Analysis on port-city growths in China

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Abstract

This paper aims to model the economic production of port-cities and their evolution by considering the port production versus city factors. The paper uses the economic production equation to determine the growth of China's port cities over the period 1995-2005. There have been numerous studies examining general port growth and development on the basis of conceptual discussion. It is generally accepted that the Anyport Model and the Port Generation Model are considered the valuable models for a port developing into a port city. However, quantitative studies on port growth and factors that influence the growth rate are rather few. This study seeks to identify the factors that are critical to determine port city growth and attempts to develop an empirical model in the macroeconomic perspective. Seven major China port-cities and their interface with the reliance-ports are studied in the paper. This paper contributes to literature by identifying the port activities as economic production and the city factors as production inputs. This paper provides a quantitative analysis of port growth and policy insights on the interdependence between port and port-city.

Keywords: Port city, Anyport model, Cobb-Douglas production function

1. Introduction

Globalisation is a trend in the business world. Businesses are all looking globally for effective logistics solution. In the shipping and port industry, logistics integration is reinforced by globalisation. Forming networks with neighbour ports or having strategic alliance with remote destination ports are usual practices of scaled ports nowadays. The ports can enhance efficiency, strengthen competitiveness and achieve synergy effects and economies of scale. The role of ports is broadened and elaborated from a simple sea-shore interface to a comprehensive logistics centre. It is developed from an isolated facility to a community asset. The port and city are then inter-related and inter-dependence. A port facilitates the growth of its city and regional economy, whereas the growth of city pushes the development and evolution of its port. The city and port issues may be complementary as well as contradictory. On one hand, successful ports around the world are often city-ports. On the other hand, the port-city interface is one of the major determinants of the successfulness of modern ports, and therefore the formation of major port-cities.

Both port and city tend to focus on global outlook, logistics integration and transportation network. Under globalisation, there exists a close relationship between port and city developments, city-ports (and so as port-cities) serve the global markets with integrated logistics and supply chain flows. In modern shipping and port industry, in order to facilitate efficiency and trades, globalisation encourages standardisation in shipments and cargo handling. Containerisation is resulted. Containerisation advances the port facilities and develops cities. Major city-ports are having advanced container terminals. The port-cities are also having integrated logistical facilities to support the port operations and the city activities.

China is a continuously growing country in terms of economy and world position. The world is now looking into China for opportunities. With the China Open-Door Policy in 1978 and China joining into the World Trade Organisation (WTO) in 2000, trades play a crucial role to the growth and

development of ports and coastal cities, as well as economies in China. In addition to the long coastal line, undoubtedly, the development of sea-bound international trades in China has a bright future.

From the geographical perspective, a port-city can be classified into two spatial scales. At a local scale, a port-city is the "area in transition" where combining port and urban jurisdiction and functions (Hoyle, 1989). At a wider scale, assuming land-sea connexion, a port-city is the nodal system as a whole within a regional area, consisting multiple cities and ports (Ducruet and Jeong, 2005). From the economic perspective, port-city is a city with port functions, which the city functions and port functions are keeping a balanced combination of centrality and intermediacy (Ducruet, 2005). A port-city is a product of the integration of port and city. Not only can it reflect the common characteristics of a general city, but also have its specific contents and rules of movement (Ducruet and Lee, 2006).

This paper aims to explore the economic function of port-cities and their evolution by considering the port production versus various factors of port-cities.

2. Literature Review

There are two hypotheses on the evolution of port and city: port-led growth and city-led growth. From the port-led hypothesis, the port development is described in the Anyport Model with 6 stages (Bird, 1963). Starting from the initial port site with small lateral quays adjacent to the town centre, the elaboration of wharfs is the product of evolving maritime technologies and improvements in cargo handling. This is also marked by changing spatial relationships between the port and the urban core, as docks are built further away from the central business district. In the final stages, increased specialization of cargo handling, growing sizes of ships, and ever increasing demands for space for cargo-handling and storage resulted in port activity being concentrated at sites far removed from the oldest facilities.

The Anyport Model implicates the changing relation between ports and their host cities. It describes the growing repulsion by the rest of the urban milieu. This aspect has been worked upon over the last two decades by a number of geographers investigating the redevelopment of harbour land. Hoyle (1989) proposed the Anyport-City Model to emphasize the changing linkages between the port and the city, instead of stressing the port infrastructure development. One of these urban linkages is the redevelopment of old port sites for other urban uses.

3. The Port-City Growth Model

Rather than remaining static, a port-city may be constantly growing over time. The port growth can be quantified by the port's activities. The port production should be the most remarkable factor of port activities. We consider a port-city as an organisation, the port production as the output of the organisation and the city factors as factors of production. In other words, the port factors (throughput, turnover or total trade value) are treated as the port productivity which is the combined result of city factors of production (Eq. 1). For the overall productivity of a port, it can be represented by Cobb-Douglas production function (Eq. 2).

$$Production = \mathrm{f}(Land, Capital, Labour) \quad (1)$$

$$Y = A\, L^{\alpha}\, K^{\beta}\, D^{\gamma} \quad (2)$$

where: Y = total port production (the monetary value of production in one year), L = Labour input, K = capital input, D = Land input, A = Constant, α, β and γ = constant output elasticities of labour, capital and land, respectively.

Output elasticity measures the responsiveness of output to a change in levels of either labour or capital used in production. For example if $\alpha = 0.15$, a 1% increase in labour would lead to approximately a 0.15% increase in output. Applying to the port-city, for example, '*Land*' can be

quantified by the '*Infrastructure*', '*Capital*' by '*Economic*' factors and '*Labour*' by '*Demographic*' factors. The city factors affect the port factors and facilitate the port development, and vice versa. The port production is therefore the combination result of all the city factors. Presenting the factors by function formula, Eq. (3), port production is the dependent variable, whereas economic, demographic, fixed assets and FDI are independents in the given years. For easy comparison and statistic calculation, the factors are turned into logarithm, as Eq. (4).

$$\textit{Port Production} = f_1(\textit{Economic}, \textit{Demographic}, \textit{Infrastructure}) \quad (3)$$

$$\ln\textit{Port Production} = f_2(\ln\textit{Economic}, \ln\textit{Demographic}, \ln\textit{Infrastructure}) \quad (4)$$

Where
Port Production = *Throughput*, or *Total trade value*, or *Turnover*,
Economic = g_1 (*GDP*, *GDP per capita*),
Demographic = g_2 (*Population*, *Total employment*, *Employment in tertiary sector*),
Infrastructure = g_3 (*Fixed assets investment*, *Contracted foreign direct investment*), and
ln = Log of the figure of the year,

Combining port production and factors of port production, it has Eq. (5).

$$\ln Y = \ln A + \alpha \ln L + \beta \ln K + \gamma \ln D \quad (5)$$

where $\ln Y$ is the factor quantifying the port growth rate.

4. Data and Analysis

Table 1 summarises the data collected from China Statistics Yearbooks (1995 to 2007 data). The seven ports are the leading ports in China. The data for the port and the city where the port is located in are then collated.

Table 1: Data on Port and City Factors from 1995 – 2007

	Production			Economic		Demographic			Infrastructure	
	Port Throughput 10k tons	Port Freight 100m ton-km	Trade value Total 100m USD	GDP 100m USD	GDP per Capita	Population 10k persons	Total Employment 10k persons	Employment in tertiary 10k persons	Investment in Fixed Asset 100m Yuan	Contracted FDI 100m USD
Dalian	6,417 – 17,085	–	133 – 256	733 – 2,152	13,676 – 42,579	537 – 572	85 – 280	43 – 102	115 – 1,469	24 – 46
Tianjin	5,787 – 24,069	73 - 12108	65 – 716	918 – 5,018	10,281 – 45,829	942 – 1,115	403 – 614	159 – 276	393 – 2,389	35 – 73
Qingdao	5,103 – 18,678	–	88 – 330	710 – 2,696	10,331 – 38,892	690 – 749	103 – 393	42 – 254	79 – 1,486	7 – 80
Shanghai	16,388 – 44,317	117 – 13,695	190 – 2,830	2,463 – 12,001	18,943 – 57,695	1,415 – 1,858	670 – 906	284 – 503	1,602 – 4,459	15 – 149
Ningbo	6,853 – 26,881	–	–	796 – 2,449	15,069 – 51,460	530 – 560	57 – 414	30 – 96	146 – 1,503	5 – 41
Xiamen	1,314 – 4,771	–	76 – 286	308 – 1,007	25,248 – 50,130	123 – 160	94 – 96	15 – 32	79 – 648	7 – 19
Shenzhen	5,697 – 15,351	–	639 – 1,828	950 – 4,951	46,388 – 115,060	103 – 201	93 – 272	41 – 100	186 – 1,287	12 – 48

Source: China Data Online

The findings are generated by SPSS correlation and regression analysis programme. They consist of analysis of the port growth rate and corresponding city factors from 1995 to 2007. The correlation test is used to test the correlation between port and city factors. Port factors (i.e. annual throughput, port turnover and total trade value) are tested with city factors one by one. From Table 2, the correlations among port factors and city factors can be statistically supported. Based on the

significance of the city factors to port factors, the model specification of Cobb-Douglas production function is then tested.

Table 2: Correlation Coefficient (R) of the Growth in Port and City Factors

Growth		Port Productivity		
		Throughput	Freight	Trade
Economic	GDP	0.912 **	0.563 **	0.862 **
	GDP per Capita	0.310 *	0.628 *	0.819 *
Demographic	Population	0.738 **	0.348	0.171
	Total employment	0.503 **	0.228	0.377 *
	Employment in tertiary sector	0.610 **	0.294	0.430 **
Infrastructure	Fixed Asset Investment	0.819 **	0.506 *	0.775 **
	Contracted FDI	0.760 **	0.386	0.648 **

** Correlation is statistically significant if $p < 0.01$ (2-tailed)
* Correlation is marginally significant if $p < 0.05$ (2-tailed)

Table 3 summarizes the regression outputs of the port production and city factors, where each of 3 models uses one single port factor as port production. The *R*-squares are 0.971, 0.690 and 0.983 indicate the high explaining power of the proposed models. Therefore the city factors can be used to predict the port production. Regarding the level of significance, the factors are highly significant when *p* is smaller than 0.01 (**) and are moderately significant when *p* is smaller than 0.05 (*). If the significant level is larger than 0.05, the independent factor will not be considered significant to the dependent factor. As the three models show similar regression results, the finding is robust and independent of different ways to define the port production. However, there are some discrepancies of variable signs among the three models.

Table 3: Significant (p) of the Growth in Port Throughput and City Factors

Growth		Port Throughput		
		Throughput	Freight	Trade
Economic	GDP	1.282**	16.652	1.731**
	GDP per Capita	–0.301*	–1.617	0.419**
Demographic	Population	0.365**	–7.260	–0.635**
	Total employment	–0.427**	15.786*	0.531**
	Employment in tertiary sector	0.039	–12.312	–0.304
Infrastructure	Fixed Asset Investment	–0.179*	–9.463*	–0.541**
	Contracted FDI	–0.075	–2.747*	0.112*
Constant		3.939*	–11.054	–6.110**
R^2		0.971	0.690	0.983

** Correlation is statistically significant if $p < 0.01$ (2-tailed)
* Correlation is marginally significant if $p < 0.05$ (2-tailed)

From Table 3, economic and demographic factors are highly significant to port throughput in general. In the 'throughput' model, the employment in tertiary sector and the contracted FDI are not significant to the port throughput. Due to the limited number of observations of port freight, the 'freight' model is not statistically satisfactory, in which only the total employment, fixed asset investment and the contracted FDI are significant in the model. The 'trade' model shows the most satisfactory results, and only the employment in tertiary sector is not significant to the total trade value.

The significance of economic and demographic factors to port productivity is understandable. In a port-city, the port and city are inter-reliance in which the economic factors will affect the capital input to port and the demographic factors would affect the labour input. Nevertheless, apart from the total trade value, the significance of fixed assets investment and contracted FDI are not obvious.

It is believed that the growth in fixed assets investment and contracted FDI are getting along with the port productivity of a port-city. The low significance of fixed assets investment and contracted FDI may be attributed to without considering the time lags in generating the regression analysis of economic production model. Investment on fixed assets such as superstructure in port and infrastructure of the city take a long time to complete. The investment decision may be made on the basis of performance of previous years. Similar to investment in fixed assets, the contracted FDI of a year may contribute the port production in the later years. The effect and significance of fixed assets investment and contracted FDI to port production cannot be immediately represented well by the annual data. Moreover, the contracted FDI is usually investing in businesses such as commercial bank and manufacturer, which are not directly related to port operation. The contracted FDI is much belonging to the capital input of a city. Therefore, the significance of contracted FDI to port productivity is also very low.

5. Implications

The first author further conducted site visits in the first half of year 2008, in addition to statistical analysis. The port-city interface of the national port-cities is revealed. The investigation in the port-city interface answers the 2 fundamental questions: (1) how port facilitates city functions; and (2) how city favours port functions.

5.1. How Port Facilitates City Functions

Port functions, from a primitive port to a sophisticated port, are direct cargo flow, simple trade, cargo handling, transhipment, warehousing, consolidation and information flow and other high value adding services. In the settings, the port factors are combined of annual throughput, port turnover and total trade value. At each enhancement and development of the port, the reliance-city is benefited.

When the port's productivity increases with more than simple cargo flow and handling, e.g. transhipment, early medium scale trading companies established around the port to facilitate shippers. These trading companies can improve the efficiency of cargo handling, and therefore rise the turnover of port. In the meanwhile, around the trading companies, which are sources of goods, markets and fairs agglomerate and formal commercial activities like banking and financing began. With commercial activities in the markets, traders and sellers require storage space for incoming or outgoing cargoes, therefore using the port as the warehouse.

From time to time, when trading is boosting around the port and the economy is rising in the city, port throughput can satisfy the growing demand of goods and different commodities. To further facilitate economic activities in the city, infrastructure such as highways and railways are constructed to transport the cargo from the port to the city. Apart from cargo, infrastructure also brings population into the city from outside.

Meanwhile, the consolidation and value added services impose enforcement onto traders to stick with the port. Having a fully functioned port and well established commercial activities and infrastructure, investment can be attracted from the region nearby and overseas. In a port-city, a productive port with whole package of services is beneficial and crucial to the development of city functions. The port-city interface helps the economic growth and demographic upgrading of the city.

5.2. How City Favours Port Functions

City functions, from a little village to a big city, are for better life of people who living in, education, commercial activities, manufacturing and political reasons. In the settings of the previous chapter, city factors of a port-city are economic factors (GDP and GDP per capita), demographic factors (Total employment and employment in the tertiary sector), investment in fixed assets and contracted foreign direct investment. At each enhancement of the city, the reliance-port is benefited. The combination of city factors is also the factors of port productivity.

When markets and fairs start to agglomerate around the port, the cargo at ports can be distributed quickly. The berthing time at port can be shortened and more trade turns in. This can increase the port turnover. When the commercial activities boost in the city, more goods from the incoming vessel is demanded. Having more port calls can boost the port throughput and numbers of direct shipments and transhipments. In the meanwhile, the rise in commercial activities enhance the economic conditions of the city, more trades are shipped through the port and therefore boost the total trade value in the port.

Moreover, to facilitate trade, infrastructure such as railways, highways and bridges are built. With these infrastructures, the connectivity between the port and the outer areas of the city can be achieved. The linkage between the port and the entire city and outside brings population to the city. The population can employed in the port-related value added and supporting logistics services, which is tertiary sector. These services make the port more competitive with more integrated port functions.

Once the port productivity is continuous to rise, the performance of the port becomes advanced and has attracted more capital from the city for port enhancement and expansion. The port can therefore become sophisticated and world ranked. In a port-city, the matured city development is essential and critical to port functions. The port-city interface helps enhancement and specialisation of the port to meet the world pace.

6. Conclusions

An economic production model is developed to study the growth of port-city. The economic production of ports is specified by Cobb-Douglas production function. Regression analysis is applied on port production and city factors by assuming a port-city as a production organisation. It is identified that the city economy is the most significant contributor of port production growth, but there are no consistent effects of the infrastructure and demographic factors. The study offers statistical evidences to the city-led evolution of port-cities and provides a solid foundation to derive economic policies of port development.

Previous conceptual discussion and qualitative analysis have been found very fruitful to understand the mechanisms of port-city evolution. This paper should have contributed to the issues of port-city development model, when the quantitative analysis are desired to determine the port activities against city inputs. However, further research is needed to compare the port growth models across the world and to explore the explaining power of various model specifications. This study should be extended to consider some other city factors and some other modes of port-city evolution. This is important because future port-city planning should include the port management.

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