【土木計画学研究・論文集 No. 14 1997年9月】

MID-TERM FEEDER CONTAINER FORECAST FOR KOREAN PORTS*

by Ja-yeong GU**, Meor Aziz Osman** and Hajime INAMURA***

1. Introduction

(1) Background and Objectives

This paper focused on feeder container cargo since it is gaining more importance and experience rapid growth. Conventional methods for container forecasting is mainly done through regression methods based on GNP growth trends which proves to be inaccurate. Several papers [4),7)] which studied on the feeder traffic service and hub network system were also reviewed and with the following observations:

i. Demand forecasting container freight was proposed but focused only on the behavior of shipper and shipping company,
ii. In transportation of foreign trade, the port choice selection is determined by performing behavioral analysis of own country,
iii. Port demand of traffic volume was developed using domestic feeder traffic taking into consideration only the lot size and unit price,
iv. International container simulation model was developed from the behavior of consignor and shipping company in relation to container movement variables such as trade port service level and size of vessels.

Basically, port facilities are decided by two dimensional relationship producing a less accurate freight demand forecasting, imbalance between container freight demand and port facilities. Thus, comprehensive analysis between container freight flow and port development need to be integrated.

The objective of this paper is to obtain a more reasonable forecasting method which can take account of international competition among ports.

Multiple Regression Curved Surface (MRCS hereafter) is introduced by considering the main port determinants-traffic volume, transportation fare and port charges forming a three dimensional relationship. Using this MRCS which considers ports of competitive power, an effective transportation policy for port planning in terms of development and improving the service facility efficiency can be formulated.

(2) Location and Status of Korea Ports

There are several Korea ports, namely Incheon, Asan, Kunsan, Mokpo, Kwangyang, Masan, Pusan, Ulsan, Pohang, and Donghue. Since 95% of Korea seaborne cargo including both containerized cargo and the others is handled by Pusan port, the analysis and discussions in this study are made with respect to this port. From early 1990s changes in transportation pattern is observed in Northeast Asia region when compared to the middle 1980s where Hong Kong, Kaoshiung and Kobe are the hub-ports. Taking this phenomena into perspective, Korea port is capable of developing into an international trade center and has a geographical advantage as a hub port.

Under Korea port development plan, several development measures have been implemented but proven to be inadequate. Taking handling volume and handling capacity as a crude measurement, great disparity exists as shown by Table 1. Other confronting problem is congestion due to increasing freight and insufficient container terminals. This warrants new approach to be adopted in analyzing feeder traffic.

Table 1: Korea port capacity and handling cargo (Unit: million ton)

	1989	1990	1991	1992	1993	1994	1995
Handling Volume (V)	259	284	339	371	413	471	534
Handling Capacty(C)	190	224	248	258	269	276	285
Excess Handling (%)	36.3	26.8	36.7	43.8	53.5	70.7	87.4

note: Excess Handling = (V-C)/C
Source: Statistical Yearbook of Shipping and Ports 1996-Korea Maritime and Port Administration

2. Methodology

(1) General Flow Chart

Figure 1 shows the general flow chart to forecast container cargo. In order to estimate the volume of feeder container freight flow within any origin/destination (called as O/D hereafter) in a transportation network, it is necessary to analyze the relationship between trade value and container freight volume of a country. The said relationship is further used in the analysis

*Key words: maritime traffic, port planning
** Student Member, Graduate School of Information Sciences, Tohoku University
*** Fellow Member, Professor, Graduate School of Information Sciences, Tohoku University,
(Graduate School of Information Sciences, Tohoku University, Aoba, Aoba-ku, Sendai 980-77;
Tel: (022)-217-7492 ; Fax. 022-217-7494)

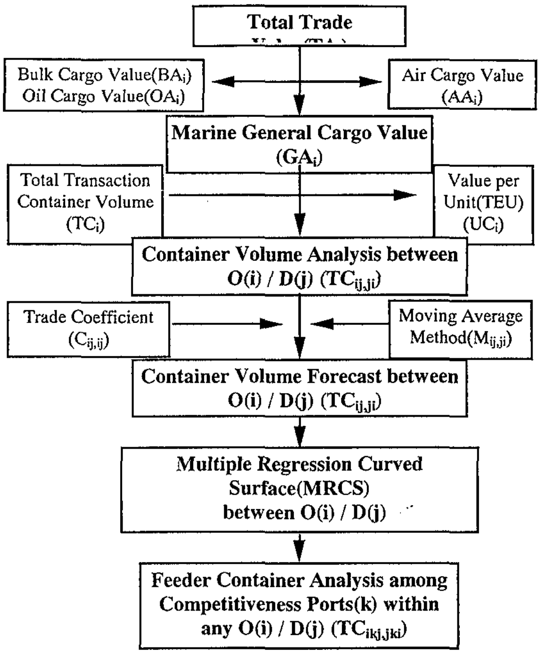

Figure 1: Flowchart of Container Forecasting

of container freight flow on sea routes followed by container volume forecasting and applying moving average method. MRCS model is then used to ascertain the non linear relationship between traffic volume, transportation fare, and port charges in order to analyze feeder container among competitive ports.

a) Marine General Cargo

Total amount of general cargo handled at Korean ports is simply calculated by the equation (1). The cargo labeled by asterisk is defined by SITC (Standard International Trade Classification) groups.

$$GA_i = TA_i - (AA_i + BA_i + OA_i) \tag{1}$$

where, GA_i : marine trade general cargo's values of *i* country,
TA_i : total trade values of *i* country,
AA_i : air cargo trade values of *i* country,
BB_i: break bulk cargo* trades values of *i* country,
OA_i : liquid cargo* trade values of *i* country

b) Total Transaction Container Volume (TCi)

The estimation of container volume is difficult to ascertain from the general cargo volume. However fortunately, "the Statistical Yearbook of Shipping and Ports" edited by the Korea Maritime and Port Administration has classified the transshipment container traffic from total container cargo handled at Korean ports. The containerized cargo volume in Korea in the past can be estimated by a historical trend of containerized cargo obtained from the statistics.

c) The Value per TEU (UCi)

It is possible to find the value per TEU (twenty feet equivalent unit) of any country given the volume of container freight as given by equation (2).

$$UC_i = \sum GA_i \,/ \sum TC_i \tag{2}$$

where, UC_i: values per container unit(TEU) of *i* country,
TC_i; total transaction container volumes (TEU) of *i* country.

d) Analysis of Transaction Container by O/D

The survey of 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. In the case of export, own country's UC is applied while for import using trade partner's UC.

$$TC_{ij,ji} = \{(GA_{ij} + GA_{ji})/2\}/(UC_{i,or,j}) \tag{3}$$

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.

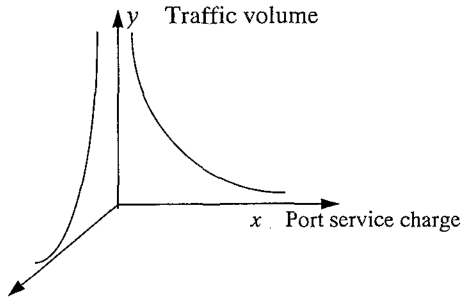

Figure 2: Relationship between selected port variables for traffic service with O/D

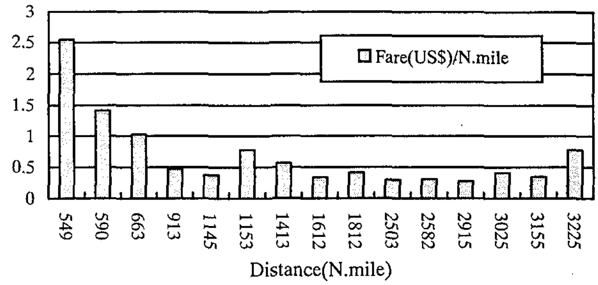

Figure 3 : Sea transportation fare and distance relationship
Data source: Obtained from two Japanese shipping line, one Taiwanese shipping line, and one Korean shipping line

Table 2: Relationship between inland transportation fare, distance, and lot size (Unit: US$)

Fare	Distance(km)	Fare/km	Fare	Lot size(ton)	Fare/ton
300	15	20.0	13.9	1	13.9
205	15	13.7	15.9	2	8.0
1075	120	9.0	17.3	3	5.8
1265	180	7.0	19.0	4	4.8
1170	140	8.4	21.1	5	4.2
1410	190	7.4	23.0	6	3.8
1455	200	7.3	25.7	8	3.2
1505	207	6.8	29.3	10	2.9
1695	250	5.9	30.3	12	2.5
2100	356	5.6	34.0	14	2.4

Data source: Two inland transportation co. ltd. in Japan, and Japan domestic tariff table 1996.
Data application: Round trip distance for inland truck transportation fare, and classification of lot size were done as follow; Within 10 ton; use gen. truck transportation fare, 10-20 ton; use 20ft container transportation fare, 20-30 ton; use 35ft container transportation fare, 30-40 ton; use 40ft container transportation fare.

e) Container Volume Forecast by Oi/Dj

From equation (3), the traffic volume between O/Ds for a period of 5 years were calculated and forecast by using moving average method [2].

(2) Development of MRCS

MRCS is developed based on the relationship between container traffic volume, transportation fare, and the level of port service charge which can be reflected by 3-D figure shown in Figure 2. This model adopted an exponential function in its algorithm formulation due to the fact that in the analysis carried out between the selected port variables, they follow an exponential curve pattern as depicted by Table 2 and Figure 3. The curve regression lines in Figure 2 can be expressed by the equations below.

$$Y = f(x,z) \Rightarrow \partial f / \partial x = \alpha h(z), \partial f / \partial z = \beta g(x) \tag{4}$$

$$y = g(x) = \alpha e^{(-\beta x)}, y = h(z) = \gamma e^{(-\delta z)} \tag{5}$$

α, β, γ are parameters determined by regression analysis.

To plot a three dimension[3] multiple regression curved surface (MRCS), the three axes, *x, y, z* of Figure 4 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 plane as shown in the figure. The MRCS equation can be given by;

$$F = g(x) \cdot h(z) = \alpha e^{(-\beta x)} \cdot \gamma e^{(-\delta z)} \tag{6}$$

The container traffic volume demand decreases with increasing transportation fare, as would be expected, and also with increasing time on the level of port service charge axis, indicating that high transportation fare have increasing disutility.

The figure also shows the relationship among traffic volume, the fare which the shippers will charge, and the level of port service charge which depend on the manner in which the system management decides to operate the service charge as a function traffic volume. The underlying choices made by the management of the facility and service charge which lead to this function are quite complex. In general, given the particular technology or production function, they will result in a unique cost and unique level of port service charge for each volume of traffic. Assumptions of MRCS are:

i. the volume is the total available container with fixed volume between any O/D, and
ii. the ship size is classified by route given in the Table 3.

In order to calculate transportation total transportation fares and service charge, equations using simple algorithm are provided in the succeeding section.

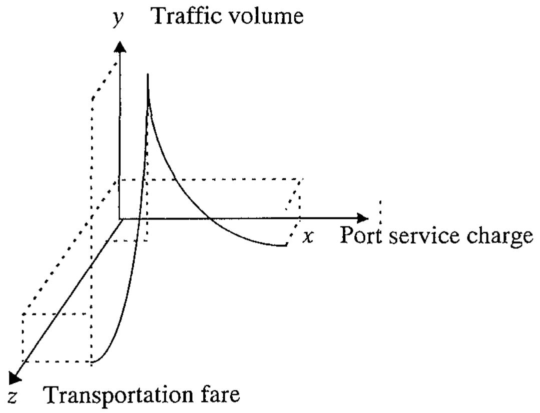

Figure 4: Multiple-regression curved surface

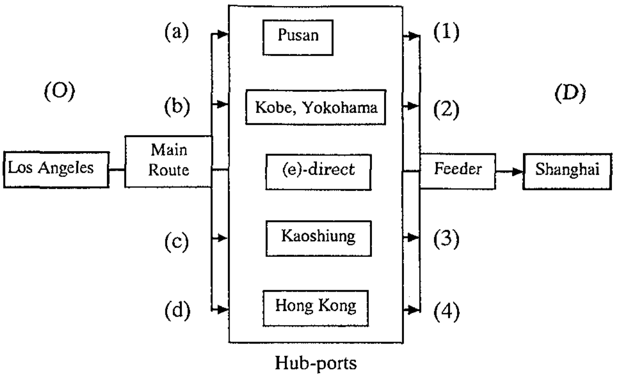

Figure 5: Feeder transportation route pattern

Table 3: Distribution of ship size by route (Unit: number (ship) and TEU)

Route	-1000	-2000	-3000	-4000	4001-	Avg
USWC	12	22	95	49	44	2888.6
UKCS	0	10	75	77	45	3298.3
SE AS	272	88	7	0	0	745
NE AS	8	-	-	-	-	748
KOCH	28	-	-	-	-	345
JPCH	118	-	-	-	-	405
KOJP	59	-	-	-	-	169

Data source: International Transportation Handbook 1996.
Route: USWC-West Coast of North America, UKCS-United Kingdom, Continent and Scandinavia, SEAS-Inter Southeast Asia, NEAS-Inter Northeast Asia, KOCH-Korea and China, JPCH-Japan and China, KOJP-Korea and Japan.

(3) Feeder Container Traffic Volume

From the MRCS model, the next main step is to determine the feeder container traffic volume and this can be calculated by summing up the cost by origin(*g or i*)/destination(*j*) from the computed transportation fare and port service charge by route. As an example, consider the case of transportation between USA (Los Angeles) and China (Shanghai) serviced by four feeder routes as shown Figure 5.

The volume of feeder traffic at a hub port is calculated by proportioning cost via port to sum up cost (equation (7)).

$$FT_k = \sum_{i=1}^{n} \frac{1}{(PC_i + TF_i)} / \left(PC_k + TF_k\right) * TFV \tag{7}$$

where, FT_k: feeder traffic volume at port k
TFV: total feeder traffic volume between an O/D pair
PCi : port service charge at port i
TFi : transportation fare of an O/D when it use port i as a transshipment port
TFV can be obtained by using equation (8).

$$TFV = \sum_{i,j} (TTV - Fq * SV * r) \tag{8}$$

where, i,j : countries of origin/destination
Fq: direct calling at port between O/D by region or country
SV: average size of vessel inter O/D
r: proportion of loading between O/D
TTV: total traffic volume between O/D

In the analysis of feeder traffic volume forecasting by taking account of Pusan port interest, three case studies were carried out to find the forecast results.

i. Container freight distribution of PRC (People's Republic of China)
ii. Import and export freight flow of Japan North East District
iii. Container Flow Pattern from/to North America and East/Southeast Asia

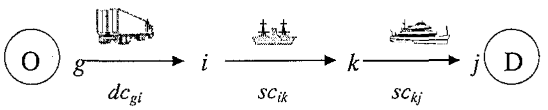

Figure 6: Distinction of variables by route

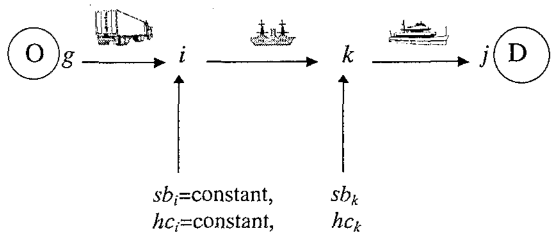

Fig. 8: Distinction of variables by route

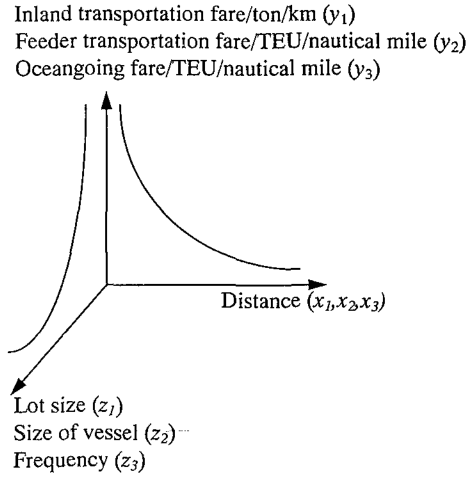

Figure 7: Relationship between the various port variables

The success in calculating, equation (8) is highly dependent on the data availability with respect to frequency (F_q) and size of vessel (SV). In this study due to data constraint, the equation was not performed. Nevertheless feeder container traffic forecasting scenario based on 30%, 50%, and 80% proportion were used instead in equation (7).

3. Analysis of Variables

(1) Transportation Fare

It is the total fare from/to a port by route. Port handling volume depend greatly on the transportation fare (economic benefit) from/to a port which is influenced by several fluctuating factors. Naturally shippers and carriers route choice would be that of minimum transportation cost. In the selection, however, the domestic transportation fare (truck) normally has not been considered since it is not related in measuring port total traffic volume.

The components of transportation fare can be illustrated by Figure 6 and represented by equation (9).

$$TF_{gi} = \sum (dc_{gi} + sc_{ik} + sc_{kj}) \tag{9}$$

where, TF_{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

$sc_{i\,k}$: 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

a) Domestic Transportation Fare(dc_{gi})

In equation (9), dc_{gi} is inclusive of land (truck) and coastal (ship) transport. For the Korea's case, the value of y_1 in Figure 7 is taken as the discounted value of 50% from the normal inland transportation (truck) tariff based on Japan fare indicator. With this consideration, the equation is then given by equation (10).

$$dc_{gi} = y_1 e^{-\{(\alpha_1 d)+(1-\beta_1 l)\}} \tag{10}$$

where,

l: lot size(ton), d: distance(km)

b) Transportation Fare Between Feeder Routes for Inter Nations ($sc_{i,k}$)

Similar to domestic transportation fare, the inter-nations feeder transportation fare relationship take the shape of non-linear as in Fig. 7 (x_2, y_2, z_2). fare/unit. The curved path follows the relationship among distance, size of vessel and fare per unit (TEU) which is representative of general competitiveness case in any O/D. Feeder route is define as that within 2,000 miles. The curve is set based on the longest section (Hong Kong-Kobe: 1,387 miles) inter-hub ports in Northeast Asia and the longest route (Tomakomai-Kaoshiung:1,655 miles) of the present feeder shipping service. The feeder route equation can be written as equation (11).

$$sc_{ik} = y_2 e^{-(\alpha_2 d + \beta_2 sv)} \tag{11}$$

where, sv: size of vessel (TEU), d: distance(mile)

c) Transportation Fare of Oceangoing($sc_{k,j}$) by Distance and Frequency

The analysis of frequency calling at a port, distance of inter-port, and the oceangoing fare are represented similarly as in

Figure 7 (y_3, z_3, x_3). For the main service route, it is define as exceeding 2,000 miles distance between inter-port and the route equation is expressed as equation (12).

$$sc_{kj} = y_3 e^{-\left(\alpha_3 d + \beta_3 f_{kj}\right)} \tag{12}$$

where, f_{kj}: frequency(numbers) from k to j, d: distance(mile)

(2) Port Service Charge at a Calling Port

It plays an important role in deciding port handling volume. As port facilities changes, port service charge also changes. This variable determines the competitiveness power of a port and a key factor in the selection by shipper and shipping company. To obtain the value in relation to service charge per unit (TEU) at a calling port, equation (13) is used to analyze the relationship between port facilities, traffic volume and wage rate. Port service charge consists of ship-based charge and handling charge for container freight. The ship-based charge include tonnage dues, berth hire, pilotage, towage, mooring/unmooring charges et cetera.

$$PC_{i,k} = \sum(sb_i + sb_k + hc_i + hc_k) \tag{13}$$

where, $PC_{i,k}$: total port service charge at calling port i, k
sb_i: ship-base charge at supply port i
sb_k: ship-base charge at via port j
hc_i: fare of freight handling at supply port i
hc_k: fare of freight handling at via port k

Referring to Fig. 8, two of the four factors are constant since the charges incurred are related to own port. In this case, the solution in handling cost and ship-base charges at the hub-port is as equation (14).

$$PC_k = y_4 e^{-(\alpha_4 nb + \beta_4 nc + \gamma_4 hv + \delta_4 wr)} \tag{14}$$

where, PC_k: port service charge at a calling port k
nb: number of berth,
nc: number of crane,
hv: total handling volume of container freight
wr: wage rate
y_4: unknown constant

4. Relationship of Port Variables

By integrating all the port variables as stated in the preceding sub-chapters, the equation formulated is given by equation (15). By considering equations (5) and (9), the following equation (16) is obtained.

$$TV = y_{11} e^{\alpha_{11}(TF) + \beta_{11}(PC)} \tag{15}$$

$$TV_k = \alpha e^{-\beta\left(TF_{gi}\right)}$$

$$= \alpha e^{-\beta\left[y_1 e^{-\{(\alpha_1 d)+(1-\beta_1 l)\}} + y_2 e^{-(\alpha_2 d + \beta_2 sv)} + y_3 e^{-\left(\alpha_3 d + \beta_3 f_{kj}\right)}\right]} \tag{16}$$

Also, from equations (5) and (9), port service charge can be computed as equation (17).

$$y = h(z) = \gamma e^{-\delta x} \Rightarrow TV_k = \gamma e^{-\delta x}$$

$$TV_k = \gamma e^{-\delta\left(PC_{ik}\right)} \tag{17}$$

From equation (6):

$$TV_k = \theta \cdot e^{-\beta TF_{gi}} \cdot e^{-\delta PC_k} \tag{18}$$

Giving,

$$TV_k = y_{12} \theta \cdot e^{u} \cdot e^{v} \tag{19}$$

where

$$u = -\beta y_1 e^{-\{(\alpha_1 d)+(1-\beta_1 l)\}} + y_2 e^{-(\alpha_2 d + \beta_2 sv)} + y_3 e^{-(\alpha_3 d + \beta_3 kj)}$$

$$v = y_4 e^{-(\alpha_4 nb + \beta_4 nc + \gamma_4 hv + \delta_4 wr)}$$

θ : unknown parameter can be determined by regression analysis

5. Result of the Analysis

Using the derived equations and data availability using MRCS model concept, the results obtained are as follows.

(1) Domestic Transportation Fare

Using equation (10), the results of regression analysis is given by Table 4. It can be seen that for the relationship between distance, lot size, and inland transportation(truck), ship size has greater influence on the fare compared that of distance.

Table 4 : Regression analysis for domestic transportation fare (*DCgi*: Eq.(10))

	Partial Regr Coefficient	Std. Partial Regr. Coefficient	t-value
d(km)	-0.00129	-0.816	8.26
l(ton)	-0.0208	-0.411	4.16
Constant	3.48	*	*
Coefficient of determination: 0.834 ; Data numbers: 20			

Data source: Two inland transportation co. ltd. in Japan, and Japan domestic tariff table 1996.
Data application: Round trip distance for inland truck transportation fare, and classification of lot size were done as follow; Within 10 ton; use gen. truck transportation fare, 10-20 ton; use 20ft container transportation fare, 20-30 ton; use 35ft container transportation fare, 30-40 ton; use 40ft container transportation fare.

(2) Feeder Transportation Fare

Table 5 shows the results from equation (11). Using the distance and size of vessel variables relationship, ship size affects the feeder transportation fare to a certain extent.

Table 5: Regression analysis of feeder transportation fare (*SCik*: Eq. (11))

	Partial Regr Coefficient	Std. Partial Regr. Coefficient	t-value
d (km)	-0.00025	-0.0746	0.43
sv(TEU)	-0.00421	-1.03	5.93
Constant	4.64	*	12.63
Coefficient of determination: 0.950 ; Data numbers: 7			

Data source:<H> Shipping Co. Ltd., of Korea and <N> of Japan for sc_{ik}, and *sv*(ship size) data from International Transportation Handbook 1996.
Data application: Ship's size is obtained through average by route. Feeder route for ship's size are divided in 4 sections-Korea-Japan, Korea-China, Japan-China, (Korea, Japan)-(Hong Kong, Taiwan).

(3) Oceangoing Transportation Fare

For this analysis the purpose is to find the relationship between frequency at port of call, and distance. Equation (12) is applied and the results is shown as Table 6. It is found that for main route transportation, transportation fare has a very close relationship with distance.

Table 6: Regression results of oceangoing transportation fare (*SCkj*: Eq.(12))

	Partial Regr Coefficient	Std. Partial Regr. Coefficient	t-value
d(100km)	-0.0192	-0.674	8.08
Freq/mth	-0.0248	-0.9	10.78
Constant	1.73	*	7.96
Coefficient of determination: 0.954 ; Data numbers: 10			

Data source: International Transportation Handbook 1996, Shipping gazette(June 1996) for Japan and Korea. Taking <H> shipping co. ltd., of Korea and <N> of Japan for sc_{ik},
Data application: Ship's frequency is obtained through by route. Main route for ship's frequency is divided into 3 sections centering from Northeast Asia(Japan, Korea, Hong Kong, Taiwan) to Europe(Rotterdam), Southeast Asia (Singapore), and North America (Los Angeles: USA).

(4) Port Service Charge

The relationship between port service charge (number of berths, number of cranes, wage rate, handling volume) were analyzed using equation (14) and as Table 7. The analysis shows that port service charges are affected by the number of berths and number of crane variables.

Table 7: Regression results of port service charge (*PCk* : Eq. (14))

	Partial Regr Coefficient	Std. Partial Regr. Coefficient	t-value
nb	0.0577	1.29	2.13
nc	0.0375	1.29	2.63
hv(1000)	7.50E-06	0.05	0.19
wr	9.60E-06	0.21	0.06
Constant	5.71	*	36.41
Coefficient of determination: 0.907 ; Data numbers: 10			

Data source: Containerization International June, Aug. 1996, Yearbook of Containerization International 1992, 1994, 1996, and Research Discussion Paper for Great Port Competitiveness Era of Civil Engineering Conference 1996 in Nagoya University.

Data application: Port service charges by year and ports were calculated by using the index of 1995. This index is converted to US$(110Yen/US$) value based on Kobe situation. Wage rate for Singapore is assumed the same as Hong Kong while handling cost of Hong Kong is assumed the same as Singapore because of the similar economic environment such as GNP growth.

(5) Traffic Volume, Transportation Fare, and Port Service Charge

The integration of three variables (TV, TF, PC) including their related factors were considered which completes the MRCS model. Using equation (19), the results of the variables relationship are given in Table 8.

From the Table 8, the correlation between all the port variables were correlated except traffic volume (TF) as indicated by the t-value which is less than one.

Table 8: Regression results for traffic volume, transportation fare, and port service charge (*TVk*: Eq. (19))

	Partial Regr Coefficient	Std. Partial Regr. Coefficient	t-value
d(100km)	-0.0192	-0.674	8.08
Freq/mth	-0.0248	-0.9	10.78
Constant	1.73	*	7.96
Coefficient of determination: 0.954 ;Data numbers: 10			

6. Comparison of Results

Table 9 shows the comparisons between computed results using MRCS to the actual figures for the hub-ports in the East/Southeast Asia. It shows a close resemblance between using MRCS model and the actual data. Table 10 shows the comparisons done between computed results using MRCS to forecast figures as obtained from the existing Korean ports development plan. Short term planning is complementary of each other, while for long term planning the forecast figures between MRCS and Korea Port Authority(KPA) show a big contrast. The figures of the KPA forecast is simply estimated by the exploration of the historical trend.

For feeder container traffic analysis, the O/D container forecast for the year 2001 and 2011 are given in Table 11. In terms of feeder traffic, by using the moving average method and the feeder traffic scenario, the proportion of 30%, 50% and 80% out of the total container volume have been assumed. In this connection, the future port development plan for Northeast Hub-Ports for berth facility and crane equipment is given by Table 12. For the year 2011 most ports dramatic increase in berth and crane.

Table 9: Comparison of actual data and computed data (Unit: TEUs)

Port	Computed(a)	Actual(b)	Ratio(a/b)
Pusan	4,543	4,500	1.009
Kobe	1,315	1,350	0.974
Hong Kong	13,170	12,600	1.045
Kaoshiung	5,667	5,232	1.083
Singapore	10,516	11,850	0.887

Table 10: Comparison of Korea existing plan and MRCS value

Target Year		1995	1997	2001	2011
Existing	Berth	7	7	15	21
	Cr	20	20	38	46
Planned	Berth	*	8	6	36
	Cr		18	8	72*
Total	Berth	7	15	21	57
	Cr	20	38	46	118
KPA Forecast Vol. (a)		4,500***	6,560**	9,850	19,000
MRCS Forecast Vol. (b)		4,543	7,289	6,630	14,885
Ratio (b/a)		1.0096	1.1111	0.6731	0.7834

Note: Existing means existing port, and Planned means newly planned port. Values only in 1995 are the actual figure, and others are planned or estimated figures. * Crane numbers are calculated by 2crane per berth, ** The value was interpolated by the value of during the 1995-2001. ***Actual figures. Vol. unit:1,000TEU

Table 11: Total container transaction volume and feeder traffic volume forecasting (Unit: TEUs)

			Feeder Traffic Volume Scenario					
Unit TEU	Total Volume		2001			2011		
Route	2001	2011	30%	50%	80%	30%	50%	80%
USA - PRC	415,145	1,901,141	124,544	207,573	332,116	570,342	62,272	166,058
N. E Japan - EU	11,886	17,701	3,556	5,943	9,509	5,310	1,783	4,754
PRC - EEC	844,160	7,260,354	253,248	422,080	675,328	2,178,106	3,630,177	5,808,283

NE Japan: Northeast district of Japan, PRC: People's Republic of China

Table 12: The future of Northeast hub-ports development

Year	1994			2001			2011		
Port	Berth(b)	c/b	Crane(c)	Berth(b)	c/b	Crane(c)	Berth(b)	c/b	Crane(c)
Pusan	7	2.9	20	21	2.2	46	57	2.1	118
Kobe	37	1.4	51	42	1.6	66	42	2.0	84
Hong Kong	16	3.3	52	24	2.5	60	32	2.5	80
Kaoshiung	20	2.2	43	27	2.2	60	32	2.5	80
Singapore	20	3.1	61	28	2.5	70	46	2.6	106

Note: Existing means existing port, and Planned means newly planned port. Values only in 1995 are the actual figure, and others are planned or estimated figures. * Crane numbers are calculated by 2crane per berth, ** The value was interpolated by the value of during the 1995-2001. ***Actual figures. Vol. unit:1,000TEU

7. Summary

1) Analysis results show that the correlation among the variables were significant. Some results prove to be insignificant or having no correlation such as that in Table 5 (distance and ship size), Table 7 (handling time and wage rate), and Table 8 (*transportation fare*).
2) For the complete MRCS regression analysis (Table 8), variable concerning transportation fare is insignificant with a t-value of 0.769 while for the coefficient of determination with 0.993 value showing a very high correlation.
3) Comparing the MRCS results and the simple regression analysis based on the GNP growth, MRCS proves to be more reliable because of its comprehensives with an average error ratio of 5.5% when compared to the actual data.
4) From the feeder traffic analysis of the selected route and several ports development plan, it is observed that after the year 2001, port service level for the respective ports analyzed will be at the same level.
5) In the MRCS development and the analysis performed, data availability (ranging from 5 to 20 numbers) is the major problem. Transportation fare data and total frequency for ports of Hong Kong, Singapore and Kaoshiung are estimated from data of Korea and Japan .
6) The relationship between frequency, number of berth and crane has it constrains whereby the frequency will extremely large with the increase in the number of berth and crane indefinitely. For example, from the equation (20), the coefficient of parameters is (-) 0.08349/0.070824 per berth/crane. Although berth and crane number of can be increased indiscriminately resulting to the surge of frequency, this condition is not practical since generally a berth will be equipped 2 cranes. In addition, from equation 12, sc_{kj} (transportation fare of main route) approaches zero. To be in line with the real conditions, the analysis adopted 10% of the calculated frequency increment since the world container ship fleet only increased by 10% during 1993-1994.

8. Conclusion

1) MRCS introduced in this paper proves to be effective in analyzing transportation policy such as handling cost, establishment of new route (for frequency, ship size), construction of new port (for berth), and rearrangement of port equipment (for cranes). Reliability is still yet to be perfected since the definition of reliability is complex because of its dependence on the behavior of shippers and carriers, transportation fare changes and improvement of service facilities within a given range.
2) Using MRCS model in the port development, it only considers a single port having changes while its competitors remain constant. This behavior is unrealistic in the real world since most of the ports are striving to excel simultaneously by improving their facilities et cetera.
3) There are certain limitations in adopting this MRCS model as mentioned above, but these are only minor problems which do not discredit the model as a whole. MRCS integrate the main port variables represented by 3-D figure and thus more comprehensive and closer to the real world situation. This is truly so when compared to previous studies whereby only individual port variables are considered. Its simplicity by using non complex data is also an advantage.

References

1) " Containerization International", Nov.1995.
2)Wayne L. Winston, "Operation Research Applications and Algorithms; Second Edition", Thomson Information Publishing Group, 1991.

3) Edward K. Morlok, "Introduction to Transportation Engineering and Planning", -Transportation Network Flows-, McGraw-Hill Book Company, 1971..
4) Masahiro Nakamura, "A demanding forecasting model for international feeder container cargo taking account of modal choice", Master Thesis, Tohoku Univ. in Japan, 1995.
5) Moris Hamburg et al, "Statistical Analysis for Decision Marking; Multiple Regression and Correlation Analysis", Six Edition, The Dryden Press, 1994.
6) "Container Market Profitability to 1997 ; Forecast Profitability to 1997", Drewry Shipping Consultants Ltd., 1992
7) Katsuhiko Kuroda, "A planning method for International Network of hub container terminal", Discussion paper for 9th ARSC(Applied Regional Science Conference), 1994.

MID-TERM FEEDER CONTAINER FORECAST FOR KOREAN PORTS

Ja-yeong GU, Meor Aziz Osman, Hajime INAMURA

Conventional methods of feeder container forecasting is done through regression methods based on the GNP growth trends and other forecasting methods proposed by several authors. However these efforts prove to be inadequate with visible weakness which cannot take account of international competition. In order to solve the difficulty, this paper introduced multi-regression curved surface model (MRCS) to ascertained the non-linear relationship between international variables comprising of traffic volume, transportation fare, and port charges through simple algorithm formulation. Using this MRCS model, feeder traffic forecast was calculated. Results output are based on statistical methodology utilizing regression and correlation analysis, and t-test. The usefulness of the MRCS model was confirmed by comparing the actual and computed results of traffic volume for Korea port development plan and other neighboring competitor ports.

韓国港湾のフィーダーコンテナ貨物の短期予測

具　滋永, ﾒｵﾙ･ｱｼﾞｽﾞ･ｵｽﾏﾝ, 稲村　肇

従来，フィーダーコンテナ貨物需要予測はＧＤＰの成長を基礎とした回帰分析を中心とし，様々な方法が提案されてきた．しかし，これらの方法はいずれも国際競争を明示的に考慮できないという明らかな欠点を持っている．本研究は貨物量，輸送運賃，港湾料金といったフィーダー貨物の取扱量を決定づける変数間の関係を非線形の多次元曲面として捉え，この問題を解決している．モデルの信頼性は統計量によって検定された．モデルによる推計結果は韓国の港湾計画とそこで使用された推計値と比較され，その有用性を確かめている．
