	8.11		
Tqs	0.59	-	-	-	-	-	-	-	-	-	-	
Tqg	0.80	-	-	-	-	-	-	-	-	-	0.50	-

Notes: variable means are depicted on the diagonal, and all coefficients are significant ($p < 0.01$)

Tables 3 and 4 display the beta coefficients (β's), significance tests (F's), and explained variance (adjusted R^2's) for six models according to the hypothesized relationships between exogenous variables and measures of port users' satisfaction. The values from the Tables show that each of the models is significant.

Table 3: Antecedents to overall Port Users' Satisfaction – Regression Analyses

Independent variables	Dependent variables	Model fit	Beta coefficient
Model 1a	Overall Satisfaction		
Functional quality			0.79***
Technical quality			0.26***
Adjusted R^2		0.80	
Overall *F*		84.6***	
Model 1b	Overall satisfaction		
Tangibility			0.09
Reliability			0.11
Responsiveness			0.60
Assurance			-0.40
Empathy			0.58*
Adjusted R^2		0.30	
Overall *F*		4.80***	

Notes: **p<0.05; p<0.01; *** p<0.001*

Table 4: Antecedents to Technical/Functional Customer Satisfaction

Independent variables	Dependent variables	Model fit	Beta coefficient
Model 2a	Functional satisfaction		
Functional quality			0.91***
Technical quality			0.06
Adjusted R^2		0.80	
Overall *F*		73.1***	
Model 2b	Functional satisfaction		
Tangibility			0.37
Reliability			-0.06
Responsiveness			0.34
Assurance			0.00
Empathy			0.26
Adjusted R^2		0.22	
Overall *F*		4.02	
Model 3a	Technical satisfaction		
Functional quality			0.71***
Technical quality			0.43***
Adjusted R^2		0.62	
Overall *F*		41.3***	
Model 3b	Technical satisfaction		
Tangibility			-0.22
Reliability			0.35
Responsiveness			0.85
Assurance			-0.93
Empathy			0.93***
Adjusted R^2		0.22	
Overall *F*		4.61***	

Notes: * *p< 0.05; ** p < 0.01; *** p< 0.001*

The first two models test the effects of Gronroos' Technical/Functional Quality dimensions of service quality and the SERVQUAL dimensions of service quality on the overall satisfaction measures (Table 3). From the table, each of the Technical/Functional Quality dimensions was significant (Model 1a) and only one of the SERVQUAL dimensions was significant (Model 1b). This means that functional quality, technical quality, and empathy were found to significantly and positively predict overall satisfaction.

The second set of (four) models assess the effects of the Functional/Technical Quality and SERVQUAL dimensions on both the functional and technical based measures of satisfaction (see Table 4). Only the functional quality appears to have affected significantly the functional satisfaction measures (Models 2a and b). Technical satisfaction, on the other hand, appears to be a function of functional quality, technical quality, and empathy (Models 3a and b).

Table 5 shows the correlations among the predictor, moderator, and dependent variables.

Table 5: Correlation Coefficients – Moderation Analyses[a]

var	Osa	Fsa	Tsa	Emp	Fqu	Tqu	SerFail	Comm
Fsa	0.891***	-						
Tsa	0.90***	0.69***	-					
Emp	0.60***	0.45***	0.55***	-				
Fqu	0.76***	0.74***	0.70***	0.45***	-			
Tqu	0.60***	0.50***	0.58***	0.34**	0.55***	-		
SerFail	-0.38**	-0.32**	-0.37**	-0.20	-0.38**	-0.33**	-	
Comm.	0.20	0.27*	0.15	0.24	0.22	0.26*	-0.07	-
PortServ[b]	0.06	0.10	0.04	-0.08	0.09	-0.02	0.01	0.17

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

[a] All correlations involving the service failure (SerFail) and communication (Comm.) variables represent the point biserial coefficient

[b] Port Service (PortServ) represents the total services offered to port users' in a given port.

Also reported in Table 5 is an additional variable that was included in the correlation analyses, and corresponds to port service. Specifically, this variable measured the services offered by any of the ports to the respondents and was tested in order to rule out the possibility that the communication variable was associated with services offered. As seen from the Table 5, the findings suggest that no such association was apparent.

The moderator hypothesis is supported if the interaction is significant, and, although there may also be significant main effects for the predictor and moderator, these are not directly relevant to testing the moderator hypothesis (Baron and Kenny, 1986). Accordingly, we report only the significant, interaction path (beta) coefficients (see Tables 3 – 6). The moderation models were tested using OLS regression, and the variables in the models were standardized. Because the degrees of freedom were equivalent across the initial quality/satisfaction models and the moderator models, R^2 difference tests were not calculable. We tested for the effects of autocorrelation via a plot of residuals over time and Durbin-Watson statistics. The plots of residuals over time show no apparent patterns. Thus it appears that autocorrelation is not present to any significant extent in the moderation models. However, the analyses revealed significant effects of moderation (i.e. significant interaction path coefficients):

(1.) Service failure moderated the effect of functional quality on overall satisfaction; and

(2.) Communication moderated the effect of functional quality on functional satisfaction (see Table 6). As seen in the Table 6, the two overall models wherein these paths were estimated were also significant. An important finding here is that as the number of service failure encounters decreases, the influence of functional quality on overall satisfaction is intensified. That is, the effect of functional quality on (overall) satisfaction appears to be sensitive to the occurrence of service failure, such that the lack of a negative encounter is meaningful and serves to increase significantly the positive outcome of consummate functional service quality.

Table 6: Significant Moderator Models

Independent variables	Dependent variables	Model fit	Beta coefficient
Model 1	Overall satisfaction		
Functional quality			0.77***
Service failure			-0.15
Interaction			-0.27**
Adjusted R^2		0.60	
Overall F		22.37***	
Model 2	Functional satisfaction		
Functional quality			0.70***
Communication level			0.14
Interaction			-0.36
Adjusted R^2		0.67	
Overall F		29.14***	

Notes: * p< 0.05; ** p < 0.01; *** p< 0.001

7. Discussion of Findings

7.1 SERVQUAL vs. Functional/Technical Quality: A Quality Comparison

The analyses performed above compares the SERVQUAL model of service quality with the Technical/Functional quality model with regard to predicting the relationship between service quality and port users satisfaction within the Nigerian Ports context. Although the Functional/Technical Quality dimensions clearly outperformed the SERVQUAL dimensions in terms of explaining the variances in three separate (yet related) measures of port users' satisfaction within the port industry, the implications of these findings are less clear. Since these studies only examined the respective utilities of each model within a single industry, however, any suggestion that the Functional/Technical Quality model is generally superior would be premature and largely unjustifiable. Nonetheless, the current findings do provide some important insights into how these models of service quality compare with one another. As the models did not perform equivalently in the present analyses, the results clearly reveal that these two approaches likely possess distinct and unique strength for measurement of various aspects of service quality.

7.2 Multidimensional Aspects of Customer Satisfaction

We tested the two models of service quality with regard to their ability to predict both overall port users' satisfaction (using a composite or general array of measures) and also individual (functional and technical) dimensions of port users' satisfaction. Our findings suggest that it may be more appropriate to conceptualize satisfaction as a multidimensional construct, as opposed to simply a general affect.

7.2.1 Overall Satisfaction

With the overall (dependent) measure of satisfaction, the findings with previous research (Mittal and Lassar, 1998) and suggest that, apart from the empathy dimension of SERVQUAL, the Functional/Technical Quality model of service quality fits and/or explains the data, while the SERVQUAL model generally does not. That is, in terms of overall satisfaction, the current group of port users appears to have related more closely to Gronroos depiction of service quality compared with the SERVQUAL depiction. From an empirical standpoint, the findings suggest that Gronroos' model compared with SERVQUAL model, more fully explains the variance in the overall satisfaction measure. Arguably, one of the most important if not obvious differences between the two quality models is the lack of a technical-oriented dimension in the SERVQUAL model. In other words, it is plausible that the lack of fit in the SERVQUAL model may be owing in part to the fact that there are no SERVQUAL items addressing specifically what is being provided (versus how it is being provided) by the ports. This shows that the SERVQUAL dimensions of service quality are likely akin to a process-type of service quality. Process quality, in turn, is associated with Gronroos' functional quality.

7.2.2 Functional Satisfaction

Only one dimension of quality proved significant in terms of explaining the functional satisfaction measure – Gronroos' functional dimension of quality. From the standpoint of validity, this result is appealing in that we would predict the functional aspect of quality to affect a functional-based measure of satisfaction. The finding is consistent with previous research suggesting that functional quality (compared with technical quality) is often easier for customers to identify (Baker and Lamb, 1993). In addition, this finding suggests that, as with the quality construct, the satisfaction construct is perhaps more accurately depicted and measured as distinct sub-dimensions, as opposed to one large, overarching, second-order factor. For instance, by measuring more distinct elements of satisfaction – such as functional and/technical elements – researchers may advance theory in the area of services and service delivery by deriving models that are more accurate (compared with previous models), and, concomitantly, generalizeable across distinct service settings.

7.2.3Technical Satisfaction

The technical satisfaction measure behaved much like the overall satisfaction measure. That is, both of Gronroos' dimension of quality and the empathy dimension of SERVQUAL affected positively levels of port users' technical satisfaction in the same way they affected levels of overall satisfaction. These findings seem to suggest that the port users could not ignore the quality of how the service was delivered (functional quality) even when asked specifically to evaluate whether or not they were satisfied with what was delivered (technical satisfaction). Empathy is the only dimension of SERVQUAL to behave like Gronroos' dimensions. Empathy, unlike the other SERVQUAL dimensions, may crossover the two Gronroos dimensions (i.e. contain elements of both) as it affects port users' satisfaction. Finally, since the models that included a technical-based endogenous variable (i.e. technical satisfaction) differed from the models incorporating a functional-based endogenous variable (i.e. functional satisfaction), further evidence is provided to suggest that satisfaction is perhaps best viewed (and measured) as a multidimensional construct.

8. Conclusion

The primary objective of this research was to test and compare the relative efficacy of two predominant conceptualization of service quality with regard to their ability to predict port users' satisfaction in the Nigerian ports. The findings indicate that these models of service quality do not perform equivalently in this particular setting (port industry). Although the Functional/Technical Quality dimensions reliably predicted levels of port users' satisfaction, a majority of the SERVQUAL dimensions did not. To the extent that the port industry represents high-level service situation, we might conclude that the Functional/Technical Quality-based model of service quality – compared with SERVQUAL based model- is better suited to predict port users' satisfaction when port users are actively involved or highly interested in service delivery.

The results suggest that functional quality is not only more important, but also more complex. In contrast to the other quality dimensions, the functional dimension influenced significantly each of the satisfaction measures - even the technically oriented measure. Thus customers of high-level service firm may ultimately rely on functional quality to distinguish between alternative service providers. Less clear are the findings involving the empathy factor. As the only SERVQUAL dimension to achieve significance, empathy performed like the significant combinations of both functional and technical quality. Accordingly, empathy may, in fact, contain elements of both functional and technical quality.

Also, the results demonstrate that the various dimensions of service quality differentially predict the three measures of satisfaction. This allows us to conclude that, to some degree, these separate measures of satisfaction are valid and warranted.

9. Study Limitations

Although 100 questionnaires were mailed out, only 50 were returned. This is because most of the participants declined to respond to questions they see as sensitive, thus leading to a very low response rate. This low response rate and the relatively small number of respondents for whom data were included in the analyses impedes external validity. Therefore, further research in this area should aim at obtaining a higher response rate, thus verifying external validity. Another limitation is that the survey was of a single service industry. Results from a single industry may raise concerns about limited generalizability. Limiting the study to a single industry eliminates problems associated with the effects of industry differences. It is thus important to recognize that studies which replicate the Gronroos' Functional/Technical and SERVQUAL framework to some degree presume that the scale is generalized, since that is the proposition put forth by the scale developers. In addition, the moderator model should be expanded and validated beyond incidence of service failure and the type of buyer-seller communication/interaction research stream.

The current study provides initial support in favour of the idea that the SERVQUAL and Technical/Functional Quality-based models may be unequally or asymmetrically applicable across differing settings and situations. It is crucial therefore for researchers to address further the unique properties and dimensions of these other service quality models.

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Dynamic Interrelationships between Sea Freight and Shipbuilding Markets

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Abstract

This paper examines the dynamic interrelationships between the sea freight and shipbuilding markets. Many practitioners argue that the freight rates rely on the shipbuilding activities, because the shipbuilding is the primary source of ship supply. Other specialists argue that demand for shipbuilding is activated by the demand of freight market, where the shipbuilding decisions are made on the outlook of future freight rates. We examine these competing views by analysing the time series in dry bulk shipping. The results indicate the shipbuilding market unlikely leads the freight market, implying that the shipbuilding activity depends on the freight market.

Keywords: Shipbuilding; Sea freight; Time series analysis; Cointegration; VECM

1. Introduction

This paper studies the dynamic interrelationship of shipbuilding and sea freight markets, both are in the shipping industry. The shipping industry is quite different from other industries. The shipping industry is capital intensive and truly global competition, that contributes to competition prevailing in shipping industry. Ships are central in the shipping industry. The sale of a ship is one of the major capital transactions in the world and involves in a capital expenditure generally running into millions of US dollars. Ships are physical assets with limited economic life (about 20 years) but a significant residual (scrapping) value (i.e. value of steel). A ship functions on two levels in shipping industry: firstly as part of the supply of carrying capacity in the sea freight market and secondly, as a physical asset in the capital market.

Freight rates in the sea freight market are determined as the interaction of the supply and demand for cargo carrying services. Shipbuilding prices depend on the supply and demand for shipbuilding capacities. While both are in the shipping industry, the shipbuilding market is very different from the freight market. As the shipbuilding contracts are not traded in any exchange, they are not standardized and they are negotiated individually between the shipowner and the shipbuilder, and as a consequence, they can be tailor-made to their needs. At the same time, there is no secondary market to trade shipbuilding contracts. In other words, the capital involved in the shipbuilding process is a huge amount of sunk cost, meaning that it is non-redeemable during the shipbuilding.

As the ship investment exercise is highly risky, a shipowner always faces a difficult decision to make about the right timing of shipbuilding. For instance, shipbuilding needs to be designed, constructed and commissioned long before coming into services, a new ship is usually be delivered into the freight market after one and a half to two years with a totally different market situation. Therefore, the timing of the ship investment decisions is extremely important. Wrong timing of shipbuilding can turn the possibility of profits into heavy losses and to the closure of the business. However, the up-to-date understanding in shipbuilding markets may not be useful in timing the shipbuilding investment, which is increasingly a key dimension for competitive success.

Many argue that the freight rates depend on the shipbuilding activities (*e.g. Stopford 1997*). Others argue that demand for shipbuilding depends mainly on the operating environment of the shipping market. We examine these competing views by testing whether freight rates and shipbuilding prices are related in the long-run and, if related, whether it is mono-directional or bi-directional relationship between them. Therefore, we analyze the dynamic relationship between shipbuilding market and freight market. We further investigate whether the decisions are made on the basis of short-term market trend (small time lags) or long-term prospects (long time lags). Furthermore, to quantify the dynamic relationship among shipping markets, we determine the number of time lags between two shipping markets and whether it is mono-directional or bi-directional relationship between the time series.

This paper is organized as follows. Section 2 reviews the related literature in the shipping markets and theoretical considerations. Section 3 discusses the data, the empirical results and the implications. Section 4 summarises the findings.

2. Literature Review and Theoretical Framework

Two areas of the previous literature are related to this research: first, the existing research on shipping freight rate and shipbuilding price, and second, the dynamic relationship of two markets.

The sea freight market trades sea transport service, and the shipbuilding market trades new ships. Freight rates have been considered the most critical indicators among the shipping markets because freight rates represent the principal source of earnings for shipping companies. Many existing studies have focused on the characteristics of shipping freight rate and have looked at the factors influencing the rates, the relative forecasting ability of market rates, their stationarity, cointegration, term structures, optimal split for a risk-averse shipowner (*Evans and Marlow, 1990; Hsu and Goodwin, 1995; Kavussanos, 1996; Koekebakker, Adland and Sodal, 2006*). Previous studies showed that the freight rate is not stationary as most economic and financial time series, the freight rates are less volatile for smaller size vessels than for larger ones, and the volatilities of freight rates in the spot rates is higher than those in the time-charter (long time contracts) rates.

The lead-lag relationship between two markets indicates how fast one market reflects information relative to the other and how well the two markets are linked (*e.g., Bollerslev and Melvin, 1994; Tse and Booth, 1995; Kavussanos and Nomikos, 2003; Kavussanos and Visvikis, 2004; Batchelor, Alizadeh and Visvikis, 2005*). An abundance of empirical work analyzed the lead-lag relationship in the financial economics literature, for example, spot and futures markets, foreign exchange rates, and stock returns. The spot and futures markets are linked by the cost-of-carry model. The foreign exchange markets across countries are linked on the basis of law of one price or purchasing power parity (PPP). Although the price relationships across financial markets have been incorporated into some applied investment models, the studies into the price interdependence across shipping markets are still very limited.

Existing shipping studies in the literature are based upon the use of freight market models by determining the demand and supply of ships but do not know what circumstances affect the decision-making of shipbuilding. This left the more fundamental question about mutual economic effects between shipbuilding price and freight rate. While this study may compliment the traditional economic perspective that the freight market depends on the supply and demand of ships, this paper on the dynamic relationship between freight market and shipbuilding market may suggest new insights on the commercial judgments.

3. Empirical Results and Discussions

The three stages approach to assessing a causal relationship has been widely adopted. Firstly, the unit root test is performed for checking the non-stationarity of time series. Secondly, the test for cointegration is conducted to check the existence of long-run relationships between two or more time series. Finally, Granger causality test is used to find the direction of the cause-effects among the variables.

3.1. Data Description and Properties

The time series data used covers two shipping markets over the period of 1998 to 2007 (data source: *Clarkson 2007*). All the time series data are transformed into *natural logarithm*, since the logarithm transformation tends to squeeze together the larger values in data set and stretches out the smaller values. In order to have robust results, data are divided into the three ship sizes (capesize, panamax and handymax), because three ship sizes are used for three types of sea trades and represent three markets. Time series are into monthly, quarterly and yearly data of Shipbuilding Price (*SBP*) in US dollars per compensated gross ton and Freight Rate (*FRT*). Without the bias on which way of using ships, three freight rates *FRT* are quoted and they are:

- Baltic Dry Index (*BDI*) for short-term contract,
- one-year time charter rate (*TC1*) for one-year term contract, and
- three-year time charter rate (*TC3*) for three-year term contract.

The subscripts *C*, *P* and *H* denote capesize, panamax and handymax ship sizes, respectively. And the *SBP* and *FRT* (= *BDI*, *TC1*, or *TC3*) are interpreted as the percentage changes of the values. This squeezing and stretching can correct one or more of the following problems with data: skewed data, outliers, unequal variation. Figure 1 illustrates the freight rates in logarithm of Baltic Dry Index, one year time-charter rates, three year time-charter rates and shipbuilding prices for capesize ships. The time series do not exhibit any particular linear trending pattern. Summary descriptive statistics in logarithms of monthly freight rates and shipbuilding prices for three sizes of dry bulk ships are shown in Table 1.

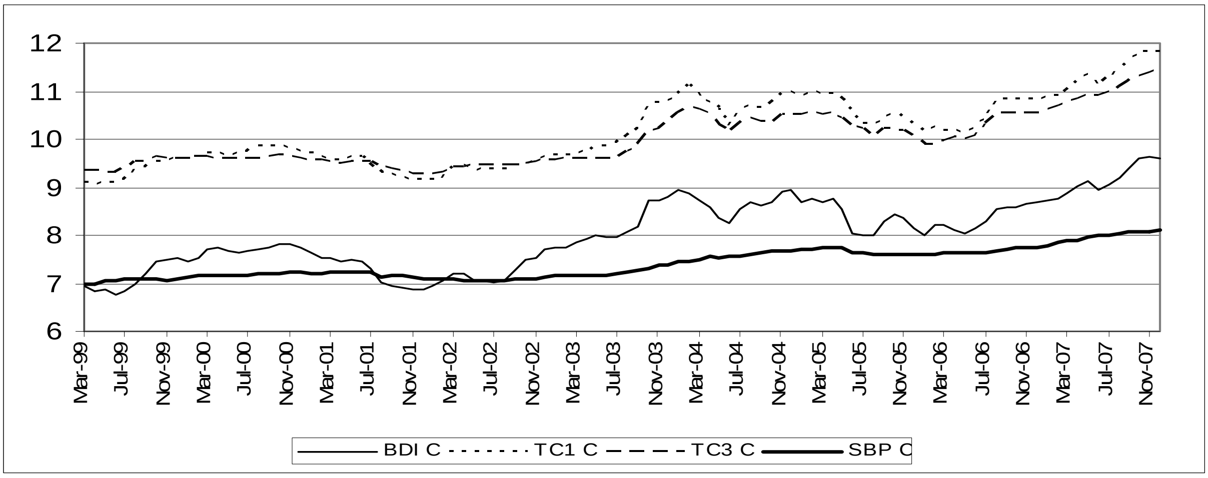

Figure 1: Freight rates (BDI_C **,** $TC1_C$ **&** $TC3_C$ **) and shipbuilding prices (** SBP_C **)**
in logarithm; Capesize bulker; monthly data (1999:03 to 2007:12)

Table 1: Descriptive statistics in logarithm; Capesize, Panamax and Handymax ships

	N	Mean	Std.Dev.	Skewness	Kurtosis	J-B	Probability
Capesize Bulker series (1999:03-2007:12)							
BDI_C	106	8.013	0.732	0.133	2.103	3.863	0.145
$TC1_C$	106	10.151	0.726	0.378	2.097	6.128	0.047
$TC3_C$	106	9.984	0.560	0.669	2.432	9.331	0.009
SBP_C	106	7.409	0.314	0.537	2.050	9.080	0.011
Panamax Bulker series (1998:05-2007:12)							
BDI_P	116	7.644	0.679	0.451	2.187	7.129	0.028
$TC1_P$	116	9.401	0.617	0.883	3.179	15.238	0.000
$TC3_P$	116	9.209	0.441	1.597	5.447	78.237	0.000
SBP_P	116	7.285	0.296	0.599	1.959	12.179	0.002
Handymax Bulker series (2000:09-2007:12)							
BDI_H	88	9.722	0.596	0.129	1.935	4.399	0.111
$TC1_H$	88	7.510	0.293	0.361	1.865	6.639	0.036
$TC3_H$	88	9.645	0.592	0.290	2.046	4.573	0.102
SBP_H	88	9.442	0.434	0.799	2.820	9.477	0.009

Note:
All series are measured in logarithmic.
BDI, TC1 and TC3 denote the freight rate for short-term, 1-year term and 3-year term contracts
SBP denotes the shipbuilding price.
N is the number of observations.
J-B is the Jarque-Bera statistic for testing whether the series is normally distributed.
Probability is the probability that a Jarque-Bera statistic exceeds (in absolute value) the observed value under the null hypothesis: A small probability value leads to the rejection of the null hypothesis of a normal distribution.

3.2. Unit Root Test

In order to test for cointegration between *SBP* and *FRT*, testing the order of stationarity of the variables is a prerequisite. The existence or absence of stationarity in the time series of *SBP* and *FRT* are checked by the augmented Dickey-Fuller (*ADF*) test (*Dickey and Fuller, 1979*) and Phillips and Perron (*PP*) test (*Phillips and Perron, 1988*). Two tests are carried out in order to make sure the results are robust. To determine the lag lengths, the Akaike information criterion (AIC) is used (*Akaike, 1973*). Table 2 shows that the results of both ADF and PP tests and reveals that the time series of *SBP* and *FRT* in three sizes of dry bulk ships are all stationary in their log-first difference, all containing a unit root in their log-level representation. The results are in line with the statement that only $I(1)$ variables are considered as candidates for a possible cointegrating relationship (*McAleer and Oxley, 1999*).

Table 2: Unit Root Tests of Capesize, Panamax and Handymax ships

	Levels			First Difference		
	ADF	lags	PP	ADF	lags	PP
Capesize Bulker series (1999:03-2007:12)						
BDI_C	-0.799	-0.669	2	-6.741**	-7.046**	1
$TC1_C$	-0.615	-0.197	1	-7.588**	-7.588**	0
$TC3_C$	-0.016	0.632	1	-6.371**	-6.371**	0
SBP_C	0.158	0.735	4	-3.016*	-8.696**	3
Panamax Bulker series (1998:05-2007:12)						
BDI_P	-0.590	-0.223	1	-8.643**	-8.643**	0
$TC1_P$	-0.586	-0.494	2	-7.306**	-6.910**	1
$TC3_P$	-1.221	-0.164	1	-6.610**	-7.037**	1
SBP_P	0.774	1.527	1	-6.707**	-6.707**	0
Handymax Bulker series (2000:09-2007:12)						
BDI_H	-0.594	-0.062	1	-6.278**	-6.278**	0
$TC1_H$	-0.819	-0.064	1	-5.386**	-5.386**	0
$TC3_H$	-0.125	0.246	2	-5.451**	-5.366**	1
SBP_H	0.674	1.185	1	-6.350**	-6.350**	0
1% critical value	-3.50833	-3.50833		-3.50833	-3.50833	
5% critical value	-2.89551	-2.89551		-2.89551	-2.89551	

Note:
ADF is the Augmented Dickey and Fuller (1981) test.
PP is the Philips and Perron (1988) test.
Levels and First Difference correspond to series in log-levels and log-first differences.
The lag lengths of the ADF test is determined by Akaike Information Criterion (AIC).
*(**) denotes rejection of the null hypothesis of a unit root at 5% (1%) critical value levels.

3.3. Cointegration between Markets

After having established that all the variables possess *I*(1) characteristics for long-run equilibrium relationship, we proceed to test the cointegration between *SBP* and *FRT*. Johansen's (1988) cointegration test is applied based on the vector error correction model (*VECM*) as follows:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t , \qquad (1)$$

where $y_t=(SBP_t, FRT_t)'$ is the column vector of logarithm shipbuilding price and freight rate, each being non-stationary, *I*(1) variables; Δ denotes the first difference operator; coefficient matrix $\prod$ and Γ_i are used to test the long-run and short-run adjustment to changes in y_t, such that

$$\prod = \sum_{i=1}^{p} A_i - I , \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j . \qquad (2)$$

Johansen's (1988) method is to estimate $\prod$ matrix in an unrestricted form, and then test whether we can reject the restrictions implied by the reduced rank of $\prod$. If the coefficient matrix $\prod$ has a reduced rank $r<k$, where *k* is the number of endogenous variables of y_t, then there exist $k\times r$ matrices α and β each with rank r such that $\prod=\alpha\beta'$ and $\beta' y_t$ is stationary, *I*(0). The reduced rank r is known as the number of cointegrating relations (the cointegrating rank). The simplest case of cointegration tests appears when *k* = 2, or the maximum number of cointegrating relations is one.

The estimated trace statistic λ_{trace} and maximum eigenvalue statistics λ_{max} are used to determine the number of cointegrating vectors. The variables are tested in pairs of *SBP* and *FRT* for the three ship sizes. The Akaike information criterion (*AIC*) is used to determine the lag length in the *VECM* model.

Besides, *Figure 1* illustrates that the freight market becomes volatile after the year of 2003. Therefore, in order to investigate whether the cointegration relationship between *FRT* and *SBP* has altered along the sample period, we divide the whole sample into two sub-periods: up to December 2002, and from January 2003 to December 2007. The Johansen's (1988) cointegration test results on monthly data are shown in *Table 3* to *Table 5*.

Table 3: Johansen's Tests for the number of cointegrating vectors between freight rates and shipbuilding price; Capesize ships

	Order of VAR	Hypothesis H0	Hypothesis H1	Eigenvalue	Test Statistics $\lambda_{\max}$	Test Statistics λ_{trace}	5% (1%) critical values $\lambda_{\max}$	5% (1%) critical values λ_{trace}
Period A. The whole period from 1999:03 to 2007:12								
BDI_C, SBP_C	2	r = 0	r = 1	0.183	20.772**	20.773**	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.000	0.002	0.002	3.76 (6.65)	3.76 (6.65)
$TC1_C$, SBP_C	2	r = 0	r = 1	0.151	16.853*	16.925*	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.001	0.072	0.072	3.76 (6.65)	3.76 (6.65)
$TC3_C$, SBP_C	2	r = 0	r = 1	0.148	16.483*	16.791*	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.003	0.308	0.308	3.76 (6.65)	3.76 (6.65)
Period B. The sub- period from 1999:03 to 2002:12								
BDI_C, SBP_C	4	r = 0	r = 1	0.305	14.936*	15.055*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.003	0.118	0.118	3.84 (6.51)	3.84 (6.51)
$TC1_C$, SBP_C	4	r = 0	r = 1	0.360	18.318**	18.510**	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.005	0.192	0.192	3.84 (6.51)	3.84 (6.51)
$TC3_C$, SBP_C	6	r = 0	r = 1	0.312	14.586*	14.646*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.002	0.060	0.060	3.84 (6.51)	3.84 (6.51)
Period C. The sub- period from 2003:01 to 2007:12								
BDI_C, SBP_C	2	r = 0	r = 1	0.165	10.274	13.479*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.055	3.205	3.205	3.84 (6.51)	3.84 (6.51)
$TC1_C$, SBP_C	2	r = 0	r = 1	0.134	8.169	8.935	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.013	0.767	0.767	3.84 (6.51)	3.84 (6.51)
$TC3_C$, SBP_C	2	r = 0	r = 1	0.112	6.779	7.473	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.012	0.695	0.695	3.76 (6.65)	3.76 (6.65)

Note:
r represents the number of cointegrating vectors.
Order of VAR is the lag length of a VAR model; the lag length is determined by Akaike Information Criterion (AIC).
$\lambda_{\max}$ and λ_{trace} are the Maximum Eigenvalue Statistic and Trace Statistic used to determine the number of cointegrating vectors.
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 4: Johansen's Tests for the number of cointegrating vectors between freight rates and shipbuilding prices; Panamax ships

	Order of VAR	Hypothesis H0	H1	Eigenvalue	Test Statistics $\lambda_{\max}$	Test Statistics λ_{trace}	5% (1%) critical values $\lambda_{\max}$	λ_{trace}
Period A. The whole period from 1998:05 to 2007:12								
BDI_P, SBP_P	2	$r = 0$	$r = 1$	0.134	16.318*	16.322*	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.000	0.005	0.005	3.76 (6.65)	3.76 (6.65)
$TC1_P$, SBP_P	2	$r = 0$	$r = 1$	0.128	15.441*	15.676*	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.002	0.235	0.235	3.76 (6.65)	3.76 (6.65)
$TC3_P$, SBP_P	2	$r = 0$	$r = 1$	0.052	6.087	6.156	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.001	0.069	0.069	3.76 (6.65)	3.76 (6.65)
Period B. The sub- period from 1998:05 to 2002:12								
BDI_P, SBP_P	1	$r = 0$	$r = 1$	0.386	26.321**	28.776**	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.044	2.456	2.456	3.76 (6.65)	3.76 (6.65)
$TC1_P$, SBP_P	2	$r = 0$	$r = 1$	0.336	21.670**	25.126**	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.063	3.456	3.456	3.76 (6.65)	3.76 (6.65)
$TC3_P$, SBP_P	2	$r = 0$	$r = 1$	0.357	23.399**	26.714**	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.061	3.316	3.316	3.76 (6.65)	3.76 (6.65)
Period C. The sub- period from 2003:01 to 2007:12								
BDI_P, SBP_P	2	$r = 0$	$r = 1$	0.198	12.609*	14.947*	11.44 (15.69)	12.53 (16.31)
		$r \leq 1$	$r = 2$	0.040	2.338	2.338	3.84 (6.51)	3.84 (6.51)
$TC1_P$, SBP_P	2	$r = 0$	$r = 1$	0.200	12.752*	15.518*	11.44 (15.69)	12.53 (16.31)
		$r \leq 1$	$r = 2$	0.047	2.766	2.766	3.84 (6.51)	3.84 (6.51)
$TC3_P$, SBP_P	2	$r = 0$	$r = 1$	0.088	5.264	7.400	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.037	2.136	2.136	3.76 (6.65)	3.76 (6.65)

Note:
r represents the number of cointegrating vectors.
Order of VAR is the lag length of a VAR model; the lag length is determined by Akaike Information Criterion (AIC).
$\lambda_{\max}$ and λ_{trace} are the Maximum Eigenvalue Statistic and Trace Statistic used to determine the number of cointegrating vectors.
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 5: Johansen's Tests for the number of cointegrating vectors between freight rates and shipbuilding prices; Handymax bulker series

	Order of VAR	Hypothesis H0	Hypothesis H1	Eigenvalue	Test Statistics λ_{max}	Test Statistics λ_{trace}	5% (1%) critical values λ_{max}	5% (1%) critical values λ_{trace}
Period A. The whole period from 2000:09 to 2007:12								
BDI_H, SBP_H	1	r = 0	r = 1	0.139	12.687*	14.625*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.023	1.938	1.938	3.84 (6.51)	3.84 (6.51)
$TC1_H$, SBP_H	2	r = 0	r = 1	0.130	11.815*	14.277*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.029	2.461	2.461	3.84 (6.51)	3.84 (6.51)
$TC3_H$, SBP_H	2	r = 0	r = 1	0.079	6.972	7.111	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.002	0.139	0.139	3.76 (6.65)	3.76 (6.65)
Period B. The sub-period from 2000:09 to 2002:12								
BDI_H, SBP_H	6	r = 0	r = 1	0.397	10.618	13.949*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.147	3.331	3.331	3.84 (6.51)	3.84 (6.51)
$TC1_H$, SBP_H	6	r = 0	r = 1	0.567	17.587*	17.600*	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.001	0.013	0.013	3.76 (6.65)	3.76 (6.65)
$TC3_H$, SBP_H	2	r = 0	r = 1	0.415	13.390	15.617*	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.085	2.227	2.227	3.76 (6.65)	3.76 (6.65)
Period C. The sub-period from 2003:01 to 2007:12								
BDI_H, SBP_H	1	r = 0	r = 1	0.122	7.448	8.040	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.010	0.593	0.593	3.76 (6.65)	3.76 (6.65)
$TC1_H$, SBP_H	2	r = 0	r = 1	0.099	5.964	6.479	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.009	0.514	0.514	3.76 (6.65)	3.76 (6.65)
$TC3_H$, SBP_H	2	r = 0	r = 1	0.096	5.744	6.460	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.012	0.716	0.716	3.76 (6.65)	3.76 (6.65)

Note:
r represents the number of cointegrating vectors.
Order of VAR is the lag length of a VAR model; the lag length is determined by Akaike Information Criterion (AIC).
λ_{max} and λ_{trace} are the Maximum Eigenvalue Statistic and Trace Statistic used to determine the number of cointegrating vectors.
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels

In the first sub-period, the estimated λ_{trace} and λ_{max} statistics show that *SBP* and *FRT* of three ship sizes are all cointegrated. The second subperiod shows a relatively weaker cointegration relationship between *SBP* and *FRT*, especially in handymax size case. However, the results of the whole sample period show that *SBP* and *FRT* of three ship sizes are cointegrated essentially, which indicates a long-run relationship between the two shipping markets.

It is worth to mention that quarterly and annual data have also been tested for possible cointegration, but no cointegration relationship is shown. This may suggest that the long-run equilibrium relationship between freight and shipbuilding markets is mainly based on a monthly adjustment.

3.4. Granger Causality Test

When two variables are cointegrated, one time series is useful in forecasting the other or there exists causality along at least one direction (*Granger, 1986*). Granger causality test is conducted to find the direction(s) of the causal effect between the two time series. As Engle and Granger (1987) pointed out, if the variables are cointegrated, a pure Vector Autoregressions (*VAR*) in difference to test the existence of Granger causality will be miss-specified. The *VECM* is suggested to estimate cointegrated data. In this study, the causal relationship between *SBP* and *FRT* is investigated using the *VECM* and *VAR*. In order to make the results robust, both *VECM* and *VAR* models have been tried to test the existence of Granger causality. The results of *VAR* are in line with the reported results using *VECM* and thus are not reported here.

The expanded *VECM* of equation (1) can be estimated by the ordinary least squares (OLS) method:

$$\Delta SBP_t = \sum_{i=1}^{p-1} a_{SBP,i} \Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{SBP,i} \Delta FRT_{t-i} + \alpha_{SBP} ECT_{t-1} + \varepsilon_{SBP,t} \quad (3)$$

$$\Delta FRT_t = \sum_{i=1}^{p-1} a_{FRT,i} \Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{FRT,i} \Delta FRT_{t-i} + \alpha_{FRT} ECT_{t-1} + \varepsilon_{FRT,t} \quad (4)$$

The null hypothesis that *FRT (= BDI, TC1, TC3)* does not Granger-cause *SBP* in the first regression Eq. (3) is formed as H_0: $b_{SBP,i} = 0$. Similarly, in the second regression Eq. (4), the null hypothesis that *SBP* does not Granger-cause *FRT* is H_0: $a_{FRT,i} = 0$. The test statistic is the usual *F*-statistics. $a_{SBP,i}$, $b_{SBP,i}$, $a_{FRT,i}$ and $b_{FRT,i}$ are short-run coefficients, ECT_{t-1} is the error correction term. The coefficients (α_{SBP} and α_{FRT}) of the error correction term provide insights into the adjustment process of *SBP* and *FRT* towards equilibrium, and their signs show the direction of convergence to the long-run relationship.

Table 6 to *Table 8* show *VECM* estimates and Granger causality tests for *FRT* and *SBP* in three ship sizes. The results show a positive correlation between *SBP* and *FRT*, and confirm a causal relationship that *FRT* leads *SBP*. The results in *Panel A* show the *VECM* estimates. The coefficients (α_{SBP} and α_{FRT}) of the ECT_{t-1} provide insights into the adjustment process of *SBP* and *FRT* towards equilibrium. The results are consistent among the three ship size cases. The coefficient α_{SBP} of the ECT_{t-1} in *Eq. (3)* is statistically significant and negative, while the coefficient α_{FRT} of the ECT_{t-1} in *Eq. (4)* is statistically significant and positive. Therefore, both *SBP* and *FRT* adjust to eliminate any disequilibrium of their long-run relationship. If there is a positive deviation from their equilibrium relationship at period *t*, *SBP* in the next period will decrease in value, while *FRT* in the next period will increase in value, thus converging to the long-run relationship. To sum up, the long-term relationship between *SBP* and *FRT* are stable.

Table 6: VECM estimates and Granger causality test for freight rates and shipbuilding prices; Capesize ships

$$\Delta SBP_t = \sum_{i=1}^{q-1} a_{SBP,i}\Delta SBP_{t-i} + \sum_{i=1}^{q-1} b_{SBP,i}\Delta FRT_{t-i} + \alpha_{SBP}ECT_{t-1} + \varepsilon_{SBP,t}$$

$$\Delta FRT_t = \sum_{i=1}^{q-1} a_{FRT,i}\Delta SBP_{t-i} + \sum_{i=1}^{q-1} b_{FRT,i}\Delta FRT_{t-i} + \alpha_{FRT}ECT_{t-1} + \varepsilon_{FRT,t} \qquad \text{where } \Delta FRT_t = \Delta BDI_t,\ \Delta TC1_t,\ \text{or } \Delta TC3_t$$

	ΔSBP_{C_t}	ΔBDI_{C_t}		ΔSBP_{C_t}	$\Delta TC1_{C_t}$		ΔSBP_{C_t}	$\Delta TC3_{C_t}$
Panel A: VECM model Estimates								
ECT_{t-1}	-0.049	0.158	ECT_{t-1}	-0.054	0.218	ECT_{t-1}	-0.075	0.169
	(0.015)	(0.074)		(0.019)	(0.091)		(0.027)	(0.082)
	[-3.356]	[2.138]		[-2.750]	[2.384]		[-2.783]	[2.075]
$\Delta SBP_{C_{t-1}}$	0.000	0.330	$\Delta SBP_{C_{t-1}}$	0.005	0.809	$\Delta SBP_{C_{t-1}}$	0.012	0.276
	(0.098)	(0.498)		(0.098)	(0.458)		(0.099)	(0.297)
	[0.000]	[0.663]		[0.049]	[1.767]		[0.125]	[0.931]
$\Delta SBP_{C_{t-2}}$	0.091	1.016	$\Delta SBP_{C_{t-2}}$	0.043	0.682	$\Delta SBP_{C_{t-2}}$	0.070	0.505
	(0.099)	(0.498)		(0.097)	(0.453)		(0.098)	(0.296)
	[0.921]	[2.039]		[0.449]	[1.506]		[0.715]	[1.702]
$\Delta BDI_{C_{t-1}}$	0.046	0.457	$\Delta TC1_{C_{t-1}}$	0.059	0.301	$\Delta TC3_{C_{t-1}}$	0.072	0.479
	(0.020)	(0.100)		(0.022)	(0.102)		(0.034)	(0.103)
	[2.303]	[4.563]		[2.693]	[2.947]		[2.109]	[4.642]
$\Delta BDI_{C_{t-2}}$	-0.034	-0.165	$\Delta TC1_{C_{t-2}}$	-0.001	-0.002	$\Delta TC3_{C_{t-2}}$	-0.024	-0.040
	(0.021)	(0.105)		(0.023)	(0.108)		(0.037)	(0.111)
	[-1.624]	[-1.574]		[-0.034]	[-0.015]		[-0.656]	[-0.362]
Panel B: Walt tests for Granger causality								
	ΔSBP_{C_t}	ΔBDI_{C_t}		ΔSBP_{C_t}	$\Delta TC1_{C_t}$		ΔSBP_{C_t}	$\Delta TC3_{C_t}$
Walt tests	H0:	H0:	Walt tests	H0:	H0:	Walt tests	H0:	H0:
	$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0
	6.461	4.642		7.326	5.467		4.483	3.832
	[0.040]*	[0.098]		[0.026]*	[0.065]		[0.106]	[0.147]

Note:
Sample (adjusted): 1999:03 to 2007:12
In Panel A, Figures in ( ) and [ ] indicate Standard errors and *t*-statistics, respectively.
In Panel B, Figures in [ ] stands for P-values.
The lag length of the VECM model is determined by Akaike Information Criterion (AIC).
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 7: VECM Estimates and Granger causality test for freight rates and shipbuilding prices; Panamax ships

$$\Delta SBP_t = \sum_{i=1}^{p-1} a_{SBP,i}\Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{SBP,i}\Delta FRT_{t-i} + \alpha_{SBP}ECT_{t-1} + \varepsilon_{SBP,t}$$

$$\Delta FRT_t = \sum_{i=1}^{q-1} a_{FRT,i}\Delta SBP_{t-i} + \sum_{i=1}^{q-1} b_{FRT,i}\Delta FRT_{t-i} + \alpha_{FRT}ECT_{t-1} + \varepsilon_{FRT,t} \qquad \text{where } \Delta FRT_t = \Delta BDI_t,\ \Delta TC1_t, \text{ or } \Delta TC3_t$$

Error Correction:	ΔSBP_{P_t}	ΔBDI_{P_t}	*Error Correction:*	ΔSBP_{P_t}	$\Delta TC1_{P_t}$	*Error Correction:*	ΔSBP_{P_t}	$\Delta TC3_{P_t}$
Panel A: VECM model Estimates								
ECT_{t-1}	-0.055	0.044	ECT_{t-1}	-0.035	0.138	ECT_{t-1}	-0.010	0.115
	(0.015)	(0.078)		(0.014)	(0.072)		(0.012)	(0.052)
	[-3.735]	[0.562]		[-2.575]	[1.922]		[-0.865]	[2.204]
$\Delta SBP_{P_{t-1}}$	0.175	0.549	$\Delta SBP_{P_{t-1}}$	0.123	0.395	$\Delta SBP_{P_{t-1}}$	0.218	0.445
	(0.094)	(0.493)		(0.097)	(0.510)		(0.093)	(0.417)
	[1.859]	[1.113]		[1.270]	[0.774]		[2.333]	[1.069]
$\Delta SBP_{P_{t-2}}$	-0.073	-0.571	$\Delta SBP_{P_{t-2}}$	-0.028	0.462	$\Delta SBP_{P_{t-2}}$	0.030	0.237
	(0.090)	(0.469)		(0.091)	(0.482)		(0.078)	(0.349)
	[-0.817]	[-1.218]		[-0.305]	[0.958]		[0.376]	[0.677]
$\Delta BDI_{P_{t-1}}$	0.054	0.199	$\Delta TC1_{P_{t-1}}$	0.079	0.555	$\Delta TC3_{P_{t-1}}$	0.152	0.483
	(0.020)	(0.103)		(0.019)	(0.098)		(0.023)	(0.101)
	[2.772]	[1.936]		[4.235]	[5.664]		[6.738]	[4.793]
$\Delta BDI_{P_{t-2}}$	0.007	-0.020	$\Delta TC1_{P_{t-2}}$	0.006	-0.237	$\Delta TC3_{P_{t-2}}$	0.005	-0.144
	(0.020)	(0.107)		(0.021)	(0.109)		(0.028)	(0.125)
	[0.360]	[-0.185]		[0.297]	[-2.178]		[0.177]	[-1.152]
Panel B: Walt tests for Granger causality								
Walt tests	H0:	H0:	Walt tests	H0:	H0:	Walt tests	H0:	H0:
	$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0
Walt tests	7.899	2.228	Walt tests	19.581	1.858	Walt tests	46.467	2.339
	[0.019]*	[0.328]		[0.000]**	[0.395]		[0.000]**	[0.311]

Note:
Sample (adjusted): 1998:05 to 2007:12
In Panel A, Figures in ( ) and [ ] indicate Standard errors and *t*-statistics, respectively.
In Panel B, Figures in [ ] stands for P-values.
The lag length of the VECM model is determined by Akaike Information Criterion (AIC).
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 8: VECM Estimates and Granger causality test for freight rates and shipbuilding prices; Handymax ships

$$\Delta SBP_t = \sum_{i=1}^{p-1} a_{SBP,i}\Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{SBP,i}\Delta FRT_{t-i} + \alpha_{SBP}ECT_{t-1} + \varepsilon_{SBP,t}$$

$$\Delta FRT_t = \sum_{i=1}^{q-1} a_{FRT,i}\Delta SBP_{t-i} + \sum_{i=1}^{q-1} b_{FRT,i}\Delta FRT_{t-i} + \alpha_{FRT}ECT_{t-1} + \varepsilon_{FRT,t} \qquad \text{where } \Delta FRT_t = \Delta BDI_t,\ \Delta TC1_t \text{, or } \Delta TC3_t$$

Error Correction:	ΔSBP_{H_t}	ΔBDI_{H_t}	*Error Correction:*	ΔSBP_{H_t}	$\Delta TC1_{H_t}$	*Error Correction:*	ΔSBP_{H_t}	$\Delta TC3_{H_t}$
Panel A: VECM model Estimates								
ECT_{t-1}	-0.043	0.033	ECT_{t-1}	-0.052	0.022	ECT_{t-1}	-0.053	0.088
	(0.015)	(0.060)		(0.018)	-0.071		(0.030)	(0.078)
	[-2.898]	[0.552]		[-2.827]	[0.310]		[-1.785]	[1.125]
$\Delta SBP_{H_{t-1}}$	0.034	-0.177	$\Delta SBP_{H_{t-1}}$	-0.057	-0.555	$\Delta SBP_{H_{t-1}}$	-0.049	-0.518
	(0.115)	(0.461)		(0.116)	(0.450)		(0.113)	(0.298)
	[0.295]	[-0.383]		[-0.489]	[-1.233]		[-0.436]	[-1.736]
$\Delta SBP_{H_{t-2}}$	–	–	$\Delta SBP_{H_{t-2}}$	-0.001	-0.162	$\Delta SBP_{H_{t-2}}$	0.036	0.343
				(0.111)	(0.431)		(0.106)	(0.282)
				[-0.011]	[-0.375]		[0.341]	[1.218]
$\Delta BDI_{H_{t-1}}$	0.094	0.405	$\Delta TC1_{H_{t-1}}$	0.125	0.598	$\Delta TC3_{H_{t-1}}$	0.176	0.726
	(0.030)	(0.121)		(0.031)	(0.122)		(0.046)	(0.122)
	[3.106]	[3.350]		[3.982]	[4.903]		[3.821]	[5.958]
$\Delta BDI_{H_{t-2}}$	–	–	$\Delta TC1_{H_{t-2}}$	0.012	-0.036	$\Delta TC3_{H_{t-2}}$	0.054	-0.114
				(0.035)	(0.135)		(0.053)	(0.139)
				[0.339]	[-0.267]		[1.023]	[-0.818]
Panel B: Walt tests for Granger causality								
Walt tests	H0:	H0:	Walt tests	H0:	H0:	Walt tests	H0:	H0:
	$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0
	9.653	0.147		18.888	1.741		18.935	3.961
	[0.002]**	[0.702]		[0.000]**	[0.419]		[0.000]**	[0.138]

Note:
Sample (adjusted): 2000:09 to 2007:12
In Panel A, Figures in ( ) and [ ] indicate Standard errors and *t*-statistics, respectively.
In Panel B, Figures in [ ] stands for P-values.
The lag length of the VECM model is determined by Akaike Information Criterion (AIC).
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

The results in *Table 6* to *Table 8* (*Panel B*) show the Granger causality test results through *VECM*.

The null hypothesis that *FRT* (= *BDI, TC1, TC3*) does not Granger-cause *SBP* is rejected in general at 1% critical value (with the exception of SBP_C and $TC3_C$ for capesize ships), while that the null hypothesis that *SBP* does not Granger-cause *FRT* is acceptable at 5% critical value across three ship sizes. Therefore, *FRT* are statistically significantly Granger-cause *SBP*.

The estimates of *Table 6* to *Table 8* further show that the coefficients of *SBP* lags in *Eq. (3)* are generally larger in magnitude than the coefficients of *FRT* lags in *Eq. (4)* for three sizes of bulk ship. Therefore, *FRT* seems to be more sensitive to market changes, and *FRT* plays a price-leading role in incorporating new information.

4. Discussion and Further Research

The interdependence of two shipping markets has been studied, where the sea freight market trades cargo-carrying service and the shipbuilding market trades new ships. Many argue that the freight rates depend on the shipbuilding activities. Others argue that demand for shipbuilding depends mainly on the operating environment of the shipping market. We have examined these competing views by testing whether freight rates and shipbuilding prices are related in the long-run.

This study establishes an econometric model of shipbuilding price and freight rate so as to determine their dynamic relationship. Similar to many financial and economic time series, shipping time series are non-stationary. However, we confirm that there exists a co-integration relationship between freight rate and shipbuilding price, such that the two rates are related to form an equilibrium relationship in the long run. The results have showed a positive correlation between freight market and shipbuilding market, and demonstrate a causal relationship that freight rate leads shipbuilding price.

The time lags of from freight rate to the shipbuilding price are approximately two months. The existence of time lags implies that the information flow between these two markets is not in a timely manner, as rational expectations by the Efficient Markets Hypothesis. This information delay is however expected because the market players are essentially different in these two markets, despite the fact that these markets are related. The market players in the freight market are ship operators and cargo owners who trade the cargo-carrying capacities, while the shipowners and shipbuilders buy and sell the shipbuilding capacities in the shipbuilding market.

The finding concludes that the shipbuilding prices are a function of the past history of freight rate, rather than the expected future values of freight rate. At the same time, the supply of ships alone is not sufficient to forecast the future freight rate. This finding implies that, due to the long delivery time, the future supply of ships is not consistently interpreted in the freight market at the micro level so that the shipbuilding price appears not to depend on freight market outlook.

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Models and Algorithms for Multi-crane Oriented Scheduling Method in Container Terminals

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Abstract

"Multi-crane oriented" is a scheduling method that yard trailers can be shared by different quay cranes. In this paper, two models for this problem is developed. The first one is model for inter-ship based sharing method. In this model, yard trailers can be shared by quay cranes of different ships. To slovle the model, a two-phase tabu search algorithm is disigned. The second one is model for ship based sharing method. In this model yard trailers can only be shared by quay cranes of the same ship. Q-learning algorithm is designed to solve the model. Numerical tests show that "multi-crane oriented" can decrease the yard trailers travel distance, reduce the disequlibrium of different working line, and thus improve the operation efficiency in container terminals.

Keywords: Container terminals; Multi-oriented scheduling method; Yard trailer scheduling; Q-learning algorithm

1. Introduction

As the world container volumes are soaring, container terminals have become the important nodes in global transportation network. Presently, container terminals are faced with bigger challenges to provide better services so as the vessel turn around time can be shortened. Therefore, how to improve the operation efficiency is one of the most important issues for container terminals. To improve the operation efficiency, two methods can be used. One is increasing the equipment processed loading and unloading operations, and the other is optimizing operation scheduling. In this paper, a new scheduling methods, namely "multi-crane oriented" methods are studied.

For most container terminals, there are mainly three types of equipments involved in the loading and unloading, i.e., quay cranes (QCs), yard trailers (YTs) and yard cranes (YCs). Upon a ship's arrival, QCs unload containers from or load containers onto the ship, and YTs move containers from quayside to storage yard and vice versa. At the storage yard, YCs perform the loading and unloading for YTs.

Currently, "single-crane oriented" scheduling method is wildly used at container terminals. In this method, a set of YTs is usually assigned to a specific QC until the work is completed, the YTs return to the QC directly after delivering the inbound containers to the storage yard. And the yard trailers can't be shared by different QCs. "Single-crane oriented" method is simple to implement, but it leads to the increment of empty travel of yard trailers.

To improve the utilization of YTs and operation efficiency of container terminals, "multi-crane oriented" scheduling method is getting increasingly attention. In this method, YTs no longer serve the fixed QC and be assigned dynamically based on the real time information. For example, after delivered the inbound container to a yard, YT may move an outbound container to the quayside rather than move back the quayside emptily. The "multi-crane oriented" method can reduce the needed trailers without increasing the loading and unloading time of the ship. Moreover, it can decrease the disequilibrium among different "quay crane working line", and thus improve the operaiton efficiency.

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In this paper, two scheduling models for "multi-crane oriented" scheduling method will be developed. This paper is organized as follows: In section 2, a brief review of previous works is given. Description of the "multi-crane oriented" method is given in Section 3. Model for inter-ship based sharing method is developed in section 4. And model for ship based sharing method is developed in section 5. Numerical examples are used to test the performance of the proposed model in section 4 and section 5 respectively. And conclusions are given in section 6.

2. Literature Review

Issues related to container terminal operations have gained attention recently due to the increased importance of marine transportation systems. Here, we provide a brief review of existing studies related to the operation scheduling in container terminals.

Due to the complexity of container terminal operation, it is difficult to optimize the whole system with a single analytical model, therefore, generally the operation system in container terminal are divided into several sub-processes and each sub-process is optimized respectively. Researchers developed optimization models and algorithms for different sub-processes of the container terminal operation system, such as QCs scheduling, YCs allocation and scheduling model, storage optimization, and YTs routing model etc.

For an arrived vessel, the first thing is to assign a berth for loading and unloading, thus berth assignments have significant effects on the efficiency of terminal production. Berth assignment affects both quay scheduling and travel distance of trucks, consequently affects the efficiency of the whole system of the container terminals. While the traditional "First-come-First-serve" rule can not indicate the differences among shipping companies, neither guarantees the loading/unloading efficiency and a minimum operation cost, therefore, some researchers have developed several optimization models on berth assignment. Nishimura *et al* (2001) constructed a discrete assigning model in terms of public berths and designed a GA based algorithm to test the validity of the model. Imai *et al* (2003) further considered the docking privileges of different shipping company to assign the berth. Moreover, Kim *et al* (2003) solved the discrete berth assignment model with simulated annealing and compared the results from simulated annealing and optimal solution method. Imai *et al* (2005) developed a continuous berth assignment model to minimize the total service times, and in 2007 they further studied the berth assignment problem in the context of indented berths and designed a genetic algorithm to solve the model. Wang and Lim (2007) took berth assignment problem as a multi-stage decision making problem and solved their model with stochastic beam search algorithm.

QCs are the main bottleneck of the efficiency of the container terminals, and their operation plan determines the turnaround time of a ship in the terminals. Daganzo (1989, 1990) suggested an algorithm for determining the number of QCs assigned to ship-bays of multiple vessels. Kim (2004) developed a mixed-integer programming model considering various constraints related to the operation of QCs, and proposed a heuristic search algorithm to solve the problem. Lee *et al*(2008) provided a mixed integer programming model for the considered quay crane scheduling problem, and developed a genetic based algorithm to solve the model. Goodchild and Daganzo (2007) studied the double cycling method of QCs, and the performance of the double cycling method was evaluated.

Yard vehicles are used to transfer containers between the quay and the yard. Most of Studies about routing problem in container terminals are focus on automated guided vehicle (AGV) and straddle carrier. Evers and Koppers (1996) developed a hierarchical AGV control system by using semaphores. Liu and Ioannou (2002) compared different AGV dispatching rules in container terminals. Vis (2005) develop a heuristic based on the maximum flow problem to determine the fleet size of AGVs. Kim (1999) developed models and algorithms to optimize the routing of straddle carrier. Considering YTs, Nishimura *et al* (2005) proposed dynamic routing trailer assignment method, and developed a heuristic algorithm to solve the problem.

The scheduling of YCs determines the terminal efficiency to a great extent. Research focused on scheduling of YCs has been conducted widely. Zhang *et al* (2002) formulated the dynamic crane deployment problem as a mixed integer programming model and solved it by Lagrangean relaxation. Linna *et al* (2003) proposed an algorithm and a mathematical model for the optimal yard crane deployment problem. Kim *et al*(2003) developed a dynamic programming model to optimize the receiving and delivery operations of outside trucks, and derived the decision rule by learning based method. Ng W.C (2005) examined the problem of scheduling multiple yard cranes to perform a given set of jobs with different ready times in a yard zone with only one bi-directional traveling lane.

The operation efficiency of container terminals depend on the coordination of different sub-processes, while the optimization models mentioned above can not deal with the cooperation issues. Moreover, most of the research focused on "single-crane oriented" method, the YTs trailers can not be shared by different QCs. Nishimura *et al*. (2005) considers dynamic YTs scheduling problem in his model, however, the loading and unloading operations of QCs are not considered, and thus it can not realize the operation coordination between different QCs.

To improve the coordination and efficiency of operation in container terminals, some researchers carried out study on the cooperation or harmonization among several activities. For example, Kozan and Preston (1999) established a model to optimize the loading and unloading together. The model involved two decisions: storage strategy of the containers in the yard, loading and unloading orders. The objective of the model is to minimize the stay time of a vessel in a berth. Bish (2003) provided models and algorithms to integrate several sub-processes; the problem is (1) to determine a storage location for each unloaded container, (2) to dispatch vehicles to containers, and (3) to schedule the loading and unloading operations on the cranes, so as to minimize the maximum time it takes to serve a given set of ships. He proposed operation scheduling model based on vehicle pooling policies to schedule unloading and unloading simultaneously. Chen *et al* (2007) developed an integrated model to optimize the whole loading and unloading process. Due to the complexity of the model, he designed a Tabu search-based solution method. Lau and Zhao(2007) constructed an operation model for an all-automatic container terminal. The model optimized the AGV, working orders of QCs and YTs simultaneously.

These models and algorithms improve the coordination and integration of the operation scheduling in container terminals. However, how to tackle the complex constraints and interrelation; how to improve the computation efficiency; how to realize coordination among different sub-processes; and how to realize the integrating scheduling of loading and unloading operations are the problems that have not been solved well.

In this paper, two scheduling model base on the "multi-crane oriented" method is developed to optimize the loading and unloading operation simultaneously. Meanwhile, a two-phase tabu search (TS) algorithm and Q-learning algorithm are designed to solve the models respectively. And numerical tests are given to illustrate the validity of the models and their algorithm.

3. Problen Descriptions

In container terminals, equipments processing loading or unloading operations can be divided into different working lines. A working line is composed of a QC, certain number of YTs and YCs. If the YTs can be shared by different working lines, it is called "multi-crane oriented" method.

Based on the mode to share YTs, "multi-crane oriented" method can be divided into two types, the first is sharing YTs in different working lines of the same ship, we call it ship based sharing method. And the other is sharing YTs in different working lines of the different ships; we call it inter-ship based sharing method.

The first type is shown as Figure1. YTs can be shared by the working lines of the same ship. E.g. equipments processing unloading operations of ship1 can be divided into 3 working lines (QC1, QC2, and QC3); YTs assigned to ship1 can be shared by QC1, QC2, and QC3. If YTs can not be shared by different QCs, disequilibrium of different working line may occur, e.g. some QCs may face to a shortage of YTs, while other QCs accumulate a large number of waiting YTs, which may decrease the whole operation efficiency. By the ship based sharing method, the disequilibrium of different working lines can be reduced, and thus the operation efficiency can be improved, but the YTs travel distance can not be decreased.

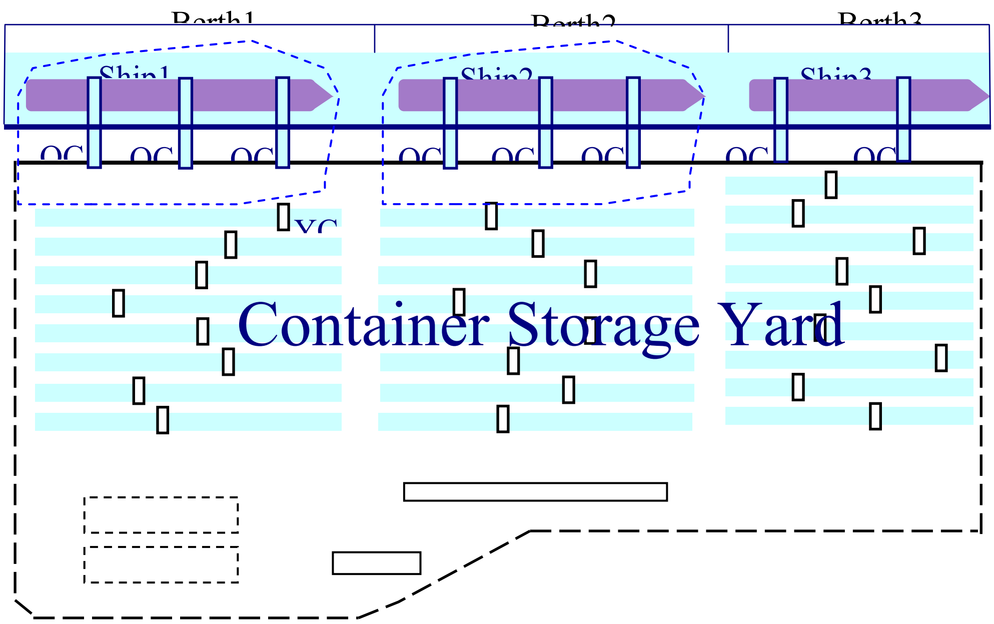

Figure 1: Sharing YTS in differents working lines of the same ship

The mechanism of the second type is shown in Fig 2, where D denotes the storage point of an unloading container and L denotes the storage point of a loading container. When a trailer reaches at a storage point in the yard after receiving a container from the QC, instead of returning to the QC directly, it proceeds to the next storage point to get a container for loading, and then transport it to the QC for loading. This method can reduce the needed trailers without increasing the overall dwell time of the ship in port, and decrease unproductive empty travel.

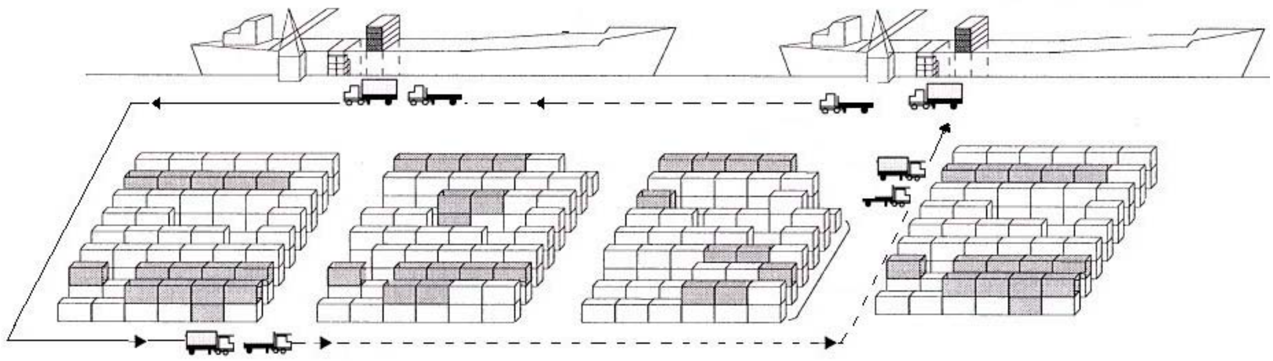

Figure 2: Sharing YTS in differents working lines of different ships

4. Model for Inter-ship Based Sharing Method

4.1 Model Formulation

Suppose there are two ships, sh^{-}, sh^{+} for uunloading and loading respectively, the operations of the two ships are scheduled simultaneously; N^{-}, N^{+} denote the set of containers being unloaded and loaded respectively; $i \in N^{-}$ denote the ith unloading container and $j \in N^{+}$ denote jth loading container; n^{-}, n^{+} denote the number of unloading and loading containers respectively. Firstly, an ideal model is developed supposing $n^{-} = n^{+}$, then the model is extend to more general cases with $n^{-} \neq n^{+}$.

As the YTs serve loading and unloading ships simultaneously, therefore each inbound container should be matched with a outbound container to be served by one YT. Let L^{-}, L^{+} denote set of storage points of unloading and loading containers, and l_i^{-}, l_j^{+} denote the storage points of unloading and loading containers. $\lambda_{sh^{-}, l_i^{-}}$ is the YT travel time from sh^{-} to storage point l_i^{-}, $\lambda_{l_i^{-}, l_j^{+}}$ is the travel time from storage point l_i^{-} to storage point l_j^{+}, $\lambda_{l_j^{+}, sh^{+}}$ is the travel time from storage point l_j^{+} to sh^{+},and $\lambda_{sh^{+}, sh^{-}}$ is travel time between sh^{-} and sh^{+}. Therefore, the problems for inter-ship based sharing method is a) operation sequence of QCs, namely the loading and unloading order; b) matching each outbound container with inbound container, which are transported by one YT; c) optimizing YT scheduling, determine the loading and unloading oders, the ojective is to mimize the total operation time.

Firstly, we matching each outbound container with inbound container. Supposing that the container storage location is pre-determined, and then the model can formulated as follows:

$$Min \sum_{i \in L^{-}} \sum_{j \in L^{+}} \lambda_{ij} Y_{l_i^{-}, l_j^{+}} \tag{1}$$

$$\text{s.t.} \quad \sum_{i \in L^{-}} Y_{l_i^{-}, l_j^{+}} = 1 \quad \forall j \in L^{+} \tag{2}$$

$$\sum_{j \in L^{+}} Y_{l_i^{-}, l_j^{+}} = 1 \quad \forall i \in L^{-} \tag{3}$$

$$Y_{l_i^{-}, l_j^{+}} = 0 \quad or \quad 1 \tag{4}$$

Where, Y_{uv} is decision variable, if arc (u, v) is in the route, $Y_{uv} = 1$; and 0, otherwise. Equation (1) is the objective function; Constraints (2) and constraints (3) ensure that each loaded trip is matched with an unloaded trip, and each unloaded trip is matched with a loaded trip. Constraints (4) are simple binary constraints.

Equation (1)-(4) determine the matching container pairs. The loading order is determined once the unloading order is given. Therefore, the scheduling of loading and unloading operations in containers involves two aspects: the first is QCs scheduling, which is to determine the operation orders of QCs; the second is YTs scheduling, which is to determine the matching container pairs according to Equation (1)-(4), and assign the container pairs to YTs. The objective is to minimize the total operation time.

Let $k^{-} \in K^{-}, k^{+} \in K^{+}$ denote the sets of QCs for unloading and loading operations respectively; $v \in V$ denote the YTs; q denote the unit operation efficiency of QCs; p denote the unit operation efficiency of YCs; l_i denote the location of container i on the ship (expressed by the ship-bay number); $t_{i,i+1}$ denote the travel time of QC from location of container i to location of container $i+1$; T_i^{-}, T_j^{+} denote the completion time of container i, j respectively; M denote a sufficiently large constant.

If operation of container i is assigned to QC k $x_{ik}=1$; and 0, otherwise. If operation of container i immediately precedes i' on QC k, $x_{ii'k}=1$; and 0 otherwise. If operation of container i is assigned to yard trailer k, $y_{ik}=1$; and 0, otherwise. If operation of container i immediately precedes i' on yard trailer k, $y_{ii'k}=1$; and 0 otherwise.

Thus the scheduling model for inter-ship based sharing method can be formulated as follows:

$$\text{Min } T_{\max} = \min\max(T_i^-, T_j^+) \tag{5}$$

$$\text{s.t. } \sum_{k^- \in K^-} x_{ik^-} = 1, \ \forall i \in N^- \tag{6}$$

$$\sum_{k^+ \in K^+} x_{jk^+} = 1, \ \forall j \in N^+ \tag{7}$$

$$\sum_{v \in V} y_{iv} = 1, \ \forall i \in N^- \tag{8}$$

$$\sum_{v \in V} y_{jv} = 1, \ \forall j \in N^+ \tag{9}$$

$$\sum_{i' \in N^-} x_{ii'k^-} \le 1, \ \forall i \in N^-, \forall k^- \in K^+ \tag{10}$$

$$\sum_{j' \in N^+} x_{jj'k^+} \le 1, \forall j \in N^+, \forall k^+ \in K^+ \tag{11}$$

$$\sum_{i' \in N^-} y_{ii'v} \le 1, \forall i \in N^-, \forall v \in V \tag{12}$$

$$\sum_{j' \in N^+} y_{jj'v} \le 1, \forall j \in N^+, \forall v \in V \tag{13}$$

$$T_i^- + t_{ii'} + q - T_{i'}^- \le M\left(1 - x_{ii'k^-}\right), \forall i, i' \in N^-, \forall k^- \in K^- \tag{14}$$

$$T_j^+ + t_{jj'} + q - T_{j'}^+ \le M\left(1 - x_{jj'k^+}\right), \ \forall j, j' \in N^+, \forall k^+ \in K^+ \tag{15}$$

$$T_j^+ + p + \lambda_{l_j^+, sh^+} - T_i^- \le M\left(1 - y_{ijv}\right), \quad \forall i \in N^-, j \in N^+, \forall v \in V \tag{16}$$

$$T_i^- + p + \lambda_{sh^+, sh^-} + \lambda_{sh^-, l_i^-} - T_j^+ \le M\left(1 - y_{jiv}\right), \quad \forall i \in N^-, j \in N^+, \forall v \in V \tag{17}$$

$$\sum_{v \in V} y_{ijv} \le Y_{ij}, \forall i \in N^-, \forall j \in N^+ \tag{18}$$

$$y_{iv} - 0.5 \le 0.5(y_{ijv} + y_{ijv}) \le y_{iv}, \ \forall i \in N^-, j \in N^+, \forall v \in V \tag{19}$$

$$x_{ik}, y_{iv}, x_{ii'k}, y_{jj'v} = 0 or 1 \tag{20}$$

The objective function (5) is to minimize the total operation time. Constraints (6)-(9) guarantee that each container can be assigned to one QC or YT only. Constraints (10)-(13) ensure that in the operation sequence of QCs and YTs, there are at most one pre-sequence and post-sequence for each container. Constraints (14)-(15) define the relation of completion time between two successive operation tasks from the point view of QCs. Constraints (16)-(17) define the relation of completion time between two successive operation tasks from the point view of YTs. Constraints (18) are the container pair constraints. Constraints (19) define the operation sequence of YTs. Constraints (20) are simple binary constraints.

4.2 Extension of ideal model to more general cases

During the operation practice in container terminals, the more cases are that the numbers of loading and unloading containers are not equal, namely $n^- \neq n^+$. Therefore, the model in 4.1 should be extended to more general cases.

Suppose $n^+ > n^-$, there will be $n^+ - n^-$ loading containers in set N^+ that are not matched with unloading container, thus, the YTs assigned to these loading containers should make empty travel from unloading ship to storage yard. To solve the problem, dummy supply nodes are added, namely $n^+ - n^-$ dummy unloading containers are added. We replace Equation (2)-(3) by Equation (21)-(22).

$$\sum_{i \in L^-} Y_{l_i^-, l_j^+} + \sum_{c_i \in \text{dummy}} Y_{c_i, l_j^+} = 1 \quad \forall j \in L^+ \tag{21}$$

$$\sum_{j \in L^+} Y_{c_i, l_j^+} = 1 \quad \forall c_i \in \text{dummy} \tag{22}$$

For the case $n^+ < n^-$, $n^- - n^+$ dummy demand nodes (dummy loading containers) are added. Equation (2)-(3) are replaced by Equation (23)-(24).

$$\sum_{j \in L^+} Y_{l_i^-, l_j^+} + \sum_{c_i \in \text{dummy}} Y_{l_i^-, c_i} = 1 \quad \forall i \in L^- \tag{23}$$

$$\sum_{i \in L^-} Y_{l_i^-, c_i} = 1 \quad \forall c_i \in \text{dummy} \tag{24}$$

4.3 Solution algorithm

In this paper, two-phase Tabu search (TS) algorithm is disigned to solved the model. Figure3 shows the general diagram of this algorithm. The two-phase approach integrates two levels of decision making: QCs scheduling and yard trailer routing. In the QCs scheduling phase of the algorithm, a TS is performed to determine a good unloading operation order of QCs, and each outbound container is matched with an inbound container. For each unloading operation order of QCs obtained in the QCs scheduling phase, another TS was run to obtain a good YTs scheduling scheme, determine the loading order of QCs, calculate the total operation time, so as to influence the TS process in the QCs scheduling phase. The satisfied solution can be obtained by feedback of the two phase search process.

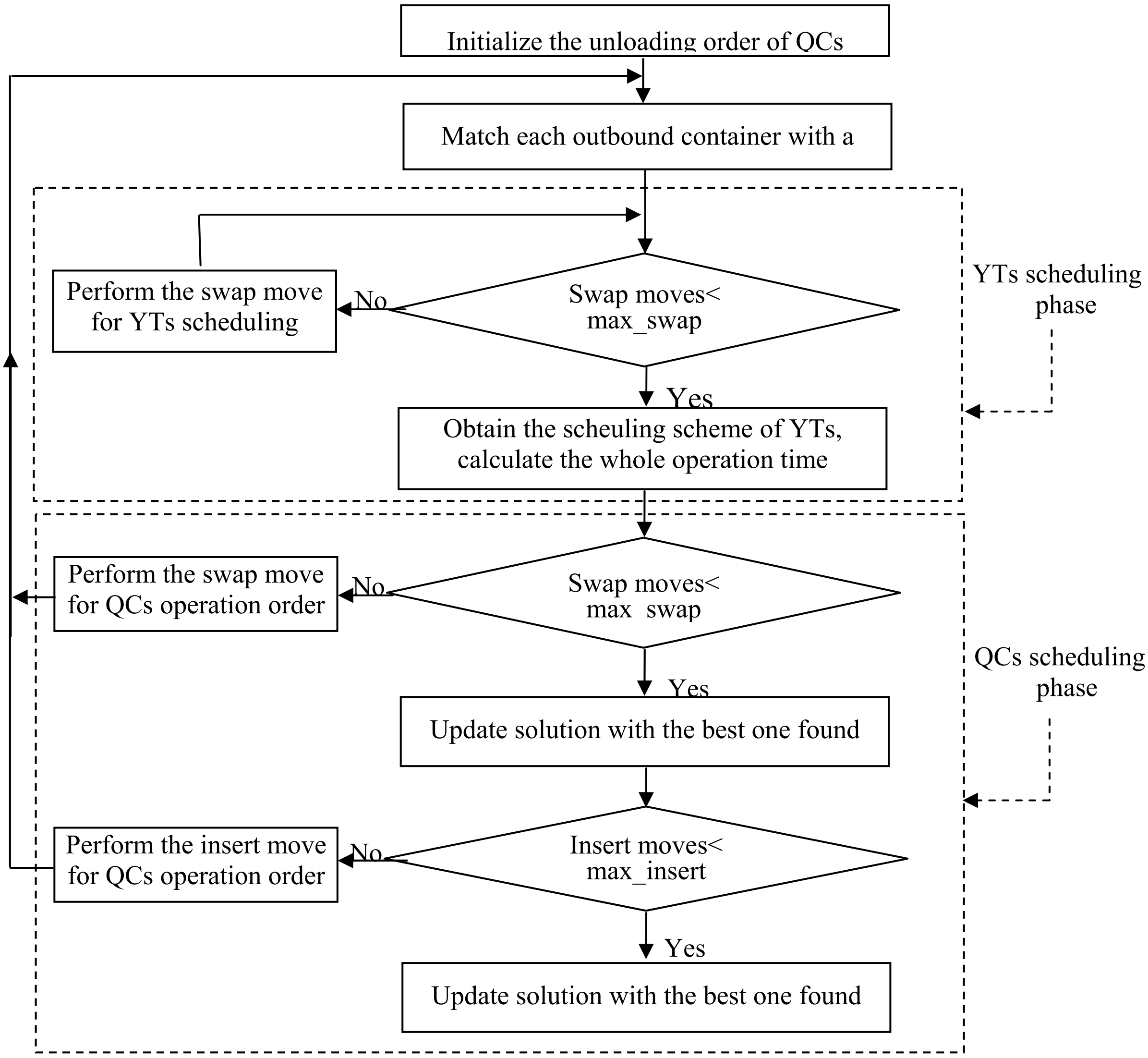

Figure 3: Two-phase tabu search algorithm for "multi-crane oriented" scheduling model

4.4 Numerical tests

Firstly, numerical tests are used to examine the validity of the two-phase TS algorithm. The needed data and the parameters are designed based on the average level. Suppose that the efficiency of a QC is 2minutes/TEU; the velocity of YTs is 15km/h; the ratio of QCs to YTs is 1/4; the distance from storage yard to quayside is between 200-1000m; and the numbers of inbound and outbound containers are equal. According to the numbers of inbound containers and QCs, 6 scenarios are designed. Results are shown as Table 1.

From table 1, we find that two-phase TS algorithm can improve the solution significantly and reach convergence in relatively efficient time. With the increase of problem size, the time required is increased, but its computational time requirement is reasonable, thus it can be applied in realistic container terminal scheduling.

Table 1: Computational results of the two phase TS algorithm

Inbound containers/ QCs for unloading	YTs travel (Km)		Total operation time (Minute)		Computation time (s)
	Initial solution	TS search	Initial solution	TS search	
100/1	177.82	160.20	248	218	0.5
400/2	707.94	626.50	473	430	2.3
500/2	936.94	814.73	603	549	3.7
1000/3	1899.26	1637.30	779	702	8.1
2000/5	3556.85	3082.20	1012	912	47.5
2000/6	3770.27	3230.70	815	728	63.2

Moreover, inter-ship based sharing method is compared with present "single-crane oriented" scheduling method. Six scenarios are deigined (Table2). In the crossover condition, the ship is not allocated the berth close to its container storage locations, so there are certain outbound containers stored on the side of unloading ship, which results long YTs travel. Suppose that the loading and unloading containers are 1000 respectively, the results are shown as table 2.

Table 2: Comparison of " inter-ship based sharing method" with "single-crane oriented" method

QCs/YTs	Crossover operation?	"multi-crane oriented" mehod		"single-crane oriented" mehod		(2)/(1)
		YTs travel (Km) (1)	Total operation time (Minute)	YTs travel (Km) (1)	Total operation time (Minute)	
6/18	Yes	2581	763	3751	825	1.45
	No	1656	727	1973	749	1.19
6/24	Yes	2573	731	3726	748	1.44
	No	1637	702	1987	726	1.21
6/30	Yes	2569	723	3721	720	1.45
	No	1625	697	1974	703	1.21

From the results we can find that the method proposed in this paper can decrease the YTs travel distance, and the decrease ratio in the crossover operation is more than that of non-crossover operation. Moreover, when the number of QCs are small (e.g. the number of QCs and YTs are 6, 18 respectively), comparing to "single-crane oriented" mehod, "multi-crane oriented" mehod can decrease total operation time greatly. With the increase of YTs(e.g. the number of QCs and YTs are 6, 30 respectively), the decreasing ratio of total operation time becomes less.

5. Model for Ship Based Sharing Method

5.1 Model formulation

In the ship based sharing method, YTs are assigned to QCs of the same ship accoring to real-time operation condition. The objective is to reduce the waiting time of QCs and improve the operation efficiency.

Taking unloading operation as an example, YT transport a inbound container from quayside to storage yard first, and then return to quayside emptily to transport next inbound container. Let $J = \{1,2,\ldots i,\ldots,n-1,n\}$ denote the operation sequence of QCs, and i denote a inbound container. s

is the operation efficiency of QCs. λ_i is the time for a YT transport container i from quayside to storage yard. ST_i is the starting time for container i, namely the time when a QC unloading container i from ship to a YT. CT_i is the comletion time for container i, namely the time when YT returning quayside after it has transport container i to storage yard. $V = \{v_1, v_2, \ldots, v_K\}$ denote the set of YTs. If container i is transported by YT k, $x_{ik} = 1$; and 0 otherwise. If the operation of container j is processed immediately after i by YT k, $y_{ijk} = 1$; and 0 otherwise. Thus, the model for ship based sharing method can be formulated as:

$$\min(CT_n - ST_1) \tag{25}$$

$$\text{s.t. } ST_i \geq 0 \quad i = 2,3,\cdots,n \tag{26}$$

$$CT_i = ST_i + 2\lambda_i, \quad i = 1,2,\cdots,n \tag{27}$$

$$\sum_{k \in K} x_{ik} = 1, i = 1,2,\cdots n \tag{28}$$

$$\sum_{j \in N} y_{ijk} \leq 1, \forall k \in K, \forall i \in N \tag{29}$$

$$CT_i \leq ST_j + H(1 - y_{ijk}) \tag{30}$$

$$ST_i + s \leq ST_j + H(1 - y_{ijk}) \tag{31}$$

$$x_{ik}, y_{ijk} = 1 \ or \ 0 \ \forall i, j \in N, k \in K \tag{32}$$

The objective function (25) is to minimize the total unloading time. Constraints (26) ensure that all the operaiton task begin after time zero. Constraints (27) denote the relation between starting and completion time of each operation task. Constraints (28) enure that each operation task is assigned only one YTs. Constraints (29) ensure that each operation task has at most one sucessor operation task. Constraints (30)-(31) denote the relation between two adjacent operation task. Constraints (32) are simple binary constraints.

5.2 Solution algorithm

The models for ship based sharing method are NP-hard problem. It is doomed unable to obtain optimal solutions for large-scale problems. Hence, heuristic algorithms are wildly used to obtain near-optimal solutions efficiently. However, because of the numerous constraints, it is difficult to evaluate a scheduling scheme in the process of heuristic algorithms. Meanwhile, although many constraints are considered in above scheduling model, it is too complex to model all the constraints analytically. Also uncertainty is difficult to tackle by analytical model alone. And in practice, how to assgin YTs accoring to real-time condition is important.

In this paper, reinforcement learning is used to solve the problem. Reinforcement learning is a kind of unsupervised machine learning technique. It deals with the problem how an autonomous agent can learn to select proper actions for achieving its goals through interacting with its environment. Each time after an agent performs an action, the environment's response (as indicated by its new state) is used by the agent to reward or penalize its action. The objective is to develop a decision-making policy on selecting the appropriate action rule for each agent . By reinforcement learning, the optimal assigning rules for YTs can be obtained.

Q-learning algorithm is one of the most wildly used reinforcement learning algorithms. It was proposed by Watkin in 1989. The objective of this algorithm is to learn the state-action pair value, $Q(s,a)$, which represents the long-term expected reward for each pair of state and action (denoted by s and a respectively). $Q(s,a)$ can be denoted by the following equation:

$$Q(s_t,a_t) = (1-\alpha)Q(s_t,a_t) + \alpha(r + \gamma V^*) \qquad (33)$$

Where, $Q(s_t,a_t)$ is the expected value to execute action a_t at state s_t; r is the immediate reward to execute action a_t; α is the stepsize parameter and influences the learning rate. γ is discount-rate parameter ($0 \le \gamma \le 1$), it impacts the present value of future rewards. V^* is the maximal value of Q under state s_{t+1}:

$$V^* = \max_b Q(s_{t+1},b) \qquad (34)$$

The process of Q-learning algorithm for ship based sharing YTs model is:

Step0: Initialize the value of Q. For all the state s and action a, let $Q\ (s,a) = 1$, $n = 1$.

Step1: Obtain the current state s, if $n > N$, the algorithm is end; and go to Step2, otherwise.

Step2: Select the action according to current stat. The probability to excute certain action can be calculate by the following equation.

$$p(a_i / s_0) = \frac{\{1/Q(s_0,a_i)\}}{\sum_j \{1/Q(s_0,a_j)\}} \qquad (35)$$

Step3: Excute the selected action, obtain the immediate rewards r and the next state. The objective of our model is to minimize the waiting time of QCs, therefore, r denote the time penalty to excute certain action, namely the change of QCs waiting time. r can be calculated by equation(36). Where, $n^{'}, n$ are number of QCs waiting YTs at time $t^{'}, t$, D_i is the time that QC i can start next operation task.

$$r = \sum_{i=1}^{n^{'}} \max(0, t^{'} - D_i) - \sum_{i=1}^{n} \max(0, t - D_i) \qquad (36)$$

Step4: Update Q accoring to equation(33).

Step5: Update the system state, let $n = n + 1$.

Step6: If the stop criterion is reached, stop the algorithm; and go to Step1 otherwise.

N is the maximum number iterations. In the first iteration, the probabilities to select all the possible actions will be the same. However, with the iteration repeats, action with a smaller estimate of $Q(s,a)$ has a higher probability to be selected. By the iterations, the optimal scheduling rule for YTs can be obtained.

To apply Q-learning, the states and policies table should be designed. In this paper, the state is determined according to the number of waiting YTs (Table3), where, n denotes the number of QCs in processed operation. Three actions (dispatching rules) are used, namely assign YTs to the longest waiting QC(LW), assign YTs to the container with longest travel time (LT), and assign a YT to a fixed QC (single-crane oriented, SCO). Thus the table for $Q(s,a)$ can be denoted as Table 3.

Table 3: State policy for Q-learning algorithm for ship based sharing method

State	State criteria	LW	LT	SCO
Dummy state	No waiting QC	0	0	0
Dummy state	One waiting QC	0	0	0
1	Number of waiting QCs=1	Q(1,1)	Q(1,2)	Q(1,3)
2	Number of waiting QCs =2	Q(2,1)	Q(2,2)	Q(2,3)
3	Number of waiting QCs =3	Q(3,1)	Q(3,2)	Q(3,3)
4	Number of waiting QCs =4	Q(4,1)	Q(4,2)	Q(4,3)
5	Number of waiting QCs =5	Q(5,1)	Q(5,2)	Q(5,3)
6	Number of waiting QCs =6	Q(6,1)	Q(6,2)	Q(6,3)
7	Number of waiting QCs =7	Q(7,1)	Q(7,2)	Q(7,3)
8	Number of waiting QCs =8	Q(8,1)	Q(8,2)	Q(8,3)
i	Number of waiting QCs =i	Q(i,1)	Q(i,2)	Q(i,3)
n	Number of waiting QCs =n	Q(n,1)	Q(n,2)	Q(n,3)

The value of α influences the learning efficiency, it can be constant or change with the learning process. In this paper, we suppose $\alpha = 0.1$. The value of γ is between 0 to 1, if is close to zero, only the immediate penalty will be considered when selecting an action; if it is close to one, the immediate penalty has a small weight relative to succeeding cumulative penalty. Because this paper is attempted to minimize the total penalty in the long run, γ is set to be 0.9.

5.3 Numerical tests

Suppose 6 QCs are assigned to process unloading operation; the processing time of QCs are generated from uniform distribution of $U(100,150)$ seconds; the number of YTs are 30; the number of unloading containers are 400; and the travel time of YTs from quaysise to yard storage follows the uniform distribution of $U(8,11)$ seconds. The number of iterations is 10,000. Results are shown as Figure3. From the results, we can find that the algorithm can reach convergence efficicently.

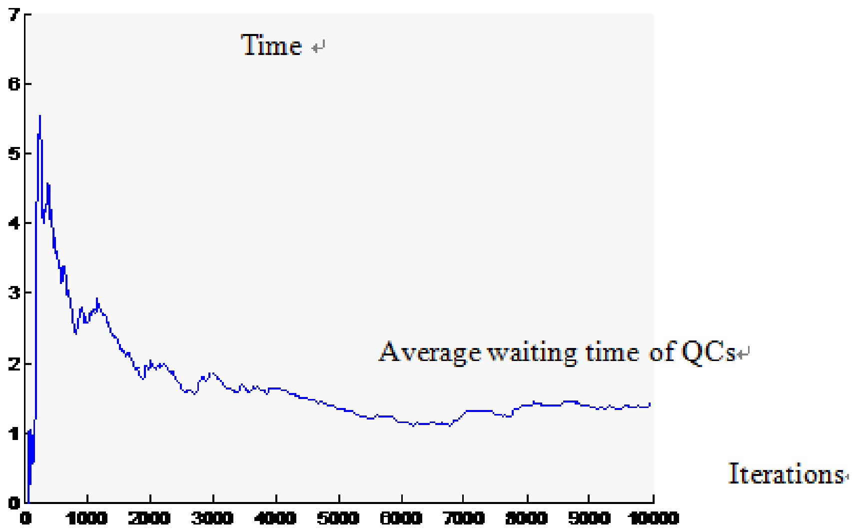

Figure 4: Results of Q-learning algorithm

Furthermore, numerical tests are used to compare Q-learning algorithm and other three scheuling rules e.g. LW, LT, SCO. Table 4 shows the average QC waiting time of the four methods and the selected probability of LW, LT, SCO rules in Q-learning. From the results, we can find that SCO is the worst rule of three rules (LW, LT and SCO), and the LW is the best one. When the number of YTs is

25, Q-learing is not the best methods comparing to other three rules, but in other conditions (when the numbers of YTs are 30, 35, 40 respectively), Q-learning is the best one. This indicates that with the increase of YTs, Q-learing algorithm becomes more efficient comparing to other three rules. In the results of Q-learning algorithm, LW is the rule be selected with highest probability, and SCO is the rule be selected with lowest probability. Also, the results in Table 4 indicate that Q-learing method is better than "single-crane oriented" method (in Table 4 SCO rule is "single-crane oriented" method).

Table 4 Average QC waiting time of different scheduling policies

Rules	Number of YTs			
	25	30	35	40
SCO	6.9873	3.8525	1.8374	1.3803
LW	2.7280	1.1837	0.5471	0.2524
LT	3.8391	1.3872	0.8735	0.3589
Q-learning	2.8290	0.9529	0.3201	0.2029
SCO (%)	5.14	3.01	3.47	1.35
LW(%)	80.26	86.42	81.96	89.83
LT (%)	14.58	10.57	14.57	8.82

6. Conclusion

In this paper, "single-crane oriented"method for operation scheduling in container terminals is studied. Two models are developed, namely model for inter-ship based sharing method and model for ship based sharing method. And two-phase tabu search algorithm and Q-learning algorithm are designed to sovle the two models respectively. Numerical tests are used to test the proposed models and algorithm.

Numerical results show that inter-ship based method can decrease YTs empty travel, improve the YTs utilization, and thus improve the operation efficiency of container terminals. Ship based sharing method can reduce the disequlibrium of different working line, and thus can improve the loading or unloading efficiency.

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Analysis of Dynamic Correlation between Dry Bulk Shipping Freight Indices

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Abstract

The purpose of this paper is to investigate the volatilities and correlations of Baltic Exchange Capesize Index and Baltic Exchange Panamax Index in the dry bulk shipping freight industry, which could be helpful for the hedging and portfolio on the shipping market. This paper applies the Dynamic Conditional Correlation Multivariate Generalized Autoregressive Conditional Heteroscedasticity model to analyze the volatilities and correlations, and the parameters of the model are estimated via the software package Matlab. The empirical results based on the returns of Baltic Exchange Capesize Index and Baltic Exchange Panamax Index from fifth Mar 1999 to ninth April 2008 suggests the changes of correlations between the two markets (Baltic Exchange Capesize market and Baltic Exchange Panamax market) and the volatilities on each market.

Keywords: Dry bulk; Freight index; Correlation; Volatility; DCC-MVGARCH model

1. Introduction

The volatility is always the hot point of market research. One side, the volatility is closed to the characters of uncertainty and risk, which is important for the corporations to do the risk management, investment and decision-making. The other, volatility is the key variable in assets pricing. Then, are there some influences and relationship between different markets? If it is true, how about the correlations change?

Correlations and volatilities are critical inputs for risk management on financial market, also on the shipping market. Hedges require estimates of the volatilities and correlation between the returns of the assets in the hedge, for example, it needs understand the volatilities and correlations between different shipping freight markets in the hedge with forward freight agreement. If the correlations and volatilities are changing, then the hedge ratio should be adjusted to account for the most recent information. Also it is necessary to know the volatilities and correlations in asset allocation and risk assessment.

Recently, in the area of financial market volatility research, it is considered that heteroskedasticity models are good at characterizing the financial market volatility. So the ARCH family models are used to the research on financial market volatility, also in shipping market. Kavussanos studies a lot about the volatilities in shipping industry. In his 1996 study, he models the volatility directly of various types of ship prices (e.g., spot versus time-charter) and discovers that the various prices have all exhibited consistently large periods of volatility (that tend to time-cluster). In 1997, he examines the dynamics of conditional volatilities in the world dry-bulk market for second-hand ships with the ARCH models, and he finds that broadly speaking prices of small vessels are less volatile than larger ones, and the nature of these volatilities vary across sizes; conditional volatilities of Handysize and Panamax prices are positively related to interest rates and Capesize to time-charters.

With the development of the heteroskedasticity models, some experts propose multivariate dimensions time series models. Bolerslev (1988) propose VECH-GARCH model to investigate the vector

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volatilities process; and in 1995, Engle and Kroner put forward the GARCH (1, 1)-BEKK model, which balances generality with parsimony, but it could not be deemed to be worth pursuing in view of the algebraic complications. In 2002, Engle and Sheppard proposed a new method – Dynamic Conditional Correlation, which could research dynamic correlation between different markets or assets, and they analyze the performance of Dynamic Conditional Correlation methods for large covariance matrices.

So this paper introduces the Dynamic Conditional Correlation Multivariate Generalized Autoregressive Conditional Heteroscedasticity (DCC-MVGARCH) model which could describe the correlations and volatilities well and apply it to research the volatility and correlations in dry bulk shipping industry.

The primary contribution of this paper is therefore the development of a framework of researching volatilities and correlations in shipping industry; also it could be useful for risk management in shipping industry, such as hedging (e.g. with Forward Freight Agreement) and portfolio.

The remainder of this paper is structured as follows. Section 2 describes the methodology and presents some theoretical considerations. The empirical results are presented in Section 3. The last section concludes the paper.

2. Methodology and Theoretical Consideration

2.1 DCC-MVGARCH model

Dynamic Conditional Correlation Multivariate Generalized Autoregressive Conditional Heteroscedasticity (DCC-MVGARCH) model (Engle and Sheppard, 2002) could estimates correlation parameters matrix of large scale, which insists that the correlation parameters are dynamic, they change with time. The Dynamic Conditional Correlation estimators have the flexibility of univariate GARCH model but not the complexity of conventional multivariate GARCH. The model which parameterize the conditional correlationas directly, is naturally estimated in two steps- the first is a series of univariate GARCH estimates and the second the correlation estimate. Therefore, potentially very large correlation matrices can be estimated.

The DCC-MVGARCH model is defined as follows:

$$r_t = u_t + e_t \tag{1}$$

$$e_t \left| \Omega_{t-1} \sim N(0, H_t) \right. \tag{2}$$

$$H_t = D_t R_t D_t \tag{3}$$

$$Q_t = (1 - \sum_{m=1}^{M} \alpha_m - \sum_{n=1}^{N} \beta_n)\overline{Q} + \sum_{m=1}^{M} \alpha_m (\varepsilon_{t-m} \varepsilon_{t-m}^{'}) + \sum_{n=1}^{N} \beta_n Q_{t-n} \tag{4}$$

In this model, the conditional variance matrix can be expressed as $H_t = D_t R_t D_t$. Ω_t indicates the information set for the r_t at time t.

$\overline{Q} = T^{-1} \sum_{t=1}^{T} \varepsilon_t \varepsilon_t^{'}$. It represents the unconditional variance matrix of standardized residuals.

$R_t = (Q_t^*)^{-1} Q_t (Q_t^*)^{-1}$, $Q_t^* = diag(\sqrt{q_{11}, t}, \sqrt{q_{22}, t}, \cdots, \sqrt{q_{kk}, t})$, R_t represents dynamic correlation parameter matrix.

$D_t = diag(\sqrt{h_{it}})$,

$h_{it} = \omega_i + \sum_{p=1}^{p_i} \alpha_{ip} e_{it-p}^2 + \sum_{q=1}^{Q_i} \beta_{iq} h_{it-q}$, it means that every asset return obeys GARCH (p, q).

$\varepsilon_t^{'} = D_t^{'} e_t$, it represents vector standardized residuals.

2.2 Parameters Estimating

The DCC model could be estimated consistently using a two-step approach. The first, estimating the GARCH process of every asset. The second estimate dynamic conditional correlation parameters with the standardized residuals estimated by the first step. Start to estimate the parameters of DCC-MVGARCH model only after doing the tests, such as the autocorrelation test.

The likelihood functions in the first step could be expressed as:

$$QL_1(\phi|e_t) = -\frac{1}{2}\sum_{t=1}^{T}\left(k\log(2\pi) + 2\log(|D_t|) + \log(|R_t|) + \varepsilon_t^{-1} R_t^{-1} \varepsilon_t^{-1}\right) \quad (5)$$

On the basis of the first step results, the likelihood function in the second stage is as follows:

$$QL_1(\varphi|\hat{\phi}, e_t) = -\frac{1}{2}\sum_{t=1}^{T}\left(k\log(2\pi) + 2\log(|D_t|) + \log(|R_t|) + \varepsilon_t^{-1} R_t^{-1} \varepsilon_t^{-1}\right) \quad (6)$$

Engle and Sheppard explain that the estimators obtained by maximizing the following likelihood function:

$$QL_2^*(\varphi|\hat{\phi}, e_t) = -\frac{1}{2}\sum_{t=1}^{T}(\log(R_t^{-1}) + \varepsilon_t^{'} R_t^{-1} \varepsilon_t) \quad (7)$$

In the DCC (m, n), the first number represents the innovation lags of standardized residuals square, and the second number indicates the autoregressive term.

2.3 Hypothesis Test

The test method is proposed by Engle;

$$H_0: \; R_t = \overline{R} \quad (8)$$

$$H_1: \; R_t \neq \overline{R} \quad (9)$$

First, standardized residual multiplies unconditional correlation parameters. So under the hypotheses of H_0, it could be expressed as the method of VAR that:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \cdots + \beta_s Y_{t-s} + e_t \quad (10)$$

Resolve the equations with the seemingly unrelated regression, and use TR^2 to test the correlation. $TR^2 \sim \chi^2(s)$.

3. Empirical Result

3.1 Description of the data and preliminary statistics

The data set comprises daily observations of Baltic Capesize Index and Baltic Panamax Index. It covers the periods fifth Mar 1999 to ninth Apr 2008. The data are from the Baltic Exchange, and shown in graphical form in Figure 1 and Figure 2.

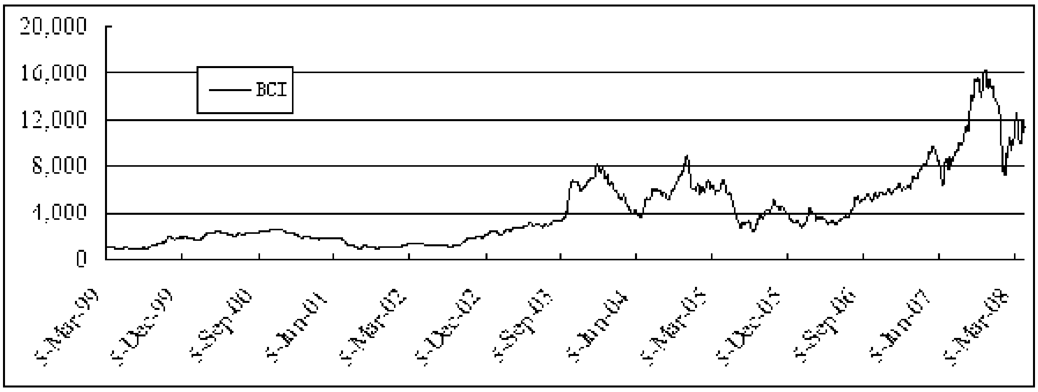

Figure 1: BCI; daily data (3/5/1999-9/4/2008)

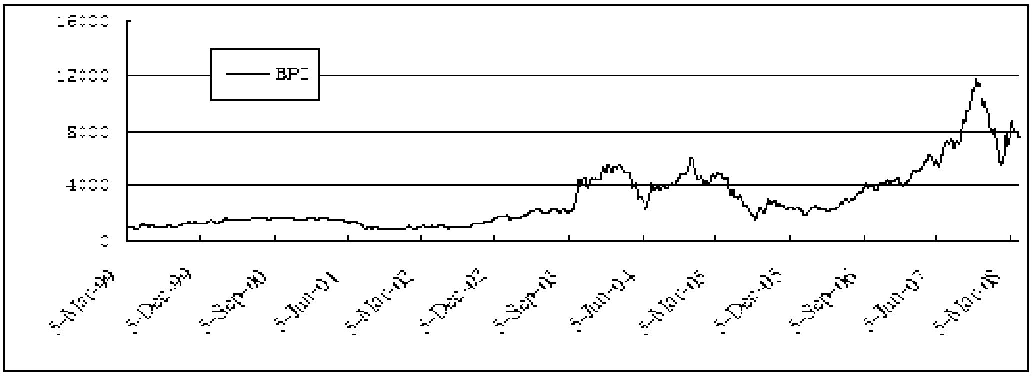

Figure 2: BPI; daily data (3/5/1999-9/4/2008)

When studying financial time series, usually, the researchers analyze the daily return data, also this paper does the same work, calculates the daily return data. There are two methods to deal with the data of daily return, one is simple, return $r_t = \frac{P_t - P_{t-1}}{P_{t-1}}$, P_t is the index at time t. The other is the logarithmic return, $R_t = \ln P_t - \ln P_{t-1}$, and using $y_t = \left[R_t - \frac{1}{T}\sum_{t=1}^{T} R_t \right]$ to amend, then get the daily return series. Most of researches make use of the latter, and this paper does too.

The daily returns data are shown in graphical form in Figure 3 and Figure 4.

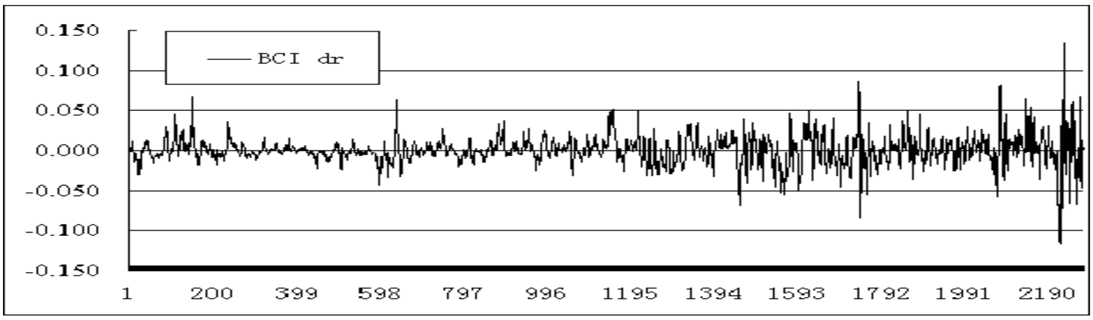

Figure 3: BCI daily returns

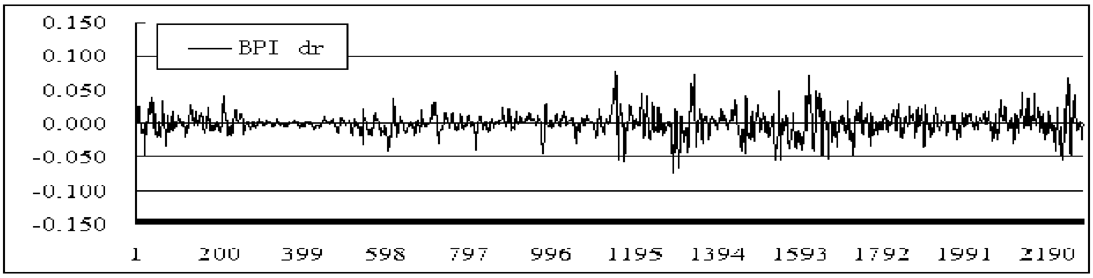

Figure 4: BPI daily returns

The descriptive statistics of the returns are reported in Figure 5 and Figure 6.

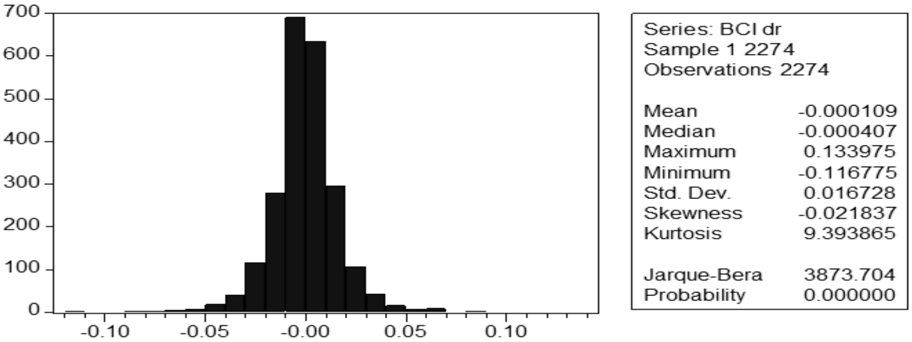

Figure 5: BCI dr descriptive statistics

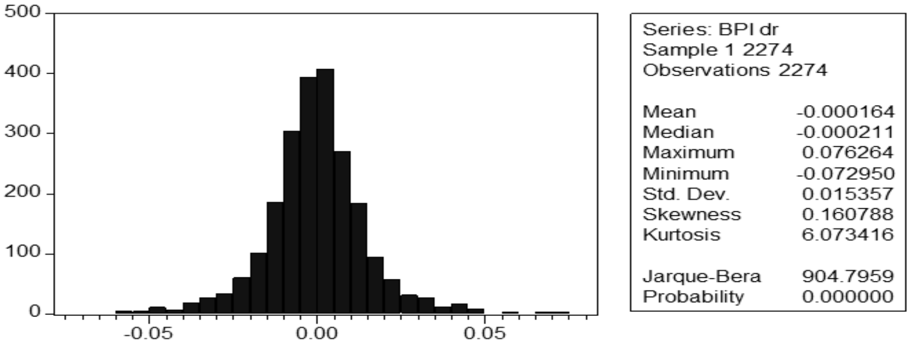

Figure 6: BPI dr descriptive statistics

From the descriptive statistics results, they indicate excess skewness and kurtosis. In turn, Jarque-Bera tests indicate departures from normality for the returns.

Figure 7 and Figure 8 show the autocorrelation and partial correlation tests of the returns, so we should considerate the autocorrelation and partial correlation in the model.

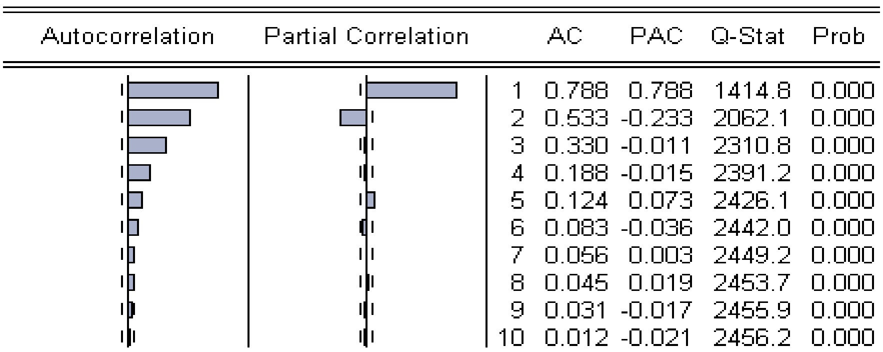

Figure 7: The correlation test of BDI dr

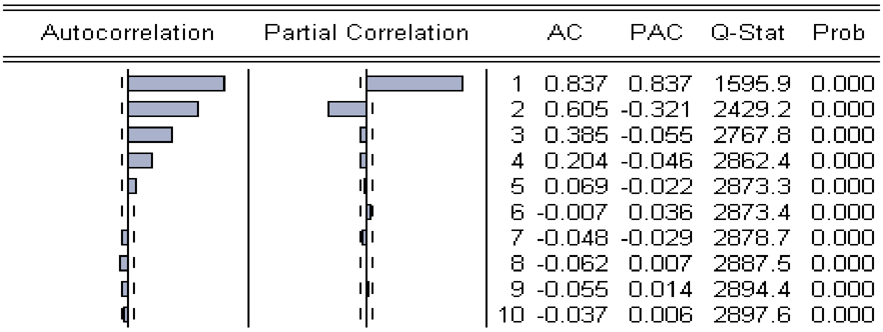

Figure 8: The correlation test of BPI dr

The Augmented Dickey-Fuller test statistic display that the two time series have no unit root, they are stationary seen from Table 1 and Table 2.

Table 1: the unit root test of BCI dr

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.651	0.0000
	1% level	-3.433	0.0000
Test critical values:	5% level	-2.863	0.0000
	10% level	-2.567	0.0000

Table 2: the unit root test of BCI dr

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.957	0.0000
	1% level	-3.433	0.0000
Test critical values:	5% level	-2.863	0.0000
	10% level	-2.567	0.0000

In this paper, the ARCH LM test is used to test the ARCH effect. Form the Table 3; it indicates that the returns have stronger ARCH effect.

Table 3: ARCH test

BCI dr	F-statistic	67.67	Probability	0.00
	Obs*R-squared	186.65	Probability	0.00
BPI dr	F-statistic	93.40	Probability	0.00
	Obs*R-squared	249.78	Probability	0.00

3.2 Estimating Results

The Akaike info criterion and Schwarz criterion are used to select the suitable autocorrelation (AR) model, which could filter the return data. The two returns AR models are calculated in the following table.

Table 4: The AR model

	AR model
BCI dr	$r_t = 0.972 r_{t-1} - 0.233 r_{t-2} + e_t$
BDI dr	$r_t = 1.106 r_{t-1} - 0.321 r_{t-2} + e_t$

Test the AR model, and it is found that the residual series have no autocorrelations. Then get the GARCH model to estimate the returns by minimizing the AIC standard. Table 5 displays the results.

The higher α , the higher sensitive for the innovation to the market. And $\lambda = \alpha + \beta$ represent the persistence of the returns volatilities. If the λ is closer to one, it indicates that the volatilities trend is longer in future.

Table 5: The GARCH parameters estimator and the DCC parameters

	α	β	$\lambda = \alpha + \beta$
BCI dr	0.201	0.789	0.989
BPI dr	0.180	0.808	0.988
DCC(1,1)	0.011	0.957	0.968

From the Figure 9, it shows that the stationary correlation is 0.48, the correlation is not strong. But the dynamic correlations indicate that volatilities between the correlations of BCI returns and BPI' is bigger.

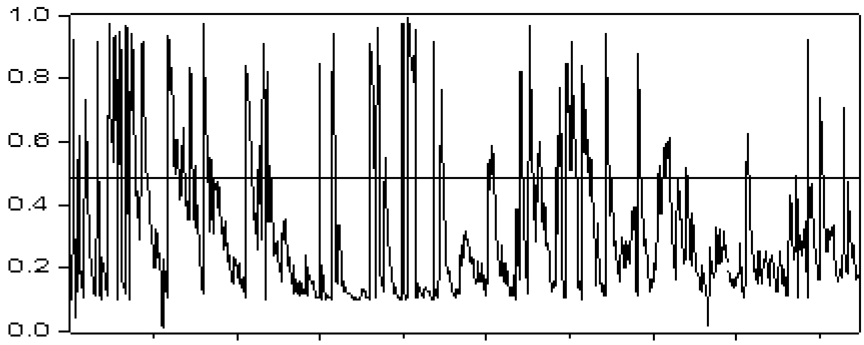

Figure 9: The correlation and the dynamic correlation

Finally, make the test for the dynamic correlation parameters. Test the remarkable difference between the correlation and stationary correlation, by the hypothesis test. $\chi^2 = 13.46$, P=0.018, P<0.05, so it indicates the correlation is dynamic. That is to say the changes on one market could influence on the other more or less.

4. Conclusion

This paper applies the Dynamic Conditional Correlation Multivariate Generalized Autoregressive Conditional Heteroscedasticity model, according to the characters of the daily return series, by the software of Matlab to estimate the parameters and make the tests. And it is found that the correlation on the Baltic Capesize Index and Baltic Panamax Index is dynamic.

According to the results of Dynamic Conditional Correlation Multivariate Generalized Autoregressive Conditional Heteroscedasticity model, we can get some conclusions that the volatilities on the Baltic Capesize market and Baltic Panamax market are correlative, and have the volatilities spill effect. The returns change on Baltic Capesize market could make some influences on Baltic Panamax market more or less, and in turn, it is true too.

As a result of the dynamic correlation between the two indices markets, if the correlations and volatilities are changing, then the hedge ratio should be adjusted to account for the most recent information, so the investors and risk managers must think over it, and then make the decisions, such as hedging or portfolio.

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Risk Evaluation on Extreme Volatilities of Dry Bulk Ocean Freight Market

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Abstract

A systemic risk evaluation on volatility of dry bulk ocean shipping freight market is proposed to look into shipping properties of long memory and extreme fluctuation. Long memory in dry bulk ocean freight market is measured well based on which a stochastic volatility model is implemented to filtrate the correlation of the daily returns. Then, the focus lies on feasibility of normal distribution hypothesis of freight daily returns and its tailed behavior that makes significant effects on extreme volatility in dry bulk ocean shipping. Moreover, the accurate asymptotical distribution of freight daily returns is constructed and then applied to study the value at risk of dry bulk ocean shipping while extreme volatilities happen. In conclusion the theoretical framework of risk evaluation on extreme volatilities of dry bulk ocean freight market is set up from a few of different viewpoints to make instructive advices for operators and investors who can analyze the market more efficiently and make the decision more rationally.

Keywords: Dry Bulk Ocean Shipping; Freight Market; Long Memory; Extreme Volatilities; Risk Evaluation

1. Introduction

In the past decades more and more volatilities have been happening to the dry bulk ocean freight market, which incurred higher and higher risk and then greater and greater loss for the shipping operators and investors. However, unlike participates in the stock market who would fairly prefer to hedging the risks, the operators and investors in the dry bulk ocean freight market would always like to take full advantages of the risks to win the extra profits for the well-known shipping saying ”Higher Risks, Higher Returns”, who regard negative returns as risks only if that are below some comparative values when the so-called extreme volatilities occur. Statistically, extreme volatilities are shown as fat tails in non-normal distributions of the daily returns for BDI (as BDIdr, similarly to daily returns for BPI as BPIdr and BCI as BCIdr). Therefore it is necessary to study features of the distribution and its tails' behavior so that risks that the operators and investors worry about could be measured accurately in the dry bulk ocean freight market.

More and more researchers have begun to focus on this point and try to find the internal rule and the characteristics of variation with the utilization of econometric measures in order to forecast short-term trend and to avoid risks. Veenstra and Franses (1997) studied monthly freight rates from September 1983 to August 1993 for three capesize and three panamax routes by using an augmented Dickey-Fuller test and then got a conclusion that the specification of these long-term relationships does not improve the accuracy of short-term or long-term forecasts, which can be interpreted as a corroboration of the efficient market hypothesis. Tvedt (2003) rejected the random walk hypothesis of dry bulk freight rate in most cases using the unit root tests, which confirmed the classical shipping market models that

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indicated stationary in freight rates. Adland and Cullinane (2005) presented a simple argument to reject the applicability of the expectations theory in bulk shipping freight markets by showing the risk premium must be time varying and must, in a systematic fashion, depending upon the freight market conditions and the duration of a period time charter. The remarkable work in this field has been done by Kavussanos et al. who works on the dry bulk market prices issues as early as the 1990's. He (1996) studied the volatility in both of the spot and time charter freight rates of dry bulk market. Then a study on the volatility of second hand dry-cargo ships has been done (1997). Kavussanos and Nomikos (2000) made estimations on time-varying and constant hedge ratios in the BIFFEX market with the result that the GARCH-X specification is better than a simple GARCH model to reduce risks. Kavussanos (2004) used VECM-GARCH model to investigate the lead-lag relationship in both return and volatilities between spot and futures markets. Furthermore, in another work with Visvikis and Batchelor (2004), Kavussanos made a deep view on FFA trading that has no detrimental effect on the spot market.

The common lesson from financial disasters is that billions of dollars can be lost because of poor supervision and management of financial risks. The value-at-risk (as *VaR*) was developed as the response to financial disasters of the 1990s and obtained an increasingly important role in market risk management. The *VaR* summarizes the worst loss over a target horizon with a given level of confidence. It is a popular approach because it provides a single quantity that summarizes the overall market risk faced by an institution or an individual investor. *VaR* has become a key subject when quantifying portfolio market risk. *VaR* determines the maximum loss a portfolio can generate over a certain holding period; and this allows us to control the portfolio risk level at any time. Therefore, *VaR* can be used, for instance, in the evaluation of portfolio managers' performance: it provides quantified risk.

It is well known that financial returns are non-normal and tend to be of fat-tailed distributions. In addition, the returns are often characterized by a number of stylized 'facts' such as volatility clustering. One attempt to capture the extra probability mass in the tails has been to estimate a generalized autoregressive conditional heteroskedastic (as *GARCH*) process (Bollerlev, 1986). The appealing feature of incorporating conditional volatility is that it allows for a changing distribution over time. Implementing this into a *VaR* framework means that the *VaR* estimates are made conditional. This is done in J.P. Morgan's RiskMetrics as an example. The unconditional distribution of a *GARCH* process does reveal fatter tails, however, conventional *GARCH* models are unable to capture the asymmetric effect of negative or positive returns on volatility.

This paper aims to employ *FIGARCH* to cover the short and long persistence of daily returns of BPI and BCI respectively more thoroughly than general *GARCH* in order to the residuals produced from the models specified could be the sample required by the extreme value theory that prefers to capture the extreme volatilities describing in tails of the series much better. Consequently, *VaR* method could be implemented on the residuals initially and then on the daily returns accurately so that the advantages of extreme value theory and *VaR* method could be merged delicately to set up a framework to make the risk evaluation for the operators and investors.

2. Methodology

2.1 Basic extreme value theory

Fortunately, extreme value theory has been well applied to capture the characteristics of similar volatilities in stocks market. For time series $\{X_t\}$ of some stock's daily returns, which is of an independent and identical distribution and the unknown cumulative probability function $F(x) = \Pr\{X_t \le x\}$, let $Worst_n$ be the minimum value when the negative daily returns take place for n times then $Worst_n = \min(X_1, \ldots, X_n)$ and the cumulative probability function of $Worst_n$ as Equation 2-1.

$$\Pr\{Worst_n \le x\} = \Pr\{X_1 \le x, \dots, X_n \le x\} = \prod_{i=1}^{n} F(x) = F^n(x) \tag{1}$$

Because the form of $F^n(x)$ keeps unknown and estimated badly by classical distribution functions, Fisher and Tippett gave the theorem *Fisher-Tippet* to asymptotically approximate $F^n(x)$ and then infer the form of $Worst_n$. Besides, if x is fixed and n is infinite asymptotically, $F^n(x)$ could be asymptotically approximate to 0 or 1 and the asymptotical form of $F^n(x)$ could be transformed to standardized form

$$Z_n = \frac{Worst_n - \mu_n}{\sigma_n} \tag{2}$$

where μ_n is the expectation of $Worst_n$, σ_n is the standardized variance of $Worst_n$ and $\sigma_n > 0$. According to *Fisher-TippetI* (1928), if Z_n converge to some non-negative distribution function, Z_n should satisfy the followings

$$G_\xi(z) = \begin{cases} e^{\left\{-(1+\xi z)^{-1/\xi}\right\}}, & \xi \ne 0, 1+\xi z > 0 \\ e^{\left\{-e^{-z}\right\}}, & \xi = 0, -\infty \le z \le \infty \end{cases} \tag{3}$$

where G_ξ is the distribution function of the tail's distribution for $\{X_t\}$, and ξ, nominated Tail Index, determines the tail behavior of G_ξ and the larger ξ is, the fatter the tail is.

If $\xi = 0$, $F^n(x)$ decreases by exponential function, and G_ξ behaves like distributions of thin tails, for examples, normal distribution, log-normal distribution, exponential distribution, and gama distribution, etc.

If $\xi > 0$, $F^n(x)$ decreases by powerful function, and G_ξ behaves like distributions of fat tails, for examples, generalized Pareto distribution (as *GPD*), and t distribution, etc.

If $\xi < 0$, $F^n(x)$ is of finite tails， G_ξ behaves like distributions of finite thin tails, for examples, uniform distribution, and beta distribution, etc.

Moreover as said above, the operators and investors in the dry bulk ocean freight market always pay much attention to the negative daily returns below some value that is nominated threshold *u* theoretically. So given a conditional distribution of $\left\{X_i \middle| X_i > u\right\}$

$$F_u(y) = \Pr\left\{X - u \le y \middle| X > u\right\} = \frac{F(y+u) - F(u)}{1 - F(u)}, \quad y > 0 \tag{4}$$

If -*u* is large enough, let (4) be approximate asymptotically by a positive function $\beta(u)$

$$G_{\xi,\beta(u)}(y)=\begin{cases}1-(1+\xi\dfrac{y}{\beta(u)})^{-\frac{1}{\xi}}, & \xi\neq 0\\ 1-e^{-\frac{y}{\beta(u)}}, & \xi=0\end{cases},\quad \beta(u)>0 \tag{5}$$

where $y\geq 0$, if $\xi\geq 0$; $0\leq y\leq -\beta(u)/\xi$, if $\xi<0$; and $G_{\xi,\beta(u)}$ is so-called *GPD*.
Given u_0, $\beta(u_0)$ and $F(u_0)$ could be inferred. If $u>u_0$, $\beta(u)=\beta(u_0)+\xi(u-u_0)$ and then F_{u_0+y} is of *GPD* with parameters ξ and $\beta(u_0)+\xi y$. If $X-u_0$ is of *GPD* with parameters $\xi<1$ and $\beta(u_0)$, the expectation of $X-u_0$ could be

$$E\left[X-u_0\middle|X>u_0\right]=\frac{\beta(u_0)}{1-\xi} \tag{6}$$

For $u>u_0$, $e(u)$ is given as followings

$$e(u)=E\left[X-u_0\middle|X>u_0\right]=\frac{\beta(u_0)+\xi(u-u_0)}{1-\xi} \tag{7}$$

then for $y=u-u_0>0$

$$e(u_0+y)=E\left[X-(u_0+y)\middle|X>u_0+y\right]=\frac{\beta(u_0)+\xi y}{1-\xi} \tag{8}$$

Hereby given ξ, $e(u)$ is the linear function of y, namely

$$e_n(u)=\frac{1}{n_u}\sum_{i=1}^{n_u}(x_{(i)}-u) \tag{9}$$

where $x_i>u$, $i=1$、2、…、n_u and $e_n(u)$ should be asymptotically linear approximation of u if $u<u_0$. Accordingly, the trend of its curve could be used to infer the tail behavior of negative daily returns: fat tailed if upward totally, and thin tailed if downward totally. More than that, given $u<u_0$, the tail distribution is *GPD* if the slope of the curve is positive and exponential distribution if negative. Correspondingly, the characteristics of the curve and its slope could be used to infer the u_0。

After u_0 is given previously, ξ and $\beta(u)$ could be estimated by the means of maximum likelihood estimation method.
If $\xi\neq 0$, the log-likelihood function of (5) is

$$l(\xi,\beta(u))=-k\ln(\beta(u))-(1+1/\xi)\sum_{i=1}^{k}\ln(1+\xi y_i/\beta(u)) \tag{10}$$

where $y_i\geq 0$ if $\xi>0$, and $0\leq y_i\leq -\beta(u)/\xi$ if $\xi<0$.

If $\xi=0$, the log-likelihood function of (5) is

$$l(\beta(u)) = -k\ln(\beta(u)) - \beta(u)^{-1}\sum_{i=1}^{k} y_i \tag{11}$$

Actually and empirically, $F_u(y) \approx G_{\xi,\beta(u)}$, if $-u$ is large enough.。From (4), let $x=u+y$, then the tail distribution $\{x_i \mid x_i > u\}$ could be approximated asymptotically as followings

$$F(x) = (1 - F(u))G_{\xi,\beta(u)} + F(u) \tag{12}$$

Then

$$\hat{F}(u) = \frac{(n-k)}{n} \tag{13}$$

where k is the number of x_i of $\{x_i \mid x_i > u\}$ that mean the extreme risks specified by the operators and investors. Furthermore, (13) is non-parametrical approximation of $F(x)$ essentially comparing to (5) that is parametrical approximation of $F(x)$. Both of them could combine as followings

$$\hat{F}(x) = 1 - \frac{k}{n}\left(1 + \hat{\xi}\cdot\frac{x-u}{\hat{\beta}(u)}\right) \tag{14}$$

where $\hat{\xi}$ and $\hat{\beta}(u)$ are estimates of ξ and $\beta(u)$ respectively using maximum likelihood estimation method. It is necessary to balance u and k, because k would be hard to work out efficiently if u is given as too small value previously.
Consequently, risks of the extreme volatilities could be measured using Value at Risk (as *VaR*) method based on the extreme value theory. As well-known, the *VaR* of $\{X_i\}$ is defined as followings

$$VaR = \mu - \sigma\alpha \tag{15}$$

where μ is the expectation of $\{X_i\}$, σ is the variance of $\{X_i\}$, and α is the quartile of the distribution of $\{X_i\}$.Then in other words, *VaR* is determined by features of the distribution of $\{X_i\}$ where (14) is the right distribution for daily returns of dry bulk ocean freight market when the extreme volatilities happen, so the *VaR* is rewritten as followings

$$VaR = u + \frac{\beta(u)}{\xi}\cdot\left(\left(\frac{n}{k}(1-q)\right)^{-\xi} - 1\right) \tag{16}$$

then the value specified above could be measured accurately.

2.2 Improved application

Unfortunately, the basic extreme value theory could not be directly implemented to model the extreme volatilities of dry bulk ocean freight market because daily returns of dry bulk ocean freight dissatisfy the most important prerequisite that the extreme value theory requires the time series specified is of an independent and identical distribution. That is to say the daily returns are correlative highly as proved well by literatures specified above. Therefore the correlation must be trailed off above all.

Auto Regressive Moving Average (as *ARMA*) model is an effective method to realized the goal but could only whittles the correlation of linearity or so-called first order moment whereas Generalized Auto-Regressive Conditional Heteroskedasticity (as *GARCH*) could play an ideal role about the correlation of non-linearity or so-called second order moment namely the volatilities besides the correlation of linearity. Here, parameters α and β from general *GARCH* for daily returns of dry bulk ocean freight market always result in $\sum_{j=1}^{p}\beta_j+\sum_{i=1}^{q}\alpha_i \geq 1$ which shows significant persistence of the second moment namely the variance. In order to make $\sum_{j=1}^{p}\beta_j+\sum_{i=1}^{q}\alpha_i \leq 1$, an Integrated *GARCH* (as *IGARCH*) (Engle,R.E and Bollerslev,T. ,1986) model is introduced with first difference namely *I*=1 before general *GARCH*, which also always result in $\sum_{j=1}^{p}\beta_j+\sum_{i=1}^{q}\alpha_i \approx 1$ empirically. Obviously, *IGARCH* could be transferred to *GARCH* if *I*=0. Both of them proves the daily returns correlated greatly not only in the first moment but also in the second moment. So it is reasonable to doubt that the daily returns include particularly significant correlation more than common correlation. Consequently and accordingly, a Fractal Integrated *GARCH* (as *FIGARCH*) (Baillie,R.T., Bollerslev,T., and Mikkelsen,H.,1996) model is developed to describe the correlation if 0<*I*<*1* as followings

$$\sigma_t^2=\omega\left[1-\alpha(L)\right]^{-1}+\left\{1-\left[1-\beta(L)\right]^{-1}\phi(L)(1-L)^d\right\}\varepsilon_t^2 \tag{17}$$

where L is a lagging operator; $\alpha(L)=\alpha_1 L+\alpha_2 L^2+\ldots+\alpha_q L^q$; $\beta(L)=\beta_1 L+\beta_2 L^2+\ldots+\beta_p L^p$; $\phi(L)=\left[1-\alpha(L)-\beta(L)\right](1-L)^{-1}$; the lagging order is $\left[\max\{p,q\}-1\right]$; and fractal difference operator is $(1-L)^d$. Apparently, parameter *d* is particularly nominated to measure the correlation specified above called long memory theoretically with a range $0\leq d\leq 1$. So the flexible *FIGARCH* could be *IGARCH* if *d*=1 and common *GARCH* if *d*=0, where *d* captures correlation of higher order but ϕ and β capture correlation of lower order.

After filtrating the total correlation of daily returns of dry bulk ocean freight market using *FIGARCH*, a residuals series could be produced simultaneously, which should be of an independent distribution. More than that, let the residuals series be of an identical distribution, such as normal or *t* distribution that is also the requirement of *FIGARCH*, then an independent and identical distribution could be worked out to be the data specified by the extreme value theory.

Consequently the *VaR* for the residuals series could also be calculated as above and then the *VaR* for the daily returns could be measured as followings

$$VaR_t^{dr}=\mu_t-VaR_t^{residuals}\cdot\sigma_t \tag{18}$$

3. Analysis

<u>3.1 Data and basic statistical features</u>

BPI and BCI could be most important indices in dry bulk ocean freight market. Take BPI and BCI from Nov,2nd,1999 to Feb,29th,2008, 2083 observations respectively and totally, as the statistical sample. Moreover, log daily returns are often used to this type of analysis by the means of

$$x_t=\ln P_t-\ln P_{t-1} \tag{19}$$

Figure 1 and Figure 2 show basic statistical features of BPIdr and BCIdr. The Skewness of BPIdr and BCIdr are larger than 0 and both the Kurtosis are also larger than 3 and both the Jarque-Bera statistics are larger the critical value too. All of them prove BPIdr and BCIdr of significant non-normal distribution and then strongly fat tails. Furthermore the Skewness is larger for BPIdr than for BCIdr and the Kurtosis is smaller for BPIdr than for BCIdr, which means BPIdr scatter more greatly than BCIdr namely the extreme volatilities take place probably more often in Panamax freight market than in Capesize freight market.

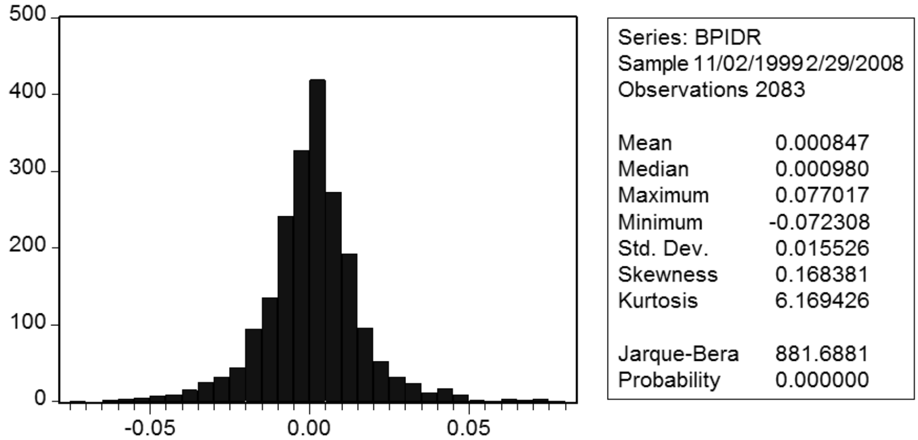


Figure 1: Basic statistical features of BPIdr

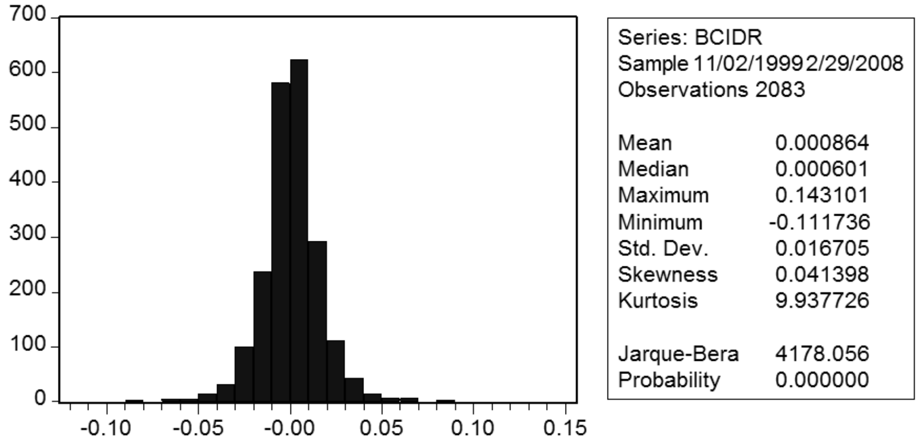
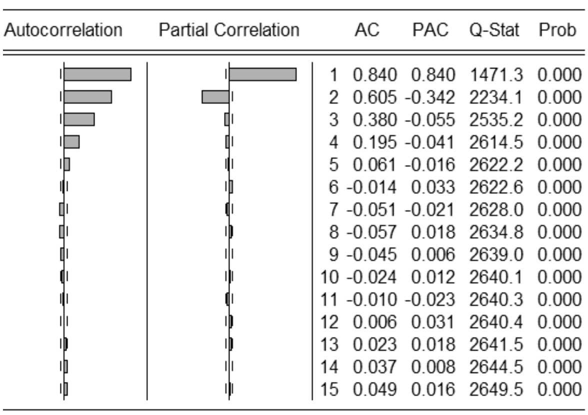


Figure 2: Basic statistical features of BCIdr

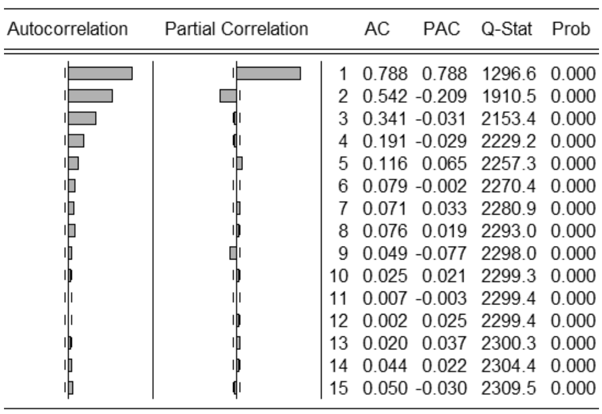
3.2 Filtration of Correlation

BPIdr and BCIdr are highly linearly correlated using Ljung-Box Q test giving as followings.



	AC	PAC	Q-Stat	Prob
1	0.840	0.840	1471.3	0.000
2	0.605	-0.342	2234.1	0.000
3	0.380	-0.055	2535.2	0.000
4	0.195	-0.041	2614.5	0.000
5	0.061	-0.016	2622.2	0.000
6	-0.014	0.033	2622.6	0.000
7	-0.051	-0.021	2628.0	0.000
8	-0.057	0.018	2634.8	0.000
9	-0.045	0.006	2639.0	0.000
10	-0.024	0.012	2640.1	0.000
11	-0.010	-0.023	2640.3	0.000
12	0.006	0.031	2640.4	0.000
13	0.023	0.018	2641.5	0.000
14	0.037	0.008	2644.5	0.000
15	0.049	0.016	2649.5	0.000

Figure 3: Test on correlation of BPIdr



	AC	PAC	Q-Stat	Prob
1	0.788	0.788	1296.6	0.000
2	0.542	-0.209	1910.5	0.000
3	0.341	-0.031	2153.4	0.000
4	0.191	-0.029	2229.2	0.000
5	0.116	0.065	2257.3	0.000
6	0.079	-0.002	2270.4	0.000
7	0.071	0.033	2280.9	0.000
8	0.076	0.019	2293.0	0.000
9	0.049	-0.077	2298.0	0.000
10	0.025	0.021	2299.3	0.000
11	0.007	-0.003	2299.4	0.000
12	0.002	0.025	2299.4	0.000
13	0.020	0.037	2300.3	0.000
14	0.044	0.022	2304.4	0.000
15	0.050	-0.030	2309.5	0.000

Figure 4: Test on correlation of BCIdr

As said above, *ARMA* model could filtrate the linear correlation. But before the implementation of *ARMA*, it is necessary to test if BPIdr and BCIdr are stationary, where both *ADF* and *PP* tests prove them of significant stationarity giving Table 1.

Table 1: Test on stationarity of BPIdr and BCIdr

	ADF test	*PP* test
BPIdr	-18.4357 （0.0000）	-102535 (0.0000)
BCIdr	-18.2636 （0.0000）	-13.8456 （0.0000）

Note: Probability of acceptance in parentheses

Hereby *ARMA* modeled parameters for BPIdr and BCIdr are well shown as Table 2.

Table 2: *ARMA* model of BPIdr and BCIdr

	BPIdr	BCIdr
$AR(1)$	1.1395 （0.0000）	0.9724 （0.0000）
$AR(2)$	-0.3524 （0.0000）	-0.2247 （0.0000）
$AR(3)$	\	\
R^2 test	0.7435	0.6441
Adjusted R^2 test	0.7433	0.6439
S.E. of regression	0.0079	0.0100
Durbin-Watson	2.0257	1.9964
AIC	-6.8510	-6.3774
BIC	-6.8456	-6.3719
Inverted AR Roots	$0.57 \pm 0.17i$	0.59，0.38

Note: Probability of acceptance in parentheses

Then the *ARMA* modeled residuals of BPIdr and BCIdr are produced, whose linear correlation could be measured using histogram method namely describing correlated coefficients along a lagging line as Fig. Obviously, almost all correlated coefficients could not be beyond the up and down lines of 95% confidence interval, which means the residuals are not correlated greatly. However Fig shows correlation happens to squared residuals using the same diagnostic method, which proves the existence of non-linear correlation.

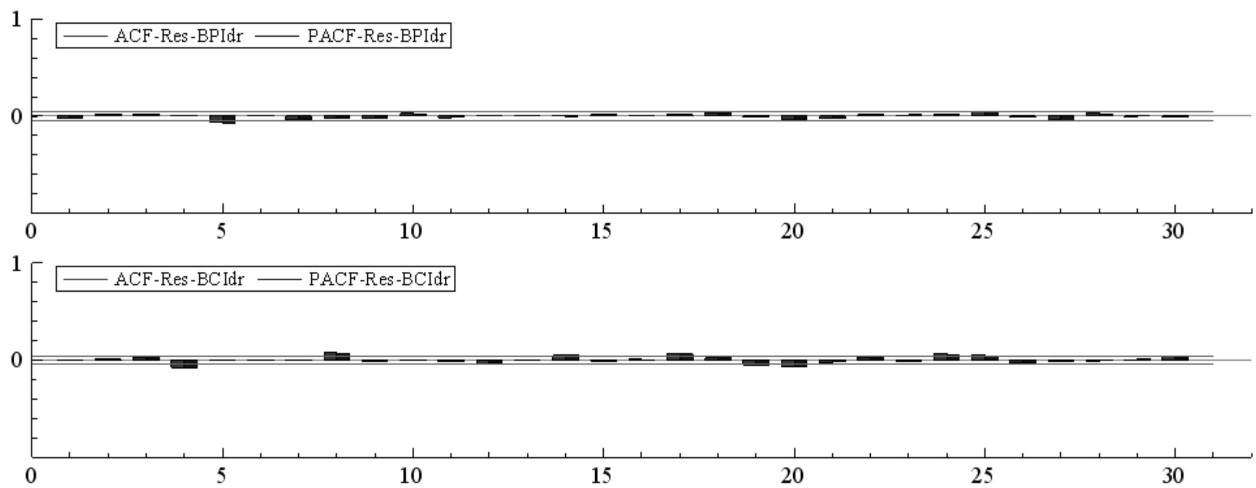


Figure 5: Test on correlation *ARMA* modeled residuals of BPIdr and BCIdr

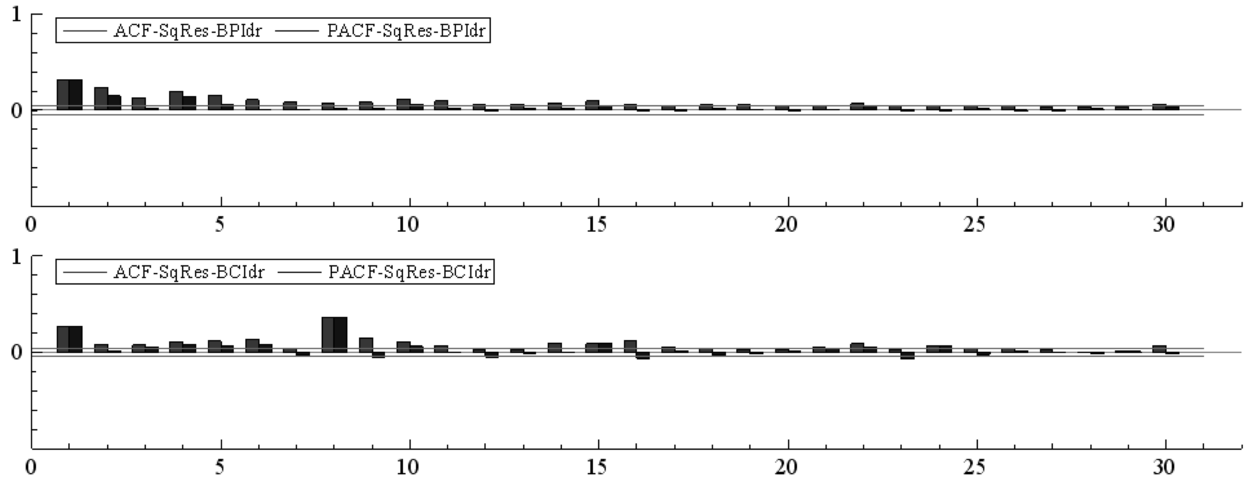


Figure 6:Test on correlation of *AR* modeled residuals of BPIdr and BCIdr

Furthermore it is reasonable to test the auto-regressive conditional heteroskedasticity (as *ARCH*) effects of BPIdr and BCIdr because such significant correlations of first order moment and second order moment could probably result in the former volatility affecting the later volatility to great extension and then large volatilities following large volatilities nominated Clustering of Volatilities, where *ARCH LM* test on the residuals is a well-known good method. Tab shows BPIdr and BCIdr are of significant *ARCH* effects.

Table 3:Test on *ARCH* effect of *ARMA* modeled residuals of BPIdr and BCIdr

	F-statistic	Obs*R-squared
BPIdr	233.1596 （0.0000）	203.8392 （0.0000）
BCIdr	163.3445 （0.0000）	151.5860 （0.0000）

Note: Probability of acceptance in parentheses

After all the above necessary diagnostic, it is time to filtrate the correlation of BPIdr and BCIdr using *FIGARCH* with a hypothesis that the residuals are of a non-normal distribution where taking *t* distribution. So as for BPIdr and BCIdr, let the function of their stochastic process be as followings

$$\begin{cases} x_t = \mu_t + \varepsilon_t \\ \varepsilon_t = z_t \cdot \sigma_t \end{cases} \tag{20}$$

where μ_t is the expectation, ε_t is stochastic error, z_t is residuals, σ_t is standardized variance, and the log-likelihood function of *t* distribution is

$$L_t = n\left\{\log\Gamma\left(\frac{\upsilon+1}{2}\right) - \log\Gamma\left(\frac{\upsilon}{2}\right) - \frac{1}{2}\log\left[\pi(\upsilon-2)\right]\right\} - \frac{1}{2}\sum_{t=1}^{n}\left[\log\left(\sigma_t^2\right) + (1+\upsilon)\log\left(1+\frac{z_t^2}{\upsilon-2}\right)\right] \tag{21}$$

where Γ is a gama function; υ is degree of freedom (as *df*) and $2 < \upsilon \leq \infty$ with the smaller υ is, the fatter the tail is. Tab shows the estimation for the *FIGARCH*.

Table 4: Estimation on *ARMA-FIGARCH*'s coefficients of BPIdr and BCIdr

	Model	BPIdr *FIGARCH*	BCIdr *FIGARCH*
Mean	*AR*(1)	1.1379 (0.0000)	1.0676 (0.0000)
	AR(2)	-0.3278 (0.0000)	-0.2593 (0.0000)
Variance	*Constant*	\	0.0242 (0.0000)
	d	0.4011 (0.0000)	0.5427 (0.0000)
	ARCH(1)	0.2852 (0.0000)	0.2018 (0.0000)
	GARCH(1)	0.4258 (0.0000)	0.4356 (0.0000)
	ARCH(1) + *GARCH*(1)	0.7110	0.6374
df		5.8384 (0.0000)	4.1388 (0.0000)
Criterion	*LLF*	7686.175	7552.700
	AIC	-7.3777	-7.2485
	SIC	-7.3614	-7.2295
	MSE	0.001051	0.001318
	MedSE	0.0002452	0.0002608

Note: Probability of acceptance in parentheses

It is necessary to make a total diagnostic asFigure 7 and Figure 8 about the residuals produced from the *FIGARCH* specified above in order to test if the correlation is modeled by the model. Both the curves of probability density functions for the residuals of BPIdr and BCIdr show *t* distribution is a comparatively suitable asymptotical approximation. Moreover the correlations of both first order moment and second order moment for the residuals of BPIdr and BCIdr are not significantly shown in the histograms, which proves the *FIGARCH* specified above could capture the correlation of BPIdr and BCIdr well.

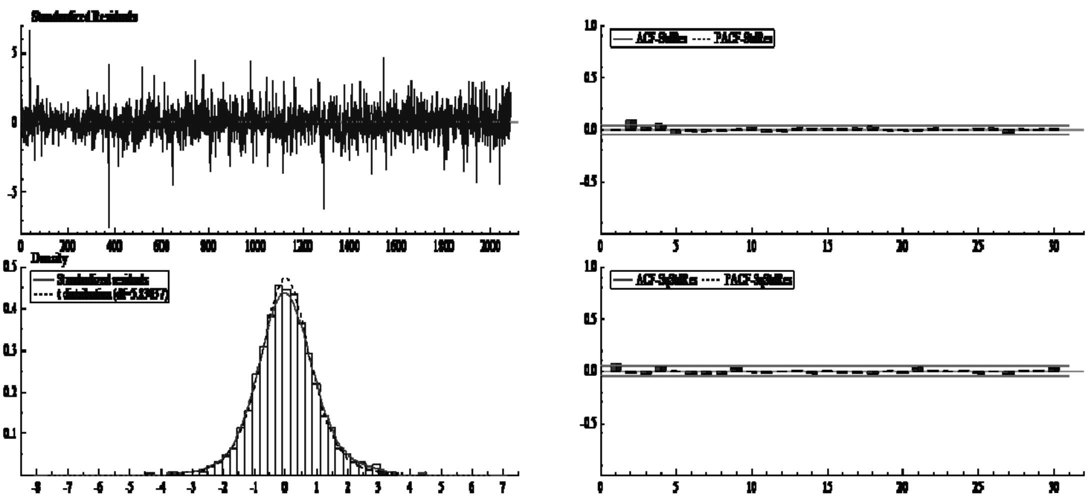


Figure 7: Curves of *FIGARCH* modeled residuals of BPIdr

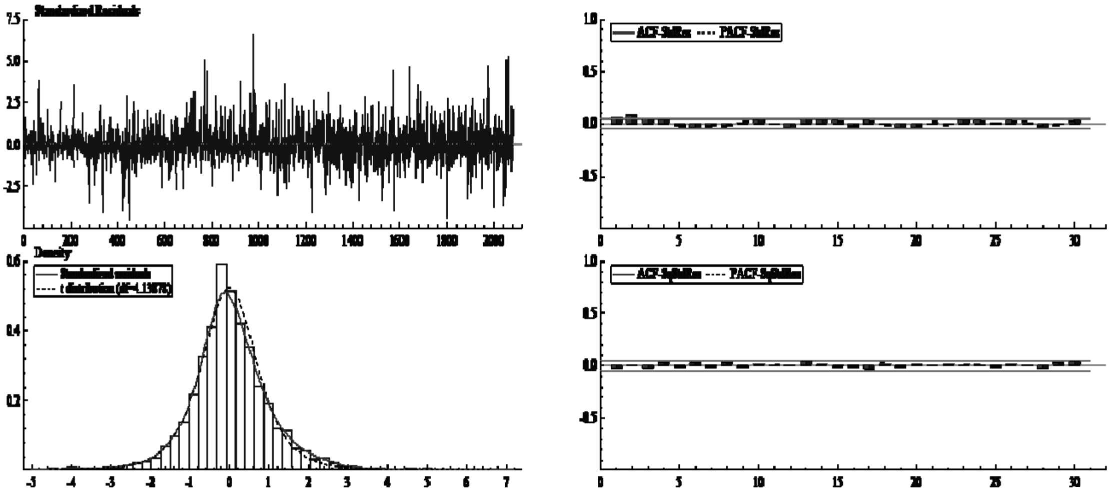


Figure 8: Curves of *FIGARCH* modeled residuals of BCIdr

Comparably speaking, *ARCH*(1)+*GARCH*(1) is larger for BPIdr than for BCIdr, which means short memory exists more strongly in Panamax freight market than in Capesize freight market. And *d* is smaller for BPIdr than for BCIdr, which means long memory exists less strongly in Panamax freight market than in Capesize freight market. Both of them are resulted from the fact that more operators and investors in Panamax freight market than in Capesize freight market could make good decisions according to recent historical information while could not master the trend in the long run, which alternatively guarantees the weak effectiveness of Panamax freight market in order to lead to the equilibrium of demands and supplies for Panamax fleets. Actually, some investigations from some giant bulk shipowners like COSBULK prove well that Panamax vessels really be the most flexible and effective fleets. In comparison, Capesize vessels fairly often carry cargoes of huge quantity and distance, such as coal and iron ore, which are always documented on Contract of Affeightment (as COA) and other similar contracts to fix freights for a long time instead of being sensitive to the close historical impacts so that Panamax freight market prefers to memorizing the information comparatively long time ago.

3.3 Tail's Features

After *ARMA-FIGARCH* modeled BPIdr and BCIdr, the residuals of BPIdr and BCIdr repectively could be required sample data by the extreme value theory. Take the upper tail of the residuals of BPIdr as the example to describe the analysis process on tail's features.

Firstly, the threshold u could be estimated initially by observing the curve of $e_n(u)$ giving the Threshold-Mean Excess of Fig. That shows the curve becomes upward linearly after threshold is beyond 1.25 so the threshold could be 1.25 probably. Moreover, the Exceedances-Shape of Fig shows ξ keeps comparably steady from 1.20 to 1.35 at the 95% confidence interval that is represented by the two dotted lines. Besides, the number of observations beyond the threshold 1.25 is about 8.85% of the total sample, which is an ideal proportion close to 10% proved by DuMouchel (1983). So the threshold for the residuals for BPIdr could be 1.25 approximately and the *Tail Index* $\xi = 0.2032$ also given by the Exceedances-Shape of Fig. Then the *GPD* for the upper tail of residuals of BPIdr is estimated as $GPD(0.2032, 0.5175)$.

Secondly, the *Tail Index* ξ and *GPD* specified above could be tested. On one hand, the curve of cumulative probability function of the *GPD* specified v.s. actual observations beyond the threshold 1.25 could test fitted *GPD*. As shown in x-Fu of Fig, almost all the actual plots scatter very closely near the curve, which means the *GPD* specified could fit the actual distribution of the upper tail of the residuals so well. On the other hand, the QQ plots could test fitted ξ. As shown in Order Data-Exponential

Quantiles of Figure 9, almost all the plots behave closely near the line, which means the ξ specified could fit the *Tail Index* also well.

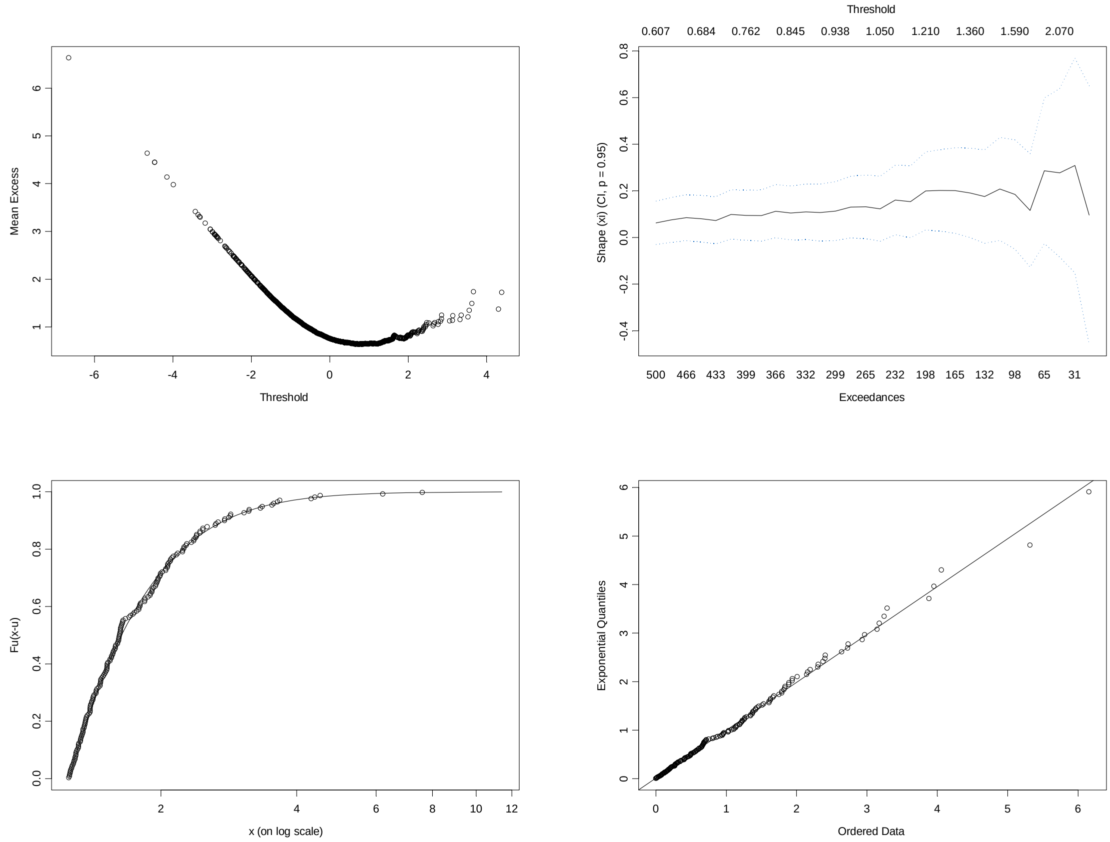
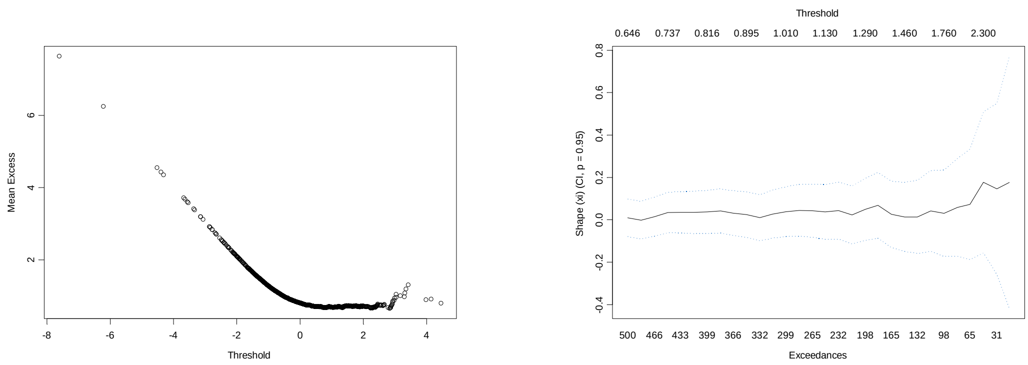


Figure 9: Estimation and test on lower tail index of BPIdr residuals

As above, *Tail Index* ξ and *GPD* for the lower tail of residuals of BPIdr could be estimated shown in Figure 10, which results in $u = 1.10$ and $GPD(0.0405, 0.6571)$.



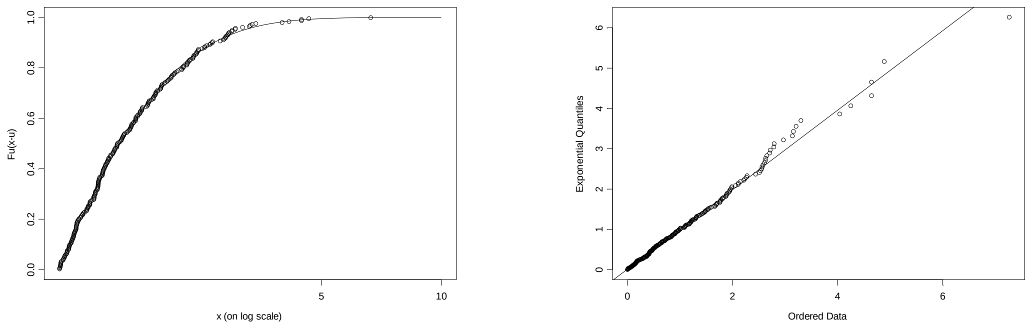


Figure 10: Estimation and test on upper tail index of BPIdr residuals

So the distribution of the residuals of BPIdr could be summarized accurately as followings

$$F(x) \sim \begin{cases} GPD(0.0405, 0.6571) & x > 1.10 \\ t(5.8384) & -1.25 \le x \le 1.10 \\ GPD(0.2032, 0.5175) & x < -1.25 \end{cases} \tag{22}$$

where the distribution is of *t* distribution with the degree of freedom 5.8384 if residuals are between the two thresholds namely -1.25 and 1.10 while *GPD* specified above. Furthermore, QQ plots of *GPD* specified v.s. lower and upper tails of actual residuals beyond the threshold behave like a straight line shown in

Figure **1**, which proves the good fitness of the *GPD* specified too.

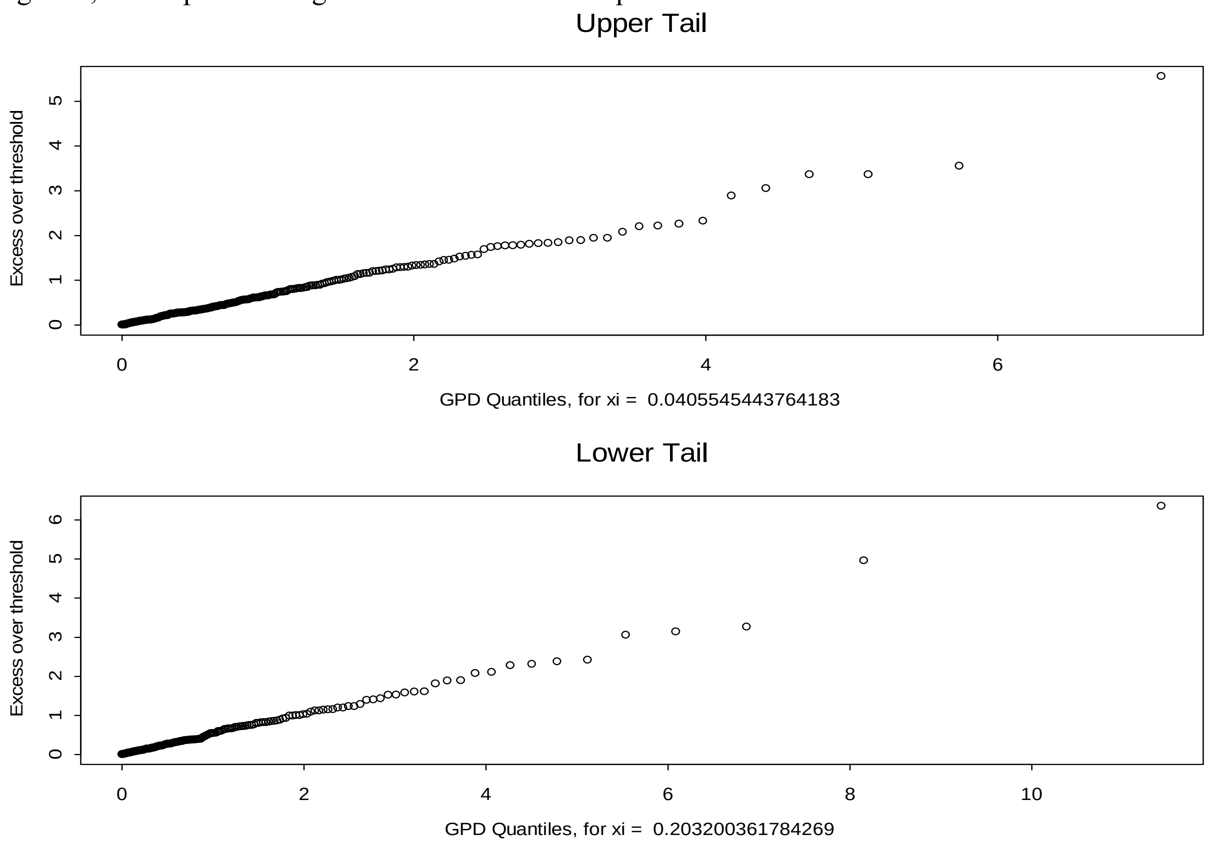


Figure 1: QQ plot of *GPD* of BPIdr residuals

As above, *Tail Index* ξ and *GPD* for the lower and upper tails of residuals of BCIdr could be estimated shown in

Figure **2** and

Figure **3**, which results in $u = 1.10$ and $GPD(0.0686, 0.6195)$ for the lower tail and $u = 1.10$ and $GPD(0.0541, 0.7390)$ for upper tail.

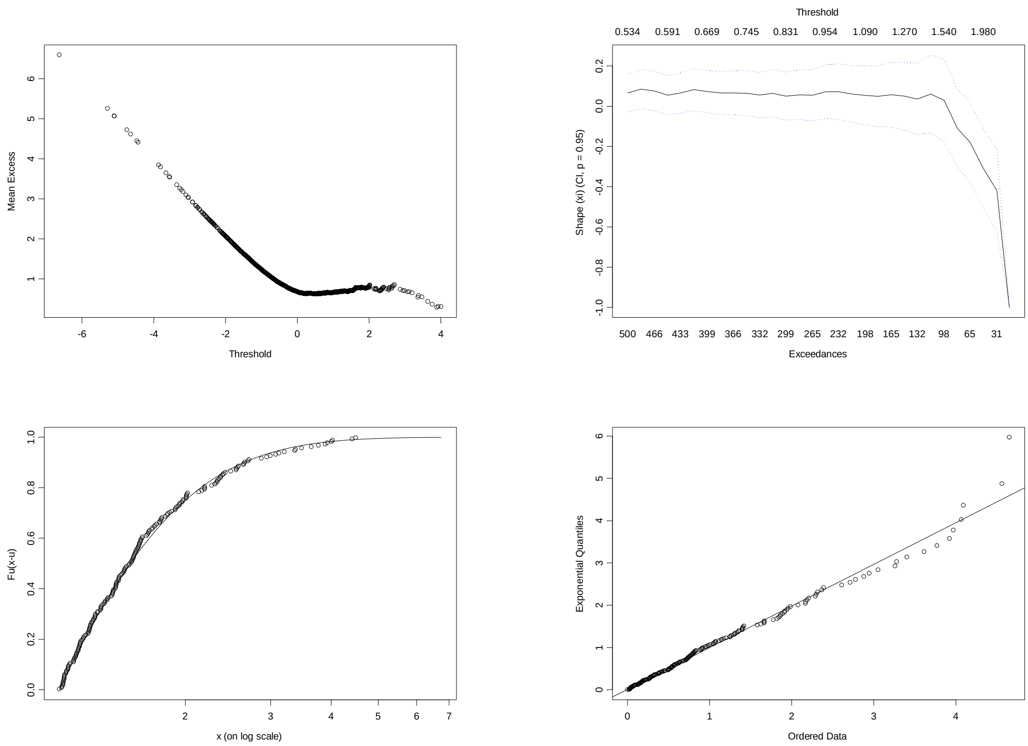


Figure 2: Estimation and test on upper tail index of BCIdr residuals

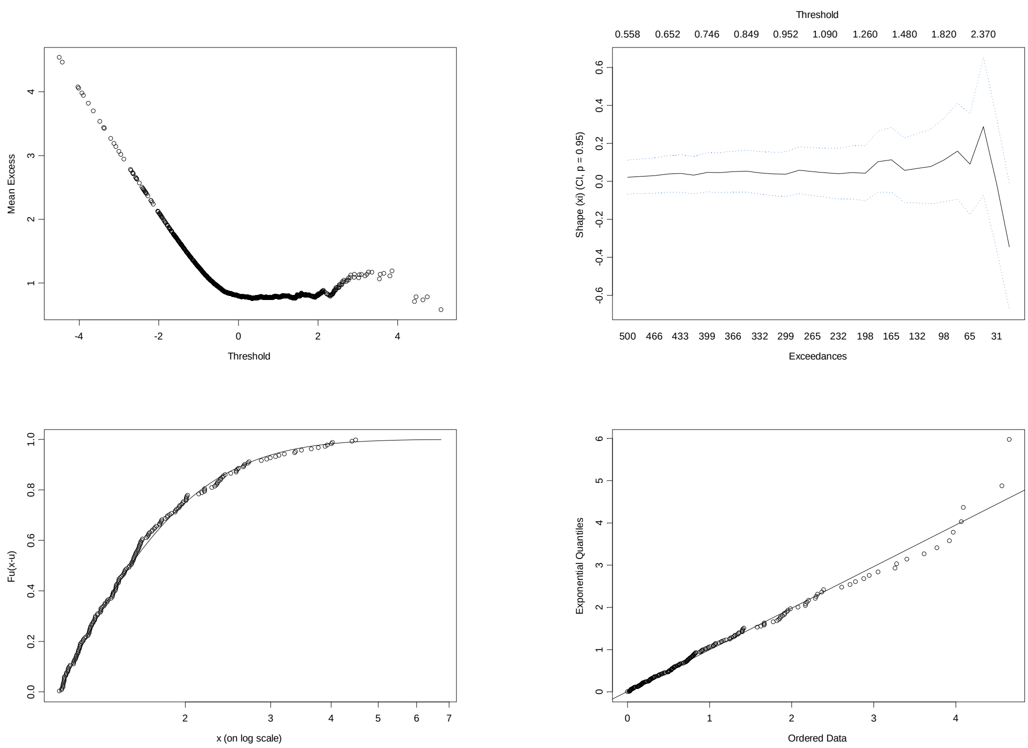


Figure 3: Estimation and test on upper tail index of BCIdr residuals

So the distribution of the residuals of BCIdr could be summarized accurately as followings

$$F(x) = \begin{cases} GPD(0.0541, 0.7390) & x > 1.10 \\ t(4.1388) & -1.10 \le x \le 1.10 \\ GPD(0.0686, 0.6195) & x < -1.10 \end{cases} \tag{23}$$

where the distribution is of *t* distribution with the degree of freedom 4.1388 if residuals are between the two thresholds namely -1.15 and 1.10 while *GPD* specified above. Furthermore, QQ plots of *GPD* specified v.s. lower and upper tails of actual residuals beyond the threshold behave like a straight line shown in Figure 4, which proves the good fitness of the *GPD* specified as well.

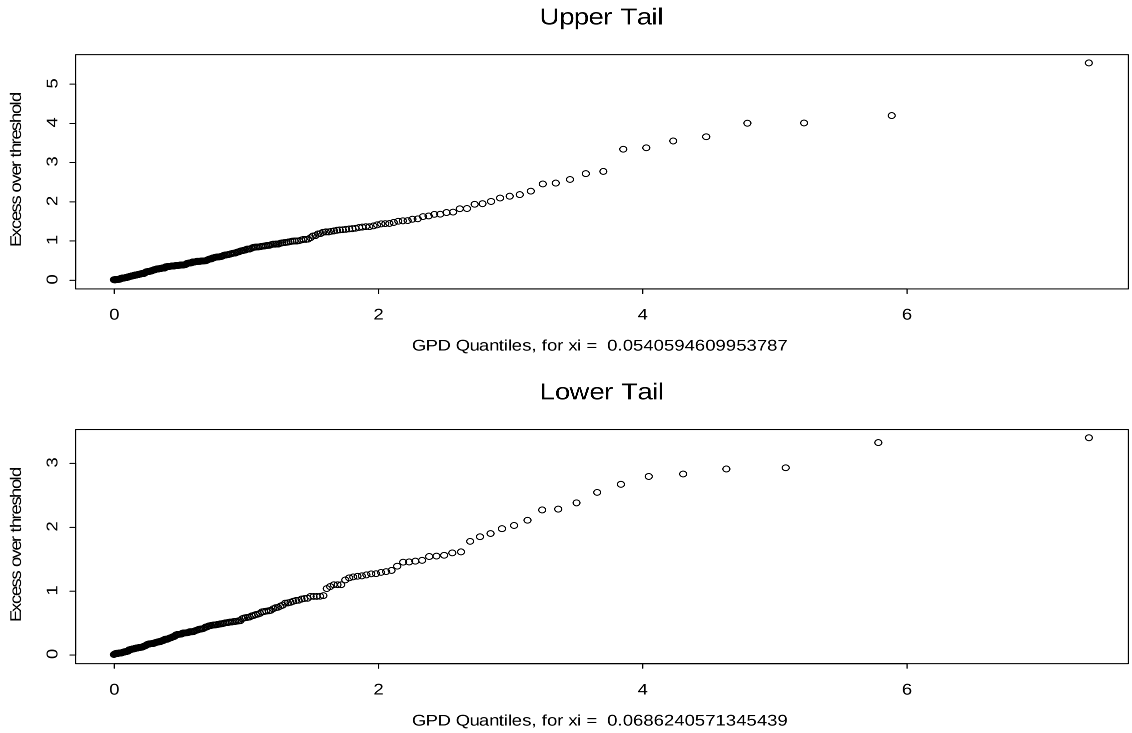


Figure 4: QQ plot of *GPD* of BCIdr residuals

General speaking, the *Tail Indices* of residuals of both BPIdr and BCIdr are positive respectively, which describes fat tail in Panamax and Capesize freight market from the perspective of the extreme value theory. More important, the ξ for residuals of BPIdr is larger for the lower tail than for the upper tail ,which means bad information persists longer in Panamax freight market than in Capesize freight market, while the fact reverses for good information. Other than that, the smallest ξ for the lower tail of residuals of BPIdr gives extreme volatilities resulting in loss happen to Panamax freight market most often.

3.4 Value at Risk

Consequently, *VaR* for residuals of BPIdr and BCIdr could be calculated respectively given as Tab.

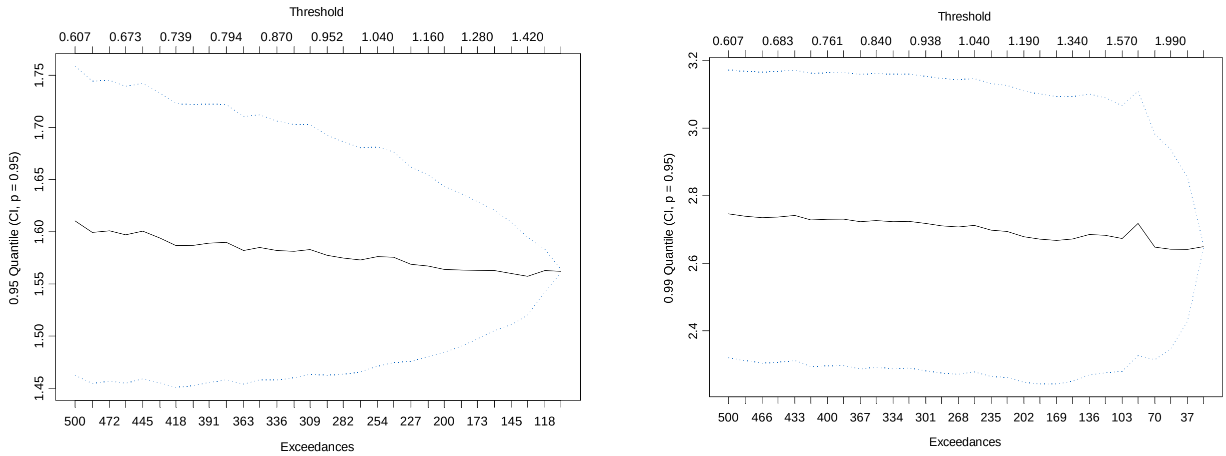
Table 5: *VaR* of BPIdr and BCIdr residuals v.s. thresholds

Confidence level	BPIdr residuals	BCIdr residuals
0.95	1.5630	1.5013
0.99	2.6693	2.6024

It is necessary to pay attention to effects of the threshold *u* on the *VaR*, whose fitness could be observed in

Figure 5 of *VaR* v.s. Threshold (also Exceedances) that shows the *VaR*s for the residuals keep comparably robust near the thresholds respectively so that the *VaR*s for the residuals could be furthered to calculate the *VaR* for the BPIdr and BCIdr using (18) shown in Figure 6 and
Figure **7**.

BPIdr residuals



BCIdr residuals

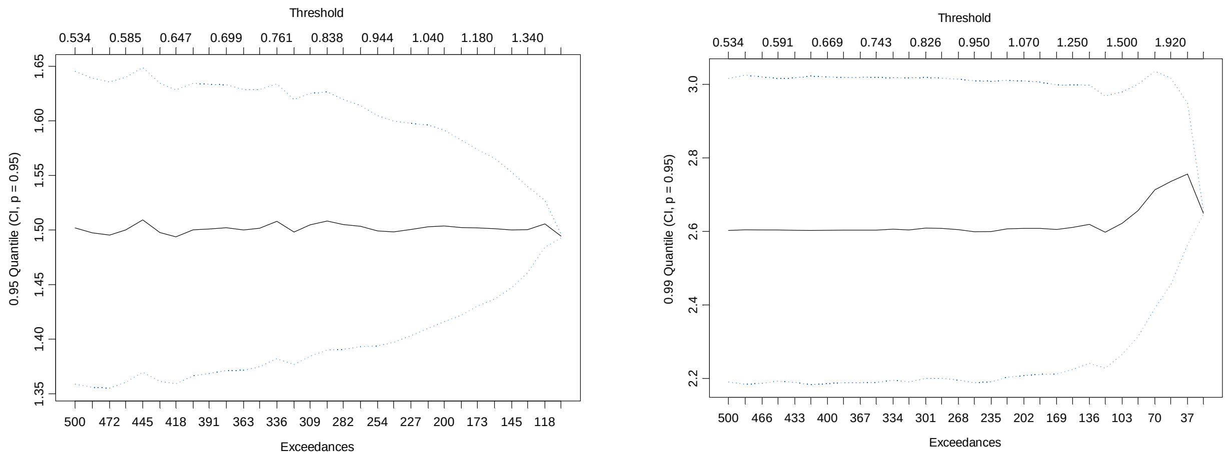


Figure 5: Sensitivity of *VaR* of BPIdr,BCIdr residuals v.s. thresholds

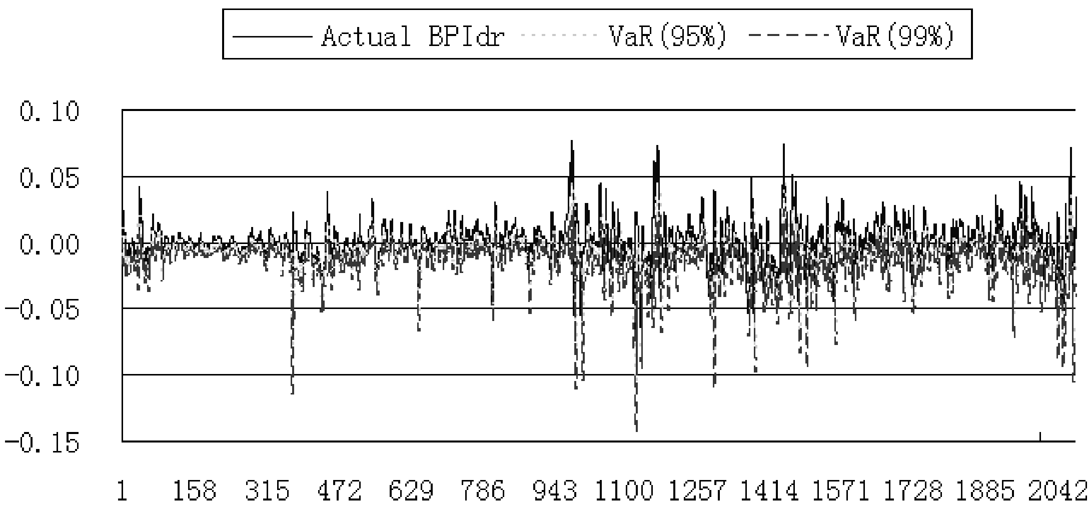


Figure 6: VaR of extreme volatilities of BPIdr

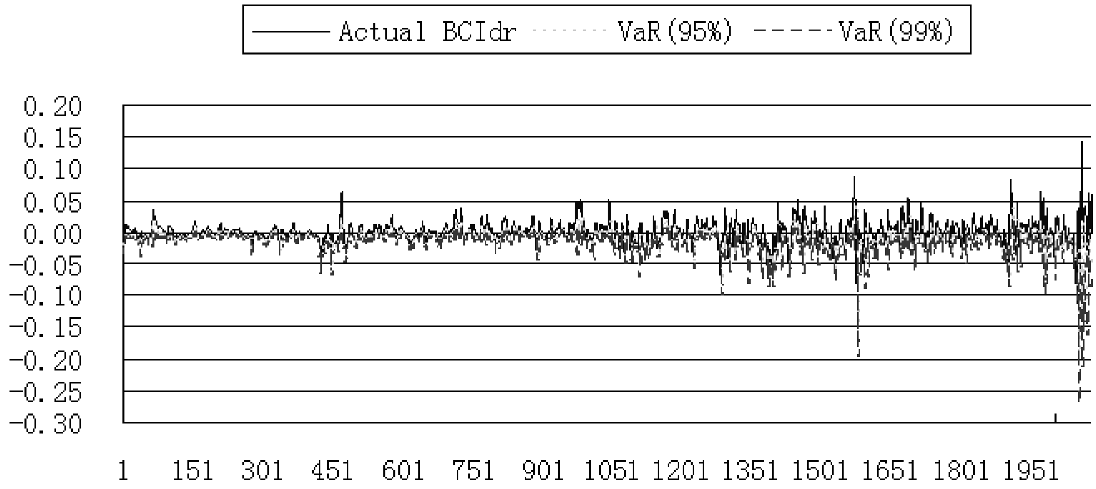


Figure 7: *VaR* of extreme volatilities of BCIdr

Before the *VaR*s for BPIdr and BCIdr are applied to measure the extreme volatilities of dry bulk ocean freight market, *Kupiec* diagnostic must be implemented to test if the *VaR*s specified be acceptable. Kupiec (1995) presents a likelihood-ratio test that could be employed to test whether the sample point estimates statistically consistence with the *VaR* model's prescribed confidence level. Hence, testing the accuracy of the model is equivalent to testing the null hypothesis that the probability of failure on each trial (π) equals the model's specified probability (p). The likelihood-ratio test statistic is given by

$$LR = -2\log\left[\frac{p^{n_1}(1-p)^{n_0}}{\hat{\pi}^{n_1}(1-\hat{\pi}^{n_0})}\right] \sim \chi^2(1) \tag{24}$$

where $\hat{\pi} = \dfrac{n_1}{n_0 + n_1}$ is the maximum likelihood estimate of π, and n_1 denotes a Bernoulli random variable representing the total number of observed failures. Table 1 shows the *Kupiec* failure test results. The *LR* statistic at 95% and 99% confidence level is 3.841 and 6.635 respectively, so all the series pass the *LR* test.

Table 1: Test on failure rate of *VaR* of BPIdr and BCIdr

Confidence Level	BPIdr	BCIdr
95%	3.56	3.17
99%	5.04	4.13

4. Conclusion

Risk management has gained an important role in the past decade due to the increasing extreme volatilities of shipping financial markets. Hereby the paper uses the models specified to estimate the values at risks of volatilities of two kinds of freight indices. Furthermore all the series have the features of strong fat tail, significant auto-correlation and *ARCH* effects. So the *FIGARCH* models based on *t* distribution can better describe the volatilities and then the *VaR* models using the improved extreme value theory could calculate the daily worst loss of the series with the results passing the *Kupiec* failure rate test. Summarily, the *VaR* provides an important recommended quantity of worst loss that not only helps the dry bulk shipping firms to avoid risks when they make business policies but also benefits investors and supervising organizations in the trading of BIFFEX and then FFA.

There are also a few of flaws in the paper. First, the paper only chooses the *FIGARCH* to capture the correlation of the series while there are also many other options such as *SV* models to realize the result but the paper does not make a comparison among estimated effects of different kinds of such models. Second, the application of *VaR* model is not inspected deeply because of the lack of practice. All the above mentioned should be focused on in future.

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Are Shipping Companies Going Green?

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Abstract

The environment is very much on the international political agenda as the world strives to find ways to reduce or even stabilise the level of greenhouse gas emissions. Given the high impact of the transport sector, this paper asks whether shipping companies are demonstrating environmental responsibility. The question has become more pertinent in the light of recent research which suggests that investors should take account of climate change or carbon risk in their portfolio selection. Indeed, the development and subsequent performance of socially responsible stock indices also provide persuasive financial arguments for the need to address the climate change issue. This research conducts a preliminary investigation of environmental awareness and reporting of the shipping industry from the investment perspective. It does this by examining information provided by leading shipping companies against criteria laid down by the FTSE4Good index on environmental reporting. It finds that relatively few companies are seriously embracing this challenge. Although many recognise the need for an environmental policy, measurement of environmental impact and target setting is rare. Much of the policy is ostensibly directed towards IMO regulation with climate change often ignored. There is a clear need for more detailed strategies and reporting in order to convince the investment community of a desire to reduce carbon risk. If they do then the financial rewards may follow.

1. Introduction

Environmental issues are very much on the international political agenda as the world strives to find ways to reduce or even stabilise the level of greenhouse gas emissions. On 16th February 2005 the 1997 Kyoto Protocol to control climate change finally became international law, implementing the United Nations Framework Convention for Climate Change. Industrialised nations who signed up to the treaty are legally bound to reduce worldwide emissions of six greenhouse gases (collectively) by an average of 5.2% below their 1990 levels by 2012. [1]

It is interesting to note however, that carbon dioxide emissions from ships do not come under the Kyoto agreement or indeed any other proposed legislation. Regulation in this area comes under the auspices of the International Maritime Organisation (IMO) which does set limits on sulphur and nitrous oxides but has yet to announce targets for carbon emissions. Against this background, recent studies suggest that the shipping industry's contribution to environmental pollution is much higher than previously thought. There is an argument that companies themselves should be taking the lead on corporate and social responsibility developing policies, management systems, targets and reporting.

This paper investigates whether the leading shipping companies are taking a proactive approach to environmental standards. In other words, are they going green?

The question has become more pertinent in the light of recent research which suggests that an increasing number of investors are taking account of environmental risk in their portfolio selection.

[1] For the protocol to come fully into force, the pact needed to be ratified by countries accounting for at least 55% of 1990 carbon dioxide emissions. With countries like the US and Australia unwilling to join the pact, the key to ratification came when Russia, which accounted for 17% of 1990 emissions, signed up to the agreement on 5th November 2004. The final ratified agreement means Kyoto will receive support from participating countries that emit 61.6% of carbon dioxide emissions. The protocol is officially the first global legally binding contract to reduce greenhouse gases. More information is available from www.unfccc.int/kyoto-protocol/items/2830.php.

Indeed, the development and subsequent performance of socially responsible stock indices also provide persuasive financial arguments for the need to address the enviornmental issue.

This research conducts a preliminary investigation of environmental awareness and reporting of the shipping industry from the investment perspective. It does this by examining information provided by leading shipping companies against criteria laid down by the FTSE4Good index on environmental reporting which demands adequate representation of policy, strategy, targets and measurement in relation to emissions.

The paper is structured as follows. Section 2 discusses the recent research and literature on the maritime contribution to climate change and air pollution. It also considers what the shipping industry is doing to address this issue primarily through regulation. Section 3 discusses the importance of the environment agenda from an investment perspective. A methodology for a corporate analysis of leading shipping companies is developed in Section 4 which is then used to assess the standard of environmental reporting of the Lloyds List Bloomberg 50 listed shipping companies. Section 5 presents the results of the analysis and Section 6 draws some conclusions.

2. Shipping and the Environment

According to the Intergovernmental Panel on Climate Change (IPCC)[2], the temperature over the last 100 years (1906 to 2005) has increased by 0.74%, with the increase more significant in the northern hemisphere. It further suggests that the average northern hemisphere temperatures during the second half of the 20th century were 'very likely higher than during any other period in the last 500 years' (p.1). Green house gas (GHG) emissions due to human activities have grown by 70% between 1970 and 2004. Of these CO2, the most important GHG has increased by around 80% in the same period. The IPCC Special Report on Emission Scenarios[3] (SRES 2000) projects an increase in global GHG emissions of 25 to 90% of CO2 equivalents over the next 25 years if current practices continue. This will be primarily the result of expansion in the use of fossil fuels, which continue to be the dominant energy source.

The best estimate for total CO2 equivalent concentration in 2005 was 445 ppm for all long lived GHG. Stabilisation at between 445 and 490 ppm by 2050 requires a 50 to 85% reduction in emissions based on 2000 levels (p.21)[4]. In response to such statistics, Governments around the world have pushed environmental concerns up the political agenda and are actively seeking ways to reduce emissions. At the same time the business community is rising to the challenge by setting its own standards and targets as part of corporate and social responsibility.

The focus of this paper is the shipping industry in terms of its contribution to air pollution and climate change and the corporate response.

Maritime transport emits a number of greenhouse gases - CO2, F gases (refrigerated ships), Methane (LNG tankers), NOx (nitrogen oxides) and SO2 (sulphur dioxide). NOx has two indirect climate effects. It causes the formation of ozone, a greenhouse gas which contributes to global warming, but also reduces methane (CH4) which is a benefit in curbing global warming. SO2 also has two effects. It also creates aerosols which reflect solar radiation and therefore cool the surface of the earth and ship tracks (low cloud over shipping lanes) which reflect sun and cool. However, the extent of these positive impacts is not precisely known.

According to estimates made in 2000[5], transport accounts for 14% of greenhouse gas emissions, in third

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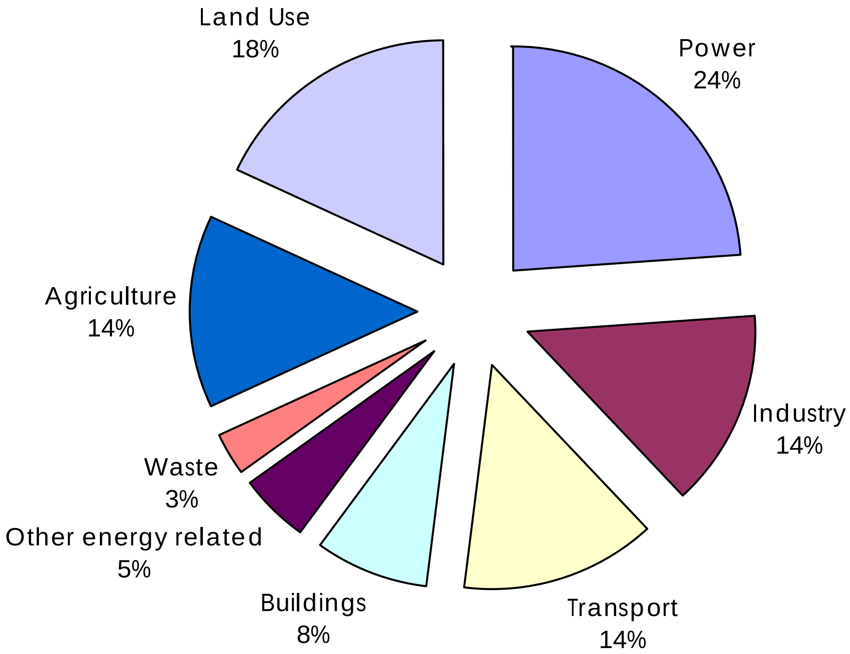
[2] Fourth report from the Intergovernmental Panel on Climate Change (IPCC): Summary for Policy Makers of Synthesis Report

[3] The IPCC Special Report on Emission Scenarios (SRES 2000)

[4] Op Cit IPCC

[5] World Resources Institute (2006): Climate Analysis Indicators Tool (CAIT) on line database version 3.0,

place after power generation, and land use (Figure 1). It is generally recognised that the majority of transport emissions are produced by road but in terms of acidification (NOx and SO2) shipping makes a much higher contribution.



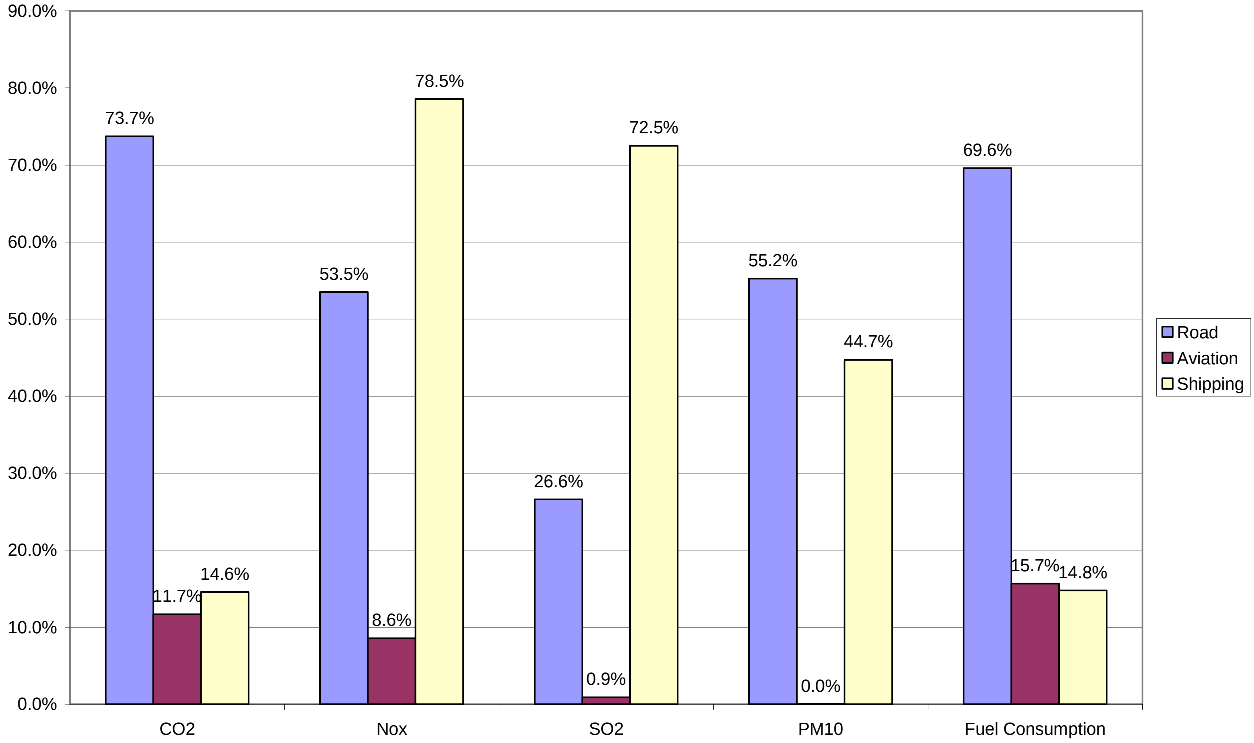
Source: World Resources Institute (2006)

Figure 1: Greenhouse Gas Emissions by Sector 2000

The exhaust composition of the different transport modes depends on the type of fuel burned, engine size, and technology relating to other emissions. As can be seen from Figure 2 international shipping in 2000 accounting for some 15% of fuel consumed by transport but had a more dramatic impact relating to NOx, SO2 and PM10 (particulate matter). This is largely due to the absence of stringent regulation in shipping compared to road and aviation. Shipping produced 79%, 73%, 45% of NOx, SO2 and PM10 emissions respectively.

A 2003 study by Corbett and Koehler showed that emissions from ocean shipping was higher than previously thought, with global nitrous oxide more than double recognised estimates. They used a bottom up estimate of fuel consumption and vessel activity for internationally registered vessels which included cargo vessels, other commercial vessels and military vessels. There estimates were compared with previous studies as shown in Table 1.

Washington D.C.: World Resources Institute, available at http://cait.wri.org



Source: Adapted from Eyring *et al*..

Figure 2: Transport Related Annual Emissions

Table 1: Emissions from Ocean Shipping

Source	Fuel consumption (million tonnes)	NOx Tg N	SOx Tg S
Corbett and Koehler (2003)[6]	289	6.87	4.72
Endersen *et al*. (2003)	165-200	3.45	3.23
IMO Study of Greenhouse Gas Emissions from Ships (2000)[7]	120-147	3.06	2.83
Corbett *et al*. (1999)[8]	140-147	3.08	4.24
RIVM and EDGAR databases (2001 and 1999)[9]	121	2.77	2.45
Benkovitz *et al*. (1996)	Not provided	1.60	2.30

Source: Corbett and Koehler 2003

The study revealed that fuel consumption could be as much as 289 million tonnes, 75% higher than the study by Endersen *et al*. in 2003[10] and 140% higher than the IMO study on greenhouse gas emissions from ships in 2000[11]. It is argued that these previous fuel based models were systematically biased in their assumption that internationally registered ships would exclusively use fuel identified as being sold

6 Op Cit Corbett and Koehler (2003)

7 Skjolsvik K O, A B Andersen, J J Corbett and J M Skjelvik, Study of greenhouse gas emissions from ships (report to International Maritime Organization on the outcome of the IMO study on Greenhouse Gas Emissions from Ships), MEPC, 45/8, MARINTEK Sinlet Griup/Carnegie Mellon University, Center fro Economic Analysis/Det Norske Veritas, Trondheim, Norway. 2000.

8 Corbett, J J, P S Fishbeck, and S N Pandis, (1999) Global nitrogen and sulphur emissions inventories for oceangoing ships, Journal of Geophysics Research, 104(D3), 3457-3470

9 Olivier J, G J and J J M Berdowski, (2001), Global emissions sources and sinks in *The Climate System,* edited by J Berdowski, R Guicherit and B J Heij, pp. 33-78. A A Balkema, Brookfield, Vt. Olivier J, G J and J A H W Peters, International marine and aviation bunker fuel: Trends ranking of countries and comparison with national CO2 emissions, Rijksinst voor Volsgezondheid and Milieu, Bilthoven, 1999.

10 Op Cit. Endersen *et al*. 2003

11 Op Cit Skjolsvik *et al*. 2000

for international vessel activity. Corbett and Koehler found a large discrepancy between fuel usage and actual fuel reported for international marine bunkers. This was due to the fact that there was domestic fuel was also consumed by these vessels. Their study found that nitrous oxide levels previously estimated at around 3 Tg were twice that of level at 6.87 Tg. Sulphur dioxide emissions were also more than 46% higher than existing statistics.

Eyring *et al.*[12] considered emissions since the 1950s which allows a calculation of their growth over the last 50 years. They use a similar activity based approach to the one adopted by Corbett and Koehler.[13] The average ship based engine output for the fleet with ships greater than 100 gross tons could be calculated exactly for 2001, 1995 and 1980. These figures were extrapolated back to 1950 by taking account of the average propulsion power per vessel. It should be noted that pre 1970, the proportion of steam ships in the fleet was higher leading to lower NOx emissions. Propulsion engines in 1995 and earlier were fuel optimised rather than NOx optimised resulting in higher NOx than the more sophisticated emission regulated engines which form part of the 2001 fleet.

Table 2: Trends in Emissions since 1950

		1950	1960	1970	1980	1995	2001
Number of ships		30,844	36,344	52,444	81,000	87,600	89,063
Total fuel consumption	Mt	64.5	77	124	213	240	280
NOx	Tg NO2	5.4	6.6	10.7	18.5	20.8	21.4
CO2	Tg CO2	187	224	360	619	697	813
CO	Tg CO	0.3	0.36	0.58	0.99	1.12	1.31
SO2	Tg SO2	2.77	3.31	5.33	9.16	10.32	12.03
Particulate matter	Tg PM10	0.39	0.46	0.74	1.27	1.43	1.67
CH4	Tg	0.12	0.14	0.23	0.4	0.45	0.52
NMHC	Tg	0.78	0.84	1.51	2.58	2.91	3.4
Total hydrocarbon	Tg	0.9	1.08	1.74	2.98	3.36	3.92

Source: Eyring *et al*. 2005

Over the period, the fleet grew by 189% with the largest increase of 28,556 (54%) recorded in the 1970s. During this time fuel consumption and other emissions, however, increased by more than 70%. More recently it can be seen that while the number of ships in the fleet between 1995 and 2001 increased by 0.3% per annum, whilst the fuel consumption and CO2 increased by 2.6%. It is suggested that the engine power per ship in 2001 is higher than in 1995. The results also provided confirmation of fuel consumption estimates of Corbett and Koehler (2003)[14]. Increases in nitrous oxide were only slight because the newer engines are NOx optimised.

Air pollutant emissions from ships are now covered by Annex VI of the Marine Pollution Convention, MARPOL 73/78, of the International Maritime Organization (IMO). The Annex sets the limits on sulphur oxide and nitrogen oxide emissions from ship exhausts, putting a global cap on the sulphur content of fuel oil of 4.5% m/m. It also contains provisions allowing for Special SOx Emissions Control Areas (SSECs) where more stringent limits operate. In these areas, sulphur content of fuel must not exceed 1.5% m/m. Alternatively ships must fit an exhaust gas cleaning system to limit SOx emission[15]. IMO monitors sulphur content of fuel on an annual basis. The Maritime Environment Protection Committee (MEPC) announced that average sulphur content in 2006 was 2.59% representing an improvement on the 2005 figure of 2.7%.

The MEPC at its 56th session in July 2007 agreed to update its 2000 study on greenhouse gases (GHGs). The scope of the revised study covers global inventories of GHGs from ships engaged in international

[12] Op Cit. Eyring *et al.*

[13] Op Cit Corbett and Koehler

[14] Ibid

[15] www.imo.org

transport, identifying progress made to date. In addition it will identify future possible measures to reduce emissions of GHGs and specifically measure the impact of shipping emissions on climate change. This study is scheduled for presentation at the 59th session of the MEPC. MEPC have since established an Intersessional Correspondence Group on GHG related issues to address emissions. [16]

3. Environmental Impact from an investment perspective

Apart from ethical issues of environmental responsibility, the argument for addressing such concerns is made even more persuasive by potential impact on financial performance. Increasing environmental awareness amongst the private sector and in particular the investment community has lead to the establishment of a number of social responsibility indices which chart stock market performance. In the Climate Change and Shareholder Value Report produced by the Carbon Trust, it was claimed that there would be a large creation and re distribution of shareholder value in the transition to a low carbon economy. There would be winners and losers at both sector and company level but the winners were more likely to be those that addressed the carbon issue.

More recently a study by Innovest (2007) establishes a direct relationship between environmental and financial performance. The study suggests four reasons why carbon risk should be assessed as part of an investment portfolio as follows:

Superior performance in managing climate risk can and is viewed as a proxy for better strategic corporate management and thus superior financial performance and creation of shareholder value.

Carbon risks are not transparent and not well understood by analysts. The value potential of good practice is therefore essentially hidden

In the longer term the performance potential of low carbon risk shares will be even greater as the capital markets become more sensitised to financial and competitive implications of such products

Institutional investors are taking more interest in such concerns.

The research calculates a ‘carbon beta’ which takes account of 4 variables:

- Overall carbon footprint adjusted to reflect different regulatory regimes in different countries and regions
- Ability to manage and reduce carbon risk
- Ability to recognise and seize climate driven opportunities
- Improvement

The greater the carbon beta the greater the company’s exposure to climate change risk. Some 1500 major companies were investigated with over 800 from ‘high impact’ sectors which were ranked relative to same sector peers. This was followed by a rigorous examination of financial performance to test the proposition that companies with better carbon management strategies can outperform their peers based on share price return and dividends reinvested.

The results found that the carbon beta premium varies considerably both by industrial sector and region. Across the whole sample, companies rated as top carbon performers surpassed the return of companies rated below average over a 3 year period by an average annualised return of 3.06%. Subsample analysis revealed some interesting regional differences. In both North America and Europe the low carbon risk companies performed better than the high risk by varying degrees – 2.4% in North America and a staggering 6.6% in Europe. However, from the Asia Pacific companies a very different pattern emerged with the low risk carbon companies lagging behind the higher risk by some 4.45% per annum. This anomaly is explained by the fact that carbon restrictions are not widely in force in the region and

[16] Ibid

that the market is not likely to 'reward' companies at this early stage of awareness. Another explanation is that the marginal costs of carbon reduction are substantially higher in this region. However, no evidence is provided to substantiate these assertions. It was also proposed that in this high growth region, the poorly rated businesses are those focussing on this growth rather than carbon emissions. Maritime transport is cited as one such sector.

The idea of a link between social responsibility and financial performance is not new as witnessed by the number of indices established for monitoring 'ethical' companies, e.g. Domini 400 Social Index (DS 400 Index), Calvert Social Index, the Dow Jones Sustainability Index, and the FTSE4Good Index. All differ in the emphasis placed on social characteristics but research shows that results have been favourable.

The FTSE4Good index was launched in 2001 using social and ethical criteria to rank corporate performance. The index specifically excludes three sectors – tobacco, weapons and nuclear power which represent some 10% of all FTSE Companies. The criteria applied in the ranking process are environment, human rights and social issues based on a broad consensus of what constitutes good corporate responsible practice globally. The criteria are reviewed on a regular basis and data used in determining inclusion in the index is independently researched.

The FTSE 4 Good index classifies companies as high medium and low impact as far as the environment is concerned. The higher the impact the more stringent the criteria for inclusion in the index. Not surprisingly shipping is considered to be a high impact industry together with air and road transport. The index sets out standards for policy, management and reporting of environmental issues. In addition the FTSE 4 Good is in the process of establishing specific climate change criteria. As yet the classification of the shipping industry in terms of impact has not been defined. Implementation of practices to meet the criteria scheduled for January 2008 up to July 2009.

Both the results of the Innovest study and the positive performance of the various social responsibility indices highlight some key issues in relation to tackling climate change at a corporate level. Increasingly businesses need to develop a sound carbon strategy which reduces their exposure and they will be rewarded with increased shareholder wealth. Socially Responsible Investments are extremely attractive with premia on these financial instruments increasing with greater investor focus.

4. Methodology

Section 3 highlighted the impact of the shipping industry on the environment and discussed what is being done at an industry level through IMO to address to embrace the green agenda. However the discussion in the previous section demonstrates the importance of action at a micro level not only in terms of social responsibility but also financial performance. This research therefore examines environmental credentials of shipping at a corporate level. It does this using the established environmental benchmarks of the FTSE4Good index in order to assess the extent to which these businesses are addressing green issues in their corporate strategy. The environmental criteria which must be satisfied in order to secure a place in the index are set out in Table 3.

Table 3: FTSE 4 Good: Criteria for Environmental Policy, Management and Reporting

Policy Must cover whole group and either meet All five core indicators plus one desirable indicators 4 core indicators plus two desirable indicators	
Core indicators: Policy refers to all key issues Responsibility for policy at board or department level Commitment to use of targets Commitment to monitoring and audit	Desirable indicators: Globally applicable corporate standards Commitment to stakeholder involvement Policy addresses product or service impact Strategic moves towards sustainability

Commitment to public reporting	
Management If the EMS covers one to two thirds of the activities then 5 indicators must be satisfied. I less than these 5 indicators of which one must be number 3.	
Core indicators: Presence of environmental policy Identification of significant impacts Documentation of objectives and targets in key areas Outline of processes and responsibilities – manuals, action plans, procedures Internal audits against the requirements of the system Internal reporting of management review	
Reporting Publication must be within the last three years If it covers the whole group then 3 core criteria must be met If not covering the whole group than must meet all 4 core criteria plus 2 desirable criteria	
Core indicators: Text of environmental policy Description of main impacts Quantitative data Performance measured against targets	Desirable indicators: Outline of an EMS Non compliance, prosecution, fines accidents Financial dimensions Independent verification Stakeholder dialogue Coverage of sustainability issues

Source: FTSE4Good

The criteria cover three areas of policy and governance, management and strategy, and disclosure. Core and desired indicators are used to assess performance in these areas. The process is dynamic with new companies being considered and existing ones excluded if there is a failure to meet the standards.

In order to address the issue of climate change more specifically, some further criteria have been established by FTSE4Good but these are yet to be implemented. These are shown in Table 4.

Table 4: FTSE4Good Climate Change

	High Impact	Medium Impact
Policy and Governance	Board level or senior executive level responsibility for climate change issues Public statement/policy identifying climate change as relevant to business activity and the need to address it as a key concern	Board level or senior executive level responsibility for climate change issues Public statement/policy identifying climate change as relevant to business activity and the need to address it as a key concern
Management and Strategy	At least one of the following must be met Long term strategic goal of significant quantified reductions of operations GHG emission or carbon intensity improvement over more than 5 years which must be publically available Short/medium term management targets for quantified GHG operational emissions reduction over	No requirements as yet. Medium impact company requirement mainly related to disclosure

	less than 5 years	
Disclosure	Public disclosure of both the following: Total operational CO2 of GHG emissions as tonnes of CO2 equivalent Sector metric where established as an industry norm	Public disclosure of both the following: Total operational CO2 of GHG emissions as tonnes of CO2 equivalent 2. Sector metric where established as an industry norm

Source: FTSE4Good

This research uses these indicators to assess the environmental awareness of leading shipping companies. Due to accessibility and availability of information it was decided to focus on the reporting and disclosure criteria. It also seemed a reasonable assumption that companies which have devoted resources to developing an environmental policy would make it widely known.

The focus of the testing was listed shipping companies which appear in the Lloyds List Bloomberg top 50 index of key shipping shares (see Table 5). These companies comprise the largest in the industry and given their quotation on a variety of exchanges were expected to provide publically available information relating to corporate policies and social responsibility.

Table 5: The Sample

Company		Company	
AP Moller-Maersk	DK	U-Ming Marine Transport Corp	TT
China COSCO Holdings	CH	Ship Finance International Ltd	BM
Carnival Corp	US	Stolt-Nielsen SA	NO
Mitsui OSK Lines Ltd	JP	Wilh Wilhelmsen ASA	NO
China Shipping Container Lines	CH	Euronav NV	BE
China Shipping Development Co	CH (HK)	Euronav NV	BE
MISC Bhd	MK	Bonheur A/S	NO
Royal Caribbean Cruises Ltd	US	Golden Ocean Group Ltd	BM
Nippon Yusen KK	JP	Yang Ming Marine Transport Corp	TT
Hyundai Merchant Marine Co Ltd	KS	Wan Hai Lines	TT
Kawasaki Kisen Kaisha Ltd	JP	Cia Sudamericana de Vapores SA	CL
D/S Norden	DK	Danaos Corp	US
Orient Overseas Int Ltd	HK	Shipping Corp of India Ltd	IN
Neptune Orient Lines	SP	Seaspan Corp	US
Teekay Corp	US	Nanjing Water Transport Industry	CH
Frontline Ltd	NO	Tsakos Energy Navigation Ltd	GR
Compagnie Maritime Beige SA	BB	Daiichi Chuo Kisen Kaisha	JP
DryShips Inc	US	BW Gas ASA	NO
D/S Torm A/S	DK	Golar LNG Ltd	BM
Kirby Corp	US	Odfjell SE	NO
Pacific Basin Shipping Ltd	HK	Dfds A/S	DK
Evergreen Marine Corp Taiwan Ltd	TT	Teekay LNG Partners LP	BS
Diana Shipping Inc	US	Iino Kaiun Kaisha Ltd	JP
Overseas Shipholding Group Inc	US	Nordic American Tanker Shipping	BM
Star Cruises Ltd	HK	Shinwa Kaiun Kaisha Ltd.	JP

Source: Lloyds List Bloomberg top 50 index of shipping shares

Information contained on the websites of the above companies was analysed against the FTSE4 Good environmental reporting indicators at a core and desired level. In addition climate change criteria was considered but since no sector norm has yet been established, information was examined for reference to climate change, CO2 equivalents and GHGs and for quantification of CO2 equivalents. The results are shown in Table 6.

Table 6: Meeting Individual Environmental Reporting Criteria

Reported information	Number and % of companies meeting criteria	
Core criteria		
Environmental policy	27	(54%)
Description of main impact of activities on environment	12	(24%)
Quantitative data	9	(18%)
Set targets	21	(42%)
Desired criteria		
Outline of Environmental Management System	19	(38%)
Prosecution, fines accidents	15	(30%)
Financial dimension	7	(14%)
Stakeholder dialogue	18	(36%)
Independent verification	7	(14%)
Coverage of sustainability issues	24	(48%)
Climate Change		
Specific reference To climate change	5	(10%)
Quantification of CO2 equivalents	8	(16%)

Source: Author Analysis

The table shows compliance with core, desired and climate change criteria. Analysis revealed that the majority of the sample (54%) published an environmental policy. Only 12 companies desribed the main impact of their activities on the environment and fewer still provided any quantitative date (18%). Target setting was more prevalent with 21 companies announcing their aspirations. However, it was clear that the establishment of the targets was relatively recent since there was no measurement of performance against these standards.

The performance against the desired criteria was generally worse. Only 38% of companies provided an outline of an environmental management system. It was interesting to note that few provided information as to amounts spent on environmental considerations (7%) and the same number suggested that the data had been subject to independent verification.

Climate change is clearly a new issue for shipping business in their environmental reporting. Indeed, most of the data given only related to issues covered by IMO regulations such as sulphur, waste and the marine environment. Only 5 companies made reference to climate change or global warming and 8 attempted to quantify the emissions from their operations in CO2 equivalents.

With the exception environmental policy, more than 50% of the sample failed to meet any of the disclosure criteria.

In addition to analysis against the various core and desired criteria, the information was examined to establish how many of the companies would meet the FTSE4Good requirements on environmental reporting. As stated in Table 3 companies have to meet at least 3 of the core criteria to qualify for inclusion in the index.

Table 7: Meeting the FTSE4Good Environmental Reporting Criteria

Criteria met	Number of companies	
4 core	9	(18%)
3 core	3	(6%)
2 core	9	(18%)
1 core	7	(14%)
0 core	22	(44%)
6 desired	5	(10%)

5 desired	3	(6%)
4 desired	5	(10%)
3 desired	5	(10%)
2 desired	3	(6%)
1 desired	5	(10%)
0 desired	24	(48%)
2 climate change	5	(10%)
1 climate change	3	(6%)
0 climate change	42	(84%)

Source: Author Analysis

The table shows that 12 companies (24%) would satisfy the required environmental reporting criteria. Only 3 companies met all the criteria – core, desired and climate change, whilst at the other end of the spectrum, 22 companies met none.

It is clear that shipping companies have much work to do in the area of environmental reporting and climate change in particular. In a high impact sector there is an expectation that the leading companies would be proactive in this respect and not rely on industry regulation to drive the environmental agenda. Furthermore the evidence from the investment community strongly suggests that such a strategy may pay financial dividend. This research serves to highlight shortcomings which do need to be addressed but also indicates that a more detailed investigation needs to be carried out to determine environmental thinking within the industry.

5. Conclusions

At a global level, there is general acceptance of the need to reduce environmental pollution. However, research on corporate action indicates that micro initiatives can lead to enhanced financial performance and more than outweigh the costs of a sound environmental strategy.

Recent studies have shown that the contribution of international shipping to global emissions is higher than previously thought. Increases in international trade and the supply of new vessels are likely to lead to a huge increase in the coming years. As an industry shipping is aware of its high environmental impact and international regulation is responding to the problem through the work of IMO. However action on climate change is lagging behind work on marine pollution, air pollution and waste management. Regulation or guidelines on carbon emissions is still several years away although the work has started. It should be stressed that shipping has for many years been at the forefront of technical development on engine efficiency and new generation fuels. To this end we look to the leading shipping companies to take the initiative on climate change and environmental pollution.

This research has found that relatively few companies are seriously embracing this challenge. Although many recognise the need for an environmental policy, few of the leading shipping companies attempt to measure their environmental impact and fewer still address the climate change issue. Much of the policy and action is in fulfilment of IMO regulation which has yet to set and agenda on carbon emissions. There is a clear need for more detailed strategies and measurement in order to satisfy the environmental requirements of a socially responsible index and more importantly to in order to convince the investment community that they are serious about reducing environmental risk. If they do then the financial rewards may follow.

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