ROUTE COST EVALUATION MODEL OF CONTAINER SHIPPING

-FOCUSED ON NORTH CHINA PORTS AND BUSAN PORT-

Nam Kyu Park [a], Sang Kook Park[b]

[a]Professor of School of Port Logistics in Tongmyong University, Busan, Republic of Korea
[b]A Researcher of Hanwha S&C, Seoul, Republic of Korea

[a]nkpark@tu.ac.kr, [b]parksangkook@daum.net

ABSTRACT
Asian container routes are the area where world 10 big ports are concentrated including Busan Port based on container cargo handling records in 2013 and the competition to attract container cargos between such ports is very tough. This paper has developed an economy evaluation model corresponding to change in transshipment cargo volume of neighbor ports in North East Asia classifying to Route 1 and Route 2 with Busan Port as a starting point and carried out an economy evaluation of the sea route, an important data for deciding sea routes and calling ports of the shipping companies by applying this model. As a result of analyzing such 2 routes, the shipping company can develop a more profitable route and the port related government authority or operational institution of each country can figure out the threshold of feeder cargo volume in economic viewpoint.

Keywords: Container, Sea Route, Transshipment Cargo Volume, Feeder, Economy Evaluation Model

1. INTRODUCTION

UNCTAD Secretariat (2013) announced all of world 10 big ports(Shanghai, Singapore, Hong Kong, Shenzhen, Busan, Ningbo, Guangzhou, Qingdao, Dubai and Tianjin) based on container cargo handling volume were concentrated in East Asia from 2010 to 2012. In addition, since the rank of ports has been changed from time to time due to the difference in competitiveness according to the service cost and level of each port, maintaining the competitiveness of port according to service level is a very important point. Especially, for each port under competition relation, not only for the container cargo volume but also attracting the transshipment cargo volume becomes a significant variable (Chung and Gak 2002; Kim, Shin and Chang 2012).

While Notteboom and Vernimmen (2008) carried out an economy analysis in order to lower the fuel cost in recession period, considering such important variables, this study developed an evaluation model to figure out which route is more economic corresponding to change in transshipment cargo volume in neighbor ports of East Asia with 2 container routes starting from Busan port. This study carried out an economy evaluation of the port, which is a major data for deciding the sea route and calling port by shipping companies, in particular, could find a more economic model according to size of cargo volume of feeder from viewpoint of shipping company.

Gilman (1999) conducted an analysis to compare One Port Calling Strategy with Several Ports Calling Strategy based on Rotterdam in order to compare and evaluate the costs between the existing End to End service and Hub and Spoke service. In addition, it stressed that it takes significantly long time to tranship the cargos to feeders and is difficult to secure a stable and efficient feeder transportation system for feeders which are essential for sailing of supersized ships. Nevertheless, the shipping companies may develop the better profitable sea routes if they could figure out a proper size of feeder cargo volume of neighbor ports based on such economy evaluation models. Further, if port related central government or operational agency of each country could obtain a marginal value of feeder cargo volume exactly from economic viewpoint and reflect it to the port policy, it shall be able to carry a correct policy to make a prompt decision making and secure the port competitiveness than other competition countries.

2. STATUS OF MAJOR PORTS OF EAST ASIS

Container volume in major ports of East Asia and ship size of major container routes are important variables to decide the sailing routes of container ships. In addition, change in transshipment cargo volumes of container ships in Busan Port, a research object of this study, is also an important factor to consider. Therefore, it shall be possible to foresee how the major container routes shall be changed and to develop our port operation policies favorably coping with those of competition countries by reviewing the process of changes for such important factors.

2.1. Chronology of Major Hub Ports

Major hub ports in East Asia includes Singapore(SG), Hong Kong(HK), Kaohsiung (Taiwan, KHH), Kobe (Japan, KB), Shanghai (China, SHA) and Busan (South Korea, PUS) from 1980S to 2010S and Tsingtao(China, TAO) and Tianjin(China, TSN) are expected to be included in major ports in future.

Major hub ports in 1980's were SG, HK and KB as Figure 1 and the factor to decide the hub port was the shortest distance of sailing route.

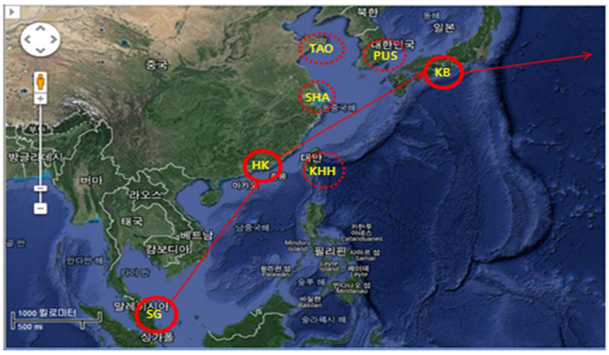

Figure 1: 1980's Main Hub Ports

Major hub ports in 1980's were changed to SG, HK, KHH and PUS as Figure 2, the major factor of change was that KB was eliminated from a hub port due to Great Earthquake in Kobe 1995 and KHH and PUS have been emerged as hub ports alternatively.

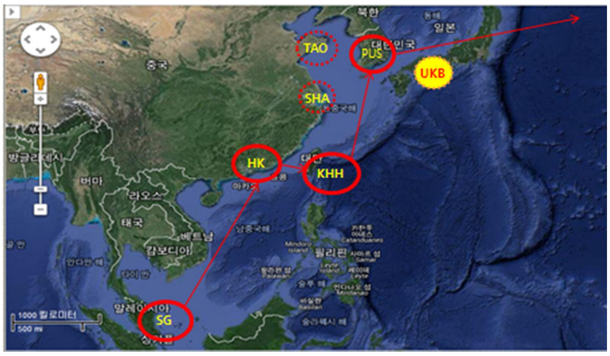

Figure 2: 1990's Main Hub Ports

Major hub ports in 2000's were changed to SG, HK, SHA and PUS as Figure 3 and the major factor of change was that existing KHH, Taiwan was replaced by SHA, China due to increase of cargo volume by rapid development of economy in China.

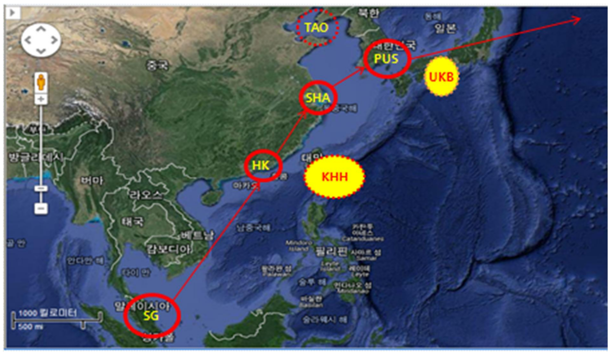

Figure 3: 2000's Main Hub Ports

Major hub ports in 2010's have been maintained same as 2000's but are most likely to be changed due to sudden increase of container cargo volume in Q'TAO and TSN of China that it became an important issue if PUS could still maintain its position as a hub port.

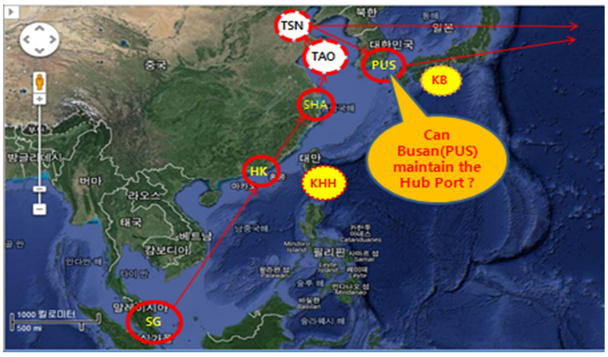

Figure 4: 2010's Main Hub Ports

2.2. Change of Ship Size in Asia Sailing Route

ICF GSK (2014) reported the size of container ships by route starting from Asia has been increased as Figure 5 based on 2013.

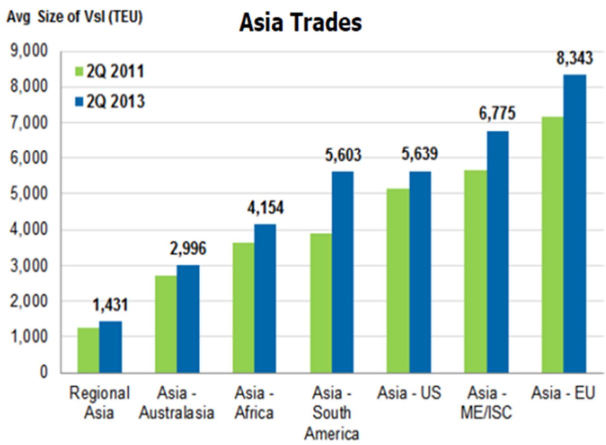

Figure 5: Asia Trades

Especially, the size of ships in Asia-South America routes has been suddenly increased from less than 4,000TEU to 5,603TEU in 2011 as well as Asia-EU routes from 7,000TEU to 8,343TEU. According to Alphaliner and Lloyd's List (2014), such phenomenon appeared to be P3 11,600TEU, G6 11,300 TEU, CKYHE 10,300TEU in average container ship size of FE-N EU based on Feb. 2014.

Such increase of container ship size could be a factor to accelerate the inflow of transshipment cargo volume to hub ports from adjacent ports according to future routes of Asia-America and Asia-EU routes and a big change in maintaining as a hub port is expected according to attraction of transshipment cargo volume.

2.3. Change of Transshipment Container Cargo Volume in Busan Port

According to BPA (2012), 31% of transshipment cargo volume in Busan Port was from China and it steadily increases from 27% in 2004 to 31% in 2012 as shown on Table 1.

Table 1: Container T/S Rank in Busan Port

Rank	Port	Country	T/S (1000TEU)	Ratio (%)
1	Tianjin	China	839	10.3
2	Qingdao	China	556	6.8
3	Dalian	China	427	5.2
4	Shanghai	China	247	3.0
5	Los Angeles	USA	235	2.9
6	Vancouver	Canada	199	2.4
7	Long Beach	USA	172	2.1
8	Seattle	USA	172	2.1
9	Ningbo	China	148	1.8
10	Vladivostok	Russia	131	1.6

In addition, out of big 10 transshipment ports of Busan, 5 are Chinese ports and located in places within 1.5 days sailing distance, so transshipment to China is one of essential factors to keep Busan Port as a hub port. Figure 6 shows transshipment status by country.

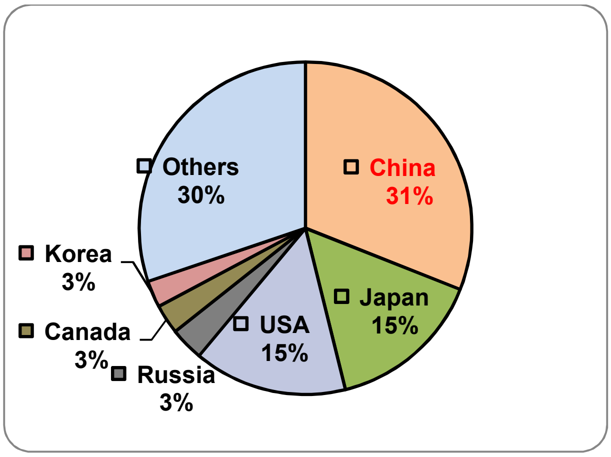

Figure 6: T/S Statistics per country in Busan Port

3. DESIGN OF ECONOMY EVALUATION MODEL

In order to design an economy evaluation model of container routes, a procedure to calculate the economy evaluation model and an equation to apply to such evaluation model shall be defined.

3.1. Calculation Procedure of Evaluation Model

Calculation procedures of evaluation model shall be implemented according to total 12 steps as Figure 7.

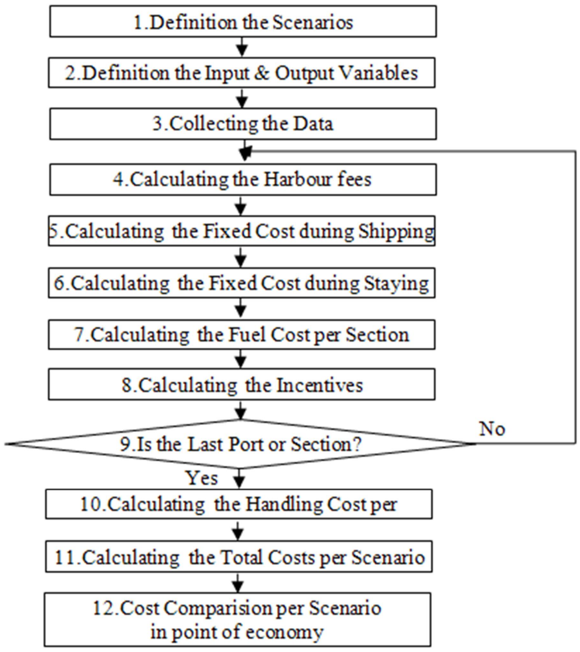

Figure 7: Calculation Procedures of Economy Evaluation Model

Detailed processes by each step are as follows:

1. Number and types of scenarios to be applied to evaluation model shall be defined.
2. Input variables and output variables to be applied to the scenarios shall be defined.
3. Correct financial data to be applied to the scenarios shall be collected and its accuracy shall be verified.
4. Harbor fee of each port shall be calculated by scenario
5. Fixed sailing cost by scenario shall be calculated.
6. Fixed staying cost by scenario shall be calculated.
7. Fuel cost of each section by scenario shall be calculated.
8. Incentives provided by individual port by scenario shall be calculated.
9. When the costs of each port by scenario are calculated, proceed to the next step; otherwise repeat the calculation of harbor fee of item 4.
10. Cargo handling cost by scenario shall be calculated.
11. All costs by scenario shall be aggregated.
12. Costs by scenario shall be compared in viewpoint of economy.

3.2. Definition of Input Variables and Output Variables

Number of input variables to be applied to evaluation model was 7 variables and were defines as Table 2.

Table 2: Definition of Input Variables

Input Variables	Description	Unit
Port Name	Busan(PUS) Long Beach(LGB) Oakland(OAK) Tianjin(TSN)	(code)
Distance	Nautical Mile	(miles)
Shipping time	Time to be consumed during shipping	(days)
Staying Time	Time to be consumed during staying	(days)
Average Speed	Average speed of ship (15 Knot)	(Knot)
Fuel Consumption	HFO(Heavy Fuel Oil) MDO(Marine Diesel Oil) MGO(Marine Gas Oil)	(LT/day)
Currency	USD:KRW=1$:1,072.00₩ CNY:KRW=1¥:175.17₩ EUR:KRW=1€:1,453.95₩	2013, 11th October

Number of output variables to be applied to evaluation model was 7 variables and were defined as Table 3.

Table 3: Definition of Output Variables

Output Variables	Description	Unit
Harbor fees(1)	Tonnage due Harbor due Pilotage Towage Dockage Husbanding fee Quarantine Line handling Entrance/clearance Pilot boat Light due Other port charge	(KRW)
Fixed Cost during Shipping(2)	Shipping duration * 1 Day charterage * Currency	(KRW)
Fixed Cost during Staying(3)	Staying duration * 1 Day charterage * Currency	(KRW)
Fuel Cost(4)	1 Day fuel consumption * Shipping duration * Fuel cost(HFO) * Currency	(KRW)
Incentive(5)	Loading Amount(TEU) * Incentive per port per TEU	(KRW)
Handling(6)	Loading Amount (TEU) * Handling cost per TEU	(KRW)
Total(7)	(1)+(2)+(3)+(4)-(5)+(6)	(KRW)

3.3. Formula of Evaluation Model

The formula of evaluation model using Input Variable of Table 2 and Output Variables of Table 3 shall be as follows:

Calculus of Harbor Fee (1) is as follows:

$$C_{hf} = \sum_{i=1}^{n}(C_{tdi} + C_{hdi} + C_{twi} + C_{dki} + C_{hf} + C_{qri} + C_{hi} + C_{eci} + C_{pbi} + C_{ldi} + C_{etci}) \quad (1)$$

i : 1 = port 1, 2=port 2, ... n=port n
C_{tdi} : Tonnage due of Port i
C_{hdi} : Habor due of Port i
C_{twi} : Towage of Port i
C_{dki} : Dockage of Port i
C_{hf} : Husbanding fee of Port i
C_{qri} : Quarantine of Port i
C_{hi} : Line handling of Port i
C_{eci} : Entrance / clearance of Port i
C_{pbi} : Pilot boat of Port i
C_{ldi} : Light due of Port i
C_{etci} : Other port charge of Port i

Calculus of Fixed sailing Cost (2) is as follows:

$$C_{fs} = \sum_{j=1}^{n}(D_{shj} * C_{ch} * R_{cu}) \quad (2)$$

j : 1 = Section 1, 2= Section 2, ... n= Section n
D_{shj} : Shipping duration of Section i
C_{ch} : 1 Day charterage
R_{cu} : Currency

Calculus of Fixed Staying Cost (3) is as follows

$$C_{f} = \sum_{i=1}^{n}(D_{sti} * C_{ch} * R_{cu}) \quad (3)$$

i : 1 = port 1, 2=port 2, ... n=port n
D_{sti} : Staying duration of Port i
C_{ch} : 1 Day charterage
R_{cu} : Currency

Calculus of Fuel Cost (4) is as follows:

$$C_{fu} = \sum_{j=1}^{n}(Q_{1dj} * D_{shj} * C_{hfo} * R_{cu}) \quad (4)$$

j : 1 = Section 1, 2= Section 2, ... n= Section n
Q_{1dj} : 1 Day fuel consumption of Section j
D_{shj} : Shipping duration of Section j
C_{hfo} : Fuel cost(HFO)
R_{cu} : Currency

Calculus of Incentive (5) is as follows:

$$C_{ic} = \sum_{i=1}^{n}(Q_{ldi} * C_{ipi}) \quad (5)$$

i : 1 = port 1, 2=port 2, ... n=port n
Q_{ldi} : Loading Amount(TEU) of Port i
C_{ipi} : Incentive per port per TEU of Port i

Calculus of Cargo Handling Cost (6) is as follows:

$$C_{hc} = \sum_{i=1}^{n} (Q_{di} * C_{hpi}) \quad (6)$$

i : 1 = port 1, 2=port 2, ... n=port n
Q_{di} : Loading Amount(TEU) of Port i
C_{hpi} : Handling cost per TEU of Port i

Calculus of total cost (7) could be made by aggregating calculus (1) to (6):

$$C_t = C_{hf} + C_{fs} + C_{ff} + C_{fi} - C_{ic} + C_{hc} \quad (7)$$

4. CASE STUDY

The evaluation model was applied to the route between PUS and USA in order to evaluate the economy of the container route. In particular, two types of models; operating feeders from PUS to TSN and calling directly at TSN out of the route between PUS and USA via TSN were evaluated.

4.1. Definition of Scenarios of Applicable Routes

Applicable routes were developed by 2 scenarios. Route-1 is to start from PUS and return to PUS via TSN, PUS, LGB and OAK. Route-2 is to start from PUS and return to PUS via LGB and OAK but operate feeders between PUS and TSN.

4 types of feeders including 1000TEU, 2000TEU, 3000TEU and 4000TEU were assumed to be operated between the feeder section of Route-2.

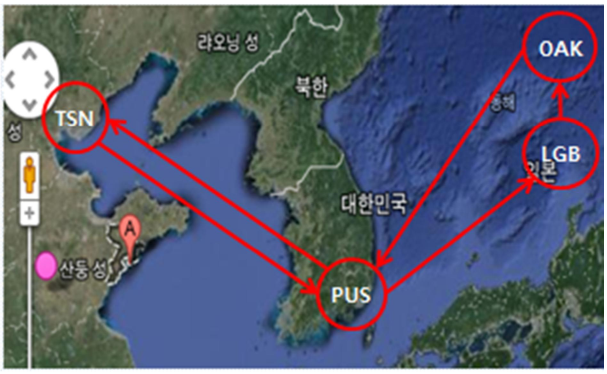

Figure 8: Route 1 Scenario

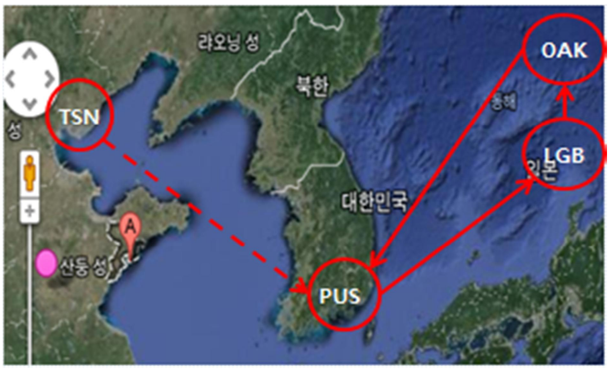

Figure 9: Route 2 Scenario

4.2. Assumption of Application by Scenario

Scenarios of two routes were applied as Table 4. Especially, Mother ship was assumed to be 5,300TEU class and sail at average 15knot speed.

Table 4: 2 Scenarios per Route

Items	Route-1	Route-2
Mother Ship	5,300 TEU	5,300 TEU
Shipping duration	33 days	29 days
Staying Time	4.00 days	2.55 days
Avg. Speed	15 Knot	15 Knot
Fuel Consumption	3,275 tons	2,911 tons
Feeder Ship	n/a	1,000/2,000/3,000 /4,000TEU

4.3. Result of Applying the Evaluation Model

As a result of analysis applying the evaluation model by 2 objective routes, the cost by item was appeared to be as Table 5.

Table 5: Evaluation Results per Items (Unit : 1,000 USD)

Items	Route-1(a) TSN-PUS-LGB-OAK	Route-2(b) PUS-LGB-OAK	Cost Differences (b-a)
Harbor fees(1)	91	37	-54(-59.3%)
Fixed Cost during Shipping(2)	270	240	-30(-11.1%)
Fixed Cost during Staying(3)	21	8	-13(-61.9%)
Fuel Cost(4)	1,966	1,747	-219(-11.1%)
Incentive(5)	3	3	0(0%)
Handling(6) :1,000TEU	599	730	+131 (+21.9%)
Handling(6) :2,000TEU	842	1,089	+247 (+29.3%)
Handling(6) :3,000TEU	1,084	1,452	+368 (+33.9%)
Handling(6) :4,000TEU	1,327	1,816	+489 (+36.9%)

5. INTERPRETATION OF RESULT AND COUNTERPLAN

5.1. Interpretation of Results

The results of economy evaluation according to feeder sizes by scenario were arranged as Table 6 based on Table 5. Namely, aggregation of (1) + (2) + (3) + (4) – (5) + (6) of Table 5 may obtain the result of (7) by feeder size of Table 6

2 scenarios based on Table 6 could be shown by graph as Figure 10. Namely, operating feeders between TSN and PUS as Route-2 is more economical than directly calling at TSN as Route-1 when the container

cargo volume is 1,000TEU or 2,000TEU. On the other hand, a direct calling at TSN and PUS is more economical when the container cargo volume exceeds 3,000TEU at side of shipping company.

Table 6: Evaluation Results per Feeder Ship (Unit : 1,000 USD)

Feeder Ship	Route-1(a) TSN-PUS-LGB-OAK	Route-2(b) PUS-LGB-OAK	Cost Differences (b-a)
1,000TEU(7)	2,944	2,759	-185(-6.3%)
2,000TEU(7)	3,208	3,118	-90(-2.8%)
3,000TEU(7)	3,472	3,481	+9(+0.0%)
4,000TEU(7)	3,736	3,845	+109(+2.9%)

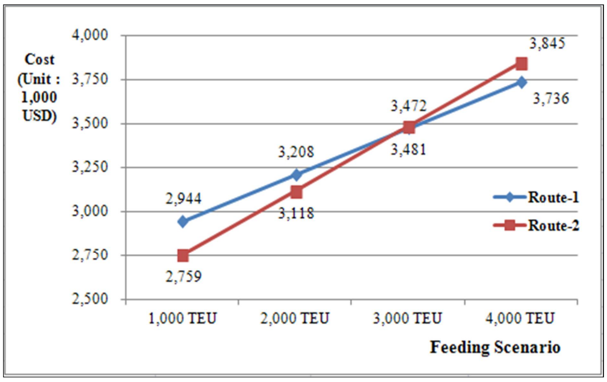

Figure 10: Cost Graph per Scenario

5.2. Counterplan

For the competitiveness of transshipment based container port, the weight of export and import containers of domestic enterprises is important but the competitiveness of port mostly depends on how much they could attract the transshipment cargo volumes of neighbor ports. Thus, a counterplan to maintain the competitiveness in terms of port operating agency and shipping company could be investigated as follows:

First, the transshipment based port operating agencies, for example, government agency or Port Authority under Government shall provide a policy providing a strategic service with which shipping company shall not move their cargos to neighbor ports. According to IMP (2009), the fuel cost which takes the biggest weight out of operational cost of shipping company could be saved by 20% if sailing speed is reduced by 10%. So, they shall reconstruct the ship sail in slow speed. If the symptom of slow steaming by shipping company is found, we need continuously to monitor the shipping liner to choose “Route 1” instead of ”Route 2” .

Furthermore Port Authority has to considering install the fueling facilities which may provide the fuel at cheaper price than those in neighbor ports (Nam, Song and Kim 2006). In other aspect, they need to operate the cargo handling system strategically in order to offer the cheaper cargo handling price. Further, they also need to maintain the docking and storage facilities which may save the waiting time in aspect of service because such systems and services, in turn, may bring an effect to lower the fixed costs of shipping companies by raising the ship usability of shipping companies.

According to Lee and Chang (2011), it was found out that when H shipping company operated the ships at slow steaming of economical speed by adding a ship to 9 ships from 8 ships in Asia-Europe sea route in 2008, the saving effect of sailing cost according to fuel cost saving was bigger than the increase of fixed cost according to additional charterage in case the fuel price is over USD200/ton, HFO average price.

In addition, in aspect of shipping company, they need to prepare and operate a decision making system whether to maintain a direct calling or feeder transportation according to size of feeder cargo volume by closely reviewing the cost system such as the service cost and the fuel cost of transshipment port and neighbor ports. Through this, an implementation of a strategy to select the competitive ports and to operate the ships at slow steaming for saving the fuel shall be important.

The economy evaluation model developed and presented by this study could be utilized as a decision making tool to maintain the optimal service in terms of economy and select the optimal calling ports in order to keep the competitiveness of port operating agencies or shipping companies which operate the ships.

6. CONCLUSION

The world 10 big ports based on container cargo handling volume are concentrated in East Asia container routes and the container handling capacity of each port is rapidly changing. Since the attraction of transshipment cargo volumes between the neighbor ports is directly related to survival and maintaining the competitiveness, such changes are the most significant and interesting matters. Thus, it is very important to decide which port as a transshipment port at the side of port operating agency and shipping company.

This paper developed a model which evaluates the economy for the container routes based on financial data and carried out an economic analysis applying such model to the container routes between PSU and America in East Asia.

According to result of economic analysis, as a result of analyzing the economy between the route which uses TSN as a transshipment port from PUS and a route which uses PSU, TSN, LGB and OAK as direct calling ports, direct calling at PUS and TSN was more economically advantageous in case the transshipment cargo volume at TSN is handled at 3,000TEU ship.

This study also presented a strategic alternative concerning the method to maintain the competitiveness of shipping company utilizing the calculation result by item of this economy evaluation model based on such results. As seen above, applying the economy evaluation model to the container routes shall be helpful for implementing the reasonable and prompt decision making.

Besides, it is, above all, very important to secure the data used as input variables such as harbor fee, cargo handling system and fuel cost timely in order to obtain the correct result from this economy evaluation model.

The economy evaluation model in this study was developed using an offline tool but it shall be possible to make a decision more promptly if the future study establishes an economy evaluation model in online system and utilizes it applying the most recent data in real time. Further, it could be utilized quite favorably in raising the business competitiveness of port operating agencies and shipping companies.

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AUTHORS BIOGRAPHY

Nam Kyu Park received his Ph.D. from department of Shipping Management, Korean Maritime University. He is currently teaching at department of Port Logistics, in Tongmyong University and Port Logistics Industrial Research director. His research focuses on Port Modeling, Port-MIS, SCM and distribution management. E-mail: nkpark@tu.ac.kr

Sang Kook Park received his Ph.D. from department of IT policy & management in Soongsil University. He is a researcher of Hanwha S&C. His research focuses on Simulation Modeling, Economy Evaluation, Financial Policy, System Design and Information Strategy.
E-mail: parksangkook@daum.net