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Factors Influencing Freight Transport Mode Choice

by

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VARIOUS KINDS of analysis have been carried out in the past with regard to the problem of "on what factors is the selection of the means of transportation decided," but it seems that these analyses have been aimed at these factors only which are expressed in terms of quantity (e.g., time, distance and cost).

However, the importance of qualitative factors which may not be quantified such as the local features in the points of departure and destination, items and facilities at the departure and arrival points, upon the selection of transportation means actually may not be overlooked.

The quantification theory enables the analysis, not alone the analysis based upon quantitative data, but the analysis in which qualitative factors are also introduced. The basis of analysis upon quantification theory is referred to as the analysis of general discrimination. Namely, it exhibits its intrinsic merit when analyzing the mutual difference where there are several subjects for comparison. Moreover, it also enables to distinguish which one is the most important, and which is the one less important, among the factors which constitute the characters.

In addition, the quantification theory makes it possible to measure the extent of validity of the result of analysis in regard to the discrimination of the subject.

Analysis Frame

The following items have been set as the factor remarkably influencing the selection of transport means. The subjects are selected only from among the manufacturing industries making shipment from Tokyo, Yokohama and Chiba areas. The number of data amounts to approximately 2,000.

Factors influencing remarkably in the selection of means of transport. As seen from partial co-efficient of correlation:

① Point of delivery (0.66289)
② Quantity of transport (0.25429)
③ Hour of transport (0.19367)
④ Kind of shipping business (0.19064)
⑤ Area of business place (0.14701)
⑥ Item (0.12710)

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⑦ Kind of business of consignee (0.12625)
⑧ Number of employees (0.07846)
⑨ Arrival facilities (0.06885)

As seen from the range:

① Delivery point (0.041055)
② Hours of transport (0.027028)
③ Kind of business of consignee (0.019417)
④ Quantity of transport (0.015680)
⑤ Kind of dispatching business (0.013713)
⑥ Area of business place (0.00844)
⑦ Arrival facilities (0.00638)
⑧ Number of employees (0.00683)
⑨ Items (0.00599)

On the basis of two results mentioned above, it may be said that such factors as the place of delivery, hour of transport, transport quantity and kind of dispatching business are factors with powerful influence upon exterior standard.

Since the place of delivery may be expressed as distance, while the kind of dispatching business as items, factors having striking influence upon exterior standard may after all be put as hour, quantity and item. In addition, because there is the trend that, as stated hereafter, production goods which have less freight bearing capacity select railway, while consumer goods with freight bearing capacity select truck, charge may be added to the factors mentioned already.

The result of this analysis is considered to have endorsed the use of hour and cost in regard to the selective model of transport means in the past (e.g., comprehensive traffic system). However, when the selective model of transport means is considered in future, reasonable classification of items is essential, and the transport lot may have to be studied. In the present study, only the analysis covering Tokyo Metropolis and Kanagawa and Chiba Prefectures is taken up, but, in the selection of transport means, local features is considered to constitute a primary factor, requiring the consideration as a model factor.

The Result of Analysis

The correlation ratio in its first axis is 0.64 which compares fairly well with similar analysis, but the correlation analysis in the second axis, being 0.14, is extremely inferior, and may not be

Item No.	Item		Category
1	Item	①	Agriculture & fishery products
		②	⌠ Forestry products
			⌡ Mineral products
		③	Metal, mechanical industry products
		④	Chemical industry products
		⑤	Light industry products
		⑥	Sundry industry products
		⑦	⌠ Special products
			⌡ Other items
2	Kinds of business of consignees	①	⌠ Agriculture, forestry and fishery industry
			⌡ Mining industry
		②	Construction industry
		③	Manufacturing industry
		④	Wholesale industry
		⑤	Retail industry
		⑥	Transport & Communication industry
		⑦	Service industry
		⑧	Other industries
3	Arrival facilities	①	Plants & works
		②	Commercial warehouse
		③	Shop
		④	Mine
		⑤	Private warehouse
		⑥	Construction site
		⑦	Offices, etc.
		⑧	Undetermined
4	Point of delivery	①	Within the same prefecture
		②	Tokyo, Kanagawa and Chiba
		③	Ibaraki, Tochigi, Gumma, Saitama
		④	Tokai
		⑤	Hokuriku, Koshinetsu
		⑥	Kinki
		⑦	Tohoku
		⑧	Hokkaido
		⑨	Chugoku, Shikoku and Kyushu
5	Transport quantity	①	2.0 ton or under
		②	2.1-4.0 or under
		③	4.1-7.4 or under
		④	7.5-12.0 or under
		⑤	12.0 or more
6	Transport forms	①	2.0 hours or less
		②	2-4 hours or less
		③	4-8 hours or less
		④	8-12 hours or less
		⑤	12-16 hours or less
		⑥	16-24 hours or less
		⑦	24-48 hours or less
		⑧	48-120 hours or less
		⑨	120 hours or more
7	Number of employees	①	20 persons or less
		②	20-29 psns or less
		③	30-49 psns or less
		④	50-99 psns or less
		⑤	100-199 psns or less
		⑥	200-299 psns or less
		⑦	300-499 psns or less
		⑧	500-999 psns or less
		⑨	1,000 psns or more
8	Area of business place	①	20 a or less
		②	20-29 a or less
		③	30-49 a or less
		④	50-99 a or less
		⑤	100-199 a or less
		⑥	200-299 a or less
		⑦	300-499 a or less
		⑧	500-999 a or less
		⑨	1,000 a or more

Item No.	Item		Category
9	Kind of dispatch business	①	Machinery, etc. Manufacture—General machinery, electric apparatus, transport machinery, precision machinery Wholesale—machinery
		②	Clothing and outfittings Manufacture & wholesale—clothing, textiles
		③	Foodstuff Manufacture—foodstuff Wholesale—agriculture, livestock, fishing, foodstuff and beverage
		④	Construction Manufacture—ceramic industry, earth & stone Wholesale—construction materials
		⑤	Chemical products Manufacture—chemicals Wholesale—medicine, toilet articles, chemical products
		⑥	Mining, metals Manufacture—petroleum, coal, iron & steel, non-ferrous metal, metal products Wholesale—ore metal
		⑦	Furniture, fittings Manufacture—lumber, furniture Wholesale—furniture & fittings
		⑧	Other items Manufacture—rubber, hide, paper, etc. Wholesale—reclaimed resources, etc.

distinguished when seen from the sample distribution by exterior standard. Therefore, it is removed from the subject of analysis. When the sample distribution by exterior standard in the first axis is observed, it is seen that truck (private and commercial) is distributed on minus side. Railway is distributed on plus side (Figure IV-2-1). Accordingly, the discrimination in the first axis is understood to distinguish the characters in truck and railway. The successful ratio of distinctive guessing at this time is 87%, which is considerably good.

Interpretation of analysis result and preferred pattern on the means of transport.

A. **Interpretation of the Analysis Result** (Refer to Table IV-2-1 in the explanation of category score)

The characteristics of truck transport:

The place of delivery is in a near distance such as the same prefecture or such area as Tokyo Metropolis, and Prefectures of Kanagawa, Chiba, Ibaraki, Tochigi, Gumma and Saitama;

The transport quantity is 2-4 tons;

The hour of transport is 16 hours or under;

Kind of dispatching business includes furniture, fitting, construction items, clothing and outfittings machinery, mineral and metals;

The area of business place is relatively small;

The items cover agricultural and fishery products, light industry items, metal and mechanical industry products, special goods, etc.;

Kinds of business of consignees are manufacturing business and retail business;

The scale of number of employees is comparatively small;

The arrival facilities are such as shops and construction sites, etc.

Characteristics of railway transport:

The place of delivery is the locality outside of one Metropolis and 6 Prefectures in Kanto district;

The transport quantity is 12 tons or more;

The hours of transport are 16 or more;

Kind of dispatching business covers foodstuff, chemicals, etc.

The area of business place is spacious;

The items comprise such as; forestry products, mineral products, chemical manufactures and miscellaneous industry goods;

Scale of employee number is either medium or large;

Arrival facilities are: works, mines, offices and those not yet determined;

The kind of business of consignees are: construction industry, wholesale industry, warehousing business, etc.

B. **Patternizing of Transport Means**

Such fact that the place of delivery of truck transport is located in near prefectures, the transport lot is small, the transport hour is short, and conversely, that the place of delivery of railway transport lies outside of the area of one metropolis and 6 Prefectures of Kanto district, the transport lot is great, and the transport hours are long, are the results established by fair commonsense.

Through the explanation of this categorical score, the following particular pattern may be observed on each of the truck and the railway.

As for the truck:

The first pattern is:

Kind of dispatching business (furniture, fittings, construction items)—items (metal products for construction)—arrival facilities (construction sites).

The second pattern is:

Kind of dispatching business (clothing, outfittings)—items (light industry articles)—kind of consignees' business (retail industry)—a r r i v a l facilities (shop).

In additon to the above, the case of minerals (petroleum and petroleum products) as kind of dispatching business, and filling station as consignee is thought of as a transport pattern of truck. The third pattern is the case of the kind of dispatching business (machinery)—consignee (manufacturing industry), and the fourth pattern is, item (agricultural and fishery products)—consignee (shop).

As for the railway, the first pattern is:

The first pattern is:

Kind of dispatching business (chemical products)—items (chemical products)—consignee (construction business) and is considered to represent the transport of cement, cement products and bricks, etc.

On the basis of the fact that the arrival facilities are works, it is inferred that they represent the raw material transport of chemical products.

The second pattern is:

Items (mineral products, forestry products) — arrival facilities (works, mining industry), and represents the transport of raw materials from overseas areas.

The third pattern is:

Kind of dispatching business (foodstuff)—items (miscellaneous industry products)—consignee (wholesale business)

In brief, it is seen that such items as building material, petroleum products, chemical products, clothing and outfittings, mineral products and forestry products are representative as the transport goods dispatched from Tokyo Metropolis, Kanagawa and Chiba Prefectures, and that, as seen by transport means, truck is in charge of consumer goods, while the railway, in charge of productive goods.

Figure IV-2-1—Discrimination of the first axis:

(Correlation ratio 0.647)—distribution of category score by exterior standard—

G 1: Motor vehicle (private use)

G 2: Railway

G 3: Motor vehicle (commercial use)

Figure IV-2-2:

Successful ratio of guessing 87%

Motor vehicle (private and commercial)

Railway

Table IV-2-1:

First axis category score (0.647)

Item		Category	Category Score
4 Place of delivery (0.66289)	①	Within the same prefecture	—0.015743
	②	Tokyo, Kanagawa and Chiba	—0.011968
	③	Ibaraki, Tochigi, Gumma and Saitama	—0.0058204
	④	Tokai	0.0084014
	⑤	Hokuriku, Koshinetsu	0.014879 (0.041055) ①
	⑥	Kinki	0.013842
	⑦	Tohoku	0.021665
	⑧	Hokkaido	0.025312
	⑨	Chugoku, Shikoku and Kyushu	0.019875
5 Transport quantity (0.25429)	①	2.0 ton or under	—0.0019477
	②	2.1-4.0 t	—0.0029373
	③	4.1-7.0 t	0.00032430 (0.0156803) ④
	④	7.1-12.0 t	0.0038610
	⑤	12.0 ton or more	0.012743
6 Hours of transport (0.19367)	①	2 hours or less	—0.0011470
	②	2-4 hours	—0.0034963
	③	4-8 hours	—0.0012620
	④	8-12 hours	—0.0096337 (0.0027028) ②
	⑤	12-16 hours	—0.019917
	⑥	16-24 hours	0.0012687
	⑦	24-48 hours	0.0012347
	⑧	48-120 hours	0.0057229
	⑨	120 hours or more	0.0071117
9 Kind of dispatching business (0.19064)	①	Machinery, etc.	—0.0011535
	②	Clothing and outfittings	—0.0059924
	③	Foodstuff	0.0041932
	④	Construction items	—0.0045068 (0.0137125) ⑤

Item		Category	Category Score
	⑤	Chemical products	0.0047250
	⑥	Minerals, metals	—0.0019036
	⑦	Furniture, fittings	—0.0089875
	⑧	Other items	0.000024977
8 Area of business place (0.14701)	①	Less than 20 acres	—0.0034854
	②	20-29 a	0.00054269
	③	30-49 a	—0.00058376
	④	50-99 a	—0.0016162
	⑤	100-199 a	0.00025553 (0.0084442) ⑥
	⑥	200-299 a	0.0000012887
	⑦	300-499 a	0.0018538
	⑧	500-999 a	0.00023932
	⑨	1000 or more	0.0049588
1 Items (0.12710)	①	Agricultural & forestry products	—0.001761
	②	Forestry products, mineral products	0.0030291
	③	Metal, mechanical industry products	—0.0010779
	④	Chemical products	0.0017101
	⑤	Light industry products	—0.0019840
	⑥	Miscellaneous industry products	0.0040406
	⑦	Special products, and other products	—0.0013692
2 Kinds of Consignees (0.12625)	①	Agriculture, and fishery, mining industry	—0.013597
	②	Construction industry	0.0017546
	③	Manufacturing industry	—0.0011844
	④	Wholesale industry	0.0017171 (0.019417) ③
	⑤	Retail industry	—0.00077774
	⑥	Transport, communication	0.0049212
	⑦	Service industry	
	⑧	Other industries	0.0058204
7 Number of employees (0.078457)	①	Less than 20 persons	0.0016629
	②	20-29 persons	—0.0046651
	③	30-49 persons	—0.0039732
	④	50-99 persons	—0.00095381
	⑤	100-199 persons	0.00071598 (0.0063280) ⑥
	⑥	200-299 persons	0.00016603
	⑦	300-499 persons	—0.00021052
	⑧	500-999 persons	0.00018115
	⑨	1000 persons or more	0.00050104
3 Arrival facilities (0.068853)	①	Works	0.00029732
	②	Commercial warehouse	—0.000022046
	③	Shop	—0.0017804
	④	Mining industry	0.00055415 (0.006384) ⑦
	⑤	Private warehouse	0.000031846
	⑥	Construction site	—0.00061585
	⑦	Offices and others	0.0019309
	⑧	Undecided	0.0046040

(Note): The idea of quantification theory.

Under the quantification theory, the category to be stratified is called exterior standard. In the instances shown above, since the characterstics in each means of transport are to be analysed, the exterior standard are such means of transport as the railway or truck.

One of the factors influencing upon the exterior standards is referred to as one item, and the contents of item is called the category.

The following table indicates the responsive pattern of each sample.

① Category Score and Sample Score

To category in each item, numerical value of category score X_{ij} is given (provided, i indicates item number, and j, category number).

Then, for each sample, sample score is defined as follows on the basis of sum of category score (Provided, K indicates sample Number).

$$\alpha\ 1 = X_{13} + X_{24} + \cdots$$
$$\alpha\ 2 = X_{14} + X_{22} + \cdots$$
$$\alpha\ 3 = X_{12} + X_{23} + \cdots$$
$$\alpha\ 4 = X_{15} + X_{25} + \cdots$$
$$\alpha\ 5 = X_{11} + X_{21} + \cdots$$

		Category	Sample				Category	Category score
			1	2	3	4	5	
1	Item	1 Agricultural & fishery products						X_{11}
		2 Mineral products, forestry products						X_{12}
		3 Industrial products, metal and machinery						X_{13}
		4 Chemical industry products						X_{14}
		5 Light industry products						X_{15}
		6 Miscellaneous industry products						X_{16}
		7 Other special products						X_{17}
2	Kind of consignees' business	1 Agricultural, fishery and mining						X_{21}
		2 Construction						X_{22}
		3 Manufacturing						X_{23}
		4 Wholesale						X_{24}
		5 Retail						X_{25}
	Exterior standard	1 Truck						
		2 Railway						

Namely, sample score is defined on the basis of the sum of score of responding category. For example, as sample 1 responds to the category in item ① and category ④ in item ②, the calculation of $\alpha\,1 = X_{13} + X_{24} \cdots\cdots$ is made.

② **Distribution of Sample Score By Exterior Standard**

At this point, $\alpha\,k$ (sample score) is divided by exterior standard, and frequency distribution table by group is prepared.

There is the instance in which the distribution curve is clearly visible by the numerical value of X_{ij} as in Figure—A.

Figure—A Undiscernible state. Figure—B Discernible state.

Under the quantification theory, the state as in Figure—A is referred to as undiscernible state, and the state in Figure—B as discernible state.

It is needless to say that such a state as is indicated in Figure—B is desirable, because discernment is the object of quantification theory. In order to facilitate the state of discernment, X_{ij} should be determined in such a way that samples with the same value of exterior standard are grouped as near to them as possible, and as far as possible from the group with different exterior standard.

The simplest method is to maximize the difference of mean value in the distribution of each group. The other method is a statistical one, being to maximize the ratio of total variation and between class variation. In the quantification theory, the value of X_{ij} is determined by this method.

③ **Measurement of Influence Degree Upon Exterior Standards by Items**

$$\alpha\,K = X_{1p} + X_{2q} + X_{3r} + \cdots\cdots$$

From the above-stated expression, $\alpha\,K$ tends to incline to plus side when X_{ij} is plus, and when X_{ij} is minus, to minus side. However, since X_{ij} takes the value ranging from —1 to +1, it may not be said that the above-mentioned fact always hold good. Namely, it is because there works the "off-setting" action of plus and minus. In the quantification theory, the decision as to the extent for which $\alpha\,i$ tends to become plus when X_{ij} becomes plus, or the extent for which $\alpha\,i$ becomes minus when X_{ij} becomes minus, is performed by means of partial coefficient of correlation of exterior standard and factor items.

That is to say, it may be said that those items with high partial coefficient of correlation play strong influence on exterior standards. In addition to above, there is the range as the similar measure. This is the maximum value of category quantity among items from which the minimum value is deducted. This range is adopted as measure on account of the fact that, when this value is great, the influence over exterior standard is also great. It may not be said generally which measure is the more appropriate, but it is said that the range is the more appropriate than partial coefficient of correlation for reason of its influence by interior correlation.

④ **Designation of the Meaning of Category Score**

Of the item intensely influencing on exterior standard, the category in which

minus category score is expressed is taken as representing the exterior standard character distributed on minus side among the sample score distribution. Similarly, the category in which plus category is expressed, is taken as representing the exterior standard character distributed on plus side.

For example, in this case, factors strongly influencing on exterior standard, is the area of delivery, in which breakdown, minus score is expressed in the same prefecture, Tokyo Metropolis, Kanagawa and Chiba Prefectures.

On the other hand, in the sample score distribution (Refer to Figure IV-2-1), motor vehicles are distributed on minus side.

Consequently, the place of delivery by motor vehicles is understood to be the near distance such as Tokyo Metropolis, Kanagawa and Chiba Prefectures.

⑤ How to Distinguish the Discrimination and Measurement of its Efficacy

In the quantification theory, when there is n unit of exterior standard, there exist (n—1) kind of the discrimination class. They are called first axis, second axis and third axis in the order of the better degree of their discrimination.

How to Distinguish the Discrimination

On the basis of sample score distribution by exterior standards, the significance of discrimination may be distinguished.

For example, when the score distribution in this case (Figure IV-2-1) is studied, private truck and commercial truck are distributed on the minus side, while on plus side, railway is distributed. Accordingly, this discrimination is understood to distinguish truck from railways.

Measurement of Efficacy of Discrimination

As the standard for measuring the efficacy of discrimination, there are the two kinds, correlation ratio and successful ratio of discrimination guessing.

Correlation ratio is defined as between class variance/total variance. When this is a figure near 1, it means that the sample distribution by exterior standard is divided mutually. Therefore, it is the measure showing the successful extent in which discrimination has been made.

The ultimate efficacy of analysis is decided by means of the successful ratio of discrimination guessing. Cumulative distribution as shown in the right Figure is formed as the result of sample score by exterior standard. The point at which each of these cumulative distribution intersects is called the discriminating point.

The discriminating point is the border distinguishing truck from railway.

In this case, as may be seen from the Figure on the right, of samples belonging to truck, the sample distributed on right side of the distinguishing point, although actually belonging to truck, may be understood as the sample which has been mingled into railway by mistake as the result of analysis. Similar cases apply to railway as well. Accordingly, the calculation may be performed at successful ratio of discriminating guessing $= \alpha/100$. From Figure IV-2-2, the successful ratio of discriminating guessing in this case represents 87%