PORT CHOICE MODEL OF TRANSSHIPMENT CARGO USING SYSTEM DYNAMICS

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ABSTRACT

The aim of this paper is to identify impacting factors that have been affecting the increase of transshipment cargoes of port of Busan and to identify forecasted result using system dynamics. To clarity the reason why T/S cargoes have increased in the port of Busan, several steps are made as follows:
The first step is to make a quantitative model for explaining the development of T/S cargoes during the last decade. To define dependent and independent variables for multiple regressions after testing variable significance is the second step. For this, data collection and the accuracy of validation have been done by the direct interview with the experienced officials in shipping companies of both domestic and foreign country. After validating the model with collected data, the final step is to find variables which are explaining the model the most.
In conclusion, 2 variables were clearly identified as core factors that explain well the development of T/S cargoes in the port of Busan: ʻMohring effectʼ and total cost. It is strongly recommended, by an empirical study, that an incentive scheme be changed to a way which more feeder vessels rather than mother vessels can reduce their direct costs to call in the port of Busan.
Based on regression analysis, sensitivity model for transhipment cargo is useful for dynamic forecasting in changing cost factor and mohring factor with time series.

KEY WORDS: Northeast Asia, Transshipment Port, Choice of Transshipment Port, Incentive, Busan Port Authority, Simulation, SD(System Dynamics)

1. INTRODUCTION

Being hub port in the Northeast Asia area by pulling transshipment cargo is the vital issue of competing ports in order to revitalize their economy and to overcome the problem of under utilization of container terminal facility. The port of Busan, Shanghai, Ningbo and Hong Kong, Kaosiung and Yokohama in Northeast Asia ports has been the competitive relation in terms of transshipment attraction. In the context of competition, Busan port authority has carried out the volume incentive policy to increase the transshipment cargo, even though individual policy such as exempting port dues, discounting terminal rental fee or handling charge is different.

This paper is to make port choice model in order to indentify for finding out impacting factors to transshipment cargo and sensitivity consequence from the model. In order to gain the research objective, several steps are designed. First step is to select quantitative model for explaining real phenomena about transshipment cargo share. Second step is to define dependent and independent variables for multiple regressions after the test of variable significance. On this step, data collection and the accuracy validation has been done by direct interview with the experienced official in shipping company in domestic and foreign country. As Northeast cargo markets have separate structures, the transshipment cargo from China, Japan or Southeast countries, individual market is to be considered independently. Third step is to validate the model using collected data, in order to reveal which variables explain the model in a good fit. Lastly, port choice sensitivity model is to be developed to find estimation according to changing independent variables.

The scope to find impacting factors is restricted within North China ports including port of Busan and port of Sanghai port in consideration of clarify objective and descriptive factors.

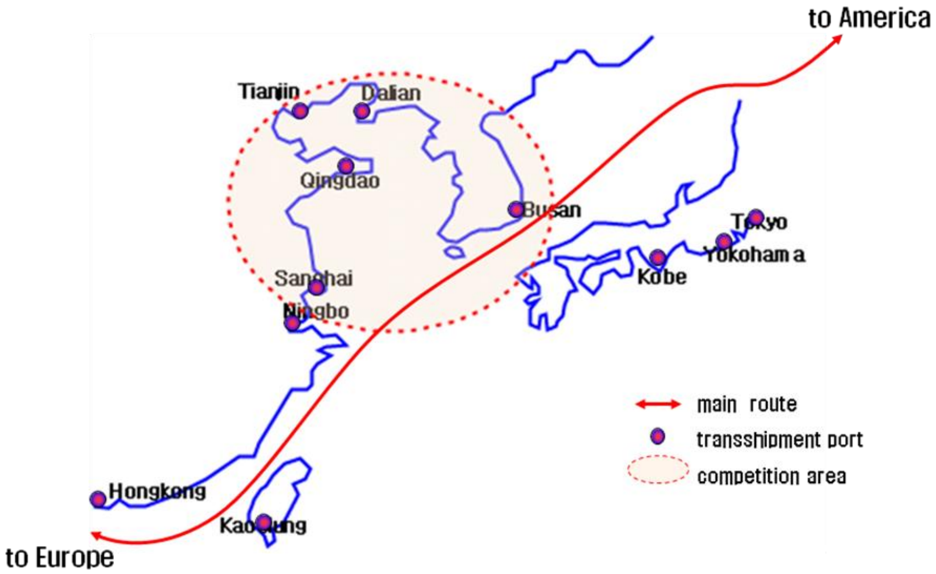

Figure 1-Scope of research

2. LITERATURE REVIEW

Hiroshi Ohashi (2005) studied the choice problem of air cargo transshipment airport in Northeast Asia. Based on a unique data set of 760 air cargo transshipment routings to/from the Northeast Asian region in 2000, this paper applies an aggregate form of a multinomial logit model to identify the critical factors influencing air cargo transshipment route choice decisions. The analysis focuses on the trade-off between monetary cost and time cost while considering other variables relevant for choice of transshipment airport. The estimation method considers the presence of unobserved attributes, and corrects for resulting endogeneity via a two-stage least-squares estimation using instrumental variables. The empirical results show that choice of the air cargo transshipment hub is more sensitive to time cost than the monetary costs such as landing fees and line-haul price.
Veldman and Bückmann (2003) analyzed earlier with respect to container port competition in Northwest Europe. They estimated demand functions for both the continental and the overseas hinterland of the West European major container ports and assessed the demand function for a port expansion project for the port of Rotterdam.
Veldman et al. (2005) estimated demand functions for a project to improve the accessibility of the Port of Antwerp by deepening the Scheldt River and thereby reducing waiting times for the tide and the ability to accommodate bigger ships. In both publications the parameters of a Logit Model were estimated with regression analysis and the demand function could be derived by systematically changing cost and assessing the resulting market shares.
Veldman et. al. (2008) studied to search significant factors for understanding the competitive position of transshipments ports and port choice elastics in the market of the Mediterranean. Statistical tests are applied using a 10-year time series of aggregate transshipment flows between 15 transshipment ports and 9 feeder regions. Tests of Logit Models with regression analysis show that variables such as feeder costs, mainline port access costs and Mohring effects are statistically significant.
Also Lirn et al. (2003, 2004) and Ng (2006) have analyzed the decision factors for transshipment port and have revealed that the cost of a shipping company, route accessibility, and time are important decision factors. Meanwhile, the domestic researches on deciding a transshipment port are as follows: a study of inducement strategies of transshipment cargo (Bae Byeong-Tae, 1999; Jeong Tae-Won and Gwak Gyu-Seok, 2002; Park Yeong-Tae and Kim Byeong-In, 2003), a study of transshipment port decision based on ISM and AHP technique from the viewpoint of a global container shipping company (Baek In-Heum, 2007), and a study of selection attribution for transshipment port from the viewpoint of a shipping company at home and abroad (Park Byeong-In and Seong Suk-Gyeong, 2008).
However, these previous studies are mainly focusing on the inducement strategies for transshipment cargo or are suggesting the selection attribution for transshipment port as well as the method to select key attributes. But these previous studies have shown that according to the questionnaire respondents (such as a shipping company, cargo owner, importer and exporter, forwarder), their study results are different. In this respect, it means lack of consistency and validity. Moreover, these preceding studies have a limitation in the sense

that they are trying to find decision factors only by way of questionnaire, not performing an analysis based on actual data.

Therefore, differently from those preceding studies, this study has analyzed 10-year actual data for comparison analysis. That is, by using Logit regression model and the regression model of Veldman (2008), this study has performed a quantitative analysis in order to suggest selection factors for transshipment port, so that it can be a more practical research.

Comparison of the results earlier Veldman′s research concerning the Northwest European market shows that the outcomes correspond rather well in terms of the resulting choice or demand elasticity. This paper shows that the use of Logit Models with respect to transshipment port choice leads to useful findings for port planning. This research in combination with earlier research by one of the authors for transshipment port choice in Northwest Europe is a step forward in the field of transshipment port choice.

3. ANALYSIS OF TRANSSHIPMENT

3.1 Calling Pattern in Northeast Asia

Recently, a shipping company changed calling pattern from traditional pattern (Figure 2) to China originated pattern. Before the year of 2000, a shipping company shows typical calling pattern from Singapore, Hong Kong, Kaohsiung, Busan, Yokohama, Tokyo and Seattle sequentially. Under this pattern, a shipping company had to decide a transshipment port between Pusan or one of Japanese port in Northeast Asia region.

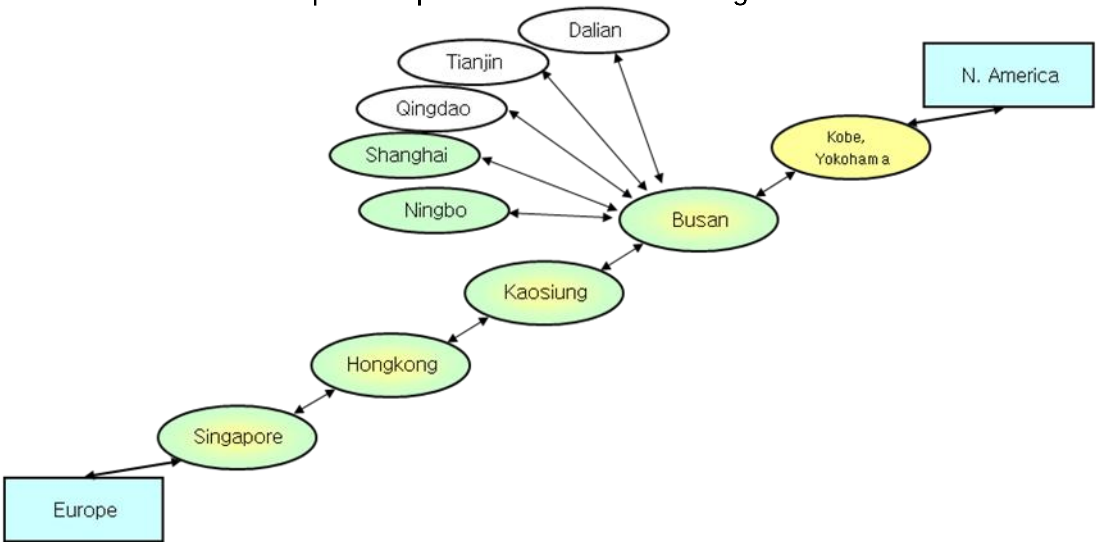

Figure 2-Traditional Route to North America and Transshipment Ports

After the year of 2000, the calling pattern of the year of 2007 is reformed due to China effect. According to Drewry report(Drewry 2006), in case of USA bound, the frequency of calling at

Chinese ports such as Hong Kong, Shanghai, Yantian have increased in comparison with the year of 2000(Figure 3, 4, 5). Furthermore, owing to Chinese volume, direct route TP5 (ETE) from Shanghai, Ningbo to Los Angeles is opened by Masker Line and it takes 28 days for one round trip (Figure 6).

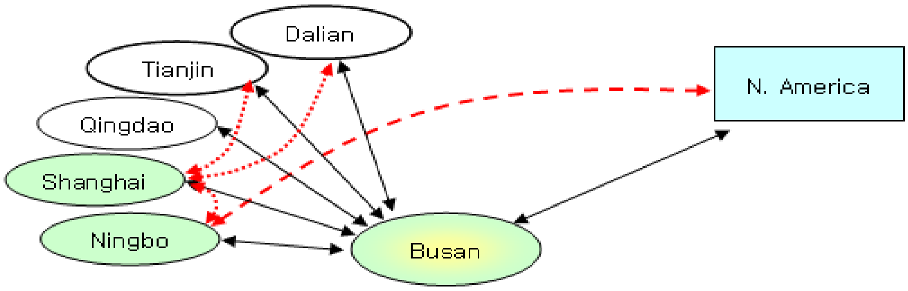

Figure 3-Current Route to North America and Transshipment Ports

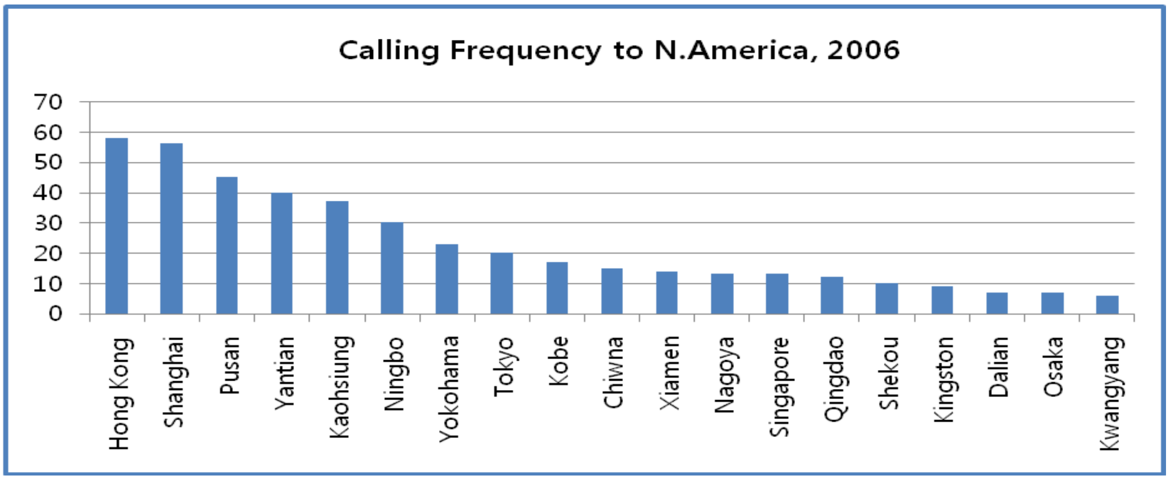

Figure 4- Calling Frequency for USA Bound
Source: Drewry(2006), compiled by authors

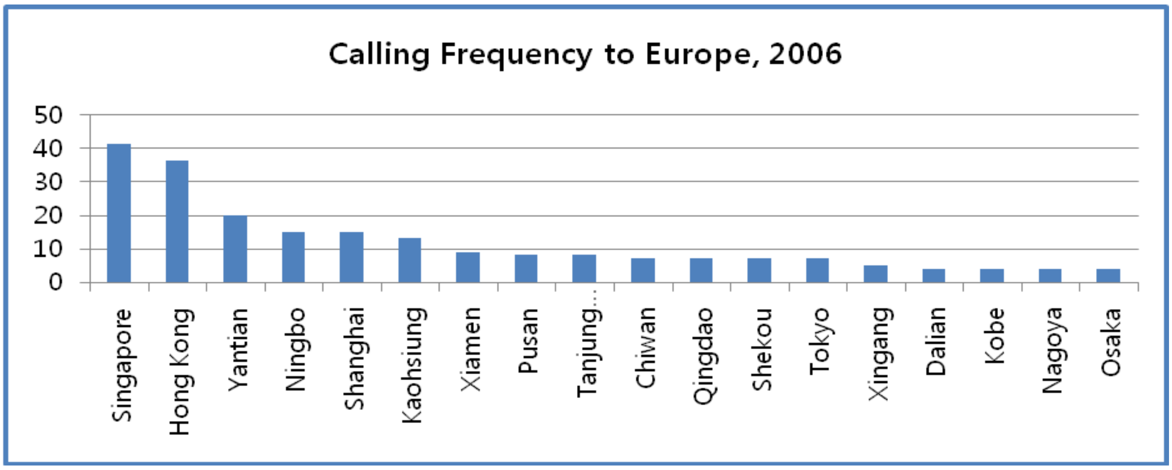

Figure 5-Calling Frequency for Europe
Source: Drewry (2006), compiled by authors

In comparison, recent competition relationship has been changed due to the rapid progress of Chinese ports caused by lower cost and local container volume. For reference, transshipment trend from the year of 1998 to the year of 2007 in Busan and Shanghai indicate why the market of transshipment for analysis is focused on port of Shanghai and Busan. For reference, the transshipment cargo of Shanghai includes coastal cargo for transshipment. The volume of transshipment is higher than OSC survey report.

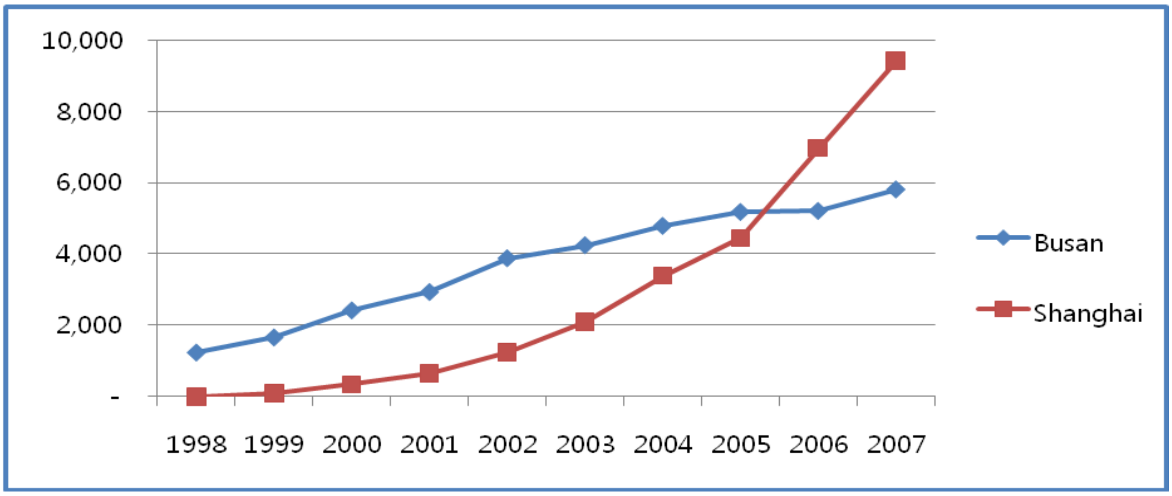

Figure 6-Transshipment Trend in Busan and Shanghai
Source: SIPG internal report, and PORT-MIS, 2008

4. PORT CHOICE MODEL OF TRANSHIPMENT CARGO

4.1 factors for transshipment port choice

Prior to suggesting port choice model, the factors are to be selected from experts who are responsible to design the shipping liner route. The 15 items to be surveyed are collected from the published papers. The collected items are questioned for measuring importance degree with 5 scores from senior managers of major container shipping liners. The way of collecting questionnaire has been performed by direct interview with a responsible person in a shipping company, or visiting in explanation of the purpose in front of a group of responsible officers in shipping companies. The questionnaires are sent to 30 container shipping liners including both domestic and foreign companies. The response rate is 90% of planned responses. The result of the analysis of the answer of the questionnaire reveals that the most important factor is cargo handling capacity such as handling moves per ship per hour. Second important factor is terminal handling charge. The sequence of priority is listed table 1. Among these factors, qualitative service factors such as container handling capability, berth facility capability, feeder frequency, feeder network, free time, overtime storage fee etc., can be represented as a proxy variable.

Table 1-Score of transshipment port deciding factors

Item	Response	Mean	SD
Cargo Handling Capability	17	4.294	0.686
THC	17	4.176	0.809
Berth Facility	17	4.059	0.748
Feeder Frequency	16	4.000	0.632
Main Route Location	16	4.000	0.632
CY Facility	17	3.941	0.748
Feeder Network	17	3.941	0.966
Cargo Volume	15	3.933	0.961
Free Time	17	3.706	0.985
Port Dues	17	3.471	1.007
Overtime Storage Fee	17	3.412	0.87
Incentive	17	3.294	0.92
CIQ Service	17	3.294	0.985
Providing Berthing Priority	16	2.938	0.929
Bunker Supply, Ship Repair Service	17	2.824	1.074

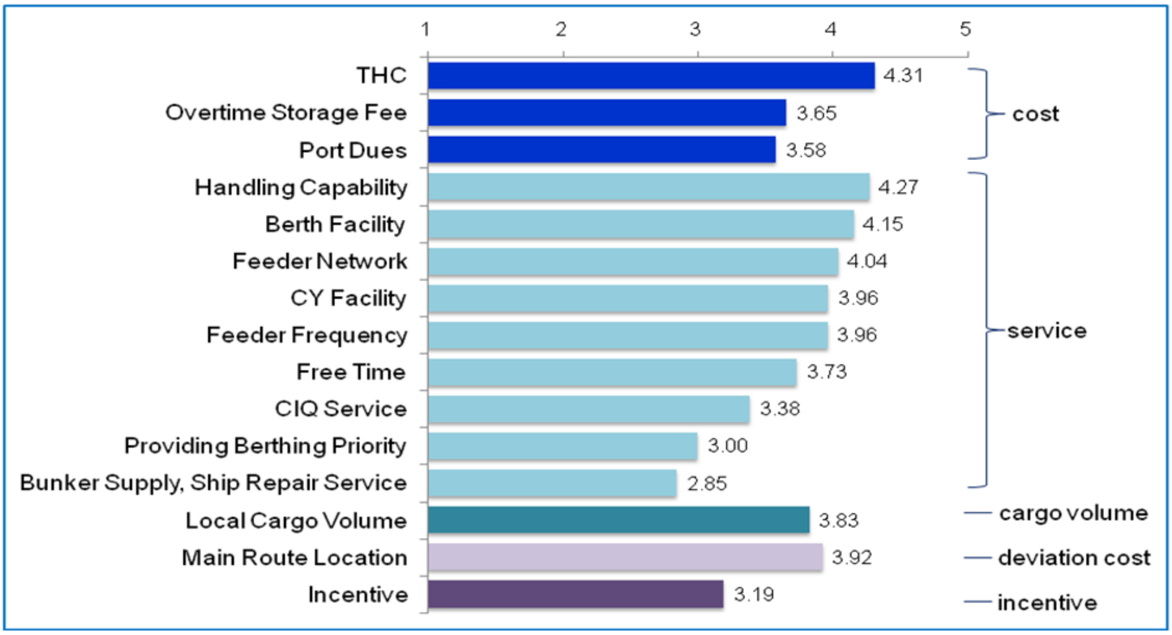

Figure 7-Transshipment deciding factors

In order to make independent variables, cost factor, service factor which is composed of local cargo as attractiveness, total cargo volume as mohring effect, and deviation cost factor and incentive factor can be drawn as figure 7.

4.2 Model specification

The probability that a shipping company in region (r) select transshipment port (p) can be expressed as:

$$P_P^r = \frac{e^{U_p^r}}{\sum_{p=1}^{p=P} e^{U_p^r}}, (P = 1, 2, ..., P)$$

U is the "utility" attached to transshipment port (p) by shipping liner in region (r) and p the index of the transshipment port in a total of P ports.
Considering Veldman's model (2008) and the factors to be surveyed, the utility function is modified as:

$$U_P^r = \alpha_1 CT_{pr} + \alpha_2 CI_{pr} + \alpha_3 CD_{pr} + \alpha_4 L_{pr} + \alpha_5 M_{pr}$$

where CTpr is the sum of feerdering cost CFpr and mother ship access cost CMpr. The feeder transport cost CF is incurred between transshipment port and feeder port (p,r) in r region; CM is the mainline access cost to transshipment port; CI is the incentive between transshipment port and competition port (p,p'r); CDpr is deviation cost between transshipment hub port and feeder port. Lpr represents the attraction of a port given its volume of local cargoes. Mpr represents the total handling throughput of a port including local and transshipment cargo. This is a part of Mohring-effects (Mohring, H., 1972) and expressed as a function of the level of port throughput. As feeder calling frequencies increase, wait times of cargo decrease, demand increases, and transit frequencies can increase again. This effect can be used as substation variable of port service. The Greek symbols α1, α2, α3, α4 and α5 are the coefficients of the utility function.
By taking for each region (r) the ratio of the market share of transshipment port (p) and of an arbitrarily chosen basic port (p*), it follows from (1):

$$\left(\frac{P_P^r}{P_{P^*}^r}\right) = \frac{e^{U_p^r}}{e^{U_{p^*}^r}}, = e^{U_p^r - U_{p^*}^r}$$

Combination of equations (2) and (3) and taking of logarithms leads to:

$$Ln\left(\frac{P_P^r}{P_{P^*}^r}\right) = \alpha_1 (CT_{pr} - CT_{p^*r}) + \alpha_2 (CI_p - CI_{p^*}) + \alpha_3 (CD_p - CD_{p^*}) + \alpha_4 (L_p - L_{p^*}) + \alpha_5 (M_p - M_p{}^*)$$

4.3 Variable Description

Dependent Variable

$Ln\left(\frac{P_P^r}{P_{P^*}^r}\right)$ is the share of transshipment in the port of Busan among total transshipment in the region.

Independent variables

Selecting independent variables is dependent on research outputs on the topic. Researchers insist that deciding transshipment port is influenced by cost, location, service factors like productivity and incentive system etc.

CTpr-CTpr' is the total cost difference between the port of Busan and Shanghai port for moving containers from origin to destination in North east region This cost is composed of operation cost, running cost and logistics cost.

CIpr-CIp' is the incentive difference between the port of Busan and the port of Shanghai, where THC of deep sea volume is discounted with some percentage or where compensation for the growth of transshipment compared with a previous year throughput is paid to shipping company.

CDpr-CDp' means the difference of deviation cost from main line route to the port of Busan or the port of Shanghai. In Northeast Asia, Traditionally, main trunk route towards USA is established via Singapore, Hon Kong, Kaosiung, Busan and Yokohama to Los Angeles (Figure 2).

Lp-Lp' can be obtained by the ratio of local cargo of Busan and the region. This is proxy variable representing attraction effect.

Mpr-Mp' can be obtained by the ratio of total handling cargo of Busan and the region. This is proxy variable representing mohring effect.

5. DATA GATHERING FOR INPUT VARIABLE

5.1 Value of Dependent Variable

In the context, there is a controversial issue concerning the scope of region. The criteria of research scope are trade direction such as USA or Europe bound. The other criteria are drawn from the relationship between the feeder sub region and transshipment port in competition. In this study, the potential hinterland of Busan port for flowing in covers four major ports in the region.

In the quantitative model research, both Northeast Asia region and North America trade will be examined together. In the context, the mother value of dependent variable is defined transshipment containers in the Northern China ports such as the port of Dalian, the port of Tianjin, the port of Qingdao including the port of Shanghai and Busan port. The child part value of dependent variable is transshipment container in the port of Busan for 10 years (see Table 2).

Table 2-Dependent variable and its value for 10 years, unit: 1,000 TEU

Year	Regional Volume (Northern China, Busan and Shanghai)	Regional TS Volume (Northern China, Busan and Shanghai)	TS ration (Busan to Regional)
1998	12,328	981	0.436
1999	16,141	1,779	0.361
2000	19,955	2,549	0.337
2001	22,645	3,261	0.311
2002	28,360	4,404	0.303
2003	33,855	4,854	0.285
2004	41,699	5,904	0.261
2005	49,478	6,458	0.266
2006	57,257	7,364	0.239
2007	65,036	8,162	0.236

5.2 Value of Independent variable

In the ship operation, different types of cost are occurred on supply chain steps. Ship cost is composed of voyage cost and running cost. Ship voyage cost is composed of fueling cost and port dues. Prior to calculation of ship cost, ship dimension of mother ship and feeder ship is to be defined for estimation cost.

Mother ship dimension for cost estimation

In the paper, mother ship's dimension is assumed to be 51,836 Gross Tonnage, 22,101 Net Tonnage, 61,153DWT, 4,400TEU Capacity, and navigation speed is 22 knots, draft is 13.6 meters, unloading moves are 600TEU (120TEU, 240FEU), loading moves are 600TEU(120TEU, 240FEU), total handling moves are 720 boxes which are assumed full containers, berthing time is 24 hours and handling time is 12 hours, the ratio of l0cal cargo and transshipment is 62.6 vs37 and bunker C consumption is 27 ton per day and bunker A is 2.5 per day.

Table 3-Mother Vessel's Specification for quantitative model

Gross Tonnage	51,836GT
Net Tonnage :	22,101NT
DWT	61,153DWT
Draft	13.6 meters
TEU Capacity :	4,400TEU
Unloading containers	600TEU (120TEU, 240FEU)
Loading containers	600TEU (120TEU, 240FEU)
Total handling containers (Assumed full containers)	720BOX
Ratio of local and transshipment	62.6:37.
Berthing time	24 hours
Handling times	12 hours
Bunker C Consumption	27 ton per day
Bunker A Consumption	2-3 ton per day

Feeder ship dimension for cost estimation

In the paper, feeder ship's dimension is assumed to be 6,764 Gross Tonnage, 39,54 Net Tonnage, 9,981 DWT, 576 TEU Capacity, and navigation speed is 13.5 knots, draft is 7.9 meters, unloading moves are 225TEU (75TEU, 75FEU), loading moves are 225TEU(75TEU, 75FEU), total handling moves are 300 boxes which are assumed full containers, berthing time is 24 hours and handling time is 10 hours, the ratio of l0cal cargo and transshipment is 62.6 vs37 and bunker C consumption is 19 ton per day and bunker A is 2 per day.

Table 4-Feeder specification for quantitative model

Gross Tonnage	6,764 GT
Net Tonnage :	3,958 NT
DWT	9,981DWT
Draft	7.9 meters
TEU Capacity :	576TEU
Unloading containers	225 TEU (75TEU, 75FEU)
Loading containers	225 TEU (75TEU, 75FEU)
Total handling containers (Assumed full containers)	300 BOX
Ratio of local and transshipment	62.6:37.
Berthing time	8 hours
Handling times	5 hours
Bunker C Consumption	19 ton per day
Bunker A Consumption	2 ton per day

Ship voyage cost

Variable cost includes expenses related to a specific voyage. Port cost and logistics cost such as THC, lashing, shuttling, tally cost and cargo wharfage, fuel consumption cost, are included into voyage cost category.

Port dues

When a mother ship calls at a port, she has to pay for various kind of charge to Port Authority, Terminal Operator, pilot, tug company and related company for providing port service.

Fuel cost for transportation

Fuel consumption cost for transportation is calculated by distance from origin to destination and daily bunker consumption. In calculating fuel consumption, the distance difference of two cases is considered from Hongkong to Sanghai or from Hongkong to Busan. Tracking historic data for 10 years, RIM data is used as bunker C and A price.

Port logistics cost

Within scope of port logistics cost, THC, lashing cost, shuttle cost, wharfage, tally cost are included in the category. Even though Port Authority used to announce THC tariff, most of terminal operators have private contract with a shipping company about real tariff according to promised volume. In case of Shanghai port, if a shipping company pays THC, the other cost such as lashing fee, storage charge in CY, shuttle fee in same terminal are included in THC. In comparison, the port of Busan charges the elements of port disbursements separately. On this reason, it is not fair to list difference of individual cost one by one.

Ship running cost

Running cost is calculated with capital and operating expenses according to period of voyage. Capital cost begin with a fixed item, i.e. the purchase price of the ship, whether acquired s a newbuilding or on the second market. Deposit, repayment of loan principal and interest are part of capital cost. Within the overall ship cost, it is operation cost category where ship owner have the greatest influence over the choices made out. The difficulty that owners face is that suppliers of services to ships operate within their markets. The core operating cost elements are manning costs, insurance costs, repair cost, the cost of stores and supplies, and management and administration. (Drewry, Ship Operating Cost, 2008) As this cost depends on market price, it is not easy task to track for 10 years. On this point, Drewery suggested ship cost and charter type relationship as proxy value of running cost. Based on the relationship, daily time charter rate is used for calculating running cost from origin to transshipment port including capital cost and operating cost like Daily Time Charter Rate x (Sailing Days + Port Days)

Table 5-Running Cost

Year	Mother Ship Running Cost to Busan or	Feeder Running Cost to Busan ($)	Feeder Running Cost to Shanghai ($)	Difference ($)

	Shanghai ($)			
1998	56,228	13,195	16,240	-3,045
1999	62,100	10,855	13,360	-2,505
2000	64,868	11,830	14,560	-2,730
2001	52,178	11,635	14,320	-2,685
2002	38,948	11,635	14,320	-2,685
2003	63,923	12,935	15,920	-2,985
2004	85,253	18,395	22,640	-4,245
2005	81,972	23,881	29,392	-5,511
2006	71,051	19,422	23,904	-4,482
2007	63,923	17,875	22,000	-4,125

Ship total cost including mother and feeder Ship

Ship costs including fuel cost, running cost and port charges from origin to destination is summed for comparison between Busan port and Shanghai port.

Table 6-Total Cost of Transshipment via Busan and Shanghai

Year	Total Cost of TS cargo to Busan($)	Total Cost of TS cargo to Shanghai($)	Difference($)
1998	88,507	62,098	25,988
1999	96,348	67,698	28,229
2000	108,843	79,366	29,056
2001	102,018	70,862	30,735
2002	100,477	69,217	30,840
2003	115,511	85,128	29,962
2004	130,144	102,102	27,621
2005	144,784	122,989	21,375
2006	148,512	124,653	23,439
2007	151,932	129,611	21,901

Data for measuring port attraction

Mohring effect is defined the ratio of captive cargo of Busan port by total captive cargo in the region. Busan’s captive container is obtained from PORT-MIS, the region data is from OSC report (OSC, Container Port Strategy, 2006).

Data for measuring mohring effect

Mohring effect is defined the ratio of total cargo of Busan port by total cargo in the region (OSC, Container Port Strategy, 2006).

Table 7-Mooring Effect of Busan Port

Year	Regional Local Volume(Northern China, Busan and Shanghai)	Local Cargo of Busan (1,000 TEU)	Mohring Effect
1998	11,347	4,539	0.400
1999	14,362	4,678	0.326
2000	17,406	5,035	0.289
2001	19,384	5,011	0.259
2002	23,956	5,522	0.231
2003	29,001	6,035	0.208
2004	35,795	6,495	0.181
2005	43,020	6,579	0.153
2006	49,893	6,803	0.136
2007	56,874	7,444	0.131

Deviation Cost

Due to recent change of route pattern, defining deviation is complex and variable. The mainline deviation distance is measured as the extra distance needed to call at a transshipment port compared to the distance of the shortest navigation course between the Hong Kong, Shanghai, Yokohama and Hong Kong, Busan to Yokohama. The remaining distance to North America is not considered because of same distance to USA.

Table 8-Deviation cost of Busan and Shanghai

Year	Mother Ship Transportation Cost from HK to Busan ($)	Mother Ship Transportation Cost from HK to Shanghai ($)	Difference
1998	28,437	28,773	-336
1999	41,935	42,427	-492
2000	65,593	66,354	-761
2001	56,897	57,557	-660
2002	61,173	61,891	-718
2003	70,950	71,783	-833
2004	80,643	81,572	-929
2005	113,252	114,563	-1311
2006	137,177	138,763	-1586
2007	159,087	160,953	-1866

Source: Port MIS and OSC Report (2006)

6. THE RESULT OF MODEL TEST

The multiple regression model is tested with 10 years data. The authors selected one observation per year, therefore the number of data is 10. The reason why just 10 data is selected is caused by the attribute of dependent variable and independent variables. If we increase the number of observation by quarterly or monthly, the result of analysis shows the anomaly, i.e. the significant probability of most of independent variables is under 5 %.

Table 9-Variable definition of model

Variable		Definition	Unit
Dependent Variable	y	Ratio of Transshipment of Busan with Region Transshipment	Ratio
Independent Variable	X1	Ratio of Local Container of Busan with Region Local Container	Ratio
	X2	Difference of Incentive Payment of Transshipment	US $
	X3	Difference of Mother Vessel Deviation Cost of Transshipment	US $
	X4	Total Transshipment Cost of Mother and Feeder	US $
	X5	Ratio of Total Handling Container of Busan with Region Total Handling Container r	Ratio

6.1 Step 1 Model Test

The regression model has been tested in 2 steps. In the beginning, 5 variables are selected as independent variables similar as Veldman's Model (Veldman 2008). The result shows that X1(mohring effect) and X4(total cost) are accepted, and X2(deviation cost) and X3(incentive payment) is rejected under 5% significance level. As the adjusted R square is 0.986, this means the model shows high explanation of phenomena.

R	R Square	Adjusted R Square	Standard Error	Durbin-Watson
0.998	0.996	0.996	0.00386	0.449

As the result of ANOVA, the regression model has effective meaning because significant probability is less than 5%.

	Sum of Square	Degree of Freedom	Mean Square	F	significant probability
Model	.137	5	.127	1,827.373	.000***
Residual	.001	34	.000		
Sum	.137	39			

* p<.1, ** p<.05, *** p<.01

The coefficient of regression model is as follows.

Variable	Non Standard Coefficient		t	Significance Probability	Mulitícollinearity	
	B	S.E			Tolerance	VIF Variance Inflation Factor
A	0.1750000	0.0190	8.9940	0.000		
X1	0.0200000	0.0970	0.2020	0.841	0.0060	175.917

X2	-0.00000214	0.0000	-1.6820	0.102	0.3590	2.7830
X3	0.00000412	0.0000	0.7040	0.486	0.0510	19.6870
X4	-0.0000043	0.0000	-11.4980	0.000***	0.1970	5.0730
X5	0.7830000	0.1180	606440	0.000***	0.0040	247.471

* p<.1, ** p<.05, *** p<.01

6.2 Step 2 Model Test

According to step 1 test, the model to be tested is modified with deletion of 3 variables which show weak significant probability. The independent variables to be selected are X4(Total Cost) and X5(Mohring Effect). The result of test is that adjusted R square is 0.995. According to ANOVA, significance probability is 0 and this indicate effective model. Furthermore, the fact that correlation indicator, VIF (variance Inflation Factor), is less than 10 means any dependence does not exist in between independent variables. The coefficient of model is Y = 0.179291199 - 0.000004782589 X4 + 0.810489669X5. This expression will be used for sensitivity analysis.

R	R Square	Adjusted R Square	Standard Error	Durbin-Watson
0.998	0.996	0.996	0.00386	.512

	Sum of Square	Degree of Freedom	Mean Square	F	significant probability
Model	0.137	2	0.068	4584.348	0.000***
Residual	0.001	37	0.000		
Sum	0.137	39			

* p<.1, ** p<.05, *** p<.01

Variable	Non Standard Coefficient		t	Significance Probability	Mulilticollinearity	
	B	S.E			Tolerance	VIF Variance Inflation Factor
A	0.17000000	0.0050	36.597	0.000***		
X4	-0.000004503	0.0000	-21.695	0.000***	0.629	1.590
X5	0.82200000	0.0090	87.179	0.000***	0.629	1.590

* p<.1, ** p<.05, *** p<.01

6.3 Step 3 Model Test

According to step 2 test, the model is to be expanded to identify which one has stronger impact to attract TS cargo between mother ship cost and feeder ship cost. Keeping X5 in the same, X4 independent variable (Total Cost), is required to expand into X6 and X7. X6 means total cost difference due to mother ship operation from Hongkong to Busan, while X7 means total cost due to feeder ship operation from Dalian to Busan. The result of test is that adjusted R square is 0.999. According to ANOVA, significance probability is 0 and this indicate effective model. Furthermore, the fact that correlation indicator, VIF (variance Inflation Factor), is less than 10 means any dependence does not exist in between independent variables. The coefficient of model is Y = 0.94 – 0.9 X5 – 0.00000231 X6 – 0.00001104. The implication from test is feeder ship impacts stronger power rather than mother ship to attract TS cargo.

R	R Square	Adjusted R Square	Standard Error	Durbin-Watson
0.999	0.999	0.999	0.00229	0.691

	Sum of Square	Degree of Freedom	Mean Square	F	significant probability
Model		3	0.046	8689.812	0.000***
Residual	0.000	36	0.000		
Sum	0.137	39			

* p<.1, ** p<.05, *** p<.01

Variable	Non Standard Coefficient		t	Significance Probability	Muliticollinearity	
	B	S.E			Tolerance	VIF Variance Inflation Factor
A	0.0940000	0.0100	9.7760	0.000		
X5	0.9000000	0.0110	81.880	0.000***	0.163	6.135
X6	-0.00000231	0.0000	-7.9150	0.000***	0.263	3.806
X7	-0.00001104	0.0000	-13.8540	0.000***	0.088	11.415

* p<.1, ** p<.05, *** p<.01

6.4. Port Choice Model for Sensitive Analysis using SD tool

The model which helps estimation of transshipment in Busan can be retransformed to system dynamics model. The SD model is useful tool for presenting social phenomena. The model is composed of total cost and mohring sub system. This system is working with time series and the cost trend, total handling container trend in region and Busan.

In making port choice model using PowerSim tool, main level is defined as transshipment ratio of port of Busan. The level variable is linked to inflow variable and outflow variable. In flow variable has sub modules of 'Morhring Effect' and 'Difference of Total Cost', which are linked to TS inflow.

In a result of SD model, demand curve is drawn like figure 8. For example, if the THC is discounted 10%, transshipment will be increased to 71,364 TEU in Northeast Asia in the year of 2009.

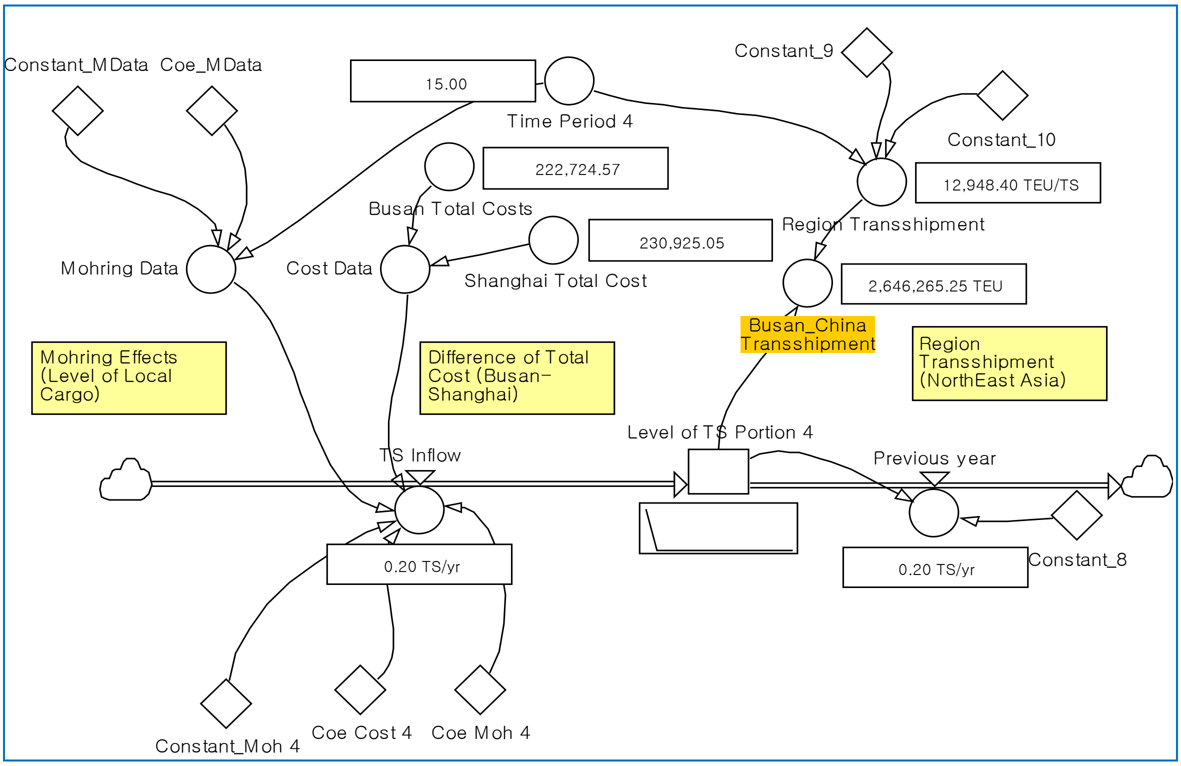

Figure 8-SD Model for Estimation Transshipment

Year	-20%	-15%	-10%	0	10%	15%	20%
2009	144,215	108,533	71,364	0	-69,877	-104,073	-139,755
2010	151,060	113,684	74,751	0	-73,193	-109,013	-146,388
2011	155,433	116,976	76,915	0	-75,312	-112,169	-150,626
2012	156,971	118,133	77,676	0	-76,058	-113,279	-152,117
2013	155,311	116,884	76,855	0	-75,253	-112,081	-150,508

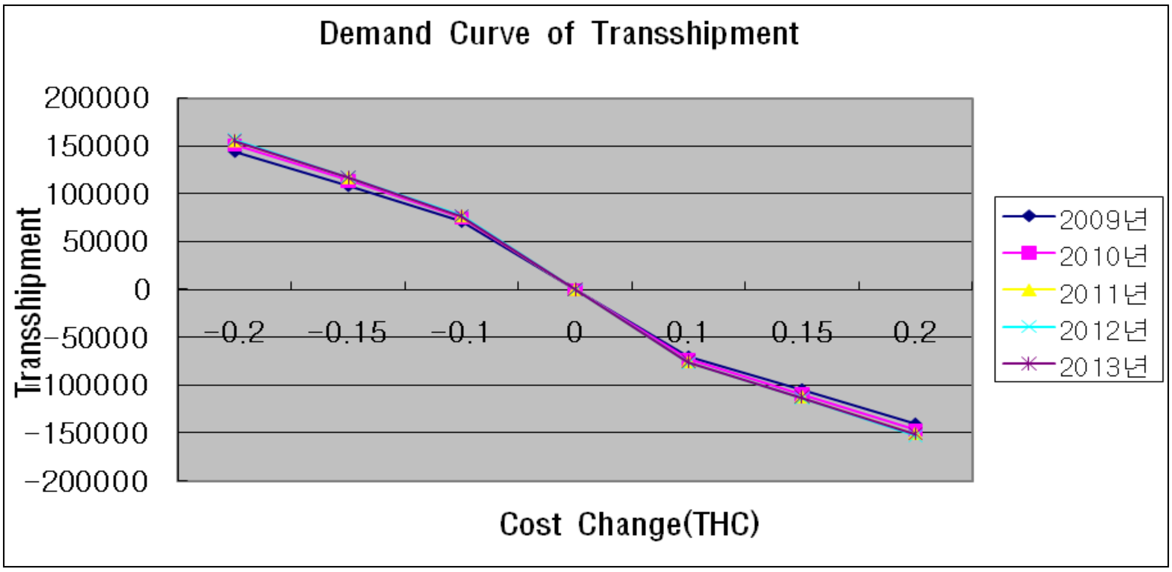

Figure 9-Demand curve of Transshipment

7. CONCLUSION

The purpose of this study is to develop port choice model to estimate the transshipment cargo. In order to pursue an aim, it is required to identify selection factors for transshipment port. To this end, this study is based on Logit model of Hiroshi Ohashi (2005) and Veldman (2008), which are being commonly used as a port selection model. Also, taking into consideration the selection factors of the previous studies, this study has produced the flowing five factors based on the past 10 years' actual data: cargo volume at a local port, incentive amount, deviation expenses of a mother ship, total expenses of a mother ship and feeders, and total cargo volume as a service substitution.

The actual data in this study has been confined to which port between Busan Port and Shanghai Port the feeder cargo in the northern area of China select. The following assumption has been made: the mother ship of 65,000 GRT departs from Hong Kong via Busan or Shanghai to the U.S. West Coast, and the feeder, a 6,700 GRT container feeder ship, sails from Dalian Port to Shanghai or from Dalian Port to Busan.

The actual data used in the model are based on the 10-year data from 1998 to 2007. Some of these data have been posted by related organizations or the others have been collected during our field visit. The collected data have been used by the above-mentioned selection model in order to calculate the difference values between the two rival ports of Shanghai and Busan. In the first test, the two variables among the five – "the transshipment cargo expenses difference between the port of Busan and the port of Shanghai in both a mother ship and a feeder" and "the rate of Busan Port's total cargo volume against the regional total cargo volume" – are statistically significant at the significant level of 0.01. Therefore,

the second test has been made for these two variables that are statistically significant, and as a result of the second test these two variables again are statistically significant at the level of 0,01. This means that ″cost reduction of a mother ship and a feeder ship″ and ″total cargo increase at the local port″ are significant factors for transshipment cargo volume. The third test has been conducted after the mother ship′s expenses and feeder′s expenses have been separated, and the results of this test have revealed that these two are statistically significant at the level of 0.01, and that the feeder′s expenses carry more significance than the mother ship′s expenses. This means that more incentives should be given to the feeders which are suffering financial difficulty.
Based on the quantitative analysis, port choice model to estimate the transshipment cargo is developed using PowerSim tool. The system is useful to anticipate the future volume in adjusting independent variables like ″the transshipment cargo expenses difference" or ″the rate of Busan Port′s total cargo volume against the regional total cargo volume.

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