IMPACT OF CONSTRUCTION OF AN INTERNATINONAL CONTAINER TERMINAL AT SHANGHAI ON THE CONTAINER CARGO FLOW IN ASIAN PACIFIC REGION

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abstract: In the marine transportation market, government (terminal administrator), a shipping company and a shipper can be regarded as gaming players of so called as Stackelberg Problem of Game Theory. The strategic behavior of these three kinds of players in the container transportation market is formulated as a three level Stackelberg Equilibrium. We provided some computational results based on the practical data of international container cargo movement of Asian countries and analyzed the impact of construction of an international container terminal at Shanghai on the container cargo flow in Asian and Pacific Region.

1.INTRODUCTION

Since 1960's, for the efficiency of loading and unloading, the containerization of international cargo has been moved forward, and now 90 percent of international cargo is container cargo. The container transportation has been the main mode for international trade. Recently, the international container cargo flow is going changes according to economic development of Eastern Asian countries. So the appropriate strategy for management and construction of container terminals is necessary.

China is becoming a great trading country now. In China, the amount of international trade cargo had been increasing at the rate of 31 percent every year on overage from 1985 to 1995. The total handling container cargo of international trade in China reached 4,387,000TEU in 1995. Especially in 1997, Hong Kong handled 12,560,000TEU in 1995 will return to China. Then it is expected that the international container cargo flow will change widely in China container transportation market as well as in Eastern Asia. On this background, construction of an international container terminal in China is required hastily. The port of Shanghai is the largest container port in China and in 1995 ranked at 19th position in the world relying on the total handling container cargo amounted to 1,526,000TEU. The total handing container cargo had been increasing at the rate of 28 percent every year on overage. Considering this situation, the construction of an international container terminal at Shanghai is quite strategic. The state of existing container terminals and those under construction at Shanghai is shown as Table 1 (1996). The port of Jung Gong Gang (J.G.G.), Zhang Hua Bin (Z.H.B.) and Bao San (B.S.) exist. From these data we can understand that large ships can not use Shanghai port, because the draft of every existing container berth is not enough deep. Therefore, the cargo for North America and Europe from China has to be transported to the other large ports in Asia shown as Figure 1.

Table 1. Present Sate of Container Terminal of Shanghai Port

District	Draft (m)	Length (m)	Number of Berth	Handling Ability (TEU/Mon.)	Total Handling Ability (TEU/Mon.)	Capacity of Ship (D.W.T)	Capacity of ship Acceptance (Vessel/Mon.)
J.G.G.	−10	750	5	21,600	50,000	16,500	30
Z.H.B.	−10	800	5	43,200	67,000	16,500	50
B.S.	−9.4	700	3	21,600	50,000	15,000	20
W.G.Q.1	−12.5	1,320	4	43,200	67,000	40,000	15
W.G.Q.2	−13	~	10	108,000	166,000	40,000	65
W.G.Q.3	−13	~	4	~	~	50,000	~
W.G.Q.4	−14	11,300	6	~	~	50,000	~

The Wai Gao Qiao (W.G.Q.) container terminal under construction is available to accept larger ships on any route. The construction is divided into four phases. In the first phase of the project, four container berths of 12.5m depth will be constructed and the second phase will construct ten berths of 13m depth. After completion of this project the total handling ability of container cargo will amount to 43,000,000 tonnage in 2020. This enables ships to carry the cargo directly to North America and Europe from Shanghai. Then the cargo flow at the large container port near China such as Singapore, Taiwan, Busan and Kobe etc. will be more or less affected. So it is important to predict the impacts of the construction of an international container terminals at Shanghai on the container cargo flow in Asian and Pacific Region.

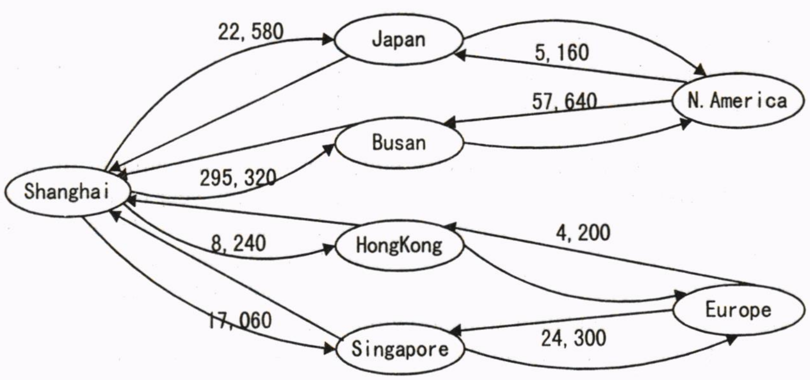

Fig. 1 Present State of Transshipment from Port of Shanghai to N. America and Europe (ton./month)

Kuroda and Yang [b] have proposed a model for Stackelberg Equilibria analysis of container cargo flow. The government, the shipping companies and the shippers can be regarded as the players who behave strategically in the container transportation market. Thus the real world of container cargo movement might be formulated as equilibrium of these three kinds of players as the Stackelberg Problem. We provide some computational results by their model and discuss on the impact of construction of an international container terminal at Shanghai on the container cargo flow in Asian and Pacific Region for the case of liner networks.

2. FORMULATION AS STACKELBERG PROBLEM

2.1 Behavior of Government, Carrier and Shipper

Government has an important role in the marine transportation market because development of container terminal including its location and number of container berth is decided by its policy. This policy will affect directly on the behavior of shipping companies and indirectly on shippers. Government will make its policy for port development from the viewpoint of national economic growth and the demand tendency of marine cargo transportation. It considers the access and the egress cost to and from the port from the viewpoint of all shippers of the country, and at the same time, it considers the idling cost of container berths from the viewpoint of the efficiency of the investment. For efficiency of port investment, the government must take into account of behaviors of shipping companies and shippers. It is, in the present approach, assumed that the government has complete information about the optimal behaviors of shipping companies and shippers in the international container transportation market. From this reason the government can be regarded as the superior player to both of the shipping company and the shipper.

Shipping companies entering the international container transportation market may compete with each other to acquire the greater share of the market by providing strategically their own transportation service. However, in the real world they make alliances to avoid over-competition and keep almost the same service level. There are some non-allied shipping companies who offer a little bit lower fees than the allied companies. Therefore detailed analysis should consider the competition among these shipping companies. In spite of existence of this competition, a loose alliance among all the shipping companies is still observed because they intend to coexist in the market. For this reason the present paper assumes one shipping company in the market. In this paper it is called a carrier. The carrier decides the liner route and the ship size and the scheduled service frequency at each route. This carrier's strategy depends upon the governmental strategy about container terminal construction and its management. On the other hand the carrier has complete information about the optimal behavior of shippers. From this reason the carrier can be regarded as the superior player to shippers but inferior to the government. It should be noticed that the forwarder has also important role in the cargo transportation market because they influence inland cargo transportation. However the present analysis assumes that the optimal inland route to and from the ports from and to every inland shipper is a prior given. Thus the forwarder is not explicitly taken into consideration in the present analysis.

Shippers may consider the total transportation cost including the inland transportation cost, marine transportation cost and the total transportation time because time loss will reduce the value of cargo. Therefore in order to reduce the time loss, the shippers prefer the port where the service of liner container shipping is much more frequent. For the same reason, shippers dislike the port, which is too much congested because queuing time may also decrease the value of cargo even if the frequency service is much more scheduled than the others. Taking these factors into consideration, the shippers choose the optimal port and carrier. Thus a shippers' strategy can be considered as port choice and cargo volume allocation to the domestic ports.

Taking into account the strategic behaviors of these three kinds of players, it can be said that they play the game at the container transportation market under the condition that the quality of information hold by each player is different. In the present paper, we assume the government strategy is already known. The strategic behavior of a shipping company and a shipper in the container transportation market is formulated as a two level Stackelberg Epuilibrium.

2.2 Premises and Assumptions

In the present analysis followings are premised and assumed.
1) Only world trade container cargo is considered.
2) OD zones of container cargo are appropriately divided corresponding to the purpose of analysis, and denoted by k. $(k,=1,2,...,N)$.
3) Each of foreign country zones except Japan is assumed to have its own representative world trade port.
4) Each of foreign zones is considered as the hinterland of the representative port. Then, if the hinterland of a specific port covers more than two countries, the transshipped cargo is implicitly considered.
5) OD distribution of the container cargo between the zone k and k' is assumed to be a priori given, and denoted by $C_{kk'}$ and, if necessary, symbols I and E are superscribed for import and export.
6) World trade container port is denoted by i, l, j $(i,l,j=1,2,...,M)$.
7) All container ships considered in the paper are liner and can route directly two ports or can drop at one more port on each route. The former is called as "direct service " and the latter is called "past service ".
8) Every container berth of any port is available for any route if ships can moor.
9) Total capacity of container berths of each country must be greater than equal to the necessary number to handle her total volume of imported and exported cargo. This is equivalent, in other words, to the constraint that the total number of container ships assigned to each country should be greater than the necessary number to carry her total imported and exported container cargo. This assumes that there is no infinite queue of cargo at ports.
10) Competition among ship companies is not taken into account. Then, only one carrier is assumed. However, competition among ship companies is implicitly considered by load factor.
11) Carrier aims to maximize his net revenue considering cargo tariff and shipping expense.
12) Capacity of total container ships assigned to a specific route is at least great than the total transportation demand for the route. This assumes all container cargo per unit period should be transported in the period.

13) Shipper allots his cargo to minimize the total cost including the inland and the marine transportation cost, the ship waiting loss and the marine transportation time loss of cargo. Inland transportation time loss of different route is assumed to be negligibly small.
14) Inland transportation is considered only for Japanese shippers. Thus the overseas shippers' behavior is neglected.

2.3 Behavior of Carrier

Carrier aims to maximize his revenue by carrying larger volume of cargo as possible and minimize the ship expenses, the cargo handling cost and the port charges. His objective function and constraints are formulated as Eq. (1) and Eq. (2) and (4) are the constraints. Eq. (3) means that the carrier can not assign the frequency of liner vessel more than the capacity of the port i and Eq. (4) shows the condition that the carrier must carry all the world trade container cargo of the country π by the ships assigned to that country.

$$SNR = RF - (CT + CP + CM + CB + CL) - (CF + CC + CS) \rightarrow MAX \tag{1}$$

sub. to

$$Y_{ij}^L,\ Y_{ilj}^L \geq 0 \qquad \forall i, l, j, L \tag{2}$$

$$z_i^L \leq Z_{i0}^L + Z_i^L \qquad \forall i, L \tag{3}$$

$$\sum_{i \in I_\pi} \{\lambda_{ij}^L cp^L Y_{ij}^L + \sum_{l,j \neq i} (\lambda_{il}^L + \lambda_{lj}^L) \cdot cp^L \cdot Y_{ilj}^L\} \geq \sum_{k \in K_\pi} \sum_{k' \neq k} (C_{kk'}^E + C_{k'k}^I) \qquad \forall \pi, L \tag{4}$$

and
the optimal behavior of shippers.

In Eq.(1), RF is the total revenue from the cargo tariff, CT is the tonnage tax for vessel size L which must be paid every time of entrance of port, CP is the entrance charge for vessel size L, CM is the pilot charge, CB is the berth charge for mooring time and vessel size, and CL is the cargo handling charge. These costs are called as the port charge. CF, CC and CS are the fuel cost, the crew cost and the redemption cost of vessels, respectively. These costs are called as ship cost. Each term of Eq. (1) is given by Eq. (5) through Eq.(12).

$$RF = \sum_{i \in I_\pi} \sum_{j \notin I_\pi} f_{ij} [\sum_{k \in K_\pi} \sum_{k' \notin K_\pi} \{X_{kijk'} + \sum_{l \neq j \notin I_\pi} (X_{kiljk'}^{(1)} + X_{kiljk'}^{(2)})\}] \tag{5}$$

$$CT = \sum_L \sum_i \sum_j GT^L \cdot (pt_i + pt_j) Y_{ij}^L + \sum_L \sum_i \sum_l \sum_j GT^L \cdot (pt_i + 2pt_l + pt_j) Y_{ilj}^L \tag{6}$$

$$CP = \sum_L \sum_i \sum_j GT^L (pf_i + pf_j) Y_{ij}^L + \sum_L \sum_i \sum_l \sum_j GT^L (pf_i + 2pf_l + pf_j) Y_{ilj}^L \tag{7}$$

$$CM = \sum_L \sum_i \sum_j GT^L (pc_i^L + pc_j^L) Y_{ij}^L + \sum_L \sum_i \sum_l \sum_j GT^L (pc_i^l + 2pc_l^L + pc_j^L) Y_{ilj}^L \tag{8}$$

$$\begin{aligned} CB = & \sum_L \sum_i \sum_j GT^L \left\{ v_i^L (ht_i^{L(i,j)} + \tau_i^L) + v_j^L (ht_j^{L(i,j)} + ht_l^{L(i,j)} + \tau_j^L) \right\} Y_{ij}^L \\ & + \sum_L \sum_i \sum_l \sum_j GT^L \left\{ v_i^L (ht_i^{L(i,l)} + \tau_l^L) + v_l^L (ht_l^{L(i,l)} + ht_l^{L(l,j)} + \tau_l^L) + v_j^L (ht_j^{L(l,j)} + \tau_j^L) \right\} Y_{ilj}^L \end{aligned} \tag{9}$$

$$\begin{aligned} CF = & \sum_L \sum_i \sum_j \left\{ fc^{L(1)} 2st_{ij}^L + fc^{L(2)} (ht_i^{L(i,j)} + ht_j^{L(i,j)} + \tau_j^L) \right\} Y_{ij}^L \\ & + \sum \sum \sum \sum \left\{ fc^{L(1)} (2st_{iil}^L + 2st_{lj}^L) \right. \\ & \left. + fc^{L(2)} (ht_i^{L(i,l)} + ht_l^{L(i,l)} + ht_l^{L(l,j)} + ht_j^{L(l,j)} + \tau_i^L + 2\tau_l^L + \tau_j^L) \right\} Y_{ilj}^L \end{aligned} \tag{10}$$

$$CC = \sum_L \sum_i \sum_j cc^L (ct_{ij}^L Y_{ij}^L / 365) + \sum_L \sum_i \sum_l \sum_j cc^L (ct_{ilj}^L Y_{iljk}^L / 365) \tag{11}$$

$$CS = \sum_L \sum_i \sum_j cs^L \left(ct_{ij}^L Y_{ij}^L / 365 \right) + \sum_L \sum_i \sum_l \sum_j cs^L \left(ct_{ilj}^L Y_{ilj}^L / 365 \right) \tag{12}$$

where

z_i^L : necessary number of berth accepting the frequency of ships of size L at the port i, and is given by

$$z_i^L = \left\{ \sum_{j \in J_G} \left(ht_i^{L(i,j)} + \tau_i^L \right) \cdot Y_{ij}^L + \sum_{l \in L} \sum_{j \in J_G} \left(ht_l^{L(i,l)} + \tau_i^L \right) \cdot Y_{ilj}^L \right.$$
$$\left. + \sum_{l \in L} \sum_{j \in J_G} \left(ht_i^{L(l,j)} + \tau_i^L + ht_i^{L(i,j)} + \tau_i^L \right) \cdot Y_{lij}^L + \sum_{l} \sum_{j \in J_G} \left(ht_i^{L(l,j)} + \tau_i^{L)} \right) \cdot Y_{jli}^L \right\} / 365$$

Z_i^L : number of newly constructed container berth for ship size L of the port i.

Z_{io}^L : number of existing container berth for ship size L of the port i.

$X_{kijk'}$: volume of " direct cargo "from the zone k to the zone k' transported via the ports i and j.

$X_{kiljk'}^{(1)}$: volume of " call cargo " from the zone k to the zone k' transported via ports i ,l and j.

$X_{kiljk'}^{(2)}$: volume of " transship cargo " from the zone k to the zone k' transported via ports i, l and j.

$Y_{\alpha\beta}^L$: number of frequency of ships directly connecting the ports α and β *(vessels/year)*.

$Y_{\alpha\beta\gamma}^L$: number of frequency of liners connecting the port α and γ via β *(vessels/year)*.

$ht_\alpha^{L(\alpha,\beta)} = \left(\lambda_{\alpha\beta}^L + \lambda_{\beta\alpha}^L \right) \cdot cp^L / u_\alpha^L$ is the cargo handling time at the port α *(day/vessel)*.

$\lambda_{\alpha\beta}^L$: load factor of the liner of size L on the route connecting the ports α and β

cp^L : capacity of the liner vessel of size L *(ton/vessel)*.

τ_α : the staying time at the port α except of the cargo handling time *(day/vessel)*.

$f_{\alpha\beta}$: cargo tariff between the port α and β *(yen/ton)*.

GT^L : gross tonnage of vessel size L.

pt_α : tonnage tax rate at the port α *(yen/gross ton)*.

pf_α : entrance charge rate at the port α *(yen/vessel)*.

pc_α : pilot charge rate at the port α *(yen/vessel)*.

v_α : cargo handling charge at the port α *(yen/ton)*.

fc^L : fuel cost per day of vessel size L *(yen/day/vessel)*.

cc^L : annual crew cost per vessel of size L *(yen/vessel/year)*.

ct_{ij}^L : cycle time of the size L vessel directly routing the port i and j *(day)/vessel)*.

This is given by

$$ct_{ij}^L = \left(ht_i^{L(i,j)} + \tau_i^L + ht_j^{L(j,i)} + \tau_j^L + 2st_{ij}^L \right) \tag{13}$$

ct_{ilj}^L : cycle time of size L vessel routing the port i and j via the port l *(day/vessel)*.

This is given by

$$ct_{ilj}^L = \left\{ \left(ht_i^{L(i,l)} + \tau_i^L + ht_l^{L(i,l)} + \tau_l^L + 2st_{ij}^L \right) + \left(ht_l^{L(l,j)} + ht_j^{L(l,j)} + \tau_j^L + \tau_l^L + 2st_{lj}^L \right) \right\} \tag{14}$$

cs^L : annual redemption cost of the size L vessel *(yen/vessel/year)*.

2.4 Behavior of Shippers

Shippers aim to reduce the total transportation costs as possible. Then, they carefully choose the port and ships to minimize the total cost of the inland transportation cost *TAC*, the marine transportation cost *RF*, and the value decrease of cargo due to time loss *ITL*. Therefore, their objective function and constraints are formulated as Eq.(15) through Eq.(19).

$$\text{Min}=TAC+RF+ITL \tag{15}$$

sub. to

$$X_{kijk'}, X^{(1)}_{kiljk'}, X^{(2)}_{kiljk'} \geq 0 \quad ; \forall k,i,l,j,k' \tag{16}$$

$$\sum_i \sum_j X_{kijk'} + \sum_i \sum_l \sum_j \left(X^{(1)}_{kiljk'} + X^{(2)}_{kiljk'} \right) = C_{kk'} \qquad \forall k,k' \tag{17}$$

$$\sum_k \sum_{k'} X_{kijk'} + \sum_k \sum_{k'} \sum_l \left(X^{(1)}_{klijk'} + X^{(2)}_{klijk'} + X^{(1)}_{kijlk'} + X^{(2)}_{kijlk'} \right) \leq \sum_L cp^L \cdot \lambda^L_{ij} \cdot Y^L_{ij} + \sum_L \sum_l cp^L \cdot \lambda^L_{ij} \cdot Y^L_{ijl} + \sum_L \sum_l cp^L \cdot \lambda^L_{ij} \cdot Y^L_{lij} \quad ; \forall i,j \tag{18}$$

$$\sum_k \sum_{k'} X^{(1)}_{kiljk'} \leq \sum_L \lambda^L_{*} \cdot cp^L \cdot Y^L_{ilj} \quad ; \forall i,l,j \; ; \quad \lambda^L_{*} = Min\left(\lambda^L_{il}, \lambda^L_{lj}\right) \tag{19}$$

where

$$TAC = \sum_k \sum_i \sum_{j \neq i} \sum_{k' \neq k} (p^*_{ki} + p^*_{jk'}) \cdot \{ X_{kijk'} + \sum_{l \neq j} (X^{(1)}_{kiljk'} + X^{(2)}_{kiljk'}) \} \tag{20}$$

$$RF = \sum_{i \in I_x} \sum_{j \notin I_x} f_{ij} [\sum_{k \in K_x} \sum_{k' \notin K_x} \{ X_{kijk'} + \sum_{l \neq j \notin I_x} (X^{(1)}_{kiljk'} + X^{(2)}_{kiljk'}) \}] \tag{21}$$

$$\begin{aligned} ITL = & \sum_{k \in N} \sum_{i \in M} \sum_{j \neq i} \sum_{k' \neq k} pc_{kk'} \cdot X_{kijk'} \cdot (1+\eta)^{365/\left(2 \cdot \sum_L Y^L_{ij} + 2 \cdot \sum_L \sum_l Y^L_{lij} + 2 \cdot \sum_L \sum_l Y^L_{ijl}\right) + \sum_L st^L_{ij}/TL} \\ & + \sum_k \sum_i \sum_l \sum_j \sum_{k'} pc_{kk'} \cdot X^{(1)}_{kiljk'} \cdot (1+\eta)^{365/\left(2 \cdot \sum_L Y^L_{ilj}\right) + \sum_L st^L_{il}/TL + \sum_L st^L_{lj}/TL} \\ & + ILT \end{aligned} \tag{22}$$

In Eq.(22), the first term shows the value depreciation of direct cargo, second is that of call cargo, and the third *ILT* means that of the tranship cargo which is given by.

$$ILT = \begin{cases} \sum_k \sum_i \sum_l \sum_j \sum_{k'} pc_{kk'} \cdot X^{(2)}_{kiljk'} \cdot (1+\eta)^{365/m + 365 \cdot (m-1)/n + \sum_L st^L_{il}/TL + \sum_L st^L_{lj}/TL} & : \text{m, n are mutually exclusive} \\ \sum_k \sum_i \sum_l \sum_j \sum_{k'} pc_{kk'} \cdot X^{(2)}_{kiljk'} \cdot (1+\eta)^{365/m' + 365 \cdot (m'-1)/n' + \sum_L st^L_{il}/TL + \sum_L st^L_{lj}/TL} & : \text{m, n have a common multiple number.} \end{cases} \tag{23}$$

p^*_{ki} : freight rate of container cargo from the zone k to the port i by cheapest transportation (yen/ton).

$pc_{kk'}$: the average value of cargo whose OD is k and k', respectively *(yen/ton)*.

η : the cargo value depreciation rate.

In the above, the constraints of Eq.(17) means the total exported and imported cargo volume must satisfies the OD distribution cargo given a priori, and the constraint of Eq.(18) expresses the condition that the total cargo volume loaded and unloaded at any port should be less than the total capacity of ships provided by carrier. The constraint, Eq.(19) means the volume of call cargo on any route must be less than the capacity of call ships.

3. COMPUTATION

It has been proved that the model can explain well the real container flow and the real behavior of carrier and shipper by Kuroda and Yang [a]. The purpose of this study is to analyze the fluctuations of cargo flow due to the construction of container terminal at Shanghai. Therefore we did some computation based on the practical data of international container cargo movement and ports for the case of only existing port (case 1) and for the case of including the new terminal of under construction at Shanghai (case 2).

3.1 Zoning and OD Distribution of Container Cargo

In order to survey roughly the impact of new container terminal at Shanghai on the container transportation market and because of lack of estimated data of OD cargo distribution in 2020, we did some computation using the data of foreign trade container movement in 1994 surveyed by Ministry of Transport of Japan [c]. It was done in one month from November 1st through 31st in order to survey the physical distribution of both of the domestic and the international cargo. To examine the zone share of Japanese ports the prefecture border is used as the unit domestic zones in Japan. The foreign zones are assumed such as North America (representative ports are Los Angels, San Francisco, Oakland and Seattle; these are called as the North America port). Europe (represented by Port of Rotterdam). Korea and North China (represented by Port of Busan). Central China (prefectures peripheral Shanghai and represented by port of Shanghai). Taiwan and Hong Kong and South China (represented by port of Kaohsiung and Hong Kong). ASEAN (represented by port of Singapore). The OD distributions of the exported and the imported container cargo volume between each zone are a priori given. It is referred to the survey report by Ministry of Transport of Japan [c].

3.2 Computation Data

Inland transportation modes are considered as either truck or ferry in Japan. So it is estimated based on Freight Rate Table [d] and the distance from each domestic zone to each of port and the freight rate of both transportation modes. The loss of value of cargo due to ship waiting time and navigation time is estimated based on the data of total export and import container cargo of each domestic zone and total monetary value of the cargo. It is referred to the report of Ministry of Transport of Japan[c].

Port and vessel data is shown in Table 2. Berth charge, port charge and handling charge are estimated referring to interview data and the unpublished data of Ministry of Transport of Japan. The acceptable number of container liner is calculated based on the number of cranes on each berth and the handling capacity, because handling capacity reflects the handling ability of cranes and work hours of labors. Those are referred to Statistics of Kobe Bureau of Port and Harbor [e] and T. Abu et al [f]

In the real container transportation market, various ship sizes can be seen on one route. However, in the computation, sizes of container ships on each route are assumed as the representative ones. Those data are shown in Table 3. The fuel cost, the crew cost and ship cost are also shown in the table.

Navigation distance for one way of each route and container tariff is shown in Table 4 and Table 5, respectively.

Table 2. Port Data

Port	Berth Charge (Yen/GT/Day)	Port Charge (Yen/GT)	Handling Charge (Yen/Ton)	Max. Capacity (Vessels/Mon.)	Min. Capacity (Vessels/Mon.))
Keihin	13.4	45.1	1794.0	321	148
Nagoya	13.4	49.5	1794.0	91	44
Hanshin	13.4	46.3	1794.0	474	178
Kanmon	13.4	31.9	1794.0	61	104
Busan	4.1	26.3	525.0	551	142
Shanghai	1.4	11.3	190.0	100	300
Hong Kong	4.4	28.6	1239.0	697	142
Singapore	6.9	15.6	838.0	955	178
North America	------	56.0	558.0	2000	2000
Europe	------	104.0	1180.0	2000	2000

Table 3. Ship Data (cost: mill. yen/vessel/month)

Route	G.T. (ton)	D.W.T. (ton)	Nav. Speed (Knot)	Capacity Tonnage (Ton)	Fuel Consume (Ton/Day)	Crew Cost	Ship Cost
Asia	15,000	20,000	18	18,000	65	12.6	32.67
Europe	30,000	40,000	20	35,000	85	12.6	48.48
N. America	30,000	40,000	20	35,000	85	12.6	48.48

Table 4. Route Distance (mile)

	Nagoya	Hanshin	Kanmon	Busan	Shanghai	Hong Kong	Singapore	Europe	N. America
Keihin	209	365	557	640	1,001	1,563	2,873	12,560	4,798
Nagoya	---	239	431	513	874	1,436	2,759	12,695	4,934
Hanshin	---	---	250	390	757	1,319	2,655	12,837	5,075
Kanmon	---	---	---	112	530	1,175	2,540	13,023	5,326
Busan	---	---	---	---	493	1,158	2,521	10,950	5,245
Shanghai	---	---	---	---	---	865	2,200	10,649	5,798
Hong Kong	---	---	---	---	---	---	1,454	9,883	6,455
Singapore	---	---	---	---	---	---	---	8,435	7,672
N. America	---	---	---	---	---	---	---	---	7,852

Table 5. Marine Tariff (US$/ton)

	Busan	Shanghai	Hong Kong	Singapore	Europe	N. America
Keihin	17.0	93.0	41.0	40.0	160.0	140.0
Nagoya	17.0	93.0	44.0	53.0	160.0	140.0
Hanshin	11.0	93.0	42.0	40.0	160.0	140.0
Kanmon	5.0	93.0	54.0	53.0	160.0	140.0
Busan	-----	48.0	54.0	36.0	154.0	163.0
Shanghai	-----	-----	92.0	110.0	149.0	171.0
Hong Kong	-----	-----	-----	35.0	140.0	182.0
Singapore	-----	-----	-----	-----	119.0	224.0

4.COMPUTATIONAL RESULTS AND DISCUSSIONS

In order to see roughly the tendency of the change of the international container cargo transportation in Asian and Pacific Region, the computation was carried out on the basis of the OD data in 1994. It is because of lack of estimated data of OD distribution of international container cargo available in the present model. However it can be roughly seen what will happen in the container liner transportation market after the new container berth planned at Port of Shanghai are completed.

Table 6. Ship Frequency **(vessel/month)**

	Busan	Shanghai	Hong Kong	Singapore	Europe	N. America
Keihin	22.12	12.30	20.74	21.19	---	25.02
	21.08	8.90	21.23	20.50		20.61
Nagoya	9.60	9.35	12.50	19.14	---	8.90
	10.19	6.20	9.38	14.28		6.74
Hanshin	20.84	13.10	23.31	26.71	---	22.13
	21.84	3.30	18.00	23.29		19.85
Kanmon	15.66	2.39	6.50	0.89	---	---
	11.18	3.24	7.12	2.83		
Busan	---	20.02	63.21	40.13	---	53.99
		28.90	40.83	41.31		50.95
Shanghai	---	---	8.71	14.42	0.00	0.00
			12.42	9.20	3.42	8.94
Hong Kong	---	---	---	60.56	18.08	65.59
				64.50	16.11	60.23
Singapore	---	---	---	---	29.68	---
					27.12	

In Table 6 are shown the computed results of scheduled service frequency of container liner ship for both the case of the present and after the completion of new container terminal at Port of Shanghai. In the table the upper shows the result of the case 1(present) and the lower shows the case 2(future). It can be seen from this table that the carrier may change the scheduled frequency if the new container berths are completed at Port of Shanghai. That is, Japanese ports except Kanmon and Singapore will loose some of service frequency connecting with Shanghai because of decrease of feeder service for the route of North America and Europe. This can be understand from figure 1 that those ports have been taking the role of transshipping Shanghai's cargo to and from North America and Europe, but large amount of those cargo will be carried directly by newly served routes connecting them with Shanghai. The influence may also be exerted more or loss to other Asian ports. This can be understood from Figure 2 and Figure 3. Figure 2 shows the change of transshipped cargo volume at each port in Eastern Asia, and Figure 3 shows the flow of Shanghai's cargo. Comparing this with Figure 1, the cargo from and to Shanghai transshipped at Japanese ports and Busan will be decreased and at the same time those to and from Europe transshipped at Singapore will be decreased. Total handling cargo volume will also be influenced by this tendency as shown in Figure 4.

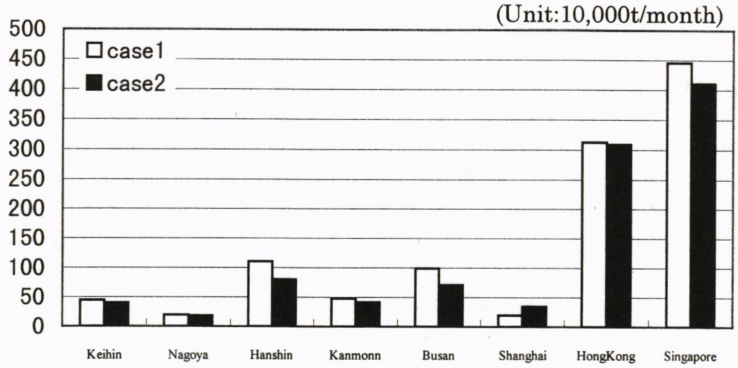

Fig. 2 Transship Cargo

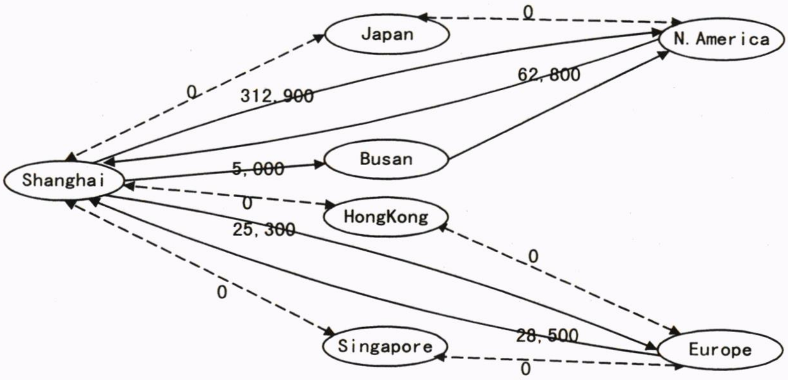

Fig. 3 Future State of Transshipments from Port of Shanghai to N. America and Europe(ton./month)

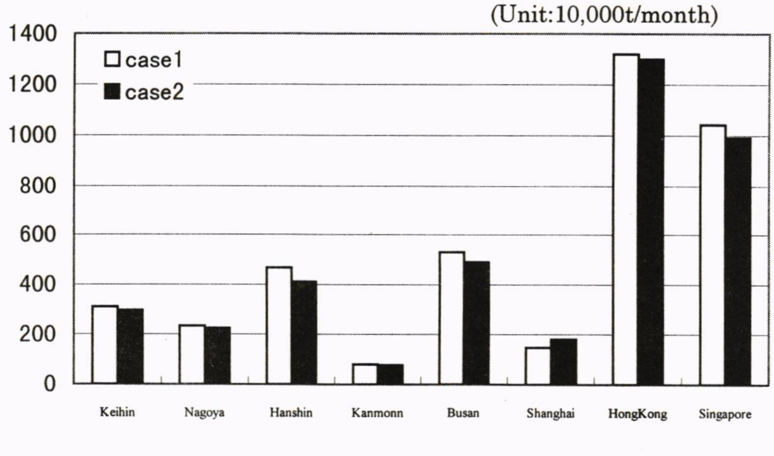

Fig.4 Total Handling Cargo

5.CONCLUDING REMARK

The present paper analyzed the influence of new container terminal planned at port of Shanghai on other Eastern Asian ports. The numerical results say it may exert a great impact on the container cargo flow in Asian and Pacific Region. It can be easily predicted that the new container terminal and change of operational policy of ports will more or less impact on the international flow of container cargo resultant from re-routing and re-scheduling of service frequency by the container liner shipping company. Thus it is very much important to take these analytical results into consideration for planning and operation of national port development policy.

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