ANALYSIS OF THE SHIPPERS' PORT-CHOICE BASED ON DISAGGREGATE MODEL

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Abstract With the development of Utility Theory, transportation behavior should be explained once again. This paper covers the analysis of shippers' port-choice. With considerations of Utility Theory, shippers choose calling port not only in account of costs, time and distance, but also the efficient utilization and good service of the port, thus the satisfaction in result. In brief, more and more shippers pay great attention to how to make his utility maximum, and that is the key factor for the port's operators, too. This paper introduces the Disaggregate Behavioral Model and Utility Theory in general; analyze the factors to which considerations are given before any decision is made by the shippers on port-choice. To obtain a good solution, the paper established the Utility Function then, by use of Disaggregate Behavioral Model, draws the conclusion: what is the main effecting factors in the shippers' port-choice action. The main purpose of the paper is to provide port-operators some reference in terms of theory.

Key Words: Utility Theory, Disaggregate Model, Shippers, Port-choice

1. INTRODUCTION

Port is defined, in general terms, as "a harbor town or city where ships may enter and work cargo (landing/unloading)". Traditionally, people hold the fact that ports have a specific vocation and may not necessarily captivate their users.

Port operators in the past years also gave little considerations on competition and service. They regarded the followings as their obligations towards their users: be able to assure safety, security, unobstructed and expeditious flow of traffic in and out of the limits of the port, complementary to which is the stability and reasonableness of port rates, tolls, dues and charges. So port industry was once a kind of monopoly.

But with the development of containerization and the increase of access methods over land,

ports, especially container ports are in great competition especially when ports are situated in close proximity of one another. The border of hinterland became vaguer than ever, ship movements remain unpredictable and have the potential of not necessarily dedicating themselves to calling at the same port on subsequent voyages, so it is not necessary for shippers to choose the nearest port geographically and this also enables shippers to remain opportunistic by maximizing their utilities.

Therefore, in developing a set of tariffs for a port, understanding and appreciating the shippers' requirements are important considerations, as are some of the other related complex factors that must also be taken into account, which is management and service. By which, port can captivate both the ships and the shippers. While this is the primary aim of any port administration, it must be appreciated that there is, as well, a parallel aim, which is to ensure that the port not only remains viable but also continues to progress into the future.

Because shippers' choice can inherently increases the ships to arriving at the port, so considering the length of the paper, only the behavior of shippers is discussed here.

On the other hand, analysis of the shippers' port-choice is also related to the behavior of shipping companies when they decide their routes. Shippers are very important to shipping companies, so the port that can provide good service to shippers can be, in great extend, chosen by shipping companies. It must be borne in mind that the guiding principle in the development of a port, apart from market forces, must always be one of fairness—captivate more users.

Disaggregate Model is used in this paper as the main method. It is a new model to forecast transportation demand and is widely applied in road and air traffic programming, while shipping industry usually takes statistics as analysis means. Generally, statistics can reflect the whole station of the subject port and its trend of the future. But lack of enough variable parameters caused the forecast result lack of individuality. In fact, when a shipper choose a port, he will take many factors into account, different shippers may exercise different options because of different commodities, O-D positions, business habits and hence, may have very different activities and utilities.

Disaggregate model can set more political parameters in order to tell different decision-makers' individualities, complementary to which is the meticulous forecast and analysis of the object port. The model will be introduced in part III.

2. REVIEW OF THE PAST

There are studies about shippers' port-choice in recent years. As far as the author knows, studies in this field are:

1 Matsumoto Masaji and Yamaguchi Kiyokazu

They summarize the following charges in their model: transporting cost over land from where

the shipper positioned to the port; harbor dues; cost and interest of the cargo caused by waiting for a ship. The sum of all the costs is defined as the shipper's "total logistic cost". A shipper will choose a port depending on whether the decision can minimize his total cost.

2 Kokuryo Eiyu

Cost over land and the cost due to a vessel entering and staying within harbor limits are added to be the "logistics cost" in the model. We get the model about shippers' port-choice by minimizing the cost and considering the port's cargo flow. Because the shippers' behavior has no reversibility to the port service, the model is then extended to a Markov chain.

3 Miki Tatehiko

Professor Miki leaded the shippers' assessment about port service into the model. Taking transit time over land and cost as the variable, the model describes shippers' behavior with disaggregate model.

All the models stated above assess port based on the shippers' logistics cost, to obtain the cost, they forecast the transporting tonnage of the shippers in a certain area, for example within a province, then predict the transit tonnage of every port. But the actual cost shippers paid is difficult to calculate and it is hard to tell the individuality of each shipper.

3. DISAGGREGATE MODEL & UTILITY THEORY

Disaggregate Model is widely used as a new kind of forecasting method. The model and its practicability are proved useful especially in the field of transportation programming, mainly because of the limitation of traditional statistics and the variety of access methods.

Besides, with the use of utility theory, travelers' individuality is amplified and reflected directly, hence, the explanation of transportation is more reasonable.

The essential prerequisite of disaggregate model is that "one can make decision according to his own willing and he will choose what can maximize his utility among all the selections". To be specific, suppose a person wants to go to the railway station that is 2 kilometers away from his home. He could get there by bicycle, bus or taxi. Which one would he choose? There is no incontestable conclusion. The result depends on not only time and cost, but also everyone's characteristics, including: the purpose of his trip, age, gender differences, occupation, income etc. Everyone will choose a proper action to meet his demand.

Here suppose "J_i" is the collection of all the samplings which person "i" can choose, if he chooses sampling "j"he will get the utility "U_{ij}". We say "j" is chosen instead of "j'" only when:

$$U_{ij} > U_{ij'} \; j \neq j' \; j' \in J_i \qquad (1)$$

According to utility theory, U_{ij} can be divided into two parts: fixed part "V_{ij}" and variable part "ε_{ij}", viz.:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{2}$$

The probability of person"i" to choose"j" is P_{ij},

$$P_{ij} = \Pr ob\left(U_{ij} > U_{ij'}; j \neq j', j' \in J_i\right) = \Pr ob\left(V_{ij} + \varepsilon_{ij} > V_{ij'} + \varepsilon_{ij'}; j \neq j', j' \in J_i\right)$$

$$\left(0 \leq P_{ij} \leq 1; \sum P_{ij} = 1\right) \tag{3}$$

Here ε_{ij} subject to Gumbel distribution model, so P_{ij} can be also expressed as:

$$P_{ij} = \frac{\exp\left(V_{ij}\right)}{\sum_{j'=1}^{J_i} \exp\left(V_{ij'}\right) + \exp\left(V_{ij}\right)} \quad j \neq j', j' \in J_i \tag{4}$$

We can get P_{ij} by calculating V_{ij}, V_{ij} is not fixed according to different subject. Usually, V_{ij} can be supposed as follows:

$$V_{ij} = \sum \theta_k \ X_{ijk}, \tag{5}$$

Here, θ_k is parameter,

X_{ijk} is the character "k" of person "i", for example, consideration of service, charge fee, time and distance etc. in terms of port-choice.

We use optimal estimation to obtain the estimation of θ_k

Suppose $\hat{\theta}$ is the optimal estimation of θ_k

Let:

$$L = \sum_i \sum_{j \in J_i} \delta_{ij} \ln P\left(i \middle| X_j, \theta_k\right) \tag{6}$$

Here:

$$P\left(i \middle| X_j, \theta_k\right) = P_{ij} \tag{7}$$

$$\delta_{ij} = \begin{cases} 1 & \text{if action "j" is chosen} \\ 0 & \text{others} \end{cases}$$

$\hat{\theta}$ can be calculated by maximizing L, Then we can get P_{ij}.

The essential idea of disaggregate model is that we can get different probability of each selection to be chosen with efficient consideration of decision-maker's individuality. In this paper, we'll discuss what factors shippers will care when they transport their cargoes through a port. We'll use utility function and disaggregate model to get the probability and to what extend the port will be chosen.

4.ANALYSIS OF THE FACTORS

There are many different factors that will affect the shippers' behavior, but every shipper, irrespective his activity and location, has two common factors for port-choice consideration, viz. time and cost.

4.1 Time

In considering time, the general logical starting point is a survey of the range of the time. Here, time means "transit time" including "transporting time over land" and "waiting time in port". That is:

"Transit time = transporting time over land (T_1) + waiting time in port (T_2)"

(1) T_1

As is well known, time is determined, physically, by distance and speed. Thereafter commences a calculation of "transporting time over land", factors for consideration are: "distance over land" and "access methods". The importance of distance over land is obvious. Usually, shippers will choose a near port or the neighboring port in the region/area.

On the other hand, with the use of container, it is easier for shippers to transport their cargo over land by many kinds of access methods, so despite of the distance, shippers usually consider how many surface modes can the port provide, for example: common road, highway, railway, special train for container only, etc. Among all the modes, shippers can choose one or some of them to complete the transportation over land, different choice need different time and cost, inherently different utilities.

(2) T_2

The other part of "transit time" is "waiting time in port". Because ship costs is calculated on a daily basis, it is important for shippers to shorten the waiting time in port as possible as they can. In general, ship's waiting time are determined mainly by:

- whether logistics system service is available
- port service time (12h/24h)
- convenient to pass the customs (how many customs brokers do they have)
- working (loading/unloading) efficiency
- frequency of dispatching a ship

4.2 Cost

Like other business, benefit is the primary aim of any shipper. Increasing revenue and decreasing cost are two main balancing methods, so cost is an important aspect for consideration. Generally, costs generated by the transportation over land fall under three groups, viz.:

- distance over land
- access methods
- whether logistics service is available

As explained earlier, the longer the distance is, the higher the cost will be. If special train for container and logistics system is available, it needs little time, while at the same time, highly priced.

Charges generated in the ports includes:

- costs connected with the cargo loading/unloading
- fuel costs of the port
- costs of canals (if have)
- costs of marine aids and piloting
- lighthouse dues and charges
- agency expenses at a domestic/foreign port
- anchorage: vessel anchoring or mooring for cargo-work or awaiting berth within defined harbor limits
- berthage: vessel trying alongside a wharf, quay, jetty etc.
- wharfage: the provision or use of a wharf and the charge for a vessel conducting cargo-work etc.

Different shippers place different emphasis on the factors, to reflect the individuality of each one, it is not necessary for shippers to consider every factor as stated above. Shipper can choose some of them that are important enough to affect his behavior. So different profit-measuring indicator can be used.

4.3 Others

Besides time and cost, there are some other factors that shippers will care, for example: management and service of the port, business habits of the shipper, special demand of the cargo, facilities of the port even the relationship between the shipper and the port. Sometimes it is necessary to compare different harbor dues among different countries, while sometimes in one country, it can be ignored.

5. FORMULATION OF THE MODEL

As analyzed above, the utility function of the shipper based of disaggregate model is:

$$U_{ij} = \alpha u_j + \beta \sigma_j + \alpha' u'_j + \beta' \sigma'_j + \sum_l \lambda_l X_{lj} + \varepsilon_{ij} \qquad (8)$$

Here:

U_{ij} : the utility of shipper "i" if port "j" is chosen

u_j : average time of transporting cargo through port "j"

α : parameter, meaning to what degree does the shipper think highly of u_j

σ_j : variance of average time u_j

β : parameter, meaning to what degree does U_{ij} be influenced by σ_j

u'_j : average cost of transporting cargo through port "j"

α' : parameter, meaning to what degree does the shipper think highly of u'_j

σ'_j : variance of average cost u'_j

β' : parameter, meaning to what degree does U_{ij} be influenced by σ'_j

l : number of the factors a shipper will care besides time and cost

X_{lj} : characters of shipper"i"

λ_l : parameter, meaning to what degree does U_{ij} be influenced by X_{lj}

ε_{ij} : variable utility of shipper "i"when the shipper choose port "j"

As defined earlier,

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

$$V_{ij} = \sum \theta_k \ X_{ijk},$$

In view of this paper

$$V_{ij} = \alpha u_j + \beta \sigma_j + \alpha' u'_j + \beta' \sigma'_j + \sum_l \lambda_l X_{lj} \tag{9}$$

$$\theta_k = [\alpha, \beta, \alpha', \beta', \lambda_l \ ] \tag{10}$$

$$X_{ijk} = [u_j, \sigma_j, u'_j, \sigma'_j, X_{lj} \ ] \tag{11}$$

To obtain the optimal estimation of θ_k

Let:

$$L = \sum_i \sum_{j \in J_i} \delta_{ij} \ln P(i | X_j, \theta_k \ ) \tag{12}$$

Here:

$$\delta_{ij} = \begin{cases} 1 & \text{if port "}j\text{" is chosen by shipper "}i\text{"} \\ 0 & \text{others} \end{cases}$$

$P(i|X_j,\theta_k) = P_{ij}\ P_{ij}$ is the probability of shipper "i"to choose port "j", according to the definition:

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_{j'=1}^{J_i}\exp(V_{ij'}) + \exp(V_{ij})} \quad j \neq j', j' \in J_i \tag{13}$$

Here, j' means other ports besides subject port "j", for example, Dalian, Yingkou, Tianjin and Qingdao are four ports located in a area, if we take Dalian as the subject port,

$J_i = \{$ Dalian, Yingkou, Tianjin, Qingdao $\}$

$i = 1 \sim 4$;

$j = \{$ Dalian $\}$;

$j' = \{$ Yingkou, Tianjin and Qingdao $\}$

Here $\hat{\theta}$ can be calculated by maximizing L, hence V_{ij} is available.

All the content stated above is personal utility and probability. As for the forecasting of collection, suppose the function of characteristic value of the collection (such as X_{ij}) is $f(x)$, to get the share of the collection to be chosen, we use integration summation here, suppose the share is "S_i"

$$S_i = \int_x P(i|X,\hat{\theta})f(x)dx \tag{14}$$

The result indicates in what proportion port "j" will be chosen by the shippers.

Attention: In the model, X_{ij} means other factors besides time and cost, such as service, business habits, special demand of the cargo, facilities of the port etc. In brief, it represents the individuality of each shipper.

Because cost and time are two main factors depending on which shippers will choose the port, so in the model, time and cost are two independent volume of variables, each shipper can choose some of the factors in each volume with the aim of gaining maximum utility.

Here, suppose all the utilities can be summed linearly, that is to say, choose "minimum cost" and "minimum time" separately, then by the model stated above get maximum utility of the shipper.

6. CONCLUSION

The combination of disaggregate model and utility theory is a new method in the forecast of shipping industry. It can take the individuality into the model, so the result is more liable.

The result is useful for the management and operation of a port. A port authority must not forget the groups of shippers, since they are the main clients. With consideration of the shippers' utilities, the port should pay more attention to service and management trying to provide more facilities. In brief, the problem is how to captivate more users of the port.

But because of the limitation of the author's level and the length of the paper, only a model is provided in the paper. Factors stated above in the paper are views of the author. It needs more work with the development and application of the theory.

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