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A study on the Relationship of Hub Ports' Transshipment and the Trade in East Asia: Focusing on Korean Ports

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Abstract : *This paper is a study of the relationships between trade and transshipment in Korea. Through the analysis of the data collected, a comprehensive model has been developed to analyze and predict relationships between trade and transshipment. By using analyses of port and trade evolution in Asia, the model identifies some important results. An application of the model to forecast developments in selected regions in China is also included in this paper. The paper provides a basis for shipping companies to decide on appropriate transshipment port strategies, and provides important theoretical references for Korean ports' development Supported by Shanghai leading Academic Discipline Project, project Number: T0602.*

Key words : *Transshipment and Trade, Port competition, Hub port, Korea ports, Forecasting, Asia*

1. Introduction

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 function.

With the rapid development of container transportation, container transshipment hub ports have become highly sought after throughout the world and especially in some Asian regions.

In modern container ports, the most important functions in international transshipment are sea to sea, followed by transfers from water to land and sea to river.

Currently, the main international transshipment ports are Singapore, Kaohsiung, Busan, Hongkong and Rotterdam. The largest amount of transshipment is through Singapore port, its transshipment rate reaching 90%.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 to Europe and North American Atlantic Coast services via the Suez Canal. This greatly encourages competitiveness between key hub ports, especially in Asia.

With the bigger and bigger size of vessels employed on the major routes, 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 a great change has taken place about locations of hub ports around north-east 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.

Korea and the Taiwanese Province of China concentrated their resources on constructing deep-water ports with a depth of at least 15 meters. Later Busan and Kaohsiung ports benefited from the opportunities to develop container transshipment with the Chinese mainland. From that time, almost all ports on the Chinese mainland transshipped their container cargoes from Busan and Kaohsiung ports to America and Europe, and even to south-east and south Asia. This stimulated the tremendous increase of transshipment container throughput in Busan and Kaohsiung ports. Shipping companies certainly put their core ship liners on the ports.

The competition between international container transshipment key ports 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, the standard of

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performance of the port. But all of them ignore a very important factor. 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. The shipping companies will choose appropriate hub ports and adjust them according to changes in the volume scale on mainlines and feeder lines. Feeder lines' volumes consist mainly of two parts. One is transshipment volume, another is the volume generated by direct trade between two ports' hinterlands. The scale of direct trade can increase the loaded rate of feeder line ship's capacity (maybe from 50% to 85%), and increase the ship's capacity scale, example from 500TEU to 1000TEU on feeder routes. Thus the total shipping cost could be cut down even a little deviation distance from hub port so as to stimulate increasing transshipment. 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 have analyzed the ports in northeastern and southeastern Asia, using Korea and its ports as the focus of discussion.

2. Overall Analysis of Korean Ports and Trade

2.1 The evolution of Container throughput and transshipment 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 Fig. 1.

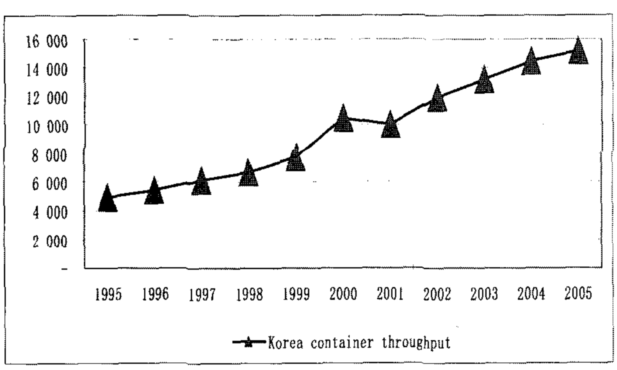

Fig. 1 Korea port container throughput(1000TEU)

The container T/S throughput in Korea increased more strongly than its total throughput Fig. 2. 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 Fig. 3. But 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.

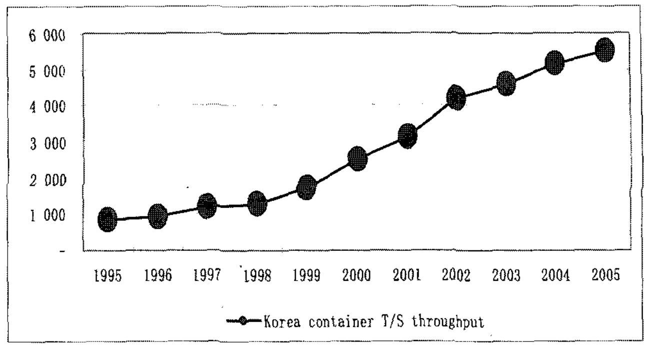

Fig. 2 Korea port container T/S throughput(1000TEU)

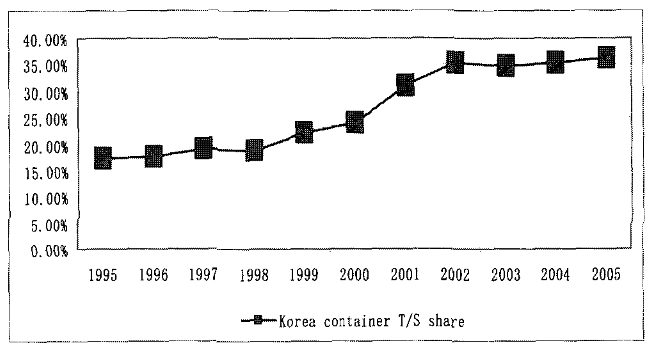

Fig. 3 Korea port container T/S share in throughput (%)

2.2 Korean trade evolution and correlation with container throughput

Korean foreign trade has experienced several different stages. In the recent stages the strong development of Korean foreign trade brought along and stimulated the development of port container throughput and also transshipment throughput. Through an analysis of correlations between the trade and the total container throughput, and between the trade and the transshipment in Korea, the correlation coefficients are higher. The correlation coefficient values are respectively 0.8662 and 0.8658. It shows that the two correlations are similar because of the closer coefficients. It seems that transshipment in Korea is affected by trade with different countries. This result encourages us to do further research about the relationship between trade and transshipment (or T/S) based on Korean ports.

3. Data collection and analysis

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

3.1 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 between Korea and the other 12 countries and regions. The major port cities in mainland of China were also included in the analysis. The container T/S 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 is sufficiently long to provide a robust analysis. As the data in repeated cross sections 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 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 T/S data aggregated from the T/S containers registered in Port MIS system one by one are mostly accurate and possible to be collected and analyzed. According to the pre-feasibility study more than 0.5 million items were taken for analysis and model setting, for trade and T/S data of container cargoes between Korea and other 12 countries, and data related to some port cities in mainland of China.

3.2 Data transformation

Before the analysis is made, the data as an observation result needs be transformed. Firstly the container T/S 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 T/S through Korea, which the 12 countries and regions respectively account for the total amount of container T/S in Korea in every month, are counted and transformed from the collected data. Then the corresponding trades between Korea and the 12 countries and 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.

3.3 Data analysis

1) The proportion data of T/S

As shown in Table 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. 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 T/S itself feeds its containers to other container T/S hubs. For instance, the proportions of T/S originating from Singapore, whose port is analyzed in chapter 1, 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 T/S. According to the analysis of proportions of T/S through Korea for the 12 countries and regions in East

Table 1 data format

Country(or region) name	Proportion of one country's or region's container transshipment 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

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

	Nation/Region \ Time	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

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 T/S hubs in East Asia, even though the competitiveness for core hubs became more and more fierce.

2) The proportion data for trades

In order to correspond to the proportion data of T/S 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 Table 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 T/S 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 T/S 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 T/S proportion is also higher. Should the relationship between trade proportion and T/S proportion exist? What and how would the relationship be between them? The further analysis in

Table 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	Vietnan	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

this paper answers these questions.

4. Analytical Method and Model Setup

4.1 Analytical method and function variables

Based on the data analysis above, an econometrics analysis was then applied. From the proportion data, the phenomenon that trade proportion higher the T/S proportion higher based on Korea in East Asia and vice versa was identified. It is also noted that T/S occurs between deep ports or core ports in East Asia. We consider that the reasons for these phenomena are that the feed line's economy of scale makes T/S containers more efficient and low cost for transport even between two core ports. It seems that the important impetus and motivation to drive the T/S transport between two ports is the direct trade between these ports' corresponding countries and regions. In qualitative analysis of the proportion data, it may be concluded that it is no trade no T/S 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 econometrics 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 T/S. Thus the trade proportion variable is defined as the independent variable. The T/S proportion variable is defined as the dependent variable. So the econometrics 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.

4.2 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 EXPONENTIAL.

As shown in Fig. 4, one month data (2004.06) as the 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 Fig. 4.

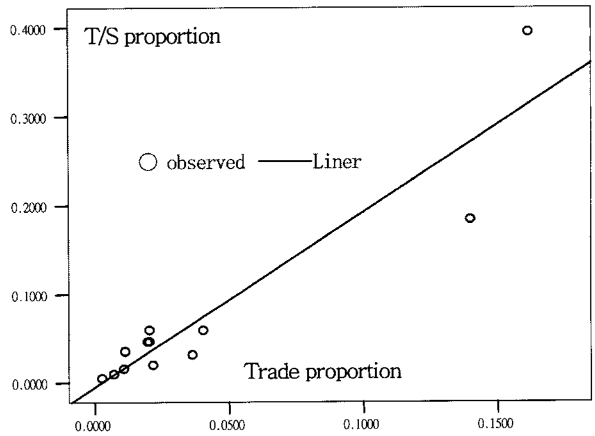

Fig. 4 the scatter plots compared with Linear line

The same analysis is done to QUADRATIC and EXPONENTIAL. The results show the three models should be analyzed respectively with the data above further more even though the data in Table 2 and Table 3 could be used with one regression model to analyze. The following analysis could accord with the development of different stages corresponding to different models between hub port and feeder ports more realistically.

2) Model setup and parameters' test

According to the results of three models' scatter plots, further analysis should be done to decide which detail models are 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 Table 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 X_L 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 Y_{L603}.So the formulae should be modified.

To determine the linear model it is considered as

$$Y_{L,t}= \beta_{1,t} + \beta_{2,t} X_{L,t} + \varepsilon_{L,t} \quad \text{(f4-1)}$$

where $\beta_{1,t}$, $\beta_{2,t}$ are coefficients of the linear formulae in

Table 4, and the index (L, t) is expressed as the Linear formula at time t. Firstly we may assume that $\beta_{1,t} = \beta_1$ and $\beta_{2,t} = \beta_2$, and consider that $\beta_{1,t}$ and

$\beta_{2,t}$ are normal distributions respectively,

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

$\beta_{2,t} \sim N(\beta_2, \sigma^2\beta)$

The assumptions are testified by using SPSS. The normal p-p plots and histograms were made, see Fig. 5 to Fig. 8.

Table 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_{L602}=-0.014+1.588*X_{L602} (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.

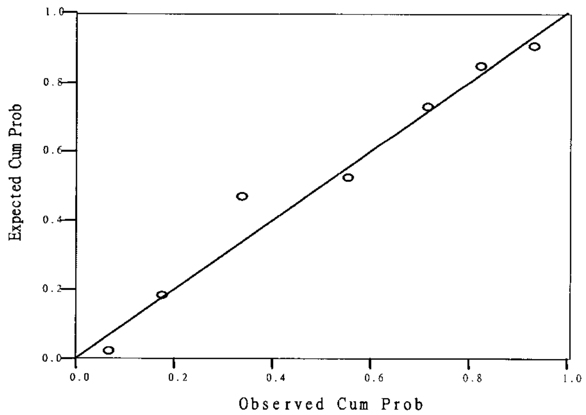

Fig. 5 Normalp-p plot of β_1

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 $\beta_{1,t} \sim N(0.014, 0.00722)$, $\beta_{2,t} \sim N(1.784, 0.2332)$. So $\beta_1 = 0.014$ and $\beta_2 = 1.784$ respectively. Based on (f 4-1), the linear model is set up as:

$$Y_L = 0.014 + 1.784 X_L \qquad (f\ 4\text{-}2)$$

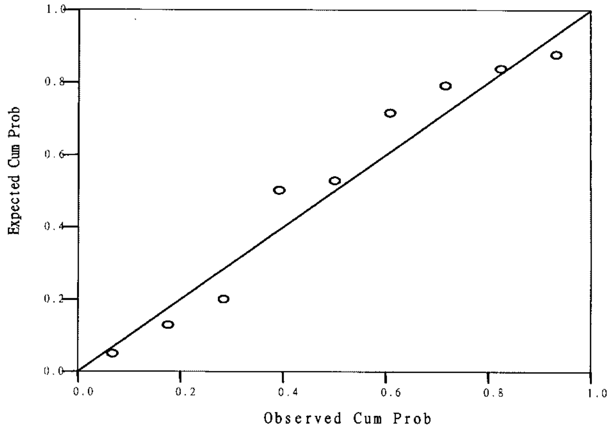

Fig. 6 Normalp-p plot of β_2

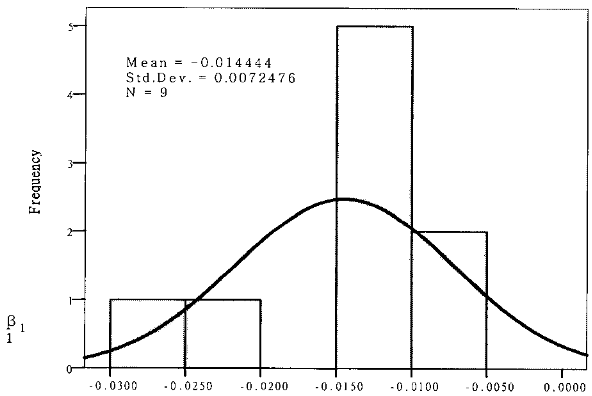

Fig. 7 Normal histogram of β_1

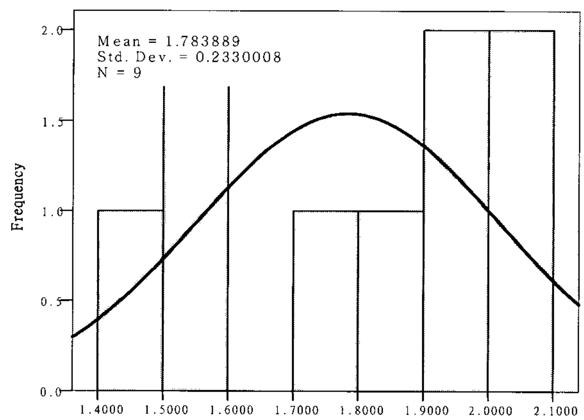

Fig. 8 Normal histogram of β_2

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, the assumption of $\beta_{1,t}$ equal to zero is significant. The model of (f 4-2) should be modified as

$$Y_L = 1.784\ X_L \qquad \text{(f 4-3)}$$

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. 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 Table 5. These formulae in Table 5 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(f4-2) and (f4-3), especially the formula $Y_{Q603}=1.406*X_{Q603}$ which is very similar to model (f4-3).

Table 5 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

Note : the value in the parentheses is significant test probability

(3) Exponential analysis

By counting the data aggregated monthly statistically with SPSS software, nine exponential formulae were produced with parameters and test results, as shown in Table 6. According to the results the significant probability of every exponential 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 exponential formulae are accepted.

The exponential model is considered as

$$Y_{G,t} = EXP\{\gamma_{1,t}+\gamma_{2,t}*X_{G,t}\} \qquad \text{(f4-4)}$$

Table 6 Exponential 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 where $\gamma_{1,t}$, $\gamma_{2,t}$ are coefficients of the exponential formulae in Table 4-3, and the index (G ,t) is expressed as the exponential 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 $\gamma_{1,t} \sim N(5.1941, 0.81262)$, $\gamma_{2,t} \sim N(26.0174, 5.61472)$. So $\gamma_1 = 5.1941$ and $\gamma_2 = 26.0174$ respectively. Based on (f 4-4), the exponential model is set up as

$$Y_G = EXP\{5.1941+26.0174*X_G\} \qquad (f4\text{-}5)$$

4.3 Analysis and discussions of the comprehensive model and its results

To Quadratic formulas regressed the rest of the quadratic formulae can be explained in the linear model qualitatively. Compared with linear formulae in Table 4, the correlation coefficients < Rt > of every exponential formula is correspondingly smaller. Thus the linear model combined with the formulae is the closest to the aggregated data. For the model (f4-5) Y_G must be smaller than 1, because the T/S proportion is smaller than 1, so X_G is smaller than 0.2. The application extent of X_G is limited in (f4-5). 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 two regions T/S would exist. In model (f 4-2), the situation is opposite. In model (f 4-2), when X_L is larger than 0.00785, Y_L is larger than zero. That means T/S begins after trade occurs between two regions. Further analysis to model (f4-5) 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 T/S 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 (f4-2), when X_L exceeds 0.01786, X_L is larger than Y_L.

Totally, the three models, (f 4-2), (f 4-3) and (f 4-5), 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 when there is no trade or trade is small, the T/S must be very small even ignored. Summarizing the analysis from all of the above a suitable comprehensive model is concluded as follows:

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

As a result the model (f 4-6) is composed of 6 parts. Although every part's contribution to the whole model's function is different, less or more, it may express and reflect the different stages of the relationship between hub ports and feeder ports clearly and directly. It is also able to express the 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:

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 (f4-6).

It is possible for T/S to occur without trade between two regions , though this seldom occurs in practice, considering trade structure and port infrastructure. But the T/S amount is very low when it occurs.

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. After the trade proportion reaches approximately 0.02, T/S's proportion would exceed the trade proportion and then a tremendous increase of T/S might occur.

For certain countries or regions the proportion of trade with the T/S country (or region) is limited to 0.2 to 0.56, and the T/S proportion with a country (or region) is impossibly close to 1.

A T/S country (or region) should have an ideal structure of foreign trade to maximize its T/S. The model indicates that a T/S country (or region) in East Asia should have a trade proportion close to 0.5 (the model counting 0.56) with the countries' (or regions') trade in East Asia, in other words for a 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. To Korea the ideal situation is that all T/S amount in Korea hub ports is from north-east regions and matches the trade with the regions. It is an ideal target for Korea to realize.

5. Forecast Application of the Model focusing on regions in China

The model 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 or throughput for some regions in mainland of China which have ports like Hongkong and Taiwan of China. So the model is applicable to regions of mainland in China and could ignore the nation's effect in this research.

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

As shown in Fig. 9 and Table 7, the proportions of trade between Korea and Shanghai are the largest, it exceeded the proportion of Qingdao in 1999. It reaches almost 4% 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.

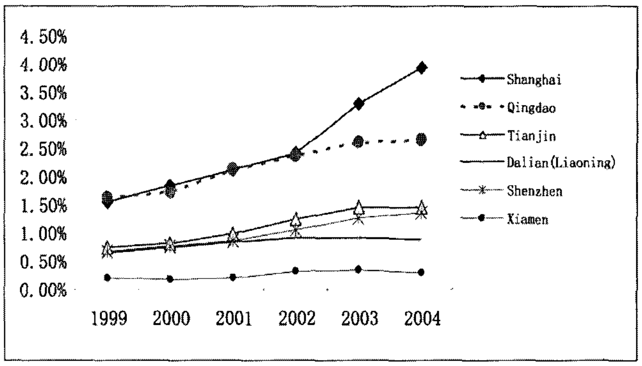

Fig. 9 the evolution of China regions' trade proportions accounting for Korea foreign trade

5.2 Predicting Trade Proportion

According to the data shown in Table 7, a time series analysis can be constructed. The time series model is defined as

$$Y_{t+T} = a_t + b_t * T \quad (f\ 5\text{-}1)$$

where Y_{t+T} is one region's trade proportion at time point T. By using SPSS, every region's detail model is constructed in Table 8. The R in Table 8 is high enough to satisfy the condition to set up time series models for every region. According to the models, every region's trade proportion in 2011 is predicted as shown in Table 9.

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

Region \ Time	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

Table 8 The correlation coefficients of time series analysis to every region's trade proportions

item \ region	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 9 The proportions of trade between Korea and regions in China accounting for Korean foreign trade in 2011

item \ region	Shanghai	Qingdao	Tianjin	Dalian (Liaoning)	Shenzhen	Xiamen
Proportion in 2011	0.074	0.040	0.031	0.019	0.018	0.0062

Table 10 The T/S proportions in 2011 for the regions in China through Korea accounting for Korea total T/S

	Shanghai	Qingdao	Tianjin	Dalian (Liaoning)	Shenzhen	Xiamen
Trade proportion in 2011	0.074	0.040	0.031	0.019	0.018	0.0062
T/S proportion in 2011	0.118016	0.05736	0.04130	0.01990	0.01811	0.00652

Table 11 The T/S amount forecasted in 2011 for the regions in China through Korea

	Shanghai	Qingdao	Tianjin	Dalian (Liaoning)	Shenzhen	Xiamen	Total
Trade proportion	0.074	0.04	0.031	0.019	0.018	0.0062	
T/S prop.	0.118016	0.05736	0.0413	0.019901	0.01811	0.00652	
T/S (TEU)	944128	458880	330432	159168	144896	52165	2089669

5.3 The Forecasting and Analysis of T/S and its Proportion through Korea for Chinese Regions

According to the model (f4-6) the T/S proportion of the regions in China through Korea is predicted. We substitute the numerical values in Table 9 for variable X_C in (f4-6) according to which interval of X_C the values locate in. The predicting results are listed in Table 10. 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.

If Korea's total T/S throughput is able to reach 8 million TEU in 2011, which is probable according to the trend in Fig2-2, the T/S amount of the regions in China through Korea could be forecasted Table 11.

In Table 11, Shanghai's T/S amount through Korea in 2011 would be almost 944 thousand TEU and Qingdao would reach approximately 459 thousand TEU. The total T/S amount through Korea for the regions in China forecasted would exceed 2 million TEU.

6. Conclusion and Suggestions

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

Because there are some limitation of the research, the comprehensive model(f4-6), mainly focused on north-east Asia around Korea, is a way to express the relationship of T/S and trade. It could be researched more in the future 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.

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

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