

An Analysis of the Decision Factors on Mokpo Port by Multinomial Logit Model

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Abstract : *Relative importance of maritime transport that takes charge of main current of freight in country' economy is very large. Especially, port and facility carry out important role which treats freight of import and export smoothly and improves international trade as turning point, to achieve key role on connection and association between sea and land. For such reason, enlargement of port facilities or development of port needs to grasp exactly the utilization of port, attributes and selective factors of shipper. On the other hand, the amounts of physical distribution on Mokpo port located in Korean west coast are increasing, with fast economic growth of East Asian including China. This study uses discrete choice model that is measuring to analyze attribute and characteristic of Mokpo port, and analyzes port selection by decision factors of shipper. This paper composed a questionnaire using the result of preceding research, to decide port selection factor among competitive ports. Through factor analysis on a basis of the questionnaire' result, five principal components were extracted. These are resorted out by Logit model, to grasp competitive elements of port. This research can present direction which raises competitive power of ports in west coast of Korea, especially on alternative and concentration of middle-class port as Mokpo may be useful.*

Key words : *Port selection, Factor analysis, Mokpo port, Multinomial logit model*

1. Introduction

The Port is vital because of its important facility in processing 90 % of the entire world's trade, but 99 % of the freight distribution is in Korea. In terms of the development or the extension of ports, the factors of port choice by the shipper and the trade company must be researched to promote this activity and to support the country's economy.

If the requests of the shipper, who is the main user of a port, cannot be sufficiently reflected, then a problem can occur with the port's disproportion. This can occur because a country's resources are restricted by investment priorities and management. It can be supposed that a port's conditions are overflowing and unaccountable in facility, or that another port has become inactive for anchoring, keeping storage and keeping a liner service in comparison with other ports. As a result, the port utilization is idle wrong throughout because the country has idle facilities that may add to the inefficiency of its economic resources.

For this reason, the port's development and the facility's expansion should be discussed with regards to the standard and the method in which necessary measures should be discussed first. With this, it is necessary to examine the

actual condition of the port's utilization and the analysis on the determinants of port selection, which has a view of the country' dimensions and efficiency.

The economic trade between Korea and China has been activated recently with the quick economic growth of China. The freight distribution quantity of the Mokpo port, located in the province of Geonra, has increased. In the research that focuses on this area's freights, we use the mathematical model in order to analyze the determinant for the Mokpo port selection. The model attempts to analyze the port's selective determinant of shippers.

The model used in this paper is the Multi Logit (Multinomial Logit Model). This model analyzes the independent variables that are estimated, and calculates the coefficient of the model. For this purpose, it tries to utilize the Non-linear Maximum Likelihood Estimation Method.

2. Preceding Research

2.1 Literatures of Port Selection

The researches started from empirical approaches and thoughts of port selection in earlier 1980s. These research results are focused generally on the primary factor of port

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selection. The 1980s research has been called the "father period" on marketing research. This research on the analysis of a port selection mostly showed a standard of the port selection through the empirical method. Also, the factors of port selection shown by the research were the developing of the facilities, the frequency of liners, the safety of the freight, the service of the port and the port fees, etc.

On the other hand, we reviewed a research study from the 1990s and began to discover more concrete elements compared with the research in the 80s. It showed the factors such as port politics, social safety, location, quantity of freight, and was concerned with geopolitics, the processing of non-standardization, and the capability of cargo handling. This research was shown because it put more importance on the quality of port service, transportation time, the capability of equipment and freight information as port choice factors.

Recent researches from the 2000s are different from earlier studies. The research stands up in the way of analyzing factoring details that are more various. The factors with port location are concerned with geopolitics and the hinterland economic scale, which are esteemed highly as research points in the past.

2.2 Overview of Preceding Research

The preceding research has analyzed the reply of questionnaires choice factors discussed beforehand, and not the analysis made on the basis of the selection preferable by the shipper and the individual company. Namely, it is not to investigate the quality of the individual shipper and to reflect the quality of the port. This cannot be connected simultaneously between the utility of the port's selective person and the quality of the port. Moreover, this owes to the used factor analysis that the approach has not made in regard to utility problems of the selection port

Therefore, this research uses the Logit model, which is based on the hypothesis that it is distributed with the Gumbel function. This is independent with a selection utility function of stochastic element. It tries to recognize the determinant of the shipper for port selection. Also, the Logit model is the multiplex selective model and is known for its easy presumptions in mathematical calculation, interpretation and application of parameter. This is easier than other selective models.

3. Model for Port Selection

3.1 Discrete Choie Model

McFadden[1] suggested the concept of the individual

decision maker who, faced with a set of feasible discrete alternatives, selects the one that yields greatest utility. He noted that for a variety of reasons the utility of any alternative is, from the perspective of the analyst, best viewed as a random variable. This leads directly to the notion of random utility models in which the probability of any alternative i being selected by person n from choice set C_n is given as following:

$$P(i | C_n) = Pr(U_{in} \geq U_{jn}, \forall j \in C_n) \tag{1}$$

Supposing random clause(random term) of utility function to Logistic distribution, each ϵ at the time follows I.I.D. Gumbel (type I weibull) distribution. Theform of cumulative distribution is same with equation (1), and probability to select alternative i is appeared with equation (2).

$$F(\epsilon_n) = \frac{1}{1 + e^{-\mu\epsilon_n}}, \mu > 0, -\infty < \epsilon_{n0} < \infty$$

$$P_n(i) = Pr(U_{in} \geq U_{jn}) = \frac{1}{1 + e^{-\mu(i)}} \tag{2}$$

Generally to display above formula that more alternative than binary choice, specially, $\epsilon_{jn} - \epsilon_{in}$ by expressed in distribution of random term is necessary to be with joint probability distribution not as one side distribution. Joint probability density function for random term is exposed as following equation (3).

$$P_n(i) = Pr(U_{in} \geq U_{jn}, \forall j \in C_n, j \neq i)$$

$$= Pr(V_{in} + \epsilon_{in} \geq V_{jn} + \epsilon_{jn}, \forall j \in C_n) \tag{3}$$

Parameter estimation

To Assume multi logit model using Maximum Likelihood Estimation method, General form of Logit model is shown as follow.

$$L = \prod_{n=1}^N \prod_{i \in C_n} P_n(i)^{y_n} \tag{4}$$

The probability selected at i in liner-in-parameter logit,

$$P_n(i) = \frac{e^{\beta x_{in}'}}{\sum_{j \in C_n} e^{\beta x_{jn}'}}$$

$$L = \sum_{n=1}^N \sum_{i \in C_n} y_{in} (\beta x_{in} - \ln \sum_{j \in C_n} e^{\beta x_{jn}}) \tag{5}$$

Statistical test

1) *t*-Test

To presume parameters making L to maximum, Logit model uses non-linear assumption. Coefficients estimated by this presumption are shown near in form with normal distribution, in accordance with increase of sample figure. Therefore, we can apply *t* test of coefficient applied in general regression analysis.

2) Likelihood Ratio test

Compare log likelihood function between limited model L_0 and not limited mode L_β . Degree of freedom *df* displays necessary independent constraint to calculate $L_0 \geq L_\beta$. Because it becomes to be $L_0 - L_\beta$, the constrained statistic condition that authorize null hypothesis is expressed to $-2(L_0 - L_\beta)$. At the time, degree of freedom *df* follows χ^2 distribution, and null hypothesis is rejected if value of $-2(L_0 - L_\beta)$ is greater.

3) ρ^2 test

ρ^2 is similar with R^2 of linear model, but R^2 is near to occasion 1 that fidelity is high, but ρ^2 is thought to be superior even if it becomes 0.2 to 0.3 degree.

3.2 Framework of Model

The model by this research uses a supposition that the probability of the selection utility function is independent. This probable element is distributed by the Gumbel function. Suppose these selective alternates of the Mokpo port (M), the Kangwang port (K), and the other port (O) by the characteristic of the port, which can handle the freights in this area. For another supposition, make two kinds of clauses which are a confirmation clause and a probability clause.

$$U_{in} = V_{in} + \epsilon_{in} \tag{6}$$

where,

V_{in} is the systematic component.

ϵ_{in} is the random part.

i is the port and n is the shipper.

The reason to select port i by shipper n is larger in the utility of port i on chooser n than a utility of other port. This is expressed with equation (7).

$$U_{in} > U_{jn} , j \neq i \tag{7}$$

The probability P_{in} when shipper n selects port i can be obtained as to equation (8). This is induced with equation (6) and equation (7).

$$\begin{aligned} P_{in} &= P(U_{in} > U_{jn} , j \neq i) \\ P_{in} &= P(V_{in} + \epsilon_{in} > V_{jn} + \epsilon_{jn} , j \neq i) \\ P_{in} &= P(\epsilon_{in} > V_{jn} - V_{in} + \epsilon_{jn} , j \neq i) \end{aligned} \tag{8}$$

Here, if we suppose that there is independent with ϵ_{in} and ϵ_{jn} , it is possible to express as equation (8):

$$P_{in} = \int_{-\infty}^{\infty} Prob(\epsilon_{in} = \epsilon) \prod_{j \neq i} Prob(\epsilon_{jn} + V_{jn} - V_{in} < \epsilon) d\epsilon \tag{9}$$

Through above equations, the variation of probability utility e^{it} is not able to be measured. Thus, we don't know the result of e^{it} , but can suppose that stochastic distribution of e^{it} . According to the independent gumbel distribution whose dispersion is equal, this equation (9) is induced to equation (10) as Multinomial Logit.

$$\begin{aligned} P_{in} &= \frac{e^{V_{in}}}{\sum_{j=1}^N e^{V_{jn}}} \\ V_{in} = \theta' X_{in} &= \sum_{k=1}^K \theta_k X_{ink} , \theta = [\theta_1, \dots, \theta_k]' \end{aligned} \tag{10}$$

where,

P_{in} : Probability in port i chosen by shipper n

V_{in} : Utility in choice of port i by n

θ : Vector, coefficient of unknown parameter

Because multinomial logit has taken a non-linear form, it is not possible to seek efficient parameters with the presumption method by minimum multiplication. Therefore, we guess correct parameters with Maximum Likelihood Estimation. The form of the Likelihood Function is shown in equation (11).

$$L = \prod_{n=1}^N \prod_{i \in C_n} P_{in}^{\delta_{in}} \tag{11}$$

where,

$\delta^{it} = 1$ is the case when shipper n selects port i

0 is not the case when shipper n selects port i

This objective function is added with an algebraic sign and shown as equation (12).

$$\begin{aligned}
 \text{Max to } \ln(L) &= \sum_{n=1}^n \sum_{i \in C_n} \delta_{in} \cdot \ln(P_{in}) \\
 &= \sum_{n=1}^N \sum_{i \in C_n} \delta_{in} (\theta X_{in} - \ln \sum_{j \in C_n} e^{\theta X_{jn}}) \quad (12)
 \end{aligned}$$

4. Presumption on Port Selection Model of Mokpo Port

4.1 Empirical Analysis

The research analyzed preceding literature on the port utilization and implements a research question based on the questionnaire. Then, it grasped basic relations among the variables through the Factor Analysis. In the case of the questionnaire, it implemented a questionnaire investigation for a target to trading companies and to individual shippers, which transported marine freight by using the port in the Geonra province. The questionnaires were sent to 60 companies and shipper concerned with ports of Geonra province including Mokpo port from Aug. 2004 to Feb. 2005. Finally, 40 questionnaires were taken for this analysis.

The questionnaire measured the variables to analyze a material in five Ricardo scale. As a result, it selected factors that were influenced to choose the Mokpo port by a shipper with table 1, as filtered through the literature. As dependable variables, these are composed of Mokpo (M), Kawangwang (K) and the other port(O).

Table 1 Result of Factor analysis

	F_1	F_2	F_3	F_4	F_5	Communality
x_1	0.812					0.682
x_2	0.656					0.805
x_3	0.798					0.665
x_4	0.418					0.776
x_5		0.863				0.791
x_6		0.616				0.542
x_7			0.799			0.664
x_8			0.325			0.698
x_9			0.816			0.760
x_{10}			0.569			0.385
x_{11}				0.848		0.774
x_{12}				0.752		0.651
x_{13}					0.765	0.386
x_{14}					0.856	0.784
x_{15}					0.811	0.680
Eigen value	4.282	3.760	2.155	1.483	1.000	

Principal Component Analysis
Kaiser Varimax rotation, 6th fixed

KMO & Bartlett's Test

Kaiser-Meyer-Olkin Measure of sampling Adequacy		0.738
Bartlett's Test of sphericity	Approx. Chi-square	1014.920
	Sig.	0.000

x_1 is utility of berth

x_2 is storing

x_3 is capability of cargo handling

x_4 is service frequency of liner

x_5 is fare in land

x_6 is distance in land

x_7 is hinterland onto port

x_8 is network with other area

x_9 is network with other country

x_{10} is multi cargo terminal

x_{11} is fare in sea

x_{12} is distance in sea

x_{13} is experience of cargo handling

x_{14} is support in occasion on claim

x_{15} is information on logistics

The primary factors which is extracted as eigen value over 1 by Factor analysis method is important to explain the amount of disparity. here took 5 primary factors. If Hessian set does not have opposite queue due to Multicollinearity between special variable of the determinants and quality variable of port, we seek best results repeatedly until model goodness-to-fit is to be suitable, excluding unfitted variable throughout calculation process and represumption continuously with factorial design.

In factor analysis of each variable, the communalities are express in table 1. The figures which are distribtuions from 0.385 to 0.816 are thought that suitable ones variables were consisted for analysis. However, it is expected that the portion on multi cargo terminal and experience of cargo handling is inferior as the explanation. As result of principal component analysis, five values were extracted finally to be an eigen value over 1. The total distribution explanation of extracted factors was shown as 68.377%. We understood the basic relation of variables through Factor analysis. In addition, these variable's averages of primary factors were used for logit model.

The approval of goodness on estimated variables is presumed by x^2 value, and ρ^2 values, prediction and

examined the significance of t value. Secondly, we examine the mark of each variable and the statistical significance of t value. Through this calculation, we exclude the variable whose inter_relationship is presumed to be high and guess it corrected through Likelihood function method.

In case of the multilogit model, the function of the selective alternate exists in order to guess the goodness-to-fit and to check the selective probability of an alternate port to lock, so it will become 0. Therefore, in order to make the utility function of the K port lock alternate with 0, we reviewed goodness-to-fit of the relative precise ratio of M port. The primary factor is reconstructed with 6 variables like table 2, which are analyzed through 15 items for the determinant in port selection.

Table 2 Variables for MNL model on M port

	Attribute	Detail
F_1	Port	attribute on port
F_2	Land	fare, distance in land
F_3	Network	connecting with other area and country
F_4	Marine	fare, distance in sea
F_5	Service	experience of cargo handling and claim
F_6	Dummy	container or bulk

In other words, the dummy variable is processed into two types of containers and bulk, largely in the type of freight, others are composed as follows: First, the port attributes of capability in port such as storing and the frequency of liners. Secondly, the land's attributes of distance and fares on land. Thirdly, the marine attributes of distance and fares on the sea. Fourthly, the network attributes of hinterland and the local network of freight, and finally, the service attributes of freight handling experience or support on claims.

As for eigen value of 5 primary factors which are extracted just the primary factor of eigen value 1 or more it appoints with primary factor extraction standard was extracted. This figure is something which displays the quantity of the dispersion which that primary factor explains.

4.2 Result of Analysis

We suppose that the shipper has a choice of port that has

a bigger expectation in utility. At this time, the model that shipper n chooses M port is exposed as the following type.

$$P_{in} = \frac{\exp^{\lambda V_{in}}}{\sum_{j \in C_n} \exp^{\lambda V_{jn}}} = \frac{1}{\sum_{j \in C_n} \exp^{\lambda(V_{jn} - V_{in})}}, \quad (i \in C_n) \quad (13)$$

C_n : Choice set on port by shipper n

P_{in} : Probability of M port selection by shipper n

V_{in} : systematic part of utility of M port

λ : Coefficient of distribution on utility function

(Here is 1, suppose independent Gumbel distribution.)

The estimated model is necessary to three kinds of review. These include the logic part, the ability for explanation and the application possibility. For these reviews, we checked the sign mark in the equation required and the stabilization of t value. The independent variables used for the final model are 6 variable; Attribute of Port, Land, Network, Marine, Service and Dummy of container and bulk. As dependable variables, these are composed of M, K and O port. The fitness degree of parameter on this model is as high as the 0.25 result. The fitness value of this model is 141.90. In all coefficients at 0 of null hypotheses, the hypothesis is rejected at result of $x_{6,0.05}^2 = 12.78$.

Table 3 Result of Presumption

Factor	Evaluation result
F_1	2.13 (2.71)
F_2	-1.52 (-1.32)
F_3	0.59 (2.37)
F_4	1.80 (2.42)
F_5	0.95 (1.96)
F_6	0.11 (4.66)
constant	-1.37 (-4.78)
x^2	141.90
ρ^2	0.25
$\bar{\rho}^2$	0.23
prediction	74 %

() is t_value.

The coefficient estimated with this model shows the degree, which has an influence on the relative probability of

the M port selection compared with the K port because it is the value that was sought by fixing the utility function of the K port selection at 0. The conformability of the model is decided at 1 value, but it understands the reliability of each individual variable at the t value. Also, the bigger the variable value is, then the higher the influence is regarded when choosing an alternative.

In the selection of the M port, the variables with high reliability (t test in variable) are occupied in order of attributes of port, marine, land, networks and service. The variables in the selection of M port are placed on port's marine, land, network, and service characteristics in order of importance.

On the other hand, it is possible to interpret the attributes of port as having influence (+) on the probability to choose the M port when examining the positive mark of estimated coefficients. It shows us that the M port has the capability of cargo handling and service frequency of liners. Thus, there is a possible advantage on the M port in terms of loading and discharging freight.

The marine aspects are interpreted as the exerting influence by (+) on the probability to choose the M port. That is, we can suppose that shippers think that the Mokpo port has an advantage in conformability of distance and fare when they need liner service, feeding work and cargo handling.

The land attributes have an influence (-) on the probability to choose the M port. It shows (-) meaning that the farther it is in distance, the higher the fare rises. So, the probability of choosing a K port instead of the M port also rises.

The network attributes among the areas have an influence (+) on the probability to choose the M port. The freight networks among local areas seem to become the consideration element by the shipper when it chooses the M port.

The service has an influence (+) on the probability to choose the M port. That is, the administration of custom procedure and service at the M port shows high efficiency so that the procedure is higher in comparison with other ports.

5. Conclusion

The Mokpo port comes to an important time in the direction of the development considering recent conditions that have been changing sharply outward. The reason why the potential possibility of developing the Mokpo port is high can be accounted for by the rapid increase of freight

quantity in the northeastern Asia area. Specifically, while Korean and Chinese trade increases rapidly with the growth of the Chinese economy, the container freight distribution quantity is increasing, too.

However, middle-class ports face keen on competition today. It only takes charge of little positions in freight processing so that the quantities are less relatively. Thereby, the management of ports is worst here, and consequently creates a ripple effect in the regional economy. The policy that grasped strongly the shipper's and the ship owner's preferences is necessary in order to improve this recursive structure and to induce freights to use ports.

In these aspects, this research extracted and analyzed some factors on port selection. For this purpose, we composed a questionnaire that was filtered from preceding research. Then, the questionnaire was distributed to and interviewed by shippers and companies which used ports located in the province of Geonra.

In order to analyze the results for the development plan on the Mokpo port, they would have to provide port services that centered on the user. Until now, we can see that port services put a priority on the supplier, and not on the user. Therefore, Mokpo port will have to improve the system so that it can satisfy the shipper as a user of the port.

Secondly, it is necessary to improve the efficiency and the productivity of the freight network. The Mokpo port is located at a place where a lot of islands exist within the province of Geonra and Kwangju city. This has a geographical advantage because the islands can connect easily to the Mokpo port. Therefore, it is necessary for a country's plan, which is tactical to increase its attraction and to increase related freights. At the same time, it is necessary for the special enterprise to attract freights for China and Asia, too.

For this purpose, Mokpo port must create a system for cargo handling, shipping and feeding with quickness and correctness in a structural order that can deliver efficiently, and thus, improving port information systems on a whole. By information interchange, it can rapidly connect with trade activity as well as transportation including the land system. This way, the facilities through which huge capital is engaged can be used more efficiently.

For the third plan, it is necessary to utilize a marketing feature in addition to the flexibility of fare policy, easily to free activity.

When the above-mentioned development plans are developed and are propelled mutually, then the quality of service for the shipper can be improved. Then, the

competitive power of the Mokpo port itself may be strengthened.

Thus, this study analyzed a selection, by way of decision factor for the Mokpo port to a large degree compared with other ports. There were some matters where the range of the shipper was set to a little ambiguity when used as an object on the questionnaire. However, we placed the meaning of this research so that it approached the decision factors in the case of the port selection by using the Multi Logit model. Its result indicated a development plan for the Mokpo port. Finally, we think that further research on Elasticity and Standardization of independent variables on Mokpo port is necessary, and we require complementary questionnaire for many shippers and companies.

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