PORT MANAGEMENT POLICY AND THE INFLUENCE ON BEHAVIOR OF LINER SHIPPING COMPANY AND SHIPPERS

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abstract: This paper is concerned with prospect of transportation market of international container cargo. Under competitive situation of container cargo transportation market, shipping companies are severely changing their strategy in routing and resulting port choice by global alliance. In such situation, port management policy is very much important to invite container liner ships for the port. The present paper analyzes the influence of port management policy on the strategy of container liner shipping companies and domestic shippers.

1. INTRODUCTION

Containerization is a common sense in transportation of general cargo because of its cost-effectiveness and protection of cargo to be injured. Recently the volume of international container cargo is steadily and rapidly increasing corresponding to the growth of world economy, especially in Eastern Asia.

Container liner shipping companies (hereafter called as carrier) are changing their operational strategies for more cost-effective transportation by introducing larger vessels into main marine routes (henceforth called as ocean liner), and choosing more fewer calling ports (called as Hub port). In near future, 60,000 G.T. class of container vessel will mainly used on transpacific and transatlantic ocean routes. Ports that the ocean liner does not make a call, will be served as feeder transportation ports. As this consequence, much more cargo will be transshipped at hub ports, and then competition among hub ports will become more and more sever. Domestic shippers, on the other hand, will be made to ship their cargo to those hub ports directly or by feeder.

Under these situations, the governments or agencies of world trade ports (called as administrator after) will be facing the serious competition among ports. Therefore, administrators of world trade ports would actively promote the development of their container terminals and change strategies of port management policy in order to invite more ocean liners and transshipped cargo. They may have great interest in the influence of port management policies on the behavior of carrier and shippers, because it is an important issue for the development of port, as well as the related industries of its hinterland. However, unfortunately, there has not been an appropriate tool to predict behaviors of ocean liner companies and shippers. Then it is necessary to develop a method to predict changes in marine container transportation market induced by port management policies. The method should have the ability to predict the behavior of ocean liner companies as well as those of hinterland shippers corresponding to change of port management policies of administrators. Kuroda and Yang (1995) proposes a model to explain the Equilibrium between carriers and domestic shippers in container transportation market as Stakerlberg Problem of Game Theory. In their model, they consider the port administrator is the leading player in market gaming to both of carrier and shippers, while the carrier is also the leading player to domestic shippers. These two level structure in market with leaders and followers can be considered as the general scheme of transportation market. Imai et al (1996) proposes a model to explain the carrier's behavior under given inter-port cargo volume, and predict the share of hub port in Asian Pacific region when large container vessels to carry 6000 TEU and 8000 TEU are used as the ocean liner ship. However, the model does not consider the Equilibrium between carriers and shippers. On the other hand, Kuroda and Yang (1996) examined their model performance by comparing the computed results with statistics associated with total handling volume of container at world trade ports in Eastern Asia, and they concluded the model well behaved to explain the behavior of carriers and domestic shippers. However, their model lacked detail terms of costs associated with port charges. This means the model should be modified appropriately for the purpose of the present paper. This will discussed in the succeeding chapter.

The present paper proposes a modified model to predict equilibrium between carriers and shippers in container transportation market, and shows some numerical results of influences of change of port charge on the Equilibrium.

2. ANALYSIS OF TRANSPORTATION MARKET AND FORMULATION

2.1 Analysis of Container Transportation Market

There can be considered three players in the container marine transportation market; port administrators, carriers (ocean liner companies) and domestic shippers. In the market the port administrators can be regarded as the superior player to others because they have complete information about the optimal behaviors of both of carriers and domestic shippers under given port management policy. Carriers, on the contrary, can be considered as superior player to shippers because carriers know complete information about the optimal behavior of shippers under given carriers' services. These lead the problem to a bi-level Stackerlberg Problem of Game.

Port administrator will make his policy to take advantage in marine transportation market for prosperity of his port. The central government, however, may consider the port administration from the viewpoint of growth of national economy and total physical distribution cost for domestic shippers, and will decides the location and the scale of ports in his country. But it is beyond the scope of the present paper to consider the effects of port management policy on the national economy. Thus, in the present paper, the port management policy is assumed as some given scenario. This means the port administrator is treated such a player as only presents his port management policy in the market. To get as many vessel's call as possible, port administrators should consider port management policies, that includes numbers and scale of terminals, tonnage tax rate and charge for port entrance, wharfage, cargo handling fee and etc. in this present paper,

The ocean container liner shipping companies, that is, the carrier can be regarded as the player who behaves to maximize his net revenue under given port management scenario taking into consideration of optimal behavior of domestic shippers and competitive situation against his rival shipping companies. In the real world the competition among carriers is the important aspect for a carrier to decide his strategy in the marine transportation market. However, they are recently intending to make consortium for more cost-effective transportation and to avoid the over competition. In fact major carriers make a global alliance for cooperation of fleet, container and terminals. Therefore in the present paper only one shipping company is assumed. However weak competition among shipping companies is taken into consideration by introducing a load factor. If competition among shipping companies becomes more severe, the averaged value of load factors for all ocean liners might be decreased. The present paper analyzes the competitive situation among carriers as sensitivity of the load factor. The carrier's aims to maximize his net revenue by using his strategy of routing, vessel type and service frequency on each route taking into account of the cargo volume of inter-port. It should be again noticed that the strategy of carrier is constrained by the strategy presented by each of port administrators. That is, routing is limited by allocation of ports, and calling frequency, vessel type is constrained by the capacity of container terminals of each port.

The carrier decides the liner's route, size and the fleets number to be assigned on each route. We call this as carrier's strategy. While making the decision, the carrier should take into account the information of cargo and shipper's behavior. Generally, the shipping companies first investigate the OD of cargo, gather information about the behavior of shippers, then make estimation of the flow of cargo, and finally decide the fleet operation plan and declare it. So we can say that carrier has complete information about shipper. For this reason the carrier can be regarded as the leader player to shippers in the game.

The domestic shippers may choose their port to minimize the total transportation cost and loss of cargo value due to waiting at port under given inland transportation network and transportation service presented by the carrier. Of course they also consider the inland access and the egress time to port as well as the transportation cost. However the access and the egress time of inland transportation can be neglected comparing with the navigation time. Thus the present paper assumes that the access and the egress transportation time to and from port can be neglected. Since the present paper focuses on the analysis of the influence of port management policy, particularly on the domestic shippers of Japan, only shippers behavior in Japan is analyzed in detail. Shippers of other countries are a priori assumed to have their own port for import and export.

Figure 1 shows the relation among the three parties in the container transportation market. And figure 2 shows the gaming structure between carrier and shipper.

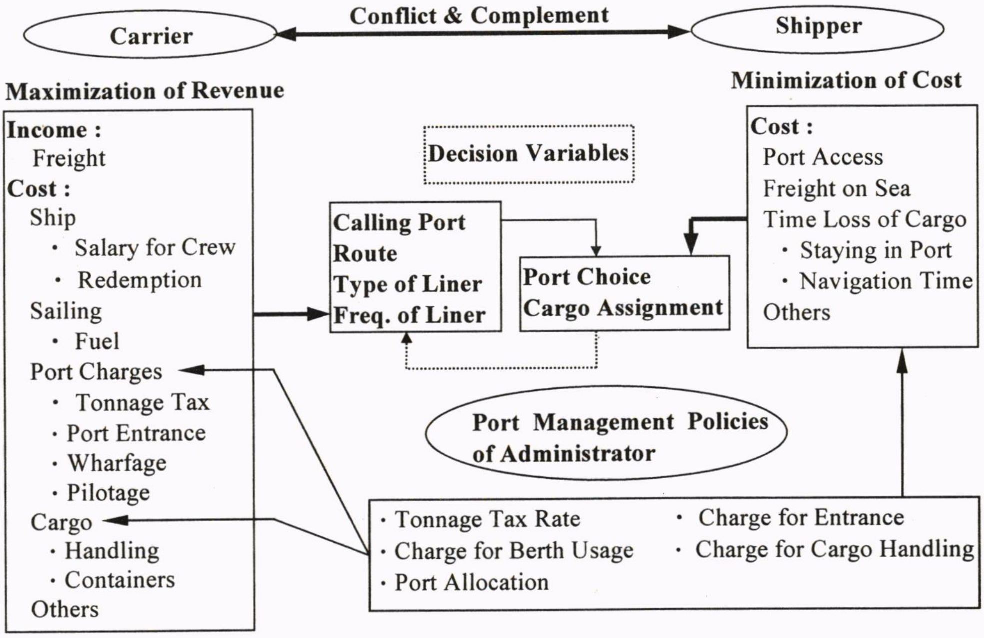

Figure 1 the relationship among the administrator, carrier and shipper

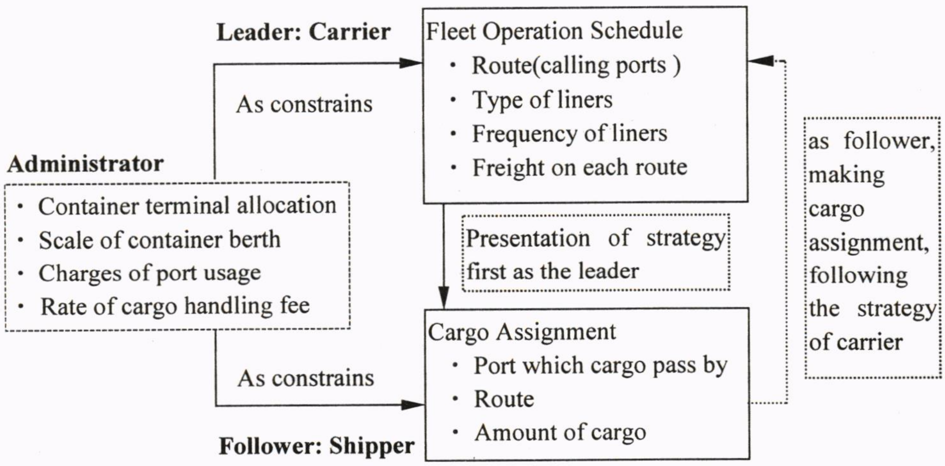

Figure 2 Structure of Stackerlberg Game

2.2 Premises and Assumptions in Formulation

In formulation of behaviors of carrier and shipper, 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 or k' (k, k'=1,2,...,N).
3) For Europe and North America we assumed that the area have only one representative world trade port, since we should make a analysis of the competition among the main container ports in Asia.
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 used for presenting import and export each other.
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 call at one port on each route.
8) Every 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, in other words, equivalent 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.
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 which includes the port access cost, the marine transportation cost, the ship waiting loss, and the marine transportation time loss.
14) Inland transportation time loss is not considered because it is negligible small, comparing with other time.
15) Inland transportation is considered only for the domestic shippers in Japan. Thus the overseas shippers' behavior is neglected.

Under these premises and assumptions, behaviors of liner shipping company and domestic shippers are formulated

2.3 Formulation of Carrier's Behavior

As previously mentioned, carrier intends to maximize his net revenue from international container cargo transportation providing liner service. Carrier's net revenue comes from freight of total volume of cargo minus total cost of fleet operation, cargo handling, and port charge. This means the net revenue is changeable depending on not only his strategy of routing, vessel type on the route and frequency service, but also the strategy of domestic shippers

His objective function and constraints are formulated as equation 1. And the equations (2) through (4) are constraints.

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

sub. to

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

$$z_{i}^{L} \leq Z_{i}^{L} \qquad \forall\, i, L \tag{3}$$

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

and

the optimal behavior of shippers.

In equation (1), **RF** is the total revenue from the cargo tariff. **CT** is the tonnage tax for L size vessels, 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 equation (1) is given by equation (5) through equation (13).

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

$$\mathbf{CT} = \sum_{L} \sum_{i} \sum_{j} GT^{L} \cdot (pt_i + pt_j) \cdot Y_{ij}^{L} + \sum_{L} \sum_{i} \sum_{l} \sum_{j} GT^{L} \cdot (pt_i + pt_l + pt_j) Y_{ilj}^{L} \tag{6}$$

$$\mathbf{CP} = \sum_{L} \sum_{i} \sum_{j} GT^{L} (pf_i + pf_j) Y_{ij}^{L} + \sum_{L} \sum_{i} \sum_{l} \sum_{j} GT^{L} (pf_i + 2pf_l + pf_j) Y_{ilj}^{L} \tag{7}$$

$$\mathbf{CM} = \sum_{L} \sum_{i} \sum_{j} GT^{L} (pc_i^{L} + pc_j^{L}) Y_{ij}^{L} + \sum_{L} \sum_{i} \sum_{l} \sum_{j} GT^{L} (pc_i^{l} + 2pc_l^{L} + pc_j^{L}) Y_{ilj}^{L} \tag{8}$$

$$\begin{aligned} \mathbf{CL} = & \sum_{L} \sum_{i} \sum_{j} \{\lambda_{ij}^{L} \cdot cp^{L} \cdot (chf_i + chf_j)\} Y_{ij}^{L} \\ & + \sum_{L} \sum_{i} \sum_{j} \sum_{l} \{(\lambda_{il}^{L} + \lambda_{ij}^{L}) \cdot cp^{L} \cdot chf_i + (\lambda_{il}^{L} + \lambda_{lj}^{L}) cp^{L} \cdot chf_l + (\lambda_{lj}^{L} + \lambda_{ij}^{L}) \cdot cp^{L} \cdot chf_j\} Y_{ilj}^{L} \end{aligned} \tag{9}$$

$$\mathbf{CB} = \sum_{L}\sum_{i}\sum_{j} GT^{L}\{\nu_i^{L}(ht_i^{L(i,j)} + \tau_i^{L}) + \nu_j^{L(i,j)}(ht_j^{l(i,j)} + ht_l^{L(i,j)} + \tau_j^{L})\}Y_{ij}^{L}$$
$$+ \sum_{L}\sum_{i}\sum_{l}\sum_{j} GT^{L}\{\nu_i^{L}(ht_i^{L(i,j)} + \tau_l^{L}) + \nu_l^{L}(ht_l^{L(i,l)} + ht_l^{L(l,j)} + \tau_l^{L}) + \nu_j^{L}(ht_j^{L(l,j)} + \tau_j^{L})\}Y_{ilj}^{L} \tag{10}$$

$$\mathbf{CF} = \sum_{L}\sum_{i}\sum_{j} \left\{fc^{L(1)}2st_{ij}^{L} + fc^{L(2)}(ht_i^{L(i,j)} + ht_j^{L(i,j)} + \tau_j^{L})\right\}Y_{ij}^{L}$$
$$+ \sum_{L}\sum_{i}\sum_{l}\sum_{j} \left\{fc^{L(1)}(2st_{il}^{L} + 2st_{lj}^{L})\right. \tag{11}$$
$$\left. + fc^{L(2)}(ht_i^{L(i,l)} + ht_l^{L(i,l)} + ht_l^{L(l,j)} + ht_j^{L(l,j)} + \tau_i^{L} + 2\tau_l^{L} + \tau_j^{L})\right\}Y_{ilj}^{L}$$

$$\mathbf{CC} = \sum_{L}\sum_{i}\sum_{j} cc^{L}(ct_{ij}^{L}Y_{ij}^{L}/365) + \sum_{L}\sum_{i}\sum_{l}\sum_{j} cc^{L}(ct_{ilj}^{L}Y_{iljk}^{L}/365) \tag{12}$$

$$\mathbf{CS} = \sum_{L}\sum_{i}\sum_{j} cs^{L}\left(ct_{ij}^{L}Y_{ij}^{L}/365\right) + \sum_{L}\sum_{i}\sum_{l}\sum_{j} cs^{L}\left(ct_{ilj}^{L}Y_{ilj}^{L}/365\right) \tag{13}$$

where

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

$$z_i^{L} = \{\sum_{j \in \Omega_G}(t_i^{L(i,j)} + \tau_i^{L})\cdot Y_{ij}^{L} + \sum_{l \in L}\sum_{j \in \Omega_G}(ht_l^{L(i,l)} + \tau_i^{L})\cdot Y_{ilj}^{L}$$
$$+ \sum_{l \in L}\sum_{j \in \Omega_G}(ht_i^{L(l,i)} + \tau_i^{L} + ht_i^{L(i,j)} + \tau_i^{L})\cdot Y_{lij}^{L} + \sum_{l}\sum_{j \in \Omega_G}(ht_i^{L(l,i)} + \tau_i^{L})Y_{ilj}^{L}\}/365 \tag{14}$$

f_{ij}; cargo tariff between the port i and j (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).

ν_{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

$$ct_{ij}^{L} = \left(ht_i^{L(i,j)} + \tau_i^{L} + ht_j^{L(j,i)} + \tau_j^{L} + 2st_{ij}^{L}\right) \tag{15}$$

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

$$ct_{ilj}^{L} = \left\{\left(ht_i^{L(i,l)} + \tau_i^{L} + ht_l^{L(i,l)} + \tau_l^{L} + 2st_{ij}^{L}\right) + \left(ht_l^{L(l,j)} + ht_j^{L(l,j)} + \tau_j^{L} + \tau_l^{L} + 2st_{lj}^{L}\right)\right\} \tag{16}$$

cs^{L}; annual redemption cost of the size L vessel (yen/vessel/year).

In the above, the constraint of equation (3) means that the number of container ships assigned to the port i must not exceed the capacity of the port, and the constraint of Equation (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.

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 **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 equation (17) through Equation (21).

$$\mathbf{TAC+RF+ITL \rightarrow MIN.} \tag{17}$$

sub. to

$$X_{kijk'},\quad X^{(1)}_{kiljk'},\quad X^{(2)}_{kiljk'} \geq 0\,; \qquad \forall k,i,l,j,k' \tag{18}$$

$$\sum_i \sum_j X_{kijk'} + \sum_i \sum_l \sum_j \left(X^{(1)}_{kiljk'} + X^{(2)}_{kiljk'}\right) = C_{kk'} \qquad \forall k,k' \tag{19}$$

$$\sum_k \sum_{k'} X_{kijk'} + \sum_k \sum_{k'} \sum_l \left(X^{(1)}_{klijk'} + X^{(2)}_{klijk'} + X^{(1)}_{kijlk'} + X^{(2)}_{kijlk'}\right) \leq \sum_L cp^L \cdot \lambda^L_{ij} \cdot Y^L_{ij} + \sum_L \sum_l cp^L \cdot \lambda^L_{ij} \cdot Y^L_{ijl} + \sum_L \sum_l cp^L \cdot \lambda^L_{ij} \cdot Y^L_{lij}\ ;\ \forall i,j \tag{20}$$

$$\sum_k \sum_{k'} X^{(1)}_{kiljk'} \leq \sum_L \lambda^L_* \cdot cp^L \cdot Y^L_{ilj} \quad ;\ \forall i,l,j;\ \ \lambda^L_* = \mathrm{Min}\left(\lambda^L_{il}, \lambda^L_{lj}\right) \tag{21}$$

where

$$\mathbf{TAC} = \sum_k \sum_i \sum_{j\neq i} \sum_{k'\neq k} (p^*_{ki} + p^*_{jk'}) \cdot \{X_{kijk'} + \sum_{l\neq j} (X^{(1)}_{kiljk'} + X^{(2)}_{kiljk'})\} \tag{22}$$

$$\mathbf{RF} = \sum_{i\in I_\pi} \sum_{j\notin I_\pi} f_{ij} [\sum_{k\in K_\pi} \sum_{k'\notin K_\pi} \{X_{kijk'} + \sum_{l\neq j\notin I_\pi} (X^{(1)}_{kiljk'} + X^{(2)}_{kiljk'})\}] \tag{23}$$

$$\mathbf{ITL} = \sum_{k\in N} \sum_{i\in M} \sum_{j\neq i} \sum_{k'\neq k} pc_{kk'} \cdot X_{kijk'} \cdot (1+\eta)^{365/(2\cdot\sum_L Y^L_{ij} + 2\cdot\sum_L\sum_l Y^L_{lij} + 2\cdot\sum_L\sum_l Y^L_{ijl}) + \sum_L st^L_{ij}/TL}$$
$$+ \sum_k \sum_i \sum_l \sum_j \sum_{k'} pc_{kk'} \cdot X^{(1)}_{kiljk'} \cdot (1+\eta)^{365/(2\cdot\sum_L Y^L_{ilj}) + \sum_L st^L_{il}/TL + \sum_L st^L_{lj}/TL} \tag{24}$$
$$+\ \mathbf{ILT}$$

In equation (23), the first term shows the value depreciation of direct cargo, second is that of call cargo, and the third **ILT** means that of the transship cargo which is given by.

$$\mathbf{ILT} = \sum_k \sum_i \sum_l \sum_j \sum_{k'} pc_{kk'} \cdot X^{(2)}_{kiljk'} \cdot (1+\eta)^{365/m + 365\cdot(m-1)/n + \sum_L st^L_{il}/TL + \sum_L st^L_{lj}/TL} \tag{25}$$

$:$ m, n are mutually exclusive

$$\mathbf{ILT} = \sum_k \sum_i \sum_l \sum_j \sum_{k'} pc_{kk'} \cdot X^{(2)}_{kiljk'} \cdot (1+\eta)^{365/m + 365\cdot(m-1)/n + \sum_L st^L_{il}/TL + \sum_L st^L_{lj}/TL} \tag{26}$$

$:$ m, n have a common multiple number

where

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

η ; the cargo value depreciation rate

TL is the total number of vessel rank L.

In the above, the constraints of equation (19) means the total exported and imported cargo volume must satisfies the OD distribution cargo given a priori. The constraints of equation (20) 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 of equation (21) means the volume of call cargo on any route must be less than the capacity of call ships.

3. ALGORITHM USED FOR THE BI-LEVEL STACKERLBERG GAME

The problem described above can rewrite in a explicit form as following.

Upper level problem $\mathbf{P}^U$

$$\underset{Y}{MAX}\ \{f^u = A \cdot Y + B \cdot X\} \quad \text{(Where X solves as } P^L\text{)} \tag{27}$$

$$\text{sub. to} \quad Y \in S^u \tag{28}$$

Lower level problem $\mathbf{P}^L$

$$\underset{X}{MIN}\ \{f^l = C \cdot Y + D \cdot X\} \quad \text{(Where Y is given as } P^U\text{)} \tag{29}$$

$$\text{sub. to} \quad X \in S^l \tag{30}$$

By Wayne.F.Bialas(1982), the above problem can be soled by the following algorithm.

Step 1:

set i=1, solve P^U with optimal solution $\{Y^*, X^*\}_{(i)}$ with simplex method, and let $W = \{Y^*, X^*\}_{(i)}$ and $T = \phi$. Go to step 2.

Step 2:

solve the following problem via bounded simplex method .

$P^L : \min_{x} \{f^l = C \cdot Y + D \cdot X\},$

sub. to $\{Y, X\} \in S^l \cap \{X | Y = \{Y^*, X^*\}_{(i)}\}$

If the optimal solution $\{\tilde{Y}, \tilde{X}\}_{(i)} = \{Y^*, X^*\}_{(i)}$, stop. Otherwise go to step 3.

Step 3:

let $W_{(i)}$ denote the set of adjacent extreme points to $\{Y^*, X^*\}_{(i)}$, and $T = T \cup \{Y^*, X^*\}_{(i)}$, and $W = (W \cup W_{(i)}) \cap T^c$. Go to step 4.

Step 4:

set $i = i + 1$ and choose $\{Y^*, X^*\}_{(i)}$ so that $f^{u*}_{(i)} = MAX_{(Y,X) \in W} \{AY + BX\}$. Go to step 2.

As to our problem, it can be solved with the process shown in figure 3.

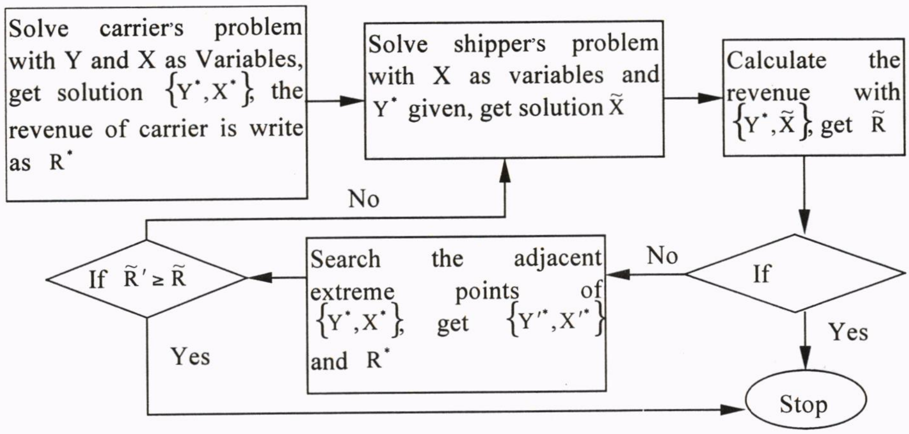

Figure 3 Process of Solution of Stackerlberg Game

4. NUMERICAL EXAMPLE

4.1 Network of Ports and Marine Route

For the analysis of the influence of port management policies, we carried out a numerical computation with the above model. Here we take the main rout of liners and the ports been high ranked in the real world as shown in figure 4.

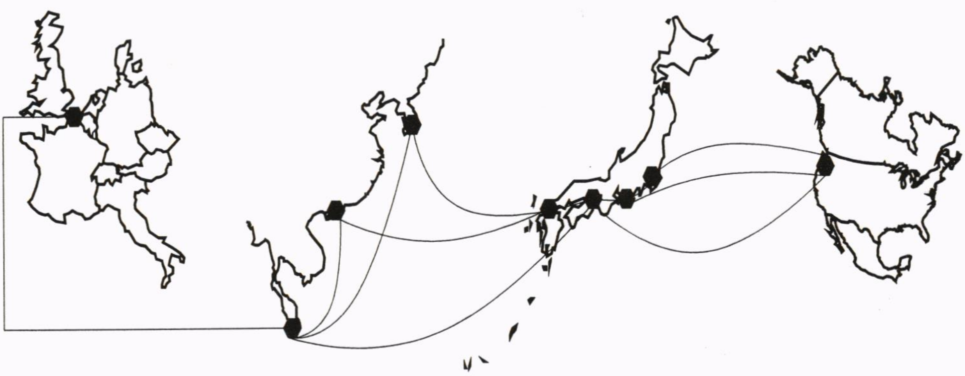

Figure 4 Network of Ports in Numerical Computation

The main transoceanic routs of liner are Europe rout, Transpacific rout, World around rout. But for analysis of the competition among ports and the change of cargo flow influenced by port management policies, we also take the main route in Asia area into consideration. In Asia, there will be liners assigned to any route between two ports in different country. The liners may call two ports (called as direct liner), or make call of three ports (called as relay liner, and the second calling port is called as relay port). Because of the physical constrain from depth of berth, the liners of large type can not make call to some port.

4.2 Analysis of Computation Result

While making the computation, we give several scenarios first according with the purpose of this study. The scenarios are given as table 1. The reason we pick up port Hanshin and Pusan to make comparison is that from the geographical allocation and the role in Asia-North America container transportation, the two ports are rival to each other in getting transship cargo.

Table 1 Scenarios in Case Study

	Port Dues	Charge for Cargo Handling
case1	Real data	Real data
case2	Hanshin=Pusan	Real data
case3	Real data	Hanshin=Pusan
case4	Hanshin=Pusan	Hanshin=Pusan
case5	Hanshin=Pusan=Keihin	Real data
case6	Real data	Hanshin=Pusan=Keihin

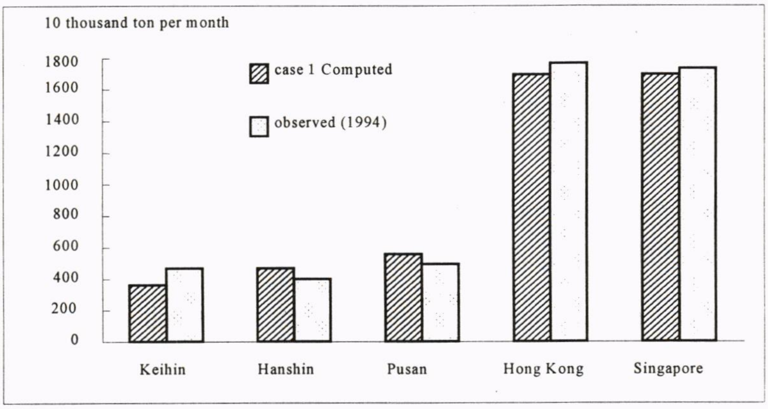

Figure 5 Comparison of the Amount of Cargo Handled

In case 1 we get a result shown in figure 5 and figure 6. From the figure 5 we can see that the difference between the computed and observed amount of handling cargo in each port is quite small. In figure 6 the transship ratios of Hong Kong and Singapore port is coincident, but the other ports have some difference. This may come from the difference of observed data of cargo from/to China to/from North America, which is transshipped through Japan or Korea generally. Because of the limitation from computation, we supposed that the cargo from/to north China to/from America passes Hanshin and Pusan only, not the port of Keihin and Nagoya. This may be a reason of the difference. In the figure 6, ports Rotterdam and Oakland are omitted, because in computation, the two ports are assumed as a node of network only dealing with the cargo of Asia to/from Europe and North America respectively. So that there is no transship cargo in our case study and omitted here.

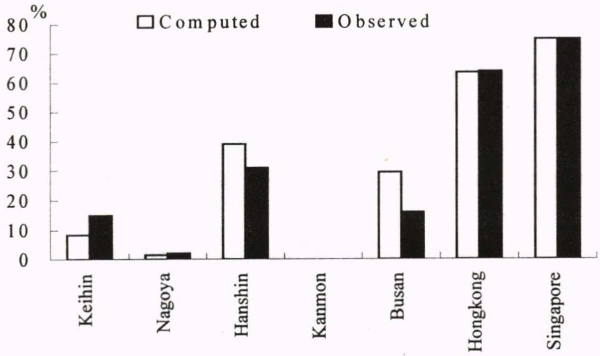

Figure 6 Comparison of Transship Ratio of Cargo

Table 2 shows the changes of the amount of handling cargo in port Hanshin and Pusan accompanying with the changes of port dues and cargo handling charge. The results are also plotted in figure 7. Comparing the results, it is understood that the change of port dues and cargo handling charge give influence to fleets assignment, so as to the cargo through the ports. When the items of Hanshin gets cheap, the amount of both total handling and transship cargo become bigger, as cases 2, 3, 4. But comparing case 2 and 3, we can see that the influence of change of cargo handling charge is greater than the one of port dues. So, for administrator, it would better to check the charge system of cargo handling charge to collect more cargo.

Table 2 Change of the Amount of Handling Cargo (Thousand Ton per Month)

	Case 1		Case 2		Case 3		Case 4	
	a	b	a	b	a	b	a	b
Hanshin	4351.4	1701.4	5000.4	1798.1	6483.5	1935.0	6827.3	2305.2
Pusan	4735.6	1403.0	4921.8	158.8	2851.6	112.6	3141.6	76.4

a: Total Handling Cargo b: Transship Cargo

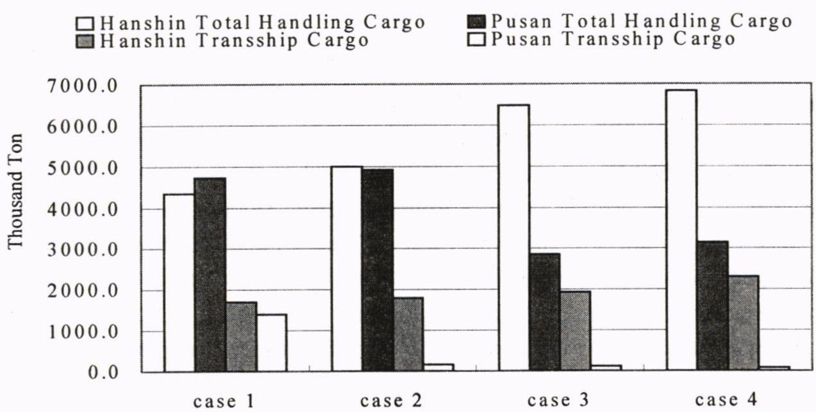

Figure 7 Comparison of Change of Handling Cargo at port Hanshin and Pusan

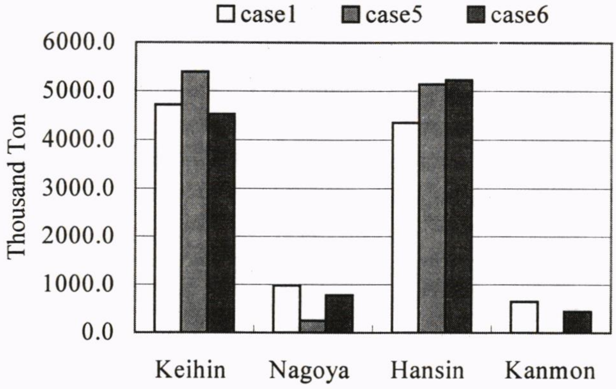

Figure 8 Change of Amount of Handling Cargo in Japan Ports

Figure 8 gives a comparison of change of handling cargo in Japan ports when change the ports dues and cargo handling charge of port Hansin and Keihin simultaneously. As the figure shows, reducing the port charges of some special ports will give influence to other domestic ports, and will call the idling loss of container terminal of the ports the charges of which is high comparing with others and not changed. It is to say that the administrator should consider all the domestic ports also, while making the items of port management policies for international hub ports.

5. CONCLUSIONS

This present paper proposes a model to simulate the flow of foreign trade container cargo with game theory, and provide a dynamic method for the analysis of container cargo transportation market. With it, we can explain well the interaction of the behavior of the parties in the market.

From the results of numeral computation for the real international container terminal network, we confirmed the effectiveness of our model, and got some meaningful results about the change of port management policies. But in case study, there are not so much cases to investigate the administrator's behavior in detail. In present stage, we have not given consideration to other administrative problems, for example of opening of port, working time in night and holidays. We will make research about this in near future.

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