# The Impacts of Ownership Structure and Competition on Port Capacity Investments and Pricing: An Economic Analysis

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**Abstract**

Contemporary economic development ensures that port performance has become pivotal within the logistical supply chain. While considerable studies have discussed the interdependence of port ownership, inter-port competition, capacity investment and port pricing, few analytical models have been developed, thus preventing researchers from drawing an overall picture of the port industry, or deriving general results of port operation. Hence, this paper proposes an integrated economic model with which the effects of the attributes stated above can be analyzed jointly. Our results indicate that capacity investments and congestion level are influenced by ownership forms, the presence of inter-port competition and possible externalities (spillover effects) due to port operation. This study allows us to investigate port behaviors systematically, rather than focusing on a single port decision, with different objective functions being specified so as to analyze possible strategic differences between public and private sectors, as well as different levels of governments. It also provides fresh insight to the ongoing debates of private participation in the ownership and operation of transport infrastructure, as well as the possible impacts of continuing governmental involvement.

## 1. Introduction

Contemporary economic development has opened up the consumer market to various regions around the world. To ensure that such products can sustain global competitiveness, the speed of cargo movement must be smooth and efficient. This is likely to exert considerable challenges, as efficiency in international transportation requires the integration of several functions along the supply chain so as to provide quality services at reasonable prices. Indeed, being transportation hubs, the performance of ports, as critical nodal points (Cowen, 2010), has become increasingly pivotal in complementing the activities of different stakeholders within the logistical supply chain (cf. Heaver, 2002; Sanchez et al., 2003; Notteboom and Rodrigue, 2005). On the other hand, with increasing ship sizes, mergers and acquisitions between shipping lines and the restructuring of the shipping networks, recent developments in global shipping have led to few port calls, thus intensifying port competition and the increasingly importance of transshipment traffic in deciding the competitive positions of ports around the world (Ng, 2009).

Hence, in many places around the world, being an important attribute in affecting service quality and thus port performance (cf. Chang et al., 2008; Ng, 2006), port congestion becomes a pressing issue to address. Congestion would deteriorate port service quality with longer average process time. In turn, this would increase the economic costs of ship operation. As a consequence, the overall costs of the marine operation would increase. Generally speaking, to address port congestion problem, there are two main approaches. One direct approach is to invest more capacity, for instance, berths, cranes and other port infrastructures. In such case, *ceteris paribus*, increasing port capacity would enhance service quality, and thereby theoretically attract more traffic to the port. The downside of such strategy, however, is that port capacity investments may be very costly, especially given the industry‟s capital intensive nature (Baird, 2000; Haralambides, 2002; Slack and Fremont, 2004). The second approach is to levy higher service charges with the aim to reduce the port service demands. If a port has substantial market power, such a strategy may be profitable. Nevertheless, if there is sufficient competition, such a strategy may not be a wise option. The pressure for more capacity but simultaneously lower service charges poses a significant dilemma to port decision-makers where real world experience indicates that, especially in regions where multiple ports compete with each other, ports have often invested too much capacity and but charged too low prices. An illustrative example can be found in the East Mediterranean where the rapid growth in port capacity of Limassol and Damietta led to fierce competition between them, with prices being set so low that neither of them is able to even cover respective operation costs (World Bank, 2007). Another illustrative example can be found among Chinese container ports, where excess capacity was estimated to reach a total of 35 million TEUs in 2010 – three times more than the actual growth between 2000 and 2008 (AXS-Alphaliner, 2009). In 2009, the berth utilization rates of Tianjin, Xiamen and Fuzhou were only 55, 42 and 27 percent, respectively, with 2, 10 and 2 new berths already under construction within respective ports (World Cargo News, 2010), while at the same time, the total container capacity in Dalian in 2010 was forecasted to be 100 percent of the total demand in 2008 (AXS-Alphaliner, 2009). Hence, port congestion may be solved but non-socially optimal excessive capacity investments may exist.

Another complicating factor is changes in ownership structure. Throughout past decades, various management reforms, including the transport sector, had been adopted so as to adjust to changing circumstances since the 1980s. Within the port sector, many such illustrative examples can be found, where a distinguished feature of such reforms is the advocacy of establishing various reform models, often based on the seductive belief of the time where capitalist economies would be better governed through the decentralization of socio-economic decisions (cf. Harrison, 2010). Through devolution and the transfer of assets and operations responsibilities to private enterprises, public-private partnership and concessionary agreements (Theys et al., 2010), ports around the world gradually move away from direct public management to autonomous, but more complex, entities, with mixed forms of ownership and/or management models being established, with the landlord port model being one of the most popular options (cf. Wang et al., 2004; Brooks and Cullinane, 2007). Although reform objectives vary, they usually share common goals: to enable the organization to evolve so as fit in a changed environment that is shared by the sector at a global scale. Being well-documented in previous works (Heaver, 1995; Wang et al., 2004; Brooks and Cullinane, 2007; Cullinane and Song, 2007; Ng and Pallis, 2010), the core objectives are similar, e.g., higher technical efficiency, economic benefits through competition, lowering bureaucracy, reducing public investments, etc. In other words, such evolutionary process mainly aims to lower transaction costs (Hall, 1986).

However, it is general knowledge that the objectives of private firms can be substantially different from those of a public, or government controlled, enterprise (Vining and Boardman, 2008). Indeed, there is no shortage of research works indicating that ports are often treated as strategic assets (cf. Ng, 2002) and, being part of the city-regional system, in many cases, their evolutionary process often cannot escape the existing political administrative boundaries (cf. McLeod and Jones, 2007). In the past decades, real world experiences within port management reform suggest that even after reforms, quite often, governments (central and/or local) may control some or even majority shares of ports, so that they can maintain certain degree of influence on port operation and strategic development, with the establishment of joint ventures between foreign and local, state-owned enterprises operating container terminals within Chinese ports being illustrate examples (Ng, 2002; Wang et al., 2004). Even within the public sector, as pointed out by Ng and Pallis (2010), the objectives between governments from different levels may not be entirely consistent: local authorities may be more concerned with the benefits to the local economies, while national authorities may focus on coordinating the planning and policies of several ports, thus ensuring that the total welfare can be maximized at the national (or regional) level. Hence, in understanding port reform (including changes in ownership and operating structure) nowadays, as warned by Harrison (2010), one should be aware of the complicated process behind leading to its final outcome, including performance.

Based on such background, in this paper, we propose an integrated economic model with which the effects of port ownership and inter-port competition on its capacity investment and pricing can be analyzed simultaneously. There is little doubt that port capacity and pricing are important attributes in deciding port‟s service quality, as various research works have suggested (see, for instance, Chang et al., 2008; Ng, 2006;

Tongzon, 2009). In particular, by defining a composite objectives function, our model can conveniently analyze the cases where ports have mixed ownership, i.e., government and private firms may control varying shares of ports. The inclusion of mixed ownership is extremely important because port management reform rarely involves complete devolution and/or privatization (cf. World Bank, 2007; Ng and Pallis, 2010). Instead, the public sector usually redefines new governance structure through various means (Theys et al., 2010). Moreover, with different definition of social welfare, our model provides a new dimension in analyzing the different strategies adopted by local and central governments. Apart from a significant research gap yet to be filled concerning the inter-relationship between port ownership and performance (see section 2), a major contribution of this study is that it focuses on explaining *how* and *why* ownership structure affects the performance of ports, rather than simply endorsing the notion that ownership *does* affect performance. In particular, our modeling results suggest that: (1) the absence of inter-port competition, profit-maximizing private investors would investment less capacity than local or central governments, who care about regional economic benefits and the well-being of port users. However, private investors also charge higher prices which reduce traffic volume. In an overall, we argue that port ownership would have little significant or systematic influence over congestion level; (2) inter-port competition plays an important role in the determination of port capacity, pricing and resultant traffic volume and congestion level. In particular, when the spillover effect of port operation to the local economy is moderate while inter-port competition is significant, private investors would invest too much capacity than social optimal level. In such cases, local governments would commit even more capacity. This reduces congestion level but lead to excess capacity (i.e., wastage of valuable resources). These results, together with other findings, can significantly contribute to the ongoing debates of the structure of private participation in the ownership and operation of transport infrastructure – to what extent, under what circumstances, as well as the relation between public and private sectors. In a nutshell, the outcomes of this study are highly relevant in enhancing our understandings on the strategies of economic actors on the evolution and development of port planning and management.

The remaining of the paper is structured as follows. Section 2 provides the literature review, followed by the establishment of the economic model in section 3, where a benchmark monopoly port case will be analyzed. Section 4 extends the analysis to cases with inter-port competition. Finally, the conclusions are provided in Section 5.

## 2. Literature Review

The potential advantages of devolution and private participation in the operation and management of transport and logistics facilities were widely recognized by researchers (see, for instance, Boardman and Vining, 1989; Estrin and Perontin, 1991; Vickers and Yarrow, 1989; Yarrow, 1986). Throughout the past decades, one had witnessed the implementation of various types of port reforms which had been comprehensively documented in existing literature (see, for instance, Brooks and Cullinane, 2007; Wang et al., 2004; Ng, 2002). Port reform often involves the participation of the private sector with the objective of reducing bureaucracy and enhancing efficiency (Beresford et al., 2004; World Bank, 2007). Given this trend, for the last two decades, the impacts of organizational structures and management systems on port efficiency had gradually become a topic which had interested transport economists. In this respect, a problem existed where considerable works investigating the effects of ownership, competition and policies on capacity and pricing were either descriptive in nature or *ad hoc* case studies (see, for instance, Cullinane and Song, 2001; De Langen and Pallis, 2006; Everett, 2007 and 2008; Goss and Stevens, 2001; Haralambides, 2002; Vining and Boardman, 2008), thus difficult to apply them directly to predict the net effects of the above variables, especially given the rather complex and inter-dependent nature of ownership and competition on capacity investment and pricing as mentioned in the introductory section.

A number of quantitative studies investigating the issue did exist though. A pioneer study can be dated back to the 1990s, when Liu (1992) undertook performance analysis on British seaports operated by different types of enterprises. An important contribution of his works was that, instead of a clear-cut distinction between public and private ownerships, Liu also identified the influence of mixed ownership which could pose significant implications on port performance. Later, Cullinane et al. (2002), by applying a stochastic frontier model, attempted to assess the influences of various types of ownership on Asian container terminals, and concluded that devolution and privatization were closely associated with performance. Based on the British experience, Baird (2000) argued otherwise, however, where the sale of port assets, including the transfer of operation rights and/or regulatory functions, to the private sector did not necessarily improve performance, or even counter-productive in some cases. He further explained that, due to the specific nature of ports nowadays (long term payback and capital intensive nature), an almost total dependence on the private sector to provide both port infrastructure and superstructure would result in significantly delayed investments on crucial operational facilities and equipments, which were obviously contrary to the original objective of port privatization. Thus, full port privatization would impede the improvement in performance although, to some extent, private sector participation could also increase the efficiency level, implying that the extent of private sector intervention in the port sector would have an inverted U-shaped effect on port operational efficiency. In this regard, Tongzon and Heng (2005), based on the stochastic frontier approach, provided some evidences that the impacts of privatization on port performance followed an inverted U-shaped curve. They conclusions were supported by Cheon et al. (2010) who argued that port performance enhancement did come from the ownership reform and asset management practices, though rejecting any roles of devolution and corporatization. Gonzalez and Trujillo (2008) disagreed, however, claiming that port performance changed little after management restructuring.

Within the same period, other researchers had applied a positivist approach investigating the relation between governmental influence and performance. For example, Oum and Yu (1994) studied the effects of government intervention, notably subsidies, on the performance of railways located within OECD countries. Results indicated that dependence on subsidies had negative correlations with performance, of which similar correlations also applied to managerial autonomy. Although they called for improved subsidizing policies, findings were far from comprehensive as they did not consider the effects of the differences in operating and market environments. A similar work on ports was undertaken by Barros (2003) focusing on the impacts of government"s "incentive regulation" (in terms of subsidizing policies) on the performance of Portuguese seaports, with the drive for greater technical efficiency being part of the government"s plan preparing for privatization within the sector. Results were rather mixed, however, leading him to conclude that public policies did not necessarily lead to better performance. A recent study was undertaken by Ng and Gujar (2009) investigating government policies, efficiency and competitiveness on Indian dry ports, arguing that governments were often keen to maintain certain degree of existence (and thus influence) on transport facilities. Finally, Bassan (2007) went even further and proposed an evaluation tool for port operation and capacity analysis, although the failure to take institutional factors (including ownership and policies) into account (other than merely mentioning their potential influences) had limited its empirical applicability.

Generally speaking, the works illustrated above provided interesting insight on the possible relation between different organizational (including ownership) structures and managerial systems and performance. However, these works shared common, but important, shortcomings, notably the concentration on technical methodologies in addressing the topic. Hence, in most cases, they addressed whether ownership *did* affect performance but did not proceed further investigating *how* and *why*, i.e., the possible reasons behind such phenomenon. Such defect can be well-illustrated by the following article"s conclusion investigating the performance determinants of container terminals:

> *"…berth utilization – a proxy of productivity analysis on this analysis – is considered the most vital contributor to overall port performance, and would be under the control of the port authority subject to a port's administrative and organizational structures. In the case of a tool or service port…the degree of terminal productivity is determined solely by the port authority. However, in a landlord port…terminal productivity relies on the private terminal operator…"*
> (Song and Han, 2004)

Under such cases, how would port authorities and private terminal operators affect performance, and why? Moreover, how could their works help decision-makers to make appropriate decisions related to devolution and/or private participation in port ownership and operation? The dynamics, including the process behind the establishment of the scene was clearly found lacking, causing the failure of such works in reflecting the complete picture. Indeed, the reform outcomes of different ports, even after the implementation of generic solutions, can be fundamentally different due to the existence of diversified political systems within different regions (Ng and Pallis, 2010). Thus, existing works only addressed half of the issue: to what extent variances in ownership and competitive structures had caused variances in performance. The other half – the roles that the dynamics behind, as well as to what extent port ownership and operation should be shared between public and private sectors, as well as governments of different levels – had been continuously overlooked. Such ignorance explains why, at least partially, despite the availability of considerable works, a generally accepted conclusion on the issue - the inter-relationship between private participation and performance - still cannot be reached (Liu, 1992 and 1995; Cullinane et al., 2002; Song and Cullinane, 2001; Tongzon and Heng, 2005). Unsurprisingly, the lack of consensus ensured that the stated works were mainly *ad hoc* in nature and did not clearly address how and why inter-port competition had affected port performance, including capacity investments and pricing, as Kent and Ashar (2001) had clearly illustrated. These shortcomings have limited the potential contributions of these stated works, implying that a significant research gap has yet to be filled. Hence, this study aims to fill in this gap through investigating the effects of port ownership and inter-port competition on port"s strategies of capacity investment and pricing, and resulting service level and social welfare effects. Below we will construct the economic model.

## 3. The Economic Model

We consider one single port facing linear inverse demand function which is specified as

(1) $$\rho = a - bQ$$

where $\rho$ is the full price paid by port users (e.g. ship liners) while $Q$ is the port output. The full price $\rho$ comprises two parts: port due/service charge $P$ plus extra cost related to congestion at the port. Port delay function $D$ increases in port traffic $Q$ but decreases in port capacity $K$, and so is specified as

(2) $$D = \frac{\alpha Q}{K} \text{ and } K \leq Q$$

Congestion parameter $\alpha$ is a constant exogenously determined by port production technology and operation efficiency. A larger $\alpha$ implies longer congestion delay for any given capacity and traffic volume. The requirement $K \leq Q$ implies that the port output can not exceed its designed capacity. Basso and Zhang (2008) reviewed the usage of such a delay function in recent studies. They propose that one should solve the equilibrium outputs first with such delay function, and then ensure the solution satisfy the capacity constraint (i.e. the solutions are interior solutions). We shall adopt a similar approach in our paper. Let congestion cost measured in monetary value to be $T = \mu D$, the demand function can be rewritten as

(3) $$P = a - bQ - \mu D$$

Denote the capital cost as $r$ and the constant marginal cost of port operation as $c$, the profit of the port is simply

(4) $$\pi = (P - c)Q - rK$$

To model the complex ownership forms in the port industry, we consider a port which is partially privatized. The private port operator owns a share of $s$ in the port and its objective is to maximize port profit $\pi$. The government owns the remaining (1-$s$) share of the port and aims to maximize social welfare. An economics text-book approach to define social welfare is to add up port profit $\pi$ to the consumer surplus of port users. With such an approach, the interests of all parties involved will be included.

However, such an approach may not be relevant for major seaports serving as international gateways. In this case, the demand for a port is a derived demand of international trade, which of involves end users (i.e. producers, importers and exporters, freight forwarders etc.) beyond municipal/national boundaries. For example, Rotterdam is the largest seaport in the world, yet less than 5% of the cargos handled in the port are destined for The Netherlands, and even few cargos are destined for the city itself (Port of Rotterdam, 2010). The same pattern holds for the Port of New York/New Jersey, Port of Shanghai and Singapore etc. In addition, since many ports are owned by local/municipal governments instead of federal/central governments, it is not clear to what extent those port authorities or local governments will take account into the welfare of im-/exporters, or the shipping companies who are not local residents. The consumer surplus defined by the port demand function, which captures the welfare of the port users, may not be of great importance to local government or port authorities.

Port operations often bring positive externalities or spillover effects to local economies: increased traffic volume often leads to increased employment, and contributes to the growth of related industries such as supply-chain management, warehousing, logistics services and to some extent local manufacturing industries. As a result, port authorities and governments routinely use traffic volume as a key index of port performances. Such spillover effects have been well recognized in practice, yet they have rarely been explicitly modeled in quantitative economic analysis.

With such complexities in port operation, it is unclear on what exactly the best specification of a port operator‟s objective function is. As a matter of fact, it is not for sure whether one single type of port objective function can sufficiently reflect the objectives of the large number of ports operating within extremely diversified environments. To ensure that our analytical conclusions are robust to alternative specifications, and more importantly, to analyze the implications of different types of government involvements, we decide to model and compare the analytical results with following two specifications of a government‟s objective function:

For a "local government" who cares the economic benefits to the port area only, its objective function is to maximize "Local Benefit" *LB* as specified in (5), which only include port profit and the spill over effects to local economy. $h$ ($h$>0) is the spill over benefits derived per unit cargo handled

(5) $$LB = \pi + hQ$$

For a "central government" who also cares about the well-being of port users, its objective function is to maximize social welfare *SW*, which is the sum of port profit, consumer surplus and spill over effects:

(6) $$SW = [(P-c)Q - rK] + [\int_0^Q \rho(x)dx - \rho(Q)Q] + hQ$$

It should be noted that the terms "local government" and "central government" are mainly used as references. In practice, a local government may also cares about users‟ interests in order to maintain long-term cooperative relationships. On the other hand, a central government does not have to always fully appreciate port users‟ well-being, especially foreign companies who do not have a major local presence. As shown in the following sections, such alternative specifications will only make a difference when there is substantial inter-port competition.

Clearly, a private port operator‟s objective is not entirely consistent with that of a government. The eventual port strategy may be best described as a compromise between the private investor and the government involved. Therefore, we define a partially privatized port‟s objective as a composite function of profit maximization and local benefit/welfare maximization, weighted by the port ownership shares controlled by the private operator and the government respectively. Below we present the models for the cases of local government and central government involvements separately.

*3.1. Partnership between private investor and local government*

In this section we consider the partnership between a private investor and a local government, where the private investor controls a share of $s$ ($0 \le s \le 1$) of the port. The port‟s objective function is thus specified as in (7), where condition $\pi \ge 0$ reflects the requirements of budget balance (thus that the port is free from government subsidy) usually imposed by the government, and of course non-negative profit condition which is essential for private port operator to participate:

(7) $Max_{P,K}\Pi = (1-s)[(P-c+h)Q-rK]+s[(P-c)Q-rK]$

$$s.t.\quad Q \le K \text{ and } (P-c)Q-rK \ge 0$$

Clearly, the objective function $\Pi$ is simply the weighed average of port profit and spill-over effects to the local economy. The port maximizes this composite / weighted objective function by choosing the appropriate port service charge *P* and the port capacity *K*. The corresponding first order conditions (FOCs) are derived as

(8.1) $$\frac{\partial \Pi}{\partial P} = Q + (P-c)\frac{\partial Q}{\partial P} + (1-s)h\frac{\partial Q}{\partial P} = 0$$

(8.2) $$\frac{\partial \Pi}{\partial K} = (P-c)\frac{\partial Q}{\partial K} - r + (1-s)h\frac{\partial Q}{\partial K} = 0$$

By demand function (3), it is straightforward to show that

(9) $$\frac{\partial Q}{\partial P} = -\frac{1}{b+\mu\frac{\partial D}{\partial Q}} \quad \text{and} \quad \frac{\partial Q}{\partial K} = -\frac{\mu\frac{\partial D}{\partial K}}{b+\mu\frac{\partial D}{\partial Q}}$$

With equation (2), (3), (8) and (9), it can be further derived that the optimal capacity and price charged by the port, and the corresponding traffic volumes are

(10.1) $$P = \frac{1}{2}[a+c-(1-s)h]$$

(10.2) $$K = \frac{\sqrt{\alpha\mu}}{2b\sqrt{r}}[a-c+(1-s)h-2\sqrt{r\alpha\mu}]$$

(10.3) $$Q = \frac{1}{2b}[a-c+(1-s)h-2\sqrt{r\alpha\mu}]$$

The constraints in (7) requires that

(11.1) $$r \le \alpha\mu$$

(11.2) $$a-c-(1+s)h \ge 2\sqrt{r\alpha\mu}$$

where (11.1) ensure the port earns non-negative profit, while (11.2) ensures that the output is smaller than port capacity invested. These two conditions ensure (10.1)-(10.3) are interior solution. In addition, it can be shown that

(12) $$\frac{\partial K}{\partial s} < 0, \quad \frac{\partial P}{\partial s} > 0, \quad \frac{\partial Q}{\partial s} < 0, \quad \frac{\partial D}{\partial s} = 0, \quad \frac{\partial K}{\partial h} > 0$$

The interpretation is straightforward: as the private investor controls a larger share of the port, less capacity will be invested (i.e., $\partial K/\partial s < 0$). Meanwhile, the port will charge a higher price which reduces port traffic volume (i.e., $\partial P/\partial s > 0$ and $\partial Q/\partial s < 0$). As a result, port ownership does not have any systematic impacts over the congestion level at the port ($\partial D/\partial s = 0$)

*3.2. Partnership between private investor and central government*

In the case of partnership between a private investor and a central government, the port"s objective function is specified as in (13). Compared to the case of partnership with a local government, the difference is that port users" consumer surplus is also included.

$$(13) \qquad Max_{P,K}\Pi = (1-s)[\int_0^Q \rho(x)dx - \rho(Q)Q + (P-c+h)Q - rK] + s[(P-c)Q - rK]$$
$$s.t.\ \ Q \le K \text{ and } (P-c)Q - rK \ge 0$$

With the specifications in (1)-(3), the first order conditions for (13) can be derived as in (14.1)-(14.3), while capacity constraint and non-negative profit constraints in (13) requires that $r \le \mu\alpha$ and $s(a-c-2\sqrt{\mu\alpha r}) \ge (1-s)h$.

$$(14.1) \qquad Q = \frac{1}{(1+s)b}[a-c+(1-s)h-2\sqrt{\mu\alpha r}]$$

$$(14.2) \qquad K = \frac{\sqrt{\mu\alpha}}{(1+s)b\sqrt{r}}[a-c+(1-s)h-2\sqrt{\mu\alpha r}]$$

$$(14.3) \qquad P = \frac{1}{1+s}[sa+c-(1-s)h+(1-s)\sqrt{\mu\alpha r}]$$

With the same proportion of private partnership *s*, compared to the case of local government, the involvement of a central government leads to larger capacity investment and lower service charge. As a result, traffic volume is higher. As a result, the congestion level (i.e. *D*) will be the same as in the case of local government. In addition, it can be shown that

$$(15) \qquad \frac{\partial K}{\partial s} < 0, \quad \frac{\partial P}{\partial s} > 0, \quad \frac{\partial Q}{\partial s} < 0, \quad \frac{\partial D}{\partial s} = 0, \quad \frac{\partial K}{\partial h} > 0$$

The results are similar to the case of local government: As the private investor controls a larger share, port charge will be increased while capacity investment will be reduced. This leads to reduced traffic volume, but congestion level will not be affected.

## 4. The Case With Inter-Port Competition

In the last section, we only considered the case of a monopoly port. In practice, many ports around the world face some competitive pressure, either from nearby ports with overlapping hinterlands, or major hub ports serving significant transshipments. In some ports, terminals are separately owned by different terminal operators. Such inter-terminal competition may also be approximated with inter-port competition modeled in our study, if terminal operators have similar autonomy in deciding price and capacity investment. Clearly, the presence of inter-port competition may affect ports" operation and competition strategy. To investigate such potential effects, we consider a case when there are *N* ports competing with horizontally differentiated services. Such differentiation may arise either from the different services provided by port operators, or simply the fact that these ports have overlapping but not identical hinterlands. As a result, even if the ports offer homogenous services, some consumers may prefer to use the nearest ports to others. The demand function faced by port *i* is specified as

$$(16) \qquad P_i = a - bq_i - \gamma\sum_{j\ne i} q_j - \frac{\mu\alpha q_i}{K_i}$$

where $P_i$, $q_i$, $K_i$ are the price, output and capacity of port *i*. The parameter $\gamma$ ( $0 \le \gamma \le b$) measures the degree of product differentiation among the ports. When $\gamma = 0$, the ports provide totally differentiated services thus that they are not competing with each other. This is essentially the same case studied in section 3. When $\gamma = b$, the ports provide homogenous services to each others and the market becomes perfectly competitive when *N* is large.

This demand function corresponds to a representative consumer maximizing the following utility function, where *M* is the numeraire good (money):

$$(17) \qquad U = a\sum_{i=1}^{N} q_i - \frac{1}{2}[\sum_{i=1}^{N}(b + \frac{\mu\alpha}{K_i})q_i^2 + \gamma\sum_{i\neq j} q_i q_j] + M$$

The ports are assumed to have identical costs of capital *r* and marginal cost *c*, and in all ports private operators own a share of *s* of the port. Such port symmetry implies that at equilibrium the outputs at all ports are the same. Consequently, consumer surplus is $CS = U - \sum_{i=1}^{N} P_i q_i$, while profits of all the ports, or producer surplus, are $PS = \sum_{i=1}^{N}(P_i - c)q_i - r\sum_{i=1}^{N} K_i$, and the total spill over effects in all the ports is obtained by summing up across all ports. The total welfare is therefore specified as

$$(18) \qquad SW = a\sum_{i=1}^{N} q_i - \frac{1}{2}[\sum_{i=1}^{N}(b + \frac{\mu\alpha}{K_i})q_i^2 + \gamma\sum_{i\neq j} q_i q_j] + [\sum_{i=1}^{N}(h - c)q_i - r\sum_{i=1}^{N} K_i]$$

While the total social welfare of all the ports can be clearly defined as in (18), the specification of each port‟s objective function is not straightforward as there is no port specific consumer surplus. The surplus of the users of a port, say port *i*, is dependent on the traffic volumes served by other ports (i.e., $q_j$ ‟s for all $j \neq i$) as well as the degree of product differentiation among the ports (i.e., $\gamma$). More importantly, each port‟s objective function is dependent on the market structure, and it can be quite complicated when a central government is involved. A central government prefer to coordinate the capacity and pricing decisions of all the ports in order to maximize overall social welfare. However, it is unclear how this can be done if multiple private investors are involved. Consider a case when private company A has shares in two ports in a region, while another private company B has interests in the remaining three ports. The central government wishes to coordinate capacity investment and pricing for all ports. However, private company A and B aim to maximize each individual port‟s profit and therefore don‟t always prefer cooperation to competition. Without additional assumptions, it is unclear how each port‟s objective shall be specified for such complex market structure and port ownership forms. Therefore we choose to consider following three special cases:

Case I: all ports are fully privatized and there is no government involved at all. This implies that $s = 1$. There are *N* private investors competing with each other in an oligopoly port market;

Case II: all ports are partially privatized where *N* private investors and *N* local government each controls proportions of *s* and 1-*s* shares in these ports respectively.

Case III: all ports are owned by a central government thus that $s = 0$. There is neither privatization nor inter-port competition. The central government coordinates the pricing and capacity investments in all ports to maximize overall social welfare:

While these cases do not cover all possible market structures, they present increasing government involvement and port coordination from Case I to Case III. This allows us to evaluate the effects of inter-port competition, port coordination and privatization by comparing modeling results across these cases.

*4.1. Case I – Oligopoly fully privatized ports*

As described above, in this case all ports are fully privatized and there is no government involvement at all. The *N* oligopoly ports compete with each other by setting its own capacity $K_i$ and port service charges $P_i$. The profit maximization problem of port *i* can be specified as:

(19) $$Max_{P_i,K_i}\Pi_i = (P_i - c)q_i - rK_i \ \ s.t. \ \ q_i \le K_i$$

leading to following first order conditions:

(20.1) $$\frac{\partial \Pi_i}{\partial P_i} = q_i + (P_i - c)\frac{\partial q_i}{\partial P_i} = 0$$

(20.2) $$\frac{\partial \Pi_i}{\partial K_i} = (P_i - c)\frac{\partial q_i}{\partial K_i} - r = 0$$

With inverse demand function defined as in (16) and the condition of symmetry so that $q_i = q_j$ at equilibrium the oligopoly competition can be solved as follows:

(21.1) $$q_i = \frac{a - c - 2\sqrt{\mu\alpha r}}{2b + \gamma(N-1)}$$

(21.2) $$P_i = \frac{a+c}{2} - \frac{\gamma(N-1)(a - c - 2\sqrt{\mu\alpha r})}{4b + 2\gamma(N-1)}$$

(21.3) $$K_i = \frac{\sqrt{\mu\alpha}(a - c - 2\sqrt{\mu\alpha r})}{\sqrt{r}[2b + \gamma(N-1)]}$$

Capacity constraint in (19) requires that $r \le \alpha\mu$, thus that the solution is an interior solution.

*4.2. Case II – Partially privatized ports with local government partnership*

In this case ports are partially privatized. In each port, a local government controls (1-*s*) of port interests, and aims to maximize local benefit which is the sum of port profit and spill-over effects. The objective function of port *i* is specified as in (22), thus that each port maximizes its respective composite / weighted objective function by choosing the appropriate port service charge $P_i$ and port capacity $K_i$, where capacity constraints and non-negative profit requirements apply as usual:

(22) $$Max_{P_i,K_i}\Pi_i = (1-s)[(P_i - c + h)q_i - rK_i] + s[(P_i - c)q_i - rK_i]$$
$$s.t. \ \ q_i \le K_i \ \text{ and } \ (P_i - c)q_i - rK_i \ge 0$$

The first order conditions of (22) imply that

(23.1) $$\frac{\partial \Pi}{\partial P_i} = q_i + (P_i - c)\frac{\partial q_i}{\partial P_i} + (1-s)h\frac{\partial q_i}{\partial P_i} = 0$$

(23.2) $$\frac{\partial \Pi}{\partial K_i} = (P_i - c)\frac{\partial q_i}{\partial K_i} - r + (1-s)h\frac{\partial q_i}{\partial K_i} = 0$$

Imposing symmetry condition $q_i = q_j$, it can be shown that at equilibrium

(24.1) $$q_i = \frac{a - c + (1-s)h - 2\sqrt{\mu\alpha r}}{2b + \gamma(N-1)}$$

(24.2) $$P_i = \frac{1}{2}[a + c - (1-s)h] - \frac{\gamma(N-1)[a - c + (1-s)h - 2\sqrt{\mu\alpha r}]}{4b + 2\gamma(N-1)}$$

(24.3) $$K_i = \frac{\sqrt{\mu\alpha}[a - c + (1-s)h - 2\sqrt{\mu\alpha r}]}{\sqrt{r}[2b + \gamma(N-1)]}$$

Port capacity constraint implies that $r \le \mu\alpha$. The results in (24.1)-(24.3) imply that

(25) $$\frac{\partial K_i}{\partial s} < 0, \quad \frac{\partial\left(\sum_i K_i\right)}{\partial N} > 0, \quad \frac{\partial P_i}{\partial s} > 0, \quad \frac{\partial q_i}{\partial s} < 0, \quad \frac{\partial D_i}{\partial s} = \frac{\partial D}{\partial N} = \frac{\partial D}{\partial \gamma} = 0,$$

Some of the results are similar to the monopoly port case: for each port, as the private investor controls a larger share of interests, capacity investment will decrease while service charge will increase. This leads to reduced traffic volume. In addition, when there is increased number of ports, the total capacity of all ports will increase. However, congestion delay at each port is not affected by port ownership, port service differentiation or inter-port competition (as measured by the number of competing ports, *N*).

*4.3. Case III - Coordinated ports controlled by a central government*

In this case, all ports are owned and controlled by a central government thus that $s = 0$. There is neither privatization nor inter-port competition. The central government coordinates pricing and capacity investments in all ports to maximize overall social welfare. The central government‟s objective function is specified as in (26), where $\vec{P} = (P_1,...,P_N)$ is the price vector of the ports while $\vec{K} = (K_1,...,K_N)$ is the capacity vector.

(26) $$Max_{\vec{P},\vec{K}} SW = a\sum_{i=1}^{N} q_i - \frac{1}{2}[\sum_{i=1}^{N}(b + \frac{\mu\alpha}{K_i})q_i^2 + \gamma\sum_{i\neq j} q_i q_j] + [\sum_{i=1}^{N}(h-c)q_i - r\sum_{i=1}^{N} K_i]$$

$$s.t. \quad q_i \le K_i \text{ for any } i$$

This leads to following vectors of first order conditions

(27.1) $$\frac{\partial SW}{\partial P_i} = \sum_{j=1}^{N}(P_j + h - c)\frac{\partial q_j}{\partial P_i} = 0, \qquad i = 1,2\ldots N$$

(27.2) $$\frac{\partial SW}{\partial K_i} = \sum_{j=1}^{N}(P_j + h - c)\frac{\partial q_j}{\partial K_i} = r - \frac{\mu\alpha q_i^2}{2K_i^2}, \qquad i = 1,2\ldots N$$

Note all ports are symmetric thus that $P_1 = P_2 = ... = P_N$. By (27.1) we have

(28) $$(P_i + h - c)\sum_{j=1}^{N}\frac{\partial q_j}{\partial P_i} = 0 \qquad i = 1,2,\ldots N$$

This implies that either $P_i = c - h$ or $\sum_{j=1}^{N} \frac{\partial q_j}{\partial P_i} = 0$. Below we show that $\sum_{j=1}^{N} \frac{\partial q_j}{\partial P_i} = 0$ is not possible so that $P_i = c - h$ must hold. Note by (16) we have $P_i = a - bq_i - \gamma \sum_{j \neq i} q_j$ for port *i* and $P_l = a - bq_l - \gamma \sum_{j \neq l} q_j$ for another port *l* ($l \neq i$). Differentiating the two equations with respect to $P_i$ leads to

(29.1) $$(b + \frac{\mu\alpha}{K_i}) \frac{\partial q_i}{\partial P_i} + \gamma \sum_{j \neq i} \frac{\partial q_i}{\partial P_i} = -1$$

(29.2) $$(b + \frac{\mu\alpha}{K_l}) \frac{\partial q_l}{\partial P_i} + \gamma \sum_{j \neq i} \frac{\partial q_j}{\partial P_i} = 0$$

If $\sum_{j=1}^{N} \frac{\partial q_j}{\partial P_i} = 0$, it follows from (29.2) that $(b + \frac{\mu\alpha}{K_l} - \gamma) \frac{\partial q_l}{\partial P_i} = 0$, or $\frac{\partial q_l}{\partial P_i} = 0$ since $b \geq \gamma$ and the cost of delay is positive. As *l* is arbitrarily chosen, this implies that $\frac{\partial q_1}{\partial P_i} = \frac{\partial q_2}{\partial P_i} = ... = \frac{\partial q_N}{\partial P_i} = 0$, which contradicts to (29.1). Therefore, we must have

(30) $$P_i = c - h$$

Such result is a variant of the well-known principle of public utility pricing: to maximize social welfare, price should be set at marginal cost *c*. In (30) the price is marked down by *h* to incorporate the positive externality of port operation to the economy. With (30), (27.1), (27.2) and the symmetry condition, it can be solved that at equilibrium

(31.1) $$q_i = \frac{a + h - c - \sqrt{2\mu\alpha r}}{b + (N-1)\gamma} \qquad i = 1,2,\ldots N$$

(31.2) $$K_i = \frac{\sqrt{\mu\alpha}(a + h - c - \sqrt{2\mu\alpha r}}{\sqrt{2r}[b + (N-1)\gamma]} \qquad i = 1,2,\ldots N$$

*4.4. Equilibrium results comparison of the three cases*

For ease of reference, superscript is used in this section to denote the outcomes in the three cases as defined above. It can be found that when the positive spill-over effect *h* is very large thus that $sh > (\sqrt{2} - 1)(a - c) - \sqrt{2\mu\alpha r}$, we always have $K^I < K^{II} < K^{III}$. That is, a fully privatized port will invest the least capacity. The involvement of local governments leads to larger capacity, which is still insufficient for overall welfare maximization. The intuition is clear: if there is significant spillover effect of port operation, a central government will fully take into account of such positive externality by coordinating larger capacities and outputs.

When the positive spill-over effect is moderate and inter-port competition is not very aggressive, in the sense that $sh \leq (\sqrt{2} - 1)(a - c) - \sqrt{2\mu\alpha r}$ and the number of competing ports $N < \frac{[(2 - \sqrt{2})(a - c) + (2 - \sqrt{2}(1 - s))h]b}{[(\sqrt{2} - 1)(a - c) + (\sqrt{2}(1 - s) - 1)h - \sqrt{2\mu\alpha r}]\gamma} + 1$, we still have $K^I < K^{II} < K^{III}$. That is, when the competition is not too sharp, private investors or local governments will still under-invest than the social optimal level.

When the positive spill-over effect is moderate and inter-port competition is very sharp with a large number of ports competing in the market, in the sense that $sh \le (\sqrt{2}-1)(a-c) - \sqrt{2\mu\alpha r}$ and $N > \dfrac{[(2-\sqrt{2})(a-c)+2h]b}{[(\sqrt{2}-1)(a-c)-h-\sqrt{2\mu\alpha r}]\gamma} + 1$ in our model, we have $K^{III} < K^{I} < K^{II}$. That is, privatized ports will over-invest than social optimal when there is significant competitive pressure. Interestingly, capacity waste is worst in the case with local government involvement. Since local governments care both (local) port profit and (local) spill over effects, under competitive pressure they tend to over-invest in port capacity.

While port capacity investment can be influenced by many factors as discussed above, when port pricing is taken into account, the condition $D^{I} = D^{II} < D^{III}$ always hold. That is, fully privatized ports will have the same congestion level as in the case of partially privatized ports involving local governments. A central government however would achieve higher congestion level. This is different from the case of monopoly port as inter-port competition promotes larger capacity investment. However, competition effect is absent if all ports are controlled by a central government.

## 5. Conclusions

Contemporary economic development ensures that port performance has become pivotal within the logistical supply chain. While many qualitative studies have discussed the inter-dependence of port ownership (including mixed ownership), inter-port competition, capacity investment and port pricing, few analytical models have been developed thus that all these factors can be analyzed simultaneously. This prevents researchers to draw an overall picture of the port industry, or to derive some general results of port operation. This paper proposes an integrated economic model with which the effects of these factors can be analyzed jointly. Our analytical results suggest that capacity investments and congestion level can indeed be influenced by factors such as ownership forms, presence of inter-port competition and possible port operation externalities. The result highlights include: (1) *ceteris paribus*, private investors would commit less capacity than governments who care more about regional economic benefits and the well-being of port users. However, given their profit maximization (or at least cost coverage) nature, private investors would charge higher prices which would likely reduce traffic volume. Under such balancing mechanism, in the absence of inter-port competition, port ownership would have no systematic influence over congestion level; moreover, (2) inter-port competition plays important roles in the determination of port capacity and pricing. As a result, congestion level will also be affected. In particular, when the spillover effect of port operation is moderate while inter-port competition is significant, private investors would invest excessive capacity than the social optimal level. Local governments would commit even more capacity. This would reduce congestion level but lead to excess capacity, and ultimately wastage of valuable resources.

Our model has provided evidence to support the proposition that port capacity and congestion can be influenced by many attributes including ownership structure, spillover effects, inter-port competition and (the continuance) of public influence. This probably explains why diversified port management structures have been observed in different regions around the world. Our study supports the standpoint of Ng and Pallis (2010) where the influence of institutions cannot be neglected in understanding diversified port reform process. Our study also serves as an ideal complement to other qualitative works (see section 2) and offers fresh insight to the topic, and indicates that it is important for port decision-makers to conduct detailed empirical investigation on the factors we modeled when actual policy/business decisions are to be made. Perhaps more importantly, our model offers some convincing empirical evidence counter-arguing the logic of unrestricted private participation in ownership and operation of large scale public infrastructures like ports (cf. Harrison, 2010). Surely, devolution and privatization can bring some positive effects. Nevertheless, as warned by Vining and Boardman (2008), it is not necessarily a cure-all strategy for port decision-makers.

Some simplifications have been made in our model due to modeling tractability. First, it is assumed that the efficiency levels of public and private ports are the same. If private ports are more efficient than public ports, then our model would predict less congestion when private share holding in a port increases. Secondly, it is assumed that the capital costs are the same for both state and private investors. In reality, state investors or governments usually are rated as low risk borrowers. As a result, their capital costs are usually lower than private investors. In such a case, capacity investment will increase as state investors have greater interests in the ports. If these two factors are explicitly considered, the actual port investment decision will deviate from our conclusion depending on the magnitudes of these two factors. The influences of these two factors are predictable thus that they should have limited impacts to the conclusions obtained in our study. However, the influences of alternative congestion functions are less clear. As Basso and Zhang (2008) pointed out, instead of imposing capacity constraints, one may introduce a more convex delay function so that congestion increases dramatically when traffic volume approaches capacity limit[1]. Future studies testing alternative delay functions will be valuable.

Despite such limitations, by modeling partial privatization (mixed ownership) and composite port objective functions, we have proposed a good framework to analyze a range of ownership options within one consistent model. Methodologically, we also offer an integrated model with which the effects of ownership, inter-port competition and positive externality/spillover effects can be analyzed jointly. In addition, ports are modeled as making decisions on both pricing and capacity. This allows us to systematically study port behaviors rather than focus on a single port decision only. Indeed, the framework we proposed is very general in that many factors have been explicitly considered. Different objective functions have been specified in order to analyze possible strategic differences between local and central governments. Such a new approach has not been widely used in the port literature. Last but not least, this study offers some fresh insight to the ongoing debates of private participation in the ownership and operation of transport infrastructure, as well as the implications of continual government involvements. Further studies incorporating empirical elements in the future would be of great value.

## References


AXS-Alphaliner (2009), *China Container Ports Review 2009*, AXS-Alphaliner, London.

Baird, A. (2000), "Port privatization: objectives, extent, process and the UK experience", *International Journal of Maritime Economics*, 2(3), 177-194.

Barros, C.P. (2003), "Incentive regulation and efficiency of Portuguese port authorities", *Maritime Economics and Logistics*, 5, 55-69.

Bassan, S. (2007), "Evaluating seaport operation and capacity analysis – preliminary methodology", *Maritime Policy and Management*, 34(1), 3-19.

Basso, L. and Zhang, A. (2008), "Congestible facility rivalry in vertical structures", *Journal of Urban Economics*, 61(2), 218-237.

Beresford, A.K.C., Gardner, B.M. and Pettit, S.J. (2004), "The UNCTAD and WORKPORT models of port development: evolution or revolution?" *Maritime Policy and Management*, 31(2), 93-107.

Boardman, A. and Vining, A. (2009), "Ownership and performance in competitive environment: a comparison of the performance of private, mixed and state-owned enterprises", *Journal of Law and Economics*, 32, 1-33.

Brooks, M.R. and Cullinane, K. (Eds.) (2007), *Devolution, Port Governance and Port Performance*, Elsevier, Oxford.

Chang, Y.T., Lee, S.Y. and Tongzon, J.L. (2008), "Port selection factors by shipping lines: different perspectives between trunk liners and feeder service providers", *Marine Policy*, 32(6), 877-885.


[1] For example, one alternative delay function is $D = \frac{Q}{Q(K-Q)}$, thus that $D$ approaches infinity when output $Q$ approaches capacity $K$.

Cheon, S.H., Dowall, D.E. and Song, D.W. (2010), "Evaluating impacts of institutional reforms on port efficiency changes: ownership, corporate structure, and total factor productivity changes of world container ports", *Transportation Research E*, 46(4), 546-561.

Cowen, D. (2010), "A geography of logistics: market authority and the security of supply chains", *Annals of the Association of American Geographers*, 100(3), 600-620.

Cullinane, K. and Song, D.W. (2001), "The administrative and ownership structure of Asian container ports", *International Journal of Maritime Economics*, 3, 175-197.

Cullinane, K., Song, D.W. and Gray, R. (2002), "A stochastic frontier model of the efficiency of major container terminals in Asia: assessing the influence of administrative and ownership structures", *Transportation Research A*, 36(8), 743-762.

De Langen, P.W. and Pallis, A.A. (2006), "Analysis of the benefits of intra-port competition", *International Journal of Transport Economics*, XXXII(1), 69-85.

Estrin, S. and Perontin, V. (1991), "Does ownership always matter?" *International Journal of Industrial Organization*, 9, 55-72.

Everett, S. (2007), "Port reforms in Australia: regulation constraints on efficiency", *Maritime Policy and Management*, 34(2), 107-119.

Everett, S. (2008), "Public sector deregulation: a paradigm in conflict", *Maritime Policy and Management*, 35(4), 341-351.

Gonzalez, M.M. and Trujillo, L. (2008), "Reforms and infrastructure efficiency in Spain‟s container ports", *Transportation Research A*, 42(1), 243-257.

Goss, R. and Stevens, H. (2001), "Marginal cost pricing in seaports", *International Journal of Maritime Economics*, 3, 128-137.

Hall, P.A., 1986, *Governing the Economy: The Politics of State Intervention in Britain and France*, Polity, Cambridge.

Haralambides, H.E. (2002), "Competition, excess capacity and the pricing of port infrastructure", *Maritime Economics and Logistics*, 4, 323-347.

Harrison, J. (2010), "Networks of connectivity, territorial fragmentation, uneven development: the new politics of city-regionalism", *Political Geography*, 29, 17-27.

Heaver, T.D. (2002), "The evolving role of shipping lines in international logistics", *International Journal of Maritime Economics*, 4, 210-230.

Kent, P.E. and Ashar, A. (2001), "Port competition regulation: a tool for monitoring for anti-competitive behavior", *International Journal of Maritime Economics*, 3, 27-51.

Liu, Z. (1992), *Ownership and Productive Efficiency: With Reference to British ports*. PhD thesis, Queen Mary and Westfield College, University of London.

McLeod, G. and Jones, M. (2007), "Territorial, scalar, networked, connected: in what sense a „regional world‟?" *Regional Studies*, 41, 1177-1191.

Ng, K.Y.A. (2002), *Port Operation, Reform and Governance in China: A Case Study*. MPhil thesis, The University of Hong Kong, Hong Kong.

Ng, K.Y.A. (2006), "Assessing the attractiveness of ports in the North European container transshipment market: an agenda for future research in port competition", *Maritime Economics and Logistics*, 8(3), 234-250.

Ng, A. (2009), *Port Competition: The Case of North Europe*, VDM Verlag, Saarbrucken.

Ng, A.K.Y. and Gujar, G.C. (2009), "Government policies, efficiency and competitiveness: the case of dry ports in India", *Transport Policy*, 16(5), 232-239.

Ng, A.K.Y. and Pallis, A.A. (2010), "Port governance reforms in diversified institutional frameworks: generic solutions, implementation asymmetries", *Environment and Planning A* (manuscript accepted, forthcoming).

Notteboom, T. and Rodrigue, J.P. (2005), "Port regionalization: towards a new phase in port development", *Maritime Policy and Management*, 32 (3), 297-313.

Oum, T.H. and Yu, C. (1994), "Economic efficiency of railways and implications for public policy: a comparative study of the OECD countries" railways", *Journal of Transport Economics and Policy*, 28(2), 121-138.

Port of Rotterdam website: www.portofrotterdam.com, last accessed in August 2010.

Sanchez, R.J., Hoffmann, J., Micco, A., Pizzolitto, G.V., Sgut, M. and Wilmsmeier, G. (2003), "Port efficiency and international trade: port efficiency as a determinant of maritime transport costs", *Maritime Economics and Logistics*, 5, 199-218.

Slack, B. and Fremont, A. (2004), "The Transformation of port terminal operations: from the local to the global", *Transport Reviews*, 25, 117-130.

Song, D.W. and Cullinane, K. (2001), "Port privatization: a new paradigm of port policy". In: Borgese, E.M., Chircop, A. and McConnell, M.L. (Eds.), *Ocean Yearbook (Volume 16)*, University of Chicago Press, Chicago, pp. 398-420.

Song, D.W. and Han, C.H. (2004), "An econometric approach to performance determinants of Asian container terminals", *International Journal of Transport Economics*, XXXI(1), 39-53.

Theys, C., Notteboom, T.E., Pallis, A.A. and De Langen, P.W. (2010), "The economics behind the awarding of terminals in seaports: towards a research agenda", *Research in Transportation Economics*, 27(1), 37-50.

Tongzon, J.L. (2009), "Port choice and freight forwarders", *Transportation Research E*, 45(1), 186-195.

Tongzon, J.L. and Heng, W. (2005), "Port privatization, efficiency and competitiveness: some empirical evidence from container ports (terminals)", *Transportation Research A*, 39(5), 405-424.

Vickers, J., Yarrow, G. (1989), *Privatization: An Economic Analysis*, MIT Press, Cambridge, Massachusetts.

Vining, A.R. and Boardman, A.E. (2008), "The potential role of public-private partnership in the upgrade of port infrastructure: normative and positive considerations", *Maritime Policy and Management*, 35(6), 551-569.

Wang, J.J., Ng, A.K.Y. and Olivier, D. (2004), "Port governance in China: a review of policies in an era of internationalizing port management practices", *Transport Policy*, 11(3): 237-250.

World Bank (2007), *Port Reform Toolkit (Second Edition)*, The World Bank Group, Washington DC.

World Cargo News (2010), "Chinese ports respond to overcapacity problem", 28 March 2010. Yarrow, G. (1986), "Privatization in theory and practice", *Economic Policy*, 2, 323-377.