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MID -TERM FEEDER CONTAINER FORECAST FOR KOREAN PORTS
韓国港湾のフィーダーコンテナ貨物の短期予測

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1.INTRODUCTION

(1) Background

The new international order is being built on economic performance and East Asia will be the locomotive pulling the global economy. Owing to the economic growth, international container traffic from/to and inside the region has been increasing rapidly. And shipping industry changed to the 5th generation of Mega-terminal[1] (over 150 acre) and Mega-ship's size(over 6,000 TEU), required for network of strategically located hubs and connecting feeder service.

In the region, Korean ports have a geographical advantages as a hub port, and are capable of developing into international trade center. But they have been hardly able to handle the traffic increase in recent years by expansion.

A number of previous papers [4),7)] studied on the feeder traffic service and hub network system were reviewed, but no comprehensive analysis for feeder traffic and in depth study was done in the part of port planning and port development strategy aspect.

(2) Objective

The purpose of this paper is to obtain international feeder container traffic volume forecasting by using the statistical data of any origin/ destination(O/D) for competitive ports, three dimension figure (transportation fare, service level, and feeder traffic volume) known as multiple regression curved surface(called as MRCS hereafter) can be plotted.

And this paper is to formulate an effective transportation policy for port planning in terms of development and improving the service efficiency using MRCS composition for ports with competitive power.

2. METHODOLOGY

(1) General Flow Chart

In order to estimate the volume of feeder container freight flow within any origin/ destination(called as O/D hereafter) that will actually occur on a transportation network it is necessary to analyze the relationships between trade value and container freight volume of a country as depicted in Figure 2-1.

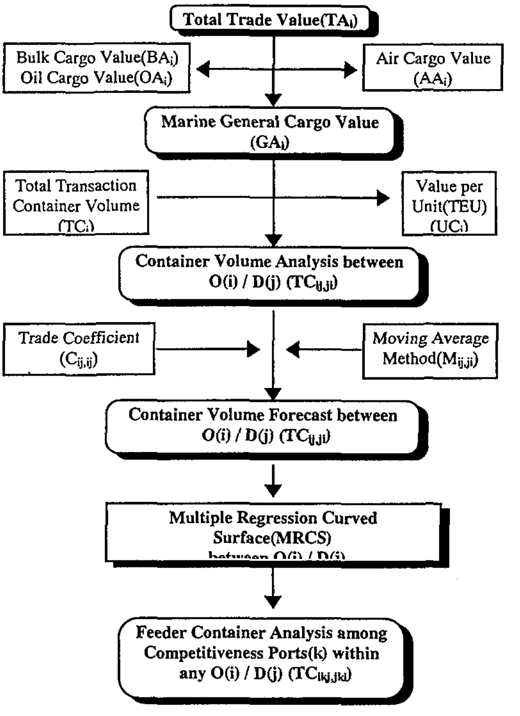

Fig.2-1 General flow chart of study.

This approach is then used in the analysis of container freight flow on sea routes. Data is made available in the Yearbook of International Trade Statistics and Containerization International etc.

(a) Marine General Cargo

A simpler approach to measure the total transaction container volumes of a country is to estimate the general cargo value of marine trade. The formulation is as follows:

$$\Sigma\ GA_i = \Sigma\ TA_i - \Sigma(AA_i + BA_i + OA_i) \text{..........(2-1)}$$

Where, GA_i; marine trade general cargo's values of i country,
TA_i; total trade values of i country,
AA_i; air cargo's trade values of i country,
BA_i; break bulk cargo's trades values of i country,
LA_i; liquid cargo's trade values of i country.

(b) The Value per Unit(TEU)

It is possible to find the value per TEU of any

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country given the volume of container freight.

$UC_i = \Sigma\ GA_i / \Sigma\ TC_i$..(2-2)

Where, UC_i; values per container 1 unit(TEU) of i country,
TC_i; total transaction container volumes (TEU) of i country.

(c) Transaction Container Analysis by O/D

The survey transaction container volume of any O/D is divided by 2 because of some difference in import/export value and value per unit(TEU) by each trade partner.

$$\Sigma\ TC_{ij,ji} = \Sigma\ \{(GA_{ij} + GA_{ji})/2\ \} / \{\ (UC_i + UC_j)/2\} \quad \text{.....................(2-3)}$$

Where, $TC_{ij,ji}$; total transaction container volumes (TEU) from/to i(j) and j(i) country,
$GA_{ij,ji}$; marine trade general cargo's values from/to i(j) and j(i) country.

(2) Feeder Traffic Demands

(a) Relationships among the variables

An alternative means of relating the demand for feeder transportation to the level and fares of the services offered is required in situations where both fare and quality of service must be considered distinctly.

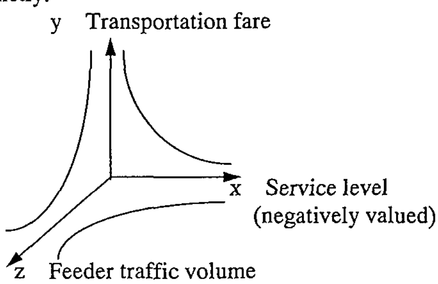

Fig.2-2 Relationships among the each variables for feeder service with a O/D

Taking this as the general case, it applies to situations where frequency of ships are being considered and occasionally the use of facilities at a calling port. This is reflected Fig. 2-2.

The curved regression line as follows;

Y = f(x, z) => ∂f/∂x=◊h(z), ∂f/∂z=⟨g(x)...............(2-4)

y=g(x)=◊ EXP(-⟨x), y=h(z)= ®EXP(-⌊z).............(2-5)

parameters can be determined by regression analysis.

In the figure, the three axes representing the quantity of transportation, such as feeder traffic volume, transportation fare, and the level of service are incorporated.

(b) Plotting of MRCS

To plot a three dimension[3)] multiple regression curved surface(MRCS), the three axes, x, y, z of Fig. 2-2 are cut at any value by each axis, then shifted a parallel move from two to three dimensions curve of each axis matching point. In this space of three dimensions, the demand function can be drawn as the surface shown in Fig. 2-3.

The MRCS can be given by as follow;

F=g(x).h(z)= ◊EXP(-⟨x) · ®EXP(-⌊z)..................(2-6)

parameters can be determined by regression analysis.

The feeder traffic volume demanded decreases with increasing transportation fare, as would be expected, and also with increasing time on the level of service axis, indicating that high transportation fare have increasing disutiltity.

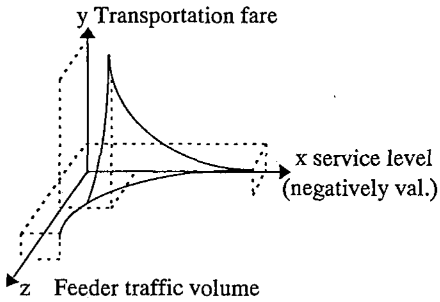

Fig.2-3 Multiple-regression curved surface

Also shown in the figure is the relationship among traffic volume, the fare which the shippers will charge, and the level of service which will result from the manner in which the system management decides to operate the service as a function traffic volume.The underlying choices made by the management of the facility or service which result in this function are quite complex, but in general, given the particular technology or production function, they will result in a unique cost and unique level of service for each volume of traffic.

The assumptions in this MRCS are that the volume is the total available container with fixed volume between any O/D, and that the ship size is 1,000 TEU and above for ocean going and for calling port, while non-limited for feeder service. In order to calculate transportation total transportation fares(b-1) and service level(c). Equations using simple algorithm are provided.

(b-1) Transportation Fare

$$\Sigma\ TR_{gj} = \Sigma\,(dc_{gi}+hc_i+hc_k+sc_{ik}+sc_{kj}+wc_i+wc_k) \quad \text{........ (2-7)}$$

Where, TR_{gj}; total fare of container freight 1 unit from supply point g via i, k port to demand port j
dc_{gi}; fare of domestic transportation from supply point g to supply port i
hc_i; fare of freight handling at supply port i
hc_k; fare of freight handling at via port k

sc_{ik}; tariff of freight transportation from supply port i to via port k
sc_{kj}; tariff of freight transportation from supply port k to demand port j
wc_i; waiting fare at supply port i
wc_k; waiting fare at via port j

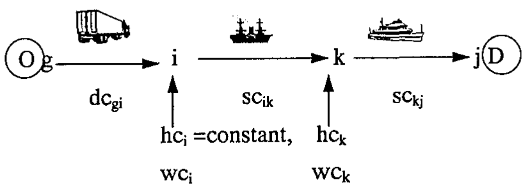

Figure 2-4 Distinction of variables by route

(b-2) Domestic Transportation Fare(dc_{gi})

In equation 2-7, dc_{gi} is inclusive of land (truck) and coastal (ship) transport. The 45% off in Fig.2-5 means discounted value(40%-45%) from the normal inland transportation (truck) tariff. The fare indicator is performed in Japan. The equation can be given by

$dc_{gi} = y_1 e^{-\alpha_1^d}(1-\beta_1 L)$..(2-8)

where, L; lot size

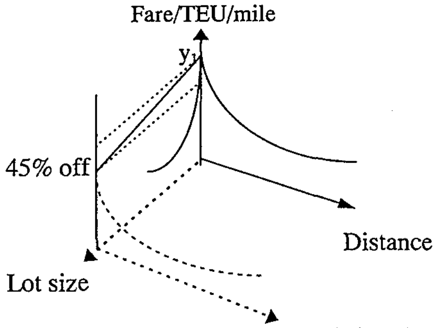

Fig.2-5 Relationships between fare per unit (TEU), lot size, and distance in domestic transportation

(b-3) Transportation fare between feeder route for inter-nations ($sc_{i,k,j}$)

An explanation of the inter-nations transportation fare through research algorithm takes the shape given in Figure 2-6.

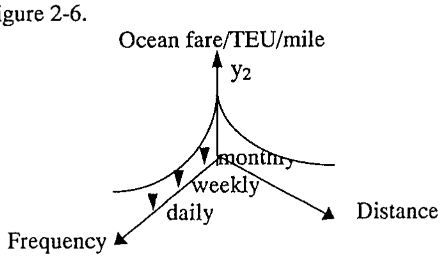

Fig.2-6 Relationship between frequency at a calling port and distance to fare per unit(TEU)

The curved path follows the relationship between frequency and fare per unit(TEU) which is representative of general competitiveness case in any O/D. The equation can be written by as follow;

(*)main route, $sc_{kj} = y_3 e^{-\alpha_4^d} \cdot e^{-\beta_4^{1/F_{kj}}}$...............(2-9)

(b-4) Transportation fare of ocean going by size of vessel($sc_{i,k,j}$)

The value is assumed constant for feeder service by a route, but is classified into 4 groups[6] (1,600 TEU, 2,800 TEU, 3,000TEU, 3,250 TEU) for oceangoing service (shown in Figure2-7).

Each equation gives as follows;

(*)case of feeder, $sc_{ik} = y_2 e^{-\alpha_2^d} \cdot e^{-\beta_2^{SV}}$...........(2-10)

where, SV; size of vessel

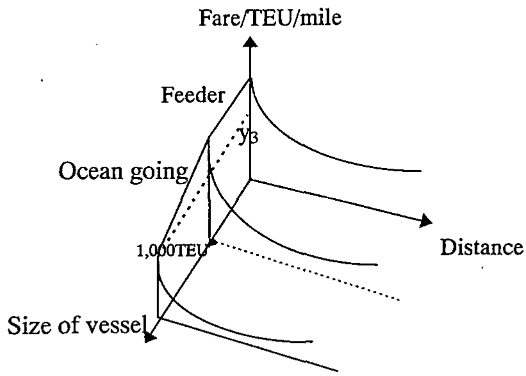

Fig.2-7 Relationship between ship's size and cost per unit(TEU) for the ocean going and feeder service.

(b-5) Frequency distribution

To obtain the value in relation to ship's frequency at calling port, this model assumed the linear ratio normal distributions[5] for the relationships between the ship's frequency of calling port, cost per hour for waiting, and average cost per unit(TEU).

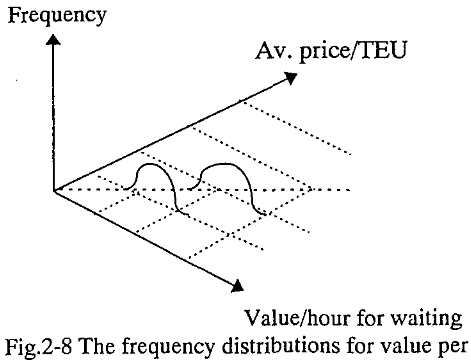

Fig.2-8 The frequency distributions for value per waiting time

(c) Level of Service(Convert to time)

Conversion of service level to service time is required. Generally, the case of inland transportation (truck), travel time is constant by route, but in the case of using port including coastal feeder transportation, different in value by port is observed depending on the number of berth, transaction volume, and handling efficiency. Application of queuing theory will be used.

$$\Sigma\ TT_{gj} = \Sigma\,(lt_{gi} + wt_i + st_{ik} + wt_k + st_{kj}) \quad (2\text{-}11)$$

Where, TT_{gj}; total transit time from supply point g via i, k port to demand port j

lt_{gi}; time of inland transportation from supply point g to supply port i

wt_i; waiting time at supply port i

st_{ik}; sailing time from supply port i to via port k

wt_k; waiting time at via port k

st_{kj}; sailing time from via point k to demand port j

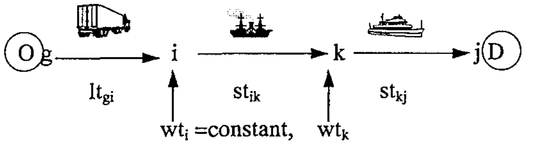

Figure 2-9 Distinction of variables by route

(c-1) Waiting Time at a Port

In this section, by analyzing the relationships between total cargo handled and handling capacity, the waiting time at a port can be obtained as shown Figure 2-10.

Solving this equation yields;

$$wc_{kj} = -1 + e^{\alpha(HV - \beta HC)} \quad (2\text{-}12)$$

where, HV; handling volume, HC; handling capacity.

The factors to analyze the waiting time are travel time, transshipment time, berth waiting time, and frequency. And each factor, travel time depend on distance and speed, transshipment time is fixed, berth waiting time on handling volume, and handling efficiency.

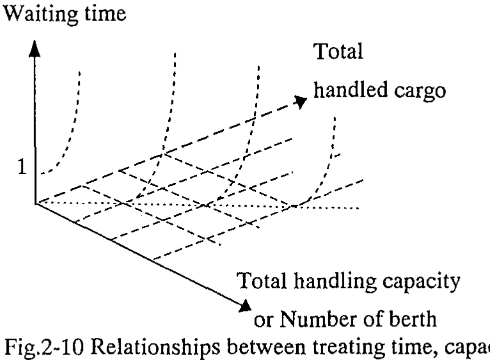

Fig.2-10 Relationships between treating time, capacity, and handled cargo.

Using queuing theory[2], the solution to the waiting time equation is as follow:

$$W_q = \lambda / \mu(\mu - \lambda) \quad (2\text{-}13)$$

Where, W_q; expected waiting time for a shipper(freight) at a port

λ; average number of frequency per unit time

μ; average number of service completions per unit time(service rate)

constraint, $\mu > \lambda$

3. SUMMARY

This research leads to a great understanding of the more accurate forecasting methods for container freight involved feeder service. In Asia, Pusan's relay traffic has grown strongly in recent year, fuelled largely by the opening of the China market in 1994 and the growing local Sea of Japan(Donghae) trade. But Pusan has been hardly able to handle the traffic increase by extension. If Kwangyang container terminals are completed in 1997, Korean ports will be improve the service level. Then, this model will be find the effects on feeder traffic volume of them from the formulation(2-12).

4.CONCLUSION

A simple Multiple Regression Curved Surface(MRCS) model using simple data for transportation cost and service level(convert to transit time) was developed. Although the definition of reliability is complex due to impacts from shippers and carriers, transportation cost changes and improvement of service level within a given range, ECS is thus effective to analyze transportation policy, such as handling cost, establishment of new route, construction of new port from the many variable elements.

REFERENCE

1) " Containerization International", Nov.1995.

2) Wayne L. Winston(1991), "Operation Research Applications and Algorithms;Queuing Theory", Second Edition, Thomson Information Publishing Group.

3) Edward K. Morlok(1978), "Introduction to Transportation Engineering and Planning", -Transportation Network Flows-, McGraw-Hill Book Company.

4)Masahiro Nakamura(1995.2), "A demanding forecasting model for international feeder container cargo taking account of modal choice", Master Thesis, Tohoku Uni. in Japan.

5) Moris Hamburg et al.,(1994), "Statistical Analysis for Decision Marking;Multiple Regression and Correlation Analysis", Six Edition, The Dryden Press.

6) "Container Market Profitability to 1997;Forecast Profitability to 1997". 1992, Drewry Shipping Consultants Ltd.

7)Katuhiko Kuroda(1994.12), "A planning method for International Network of hub container terminal", Discussion paper for 9th ARSC(Applied Regional Science Conference).