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EVOLVING SHORT-SEA CONTAINER NETWORKS IN EAST ASIA -IMPLICATIONS FROM DIRECT AND TRANSSHIPMENT SERVICES-

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Abstract: This study primarily focuses on 1) shipper's route choice preference among various short-sea container routes, 2) historical trends of cargo movement and resulting patterns of the short-sea container network structure, and 3) possible solutions to achieve a balance between demand scale and price strategy in the network, in the East Asian region. Firstly, trade-offs between transshipment and direct services are identified and measured through multinomial logit analysis using the latest container cargo flow data originating from and destined for Japan in 2003. Secondly, evolution in the structural change of emerging direct and pendulum routes[1] (Japan-Korea-China) is summarized. Based on the above quantitative and qualitative analyses, the paper finally presents key policy implications for the future prospects. Findings of this study are expected to make practical policy contributions towards resolving weaknesses inherent in hub-network structure by realizing direct and pendulum routes for the regional short-sea container network.

Key Words: Water Transportation, Transportation Demand Analysis, International Logistics

1. INTRODUCTION

A wide variety of manufacturing industries has been extending internationally integrated production system in the vital East Asian region since 1990's. Since then the intra-East Asia trade volume has also been rapidly increasing. A key factor of greater prosperity of this region heavily depends on transportation system capable of facilitating the efficient movements of goods and services and providing greater accessibility to the resources and markets (Lee and Kim, 2002). When looked at maritime shipping network, we can see newly emerging extremely large container vessels tending to limit the number of calling ports in order to fully utilize their capacity. Both container carriers and port terminal operators have rushed into an endless competition of scale expansion. Consequently, Busan and Kaoshiung, two of the world busiest ports, have emerged in this region, attracting the container demand around the neighboring countries by extending their feeder service network so as to cover one of the world's key manufacturing centers. As a network structure combining major container routes with 6,000 TEU-class vessels and regional feeder routes with 200-500 TEU-class vessels has been gradually evolving, regional short-sea routes have excessively concentrated in such mega-ports. As a result, detour transport through transshipment became inevitable even on short-sea shipping between the neighboring countries such as Japan and China.

[1] Pendulum route denotes a route where one container vessel moves like a pendulum on two different feeder routes linked through one hub port in the middle.

High value-added cargo such as both finished and half-finished products, involved in the integrated production system, may strongly require a swift and reliable transport. Consequently, shippers often prefer direct services to transshipment services especially on short-sea shipping, in order to minimize a risk of delay, longer transport time and cargo damages. While extending their regional short-sea network, container carriers have developed a variety of short-sea routes which might fall in one of the following categories; 1) direct routes linking origin and destination ports directly (direct services), 2) feeder routes linking both origin and destination ports with hub-port respectively (transshipment services), and 3) pendulum routes via hub-port (pendulum-direct services). However, transshipment services may maximize container carriers' profit but may not always satisfy the shippers. A significant advantages of the pendulum-direct services may benefit both carriers and shippers by saving transshipment costs and reducing transshipment risks. As a result, pendulum routes (Japan-Korea-China) have just swiftly emerged in the Japan-China trade market in the year 2004.

2. CONCENTRATING MARITIME CONTAINER NETWORKS

World container throughput had almost tripled in the last twelve years and reached 266 million TEUs in 2002. The world top six busiest ports in 2002 are the East Asian ports surrounding China, which accounts for 26% of the world container throughput (see Table-1). Container movements have been still concentrating in the East Asian region, together with the integrated production system being extended there. Intra-regional trade values of the East Asian region had also increased its share by 10% in the last ten years, and reached approximately 35% in 2003 (Fujita, 2004). Along with this, inter-regional and intra-regional container movements relating to the East Asian region account for 29% and 24% respectively of the world container movement in 2002 (Kado, 2004).

Table-1 Top Ten World Container Throughput by Port in 1990, 2000, and 2002

(Unit: Million)

Rank	1990		2000		2002	
	Port	TEU	Port	TEU	Port	TEU
1	Singapore	5.2	Hong Kong	18.1	Hong Kong	19.1
2	Hong Kong	5.1	Singapore	17.0	Singapore	16.8
3	Rotterdam	3.7	Busan	7.5	Busan	9.4
4	Kaoshiung	3.5	Kaoshiung	7.4	Shanghai	8.6
5	Kobe	2.6	Rotterdam	6.3	Kaoshiung	8.5
6	Busan	2.3	Shanghai	5.6	Shenzhen	7.6
7	Los Angeles	2.1	Los Angeles	4.9	Rotterdam	6.2
8	Hamburg	2.0	Long Beach	4.6	Los Angeles	6.1
9	NY/NJ	1.9	Hamburg	4.2	Hamburg	5.4
10	Keelung	1.8	Antwerp	4.1	Antwerp	4.8
World Total		85.6		225.3		266.3

Source) Containerisation International Yearbook 1992, 2002, 2004

By looking at domestic share of the busiest container port in each country, share variation of different countries can be observed. This may reflect their geographical situation and port development policy. In many of top ten countries, container cargo largely concentrates in the busiest port in the country, showing domestic share of 60-80% (see Table-2). Although U.S.

and China show relatively low domestic share of 20-35%, reflecting geographical features of huge land area of the countries, Japan only shows just lower domestic share of 20% compared to U.K. (39%) and Italy (38%) of the similar geographical features i.e., island or peninsula.

Table-2 Top Ten World Container Throughput by Country in 2002

Rank	Country	TEU (Million)	World Share (%)	Busiest Port in the Country	TEU (Million)	Domestic Share (%)
1	China	55.7	20.9	Hong Kong	19.1	34.3
2	U.S.A.	29.7	11.1	Los Angeles	6.1	20.5
3	Singapore	17.0	6.4	Singapore	16.8	98.8
4	Japan	13.5	5.1	Tokyo	2.7	20.0
5	Taiwan	11.6	4.4	Kaoshiung	8.5	73.3
6	Korea	11.5	4.3	Busan	9.4	81.7
7	Germany	9.1	3.4	Hamburg	5.4	59.3
8	Italy	7.9	3.0	Gioia Tauro	3.0	38.0
9	Malaysia	7.5	2.8	Port Kelang	4.5	60.0
10	U.K.	7.1	2.7	Felixstowe	2.8	39.4
World Grand Total		266.3	100.0	-	-	-

Source) Containerisation International Yearbook 2004

Japan's multiple major port system including Tokyo, Yokohama, Nagoya, Osaka and Kobe has been established due to the multiple-core concept of the comprehensive national land development strategy. Therefore, Japan's service quality-oriented shippers of high value-added products may usually choose frequent direct services available in the multiple major ports, in spite of additional land transport costs incurred. Hence, cost-oriented shippers tend to choose transshipment services at the neighboring huge hub-ports such as Busan and Kaoshiung, by taking more economical feeder routes available at ports in the vicinity. Those feeder routes having extended all over Japan since 1990's, made more cost-efficient transport possible, and thereby maintained their competitiveness by replacing costly land transport with less-costly maritime transport.

On the other hand, strategic location of a hub port is more important than other factors such as port capacity and productivity for the intra-regional trade within relatively short distance (200-1,600 nautical miles) in North East Asia (Ahn and Jun, 2002). Accordingly, short-sea shipping services among Japan, Korea and China have evenly increased and reached 200 (weekly frequency) for Japan-Korea, 207 (weekly frequency) for Korea-China, and 276 (weekly frequency) for Japan-China in 2002 (Wang, 2002).

3. MARITIME CONTAINER FLOWS TO / FROM JAPAN IN 2003

Japanese Ministry of Land, Infrastructure and Transport (MLIT) has conducted "All Japan international maritime container flow survey" every five years since 1970. The survey was originally designed to illustrate hinterland and foreland i.e., trading partners. It also covers true origin of export containers and true destination of import containers to/from Japan. As transshipment services get more and more popular, information concerning transshipment ports are additionally obtained by the survey, which enables us to trace and analyze door-to-door flow of containers. Shipper's route choice preference among transshipment and direct services can be analyzed by using this dataset.

3.1 Data Profile

All international maritime container cargo to/from Japan was surveyed throughout one month in October, 2003. Questionnaires were delivered to all of the customs agents throughout the country and filled up by the agents. Monthly trade value covered by the survey accounts for 83.4% of the true monthly trade statistics. Key information were collected by the survey, concerning shipper's place, vanning place, loading port, transshipment port (if necessary), discharging port, and consignee's place. Container flows covered by the survey are illustrated in Figure-1. Since level of service (LOS) information such as transport cost, transport time and frequencies are not covered by this survey, such information needs to be independently prepared by the authors.

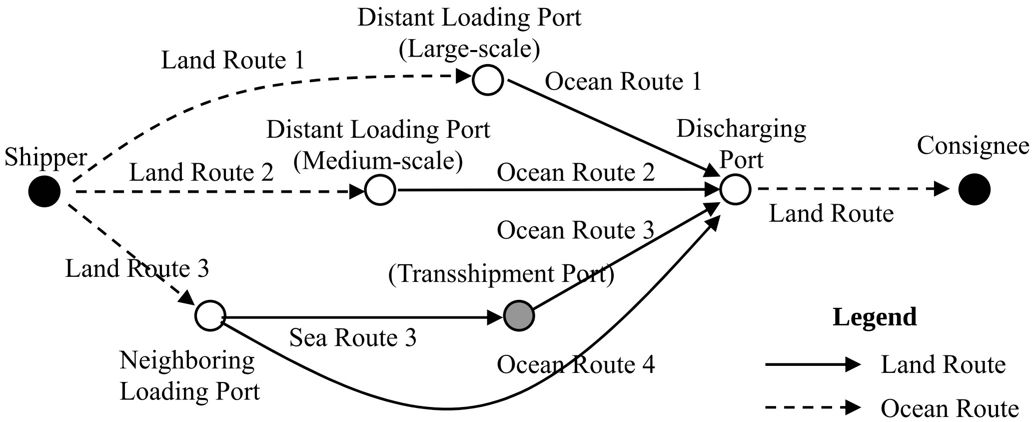

Figure-1 Illustration of Container Flow between Origin and Destination in Case of Export

3.2 Domestic Hinterland and Trading Partners of Container Cargo

Domestic land transport distance of international container cargo to/from Japan's ports has been getting shorter and shorter, because of comparatively high land transport costs. Export container cargo within 100 km of land transport distance to/from domestic ports accounts for 74.5% of the total. On the other hand, import container cargo under the same condition accounts for 82.1% of the total. Since the more value-added products are included in the export cargo, the longer land transport distance appears in the export.

Asia's share as a trading partner to the total of Japan's international maritime container cargo was 54% in 1993, and had increased up to 68%, accounting for approximately two third of that in 2003. When focusing on China as a trading partner, its share to the total was 14% in 1993, and had rapidly increased up to 34%, accounting for approximately one third of that in 2003 (MLIT, 2004). China is becoming more and more important trading partner for Japan.

3.3 Direct Service vs. Transshipment Service

Although Kobe used to play a role of transshipment port in the East Asian region in the 1980's, it has lost its role to a certain extent after Hanshin-Awaji earthquake disaster. Since then, Japan's international maritime container cargo especially trans-pacific and European cargo had gradually been transported through transshipment service at the neighboring hub ports in the East Asian region. Transshipped container cargo ratio of 2.1% to the total in 1993 had increased 5.3% in 1998, and accelerated its speed and reached 15.5% in 2003. This implies that network structure combining main routes and feeder routes has dramatically changed in the East Asian region in the last decade. We can see that transshipment service become inevitable even for the short-sea shipping users in Japan, once above-mentioned network structure dominates in the East Asian region.

4. TRANSSHIPMENT SERVICE AND SHIPPER'S PREFERENCES

4.1 Conceptual Structure of Shipper's Route Choice (Direct vs. Transshipment Services)

A very limited number of research works have been conducted on the shipper's choice preferences over land and ocean route of international container cargo. Malchow and Kanafani (2001), and Nir, Lin and Liang (2003) analyzed port selection behabiour of shippers. However, they did not deal with transshipment as an alternative route in the research. Transshipment container transport has become more and more popular throughout the world in the last decade. Therefore, we place an emphasis on analyzing shipper's preference when they choose a specific route among alternatives taking account of transshipment services.

We put forward a hypothesis that shippers take into account three factors i.e., transport cost, time and risk, while choosing the most favorable route among several alternatives available on the specific OD-pair (see Figure-2). Risk factor is defined as a part of transshipment risk such as cargo damage and delayed delivery. Then we can measure and evaluate trade-offs between direct service without risk and transshipment service with risk by applying multinomial logit analysis in shipper's route choice problem.

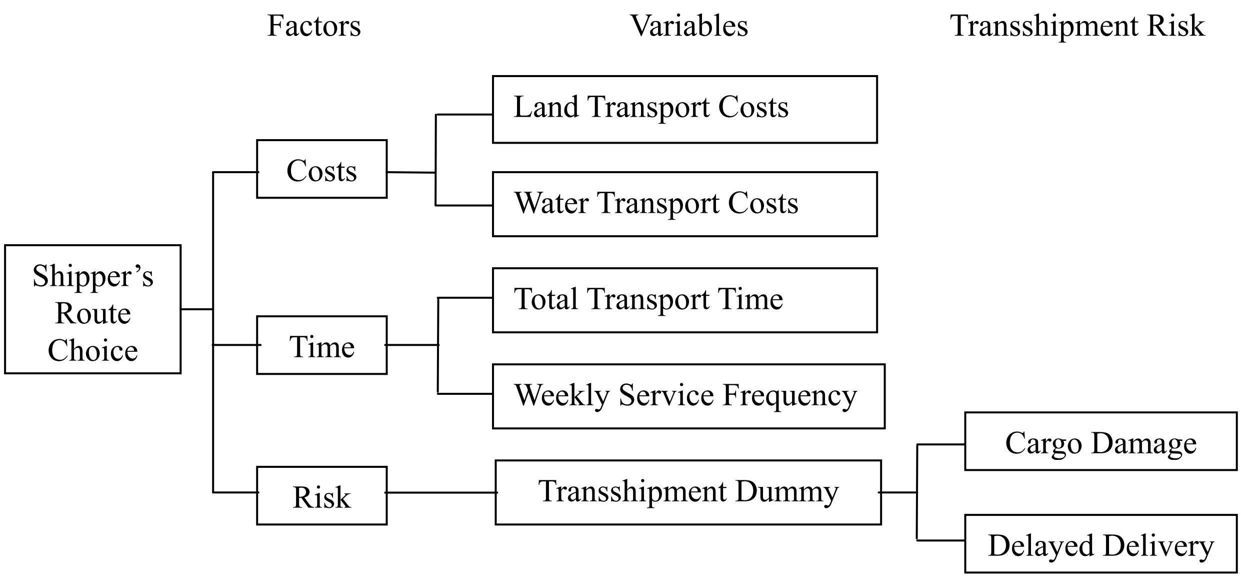

Figure-2 Conceptual Structure of Shipper's Route Choice (Direct vs. Transshipment Services)

4.2 Multinomial Logit Model of Shipper's Route Choice

Probability P_r of shipper's choosing route r can be represented as in the equation (1), by defining that deterministic utility component of route r as represented in the equation (2). Explanatory variables are land transport cost (*LTC*), water transport cost (*WTC*), total transport time (*TTT*), service frequency (*FREQ*) and transshipment dummy (*TS*).

$$P_r = \frac{\exp V_r}{\sum \exp V_r} \tag{1}$$

$$V_r = \beta_1 LTC_r + \beta_2 WTC_r + \beta_3 TTT_r + \beta_4 FREQ_r + \beta_5 TS_r \tag{2}$$

where

P_r	:	probability
V_r	:	deterministic utility component of route *r*
LTC_r	:	land transport cost of route *r* (ten thousand yen/TEU)
WTC_r	:	ocean transport cost of route *r* (ten thousand yen/TEU)
TTT_r	:	total transport (ocean and land) time of route *r* (day)
$FREQ_r$	:	feeder container frequency of route *r* (services/week)
TS_r	:	transshipment dummy of route *r* (1, 0)
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$	:	parameters of variables

4.3 Level of Service (LOS) Variables

Most important aspect for this analysis is to set up actual transport cost data for LOS variables such as *WTC* and *LTC*. There is considerable difficulty to obtain transport cost data especially for ocean container cargo, because freight level may considerably vary among the shipper's scale of annual volume. In many cases, the larger annual volume makes the freight level lower. Hence, user's benefits are usually measured by transport cost reduction, during cost/benefit analysis. For this purpose, MLIT issued the guideline for conducting cost/benefit analysis by measuring user's benefit (WAVE, 1999). In this guideline, linear relationship between basic ocean transport cost per twenty-foot container and ocean route distance is assumed and determined through data analysis. Similarly, relationship between basic land transport cost and road distance is determined through data analysis in the guideline. However, ocean freight level may vary among different flow situation i.e., export/import and/or major/minor ports. Accordingly, we conducted an interview survey on ocean freight varying among major and minor ports in order to adjust the above-mentioned basic transport cost to the extent possible for model estimation. Typical ocean freight level obtained through interview survey for specific routes and directions are presented in Table-3.

Table-3 Typical Ocean Freight Level between Japan's and World's Selected Ports

(Unit: Ten thousand Yen/TEU)

Representative Route Distance between Tokyo and World Selected Ports		Japan's Selected Port (Kanto Region)		Japan's Selected Port (Kansai Region)	
World Selected Port	(Nautical Mile)	Export	Import	Export	Import
Busan Port	669	2.8	2.8	5.0	5.0
Shanghai Port	1,048	2.9	4.8	6.0	6.0
Kaoshiung Port	1,349	3.3	3.3	5.8	5.8
Hong Kong Port	1,596	3.0	3.0	5.0	5.0
Singapore Port	2,904	4.7	4.7	5.2	5.2
Port Kelang	3,114	6.6	6.6	7.7	7.7
Bangkok Port	2,991	5.8	5.8	6.3	6.3
Los Angeles Port	4,854	32.9	16.5	-	-
Rotterdam Port	11,192	18.3	12.2	-	-

Remarks) Exchange Rate as of December, 2003 is 110Yen/US$

Ocean freight includes various additional charges.

4.4 Estimation Results

We tested several specifications around the basic specification shown in the equations (1) and (2) for both export and import shipper's route choice models. Parameters of all the variables in both models except *TTT* are significant at 99% level, and take expected sign. *TTT* consists of three components i.e., land transport time, ocean transport time, and transit time. Transit time is defined as an inverse of service frequency of specific container route. Since *TTT* and both *WTC* and *LTC* are highly correlated by a nature of cargo transport, multi-collinearity problem appeared in certain specifications when *TTT* and either *WTC* or *LTC* are included together. Accordingly, we excluded *TTT* out of the specification in order to avoid this problem and concluded the most preferred specification (see Table-4).

We also tried to evaluate trade-off relation between transshipment risk and land transport cost by using the estimation result. We define that $MRS_{TS,LTC}$ be Marginal Rate of Substitution (*MRS*) to substitute transshipment risk (*TS*) with land transport cost (*LTC*) represented as in the equation (3), and that $MRS_{FREQ,LTC}$ be Marginal Rate of Substitution to compensate service frequency (*FREQ*) with land transport cost (*LTC*) represented in the equation (4).

$$MRS_{TS,LTC} = -\frac{\partial V}{\partial TS} \Big/ \frac{\partial V}{\partial LTC} = -\beta_5 / \beta_1 \tag{3}$$

$$MRS_{FREQ,LTC} = -\frac{\partial V}{\partial FREQ} \Big/ \frac{\partial V}{\partial LTC} = -\beta_4 / \beta_1 \tag{4}$$

Table-4 Estimation Results of Shipper's Route Choice Multinomial Logit Model

Parameters (Variables)	Export Model	Import Model
β_1 (LTC_r)	-0.1005536 **	-0.2073518 **
β_2 (WTC_r)	-0.03403937 **	-0.05738792 **
β_4 ($FREQ_r$)	0.0113695 **	0.01665333 **
β_5 (TS_r)	-0.6277754 **	-0.55135951 **
Number of observations	746	697
Adjusted likelihood ratio ρ^2	0.3034	0.2761

Remarks) ** indicates statistically significant at 99% level

$MRS_{TS,\ LTC}$ are calculated as 62 (thousand yen/TEU / transshipment) and 27 (thousand yen/TEU / transshipment) for export and import cargo respectively. This implies that shippers are willing to pay up to 62 thousand yen/TEU of land transport cost (*LTC*) to access any ports where direct service is available so as to avoid transshipment risk for export cargo. On the other hand, shippers are willing to pay at most only 27 thousand yen/TEU of land transport cost (*LTC*) to access any ports where direct service is available for Import cargo, otherwise they are to choose transshipment services at ports in the vicinity. The fact that cargo values of export and import containers are 295 and 146 thousand yen/ton respectively (MLIT, 2004), further supports this result. Export container cargo doubles as much valuable as import container cargo. This preference can be understood as the fact that export cargo includes far more valuable than import cargo in Japan.

Similarly, $MRS_{FREQ,\ LTC}$ are calculated as 1.1 (thousand yen/TEU / weekly frequency) and 0.8 (thousand yen/TEU / weekly frequency) for export and import cargo respectively. Suppose that both a major port and minor port are available to the shippers in a certain region, providing forty five (45) and five (5) China direct services per week respectively, what would shippers choose? Shippers would pay up to 44 (=1.1*(45-5)) thousand yen/TEU of land transport (LTC) to access major port where more frequent direct services are available for export cargo. On the other hand, shippers would pay up to 32 (=0.8*(45-5)) thousand yen/TEU of land transport (LTC) to access major port with frequent direct service available for import cargo. This implies that scale economy in service frequency considerably benefits major port providing frequent services.

5. EVOLVING FEEDER CONTAINER NETWORKS

Japan-Korea feeder container routes cover sixty one (61) major and minor Japanese ports in 2004. There exist twenty one (21) minor ports where only Japan-Korea feeder route is available due to a small demand of their hinterland (see Figure-3). Japan-China container cargo to/from those hinterlands may need to be transshipped from Japan-Korea feeder route to Korea-China feeder route at Busan port. Since additional costs are imposed by transshipment, shippers prefer direct services to transshipment services. Moreover, they usually prefer direct service so as to avoid transshipment risk (see Figure-4). However, both Japan-Korea route and Japan-China route could not be viable simultaneously at the above-mentioned twenty one (21) ports, because of the smaller demand of the hinterland. As a result, for those ports, detour transport through transshipment became inevitable even on short-sea shipping between the neighboring countries such as Japan and China.

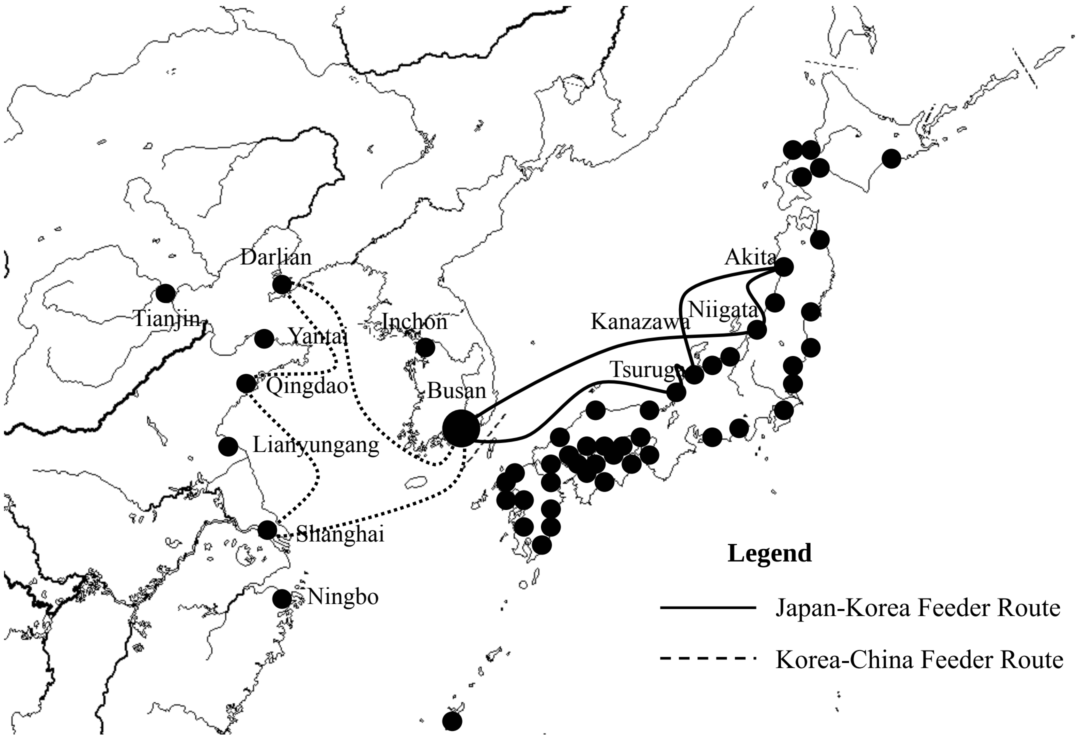

Figure-3 Typical Feeder Routes linking Japanese Ports and Chinese Ports with Busan Port

Minimum requirements of the annual demand for viable weekly services for Japan-Korea route and Japan-China route are estimated as 3,000 TEUs and 4,500 TEUs respectively, based on the 2002 container throughput statistics and port-calls on each route schedule. Multiple international container routes are available and viable at the remaining twenty nine (29) minor ports, which command comparatively the larger demand of the hinterland.

Emergence of pendulum routes (Japan-Korea-China), which makes direct services viable for both Japan-Korea cargo and Japan-China cargoes with the smaller demand, may become an important milestone for the future networking in the East Asian region (see Figure-5). Although pendulum routes (Japan-Korea-China) covered only thirteen (13) minor ports at the beginning of 2004, they have rapidly increased their coverage of up to thirty four (34) minor ports in just ten (10) months. Weaknesses inherent in hub-network structure can be resolved by realizing pendulum routes (e.g., Japan-Korea-China) for the short-sea container network in this region.

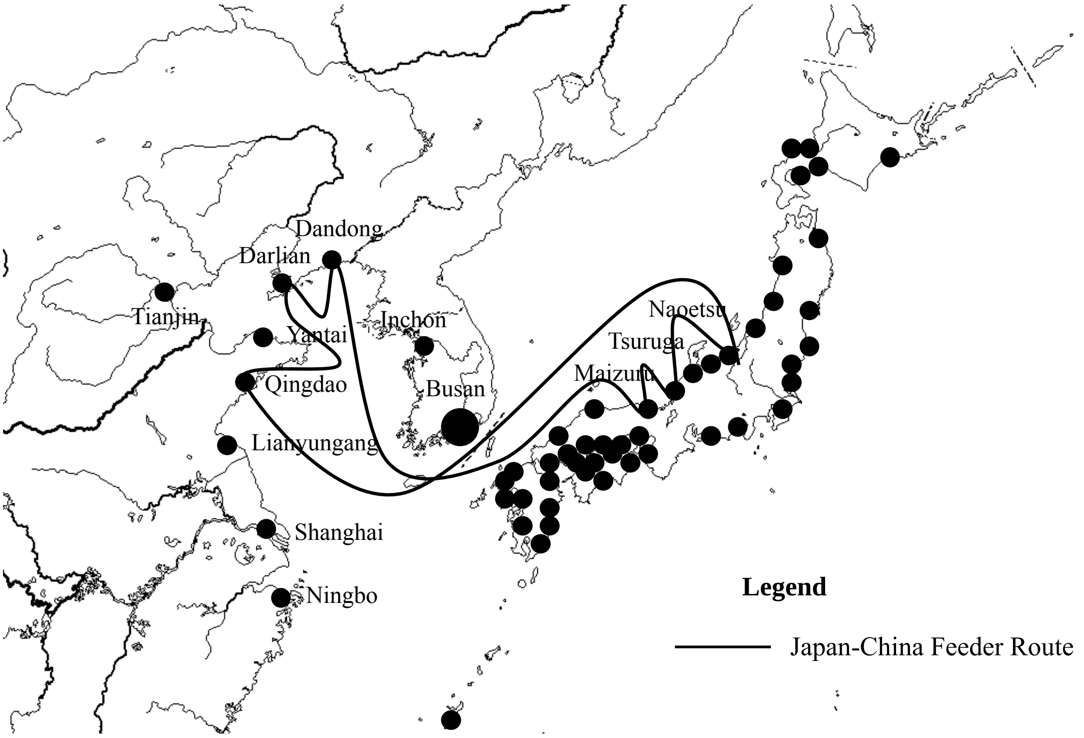

Figure-4 Typical Direct Route linking Japanese Ports and Chinese Ports Directly

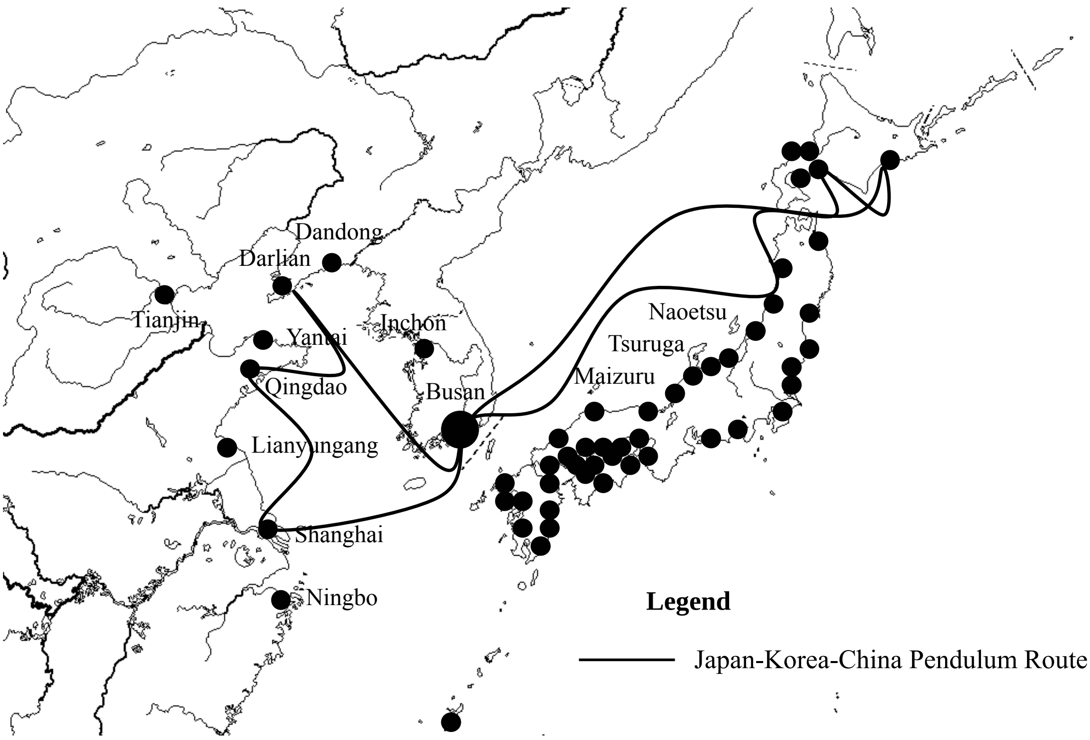

Figure-5 Typical Pendulum Route linking Japanese Ports and Chinese Ports via Busan Port

6. CONCLUSIONS

This study primarily focused on historical trends of cargo movement and resulting patterns of the short-sea container network structure in the East Asian region. There exists a certain volume of Japan-China container cargo transported through transshipment service linking Japan-Korea and Korea-China feeder routes. Shipper's route choice preference among direct and transshipment services were measured and evaluated through multinomial logit analysis. In this context, a significant advantage of the pendulum-direct service may benefit both carriers and shippers by saving transshipment costs and reducing transshipment risks. Furthermore, this pendulum-direct service may become a possible solution to achieve a balance between demand scale and level of services. Minor ports may be able to extend their container network utilizing this service with relatively small scale of demand. Networking strategy combining this service and minor port development may benefit not only in Japan-Korea-China market but also in other market such as Philippines-Taiwan (or Okinawa)-China with the similar geographical situation.

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