STACKELBERG EQUILIBRIA ANALYSIS OF CONTAINER CARGO BEHAVIOR

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abstract: In the real world, terminal administrator, ship company and shipper can be regarded as gaming players of so called as Stackelberg Problem of Game Theory. This comes from the idea that each of these players has different level of information about other players' behavior in the container transportation market. In the present paper, the strategic behavior of these three kind of players in the container transportation market is formulated as three level Stackelberg Equilibria. It also demonstrates the validity of the proposed model providing some numerical computation results based on the practical data of international container cargo movement in Japan and discussed on strategic methods of container terminal planning and management.

1. INTRODUCTION

Before 1960's the transportation cost of marine cargo had been said that the inland transportation cost, the terminal cost and the marine transportation cost were almost even. However since the container transportation has appeared, the terminal cost is tremendously reduced. Then, because of limited number of world trade ports which has container terminal, shippers in Japan have become to consider strategically how to containerize their cargo and how to choose their port in order to reduce the total physical distribution costs. They may consider the frequency service of scheduled liner container ships of port and the access and egress transportation time and costs.
On the other hand, ship companies (called as carrier hereafter) may consider what marine route they should choose, how many frequency service and what size of container ship they should provide on each route to maximize their revenue taking account of the port service such as the handling cost and port charge as well as the total cargo volume.
The government and/or the port administrator may consider how to develop and manage the container terminals in order to reduce the idling loss of container terminals and total transportation cost of container cargo from the view point of national economy.
From the overall view of container transportation, the government and/or the port administrator, the carrier 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 an equilibria of these three kinds of players. Imai(1989) proposes a game theoretic approach to behavior of ship companies where he formulate the competitions of container ship companies in the transportation market. This does not consider the strategic behavior of government and shippers. On the other hand, Kimura (1985) proposes the port choice model of shippers and the frequency service determination model of carriers. However he does not consider a equilibrium between carriers and shippers. That is, he considers at first the hinterland of every port and then determines the frequency service of carriers. This procedure is different from the real world of container transportation market behavior because the hinterland of a port should be determined automatically as the equilibrium of the shippers behavior and the carriers behavior.
In the succeeding chapters behaviors of these three kinds of players in the world trade container transportation market are formulated as the Stackelberg Problem, and some computational results by the model are discussed for the case of the imported and the

exported container cargo movement in Japan.

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 are decided by its policy. This policy will affect directly on the behavior of carrier and indirectly on shippers. Government will make its policy for port development from the view point 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 view point of all shippers of the country, and at the same time, it considers the idling cost of container berths from the view point of the efficiency of the investment. For efficiency of port investment, the government must take into account of behaviors of carrier and shippers. It is ,in the present approach, assumed that the government has complete information about the optimal behaviors of the carrier and shippers in the international container transportation market. From this reason the government can be regarded as the superior player to both of the carrier and the shipper. Ship companies entering the international container transportation market may compete each other to acquire the greater share of the market providing strategically their own transportation service. However, in the real world they make alliance to avoid over-competition and keep almost same service level. There are some non-allied ship companies who serve a little bit lower fee than the allied company. Therefore detail analysis should consider the competition among these ship companies. In spite of existence of this competition, a loose alliance among all the ship companies is still observed because they intend to coexist in the market. From this reason the present paper assumes one ship company in the market. It is in the paper called as carrier. The carrier decides the liner route and the ship size and the ship number to be assigned at each route. This carrier's strategy depends upon the governmental strategy about container terminal construction and 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 influences on the 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 priori given. Thus the forwarder is not 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 ship is much more frequently scheduled. From 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 port and the carrier. Thus 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. Figure 1 shows this relation..

2.2 Premises and Assumptions

In the present analysis followings are premised and assumed.

1) Only world trade container cargo whose origin or destination is in Japan is considered.

2) Inland zones are divided into L zones whose size are appropriately changeable corresponding to the purpose of analysis, and denoted by k. (k=1,2,...,L)

3) Overseas zones are divided into N zones which are represented by the nearest world

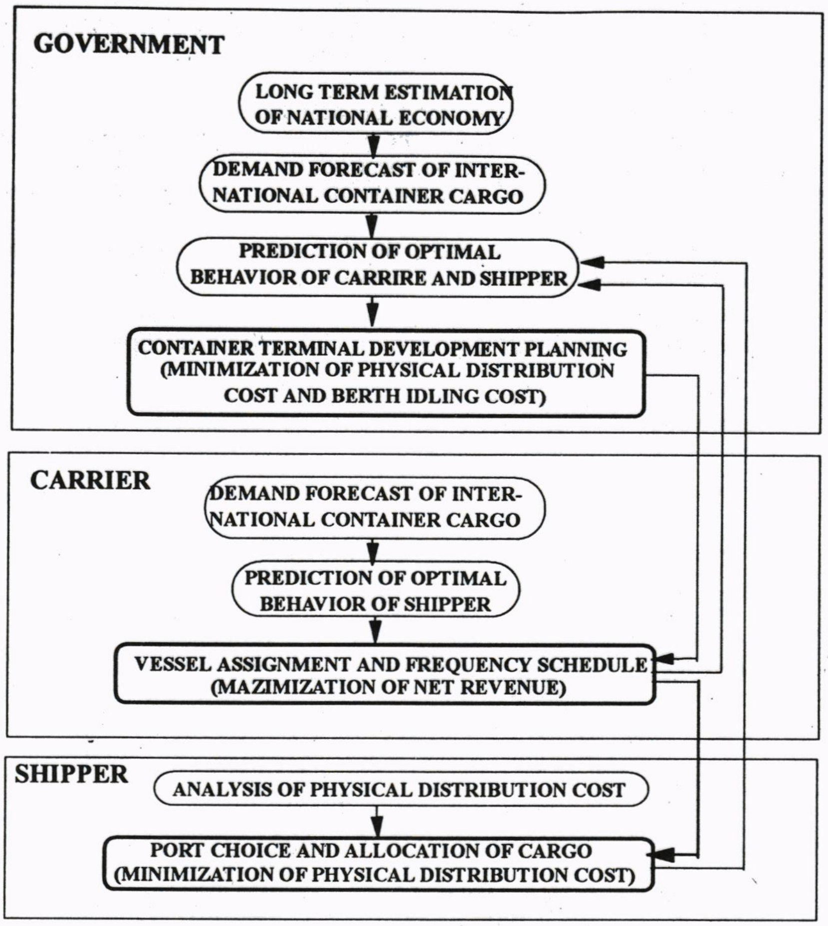

Figure 1 Relations of Three Players

trade container port j. (j=1,2,...,N).

4) O.D. distribution of the container cargo between the zone k and j is assumed to be a priori given, and denoted by C^I_{kj} and C^E_{jk} (k=1,2,...,L, j=1,2,...N)

5) Japanese world trade container port is denoted by i. (i=1,2,...,M)

6) Volume of container cargo whose origin is k and destination j and transported via port i is denoted by x_{kij} (k=1,2,...,L, i=1,2,...,M, j=1,2,...,N).

7) Number of container berth for vessel size l of port i is denoted by $\angle_i$

8) Every berth is available for any route if ships can moor..

9) Only liner container ships directly connecting ports i and j are considered. Stops at other ports on the way are not considered.

10) Government aims to minimize the idling cost of all the container berths of the domestic ports and inland transportation cost of container cargo of all domestic shippers.

11) Total capacity of container berths of all domestic ports is assumed to be able to handle the total imported and exported cargo. This assumes that there is no infinite queue of cargo.

12) Competition among ship companies is not taken into account, then only one carrier is assumed.

13) Carrier aims to maximize his net revenue considering cargo tariff and shipping expense.

14) Capacity of total container ships assigned to a specific route is at least greater than the total transportation demand for the route. This assumes all container cargo per unit period can be transported in the period.
15) Shipper allots his cargo to minimize the total cost including the inland and the sea 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 negligible small.
16) Inland transportation is considered only for the domestic shippers. Thus the overseas shippers' behavior is neglected.
Under the above premises and assumptions, the foreign trade container transportation network considered in the analysis is shown as Figure 2.

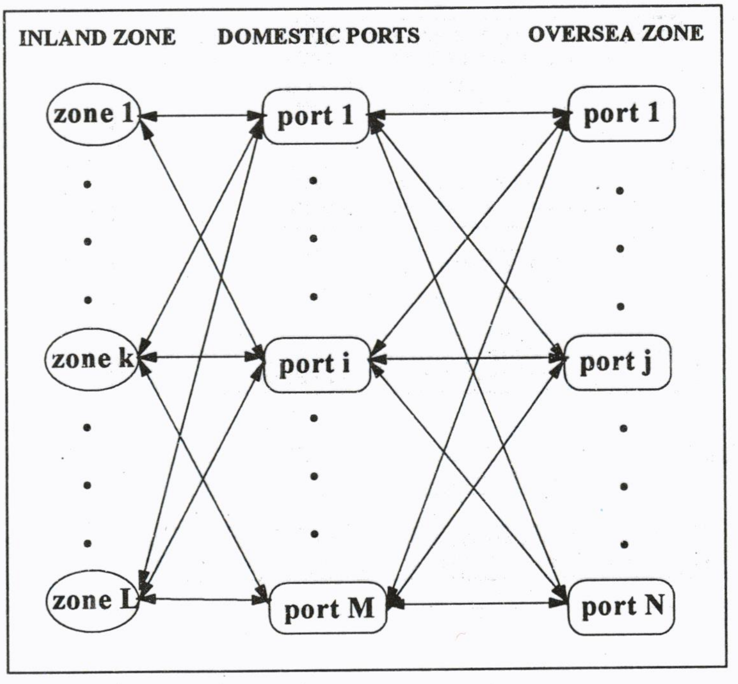

Figure 2 Domestic and Oversea Zones and Port

2.3 Formulation

2.3.1 Behavior of Government

Government behaves to minimize the total cost that is given by the summation of inland transportation costs of all domestic shippers and the idling loss of container berths of all the domestic ports under the condition that the carrier and shippers behave optimally. That is, The government must prepare at least enough number of container berths to treat all container cargo imported and exported. Thus his objective function and constraints are formulated as Eq.(1).

$$\underset{Z_i^l}{Min}\, GC = \sum_k \sum_i \sum_j \dot{p_{ki}}\left(x_{kij} + x_{jik}\right) + \sum_i \sum_l cb_i^l \{Z_i^l - [\sum_j (\lambda_{ij}^l + \lambda_{ji}^l) cp^l\, y_{ij}^l / (365u^l) - Z_{i0}^l]\}\delta_i$$
$$+ \sum_i \sum_l cb_{i0}^l \{Z_{i0}^l - \sum_j (\lambda_{ij}^l + \lambda_{ji}^\lambda) cp^l\, y_{ij}^l / (365u^l)\}\delta_i' \quad (1)$$

sub. to

$$Z_{ij}^l \geq 0 \text{ ; integer} \quad (2)$$

and the optimal behaviors of carrier and shippers.

where

p^*_{ki}; minimum freight rate from zone k to port i.(*yen / ton*)

x_{kij}, x_{jik}; container cargo volume from zone k to zone j via port i, respectively (*ton / year*)

cb^l_i; annual redemption cost per newly constructed berth (*yen / berth / year*)

cb^l_{i0}; annual redemption cost per existing berth (yen / berth / year)

Z^l_i; number of newly constructed container berths for ship size l of port i (*berth*)

Z^l_{i0}; number of existing container berth of for ship size l of port i (*berth*)

l^l_{ij}, l^l_{ji}; load factor of a container ship between ports i and j

cp^l; capacity of a ship of size l (*ton*)

y^l_{ij}; scheduled frequency of container ship on route i - j (*vessels / year*)

u^l; daily handling capacity of one berth for ship size l (*ton / day / berth*)

δ_i, δ'_i; kronecker delta defined by

$$\delta_i = \begin{cases} 1 & \text{for } \sum_j (l^l_{ij} + l^l_{ji}) cp^l y^l_{ij} (365u^l) - Z^l_i \geq 0 \\ 0 & \text{for } \sum_j (l^l_{ij} + l^l_{ji}) cp^l y^l_{ij} (365u^l) - Z^l_i \leq 0 \end{cases}$$

$$\delta'_i = \begin{cases} 1 & \text{for } \sum_j (l^l_{ij} + l^l_{ji}) cp^l y^l_{ij} (365u^l) - Z^l_{i0} \geq 0 \\ 0 & \text{for } \sum_j (l^l_{ij} + l^l_{ji}) cp^l y^l_{ij} (365u^l) - Z^l_{i0} \leq 0 \end{cases}$$

In Eq.(1) the first term gives total inland transportation costs, and the second the total idling loss of the newly constructed container berths of all domestic ports, the third the same of existing container berths.

2.3.2 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.2.

$$\begin{aligned} \underset{Y^l_{ij}}{Max}\ SB = & \sum_i \sum_j f_{ij} \sum_k (x_{kij} + x_{jik}) - \sum_i \sum_j \sum_l 2(cs^l + cc)\left\{cp^l(\lambda^l_{ij} + \lambda^l_{ji}) / u^l + st^l_{ij}\right\} y^l_{ij} / 365 \\ & - \sum_i \sum_j \sum_l 2 fc^l st^l_{ij} y^l_{ij} - \sum_i \sum_j \sum_l cp^l (\lambda^l_{ij} + \lambda^l_{ji})(w_i + w_j) y^l_{ij} \\ & - \sum_i \sum_j \sum_l GT^l \left[cp^l (\lambda^l_{ij} + \lambda^l_{ji})(v_i + v_j) / u^l + (pf_i + pf_j)\right] y^l_{ij} \end{aligned} \tag{3}$$

sub. to

$$y^l_{ij} \geq 0 \text{ ; integer} \tag{4}$$

$$\sum_j (\lambda^l_{ij} + \lambda^l_{ji}) cp^l y^l_{ij} / (365u^l) \leq Z^l_i + Z^l_{i0} \quad (i = 1,2,\ldots,\text{M}) \tag{5}$$

and the optimal behavior of shippers.

where

f_{ij}; freight tariff between port *i* and *j* (*yen / ton*)

cs^l; anual ship cost of ship size *l* (*yen / vessel / year*)

cc; anual crew cost of one container ship (*yen / vessel / year*)

st^l_{ij}; navigation time between ports *i* and *j* (*day*)

fc^l; daily fuel cost of one vessel of size *l* (*yen / vessel / day*)

w_i, w_j; loading and unloading cost per one tonnage at port *i* and *j*, respectively (*yen / ton*)

GT^l; gross tonnage of a ship of size *l* (*ton / vessel*)

v^l_i, v^l_j; berth rate for a ship of size *l* at port *i* and *j*, respectively (*yen / vessel / day*)

pf^l_i, pf^l_j; port charge for one entering of a ship of size *l* at port *i* and *j*, respectively (*yen / vessel*)

In Eq. (3) the first term expresses the revenue from container cargo transportation, the second the total redemption and the crew cost of all vessels, the third total sailing cost, the fourth total loading and unloading cost, the fifth port charge, respectively. The constraint of Eq.(5) shows the condition that total capacity of loading and unloading at all berths of a port i is at least greater than the cargo volume imported and exported via port i.

2.3.3 Behavior of Shippers

Shippers aim to reduce the total transportation costs as possible to minimize the inland transportation cost, the marine transportation cost and the value decrease of cargo due to time loss. Their objective function and constraints are formulated as Eq.(6).

$$\begin{aligned} \min_{x_{kij}, x_{jik}} NC = & \sum_k \sum_i \sum_j p^*_{ki}(x_{kij} + x_{jik}) + \sum_k \sum_i \sum_j f_{ij}(x_{kij} + x_{jik}) \\ & + \sum_k \sum_i \sum_j pc^E_k x_{kij}(1+\eta)^{365/2\sum_l y^l_{ij}} + \sum_k \sum_i \sum_j pc^I_k x_{jik}(1+\eta)^{\sum_l st^l_{ij}/ST} \end{aligned} \quad (6)$$

sub. to

$$x_{kij} \geq 0,\ x_{jik} \geq 0 \ \ (k = 1,2,\dots L),\ (i = 1,2,\dots,M),\ (j = 1,2,\dots,N) \quad (7)$$

$$\sum_i x_{kij} = C^E_{kj},\ \ \sum_j x_{kj} = C^I_{kj} \quad \forall k, j \quad (8)$$

$$\sum_k x_{kij} \leq \sum_l cp^l y^l_{ij},\ \ \sum_k x_{jik} \leq \sum_l cp^l y^l_{ij}, \quad \forall i, j \quad (9)$$

where

pc^E_k, pc^I_k; monetary value of unit volume cargo imported to zone k and exported from zone k (yen / ton)

η; interest ratio

l; number of ship size rank

C^I_k, C^E_k; annual volume of cargo imported to and exported form zone k $(ton / year)$

In Eq.(6) the first and the second terms express the total transportation cost, the third and the fourth the interest loss of cargo due to waiting time of ship and sailing time, respectively. The constraints of Eqs.(8) shows the total exported and imported cargo volume must satisfies the O.D. distribution cargo given a priori, and the constraint of Eq.(9) 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.

3. NUMERICAL EXAMPLES

3.1 Numerical Data

3.1.1. Zoning and O.D. Distribution of Foreign Trade Container Cargo

In order to examine the validity of the proposed model, a numerical example is computed using the data of foreign trade container movement in 1994 surveyed by Ministry of Transport of Japan (1994). 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 port the prefecture border is used as the unit domestic zones as shown in Fig. 3. In the figure are also shown the foreign trade ports in Japan which have the container berths.

North America, Central and South America, Asia, North Africa, Europe and Oceania are used as the foreign zones taking account of the movement of the foreign trade cargo. Those overseas zones are represented by the nearest foreign trade ports, respectively.

The O.D. distributions of the exported and the imported container cargo volume between domestic zones and overseas zones are a priori given. It is referred to the survey report by Ministry of transport of Japan (1994). Based on this report the cargo volume imported and exported from Central South America and South America, and Africa is quite small. Thus in the succeeding numerical computations, those zones are omitted because the influence on the computation results is negligible.

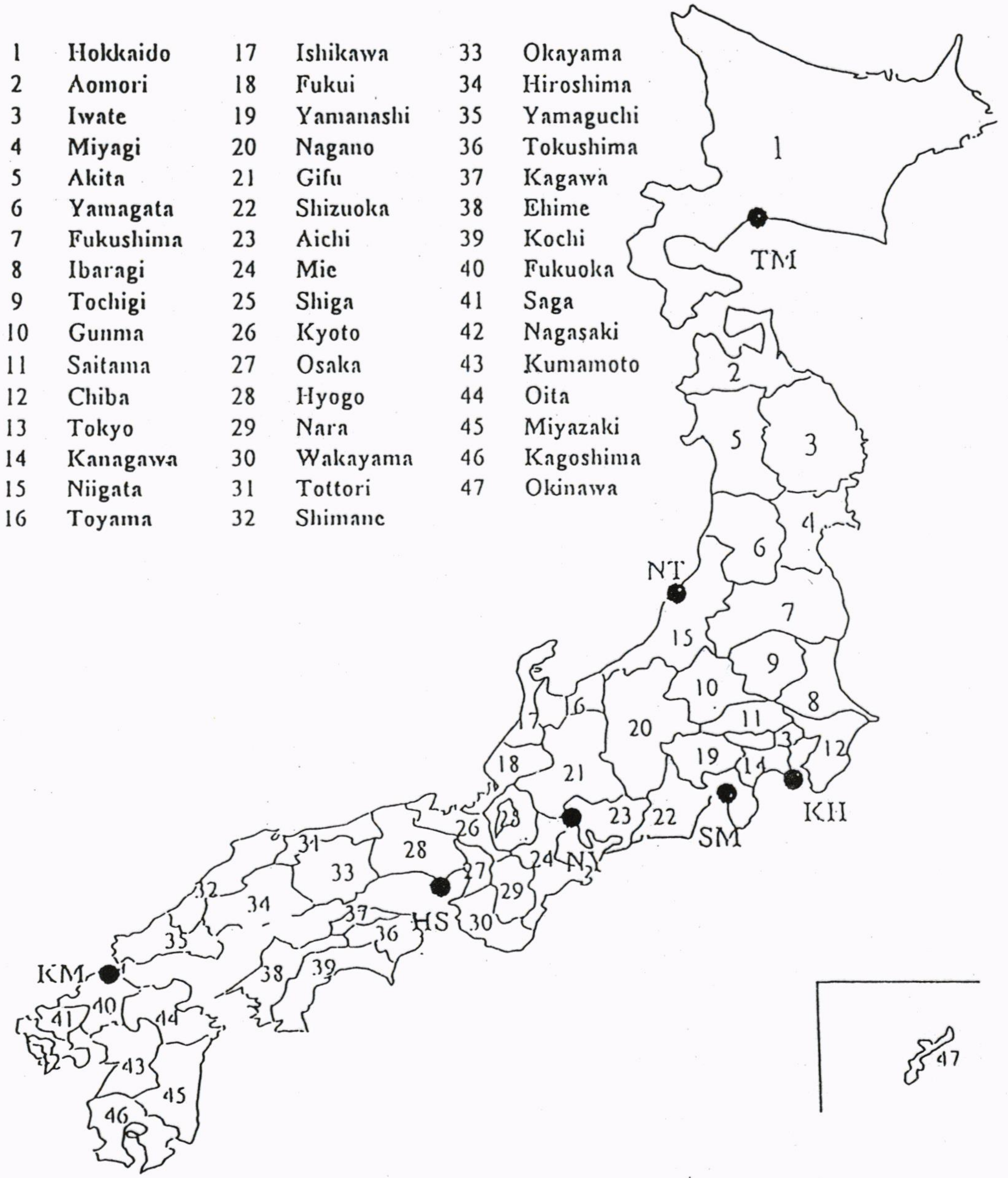

Figure 3 Domestic Zones and Foreign Trade Ports

3.1.2 Transportation Cost and Average Value of Cargo

Inland transportation modes are considered as either truck or ferry in Japan. So it is estimated based on Freight Rate Table (1989) 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 must be estimated for port choice decision of shippers. It 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 (1994).

3.1.3 Port and Vessel Data

Foreign trade container ports in Japan are already shown in Fig. 3. Number of the container berth and their total cargo handling capacity per day of those ports are shown in Table 1. It also shows the berth charge, the port charge and the cargo handling charge. It should be notified that the cargo handling capacity is calculated based on the number of cranes on each berth. Thus the 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 (1994) and T. Abu et al (1989).
It is also noticed that Table 1 shows only the number of container berth but not the physical dimensions of each berth. However in computation of the proposed model, the physical conditions of each berth are taken into account
In the real container transportation market, various ship size can be seen on one route. However, in the computation, sizes of container ships on each route is assumed as the representative ones. Those data are shown in Table 2. Volume of fuel consumption listed in the table is used for calculation of fuel expense. Crew and ship costs are also shown in the table.
Navigation time for one way of each route and container tariff are shown in Table 3 and 4.

3.2 Computation Procedure

As the characteristics of Stackelberg problem, the solution must give the Stackelberg equilibria of two level game by three different of players. Thus, repeated computation method is employed for government's strategies. That is, for given governmental strategy, all feasible combinations of the carrier's strategy is considered at first. Then in the lowest game, for given carrier's strategy, the optimal strategy of shippers is obtained by solving a linear programming problem. It can be easily understood from Eqs.(6) trough (9) that the lowest problem for shippers is formulated as Linear Programming (L.P.). Once the optimal solution for shippers is obtained, he optimal solution for the carrier is checked. If the optimal solution for the carrier is not obtained, the above procedure is repeated. In the further studies, the optimal strategy of government should be computed, but the present computation it is omitted because in the present paper, only the container movement in the present situation is studied. In Fig. 4. is shown the above computation procedure.

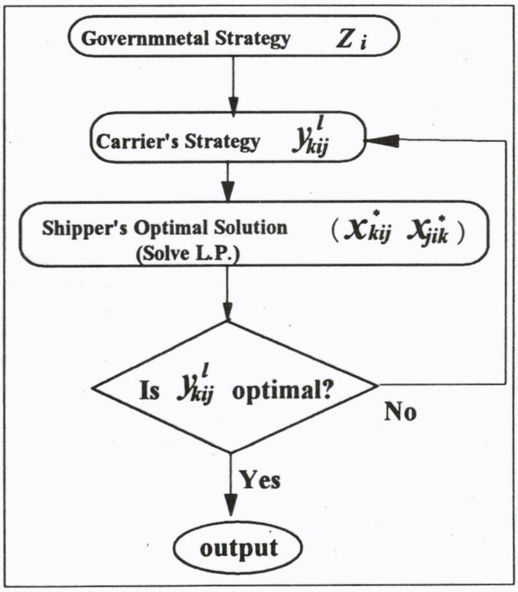

Figure 4 Computation Procedure

Table 1 Port Data

Port	Berth Charge (Yen/GT/Day)	Port Charge (Yen/GT)	Handling Charge (Yen/Ton)	Number of Berth	Cargo Handling Ability (Ton/day)
Tomakomai	9.8	2.2	743	1	6,000
Niigata	7.4	2	743	1	6,000
Keihin	11.9	2.7	867	35	348,000
Shimizu	9.8	2	867	5	30,000
Nagoya	11.9	2.7	867	10	108,000
Hanshin	11.9	2.7	867	45	414,000
Kanmon	11.9	2.7	867	11	72,000

Table 2 Ship Data

	G.T. (GT)	D.W.T. (Ton)	Navigat. Speed (Knot)	Capacity Tonnage (Ton)	Fuel Consume (Ton/Day)	Crew Cost (Million Yen/Month)	Ship Cost (Million Yen/Month)
Asia	15,000	20,000	18	18,000	60	72	88
Europe	50,000	76,000	23	67,000	113	154	223
N.America	42,000	55,000	22	47,000	90	123	178
Oceania	14,000	16,000	17	15,000	50	67	80

Table 3 Navigation Time (day)

	Asia	Europe	N.America	Oceania
Tomakomai	7.7	21	10.5	12.2
Niigata	7	20	10.6	13
Keihin	6.7	20	9.1	11
Shimizu	6.7	20	9.2	11.2
Nagoya	6.5	19.5	9.1	11
Hanshin	6.5	19.5	9	11
Kanmon	6	19.5	9.6	11

Table 4 Marine Tariff (yen/ton)

	Asia	Europe	N.America	Oceania
Tomakomai	11,000	22,000	17,700	12,000
Niigata	11,000	22,000	17,700	12,000
Keihin	9,900	22,000	16,800	12,000
Shimizu	9,900	22,000	16,800	12,000
Nagoya	9,900	22,000	16,800	12,000
Hanshin	9,900	22,000	16,800	12,000
Kanmon	9,900	22,000	16,800	12,000

4. COMPUTATION RESULTS AND DISCUSSIONS

4.1 Cargo Share of Port

In order to examine the validity of proposed model, Stackelberg equilibia are computed using data provided in Chapter 3. In Figure 5 and Figure 6 are shown the computed and the observed results of total cargo share of ports, respectively. These figures say that the total estimation error is only 5.1 %. Details of the error can be understood to observe Figure 7 and Figure 8. Figure 7 shows the computed and the observed results of the exported cargo share of ports, and Figure 8 shows those of the imported cargo. It can be understood from Figures 7 and 8 that the computed results for Hanshin port is a little bit smaller than the observed one while Nagoya's is larger than the observed. This may come from the world trade custom of shippers although the inland transportation cost is more expensive than via other port. Since Port of Kobe (included in Hanshin) is well known as the very traditional world trade port, then most of world trade agencies are concentrated at Kobe. They may keep up their old custom to use Port of Kobe. As this consequence, the practical cargo volume via Hanshin is considered to be larger than the results computed by the proposed model which does not taken into consideration of the agency's behavior.

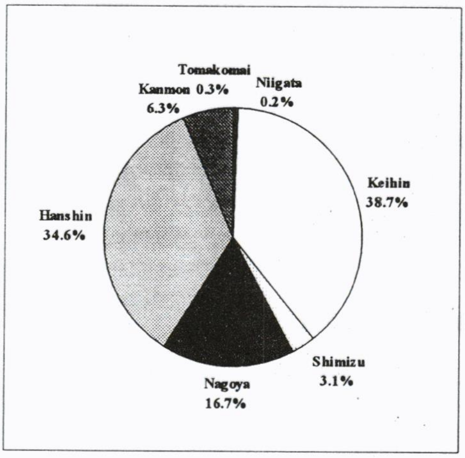

Figure 5 Total Cargo Share (observed)

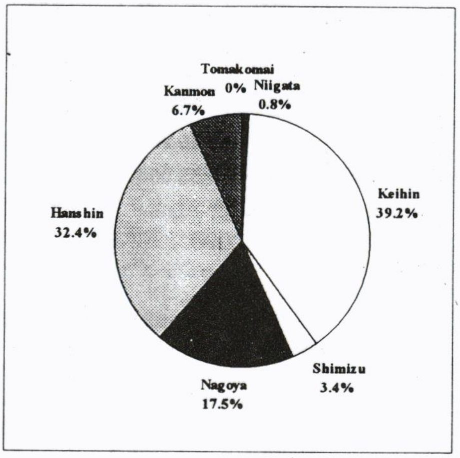

Figure 6 Total Cargo Share (computed)

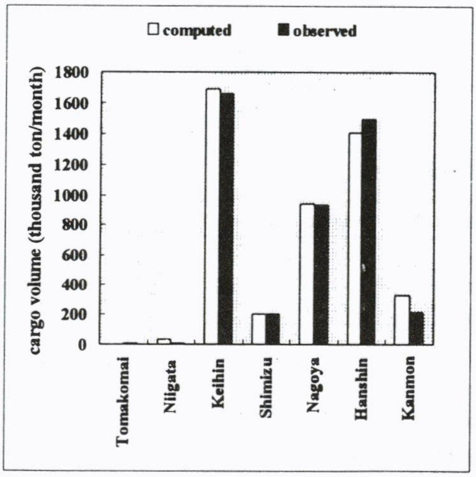

Figure 7 Exported Cargo Share

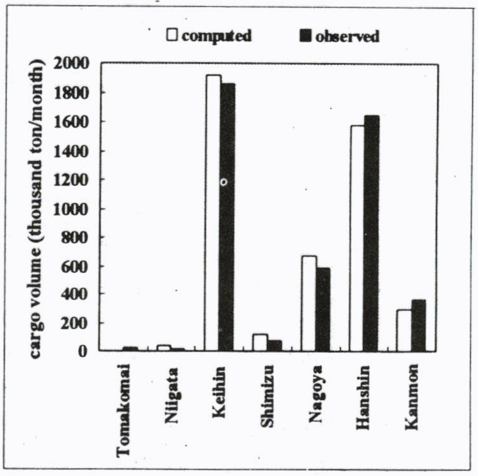

Figure 8 Imported Cargo Share

4.2 Zone Share of Port

Figure 9 shows the present situation of zone share of port area Keihin, Hanshin and Nagoya in export trade. From this figure it can be understood that Hokkaido, Tohoku, Kanto, 20% of Chubu, and 50% of Okinawa are the hinterland of Keihin (includes Port of Yokohama and Tokyo). On the other hand, Keihan (includes Port of Kobe and Osaka) shares 50% of Hokuriku, Kinki, Shikoku, Chugoku, Kyushu, and 50% of Okinawa. Nagoya port shares 10% of Hokuriku, 8% of Kinki and 75% of Chubu. Figure 10 shows the computed results of zone share of ports for the case of export trade. From these figures it is remarkable that the computed share of Hokuriku and Okinawa are quite different from the present situation. As this reason it is supposed that even though the inland transportation costs from Hokuriku to Nagoya and from Okinawa to Hanshin are cheaper than those to Hanshin and Keihin, respectively, exported cargo moves as shown in Figure 9 because shippers of Hokuriku and Okinawa may depend upon the past custom of world trade agencies. Another reason may come from that carriers do not assign enough container ships to carry all cargo from Nagoya because Nagoya has been developed recently.
Figures 11 and 12 show the observed and the computed results of zone share for the case of import. These shows the computed result does not well explain the port share of Nagoya associated with Hokuriku. The reasons may be considered as same as for the case of export.

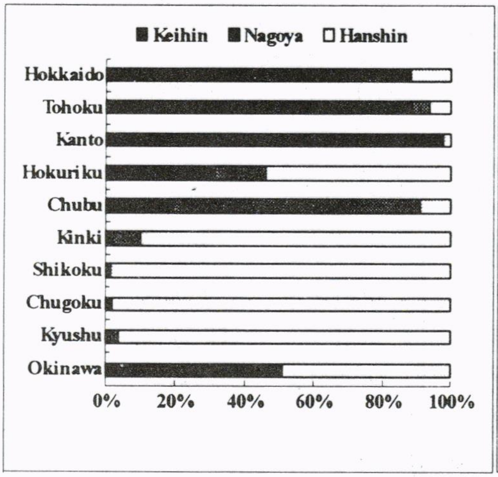

Figure 9 Observed Zone Share (export)

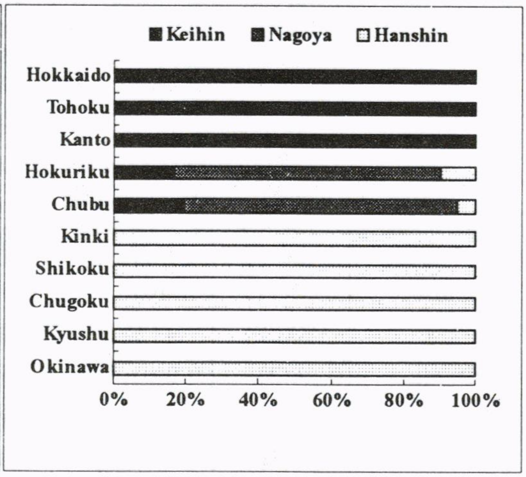

Figure 10 Computed Zone Share (export)

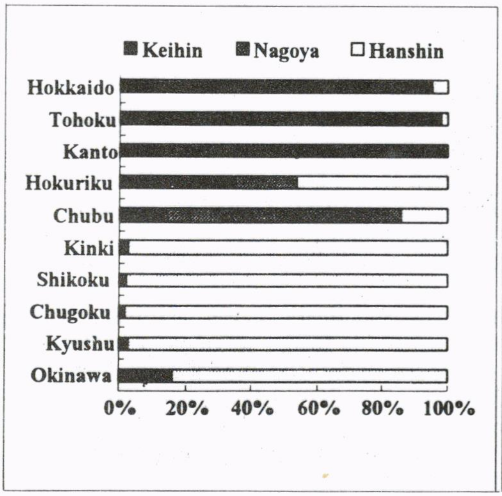

Figure 11 Observed Zone Share (import)

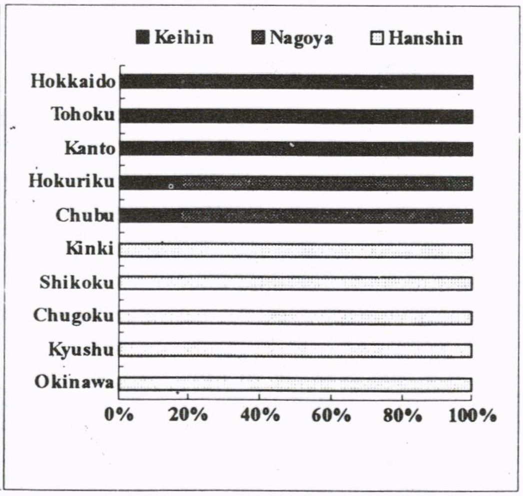

Figure 12 Computed Zone Share (import)

4.3 Frequency Service of Container Ship

Table 5 shows the number of frequency service on each route per month provided by carrier and its ratio to capacity of each port. It is notified in this table that the capacity is defined as the capable frequency service per one month for ships of size 36,750 DWT which each port can provide. It is also notified that the numerics in the parenthesis are the equivelent frequency for the ship used for calculation of the port capacity. It can be understood that all ports have enough capacity to serve the frequency per month of container ships assigned by the carrier. This means Japanese foreign trade ports can accept all container ships which transport all foreign trade container cargo imported in and exported from Japan if the volume is less than the present situation. In other ward, if the inland transportation condition is not changed from the status quo, the carrier does not change the present service condition. For example, even if the government develops more container berths at the Niigata port, the carrier does not change the assignment of ships any more from the present condition because cargo does not come to Niigata port any more than the present volume. However it should be notified that the proposed model does not take into account of transshipped cargo and ships carrying those cargo. If the transship service is considered the carrier assigns more ships to some ports, which could be Keihin port and Hanshin port at the present because they have enough capacity to accept them.
Provided that only the Japanese foreign trade container cargo is considered, it can be said that the present capacity of container ports for foreign trade is at the satisfactory level. However this does not mean that the present location of container terminals is satisfactory. From the view point of shippers' cost, development of new container terminals might be necessary.

Table 5 Frequency Service on Route per Month

	Asia	Europe	N. America	Oceania	Total/Capacity
Tomakomai	0 (0)	0 (0)	0(0)	0(0)	(0)/(4)
Niigata	2(1)	0(0)	0(0)	0(0)	(1)/(4)
Keihin	60(30)	6(12)	15(22.5)	8(4)	(68.5)/(232)
Shimizu	4(2)	0(0)	4(6)	0(0)	(8)/(20)
Nagoya	45(22.5)	4(8)	6(9)	3(1.5)	(41)/(64)
Hanshin	60(30)	4(8)	15(22.5)	6(3)	(63.5)/(276)
Kanmon	35(17.5)	0(0)	4(6)	5(2.5)	(26)/(48)

5. Concluding Remarks

The paper proposes the mathematical model to explain the foreign trade container movement as Stakelberg Equilibria of three kinds of players in the marine container transportation market. The case study of its application to the real foreign trade container movement of Japan says the proposed model well explains the real container movement.
However there is a problem that it can not completely explain the zone share of port. It may be come from the custom of the world trade agencies and shippers. At this moment it is quite difficult to consider this.
The present model does not consider the time loss of inland trasportation. However it is also very important for shippers to choose the port, particularly feeder services by vessel for some case can save much time than the truck transportation. The model also does not reflect the service time of port and work time of labors. The time delay in port very much influences on the behavior of carriers and shippers. Carriers wish so called quick dispatch in order to save time and cost, and shippers dislike the time loss in order to reduce the interest cost of cargo. This should be surveyed in more detail in near future.
In spite of these remained problems, the proposed model still has validity to explain the behavior of carriers and Japanese shippers, and it can well predict the resultant movement of

foreign trade container cargo.
The authors intend to fined the appropriate governmental policy to develop the foreign trade container terminals and their locations when all movement of the container cargo of inter-foreign countries of the world are taken into consideration. They also intend to analyze the effects on container movement of port management such as various port charge, berth fee, working hours of port and so forth. The proposed model in this paper could contribute to these farther analysis.

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