Dissertation for the degree of PhD

An analysis of the Competition & Development between Ports in Korea and in Shanghai Using the Differential Equation Models

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Abstract

The dissertation mainly focuses on the study of port container transshipment. The several models were developed in the research to analyze the competition and development of container transshipment. Following the two branch lines of the study two aspects of contents are paid attention to for establishing models and forecasting. Then the two branch lines were incorporated into the same target results.

In the first branch line the purpose of the study is to establish models to analyze the competition among hub and spoke ports, their development especially in Northeast Asia between Korean ports and Shanghai ports in China, and to forecast the T/S amount of Korean ports under the condition of competition mainly from Shanghai ports in China.

In the first branch line study the differential equations are analyzed and applied to establish competition and development models among hub and spoke ports in Northeast Asia mainly based on Korea. And some econometric models are established too by analyzing a huge amount of data about container transportation on the three main routes in the world. Incorporating the econometric models into the differential equations, the differential equations are solved.

The differential equations' approach has been opted combined with econometric analysis after a deliberate pre-feasibility study. The econometric models in the dissertation are established independently. A combination of a quantitative and a strategic analysis for the port competition and their development by applying the differential equations and econometric model analysis is a creative study firstly after the extensive analysis about the hub and spoke ports around Northeast Asia focused on Korea.

In the second branch line study the purpose is to setup the relationship models between T/S and trades focused on Korean ports. By analyzing the relationship between T/S containers and corresponding trades with other countries (or regions) in Northeast Asia based on Korea, the comprehensive model for the relationship is established to analyze and predict relationships between trade and transshipment under the analysis of the data collected.

The quantitative approach encompasses a detailed analysis of the container flow mainly to and from the principal ports on Northeast Asia- North America, in terms of the T/S containers and transpacific containers to and from the relative ports on the route. Furthermore, a model-based approach is taken to predict future T/S containers' levels. Additionally, the segment T/S markets based on Korean for Chinese regions are dealt with.

As a whole, we focus on the phenomenon of port competition and development around Northeast Asia from the perspective of the strategic development of the relevant players. An academic approach will reveal strengths and weaknesses of hub and spoke ports' development. The models of the study provide a foundation to make decisions for shipping companies and ports in selecting hub and spoke ports in a relative long dynamic process.

Chapter 1

Introduction

1.1 Background

The world economy has changed thoroughly as a result of an international redistribution of labors and capital, and the integration and globalization of markets. This trend has coincided with a substantial increase in mobility. Naturally, this also has consequences for maritime transport, to the extent that the role and the significance of seaports are too changing. Modern seaports have become critical nodes in complex logistics chains. Seaports that fail to establish themselves as key players in the optimization process unfolding within such logistics chains are in danger of 'missing the boat' and being disregarded as ports of call on international freight routes.

A port is essentially a point where goods are transferred from one mode of transport to another. Then ports have the functions of collecting, distributing cargoes, and transferring transportation mode from water to land, water to water and land to water. Thus most ports have a hub and spoke function.

In an era of economic globalization ports are evolving rapidly from being traditional land/sea interfaces to providers of complete logistics networks. This means that ports have had to face many challenges due to unpredictable environmental changes and trends in the shipping, port and logistics industries. It is estimated that 90% of the world internationally traded goods are imported or exported by sea. And the container transportation has become the most important way to global trade. There are three main long distance mainline routes of container transportation. They are East Asia-North America, East Asia-Europe and North America-Europe. The total container flow increases rapidly in the world, especially on the three routes. From 2001 to 2005 the sum of the container flow increased by 53.7% (see Figure1-1 and Figure1-2). Hereinto the flow on East Asia-North America route increased by 50% and increased by 66.1% on East Asia-Europe. But the largest flow is still on East Asia-North America, about 17940 thousand TEU which is higher than on East Asia-Europe route by 43%.

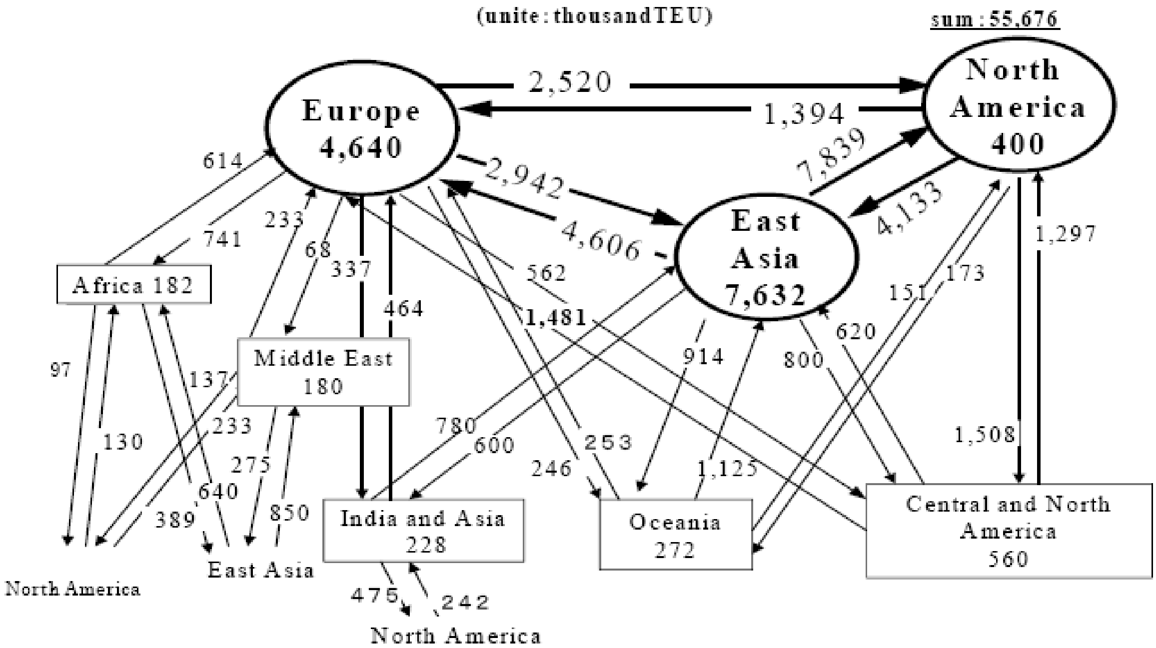


Figure 1-1. World Maritime Container Movement in 2001
(Source: MOL, Nov.2002)

This structure evolution of container flows in the world established a basis of container transshipment in the shipping market. The deployment of bigger ships is another factor to stimulate transshipment increased. Post-Panamax ships of 5000–7500TEU and above now dominate the major world trades. Ship size is still increasing with about 11000TEU ships to be delivered recently, and before 2010 more ships of around 11,000 TEU are anticipated in running.

Some yards such as Germany's HDW and Samsung in Korea have similar sized vessels on the drawing board. Maersk Sealand has put 11,000 TEU ship on routes. These vessels have a draught of between 15.5 and 16.0 meters with a service speed of 26 knots[1].

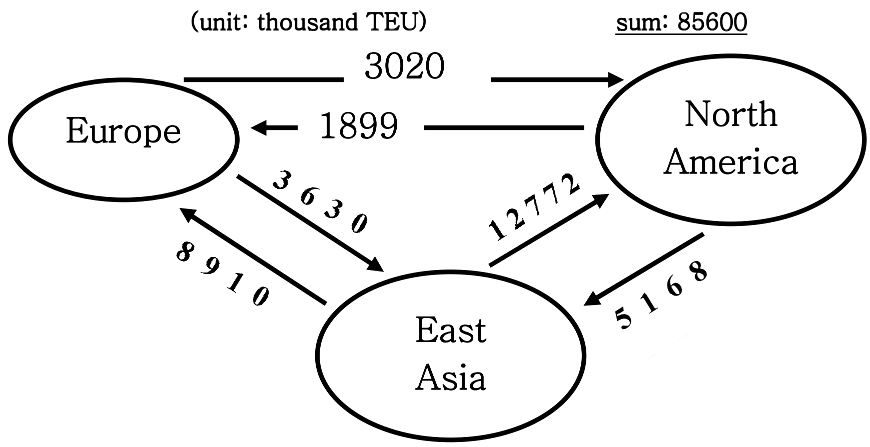


Figure 1-2. World Maritime Container Movement in 2005
(Source: Drewry 2006)

With the rapid development of both the structure of container transportation and the bigger size ships, container transshipment hub ports have become highly sought after throughout the world and especially in some Asian regions. Thus competition between hub and spoke ports arose and has become more and more fierce. It also has made some countries' governments or local governments pay a lot of attention to the intrinsic properties of the ports themselves, such as the geographical location, the available infrastructure, the degree of industrialization, government policy, and the standard of performance of the port. They have made substantial investments in upgrading their ports and corresponding infrastructure. But most of hub and spoke ports in the world still should have paid (or should pay) attention to some challenges and emerging issues, such as:

[1] O. Mahony and Porter 2004.

_rapid growth in volume of world seaborne freight, especially container
_emerging hub and spoke system in global shipping service
_increase of transshipment cargo and competition among ports and terminal operators
_introduction of the super mega size containership
_increasing competition towards hub ports

1.2 Research Objective and Scope

The development background of container shipping and ports' performance has indicated what should be researched. The purpose of this study is to establish models to analyze the competition among hub and spoke ports, their development especially in Northeast Asia between Korean ports and Shanghai ports in China, and to forecast the T/S amount of Korean ports under the condition of competition mainly from Shanghai ports in China. The study is also to setup the relationship models between T/S and trades focused on Korean ports, and to predict the T/S amount through Korea for some Chinese regions. The suggestions are given for the development of Korean ports through the study.

The research questions are quite broad. Therefore limitations in terms of scope and depth are necessary. Some major limitations of the research in this dissertation are recognized.

There are several hub and spoke ports in the world and also in Northeast Asia. The study only focuses on the correlative questions among Korean ports and some ports in China.

The number of factors that influence the T/S containers and the transpacific containers is huge. This study mainly deals with transpacific containers' and relative variables. The relationship proportion variables between T/S containers and trade are focused on based on Korean ports. A focus on these factors can yield new insights, as it has become clear that these variables have a substantial influence on the development of hub and spoke ports around Northeast Asia through the analysis of the history and present data. Although other variables, such as technological development, national policies and other container market's development clearly influence the hub and spoke ports, but most of the information are included in the data which is used for establishing the models and analyzing in the study. Some external variables are considered too in data analysis.

The differential equations are analyzed and applied to establish competition and development models among hub and spoke ports in Northeast Asia mainly based on Korea. Some econometric models are established too by analyzing a huge amount of data about container transportation on the three main routes. Incorporating the econometric models into the differential equations, the differential equations are solved.

By analyzing the relationship between T/S containers and corresponding trades with other countries (or regions) in Northeast Asia based on Korea, the comprehensive model for the relationship is established.

In the process of the study the following tasks are carried out through the course of this study:

- Collection of data and information on container transportation on three major routes and T/S containers based on Korea ports, and trade in Korea with other countries or regions in the Northeast Asian
- Research on current situation of container transportation on major routes especially on transpacific route, and relationship between T/S containers and trades based on Korean ports

- Korean T/S containers' forecast under the condition of competition with Shanghai ports in China.
- The proportions of T/S containers through Korea and trades with Korea for some Chinese regions are predicted, further more the T/S containers through Korea for the Chinese regions are predicted.
- Study and analysis on the results and the T/S ports' future direction
- Recommendation

1.3 Research Methodology

The differential equations' approach has been opted combined with econometric analysis after a deliberate pre-feasibility study. The econometric models in the dissertation are established independently. A combination of a quantitative and a strategic analysis for the port competition and their development by applying the differential equations and econometric model analysis is a creative study firstly after the extensive analysis about the hub and spoke ports around Northeast Asia focused on Korea.

The quantitative approach encompasses a detailed analysis of the container flow mainly to and from the principal ports on Northeast Asia- North America, in terms of the T/S containers and transpacific containers to and from the relative ports on the route. Furthermore, a model-based approach is taken to predict future T/S containers' levels. Additionally, the segment T/S markets based on Korean for Chinese regions are dealt with.

As a whole, we focus on the phenomenon of port competition and development around Northeast Asia from the perspective of the strategic development of the relevant players. An academic approach will reveal strengths and weaknesses of hub and spoke ports' development. The models of the study provide a foundation to make decisions for shipping companies and ports in selecting hub and spoke ports in a relative long dynamic process.

The methods employed are substantial, so that the results obtained may be collated and translated into conclusions that are economically relevant.

1.4 Structure

The dissertation consists of an introduction, six chapters centered on research results, and a final chapter with conclusions and development implications.

Chapter 1 provides an introduction to the dissertation including background analysis and the explanation of the study purpose and objectives. The scope of the study, methodology and approach, structure of the study are explained and analyzed in the chapter too.

Chapter 2 discusses the concept and definition of port competition and hub port development with the competition.

Chapter 3 is concerned with the general evolution and development of the world container trades, container transportation development on the different ocean routes. Some of the major changes that have occurred in the container shipping environment over the last decade have been analyzed. And the economic growth context related export and import between Northeast Asia and North America is set forth. The container trades on the specific route and in the ports among Korea and China are analyzed too.

Chapter 4 is devoted to discussion of the model's establishing of development and competition between ports in Korea and ports in Shanghai China. And some relative relationship models and time serials models are established in the chapter.

In Chapter 5, the differential equations are solved and forecasting of Korean ports' T/S containers is made.

Chapter 6 discusses the relationship of T/S containers and trade based on Korean ports. Some models are established to analyze the relationship.

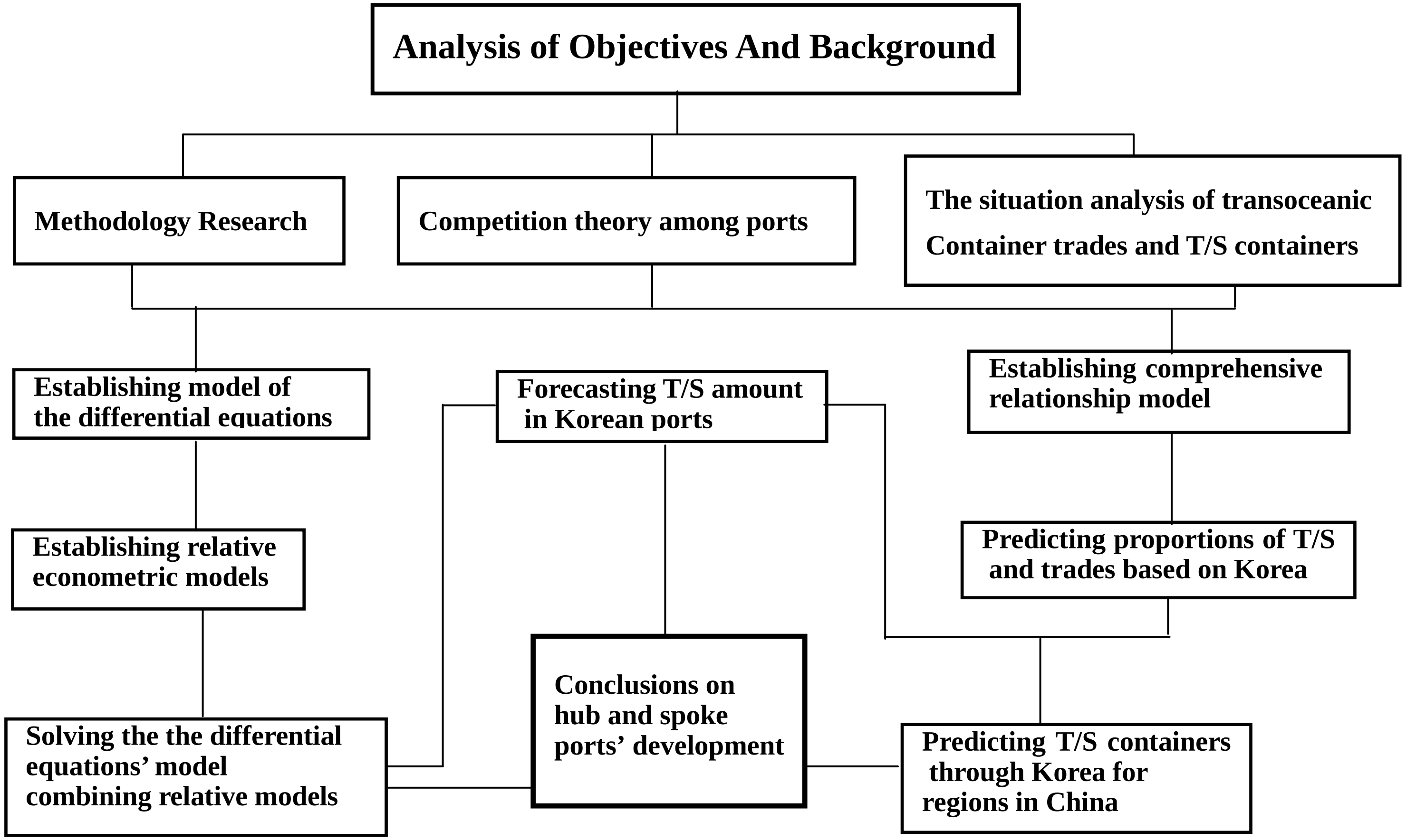
Chapter 7 predicts the T/S containers through Korean ports for the main regions in China according to the trade development between Korean and major regions in China.

In Chapter 8, the final chapter, the principal findings from the previous chapters are integrated into a coherent set of hub ports' development implications and conclusions, especially for Korean ports.

The study and content structure is shown in Figure1-3.

This chapter is an overview of the dissertation and the study. It guides to understand what the dissertation is going on in the following chapters and what the relationship is between the chapters logically.

Figure1-3 The study and content structure



Chapter 2

Port Competition and Development

2.1 A Conceptual Definition of Port Competition

Competition between ports is therefore fierce. The unstoppable rise of container traffic flow and the constant drive for specialization, and capacity increase of seagoing vessels have resulted in shipping companies concentrating as much as possible on a limited number of ports of call. Increasingly, connecting services are left to feeders. In the way, shipping companies are able to benefit maximally from the economies of scale that their larger vessels offer, while they are also able to provide more flexible and quicker transport services and sailing schedules. Emerging strategic alliances between shipping companies, meanwhile, have led to a further concentration of demand for port services. It seems that there is clearly a declining trend in the number of players requiring services from ports or container terminals.

Shipping companies are increasingly focusing on an integrated approach to transport in which logistical services are provided on a global scale. Many of these companies have in fact become inter-modal operators. Throughout the logistics chain they are tightening their grip on container flows. Consequently, shipping companies appear to have become the principal players when it comes to a choice of seaport. It used to be the case that only territorial considerations were taken into account in the selection of ports of call. But increasingly port characteristics are assessed in relation to the global logistics supply. Geographical or territorial aspects are less important than they used to be. The key consideration today is the summarized transport cost, i.e. the total transport cost (including out-of pocket costs, time costs, reliability etc.) associated with the logistics chain.

The purpose of a further standardization of freight traffic is not only to reduce maritime costs， but also transshipment and warehousing costs (i.e. costs incurred within ports), as well as the cost of hinterland transpiration. The general trend thus far has been for global transportation to become cheaper. However, there is considerable doubt about longer-term cost developments.

In the context of port competition, reference is often made to Verhoeff [2](1981), who argued that seaport competition unfolds at four distinct levels: competition between port undertakings, competition between ports, competition between port clusters (i.e. a group of ports in each other's vicinity with common geographical characteristics), and competition between ranges (i.e. ports located along the same coastline or with a largely identical hinterland).

The factors influencing competition may vary from level to level. The competitive strength of individual undertakings within a port is determined mainly by the factors of production (labor, capital, technology and power). Competition between ports, port clusters and port ranges on the other hand is also affected by regional factors, such as the geographical location, the available infrastructure, the degree of industrialization, government policy, the standard of performance of the port (measured in terms of proxy variables, such as the number and frequency of liner services, and the cost of transshipment, storage and hinterland transportation).

This traditional approach to port competition must now make way for an approach based on competition between logistics chains, in which ports (and port undertakings) are merely links. As the most important consideration is the overall cost of the transport chain, it is inevitable that, besides throughput, the industrial and commercial functions (including warehousing and distribution of goods), as well as hinterland transportation will come to occupy an

[2] Verhoeff (1981) is perhaps the first scholar who discussed seaport competition in a comprehensive manner; he claims there is ‘hardly any literature on the subject’ (Verhoeff 1981, p. 49).

increasingly important position.
A port and the undertakings established in it compete directly with a limited number of other ports, usually within the same range. Competition between ports belonging to different ranges involves just a very few types of goods flows. Consequently, the crucial question is what determines the choice of port? Why is one port preferred to another? Which undertakings located in that port are chosen? And which hinterland transport modes?

Port competition is traditionally regarded as competition between and within ports. This definition would appear to be incomplete, and it is therefore hard to assess. The operational context of the concept needs to be extended.

It should be noted in this respect that Verhoeff's levels of competition also interact with one another, so that they cannot be considered independently. Verhoeff's definition of port competition does not take into account the traffic structure of ports or port undertakings. Goss (1990c, p. 274) rightly asserts that the composition of the traffic flows is essential in the context of port competition: '(...) many commodities are exported from several countries, whose ports are therefore in competition'. Verhoef's definition fails to distinguish between ports and port undertakings in terms of the goods (i.e. the type of traffic) in which they specialize. He considered them to be comparable units. Clearly, though, an undertaking in a container port is not in competition with a maritime concern specialized in liquid bulk or forestry produce. Port competition is further influenced by other factors, such as the type of management, the know-how of port authorities and managers, the well-considered application of EDI, government intervention, the existence of niche markets, and the generation of added value. In other words, a modern definition of 'port competition' must incorporate all aspects relevant to the constituting terms 'port' and 'competition'. After all, ports are considered to be the competing entities. One can only arrive at an operational definition by combining the above mentioned aspects meaningfully. In the present study, we shall employ the following definition of port competition:

A conceptual definition of 'seaport competition': 'Seaport competition refers to competition between port undertakings, or as the case may be terminal operators (the competing players involved in the organization of entire transport chains) in relation to specific transactions (the object, taking into account the origin and destination of the traffic flows concerned). Each operator is driven by the objective to achieve maximum growth in relation to goods handling, in terms of value added or otherwise. Port competition is influenced by (1) specific demand from consumers, (2) specific factors of production, (3) supporting industries connected with each operator, and (4) the specific competencies of each operator and their rivals. Finally, port competition is also affected by port authorities and other public bodies.'

Firstly, there is competition between operators. This type of competition may be summarized as 'intra-port competition at operator level'. In recent years, operators within ports have increasingly tried to diversify their activities, offering services throughout the total logistics chain. As a result, operators are now often present in several ports, where they are involved in the handling of various traffic categories.

Intra-port competition can however be put in an even broader context, as port authorities and undertakings may also compete within a single port, albeit indirectly. This form of 'mixed competition' occurs if a port authority has stakes in a port undertaking or terminal operator'. This competition could affect the competition between two hub ports in a similar geographical position.

Secondly, there is competition between operators from different ports (level 2: 'inter-port competition at operator level'). This second level of port competition occurs mainly between operators within the same range serving more or less the same hinterland. However, Verhoeff (1977) and Goss (l990c) have both asserted that competition may also involve port ranges as such. Competition in the Hamburg -Le Havre range is usually restricted to competition within that range. Only rarely are ports belonging to other ranges involved, as there is very little overlap between the hinterlands of ports from different ranges. Consequently, operators within a given range usually do not feel threatened by operators from other ranges, and there is no evidence whatsoever of competition at this level.

Thirdly, there is competition between port authorities-be it national, regional or local-which directly affects the determinants of port competition (particularly the infrastructure in and around a port). This is of course crucially important for the competitive position of operators. This is level 3: 'inter-port competition at port authority level'.

Implementation of this theoretical framework also requires a reconsideration of the 'mainport' concept, which is based on ports' competitive position. In the economic literature, it is traditionally suggested that a mainport is a market leader in several or even most traffic categories. Moreover, it is usually claimed that such ports provide the best services and handling facilities for a broad range of goods. Such an interpretation of the mainport notion is rather misleading, as it is an illusion to believe that a port can easily become a market leader in several, let alone all, traffic categories. But a hub port for container is possible in some regions.

The fact that many ports in the world specialize in several traffic categories requires that, unlike the notion of mainport, the definition of a mainport should be reinterpreted as a hub port. It concerns the dominance of one port over others in relation to a specific traffic category e.g. container traffic.

It should be noted in this respect that the term hub port is increasingly used by port authorities who wish to assume a certain status for marketing reasons, the actual status of the ports is to compete for T/S containers.

A great many players are involved in port competition, both conceptually and operationally. Consequently, port competition and port management is influenced to a very considerable degree by a multitude of related - sometimes conflicting - interests.

Three types of port competition may be discerned, i.e. intra-port competition at operator level (competition between port undertakings within a single port), external port competition at operator level (competition between port undertakings from different ports), and inter-port competition at port authority level.

A hub port which is active in this competitive environment must therefore constantly care their T/S containers' increase. The competition for T/S containers could be various and diversiform, but the inside nature of transoceanic containers is difficult to change. Thus it may be known by the study and then to grip the trend of the development. Decisions could be made according to the development how to adjust the competition strategy for hub ports and also for shipping companies, in order to retain a competitive edge.

2.2 The Development of Hub Ports

There are close to 600 container ports across the world with an estimated combined handling capacity of more than 400 million TEU. The largest ports, those that can handle in excess of 1 million TEU per annum, account for nearly two thirds of global capacity [3].

Economic forces appear to be favoring the emergence of super-hubs and a changing pattern of port calls[4]. By limiting port calls to regional hub ports, shipping companies can reduce costs. It has been suggested that ports must have throughput of 5 million TEU and logistics facilities to support the efficient flow of cargo [5].

Drewry[6] forecasts container throughput to grow at 8.3 per cent per year from 275 million handlings in 2002 to a total of 442 million handlings in 2008. This includes growth in transshipments estimated at 9.3 per cent per year. Untill 2005, container throughput in the world has reached 393 million TEU.

In last two decades, the hub and spoke system in liner service has been introduced as larger containerships have been adopted in major sea transport routes such as Europe-Far East-American West coast. The emergence of this new system has allowed load centers along the East-West shipping lanes. Since that time the shipping and port industry has considered possible changes from direct call or multi-port itineraries to hub and spoke (i.e. transshipment) services[7].

This hub-feeder system allows shipping lines to provide a global grid of east/west, north/south and regional services. The large ships on the east/west routes will call mainly at transshipment hubs where containers will be shifted to multi-layered feeder subsystem serving north/south, diagonal and regional routes[8].

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[3] Drewry, 2001
[4] Trace, 1997.
[5] Lloyd's List,2002.
[6] Year 2001
[7] Hayuth and Fleming,1994.
[8] Notteboom, 2004.

Liner service network design depends on the balance of power between carriers and shippers (Notteboom, 2004). From the carrier’s perspective economies of scale are a critical element in order to reduce costs, which can be achieved by operating larger ships and having fewer ports of call. However, from the shipper’s perspective total freight rates, time and service quality, including frequency and flexibility, are more critical elements. There are clearly different views existing between carriers and shippers with respect to the hub and spoke system. The different views also causes the competition between hub ports.

Transshipment cargoes offer port authorities and terminal operators an opportunity to develop their businesses at a faster rate than the development of their economic hinterlands would permit. It is therefore not surprising that the competition for this business is fierce and also can be very volatile.

Thus most ports have introduced incentives to transshipment such as longer free storage periods, lower terminal handling charges and the reduction of port tariffs for shipping lines handling more than certain freight volume, which could contribute significantly to reducing the cost of shipping companies and/or shippers.

Because there has been strong trend towards mega size containerships, the service pattern of these mega size containerships may depend on the cargo volume available. If there is enough volume to fill the space, well developed ports and good land transport facilities with reasonable cost, and a direct call system may be a better service pattern. On the other hand, there is a strong possibility of ports adopting a hub and spoke service pattern with an appropriate number of ports of call.

Figure 2-1 sets out the methodological approach used to model and evaluate the relative competitiveness of competing locations as optimal transshipment centre in one region. Key elements in the modeling approach involve assessment of:

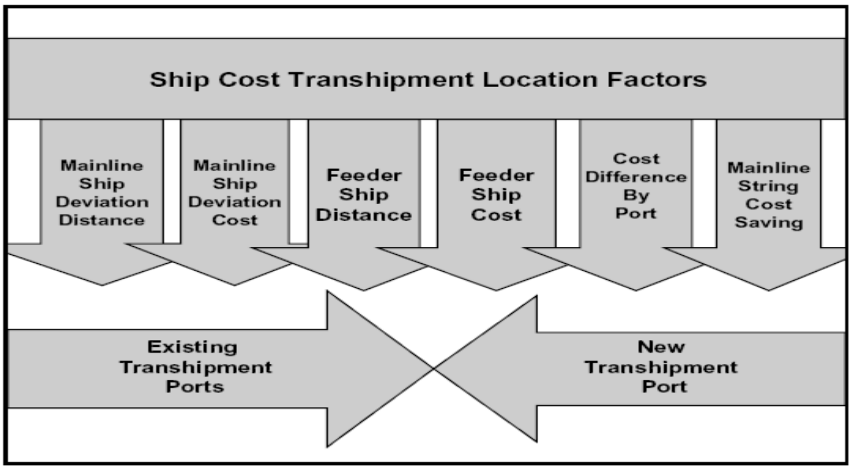

Figure2-1 Optimal transhipment port location methodology

• Mainline ship deviation distance and cost
• Feeder ship distance and cost
• Mainline plus feeder ship distance and cost
• Identification of cost differences between existing hub port locations and the new hub location, and any cost savings thereof
• Share of the container transshipment market required by a new transshipment hub
• Mainline operator deep-sea service string cost saving

The objective is to compare, in the context of the principal transshipment and feeder markets, the cost of shipping via current major hub port locations relative to a new location in the region. The alternative location in this instance is the proposed container transshipment terminal.

Cullinane et al.[9] highlight a number of reasons for carriers continuing to provide direct call services using large container ships, including:

• Feedership costs are much higher per TEU-mile than the cost of mainline ships, and

• Scale economies in liner shipping are not quite as powerful as expected and are not totally lost by multi-port calling.

However, pointing to the ongoing trend towards a higher proportion of transshipped containers, Cullinaneet al. suggest that direct calls by mainline vessels are being rationalized (by implication resulting in more transshipment) as carriers seek higher levels of return from their assets.

Yet the degree of load centering which would provide a lowest cost solution tends to be route specific, and it is therefore difficult to generalize for all trades.

Research by UK-based transport consultants MDS Transmodal (1994) suggested that multi-port schedules are preferred because relatively large volumes of cargo can be shifted and big ships can be turned around in port in under one day (i.e. through only part loading in each port). According to MDS Transmodal, the costs of making a port call are fixed and relatively small compared to the cost of transshipment, provided the size of the container exchange is significant. MDS Transmodal's study, which centered on ports situated close to the English Channel, did find similarly to Cullinane et al.[10] in that the scope for transshipment over these ports to ports further afield was considered likely to grow in future as itineraries became more concentrated.

Traditionally, the degree of load centering or hubbing has therefore been determined by evaluating the trade-off between feeding and extra handling

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[9] Year 1999
[10] Year 1999

costs, and the extra costs of calling at an additional port[11]. Even relatively recently, prominent maritime researchers have restated what almost seems to have become an inevitable view that extra feeder and handling costs must make transshipment more expensive[12].

Nevertheless, several major carriers and alliances would appear to be moving in the opposite direction, as they busily select (and in many instances help develop) new transshipment hubs and call at these hubs with ever larger vessels. This therefore raises the question: has the general theoretical and academic analysis of the direct call versus hub port strategy been sufficient?

One of the more detailed academic studies investigating container ship costs considered different ship sizes for end-to-end, global, and pendulum service types[13], each essentially multi-port itineraries. But it did not compare these service types with a hub and spoke alternative. A further study concluded that the hub-feeder system (in northern Europe) would only be competitive if there was a substantial percentage of containers on the deep-sea vessel (i.e. about 35–45%) that are not feedered, but remain in the main-port for onward distribution by land[14]. Without this base cargo, it was suggested, double handling costs involved with feeder containers and the additional transport costs involved would outweigh the benefits of ultra large container carriers.

One reason for increased interest and competition in hub and spoke transshipment service networks relates to the trend towards deployment of bigger ships. Post-Panamax ships of 5000–7500 TEU and above now dominate the major world trades. Ship size is still increasing, with 9600 TEU ships due to be delivered in 2005, and before 2010 ships of over 10,000 TEU are

[11] RSPB/MDS Transmodal,1997; Cullinane et al., 1999.
[12] Stopford, 2001.
[13] Lim,1996.
[14] Wijnolst,2000.

anticipated[15]. Ishikawajima-Harima Heavy Industries has designed a 25-knot 10,000 TEU.

There has been considerable speculation regarding how big containerships may become in future. In his analysis of ships of up to 15,000 TEU capacity, McLellan (1997) cautioned against continued upsizing suggesting that the size of the biggest ships would likely plateau due to physical restrictions in ports. Yet the number of new deep-water offshore hubs that have developed over recent years[16] means larger vessels can now be accommodated. Almost all of these new types of offshore hubs have transshipment markets as their main focus. Detailed analysis by O' Mahony (1998) also suggested that the technical barriers to handling bigger ships[17] could be overcome. The bigger and bigger size ships have motivated the competition of hub port construction between countries or regions.

Another reason for increased competition in hub and spoke transshipment service is illustrated in Figure2-2 that global container port demand has consistently increased more rapidly than output. In addition to direct, trade-related factors, container port demand has also been boosted by the continuing containerization of general cargoes in developing markets and of backhaul bulk cargoes in developed markets, as well as by the increasing use of transshipment.

Figure2-2 also shows that growth in transshipment has been even more dynamic than general container growth.

Over the 1991–2002 period, transshipment traffic expanded by an average of

[15] Flynn,2001a.
[16] E.g. Freeport, Salalah, Tanjung Pelepas, Taranto, etc.
[17] E.g. crane size/productivity, quay strength, etc.

almost 14% per annum[18]. Growth has been very steady over the period with the exception of 2001 when transshipment expanded by 6%, which was still almost three times world output growth for that particular year.

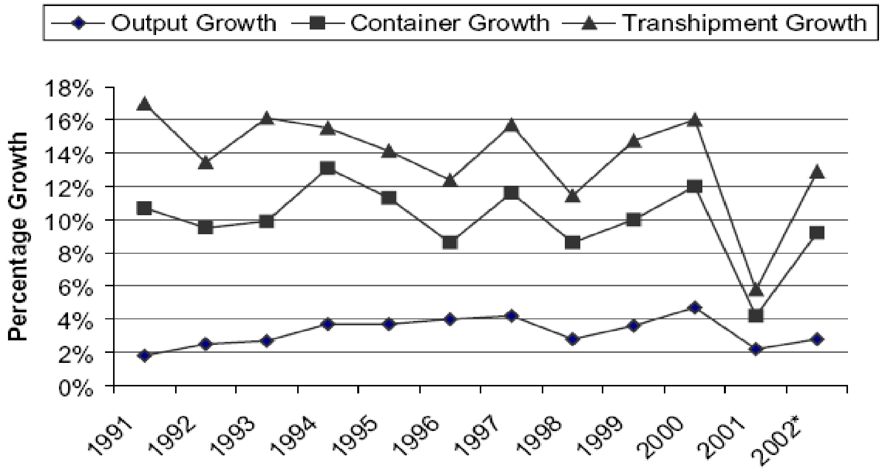


Figure2-2 World economic, container and transshipment growth
(Sources: Ocean Shipping Consultants, IMF)

In East Asia, the development of T/S ports is rapid and also the competition is fierce. Singapore emerged in the late 1980s as the first port in the world that was dependant primarily on trans-shipment cargoes for its existence. Since then it has been joined by other ports in East Asia. A number of ports that have substantial volumes of hinterland cargo also play a major role in the trans-shipment system: these include ports of Hong Kong, Kaohsiung, Busan, Tokyo, and Port Klang.

The dynamic opportunities will offer opportunities for new emerging trans-shipment hubs. The traditional port centers of Singapore, Kaohsiung and Hong Kong are expected to retain their importance throughout the period.

In Northeast Asia Shanghai is an obvious candidate for a trans-shipment hub port in mainland China with its massive hinterland volumes expected by the

[18] Ocean Shipping Consultants, 2003.

end of the forecast period. The Yangsan New Container Terminal is expected to lead to a reduction in the number of direct calls by major services at other ports of mainland China, contributing to the increased trans-shipment opportunity at Shanghai. Korean ports are most likely to gain, and the new port of Gwangyang (Republic of Korea) will join the competition and capture some trans-shipment volumes. Although the competition between Korean ports and Shanghai ports of China emerges, Korean ports will continue to play an important role in trans-shipment business in a relative long time period.

2.3 Summary

Port competition has formed at four levels in the world container transportation. For hub ports the focuses of the competition are the competition between traditional and new hub ports, to gain more T/S containers from the present flows and increase flows of transoceanic containers, the competition between direct call and transshipment for hub and spoke ports. Even though the competition becomes more and more fierce the development of T/S containers is still continuous.

In the Northeast Asia the competition of hub ports mainly exist among Korean ports and Shanghai ports of China, especially for their new container terminals, such as terminals in Gwangyang of Korea and in Yangsan of Shanghai China.

The main source of containers for the competition between Korean ports and Shanghai ports of China is from transpacific containers and the competition appears on the transpacific route.

This chapter focuses on academic analysis of port competition and its development, especially in Northeast Asia. It gives evidences and basis to support establising models in chapter 4.

Chapter 3

The Analysis of World Container Trade Volumes and Container Shipping Evolution in North-East Asia

3.1 The Evolution of the World Container Trade

The inauguration of the container some forty years ago brought about a significant structural change in international general cargo shipping which still is not completed. The development of container market was enormous.

The market environment in which container ports and shipping lines are operating is substantially changing. One of the main driving forces to change emerges from the globalization process and the large-scale adoption of the container since the late 1960s.

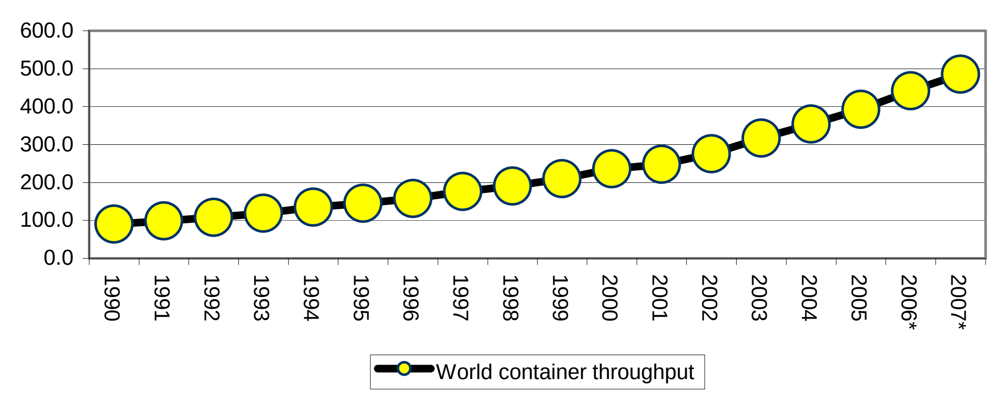
Container turnover figures of the ports of the world show exceptional high growth rates almost independent from the development of the world economy. During the seventies world container port turnover increased by an average of 22 % p.a., during the eighties by 9 % p.a. and during the nineties even again by 10.5 % p.a. During the nineties market observers forecasted a slowing down of the growth rates due to the seemingly saturation of containerization. However, yearly growth rates remained high and in some years even surpassed clearly the 10 % barrier. As is shown by the Figure3-1 and Table3-1 below from 1995 the slowing down of growth rates finally seems to have started, however, the figure for 1998 must be seen in the context of the Asian crisis.

In the absolute figures worldwide container port throughput[19] increased from 36 million TEUs in 1980 to 393 million TEUs in 2005. Forecasts point to

[19] In the dissertation the concept throughput includes transshipment. Transshipment containers be count once only for import.

between 432 and 468 million TEU in 2010 (OSC, 1997 and OSC, 2003), but it seems lower from present change. While the Atlantic Rim is the cradle of containerization, economically dynamic East Asia has become the world's main container region. The share of Asia in worldwide container port throughput rose from 25 per cent in 1980 to about 46 percent now, while Europe saw its share drop from 32 per cent to 23 percent(see Figure3-2).

Figure 3-1 World container throughput evolution (million TEU)



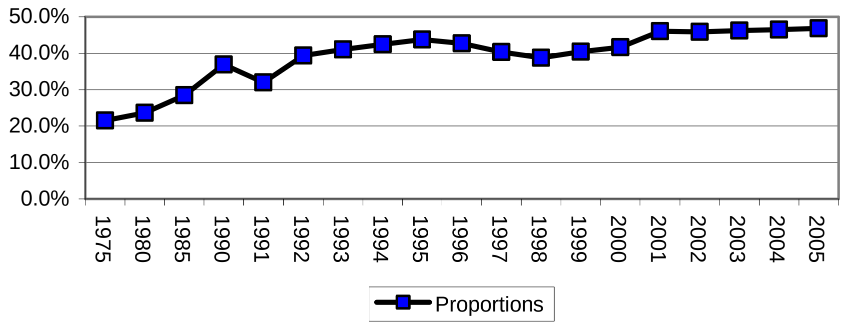
Source: Drewry Shipping Consultants, Clarkson

[20]Table3-1 The world container increase rate

Year	Throughput (million TEU)	Increase rate of throughput
1991	98.3	9.40%
1992	108.1	9.89%
1993	118.9	10.01%
1994	134.7	13.34%
1995	145.1	7.69%
1996	157.9	8.82%
1997	176.0	11.46%
1998	190.5	8.24%
1999	209.9	10.18%
2000	235.6	12.24%
2001	247.4	5.01%
2002	275.9	11.52%
2003	317.0	14.90%
2004	354.0	11.67%
2005	393.0	11.02%

[20] Drewry Shipping Consultants, Clarkson

Figure3-2 East Asia container throughput proportions accounting for world throughput(%)



Source: Drewry Shipping Consultants

No other sector of shipping or of any land-based transportation sector has experienced such a phenomenal development. The reasons for the unparalleled success of the container trade are various and partly connected to each other. The rise of world containerization is the result of the interplay of macroeconomic, microeconomic and policy-oriented factors. World trade is facilitated through the elimination of trade barriers, the liberalization mend deregulation of markets.

Gaining the benefits of containerization, however, necessitates heavy investments in all parts of the transportation chain. These investments have taken place step by step and with different velocity in the various countries. The structural change in favor of the container still is under way in a number of countries such as in Latin America, Africa and Asia but also in higher developed areas such as in Baltic and Mediterranean countries.

The container was and still is penetrating the general cargo market and for this reason growth rates have had and still will continue to develop more than proportionate in comparison to the general cargo transportation market.

With the tremendous development of containerization a more efficient system combining hub port and feeder lines has been paid attention to very much. Introducing a feeder system meant a multiple turnover of containers which, by the way, was only acceptable to the shipping companies as to times and costs involved through the high productivity and comparably low costs of modern container ports.

The advantages of the feeder system were such that an estimated 20-25 % of all container handlings in the ports worldwide are feeder containers. It is estimated that the share of feeder containers of total containers handled in the port of Singapore, one of the world market leaders, amounts to some 90%.

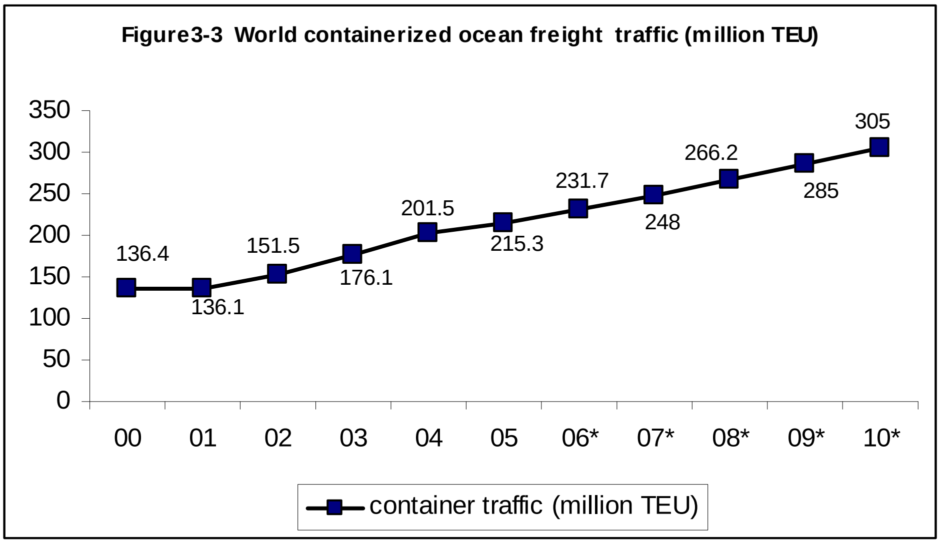
The feeder system served to push the port turnover figures in the past. Because some trade relations are still being newly containerized also in future the transshipment containers will lead to more than proportionate growth rates in container handling as against the general growth in transportation. However, the additional effects should not be estimated to be as large as in the past because there is an economical limit as to the share of feeder containers on given trade routes.

Another effect of the feeder system was to push also the transportation demand for ships. Substituting direct calls through feeder calls increases the seaborne transportation distances, some examples showed above by 35 %.

Finally to mention is the effect of reduced transportation cost for certain trade relations which attracted additional cargo volumes to be inter-continentally exchanged. Using the transshipment points of Singapore, Hong Kong and Busan etc. the cargo now is transported over a significant part of the total distance by the biggest containers ships available in the world which means that it profits from the high savings possible due to the economies of scale.

3.2 The Structure of the World Container Trade

The total world container traffic in 2000 was 136.4 million TEU, it increased to 215.3 million TEU in 2005 by 1.578 times of one in 2000. From Figure3-3 the increase curve goes with a slope up. The annual average growth rate was 9.4 percent per annum during the year 2000 and 2005, which was somewhat higher than the rate at which the global containerized cargo market was expected to grow. The total world container traffic which is forecasted from MergeGlobal will increase to 305 million TEU by the year 2010. In 2006 it is 231.7 million TEU.



Source:MergeGlobal world ocean supply & demand model

The world container traffic has formed a regional structure. On sub-routes the container traffic volumes are very different. Figure3-4 and Table3-2 show the proportions of container traffic flows on sub-routes. Except for the flow on the route of rest of the world, the bigger one is on intra-Asia route, next is transatlantic route, third is transpacific route accounting for 8.9% in 2005.

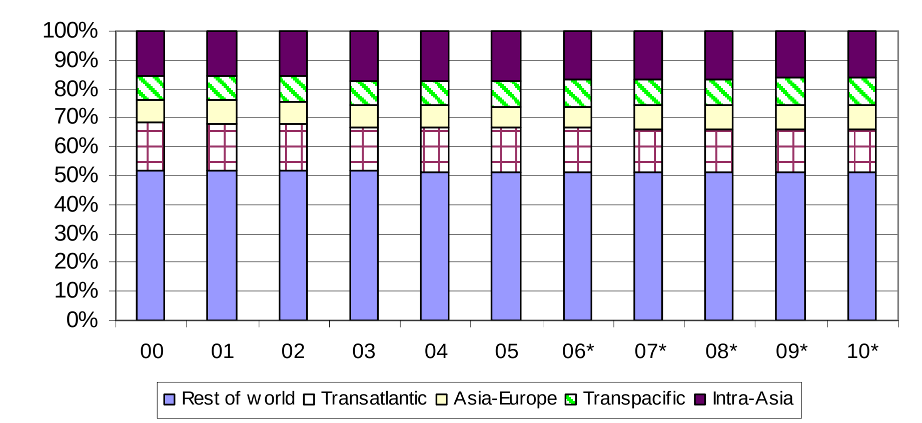


Figure3-4 Distribution structure of world container traffic(%)

Source: MPPM models' research paper

[21]Table3-2 Distribution structure of world container traffic (%)

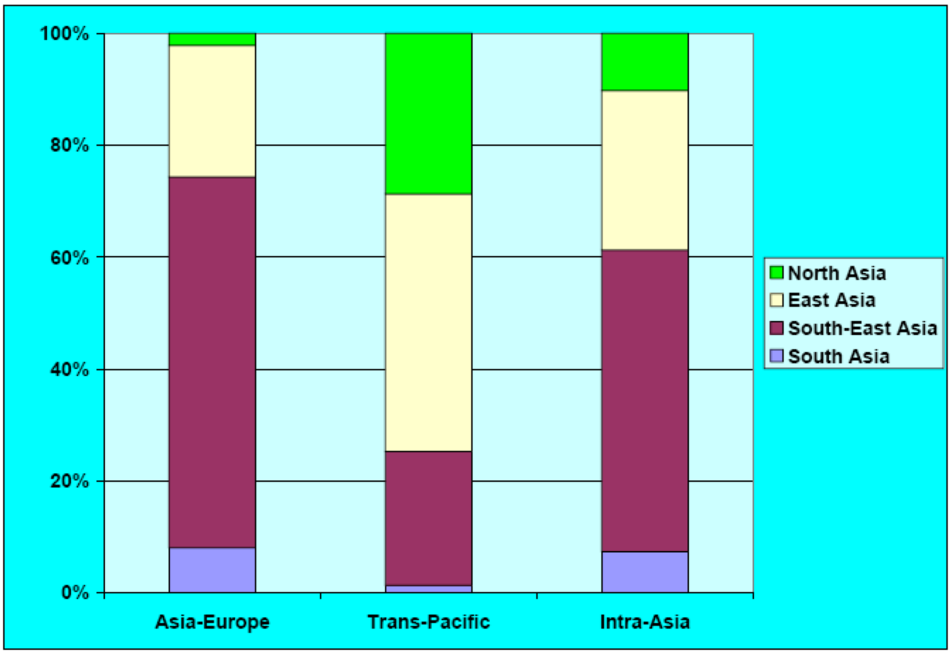
Sub-region / Year	Rest of world	Trans-Atlantic	Asia-Europe	Trans-pacific	Intra-Asia
2000	51.7%	16.7%	7.6%	8.7%	15.3%
2001	51.9%	16.2%	7.9%	8.7%	15.3%
2002	51.7%	16.4%	7.4%	9.0%	15.5%
2003	51.5%	15.4%	7.4%	8.5%	17.1%
2004	51.4%	15.4%	7.3%	8.6%	17.2%
2005	51.4%	15.0%	7.6%	8.9%	17.1%
2006*	51.4%	15.0%	7.7%	9.1%	16.8%
2007*	51.3%	15.0%	7.8%	9.2%	16.7%
2008*	51.3%	15.0%	7.9%	9.2%	16.6%
2009*	51.3%	15.0%	8.0%	9.3%	16.4%
2010*	51.3%	15.0%	8.1%	9.5%	16.1%

The other obvious feature is the structure change of the T/S container flow. The Figure 3-5, which is from MPPM models' forecast, shows the market share of individual trans-shipment ports by trade route in 2015. In the Asia-Europe route, ports of Singapore, Hong Kong and Tan Jung Pelepas are expected to continue

[21] Source: MPPM models' research paper

to dominate the trans-shipment business. In the trans-Pacific route, ports of Hong Kong and Busan will handle around 60 per cent of the total trans-shipment volume. In intra-Asian trade, Singapore will dominate the trans-shipment. The competition between Hong Kong and Busan for trans-Pacific containers reaches a stable status. The MPPM models' estimates show that ports of Singapore and Hong Kong will remain as the main trans-shipment ports of the region.

[22]**Figure 3-5 Trans-shipment shares by trade route (2015)**



3.3 The Trade Development between North-east Asia and North America

Since 2002, world economic expansion has had a strong positive impact on growth. Most developing countries have benefited from this growth momentum

[22] Source: MPPM models' research paper

as a result of strong demand for their exports of primary commodities and, to an increasing extent, of manufactures.

The expansion of world output continued unabated in 2005, and is expected to maintain its pace, with a projected GDP growth of 3.6 per cent in 2006. Output growth in developed countries is likely to continue, at 2.5–3 per cent, despite high prices for oil and industrial raw materials and a tendency towards more restrictive monetary policies.

The developing countries have contributed to the fast pace of global growth, with strong investment dynamics and an overall growth rate averaging about 6 per cent for the group as a whole. In particular, rapid growth in China and India has contributed to this outcome.

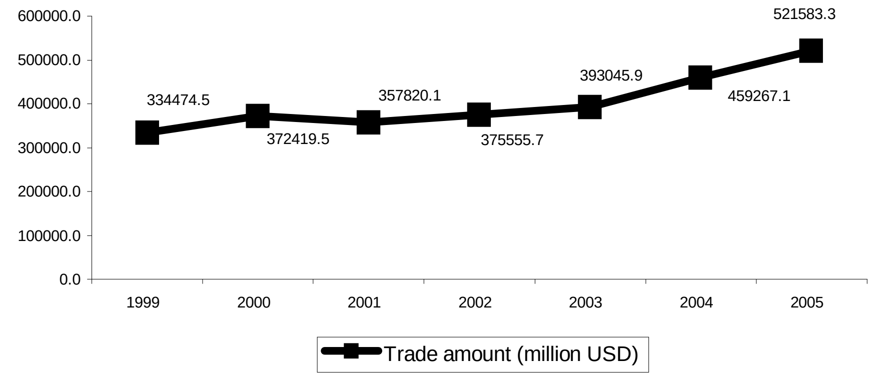
The growth that has occurred in the Asian economies over the last decade has brought changes in both the composition and the geographical structure of Asian trade, especially the trade changes between Northeast Asia and North America.

It is expected that the trans-Pacific trade will show the stronger growth among the three major Asian trades (namely, Asia-North America, Asia-Europe, and Intra-Asia) over the next decade. This is partly because the growth prospects for Asian trade with North America are likely to be comparatively enhanced as the economic adjustment ends after a period down in the United. It is also because the trade between China and America will increase continuously and it will provide a higher percentage of total cargoes.

Figure3-6 shows that the trade between Northeast Asia and North America appeared weaker and presented a fluctuation during the year 2000 and 2003. But after the year 2003 the stronger trend appears again and almost has a straight increase with a stable slope upward.

The main countries in Northeast Asia are Korea, China and Japan. The changes of the trade distribution structure among the three countries are shown in Figure3-7 and Table3-3. It is clearly seen that the trade proportion between China and North America becomes bigger and bigger, from about 20% in 1999 to 44% in 2005, and Japan appears a heavy decrease, from 63% to 41%, and Korea shows a slight decrease with a fluctuation. This change could affect the container flow and T/S containers through hub ports on transpacific route.

Figure3-6 Trade amount between Northeast Asia and North America



Source: from trade statistics of Korea, China and Japan

Figure3-7 The trade proportions for main countries between Northeast Asia and North America(%)

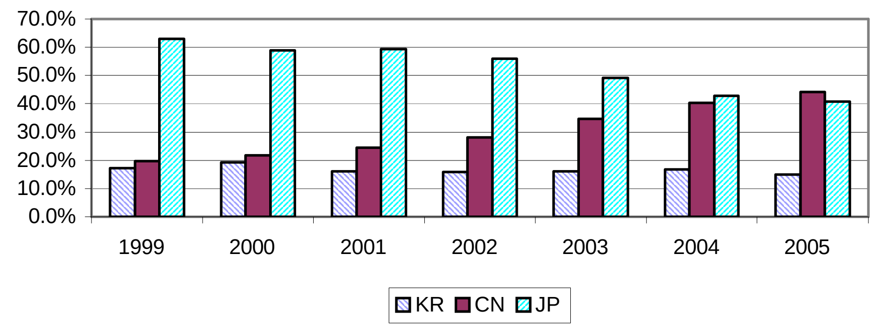


Table 3-3 The trade proportions with North America for Asia countries

	Korea	China	Japan
1999	0.1729	0.1979	0.6292
2000	0.1917	0.2186	0.5898
2001	0.1605	0.2456	0.5939
2002	0.1597	0.2800	0.5603
2003	0.1618	0.3470	0.4912
2004	0.1681	0.4034	0.4285
2005	0.1495	0.4428	0.4077

3.4 The Transpacific Ocean Container Trade Development

As analyzed in the preceding section, the container flow structure on transpacific route among countries in Asia may be discussed.

From Asia countries to USA

From the Figure 3-8 the biggest proportion of containers to USA is caused by China. The trade from China accounts for about 58 percent in 2004 on the route to USA. Hong Kong's proportion is higher than 10 percent. All of other is lower than 10 percent, Korea and Japan are respectively about 5% and 7.5% in 2004 (See Figure3-8 and Figure3-9)[23].

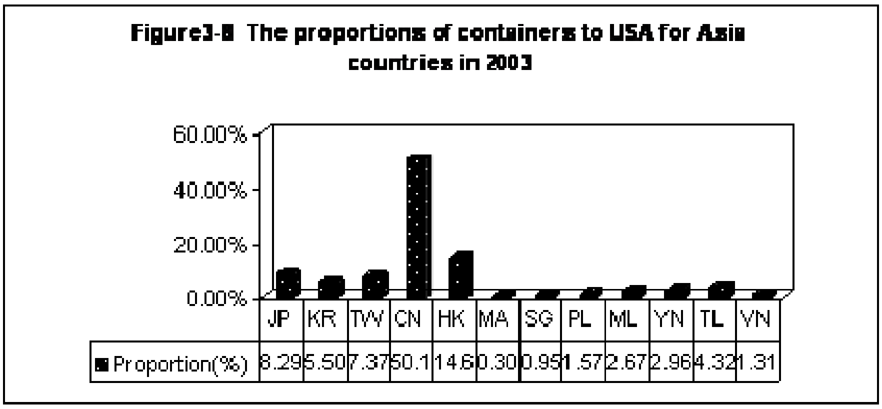
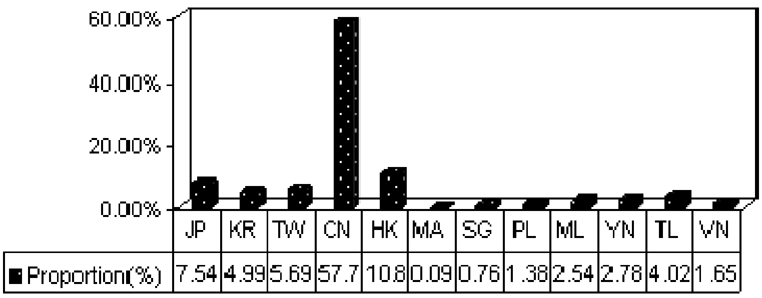


Figure3-8 The proportions of containers to USA for Asia countries in 2003

[23] Drewry Shipping Consultants

Figure3-9 The proportions of containers to USA for Asia countries in 2004



Comparing trade proportions from Asia countries to USA in 2003 with in 2004, the obvious feature is that the proportion of China got increase, and others got decrease.

From USA to Asia countries

From the Figure 3-10 the biggest proportion of containers from USA is caused by China too. The trade from USA to China accounted for about 36 percent on the route from USA in 2004. Japan's proportion ranked in the second and accounted for about 21% in 2004. Korea ranked in the third and accounted for 12% in 2004. All of other is lower than 10 percent (See Figure3-10 and Figure3-11)[24].

Comparing trade proportions from USA to Asia countries in 2003 with in 2004, the obvious feature is that the proportion of China got increase, and others almost got decrease.

[24] Drewry Shipping Consultants

Figure3-10 The proportions of containers from USA for Asia countries in 2003

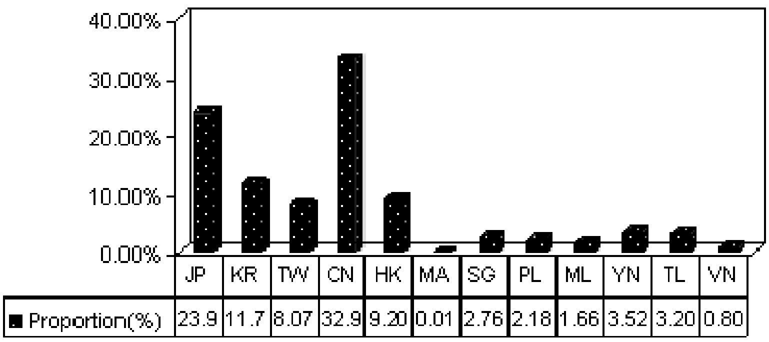
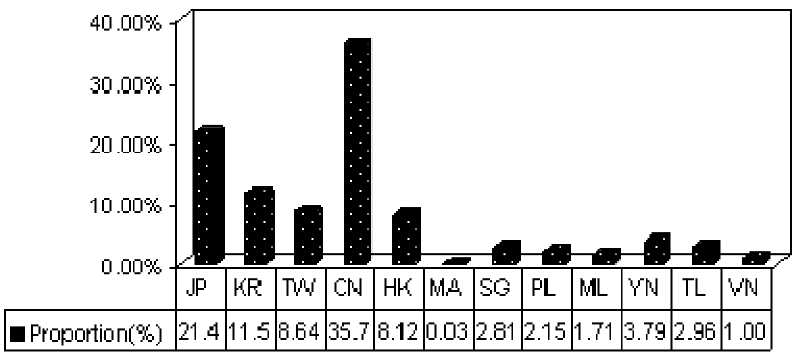


Figure3-11 The proportions of containers from USA for Asia countries in 2004



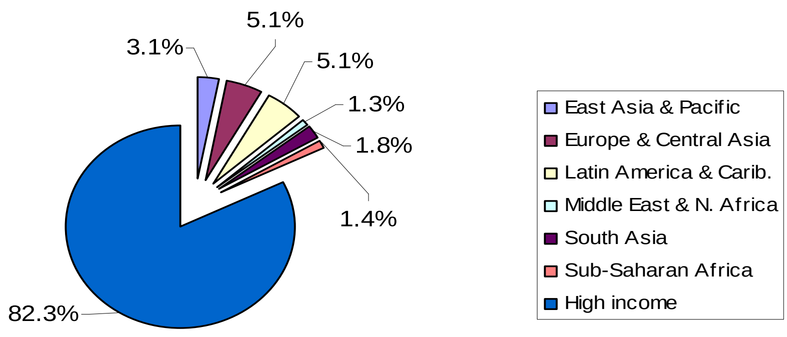
3.5 Analysis to Drive the Development of Trade and Shipping

As it is analyzed above shipping containers and its structure have developed and changed with trade development and its structure change, especially in Northeast Asia. The further analysis is done to answer what the main factors are to drive such changes in trade and its structure.

There are some factors to influence trade development and its structure change. But the main factors are economic development and the change of economy distribution, redistribution of industry in the world.

From 1990 to 2004, world economy has changed rapidly. The GDP in the world increased from 21,735,592 million dollars in 1990 to 41,290,409 million dollars in 2004. It increased by almost 90% in 10 years. The industry share in GDP decreased from 33% to 28%. The distribution of the GDP also changed from 1990 to 2004; see Figture3-12 and Figure3-13.

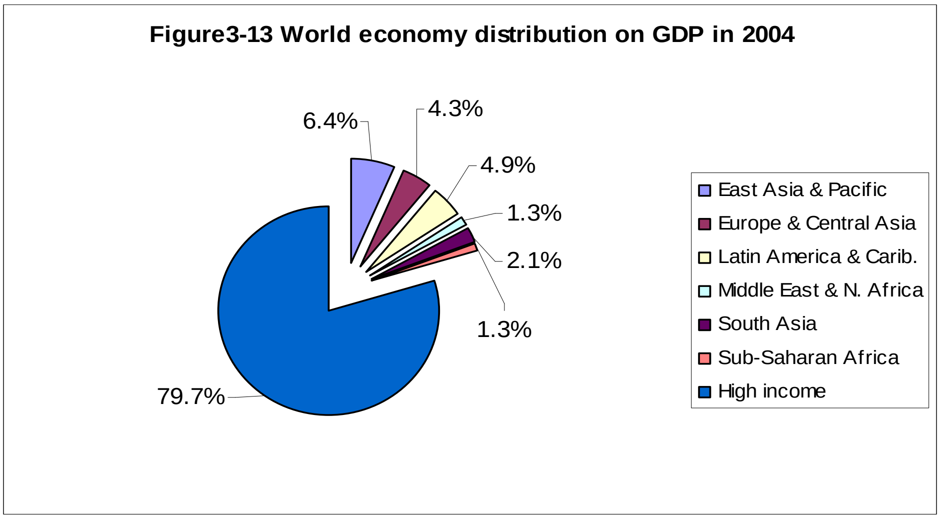
Figure 3-12 World economy distribution on GDP in 1990

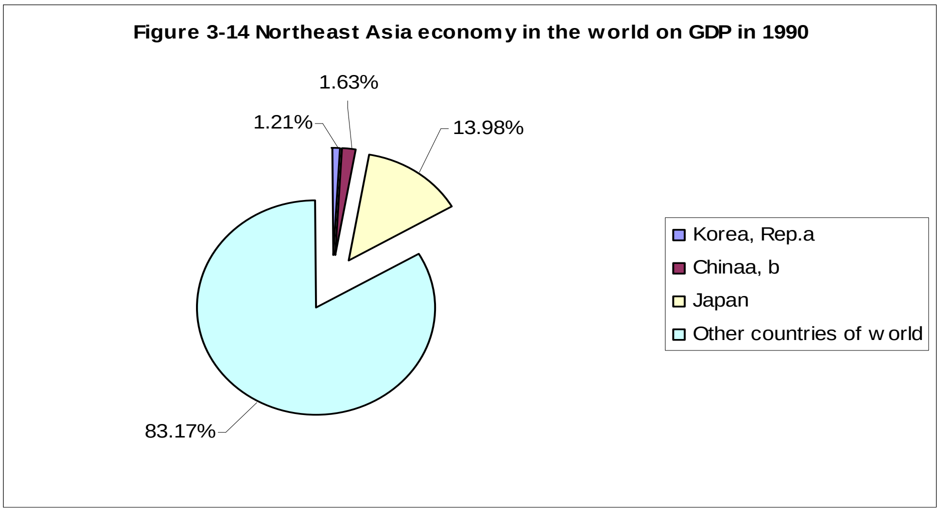


The Figure3-12 and Figure3-13 show the share of GDP in low income countries in East Asia & Pacific region increased from 3.1% in 1990 to 6.4% in 2004, more than 2 times. And the high income countries' share in the world decreased by 2.6 points of percent from 1990 to 2004.

The Figure3-14 and Figure3-15 show the main countries' change of Northeast Asia in the world. Totally shares of the main three countries' increased by 0.69

points of percent. But China's share increased almost 3 times. The unusual change happened and will continue to happen in the future.





In the main three countries in Northeast countries, the Figure3-16 and Figure 3-17 show that Japan's share of GDP decreased 19.19 points of percent, Korea's increased 2.19 points and China's increased 17.01 from 1990 to 2004. Thus the

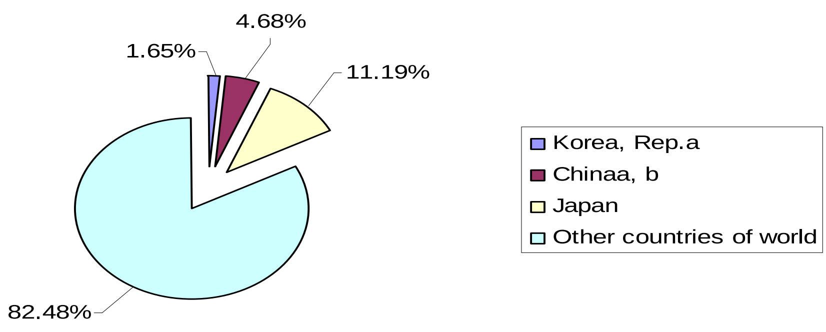


Figure 3-15 Northeast Asia economy in the world on GDP in 2004

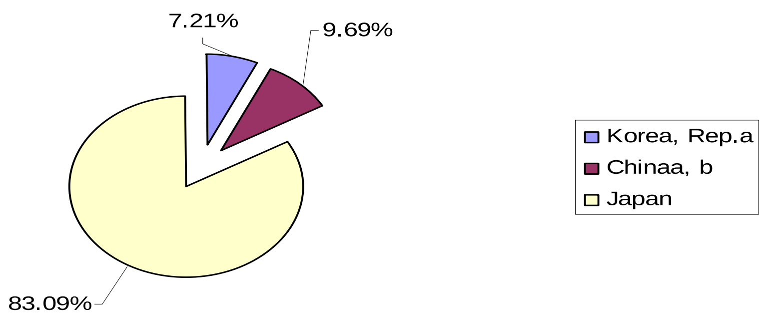


Figure3-16 Northeast Asia economy distribution on GDP in 1990

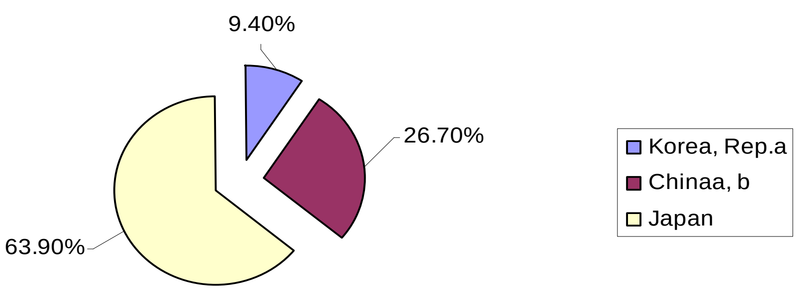


Figure3-17 Northeast Asia economy distribution on GDP in 2004

changes are strongest factors to drive trade development and its structure change. And this is consequences for container transportation development. According to Figure2-2 container growth expanded bigger than economy growth, transshipment growth expanded than container growth. Thus the containers' volume, structure and transshipment changed or will change much greater than economy itself, especially in Northeast Asia.

3.6 Summary

Container trade has experienced and will have an enormous growth with the economic globalization and the development of large-scale container and bigger vessels. Countries in East Asia play an important role in the development of containerization. The share of container throughput in East Asia accounting for the total throughput in the world increased and will increase close to 50%.

Hub ports and feeder system have been established with the development of containerization. It causes the competition among hub and spoke ports for T/S containers and transoceanic containers.

A distribution structure of world container traffic has been formed. On the Asia-Europe route the T/S business has been dominated by Singapore, Hong Kong and Tan Jung Pelepas. The competition for T/S business will happen more fiercely on the transpacific route.

The trade between Northeast Asia and North America showed a stable and stronger increase after 2003. The trend might be kept in the near future. The data shows the trade proportion between North America and China becomes higher and higher. It is over Japan's in 2005. Japan's proportion goes down quickly and Koran proportion shows a slight down.

The structure change of container flow between Asia countries and USA showed that the biggest container flow between USA and Asia is the one between USA and China. And it still shows the stronger trend of development.

With the stronger increase of the trade between USA and China, the competition for scrambling for transoceanic containers on transpacific route becomes more and more fierce; certainly the competition is from Chinese ports especially from Shanghai ports. The next chapters will discuss the competition trend by establishing academic models.

The analysis of the chapter strongly supports to establish a model about competition and development between Korean ports and Shanghai ports in China. It gives a direction to decide what kinds of variables should be considered. The issue of analysis in the chapter is addressed in the chapter 4.

Chapter 4

The Models' Establishing of Development and Competition between Ports in Korea and Ports in Shanghai China

4.1 Analysis and Assumptions of the Competition & Development between Ports in Korea and Ports in Shanghai China

In the preceding discussion the main international transshipment ports currently are Singapore, Kaohsiung, Busan, and Hong Kong in East Asia. The largest amount of transshipment is through Singapore port (it is the largest in the world too), its transshipment rate reaching 90%. The necessary conditions to become an international transshipment port are to have deep-water terminals, a strategic geographic position and a fully developed infrastructure in both the port and its immediate hinterland.

It is expected that mainline services that focus primarily on the key hub ports on inter-continental routes need to operate large scale vessels to be competitive. Large vessels are deployed in three major trade routes: the Trans-Pacific, and Far East - Europe and North American Atlantic Coast services via the Suez Canal. This greatly encourages competition between key hub ports, especially in Asia. It was estimated that a total of 490 very large vessels will be in service on these routes and approximately 130 of these would be of more than 10,000 TEU in 2011. Recently 11000TEU has been put into service. This means that if an international transshipment port is unable to accept such large vessel, the port is no longer a viable transshipment port. Consequently, several countries and regions, especially in Asia, have made substantial investments in upgrading their ports and corresponding infrastructure.

From the evolution of port development in Asia, we note that not all international transshipment ports, which had the potential to become major hub ports, have achieved this ambition. In the 1970s, Japan's Kobe Port became the key hub-port in North-east Asia relying on the huge amount of Japanese exports. But since the late 1980s to 1998, the increased competition in container hub-ports led to Kobe losing its pre-eminent position in Asia. Busan Port and Kaohsiung Port, respectively north and south of Kobe, developed rapidly and were ranked respectively the fifth and third highest TEU movement ports from 1985 to 1995. But Kobe's rank fell from fifth to seventeenth from 1985 to 1998. This occurred partly because of the upward revaluation of currency in Japan resulted in a substantial changes in the nature of Japanese industries from the mid-1980s and the consequent decrease in locally generated container cargoes. The massive earthquake in Osaka and Kobe also had major repercussions for Kobe Port. Contemporaneous with the decline of Kobe Port was the development of Kaohsiung and Busan ports. Drawing from the experience of failure in Japan, which invested its resources of financial and material across several scattered deep ports, Korea and the Taiwanese Province of China concentrated their resources on constructing deep-water ports with a depth of at least 15 meters. Later with the rapid increase of container cargoes being generated on the Chinese mainland in the 1990s, Kaohsiung and Busan ports benefited from the opportunities to develop container transshipment with the Chinese mainland. From that time, almost all ports on the Chinese mainland, which were able to load and unload large international container-ships, transshipped their container cargoes from Kaohsiung and Busan ports to America and Europe, and even to south-east and south Asia. The two ports were recognized as key transshipment hub ports by most ports on the Chinese mainland. This stimulated the tremendous increase of transshipment container throughput in Kaohsiung and Busan ports. Shipping companies certainly put their core ship liners on the ports.

From the late 1990s to the 2000s the competition between international container transshipment key ports has formed in two hotspot areas in the world, one in the North America, and another in north-east and south-east Asia. With the development of container transportation, essentially port competition between regions, which are not directly connected by land routes, is competition to be a major international container transshipment hub-port.

According to preceding analysis most of the T/S containers of Korean ports is from shipping containers on transpacific ocean route. The shipping container flow on transpacific route is the biggest one in the world and still has the great potential to increase. The trade with North America in shanghai ports' hinterland is large and still grows rapidly. Thus the opportunity for Korean ports to get T/S containers from Shanghai ports' hinterland is great too. But the competition is fierce because Shanghai ports of China will improve their infrastructure to gain back the lost containers originated from their own hinterland and will develop its ports' T/S functions to gain T/S containers especially on transpacific route (even though the T/S amount is still smaller presently, the increase rate is much higher).

Thus the preceding analysis supports that it is possible to study the competition between Korean ports and Shanghai ports of China for gaining T/S containers on transpacific route in Northeast Asia. It is also the main factor to affect Korean ports' T/S containers. In the following section the details will be discussed more.

4.2 Establishing of the Differential Equations for Competition and Development of Ports

How to describe the competition and development of ports in quantitative in a mathematics model is a very crucial issue to get a perfect result for the study. After analyzing data, main variables and their relationships it was found that differential equations are more suitable to describe the phenomenon and situation of port competition and development between Korean ports and Shanghai ports in China in this study, and a model of differential equations could be realized to describe what it is studied in the dissertation. In the competition and development situation of ports all variables relate to time finally. Thus the rates of change with respect to time are important and key factors. The relationships between the rates of change are more obvious. It is usual and necessary to use differential equations when we model the rates of change. A lot of trials of models with data collected also show that using differential equations is a best way to get the results in the dissertation. The result of the differential equations proves satisfied finally too.

Interactive situations usually occur in the study of economics and other fields. Ports' competition in a certain scope may be recognized as an interactive system. In the system cargo volume or container flows are the inter-exchangeable resource. We are modeling the change rate of container flow for each port in the interactive ports' system, so the models invariably involve differential equations.

Because it is not so easy to solve a system of differential equations we restrict our study to specific interactive ports' systems to a certain scope or one kind of cargo. According to the analysis above the key market of the ports' competition in Northeast Asia is focused, especially between Korean ports and Shanghai port of China（The main target of the market for two side ports between Korean ports and Shanghai port of China to compete is transpacific container flow. The transpacific container T/S in Korea is the main part of its total T/S, about 40%-50% according to the sample statistics data, and on Europe-Far East route the competition for T/S has almost reached a point of balance because the bigger T/S ports in the world, such as Singapore, Hong Kong and Kaohsiung, have existed for quite a long time. On the route Korean ports would not get more and lose more for the T/S flow）. Firstly an autonomous system of differential equations for two side ports is considered as

$$\begin{cases} \dfrac{dx}{dt} = f(x, y) \\ \\ \dfrac{dy}{dt} = g(x, y) \end{cases} \qquad \text{(f4-1)}$$

where x is defined as a kind of container flow in one port in the interactive autonomous system and y is defined as a kind of container flow in another port in the interactive autonomous system, and f is the change function for x, and g is the change function for y. In such a system the independent variable t is hidden in x and y.

If there is only one port in the system (in a reachable region which competition could exist), we assume that the port can support an unlimited number of container flow so that in isolation the differential equation of the change rate of container flow is considered as

$$\frac{dx}{dt} = ax \qquad \text{for } a > 0 \qquad \text{(f4-2)}$$

that is related to its own container flow, which means there is no competition within the region (we may find it desirable to refine the model and use a limited growth assumption). At the situation container flow or T/S flow would increase in its own nature in the port. But in reality it is seldom to exist, such as in Northeast Asia. Next, we modify the preceding differential equation to take into account the competition of one ports' cluster container flow with another for the common container flow source. The effect of one container flow is to decrease the growth rate of another one. The differential equations may be established according to the analysis later. Except for the two sides' interactive effect there are other factors to increase or decrease both sides' container flows.

The differential equations of (f4-1) express two sides' ports interactive situation considering the change rate of container flows in two sides' ports. As the preceding analysis this interactive system may actually be affected by other container flows from outside or from another kind container flow in each side ports. Thus the differential equations of (f4-1) might be extended as

$$\begin{cases} \dfrac{dx}{dt} = f(x, y) + \mathrm{u(t)} \\ \dfrac{dy}{dt} = g(x, y) + \mathrm{v(t)} \end{cases} \qquad \text{(f4-3)}$$

where u(t) is a function with the change of t to increase or decrease the change of one kind container flow in one side ports from outside or from another kind container flow inside, and v(t) is a function with the change of t to increase or decrease the change of one kind container flow in another side ports from outside or from another kind container flow inside. The effective process is as Figure 4-1.

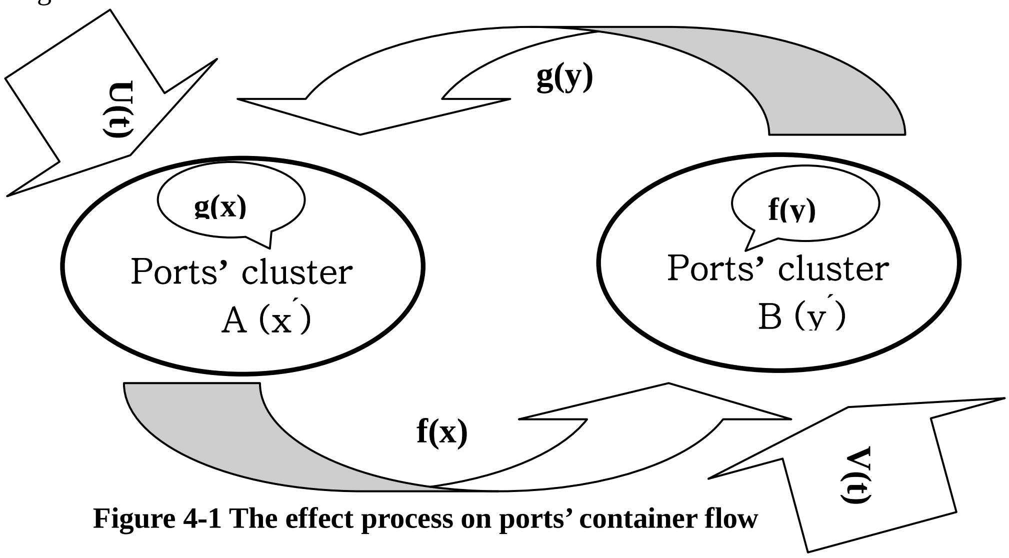


Figure 4-1 The effect process on ports' container flow

According to the analysis above, combining the differential equations of (f4-2) and (f4-3), we may establish the differential equations between Korean ports and Shanghai ports of China.

We assume that the competitive change of Korean ports' container T/S is from transpacific container flow, and that Shanghai port's change of transpacific container flow is mainly affected by Korean T/S. In Shanghai port the transpacific container flow consists of two parts, one is created by its hinterland's trade with North America and another is transshipment containers to North America from the third countries (Nowadays this part is very small but increases rapidly). An increase of Korean T/S containers may cause a decrease of the transpacific containers of Shanghai port, and vice versa. They are rivals for transpacific container transportation. Korean ports' T/S and Shanghai port's transpacific container transportation volume both may get the container sources from respectively total transpacific container flow and Shanghai port's foreign trade container flow. The differential equations' model assumptions are:

(1) The competitive change of Korean ports' T/S amount is from transpacific containers, and compared with the competitive change other change may be stable and normal.

(2) There is interactive flow between T/S containers of Korean ports and the transpacific containers of Shanghai ports.

(3) Compared with other T/S ports on the transpacific route the most effective impact on Shanghai port is mainly from Korean ports.

We assume that KT(t), SD(t), $S_s(t)$, SF(t) are respectively Korean ports' T/S containers, Shanghai port's transpacific containers, total transpacific containers, Shanghai foreign trade containers. Thus the differential equations between Korean ports' container T/S and Shanghai port's transpacific containers may be established as

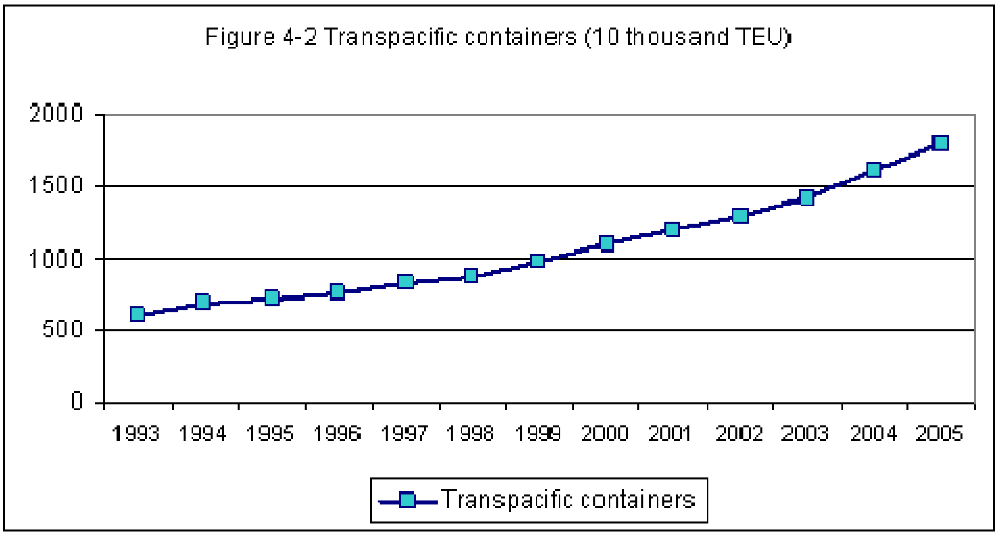
$$\begin{cases} \dfrac{dKT}{dt} = -a_{12} \times KT\ (t) + b_{21} \times SD\ (t) + d_0 \times S_s(t) \\ \dfrac{dSD}{dt} = a_{12} \times KT\ (t) - b_{21} \times SD\ (t) + d_1 \times SF\ (t) \end{cases} \quad \text{(f4-4)}$$

where t is time, a_{12} is the coefficient of interactive impact between Korean ports and Shanghai port of China due to the change of KT, b_{21} is the coefficient of interactive impact between Korean ports and Shanghai port of China due to the change of SD, d_0 is the coefficient of increase impact of total transpacific containers on Korean ports' T/S containers, d_1 is the coefficient of increase impact of Shanghai foreign trade containers on Shanghai port's transpacific containers. Solving the differential equations above is not easy. It needs more analysis in the follow sections.

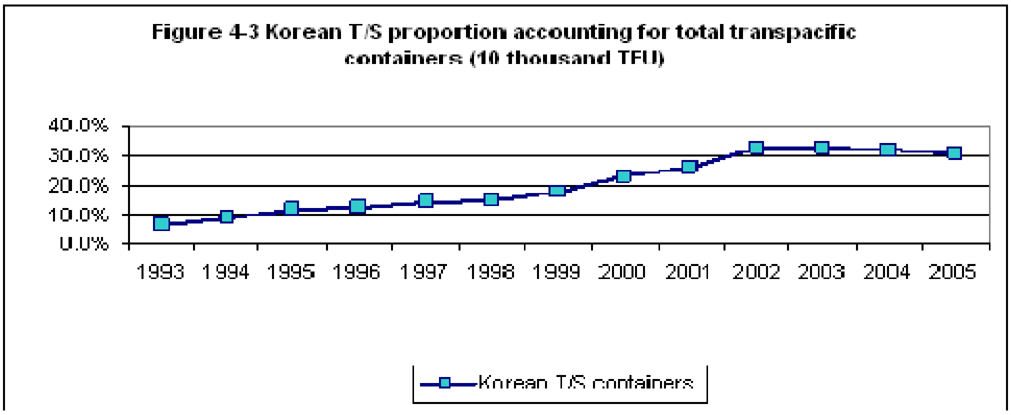
4.3 The Relationship Model of Total Transpacific Containers and Korean Ports' T/S

According to the analysis in the chapters above the source of T/S containers is almost from transoceanic containers in the world. In qualitative analysis there must be a relationship between transoceanic containers and T/S containers. In Korean ports the T/S containers mostly derive from the transpacific container flow. It accounts for 40%-50% of total T/S containers in Korean ports. And the rest of T/S containers through Korea is scattered separately from different regions, which is almost stable due to the long time competition with other T/S ports. Thus in Korean ports the relationship between T/S containers and transpacific containers is much closer. The data in Table4-1 shows that there is a disciplinarian relationship between T/S containers in Korean ports and transpacific containers. By analyzing the data the relationship may be found and proved in quantitative way.

The total transpacific containers increase steadily (seeing 25Figure4-2). After 1999 the slope of increasing line of the transpacific containers became steep gradually. In 2005 the total transpacific containers is 1794 ten thousand TEU. It shows the bright prospect.



The T/S containers of Korean ports increase correspondingly. The proportion of T/S containers accounting for total transpacific containers increased from 1993 until 2001. But it has begun to decrease since 2002 (see [26]Figure 4-3 and



[25] Source: American shipper July 2006 and early time.
[26] Source: Calculation according to data of KMI Korea.

Table 4-1). The increasing weakness of the proportion shows that the total tran spacific containers increasing stronger than Korean T/S containers.

[27]**Table 4-1 Korean T/S and Transpacific containers**

Year	Korean T/S (10 thousand)	Transpacific Containers (10 thousand)
1993	38.21	611.30
1994	59.40	688.10
1995	85.93	720.00
1996	94.40	758.60
1997	117.19	830.90
1998	126.84	875.50
1999	172.49	978.10
2000	252.85	1103.80
2001	311.08	1197.20
2002	420.50	1292.70
2003	459.88	1426.30
2004	515.87	1611.30
2005	553.30	1794.00

According to the data in Table 4-1 we may establish the relationship between Korean T/S containers and total transpacific containers by an econometric analysis. Due to deriving from transpacific containers the Korean T/S containers' variable is defined as the dependent variable(variable to be explained), called KT here. The transpacific containers' variable is defined as the independent variable(explanatory variable), called S_s here. So the econometric model function may be considered generally as

$$KT_t = F\{ S_{s\,t} \} + \varepsilon_t \qquad \text{(f4-5)}$$

where the index t concerns an observation for the variable at time t.

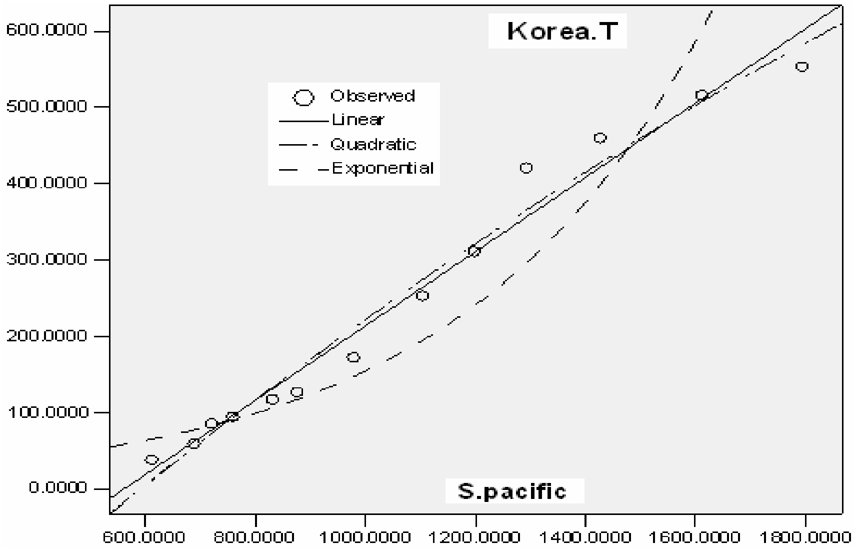
1) Scatter plots analysis

By using SPSS software, a specific model is developed for the (f4-5) function.

[27] Source: KMI website of Korea.

Firstly scatter plot of two variables' data is analyzed. After extensive analysis for some models, the three models, which seem fit to the data considered before, were chosen and employed to analyze with the scatter plots, as LINEAR, QUADRATIC and EXPONENTIAL. As shown in <Figure 4-4>, the plot shows the data spots are close to the linear line.

Figure 4-4 the scatter plots compared with Linear line for KoreanT/S



2) Analyzing of the result value

The linear model's value results and the analysis results are shown in Table4-2, Table4-3, and Table4-4.

Table4-2 Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.988	.975	.973	30.270

The independent variable is S.pacific.

Table4-3 ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	400452.381	1	400452.381	437.058	.000
Residual	10078.690	11	916.245		
Total	410531.071	12			

The independent variable is S.pacific.

Table4-4 Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
S.pacific	.487	.023	.988	20.906	.000
(Constant)	-273.230	26.252		-10.408	.000

According to the results shown in tables above the calculated F-value 437.058 is much larger than the tabular value of F 4.73 at the specified level of significance 0.05 and degrees of freedom in Table4-3. Thus the null hypothesis, H_0: all coefficients in the model are zero, is rejected and the null hypothesis's significant probability is 0.000, much smaller than 0.05, seeing Table4-3. Thus the model is acceptable. To the parameters the significant probabilities of the S_s coefficient and constant are much smaller than 0.05 too, close to zero, passing the t-test. Then the relationship model is estimated as

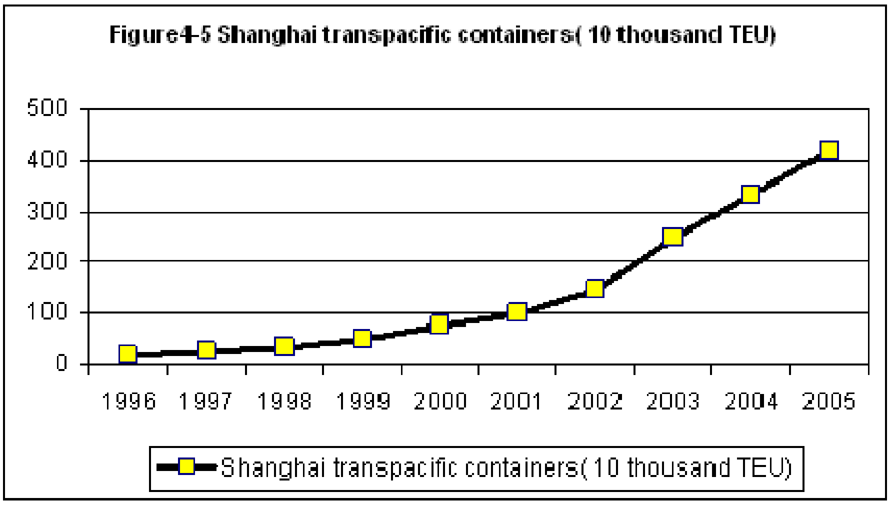
$$\tilde{KT_t} = 0.487 \times S_s - 273.230 \qquad \text{(f4-6)}$$

4.4 The Relationship Model of Transpacific Containers in Shanghai Port and Its Total Foreign Trade Containers

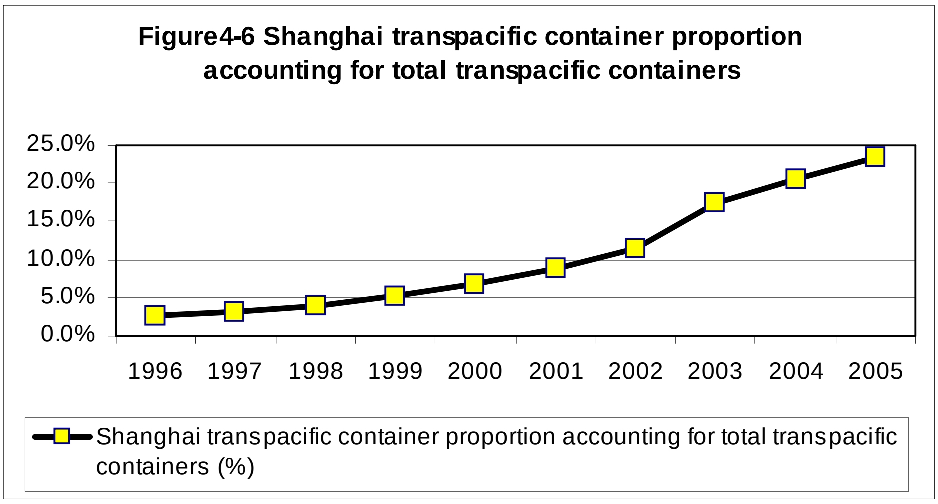
In 1996, Shanghai transpacific containers was about 19 ten thousand TEU. It reached 420 ten thousand TEU in 2005, increased about 22 times (see Figure4-5). From the figure the evolution line goes up steadily almost with a stable slope between in 1996 and in 2001, then the slope gets a leap in 2002 into a higher one.

The proportion of the Shanghai transpacific containers accounting for the total transpacific containers goes up from 2.5% in 1996 to 23.4% in 2005, raising about 21 points of percent (see Figure 4-6). It shows that the increase of Shanghai port's transpacific containers is much stronger than the total transpacific containers.

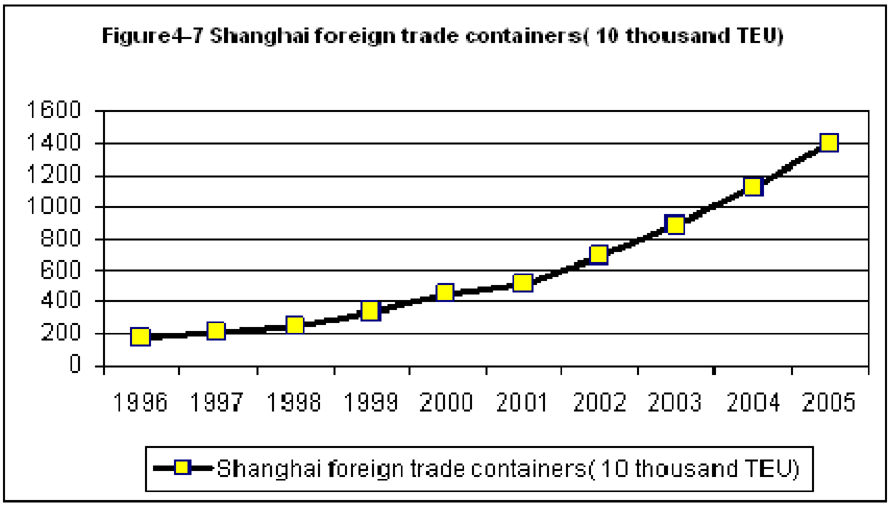
Shanghai foreign trade containers increases quickly too but more smoothly than Shanghai transpacific containers (see Figure 4-7).



Source: integration from several authority magazines and books published in China



Source: integration from several authority magazines and books published in China



Source: integration from several authority magazines and books published in China

From the preceding analysis the transpacific containers is also the largest container flow In Shanghai port. It is concluded that there exists a relationship between Shanghai foreign trade containers and Shanghai transpacific containers from the data analysis. Thus Shanghai transpacific containers' variable is defined as the dependent variable, called SD here. Shanghai foreign trade containers' variable is defined as the independent variable, called SF here. So the econometric model function may be considered as

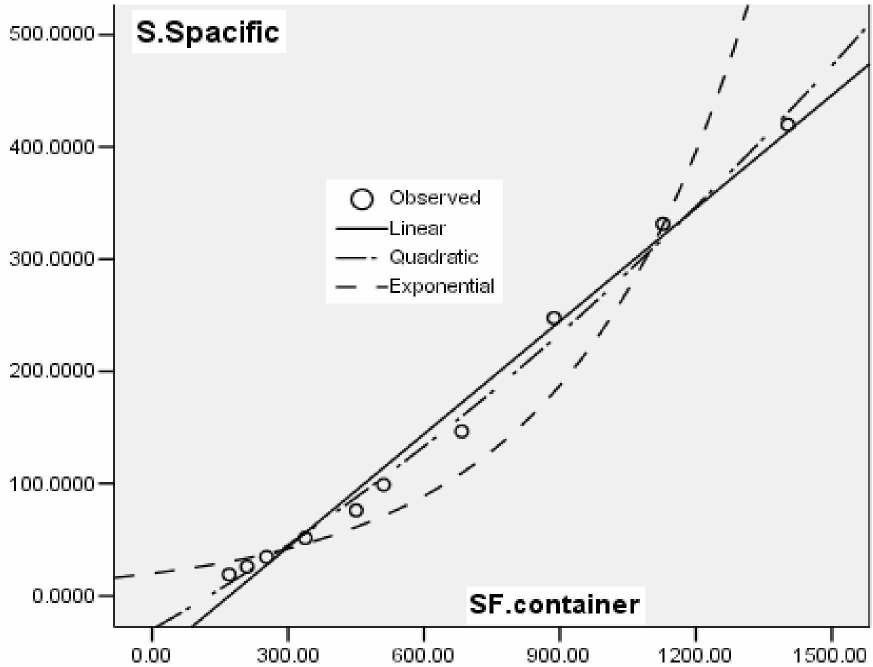
$$SD_t = F\{ SF_t \} + \varepsilon_t \qquad \text{(f4-7)}$$

where the index t concerns an observation for the variables at time t.

1) Scatter plots analysis

By using SPSS software, a model is developed for the (f4-7) function. Firstly scatter plot of two variables' data is analyzed. After extensive analysis for some models, the three models, which seem fit to the data considered before, were chosen and employed to analyze with the scatter plot, as LINEAR, QUADRATIC and EXPONENTIAL. As shown in <Figure 4-8>, the plot shows that the data spots are close to the linear line.

Figure 4-8 the scatter plots compared with Linear line for Korean T/S



2) Analyzing of the result value

The linear model's value results and the analysis results are shown in Table4-5, Table4-6, and Table4-7.

Table4-5 Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.994	.989	.987	15.825

The independent variable is SF.container.

Table4-6 ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	176627.110	1	176627.110	705.283	.000
Residual	2003.475	8	250.434		
Total	178630.585	9			

The independent variable is SF.container.

Table4-7 Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
SF.container	.336	.013	.994	26.557	.000
(Constant)	-57.289	9.119		-6.283	.000

According to the results shown in tables just above the calculated F-value is much larger than the tabular value of F at the specified level of significance 0.05 and degrees of freedom in Table4-6. Thus the null hypothesis is rejected and the null hypothesis's significant probability is 0.000, much smaller than 0.05. Thus the linear model is acceptable. To the parameters the significant probabilities of the SF coefficient and constant are much smaller than 0.05 too, close to zero, passing the t-test. Then the relationship model is estimated as

$$\tilde{SD}_t = 0.336 \times SF - 57.289 \qquad \text{(f4-8)}$$

4.5 Some Time Serials Models for Korean Ports, Shanghai Port and Transpacific Container Volume

1) Total transpacific containers' time serials model

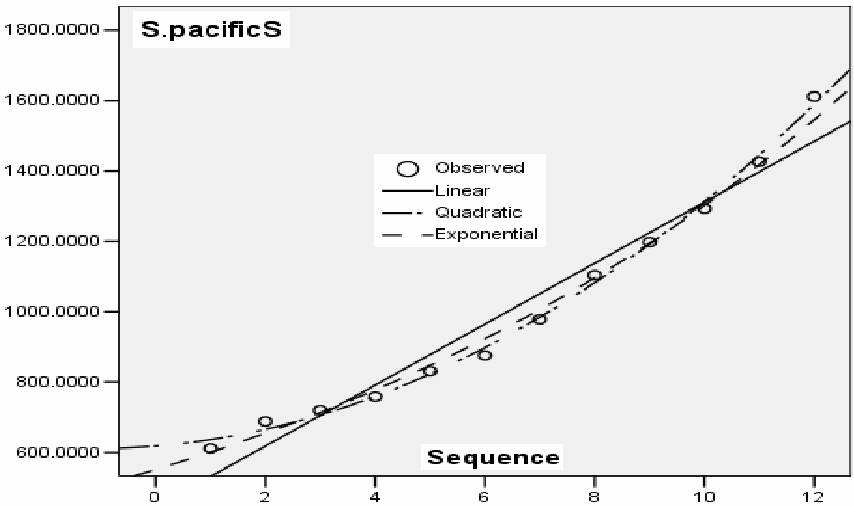
The development of transpacific containers has its own nature affected by economics and shipping environment. The data including information reflects the impacts of different factors on it. Transpacific containers are strongly affected by some factors which have close relationship with time, such as macro economy etc, in relative regions. According to the data analysis in Figure4-2 and Table4-1, it shows the serial trend with the change of time. By this token transpacific containers are correlative with the change of time. Thus the total transpacific containers changes with the time and the time serials model may be concluded as

$$S_s = F\{T\} + \varepsilon_t \qquad \text{(f4-9)}$$

where T concerns a variable which changes with time serial.

By using SPSS software, a model is developed for the (f4-9) function. The scatter plot of two variables' data is analyzed. After extensive analysis for some models, the three models, which seem fit to the data considered before (the data is used frome 1996 to 2004), were chosen and employed to analyze with the scatter plot, as LINEAR, QUADRATIC and EXPONENTIAL. As shown in <Figure 4-9>, the plot shows that the data spots are close to the exponential line.

Figure 4-9 the scatter plots compared with exponential line for total transpacific containers



The exponential model's value results and the analysis results are shown in Table4-8, Table4-9, Table4-10.

Table4-8 Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.998	.996	.995	.018

Table4-9 ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	.526	1	.526	1636.890	.000
Residual	.002	7	.000		
Total	.528	8			

Table4-10 Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Case Sequence	.094	.002	.998	40.458	.000
(Constant)	680.763	8.862		76.815	.000

The dependent variable is ln (S.pacific3

According to the results shown in the tables above the significant probability of the exponential formula's F-test is much smaller than the significant level at α=0.05, almost zero, see Table4-9. Thus the model is acceptable. To the parameters the significant probabilities of the coefficient and constant are much smaller than 0.05 too, close to zero, passing the t-test. Then the time serials model of transpacific containers is estimated as

$$\tilde{S}_s = 680.736 \times e^{0.094 \times T} \qquad \text{(f4-10)}$$

2) Shanghai foreign trade containers' time serials model

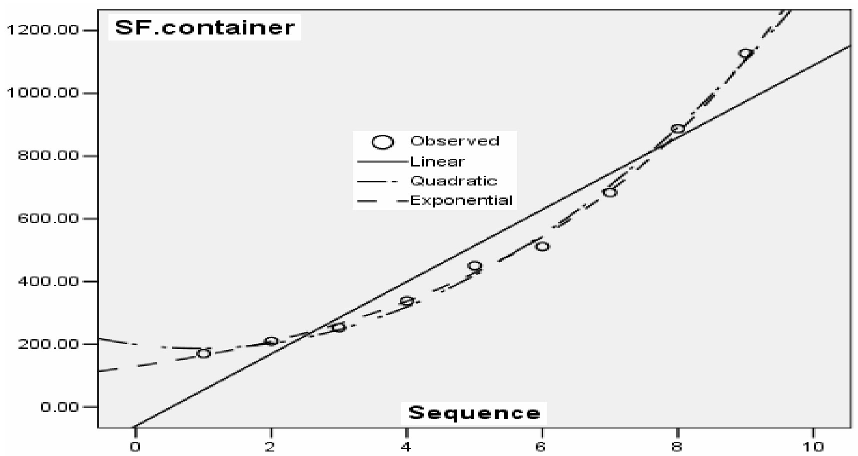
The development of Shanghai foreign trade containers has its own nature affected by Shanghai economics development and port environment. According to the data analysis in Figure4-7, It is obvious that the data has the trend with the change of time. The data including information reflects the impacts of different factors on it. Thus Shanghai foreign trade containers changes with the time, and the time serials model may be concluded as

$$SF = F\{T\} + \varepsilon_t \qquad \text{(f4-11)}$$

where T concerns an variable with time serials change.

By using SPSS software, a model is developed for the (f4-11) function. The scatter plot of two variables' data is analyzed. After extensive analysis for some models, the three models, which seem fit to the data considered before (the data is used frome 1996 to 2004), were chosen and employed to analyze with the scatter plot, as LINEAR, QUADRATIC and EXPONENTIAL. As shown in <Figure 4-10>, the plot shows that the data spots are close to the exponential line.

Figure 4-10 the scatter plots compared with exponential line for Shanghai foreign trade containers



The exponential model's value results and the analysis results are shown in Table4-11, Table4-12, Table4-13.

Table4-11 Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.998	.997	.997	.038

Table4-12 ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	3.404	1	3.404	2300.174	.000
Residual	.010	7	.001		
Total	3.414	8			

Table4-13 Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Case Sequence	.238	.005	.998	47.960	.000
(Constant)	130.022	3.634		35.781	.000

The dependent variable is ln(SF.container).

According to the results shown in the tables above the significant probability of the exponential formula's F-test is much smaller than the significant level at α=0.05, almost zero (see Table4-12). Thus the model is acceptable. To the parameters the significant probabilities of the coefficient and constant are much smaller than 0.05 too, close to zero, passing the t-test. Then the time serials model of Shanghai foreign trade containers is estimated as

$$\tilde{SF} = 130.022 \times e^{0.238 \times T} \qquad \text{(f4-12)}$$

In this chapter the acdamic model about competition and development between Korean ports and Shanghai ports in China is established. The model is solved, tested and applied in the next chapter.

Chapter 5

Analyzing and Applying the Differential Equations' Models for Forecasting Korean Ports' T/S

5.1 Solving the Differential Equations

Based on analyzing above, the model (f4-4) expresses the competition and development between Korean ports and Shanghai ports of China. In order to solve the model some assumptions are made as follows:

(1) In the model the variable $KT \approx \tilde{KT}$, the difference is the coefficient before them and may be summarized into the final constant.

(2) In the model the variable $S_s \approx \tilde{S}_s$, the difference is the coefficient before them and may be summarized into the final constant.

(3) In the model the variable $SD \approx \tilde{SD}$, the difference is the coefficient before them and may be summarized into the final constant.

(4) In the model the variable $SF \approx \tilde{SF}$, the difference is the coefficient before them and may be summarized into the final constant.

Incorporating these assumptions into the model (f4-4), we obtain the substitute model as

$$\begin{cases} \dfrac{dKT}{dt} = -a_{12} \times \tilde{KT}(t) + b_{21} \times \tilde{SD}(t) + d_0 \times \tilde{S}_s(t) + c_1 \\ \dfrac{dSD}{dt} = a_{12} \times \tilde{KT}(t) - b_{21} \times \tilde{SD}(t) + d_1 \times \tilde{SF}(t) + c_2 \end{cases} \tag{f5-1}$$

Combining the models (f4-6) and (f4-8) into the model (f5-1), we get the model as

$$\begin{cases} \dfrac{dKT}{dt} = -a_{12} \times \left\{ 0.487 \times \tilde{S}_s\ (t) - 273.23 \right\} + b_{21} \times \left\{ 0.336 \times \tilde{SF} - 57.289 \right\} \\ \qquad + d_0 \times \tilde{S}_s\ (t)\ + \mathrm{c}_1 \\ \dfrac{dSD}{dt} = a_{12} \times \left\{ 0.487 \times \tilde{S}_s\ (t) - 273.23 \right\} - b_{21} \times \left\{ 0.336 \times \tilde{SF} - 57.289 \right\} \\ \qquad + d_1 \times \tilde{SF}\ (t)\ + \mathrm{c}_2 \end{cases} \tag{f5-2}$$

Combining the models (f4-10) and (f4-12) into the model (f5-2), we get the further model as

$$\begin{cases} \dfrac{dKT}{dt} = -a_{12} \times \left\{ 0.487 \times 680.736 \times e^{0.094 \times T} - 273.23 \right\} \\ \qquad + b_{21} \times \left\{ 0.336 \times 130.022 \times e^{0.238 \times T} - 57.289 \right\} \\ \qquad + d_0 \times 680.736 \times e^{0.094 \times T}\ + \mathrm{c}_1 \\ \dfrac{dSD}{dt} = a_{12} \times \left\{ 0.487 \times 680.736 \times e^{0.094 \times T} - 273.23 \right\} \\ \qquad - b_{21} \times \left\{ 0.336 \times 130.022 \times e^{0.238 \times T} - 57.289 \right\} \\ \qquad + d_1 \times 130.022 \times e^{0.238 \times T}\ + \mathrm{c}_2 \end{cases} \tag{f5-3}$$

From the model (f5-3) we may conclude the results of the differential equations by integrals. The Integration of the model's two sides leads to

$$\begin{cases} \int \frac{dKT}{dt}dt = \int -a_{12} \times \{0.487 \times 680.736 \times e^{0.094\times T} - 273.23\}dt \\ \qquad + \int b_{21} \times \{0.336\times 130.022\times e^{0.238\times T} - 57.289\}dt \\ \qquad + \int d_0 \times 680.736\times e^{0.094\times T} dt + \mathrm{k}_1 \\ \\ \int \frac{dSD}{dt}dt = \int a_{12} \times \{0.487 \times 680.736 \times e^{0.094\times T} - 273.23\}dt \\ \qquad + \int -b_{21} \times \{0.336\times 130.022\times e^{0.238\times T} - 57.289\}dt \\ \qquad + \int d_1 \times 130.022\times e^{0.238\times T} dt + \mathrm{k}_2 \end{cases} \tag{f5-4}$$

$$\begin{cases} KT = -a_{12} \times \left\{ \frac{0.487 \times 680.736}{0.094} \times e^{0.094\times T} - 273.23\times T \right\} \\ \qquad + b_{21} \times \left\{ \frac{0.336\times 130.022}{0.238} \times e^{0.238\times T} - 57.289\times T \right\} \\ \qquad + d_0 \times \frac{680.738}{0.094} \times e^{0.094\times T} + \mathrm{k}_1 \\ \\ SD = a_{12} \times \left\{ \frac{0.487 \times 680.736}{0.094} \times e^{0.094\times T} - 273.23\times T \right\} \\ \qquad - b_{21} \times \left\{ \frac{0.336\times 130.022}{0.238} \times e^{0.238\times T} - 57.289\times T \right\} \\ \qquad + d_1 \times \frac{130.022}{0.238} \times e^{0.238\times T} + \mathrm{k}_2 \end{cases} \tag{f5-5}$$

5.2 Estimating and Deciding the Coefficients of the Differential Equations

In order to decide the coefficients of the model (f5-5), we conclude the model (f5-5) to other expressions. By the formula KT plus the formula SD, we get the result as

$$\text{KT+SD} = d_0 \times \frac{680.736}{0.094} \times e^{0.094 \times T} + d_1 \times \frac{130.022}{0.238} \times e^{0.238 \times T} + \text{k} \qquad \text{(c5-1)}$$

where k= $k_1 + k_2$

Derivative coefficients d_0, d_1 and k in (c5-1) are calculated analytically with the statistic data of KT and SD from 1996 to 2004. The results are shown in Table5-1 and Table 5-2.

Table5-1 Iteration History (b)

Iteration Number(a)	Residual Sum of Squares	Parameter		
		d0	d1	k
1.0	1925918.242	.000	.000	.000
1.1	1507308.249	.002	.008	17.176
2.0	1507308.249	.002	.008	17.176
2.1	840217.242	.005	.026	50.019
3.0	840217.242	.005	.026	50.019
3.1	153348.560	.011	.072	82.736
4.0	153348.560	.011	.072	82.736
4.1	3627.762	.011	.168	-105.976
5.0	3627.762	.011	.168	-105.976
5.1	3511.716	.014	.165	-128.650
6.0	3511.716	.014	.165	-128.650
6.1	3511.716	.014	.165	-128.650

Derivatives are calculated numerically.
a. Major iteration number is displayed to the left of the decimal and minor iteration number is to the right of the decimal; b. Run stopped after 12 model evaluations and 6 derivative evaluations because the relative reduction between successive residual sums of squares is at most SSCON = 1.00E-008.

Table5-2 Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
d0	.014	.018	-.031	.058
d1	.165	.041	.064	.267
k	-128.650	131.252	-449.813	192.512

By formula KT subtracting formula SD we get the result as

$$\begin{aligned}\text{KT - SD} &= -a_{12}\times 2\times\left\{\frac{0.487\times 680.736}{0.094}\times e^{0.094\times T}-273.23\times T\right\}\\ &+b_{21}\times 2\times\left\{\frac{0.336\times 130.022}{0.238}\times e^{0.238\times T}-57.289\times T\right\}\\ &+d_0\times\frac{680.738}{0.094}\times e^{0.094\times T}-d_1\times\frac{130.022}{0.238}\times e^{0.238\times T}+\text{p} \qquad \text{(c5-2)}\end{aligned}$$

where p = k_1 - k_2

Incorporating d_0, d_1 into (c5-2), derivative coefficients a_{12}, b_{21} and p in (c5-1) are calculated analytically with the statistic data of KT and SD from 1996 to 2004. The results are shown in Table5-3 and Table 5-4.

By combining (f5-5), (c5-1) and (c5-2) with derivative coefficients k and p in Table5-1 and Table5-3, we get linear equations to solve k1 and k2 as

$$\begin{cases} k_1+k_2 = -128.650 \\ k_1-k_2 = -1551.627 \end{cases}$$

The solving results are k1 = -840.139, k_2 = 711.489.

Table5-3 Iteration History (b)

Iteration Number(a)	Residual Sum of Squares	Parameter		
		a12	b21	p
1.0	1530033.778	.000	.000	.000
1.1	1162939.535	-.002	.020	17.531
2.0	1162939.535	-.002	.020	17.531
2.1	597965.853	-.006	.062	50.844
3.0	597965.853	-.006	.062	50.844
3.1	99704.270	-.012	.188	67.696
4.0	99704.270	-.012	.188	67.696
4.1	28632.677	-.028	.295	-160.196
5.0	28632.677	-.028	.295	-160.196
5.1	18099.953	-.079	.177	-506.482
6.0	18099.953	-.079	.177	-506.482
6.1	6002.612	-.180	-.066	-1192.997
7.0	6002.612	-.180	-.066	-1192.997
7.1	4388.028	-.233	-.193	-1551.627
8.0	4388.028	-.233	-.193	-1551.627
8.1	4388.028	-.233	-.193	-1551.627

Derivatives are calculated numerically.

a. Major iteration number is displayed to the left of the decimal, and minor iteration number is to the right of the decimal.

b. Run stopped after 16 model evaluations and 8 derivative evaluations because the relative reduction between successive residual sums of squares is at most SSCON = 1.00E-008.

Table5-4 Parameter Estimates

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A12	-.233	.036	-.320	-.146
B21	-.193	.087	-.406	.020
P	-1551.627	241.692	-2143.025	-960.228

Further conclusion from model (f4-4) may be resulted in with the derivatives. By substituting coefficients, a_{12}, b_{21}, d_0, d_1 in model (f4-4) with derivative value, the refined model may be got as

$$\begin{cases} \dfrac{dKT}{dt} = 0.233 \times KT\ (t) - 0.193 \times SD\ (t) + 0.014 \times S_s(t) \\ \dfrac{dSD}{dt} = -0.233 \times KT\ (t) + 0.193 \times SD\ (t) + 0.165 \times SF\ (t) \end{cases} \quad \text{(f5-6)}$$

The model (f5-6) implicate that Korean ports T/S containers causes the positive effect on its change and Shanghai transpacific containers causes the negative effective on the change of Korean ports' T/S containers. Korean T/S containers' effect is still stronger than Shanghai transpacific containers on the change of Korean T/S containers and on the change of Shanghai transpacific containers in the near future because the absolute value of the coefficient before KT is larger than one before SD. As it is assumed the total transpacific containers causes the positive effect on change of Korean T/S containers even though the coefficient before S_s is smaller compared with others. Certainly Shanghai foreign trade containers causes positive effect on change of Shanghai transpacific containers. Thus the model (f5-6) implicates the strenth and weakness of the competition through the different variables' effects. Finally the result of the model KT may be solved and expressed as

$$\begin{aligned} KT &= 0.233 \times \left\{ \frac{0.487 \times 680.736}{0.094} \times e^{0.094 \times T} - 273.23 \times T \right\} \\ &\quad - 0.193 \times \left\{ \frac{0.336 \times 130.022}{0.238} \times e^{0.238 \times T} - 57.289 \times T \right\} \qquad \text{(f5-7)} \\ &\quad + 0.014 \times \frac{680.738}{0.094} \times e^{0.094 \times T} + 840.139 \end{aligned}$$

5.3 Forecasting Korean Ports' T/S

According to the model (f5-7) Korean ports' T/S containers may be predicted. The starting sequence in the model (f5-7) is 1 corresponding to 1996. The contrast sequence table is shown in Table5-5.

Table5-5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
year	1996	1997	1998	1999	2000	2001	2002	2003	2004	*2005	2006	2007	2008	2009	2010	2011	2012	2013

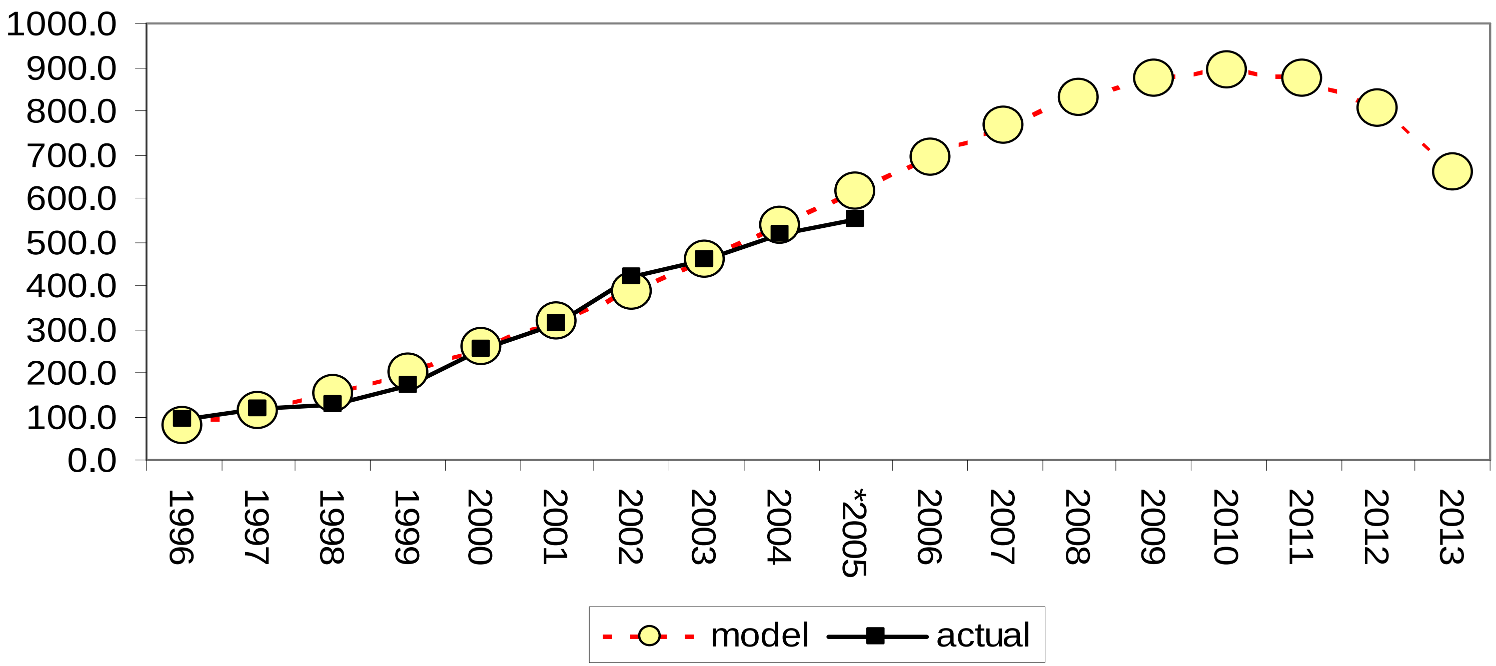
* The data in 2005 is not used in establishing model (f5-7)

Substituting T in the model (f5-7) with the sequences in Table5-5, we get the prdicting results shown in Table5-6 and Figure5-1.

Table5-6 Korean ports' T/S containers (10 thousand TEU)

Year	Model calculation	Actual data
1996	76.4	94
1997	111.7	117
1998	153.6	127
1999	202.1	172
2000	257.4	253
2001	319.1	311
2002	386.7	420
2003	459.4	460
2004	535.9	516
*2005	614.2	553
2006	691.7	
2007	764.4	
2008	827.3	
2009	873.5	
2010	893.6	
2011	875.6	
2012	803.4	
2013	656.3	

Figure5-1 The trend of Korean port's T/S containers(10 thousand TEU)



5.4 Conclusion and Analysis

In this chapter the differential equations were solved by integrals. The coefficients before variables in the differential equations were decided. The derivative coefficients were calculated analytically with the statistic data of variables of KT and SD. Some conclusions and analysis are as follows.

(1) Comparing magnitude of the coefficients before every variable, it was found that the effect of the variable of Korean ports' T/S containers is greatest and causes positive effect on the change of Korean T/S congtainers in the near future.

(2) The coefficient of the variable of Shanghai transpacific containers is the second larger. It causes the negative effect on change of Korean ports' T/S containers.

(3) The total transpacific containers is the source to increase Korean ports' T/S containers. It causes the positive effect on the change of Korean ports' T/S containers too in the past and near future.

(4) It may be concluded from the model (f5-6) that competition has formed between Korean ports and Shanghai ports of China being scramble for transpacific containers.

(5) The developed model f(5-7) fits the development of Korean ports' T/S containers. After verifying the actual data in 2005, which data was not used for establishing the model f(5-7), the model calculation result is close to the data in 2005.

(6) According to model f(5-7) the predicting curve is got for the development of Korean ports' T/S containers. The curve goes to top in 2010 then gets down because of the competition. By the model farther predicting can be done after inputing new data, especially for predicting after the time in which the predicted curve reaches the top.

(7) In 2011, the Korean ports T/S containers is predicted about 8756 thousand TEUs by the model. It is forecasted that Shanghai ports' transpacific

containers is over Korean ports' T/S containers in 2007 by the model.

(8) There are some possibilities to change the trend in the preceding discussion. It could be the changes of the trade structures in the world and in Northeast Asia which will be discussed in next chapters.

This chapter's forecasting result is used in chapter 7. Some conclusions of the dissertation are derived from the chapter' results.

Chapter 6

A Model Analysis on the Relationship between Trade and T/S in North-East Asia Based on Korean Ports

The preceding chapters' analysis mainly emphasizes on the development of Korean T/S containers under the environment of competition for scrambling transpacific containers with its important rival.

Transshipment hub-port shipping companies not only consider their mainline transportation scale but also the feeder line scale, especially to ports with a similar geographical location. Finally, competitors will improve the facilities of their ports for both hardware and software conditions. The shipping companies will choose appropriate hub-ports and adjust them according to changes in the volume scale on mainlines and feeder lines. If a transshipment hub-port wants other ports to feed it, the feeder lines' volume scale must be maintained. Feeder lines' volumes consist mainly of two parts. One is transshipment, another is the volume generated by direct trade between two ports' hinterlands. The scale of direct trade is very important. It is unimaginable for transshipment between two ports to exist if there is no direct trade between two port areas, otherwise a port must be located in a very important stronghold across oceans only. From this perspective, we may analyze the ports in northeastern based on Korea and its ports as the focus of discussion.

The following chapters will discuss more about the trend of T/S containers in the view of the relationship between trade with other countries (or regions) and T/S containers from other countries (or regions) based on Korean ports. On the basis of the preceding forecasting of Korean T/S containers the further predicting is done for T/S container through Korean ports from some important regions in China. The purpose is to try finding some strategies and clues or ways of decision for both shipping companies and T/S ports themselves.

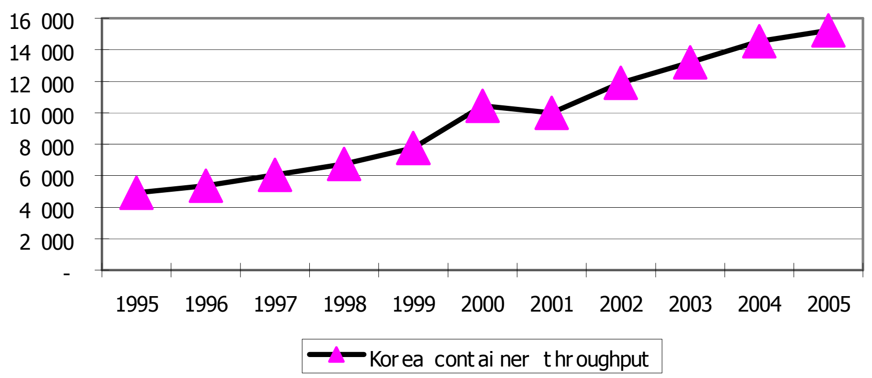
6.1 Overall Analysis of Korean Ports and Trade

6.1.1 The evolution of container throughput and T/S in Korea

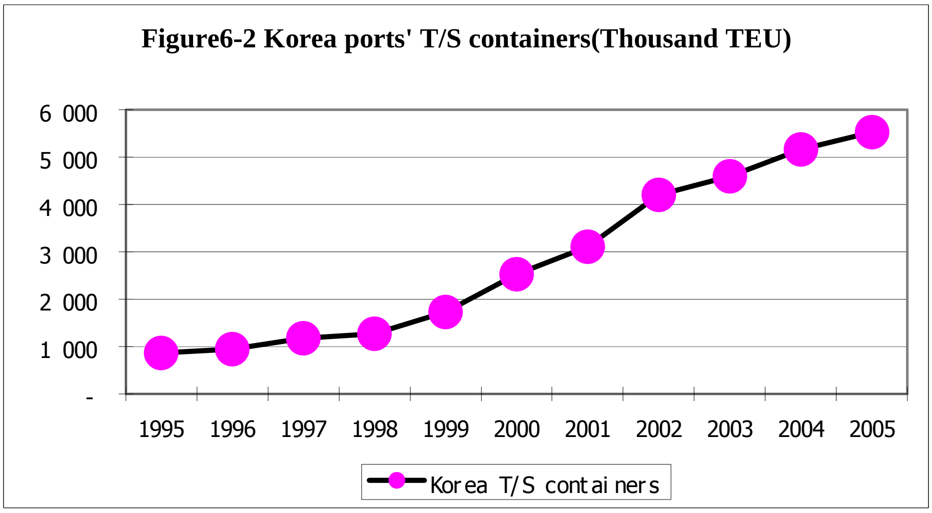
From the mid 1990s, container throughput in Korea has increased rapidly. Throughput increased from 4918 thousand TEU to 15216 thousand TEU in 2005 (see [28]Figure6-1). The highest rate of increase occurred in 2000, about 35%, but the next year adjusted to -4.45%. Then the rate of increase was maintained at more than 10% until 2004, and fell to 4.77% in 2005.

The container T/S throughput in Korea increased more strongly than its total throughput (see [29]Figure6-2). The highest rate of increase also occurred in 2000, about 47%, more than the total throughput of about 12 points of percent. Except for two years in 1998 and in 2003, which were slightly lower, the rates of increase of T/S were higher in all other years. Especially in 2001 the rate of increase of the total is negative but the T/S rate reached 23.03% in Korea. Thus it is necessary for highlighting the importance of T/S containers in Korea.

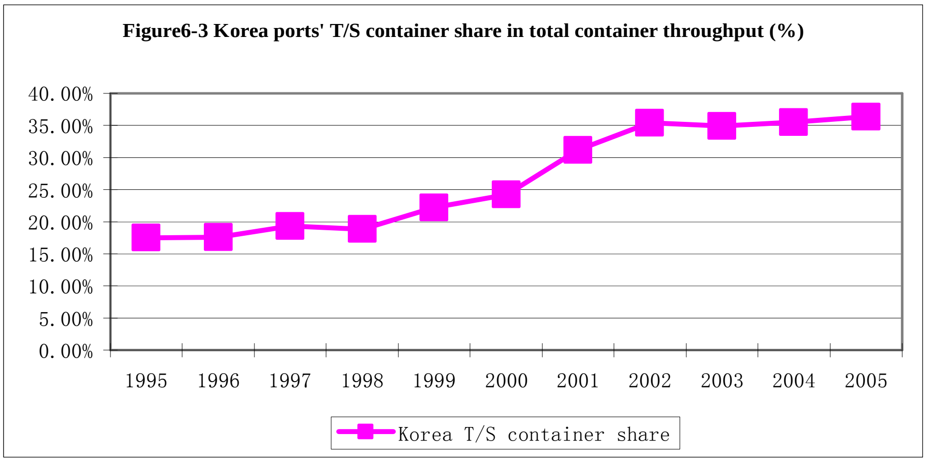
Figure6-1 Korea ports' container throughput(Thousand TEU)



[28] Source: integration from KMI.
[29] Source: integration from KMI.



From the view of T/S share accounting for the total throughput, it increased quickly from 1999. The proportion of T/S share was 22.21% in 1999, and reached 35.37% in 2002, then enters periods of slight fluctuation (Figure6-3).

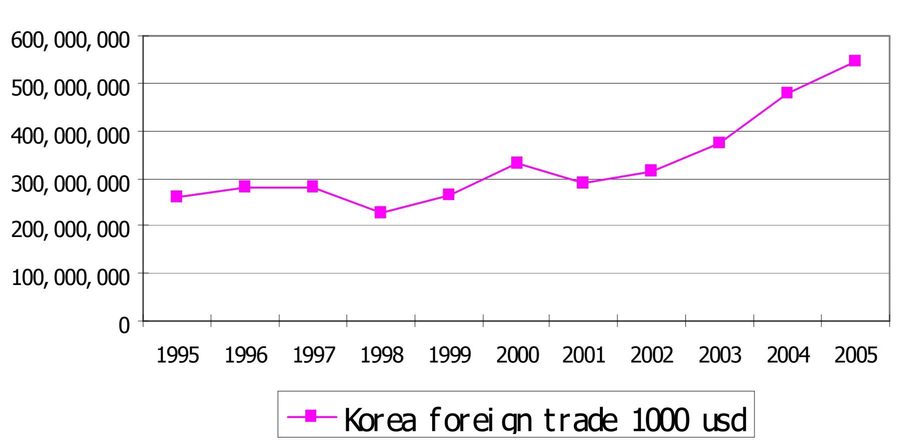


Does the proportion have a top limit or is it only in a fallow period? Nevertheless, the absolute amount of T/S is increasing in Korea ports. To properly assess the future development of T/S structure share from different countries, the factors that affect structure share for all countries need to be identified and measured.

6.1.2 Korean trade evolution and correlation with container throughput

Korean foreign trade has experienced several different stages. The amount broke through US$10 billion in 1974, US$100 billion in 1988 and US$200 billion in 1995. Even though the Asia crisis slowed development of Korean economics in 1997 and 1998, Korea foreign trade was only slightly affected. After the crisis, Korean foreign trade continued to increase and broke through US$300, US$400 and went over US$500 in 2005 (see [30]Figure6-4).

Figure6-4 Korea foreign trade development



The strong development of Korean foreign trade brought along and stimulated the development of port container throughput and also T/S containers. Through an analysis of correlations between the trade and the total container throughput, the trade and the T/S containers in Korea, both the correlation coefficients are higher, the values are respectively 0.8662 and 0.8658. It shows that the two

[30] Source: http://www.customs.go.kr

correlations are similar because of the closer coefficients. It seems that T/S containers in Korea is affected by trade with different countries too. This result encourages us to do further research about the relationship between trade and transshipment based on Korean ports.

6.2 Data Analysis of the T/S Distribution through Korea

In order to analyze the trade and the T/S containers, and to set up the relationship model we need to obtain efficient data. The purpose of the data is to analyze direct trade and T/S containers between Korea and other countries. Because the feeder line's scale consists of both direct trade and feeder T/S containers, the scale of feeder line's volume may affect a shipping company's decision to select its core transshipment hub. Based on the analysis of Korea and its ports, the data of trade and T/S containers between Korea and other countries or regions in East Asia is analyzed. Furthermore the trend of trade and T/S containers between Korea and some main port cities in China is analyzed. Based on analyzing the data collected some important results are concluded.

6.2.1 Data collection

Data was collected through KT-Net, Port-MIS, the Shipping Statistics Handbook of Korea, the monthly bulletin of The Bank of Korea, and the main Chinese cities' economic statistics for the analysis of trade and T/S containers between Korea and the other 12 countries and regions. The major port cities in China were also included in the analysis as there is a larger volume of trade and T/S containers between Korea and China. The container T/S containers data collected between Korea and other countries (or regions) covers 9 months in 3 different years for 12 countries and regions. The monthly aggregate data it is sufficiently long to provide a robust analysis. As the data in repeated crosssections is different from the panel data, we were able to analyze the behavior of 12 countries and regions in the same months and to repeat the analysis across several different months.

Accuracy of data from each source is very much dependent upon the extent to which data was available and how it was counted. In this paper, as far as the availability and the usefulness of data collection are concerned, the computerized and summarized data from port KT-Net, Port-MIS, and Shipping Statistics Handbook of Korea were the most appropriate. A pre-feasibility study was carried out for the usefulness of data. The trade data from official statistics handbook or bulletins and KT-net, and transshipment data aggregated from the transshipment containers registered in Port-MIS system one by one are mostly accurate and possible to collect and analyze. According to the pre-feasibility study more than 0.5 million items were taken for analysis, model setting, trade and T/S data of container cargoes between Korea and other 12 countries, and related to some port cities in China.

6.2.2 Data transformation and analysis

1) Data transformation

Before the analysis is made, the data as an observation result needs be transformed. Firstly the container transshipment amount from the 12 countries and regions through Korea is aggregated respectively according to every country (or region) and every month in which the data can be collected. Considering the possible relativity and comparability between the data aggregated in every different month, the proportions of the amount of container transshipment through Korea, which the 12 countries and regions respectively account for the total amount of container transshipment in Korea in every month, are counted and transformed from the collected data. Then the corresponding trades between Korea and the 12 countries(or regions) respectively in the same months are counted and the proportions of the trades between Korea and the 12 countries respectively are counted and transformed from the collected monthly data.

Table 6-1 data format

Country (or region) name	Proportion of one country's or region's T/S containers through Korea accounting for total amount of container transshipment in Korea	Proportion of trade between Korea and one country or region accounting for Korea's total foreign trade amount

2) The proportion data of transshipment

As shown in <Table 6-2>, the country (or region), which has the biggest proportion of the T/S through Korea is China, for every month in which data was collected and aggregated. The proportions fluctuated between 0.45 and 0.28 and showed a tendency to decrease.

Table 6-2 Proportion of container transshipment through Korea ports about Asia countries and regions

Time / Nation/Region		2004.06	2004.07	2004.08	2005.09	2005.10	2005.11	2006.01	2006.02	2006.03
1	China	0.3947	0.4194	0.4452	0.3141	0.2866	0.4099	0.3472	0.2904	0.3286
2	Japan	0.1838	0.1812	0.1421	0.0764	0.1678	0.1354	0.1334	0.1492	0.2118
3	Singapore	0.0596	0.0662	0.0571	0.0612	0.0697	0.0396	0.0691	0.0457	0.0512
4	Hongkong	0.0593	0.0533	0.0498	0.0223	0.0413	0.0292	0.0205	0.0229	0.0444
5	Malaysia	0.0464	0.0446	0.0424	0.0131	0.0227	0.0138	0.0164	0.0184	0.0288
6	Indonesia	0.0462	0.0364	0.0236	0.0037	0.0080	0.0069	0.0086	0.0129	0.0112
7	Thailand	0.0352	0.0204	0.0290	0.0024	0.0026	0.0056	0.0061	0.0024	0.0133
8	Taiwan	0.0314	0.0426	0.0437	0.0248	0.0449	0.0313	0.0322	0.0373	0.0428
9	Australia	0.0200	0.0190	0.0240	0.0078	0.0059	0.0013	0.0064	0.0211	0.0132
10	Philippine	0.0157	0.0176	0.0153	0.0021	0.0041	0.0023	0.0002	0.0006	0.0005
11	Vietnan	0.0096	0.0092	0.0064	0.0003	0.0001	0.0001	0.0002	0.0002	0.0004
12	New Zealand	0.0048	0.0040	0.0040	0.0110	0.0023	0.00004	0.0009	0.0060	0.0003
13	Others	0.0933	0.0861	0.1174	0.4608	0.3440	0.3246	0.3588	0.3929	0.2535

The second one is Japan. Japan's proportions of T/S through Korea fluctuated between 0.13 and 0.22 except for one month, which was 0.074. The two countries, China and Japan, accounted for the most of the T/S shares through Korea.

The data show that even a key hub in transshipment itself feeds its containers to other container transshipment hubs. For instance, the proportions of T/S originating from Singapore, whose T/S containers is greatest in the world, was quite high even compared to Japan and fluctuated between 0.04 and 0.07. The regions' T/S ports in Hong Kong and Taiwan also have some shares of T/S through Korea. This means that even between two T/S ports there exist feeder-lines for inter-transshipments. According to the analysis of proportions of transshipment through Korea for the 12 countries and regions in East Asia, the ports in Korea have formed comparatively more extensive feed lines in East Asia. These comparatively extensive feeder lines laid a solid foundation for one of the most important core transshipment hubs in East Asia, even though the competition for core hubs became more and more fierce.

3) The proportion data for trades

In order to correspond to the proportion data of transshipment monthly aggregated, the proportion data of trades between Korea and other 12 countries and regions respectively were counted based on collected data aggregated monthly. As shown in <Table6-3>, the country (or region) which has the biggest proportion of the trade with Korea, accounting for total Korea foreign trade monthly aggregated, is still China. The proportions fluctuated between 0.16 and 0.19, smaller than the transshipment proportions and its fluctuation. The second one is again Japan. Japan's proportions of trade with Korea fluctuated between 0.12 and 0.16 quite close to its transshipment proportions through Korea. The two countries, China and Japan, accounted for about 1/3 of Korea foreign trade. The trade proportions for other countries and regions in different months are distributed between from 0 to 0.05. From the analysis of the trade proportion data it seems that if the trade proportion is higher the corresponding transshipment proportion is also higher. Should the relationship between trade proportion and transshipment proportion exist? What and how would the relationship be between them? The further analysis in the following chapters answers these questions.

Table 6-3 Proportion of trade between Asia countries (or regions) and Korea respectively

Nation/region \ Time		2004.06	2004.07	2004.08	2005.09	2005.10	2005.11	2006.01	2006.02	2006.03
1	China	0.1613	0.1751	0.1734	0.1848	0.1842	0.1837	0.1791	0.1679	0.1865
2	Japan	0.1398	0.1512	0.1362	0.1338	0.1312	0.1274	0.1232	0.1309	0.1302
3	Singapore	0.0203	0.0228	0.0204	0.0261	0.0240	0.0252	0.0255	0.0244	0.0233
4	Hongkong	0.0403	0.0379	0.0407	0.0331	0.0352	0.0349	0.0349	0.0333	0.0343
5	Malaysia	0.0203	0.0192	0.0234	0.0207	0.0177	0.0184	0.0220	0.0203	0.0251
6	Indonesia	0.0196	0.0208	0.0192	0.0243	0.0234	0.0248	0.0216	0.0182	0.0220
7	Thailand	0.0113	0.0117	0.0115	0.0108	0.0113	0.0107	0.0119	0.0121	0.0125
8	Taiwan	0.0363	0.0385	0.0384	0.0343	0.0344	0.0362	0.0354	0.0346	0.0338
9	Australia	0.0217	0.0228	0.0249	0.0263	0.0272	0.0262	0.0280	0.0258	0.0246
10	Philippine	0.0108	0.0118	0.0112	0.0095	0.0098	0.0092	0.0093	0.0096	0.0097
11	Vietnam	0.0071	0.0076	0.0075	0.0077	0.0067	0.0074	0.0065	0.0059	0.0077
12	New Zealand	0.0027	0.0030	0.0029	0.0025	0.0024	0.0030	0.0025	0.0020	0.0022
13	Others	0.5085	0.4776	0.4903	0.4861	0.4925	0.4929	0.5001	0.515	0.4881

6.3 Analytical Method and Establishing Models

6.3.1 Analytical method and function variables

Based on the data analysis above, an econometric analysis was then applied. From the proportion data, the phenomenon that trade proportion higher the transshipment proportion higher based on Korea in East Asia and vice versa was identified. That transshipment also occurs between deep ports or core ports in East Asia was also noted. We consider that the reasons for these phenomena are that the feed line’s economy of scale makes some transshipment containers more efficient and low cost for efficient transport even between two core ports.

It seems that the important impetus and motivation to drive the transshipment between two ports is the direct trade between two ports or corresponding countries and regions. In qualitative analysis of the proportion data, it may be concluded that it is no trade no transshipment not vice versa, except for regions that have no alternative routes through other ports or the port itself, but it seems such regions no longer exist in East Asia. So for econometric analysis the two variables are considered to determine their relationship. Because trade will occur between two ports even if both of them do not have sufficient infrastructure for transshipment. Thus the trade proportion variable is defined as the independent variable or explanatory variable, called X here in general terms. The T/S proportion variable is defined as the dependent variable or variable to be explained, called here Y in general terms. So the econometric model function may be considered generally as

$$y_{it}=F\{ x_{it} \} + \varepsilon_{it}$$

where the index (i, t) concerns an observation for individual country or region i at time t, for data aggregated in t time period.

6.3.2 Specific model analysis

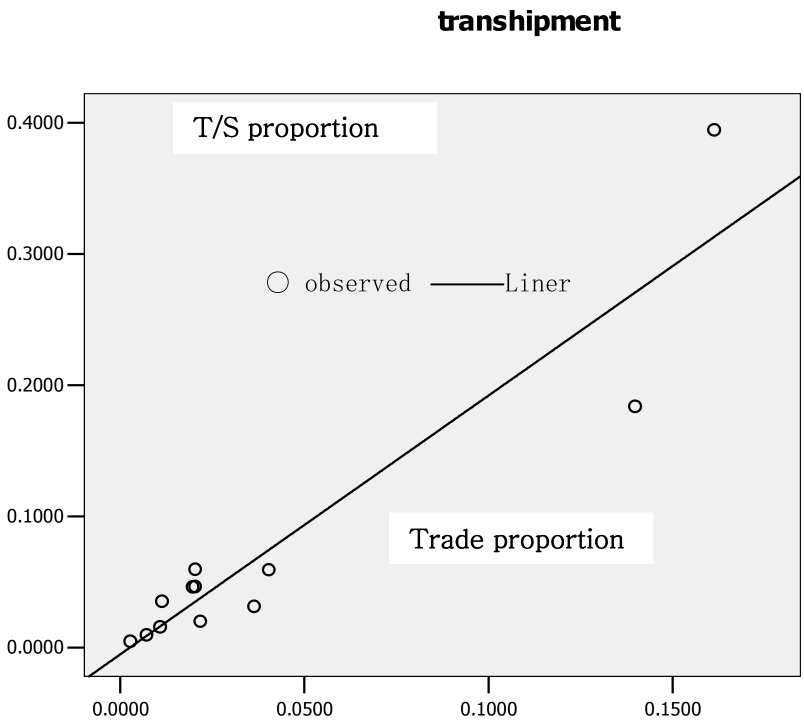
1) Scatter plots analysis

By using SPSS software, a specific model was developed for the F { x_{it} } function. Firstly scatter plots of two variables' data are analyzed. After extensively analysis for some models, the three models, which seem fit to the data considered before, were chosen and employed to analyze with the scatter plots, as LINEAR, QUADRATIC and GROWTH.

As shown in <Figure6-5>, one month data (2004.06) as a sample was plotted with LINEAR. The plot shows the data spots are close to the linear line.

Finally the 9 months' data were plotted and analyzed with LINEAR. The result is almost similar as shown in <Figure6-5>.

Figure6-5 the scatter plots compared with Linear line



As shown in <Figure6-6>, one month data (2004.06) as a sample was plotted with QUADRATIC. The plot shows the data spots are close to the quadratic line. Finally the 9 months' data were plotted and analyzed with QUADRATIC. The result is similar as shown in <Figure6-6>.

As shown in <Figure6-7>, one month data (2004.06) as a sample was plotted with GROWTH. The plot shows the data spots are close to the growth line. Finally the 9 months' data were plotted and analyzed with GROWTH. The result is similar as shown in <Figure6-7>.

Figure6-6 the scatter plots compared with Quadratic line

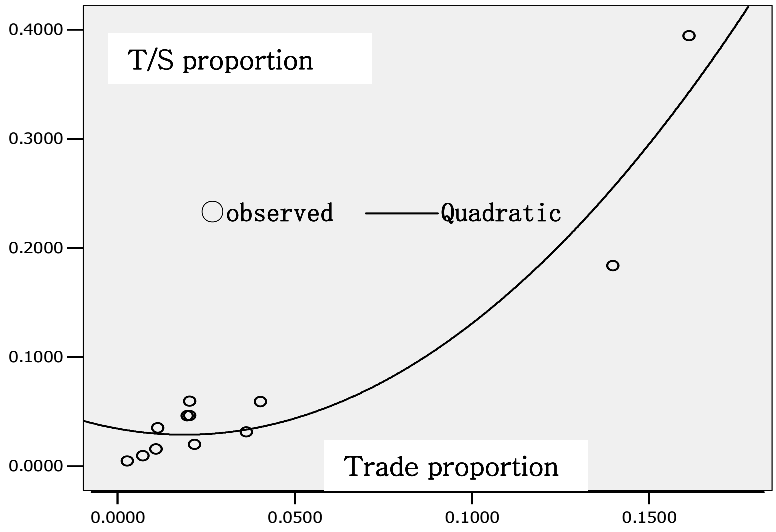
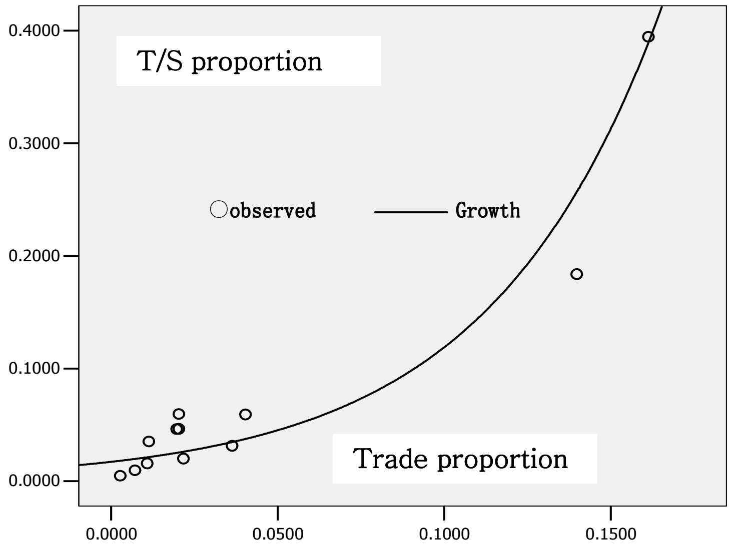


Fig 6-7 the scatter plots compared with Growth line



2) Model setup and parameters' test

According to the results of scatter plots, further analysis should be done to decide which model is a better fit to the relationship between trade and T/S proportions.

(1) Linear analysis

By counting the data aggregated monthly statistically with SPSS software, nine linear formulae were produced with parameters and test results, as shown in <table6-4>. According to the results the significant probability of every linear formula's F-test is much smaller than the significant level at α=0.05, almost zero. Thus all of the formulae are acceptable. To the parameters the significant probabilities of all the XL coefficients are much smaller than 0.05 too, close to zero. But the significant probabilities of the constant coefficients are larger than 0.05 except for YL603. So the formulae should be modified.

Table6-4 Linear formulae, parameters and their test results

Time	Formula	F-test	R
2004.06	Y_{L406}=-0.005+1.937*X_{L406} (0.741) (0.000)	68.603 (0.000)	0.934
2004.07	Y_{L407}=-0.007+1.917*X_{L407} (0.673) (0.000)	63.482 (0.000)	0.929
2004.08	Y_{L408}=-0.014+2.055*X_{L408} (0.505) (0.000)	48.106 (0.000)	0.910
2005.09	Y_{L509}=-0.015+1.401*X_{L509} (0.343) (0.000)	40.730 (0.000)	0.896
2005.10	Y_{L510}=-0.010+1.521*X_{L510} (0.202) (0.000)	215.639 (0.000)	0.978
2005.11	Y_{L511}=-0.029+2.014*X_{L511} (0.077) (0.000)	87.015 (0.000)	0.947
2006.01	Y_{L601}=-0.021+1.785*X_{L601} (0.109) (0.000)	98.461 (0.000)	0.953
2006.02	Y_{L601}=-0.014+1.588*X_{L601} (0.114) (0.000)	170.479 (0.000)	0.972
2006.03	Y_{L603}=-0.015+1.801*X_{L603} (0.006) (0.000)	848.670 (0.000)	0.994

Note: the value in the parentheses is significant test probability.

To determine the linear model it is considered as

$$Y_{L,t} = \beta_{1,t} + \beta_{2,t} X_{L,t} + \varepsilon_{L,t} \qquad \text{(f 6-1)}$$

where β1 , t , β2 , t are coefficients of the linear formulae in table 4-1, and the index (L ,t) is expressed as the Linear formula at time t. Firstly we may assume that β1 , t= β1 and β2 , t= β2 , and consider that β1 , t and β2 , t are normal distributions respectively,

$$\text{i.e.} \qquad \beta_{1,t} \sim N(\beta_1, \sigma^2_\beta)$$
$$\beta_{2,t} \sim N(\beta_2, \sigma^2_\beta)$$

The assumptions are testified by using SPSS. The normal p-p plots and histograms were made, seeing Figure6-8 to Figure6-11.

Figure6-8 Normal p-p plot of β_1

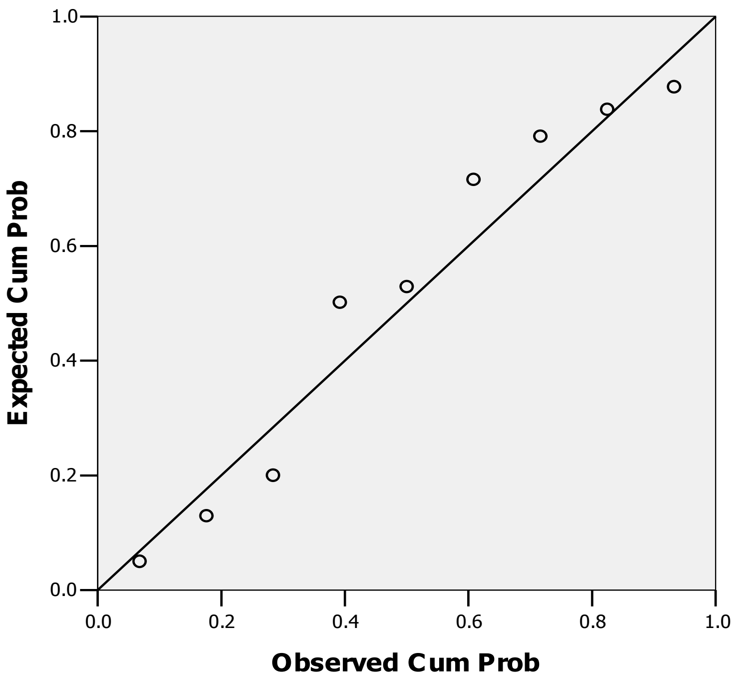


Figure6-9 Normal p-p plot of β_2

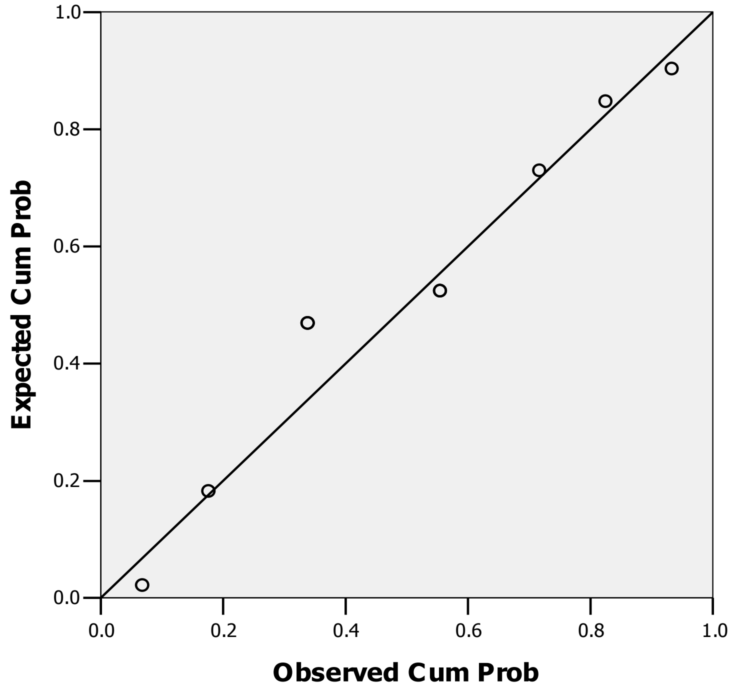
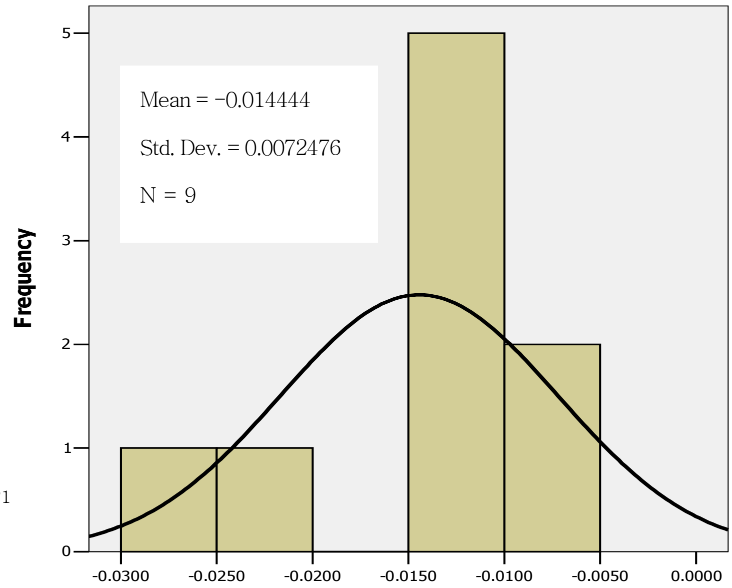
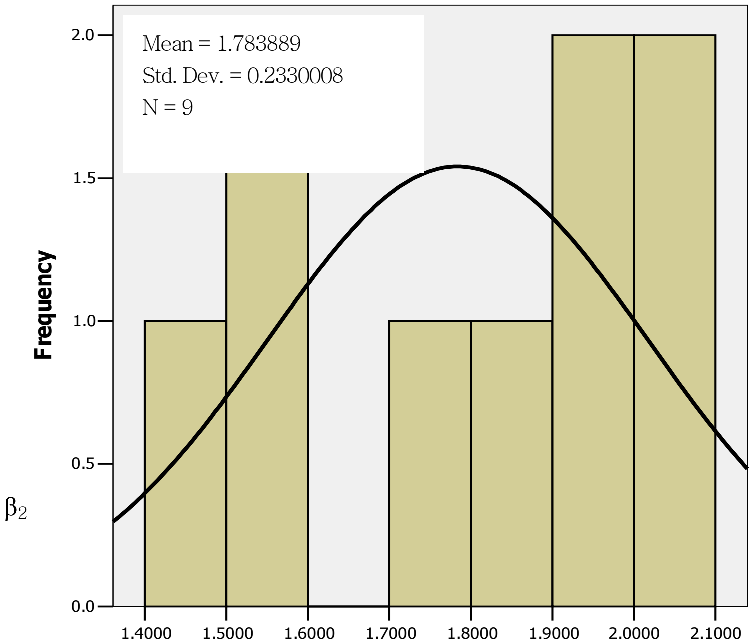


Figure6-10 Normal histogram of β_1



β_1

Figure6-11 Normal histogram of β_2



From the observation of p-p plots and the histograms it is verified that $\beta_{1,t}$ and $\beta_{2,t}$ have normal distributions. Both of them also pass the Kolmogorov-Smirnov test. The normal distributions, which $\beta_{1,t}$ and $\beta_{2,t}$ abide, are $\beta_{1,t} \sim N(-0.014, 0.0072^2)$, $\beta_{2,t} \sim N(1.784, 0.233^2)$. So $\beta_1 = -0.014$ and $\beta_2 = 1.784$ respectively. Based on (f 4-1), the linear model is set up as

$$Y_L = -0.014 + 1.784\, X_L \qquad \text{(f 6-2)}$$

where Y_L is the variable of T/S proportion, and X_L is the variable of trade proportion. Because the significant probabilities in t-test of $\beta_{1,t}$ are larger than 0.05 analyzed in <table 4-1>, the assumption of $\beta_{1,t}$ equal to zero is significant. The model of (f 4-2) should be modified as

$$Y_L = 1.784\, X_L \qquad \text{(f 6-3)}$$

But in the reality the situation of (f 4-2) appears possibly, it will be discussed in a later section.

(2) Quadratic analysis

By counting the data aggregated monthly statistically with SPSS software, nine quadratic formulae were produced with parameters and test results, as shown in <table6-5>.

Table6-5 Quadratic formulae, parameters and their test results

Time	Formula	F-test	R
2004.06	Y_{Q406}=0.034-0.587*X_{Q406}+15.507*X_{Q406}^2 (0.167) (0.641) (0.062)	48.734 (0.000)	0.957
2004.07	Y_{Q407}=0.035-0.688*X_{Q407}+14.541*X_{Q407}^2 (0.210) (0.618) (0.079)	43.018 (0.000)	0.951
2004.08	Y_{Q408}=0.044-1.413*X_{Q408}+19.992*X_{Q408}^2 (0.099) (0.250) (0.013)	49.050 (0.000)	0.957
2005.09	Y_{Q509}=0.028-1.172*X_{Q509}+14.054*X_{Q509}^2 (0.122) (0.165) (0.008)	47.372 (0.000)	0.956
2005.10	Y_{Q510}=0.000+0.929*X_{Q510}+3.258*X_{Q510}^2 (0.988) (0.094) (0.254)	113.776 (0.000)	0.981
2005.11	Y_{Q511}=0.018-0.739*X_{Q511}+15.199*X_{Q511}^2 (0.159) (0.197) (0.000)	176.060 (0.000)	0.987
2006.01	Y_{Q601}=0.012-0.161*X_{Q601}+11.000*X_{Q601}^2 (0.361) (0.787) (0.007)	109.224 (0.000)	0.980
2006.02	Y_{Q602}=0.009+0.144*X_{Q602}+8.604*X_{Q602}^2 (0.361) (0.770) (0.013)	162.084 (0.000)	0.986
2006.03	Y_{Q603}=-0.008+1.406*X_{Q603}+2.138*X_{Q603}^2 (0.244) (0.001) (0.198)	464.701 (0.000)	0.995

Note: the value in the parentheses is significant test probability

Analyzing the results the significant probability of every quadratic formula's F-test is much smaller than the significant level at α=0.05, almost zero. Thus all of the formulae are acceptable. But the parameters' significant probabilities of coefficients are not ideal, most of them are larger than 0.05. So the rest of the formulae have been modified, which coefficients pass the t-test, are listed in <table6-6>. These formulae in <table6-6> are only suitable to very specific situations, which happen seldom in practice. In qualitative analysis meanings implied in the rest of the formulae have been included in linear model (f6-2) and (f6-3), especially the formula Y_{Q603}=1.406*X_{Q603} which is very similar to model (f6-3).

Table6-6 the rest quadratic formulae modified

Time	Formula	F-test	R
2004.08	Y_{Q408}=19.992*X_{Q408}^2 (0.013)	49.050 (0.000)	0.957
2005.09	Y_{Q509}=14.054*X_{Q509}^2 (0.008)	47.372 (0.000)	0.956
2005.11	Y_{Q511}=15.199*X_{Q511}^2 (0.000)	176.060 (0.000)	0.987
2006.01	Y_{Q601}=11.000*X_{Q601}^2 (0.007)	109.224 (0.000)	0.980
2006.02	Y_{Q602}=8.604*X_{Q602}^2 (0.013)	162.084 (0.000)	0.986
2006.03	Y_{Q603}=1.406*X_{Q603} (0.001)	464.701 (0.000)	0.995

(3) Growth analysis

By counting the data aggregated monthly statistically with SPSS software, nine growth formulae were produced with parameters and test results, as shown in <table6-7>. According to the results the significant probability of every growth formula's F-test is much smaller than the significant level at α=0.05. Thus all of the formulae are acceptable. Because the significant probabilities of all the coefficients are much smaller than 0.05, close to zero, all the parameters in the growth formulae are accepted.

Table6-7 Growth formulae, parameters and their test results

Time	Formula	F-test	R
2004.06	Y_{G406}=EXP{-4.065+19.355*X_{G406}} (0.000) (0.001)	25.383 (0.001)	0.847
2004.07	Y_{G407}=EXP{-4.136+18.617*X_{G407}} (0.000) (0.000)	26.260 (0.000)	0.851
2004.08	Y_{G408}=EXP{-4.231+19.802*X_{G408}} (0.000) (0.000)	26.564 (0.000)	0.852
2005.09	Y_{G509}=EXP{-5.525+24.645*X_{G509}} (0.000) (0.006)	12.354 (0.006)	0.743
2005.10	Y_{G510}=EXP{-5.541+27.631*X_{G510}} (0.000) (0.011)	9.700 (0.011)	0.702
2005.11	Y_{G511}=EXP{-6.457+35.239*X_{G511}} (0.000) (0.009)	10.386 (0.009)	0.714
2006.01	Y_{G601}=EXP{-6.037+32.568*X_{G601}} (0.000) (0.006)	11.750 (0.006)	0.735
2006.02	Y_{G602}=EXP{-5.567+29.331*X_{G602}} (0.000) (0.007)	11.232 (0.007)	0.727
2006.03	Y_{G603}=EXP{-5.608+29.640*X_{G603}} (0.000) (0.010)	10.169 (0.010)	0.71

Note: the value in the parentheses is significant test probability

The growth model is considered as

$$Y_{G,t} = \mathrm{EXP}\{ \gamma 1 , t + \gamma 2,t * X_{G,t}\} \qquad \text{(f6-4)}$$

where γ1 , t , γ2,t are coefficients of the growth formulae in table 4-4, and the index (G ,t) is expressed as the Growth formula at time t. Firstly we may assume that $\gamma_{1,t} = \gamma_1$ and $\gamma_{2,t} = \gamma_2$ and consider that $\gamma_{1,t}$ and $\gamma_{2,t}$ are normal distributions respectively,

i.e. $\gamma_{1,t} \sim N(\gamma_1, \sigma^2_{\gamma})$

$\gamma_{2,t} \sim N(\gamma_2, \sigma^2_{\gamma})$

The assumptions are testified by using SPSS. The normal p-p plots and histograms were made as analyzed in Linear. The results are that $\gamma_{1,t}$ and $\gamma_{2,t}$ abide normal distributions, and both of them pass the Kolmogorov-Smirnov test. The normal distributions of $\gamma_{1,t}$ and $\gamma_{2,t}$ are $\gamma_{1,t} \sim N(-5.1941, 0.8126^2)$,

$\gamma_{2,t}$ ~ N(26.0174, 5.6147^2). So γ_1 = -5.1941 and γ_2 = 26.0174 respectively. Based on (f 4-4), the growth model is set up as

$$Y_G = EXP\{ -5.1941 + 26.0174 * X_G \} \quad (f6\text{-}5)$$

6.3.3 Analysis and discussions of the comprehensive model and its results

Quadratic formulas regressed from the data collected and transformed, cannot become a quadratic model because the coefficients of some formulae do not pass the t-test. But the implications for the rest of the quadratic formulae can be explained in the linear model qualitatively. Compared with linear formulae in <Table6-4>, the correlation coefficients < R_t > of the growth formulae are correspondingly smaller. Thus the linear model is the closest to the aggregated data. If the growth model is used Y_G must be smaller than 1, because the transshipment proportion is smaller than 1, so X_G is smaller than 0.2, the application extent of X_G is limited. X_G must be larger than zero, according to the model, Y_G is larger than 0.0055. That means even if there is no trade between the two regions' transshipment would exist. But for model (f6-2), the situation is the opposite. In model (f6-2), when X_L is larger than 0.00785, Y_L is larger than zero. That means transshipment begins after trade occurs between two regions. Further analysis to model (f6-5) is that after X_G exceeds 0.006587, X_G is larger than Y_G until that X_G exceeds 0.11726. These can be explained as follows, when trade increases to a comparatively high level transshipment will be stimulated and increase tremendously, and the T/S proportion will exceeds trade's proportion. This shows the driving function of trade on T/S. Similarly in linear model (f6-2), when X_L exceeds 0.01786, X_L is larger than Y_L.

Totally, the three models, (f6-2), (f6-3) and (f6-5), have almost the same characteristics or implications in qualitative analysis. The different arguments are that no trade no T/S or trade must occur before T/S or T/S could exist if there is no trade between two regions or countries. The last situation may arise if a region's port infrastructure is not sufficient to support a transoceanic shipping line and has a special trade pattern only with transoceanic countries and with countries which also have inadequate port infrastructure. Presently this situation will occasionally occur in some new developing regions. The argument if trade between two regions occurs before T/S, or at the same time, is that in most situations trade occurs first. In practice, even though there is T/S between two countries if there is no trade or trade is small, the T/S is very small, even ignored. Summarizing the analysis from all of the above a suitable comprehensive model is concluded as follows (model f6-6):

$$\left.\begin{array}{llll}
① & Y_C = EXP\{-5.1941 + 26.0174 * X_C\} & 0 < X_C \leq 0.006587 & \text{(T/S larger)} \\
② & Y_C = EXP\{-5.1941 + 26.0174 * X_C\} & 0.006587 < X_C \leq 0.01211 & \text{(Trade larger)} \\
③ & Y_C = -0.014 + 1.784\, X_C & 0.01211 < X_C \leq 0.01786 & \text{(T/S smaller)} \\
④ & Y_C = -0.014 + 1.784\, X_C & 0.01786 < X_C \leq 0.14573 & \text{(T/S larger)} \\
⑤ & Y_C = EXP\{-5.1941 + 26.0174 * X_C\} & 0.14573 < X_C \leq 0.14861 & \text{(T/S larger)} \\
⑥ & Y_C = 1.784\, X_C & 0.14861 < X_C \leq 0.56053 & \text{(T/S larger)}
\end{array}\right\} \quad \textbf{(f 6-6)}$$

6.4 Conclusion and Analysis

As a result the model (f 6-6) is composed of 6 parts. Also it is able to express the different stages or different situations of the relationship development of the trade and T/S between ports and their corresponding regions. Some implications from the model are explained as follows:

1) To set up a relationship between the proportions of trade and T/S, a single function is not sufficient or suitable enough to express all situations. The model should be a combination of several functions as (f6-6).
2) It is possible, though this seldom occurs in practice, for transshipment to occur without trade between two regions. This situation may arise if a region's port infrastructure is unable to support a transoceanic shipping

line and has a special trade pattern only with transoceanic countries and has trades with countries that also do not have sufficient port infrastructure. But the T/S amount is very low if this occurs.

3) Generally, T/S is driven by trade between two regions when the trade reaches a certain amount or a proportion about more than 0.01 according to the model analysis as previously noted. So the trade between regions has an accumulation process to stimulate T/S to occur. After T/S occurs the proportion of T/S increases gradually from smaller than the trade proportion to a level when the trade proportion reaches approximately 0.02, T/S's proportion would exceed the trade proportion and then gradually become much larger.
4) A tremendous increase of T/S may occur after the trade proportion reaches a higher level perhaps about more than 0.1.
5) For certain countries or regions the proportion of trade with the T/S country (or region) is limited to 0.2-0.56, according to the model and some components, there are possibly other factors but they do not affect our analysis, so the T/S proportion is impossibly close to 1 with a country (or region).
6) For all countries (or regions), a T/S country (or region) should have an ideal structure of trade in the foreign trade area to maximize its T/S proportion close to 1 (this is the base to develop T/S containers further more). The model indicates that a T/S country (or region) should have a trade proportion more than 0.5 (the model counting 0.56), with the countries' (or regions') trade in East Asia or the countries' (or regions') own trade, when it is geographically possible to transship their containers through the T/S country (or region) and not necessary by transoceanic transportation to the T/S country (or region), then accounting for the total foreign trade of the T/S country (or region), to maximize its T/S amount, i.e. for T/S country (or region) non-transoceanic trade should be larger than transoceanic trade, the

proportion is approximately 60:40, to maximize its T/S amount.

This chapter's established model is applied in chapter 7. Some conclusions of the dissertation are derived from the chapter's results.

Chapter 7

The T/S Prediction through Korean Ports from the Main Regions in China

The comprehensive model developed in last chapter reveals new evidence of the relationship between trade and T/S. Although both of the two variables imply relationships with other factors, the model gives us clues to describe the evolution of the relationship and helps us predict future changes.

The data from which the model was concluded show that for Korean based on trade proportions and T/S proportions the biggest partner is always China. It is better and more reasonable to apply the model to predict T/S proportion and T/S containers combined with the result of predicting Korean T/S containers in chapter 6 for some regions in mainland of China which have ports like Hongkong and Taiwan of China. Thus the model is applicable to regions of mainland in China and could ignore the nation's effect in this research.

7.1 The Evolution of Trade Proportion between Korea and Regions in China

As shown in <Figure 7-1> and <table7-1>, the proportions of trade between Korea and Shanghai are the largest, it exceeded the proportion of Qingdao in 1999. It reaches almost 4% with Shanghai in 2004, and the proportion has maintained its strong upward tendency. The second region, which has a high trade proportion with Korea is Qingdao, its trade proportion curve has maintained a stable increase with a certain slope. Dalian and Xiamen appeared to decrease in 2004.

Figure 7-1 the evolution of trade proportions with regions in China (%)

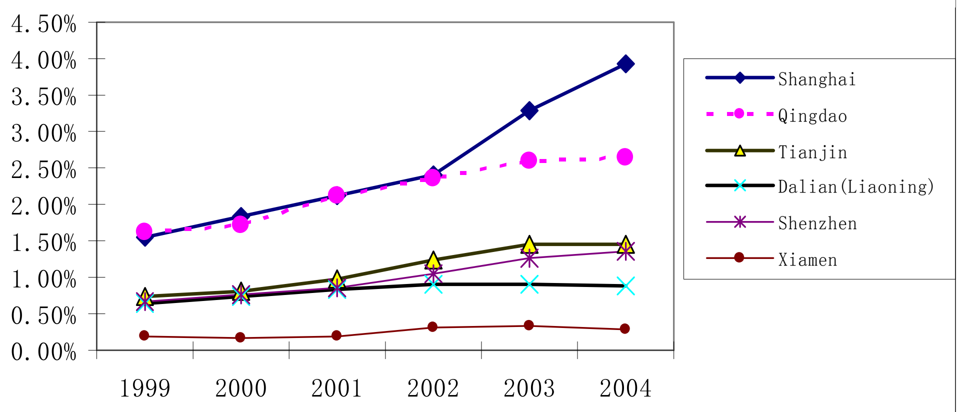


Table 7-1 The proportions of trade between Korea and regions in China accounting for Korea foreign trade

Time / Region	1999	2000	2001	2002	2003	2004
Shanghai	0.01556	0.01831	0.02121	0.02416	0.03280	0.03926
Qingdao	0.01613	0.01703	0.02109	0.02357	0.02587	0.02638
Tianjin	0.00741	0.00811	0.00973	0.01247	0.01450	0.01460
Dalian (Liaoning)	0.00651	0.00746	0.00830	0.00905	0.00910	0.00893
Shenzhen	0.00677	0.00773	0.00864	0.01051	0.01269	0.01351
Xiamen	0.00186	0.00170	0.00179	0.00302	0.00334	0.00294

Source: region's statistics book in China

7.1.1 Predicting Trade Proportion

According to the data shown in <Table7-1>, a time series analysis model may be constructed. The time series model is defined as

$$Y_{t+T} = a_t + b_t * T \qquad (f7\text{-}1)$$

where Yt+T is one region’s trade proportion at time point T. By using SPSS, every region's detail model is constructed in <table 7-2>. The values of R in <Table 7-2> are high enough to satisfy the condition to set up time series models for every region. According to the models, every region’s trade proportions from 2007 to 2011 are predicted as shown in <table7-3>.

Table 7-2 The correlation coefficients of time series analysis to every region’s trade proportions

region / item	Shanghai	Qingdao	Tianjin	Dalian (Liaoning)	Shenzhen	Xiamen
Time series (R)	0.941	0.958	0.954	0.824	0.976	0.705
Model Y_{t+T}	0.009+0.005×T	0.014+0.002×T	0.005+0.002×T	0.006+0.001×T	0.005+0.001×T	0.001+0.0004×T
F-test	63.975 (0.001)	92.222 (0.001)	83.665 (0.001)	18.712 (0.012)	163.80 (0.000)	9.563 (0.036)

Table 7-3 The proportions of trade between Korea and regions in China accounting for Korean foreign trade in predicted year

Region / Year	2007	2008	2009	2010	2011
Shanghai	0.054	0.059	0.064	0.069	0.074
Qingdao	0.032	0.034	0.036	0.038	0.04
Tianjin	0.023	0.025	0.027	0.029	0.031
Dalian(Liaoning)	0.015	0.016	0.017	0.018	0.019
Shenzhen	0.014	0.015	0.016	0.017	0.018
Xiamen	0.0046	0.005	0.0054	0.0058	0.0062

7.2 The Forecasting and Analysis of T/S and Its Proportion through Korea for Chinese Regions

According to the model (f6-6), the T/S proportions of the regions in China through Korea are predicted. We substitute the numerical values in <table7-3> for variable XC in (f6-6) according to which interval of XC the values locate in.

The predicting results from 2007 to 2011 are listed in <table7-4>. In 2011 the T/S proportion of Shanghai exceeds 11%, and Qingdao ranks second reaching 5.7%. Xiamen's T/S proportion is the lowest, so it is in the stage to accumulate trade with Korea.

Table 7-4 The T/S proportions from 2007 to 2011 for the regions in China through Korea accounting for Korean total T/S

Year / Region	2007	2008	2009	2010	2011
Shanghai	0.0823	0.0913	0.1002	0.1091	0.1180
Qingdao	0.0431	0.0467	0.0502	0.0538	0.0574
Tianjin	0.0270	0.0306	0.0342	0.0377	0.0413
Dalian(Liaoning)	0.0128	0.0145	0.0163	0.0181	0.0199
Shenzhen	0.0110	0.0128	0.0145	0.0163	0.0181
Xiamen	0.0063	0.0063	0.0064	0.0065	0.0065

Based on the predicting results of Korean total T/S containers in chapter 5, combining Table7-4 with Table5-6, the T/S amount of the regions in China through Korea is forecasted (see Table7-5).

Table 7-5 The T/S amount forecasted from 2007 to 2011 for the regions in China through Korea (unit: ten thousand TEU)

Year / Region	2007	2008	2009	2010	2011
Shanghai	62.9	69.8	76.6	83.4	90.2
Qingdao	32.9	35.7	38.4	41.1	43.8
Tianjin	20.7	23.4	26.1	28.8	31.6
Dalian(Liaoning)	9.8	11.1	12.5	13.8	15.2
Shenzhen	8.4	9.8	11.1	12.5	13.8
Xiamen	4.8	4.8	4.9	4.9	5.0
Sum	139.5	154.5	169.6	184.6	199.7

In <Table7-5>, Shanghai's T/S amount through Korea in 2011 would be almost 902 thousand TEU and Qingdao reaches approximately 438 thousand TEU. The total T/S amount through Korea for the regions in China forecasted is close to 2 million TEU in 2011. And from 2007 to 2011 the total T/S containers from China shows the trend of increase even though the Korean total T/S containers will go down from 2011 according to the preceding forecasting.

7.3 Conclusions

Based on Korean ports, the relationship between T/S and trade, T/S structure and trade structure are researched and analyzed in this chapter. Some main conclusions and suggestions are concluded.

Because there are some limitations of the research, the predicting results from the comprehensive model (f6-6), mainly focused on north-east Asia around Korea, is a way to express the relationship of T/S and trade, especially between Korea and the regions in China. It could be researched more in the future for verifying the model and predicted data, and to apply to other hub ports like Singapore, Kaohsiung and Hongkong. The lack of the recent T/S data about regions in China and other countries makes it difficulty to verify the model and modify it again. It also could be done in the future research.

Shipping companies, from their own view, will deploy their ships on mainlines and feeder lines economically, not for ports. The less calls the bigger ships on mainlines, the lower the total shipping cost. And a developed feeder lines structure, which is constructed by trade structure and container flow volume, is necessary to support it. The trade structure and volume scale by countries and regions would become one of the crucial criteria for shipping companies to choose their T/S port and adjust it strategically according to the predicted T/S containers between port regions.

There is a positive relationship between T/S and trade. The direct trade could be one of the main factors that drive T/S between two T/S ports. Direct trade has the driving function of stimulating T/S.

Some conclusions of the dissertation are derived from the chapter’s results.

Chapter 8

Conclusions and suggestions

This chapter discusses research findings of the study that can be generalized to hub and spoke ports' competition, this could be regarded as academic generalization and applicable way to measure competition status of similar types.

The study analyzed that port competition has formed at four levels in the world container transportation. For hub ports the focuses of the competition are the competition between traditional and new hub ports, to gain more T/S containers from the present flows and increase flows of transoceanic containers, the competition between direct call and transshipment for hub and spoke ports. Even though the competition becomes more and more fierce the development of T/S containers is still continuous.

The structure change of container flow between Asia countries and USA showed that the biggest container flow between USA and Asia is the one between USA and Chian. And it still shows the stronger trend of development.

With the stronger increase of the trade between USA and China, the competition for scrambling for transoceanic containers on transpacific route becomes more and more fierce. In the Northeast Asia the competition of hub ports mainly exists among Korean ports and Shanghai ports of China, especially for their new container terminals, such as terminals in Gwangyang of Korea and in Yangsan of Shanghai China. The main source of containers for the competition between Korean ports and Shanghai ports of China is from transpacific container increase. The competition certainly appears on the transpacific route.

In the study the method of a groupe of differential equations to describe and express the competition between two hub and spoke ports was developed. The calculation results of the differential equations show this method is applicable. Results from the solved differential equations imply that the competitive strength in gaining T/S containers for Korean ports is stronger in the near future compared with in gaining transpacific containers for Shanghai ports of China.

The growth of total transpacific containers is the source to increase Korean ports' T/S containers. It causes the positive effect on the change of Korean ports' T/S containers in the past and near future. And the increase of Shanghai foreign trade containers will stimulate the increase of Shanghai ports' transpacific containers.

According to model f(5-7) the predicting curve is got for the development of Korean ports' T/S containers. The curve goes to top in 2010 then gets down because of the competition. In 2011, the Korean ports T/S containers is predicted about 8756 thousand TEUs by the model. It is forecasted that Shanghai ports' transpacific containers is over Korean ports' T/S containers in 2007 by the model.

By collecting and imputing new data the models solved above may predict farther trend and development after the time in which the predicted curve reaches the top more exactly.

In the study another comprehensive model was developed to describe and express the different stages or different situations of the relationship development of the trade and T/S between ports and their corresponding regions based on Korean ports. The implications from the model are explained as follows:

1) It is possible, though this seldom occurs in practice, for transshipment to occur without trade between two regions. This situation may arise if a region's port infrastructure is unable to support a transoceanic shipping line and has a special trade pattern only with transoceanic countries and has trades with countries that also do not have sufficient port infrastructure. But the T/S amount is very low if this occurs.
2) Generally, T/S is driven by trade between two regions when the trade reaches a certain amount or a proportion. The trade between regions has an accumulation process to stimulate T/S to occur. After T/S occurs the proportion of T/S increases gradually from smaller than the trade proportion to a level when the trade proportion reaches approximately 0.02, T/S's proportion would exceed the trade proportion and then gradually become much larger. A tremendous increase of T/S may occur after the trade proportion reaches a higher level.
3) For all countries (or regions), a T/S country (or region) should have an ideal structure of trade in the foreign trade area to maximize its T/S. The model indicates that for T/S a country (or region) non-transoceanic trade should be larger than transoceanic trade, the proportion is approximately 60:40, to maximize its T/S amount.
4) There is a positive relationship between T/S and trade. The direct trade could be one of the main factors that drive T/S between two T/S ports. Direct trade has the driving function of stimulating T/S. The model developed could become a base for shipping companies and ports to make part of their decisions for developments.
5) It is possible that in some ports the trade volumes are larger but the T/S containers are smaller. It could be explained as two situations: one is that even though the total T/S containers are smaller and the trade volumes are larger, the proportion of trade for one country and the proportion of T/S for the country accord with the comprehensive model(f6-6); another is that such ports are not real hub ports, and at this

stage their trade structure and T/S structure are distorted because of their undeveloped "hub ports", but after the ports are improved and developed their trade proportion and T/S proportion will accord with model (f6-6) finally.

Because there are some limitations of the research, the predicting results from the comprehensive model (f6-6), mainly focused on North-east Asia around Korea, is a way to express the relationship of T/S and trade, especially between Korea and the regions in China. It could be researched more in the future for verifying the model and predicted data, and to apply to other hub ports like Singapore, Kaohsiung and Hongkong. The lack of the recent T/S data about regions in China and other countries makes it difficulty to verify the model and modify it again. It also could be done in the future research.

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