SPATIAL DISTRIBUTION OF WHOLESALE INDUSTRIES IN THE VIEW POINT OF PHYSICAL DISTRIBUTION AND MONETARY TRANSACTION

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abstract: This paper first, overviews current situation of wholesale industries in Japan, then, analyzes a historical changes of location factors of wholesale industries based on time series statistics of cargo volume handled. Major findings are as follows; The stronger relationship between cargo handled and size of consumption substituted by population was identified. A significant delay of wholesalers' location against transportation environment changes such as operation of new expressway was observed. A strong tendency of concentration of wholesalers into large cities suggest that they seems to locate consumption centroids nearby rather than those of procurement points of commodity.

1. INTRODUCTION

Truck flows occupies almost 50 percent of inter-city expressways' traffic and significant number of arterial highways' traffic in large cities. Large amount of truck flow causes many urban/social problems such as traffic congestion and air pollution. In order to solve these problems, appropriate measures against truck flow based on more reliable traffic demand forecasting must be required. However, because of lack of data regarding private firms, even current situation of freight flow, which is the most essential information for demand forecasting, cannot be well understood.

Location of wholesale industry deeply depend on a transportation modes and especially those with network. Lot-size and transport fare plays a very important role when choosing a transportation mode for commodity. Since these transportation characteristics varies by kinds of industry, industry should be subdivided into certain sectors for analysis. Inter-regional I-O analysis is one of the popular tools estimating future inter-regional and inter-industrial freight flow. *Kashima (1989)*, *Inamura et al. (1991, 1994)* and *Mizokami (1992)* tried to estimate the current freight flow employing I-O table and Freight Census of Japan. They estimated an inter-regional monetary flow by industry and then converted the value into weight base. However, the results did not satisfied enough for the accuracy required. There are two underlying reasons behind this fact; First, a relation between cargo weight and price of commodity is not adequately estimated. Second, locations of seller/buyer of monetary transaction and origin/destination of physical distribution are not always the same.

According to the Freight Census in 1990, commodity flows between makers account for 50 per cent of total volume. This transaction seems to be rather stable and reliable forecast can be made by exploration of past trend. Although twenty four percent of total freight flow moved from/to wholesale industries, these transactions occupied sixty four percent of transaction cases.

Wholesale industries have hierarchical structure in Japan. Primary wholesalers; they are

usually very large and mostly related to purchase of commodities from producers(makers) and sell them to the secondary wholesalers which are middle size. Secondary level of wholesalers sell commodities to other tertiary and/or final them. Primary wholesalers usually handle large lot-size of commodity and transport them by ships and/or large trucks. Most of them are located in large metropolitan area or nearby where transportation facilities are well developed. Other wholesalers are located nation wide. Wholesalers in general intend to be located in an area where transportation facilities are well equipped.

As well known, location of wholesalers also have a hierarchical structure, however they are not always located to maximize their profit because of limited amount of budget to change their location following to new transportation improvement. Wholesalers are forced to follow the transport systems of rapid growing mega-retailer and need to be modernized. The location of a wholesaler and its size should be the optimal when it was just located. However for small size wholesaler in particular, it is very difficult to adapt to its environmental changes because of lack of fund. Thus it is required to develop a model to determine a wholesale industries' location which can deal with flow of money, freight and information to analyze such wholesalers' activities.

This paper first, overviews current situation of wholesale industries in Japan, and then, analyzes a historical changes of location factors of wholesale industries based on various time series statistics in terms of cargo volume handled. The relationship between cargo handled by wholesaler and production level of manufacturing industries in the same region is analyzed. And the relation between cargo handled and size of consumption substituted by population is also analyzed. Time lag of wholesalers' location against transportation environment changes such as operation of new expressway is discussed.

2. RESEARCH OVERVIEW OF WHOLESALE INDUSTRIES IN JAPAN

2.1 Location Factors of Wholesale Industries

Matsumoto et al. (1983) suggested two dominant location factors. They are distribution of customers and availability of land lot with reasonable price. *Matsumoto et al. (1989)* explained the distance from CBD to wholesaler using scale of a city and that of a wholesale complex. *Koike et al. (1991)* conducted an original field survey and stated that facilities for physical distribution were located or shifted taking a chance of industrial complex development as a primary factor. Secondly, although facilities for physical distribution are sensitive to a transportation facility improvement, it is not a dominant factor for relocation. Location factors of wholesale industries inside city are studied to some extent by the above authors, however those results can not be applied to the nation wide problem in question.

A nation wide analysis has been studied mostly in the field of geography. *Nishioka (1976, 1977)* stated that a wholesale industry locates close to area of consumers rather than producers. *Huang (1989)* analyzed the relationship among number of wholesalers, makers and retailers using an agglomeration index and reached the same conclusion with the above. i.e. location of wholesalers are deeply influenced by retailers rather than producers. On the other hand, *Nishimura (1985-1992)* explained the changes of wholesalers' location through geographical distribution of makers and retailers employing the multiple regression analysis. and stated that wholesalers are equally influenced by producers and retailers. *Yamaguchi (1986)* analyzed sales amount of wholesale industries

classified by commodity sector, and identified an agglomeration/dispersion characteristics of wholesale by commodity. Then, the reason behind it was discussed from a view point of efficiency of inventory control. *Kawabata (1986)* analyzed the wholesale location either close to producers or to consumers. And he discussed the separation of monetary transaction and physical distribution. *Kawabata (1990, 1995)* summarized the influence of information network improvement. Service area of a wholesaler has expanded and location of sales office and terminals of physical distribution has separated. Through small sampling field survey, he also found that the agglomeration of facilities improved the efficiency of physical distribution. All of the above studies just focused on the number of establishments and employee and total sales value but did not consider freight flow.

2.2 Hierarchical Structures of Wholesale Industry

Many researches tried to find a hierarchical linkages among cities and/or city groups using some indices of wholesale activity. *Nishihara (1994)* constructed a city level diagram of wholesale industry based on the number of wholesalers and distribution of suppliers and customers in Kyushu. *Hino (1995)* discussed a hierarchical structure based on the proportion of employee working in branch offices to total number of employee in a city. *Kuwashima (1982)* confirmed a well known hierarchical structure of cities. The first rank comprised of three largest metropolitan, followed by four second class metropolitan, forty prefectural capitals, and other local cities. He proved that this tendency is clearer when he used an index of sales by wholesale industry than that of population as it is. Although the above studies did not mainly focus on the wholesale industry but hierarchical structure of cities, location of wholesale industries might be explained by a hierarchical structure of cities only if these two are closely related.

2.3 Sales Activities of Wholesale Industry

Studies of wholesale from the view point of sales amount have been conducted in the field of commerce. The main target was on the length of sales channels that has been accused by foreign countries such as US for its incomprehensible and multi-tiers. *Ejiri (1980)* suggested input point index and output point index for measurement of distribution detour. Input point index is defined as the ratio of 'short channel' input to 'long channel' input. Output point index means the point of sales from wholesalers to other industries. These two indices only deal with input and output, therefore the whole structure of distribution channel was not clarified at all. *Imamura (1981)* defined an index for length of the channel as rate of sales between wholesalers to total sales of wholesalers. It has a problem whereby direct distribution i.e. sales from makers to retailer was not considered. As the result, it shows overestimation accordingly. *Nishimura (1984)* evaluated five indices that are W/R ratio, ww/R ratio besides the above three. W, R and ww represent the sales of wholesalers, of retailers and between wholesalers respectively. These researches pay no attention to intermediate materials but only to consumers' goods. These indices are still applied in practice to measure the length of sales channels (i.e. *Kanemura (1993)*).

2.4 Freight Flow of Wholesale Industries

Although most of truck flows in the center of city are from/to wholesalers, there are a few researches which focus on physical distribution of wholesale industries. Many researches concentrate on the physical distribution for transportation planning in the city center which

were mainly conducted in the field of infrastructure planning. There are two typical researches; i.e., location of distribution centers and truck operation planning.

Kojima et al. (1986, 1987) pointed out that distribution facilities' location problem was very complex, and difficult to solve and apply to real world, since it need to consider intermingled land use, various types of O-D, traffic characteristics of commodity and so on. *Takahashi et al. (1995)* tried to determine the location of freight distribution centers for Ginza area in Tokyo. The model maximizes the transportation cost saving. Most of goods are distributed by truck in the city, and many optimal routing and allocation models of truck were formulated. *Kawashima et al. (1990)* and *Sato et al. (1995)* developed routing and allocation models which aimed to minimize total traveling distance of trucks for a large scale network using neural network algorithm. *Matsumoto (1990)* formulated a model considering not only cost for operators but also service level for customers. *Ieda et al. (1993)* developed a three step model consists of locating distribution centers, allocating trucks and routing, and tested in the Tokyo metropolitan area.

A cooperative delivery system is one of the solution to solve traffic problem in city center. Tenjin, area in Fukuoka city is the first case to apply a cooperative delivery system of small package transport in Japan. *Nakamura et al. (1992)* and *Ieda et al. (1992)* stated that, firstly, large companies did not participate, and secondly, sales activities and distributions have been separating. *Imai (1993, 1995)* reported an experimental cooperative delivery system in Osaka and developed a delivery model which is able to apply to the case involving just in time constraint. And abuse of oligopoly was pointed out as the problem of cooperation. *Hashimoto (1992)* proposed participation as a criteria to cooperative system. The trade-off between cost reduction and customer service decline was discussed based on a questionnaire survey to private firm. *Matsumoto (1992)* proposed factors to evaluate social costs and benefit. *Kuse (1992)* pointed out the necessity to keep equality among firms and standardization of operations, and also pointed out an appropriate control and instruction by public sector. *Takahashi (1992)* discussed the roles of private companies and *Takada (1992)* discussed the roles of public sector related to the above problems. *Inamura (1994)* proposed levels of public sector involvement to a project of physical distribution such as road site and terminal, market failure consideration, diminution of marginal cost, external effects, optimal supply and so on.

3. CORRELATION AMONG WHOLESALE, PRODUCTION AND CONSUMPTION

3.1 Correlation among Three Factors

Location of wholesale industries must be close to production and/or consumption site. Makers may locate inside and/or nearby consumers' area, aiming to reduce transportation costs for sales. Here, the following indices are defined in each subarea; 1) volume handled by wholesalers (W) is used as an index of location of wholesale industries, 2) amount of production by manufacturing industry (M) is regarded as production, and 3) population (P) is used as an index of consumption. Correlation coefficients of each couple of W, M and P in 1975, 1980, 1985 and 1990 were calculated respectively. Japan is subdivided into forty seven prefectures for analysis. Wholesale industries are classified into eight sectors to meet with the sector of the Freight Census. They are specified as textile, chemicals, minerals, machinery, building materials, apparel, foods, and furniture.

Correlation coefficients in 1990 are shown in **Fig.1**. Correlation coefficients of W and P (W-P) are higher than those of M-W and M-P in four sectors. W-P are comparatively higher than others in whole sectors. W-P of foods is the highest. It may be caused by the close relationship of food consumption to the number of population. By computing the correlation results of W-P and M-W, four commodities of W-P are 10 percent higher than that of M-W. Otherwise no commodity of M-W is 10 percent higher than that of W-P. It means that wholesale industries has a stronger intention to be closer to population rather than to makers.

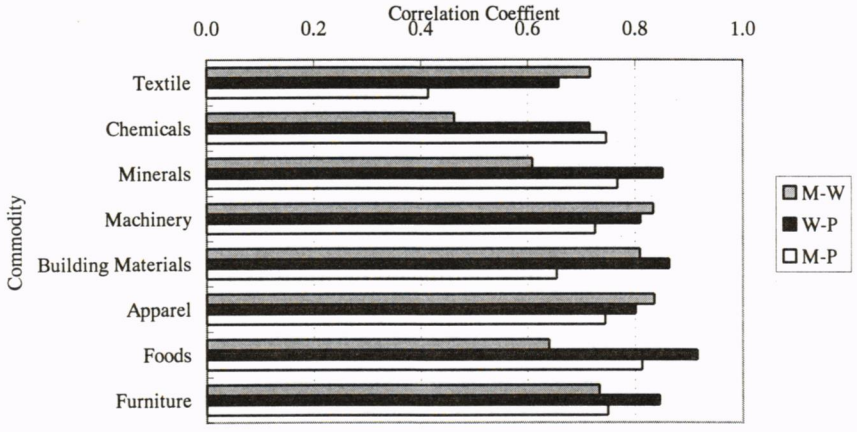

Fig.1 Correlation coefficient among three indices

Historical change of correlation coefficients are shown in **Fig.2-Fig.4**. M-P correlation have been getting weak except for chemicals and minerals and metals. **Equation** (1) can identify whether the changes of M-P correlation depends on production changes or population changes. Value of S shows degree of change of a district (d), commodity (c) and index in 15 years, and $X_{d,c,i}$ refers to any index of a district and commodity in year i. Value of S of M exceeded value of S of P in only 13 districts from the total of 376 (8*47). For districts register a maximum in apparel and the mean is 1.63. As the above, changes of M-P correlation are much influenced by production change than population change. Considering by commodity, those of consumers' goods consisting of apparel, food and beverages and furniture are comparatively high. This is because of location preference of makers to consumers. Textile on the other hand shows a very low correlation because production sites of textile are extremely concentrated in limited areas.

$$S_{d,c} = \frac{\max\left(X_{d,c,75}, X_{d,c,80}\right)}{\min\left(X_{d,c,75}, X_{d,c,80}\right)} \cdot \frac{\max\left(X_{d,c,80}, X_{d,c,85}\right)}{\min\left(X_{d,c,80}, X_{d,c,85}\right)} \cdot \frac{\max\left(X_{d,c,85}, X_{d,c,90}\right)}{\min\left(X_{d,c,85}, X_{d,c,90}\right)} \quad (1)$$

M-W have been unstable and their trend are not able to be determined. It is mainly caused by change of wholesalers. Value of S of W are also calculated, however value of S of W exceed value of S of M in most of all cases.

W-P are relatively stable both in 1985 and 1990. Limited to this last two points of time, the correlation coefficients were found to be high in any pair of three indices. W-P of textile is lower than M-W. It means that wholesale industries of whole commodities except textile locate close to consumers rather than makers. It is a common result that wholesale industries of foods and furniture as consumers' goods are closely related to

population. As for building materials, M-W have been declining and W-P have been increasing, therefore it can be concluded that location of wholesale industries has changed from makers' site to consumers' site.

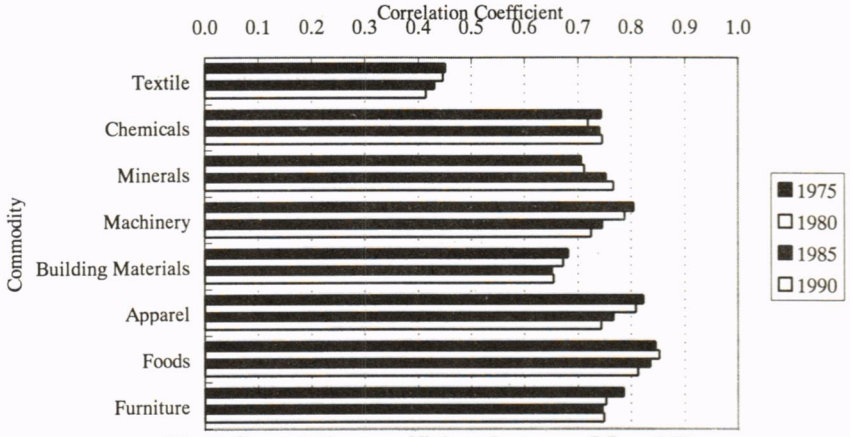

Fig.2 Correlation coefficient between M and P

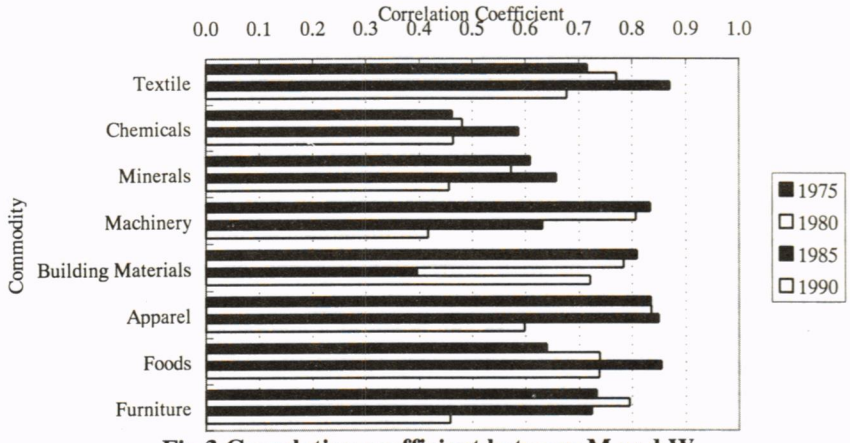

Fig.3 Correlation coefficient between M and W

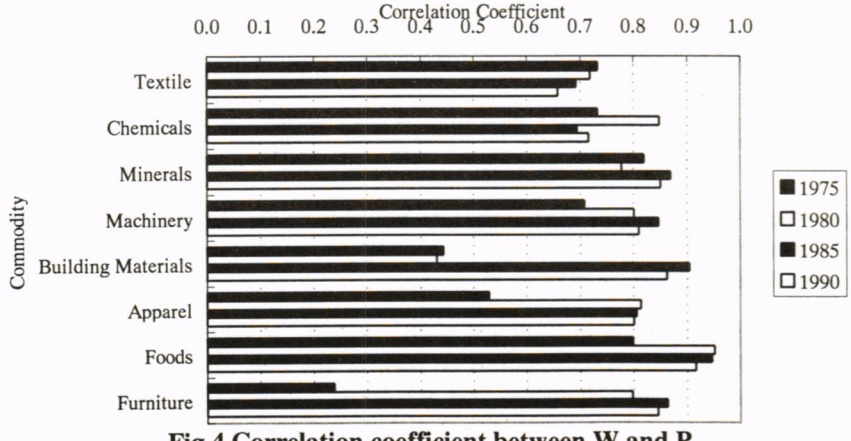

Fig.4 Correlation coefficient between W and P

3.2 Delay of Wholesale Industries' Location

Correlation coefficients between volume handled by wholesalers (W) in 1990 and production by makers (M) for four points of time are calculated, and those between W and population (P) are also calculated in the same way in order to observe time lag of wholesale industries' location in tandem with the changes of environment. The results are shown in **Fig.5** and **Fig.6**. Wholesale industries in 1990 are more closely related to environment in past years than those in 1990. It can be interpreted that wholesale industries have not been able to follow the environmental changes immediately. It seems to be natural in a certain sense considering a very high relocation cost. They have not been able to adapt to the environment for 15 years or more, since retailer, in particular, have changed dramatically. However, the decreasing correlation is a result of individual optimization by considering the improvement of transportation facilities.

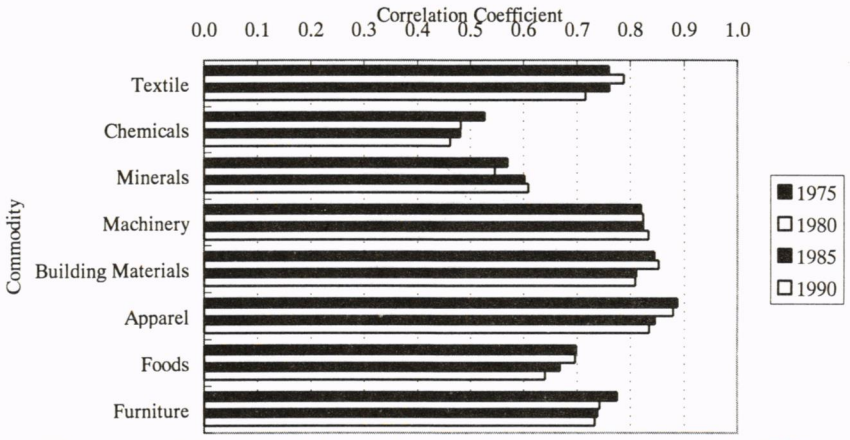

Fig.5 Correlation coefficient between M in each year and W in 1990

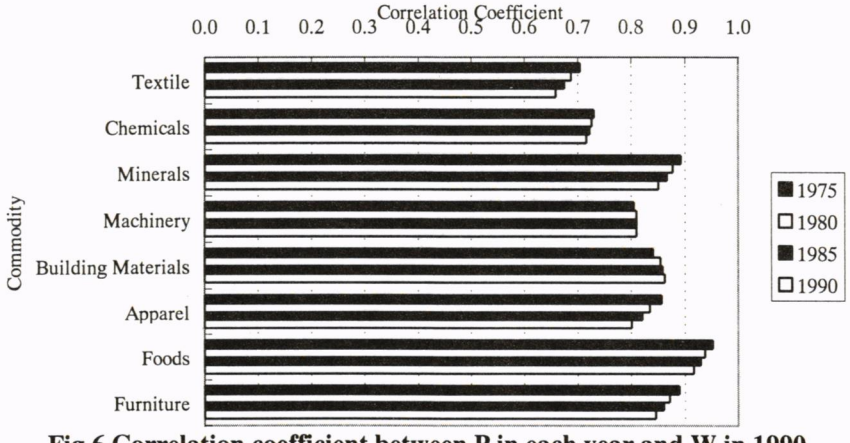

Fig.6 Correlation coefficient between P in each year and W in 1990

3.3 Concentration of Wholesale Industries

How much power (n) of M (M^n) or P (P^n) do have for the most highest correlation coefficient to W in 1990? When the value of power (n) is greater than 1 and correlation coefficient between P^n and W is high, it can be said wholesale industries are concentrated

in a large population area. Hereafter four commodities, i.e., machinery, building materials, apparel and foods will be discussed. The results are shown in **Fig.7** and **Fig.8**.

In the case of M^n-W, correlation coefficient becomes maximum when the value of power is 2.3 and the maximum is 0.91 the highest in apparel, however when the numbers of power are 0.9, 1.0 and 0.8 in machinery, building materials and foods respectively, the correlation coefficients reached to the maximum. Wholesalers of apparel are located intensively in production sites more and more, and the others are not so much.

In the case of W-P^n, trends of each commodity are clearly divided into two groups. The values of power are 0.6 and 0.4 in machinery and building materials respectively. They are not always located in large city. However, the value of power are 2.8 and 2.2 and the maximums are 0.91 and 0.96 respectively, in apparel and foods which are consumers' goods. They are located intensively in large cities and no inclination to locate in a small city. Wholesalers of apparel are concentrated nearby production site and large cities. They prefer to locate in densely populated area because it shows the high value of the value of power at the maximum correlation coefficient.

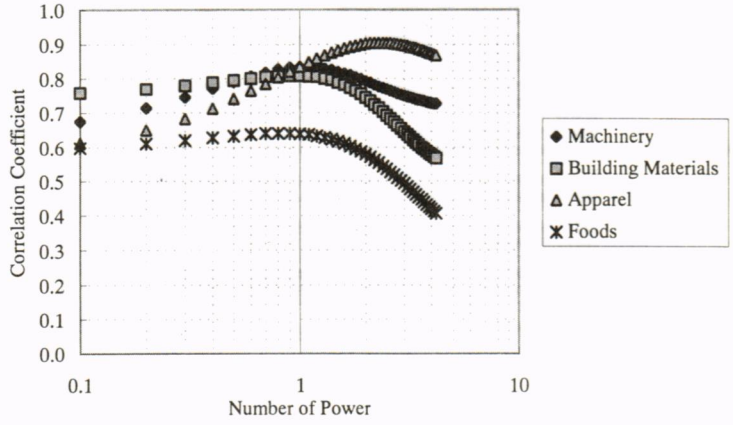

Fig.7 Correlation coefficient between powered M and W in 1990

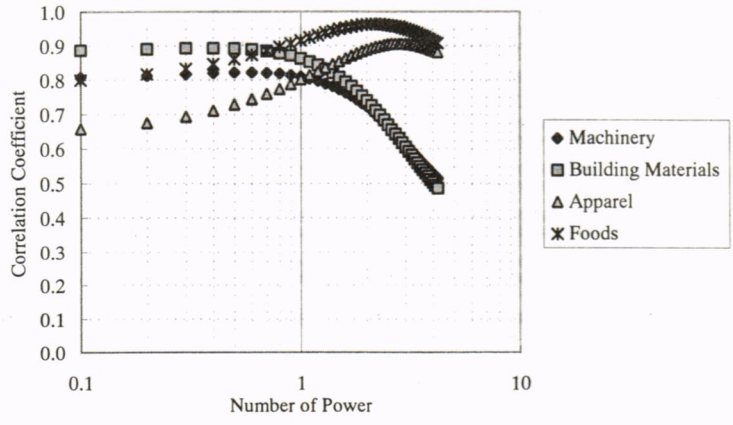

Fig.8 Correlation coefficient between powered P and W in 1990

The value of power of population when correlation coefficients maximized are shown in **Table.1**. Maximized coefficients have increased and kept at high level for fifteen years. The value of power of consumers' goods are a little bit higher than materials. The value of power of consumers' goods are always more than 1.0, however those of materials are less than 1.0. This means wholesalers of consumers' goods are concentrated in large cities and those of materials are not. The numbers of power in consumers' goods have been getting higher rapidly. This means that wholesalers of consumers' goods have been concentrated in large cities rapidly for fifteen years. Since production level and population size have not changed so much for these years, it may be due to the improvement of expressway. Owing to the improved expressway networks, transportation time is reduced and location in sub-urban area is not important any longer. Though three big cities in Japan had already been connected by expressway since 1975, it seemed wholesalers of apparel and foods had not concentrated in large city.

Table.1 Value of power of P when correlation coefficients maximized in 1990

	1975	1980	1985	1990
Machinery	0.9	0.8	0.6	0.6
	(0.71)	(0.80)	(0.86)	(0.82)
Building Materials	0.1	0.2	0.5	0.4
	(0.51)	(0.45)	(0.93)	(0.89)
Apparel	1.0	2.5	2.7	2.8
	(0.53)	(0.91)	(0.91)	(0.91)
Foods	1.0	1.0	1.6	2.2
	(0.80)	(0.95)	(0.96)	(0.96)

() : Maximum Correlation Coefficient

4. CONCLUSION

This paper overviewed previous studies for wholesale industries in Japan and clarified relationship among wholesalers, makers and population from the view point of physical distribution. Major findings are summarized as follows.

1) Most of previous studies for wholesale industries are dealing with number of establishments and employee, and sales amount, and little attention was paid on physical distribution. On the other hand, most of researches for physical distribution pay little attention on wholesale industries. Few previous studies analyze wholesale industries' activities from the view point of inter-regional physical distribution for nation wide infrastructure planning.
2) Time series changes of population is smaller than that of cargo volume handled by wholesalers and production amount. Handled cargo by wholesalers has increased the most among the three indices.
3) Wholesale industries of whole commodities except textile locate closer to consumers rather than makers.
4) Wholesale industries have not been able to follow the environmental changes immediately. It is a result of individual optimization, considering the improvement of transportation facilities.
5) Wholesalers of consumers' goods are concentrated rapidly in large cities for fifteen years.

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