Chapter 19

REMOTENESS OF PERIPHERAL REGION: TRANSPORTATION COST FOR INDUSTRY

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19.1 INTRODUCTION

Among several social and economical problem in small society in peripheral region, lack of jobs both quantitative and qualitative has been considered as the most tough issue for regional development. From firms' point of view, it is natural to avoid selecting remote location for their plant in order to conserve transportation or communication cost indispensable in business. Such a principle that transportation condition has a central role in location decision of firms has been one of the most widely accepted principles for geographers and economists. Based on this principle, Weber originated so called industrial location theory and it has been developed and sophisticated, while econometric attempts have given us some empirical proof of that firms' location decision making are explained by cost minimization to some extent.

Recent globalization of the world economy and the increase of worldwide division of labor, however, altered the meaning of the transportation cost in industrial location behavior. In the sectors where transportation-intensity is high, production locations become shifted from industrialized countries to developing countries. In a developed country like Japan, transportation intensive sectors gradually decrease in size. Other location factors such as labor cost or knowledge availability become more and more important in location decision. This trend means that less firms select their plant location based on transportation remoteness, even though some firms try to use alternative technology to save transportation cost. If this trend is in the case, peripheral regions need not give up to get industrial development simply because that they are remote from central industrialized region in the country.

This chapter aims to assess the explanatory power of transportation cost for industry location in very macro framework. The basic idea is as following; if industrial activities decide their location to minimize transportation cost, the existing (realized) industrial location, or more aggregated sense, realized product mix must possesses the most transportation saving property than any other patterns of product mix. The next section reviews the concepts of transportation cost and industrial location decision making and gives a question mark on blind worship of transportation condition. Section 19.3 follows the past development of models and also shows the model and method in this study which are to solve the question stated here. Regional input-output data in 1985 of Japan provides empirical base for this analysis. This study uses the decomposition approach in the input output framework to identify the sources of regional difference in transportation input in Japanese economy. The question tested there is whether the existing product mix pattern would save transportation input well or not. If the answer is yes, we can conclude that Japanese industrial firms determine their locations to minimize transportation cost, and that remoteness of peripheral region seems difficult to compete. If It is not the case, peripheral region has enough opportunity to get increase in industrial location even though their remoteness. Section 19.4 discusses the result of the analysis and show the picture of regional difference of transportation service input. At last, section 19.5 summarizes the study.

19.2 REGIONAL INDUSTRIAL STRUCTURE AND TRANSPORTATION COST

In industrial economics and geography, transportation cost has gathered strong worship as a location factor for industrial activities. Alfred Weber, the father of the industrial location theory, who converted other type of cost into transportation length dimension, shows the most remarkable example of the worship. Economic geography schools much owes to the conversion of geographic distance into transportation cost when they models geographic decision making. Urban economics model by Alonso also make conversion of space to commuting cost. More recently, spatial econometrics is used to test the explanation power of transportation cost for firm moves. Fingleton et al (1990) and Fingleton(1991) applied aggregated multinominal logit model to analyze the British automobile firms' selection of plant location at the time of relocation from Greater London region. As independent variables that model includes transportation cost as well as land cost, regional finance aid for industry promotion, urban development measure and so on and estimates the parameters of each variable. The finding was that transportation cost has explanatory power for location selecting, but is not so powerful factor as urban development policy like new town project. Moreover, only within a certain distance from London, firms consider finer condition about input cost; it means that many firms filter the alternative locations through distance and transportation cost and later, they consider other location factors.

Remoteness concept is rephrased that a place is far from other places and we need longer distance transportation if we make communications. Because most of modern industrial productions require so many variety of materials and energy that all of them cannot be self provided, and because they need to carry their products to the market, roughly distributed in proportion to population, remoteness has meaning of higher transportation cost. Firms are apt to gather each other to save transportation cost and build industrial complexes near large market and sea ports, while peripheral region is considered as the last location for industrial development. When we compare two regions requiring different transportation distance of input and product for a industry, if other conditions are same, less remote region is naturally expected to have larger size of activities of the industry than the remote one. This belief sounds very pessimistic for small societies in peripheral region. Even though they have cost advantages of cheaper land price, labor cost and environmental restoration cost, It is still difficult to overcome the disadvantage of remoteness and much higher transportation cost.

A relating discussion to that point is seen in Lakshmanan (1983) not on transportation cost but about energy intensity, which shows the energy intensity of Louisiana industries are about 15 times of that of New York State. The study explains the cause of such large difference by that the industrial mix in the Northeastern states with higher energy prices is weighted more heavily to the less energy intensive sectors, and even within the energy intensive sectors, such states specialize in less energy intensive sub- sectors. In the same way, industries producing heavy or bulk products are expected to choose their location in places where long transportation is not necessary or transportation condition is good, and yields transportation saving product mix in the end.

Recently, however, there are some causes to expect that the direct effect of transportation condition on industry location becomes not so decisive for most industries. First, most manufacturing plants where transportation for inputs or market accessibility is important have already developed in the earlier stage of industrialization, then locations of them have been selected in the past considering the transportation situation at that time. It does not always correspond to the present situation of transportation condition, consider for example, city center of large cities have become more and more expensive place for transportation. This point is rephrased by the difference between marginal transportation cost and average one. Second, transportation costs for most light and high-tech industries which are recently developing are a small fraction of the value of shipments. Consequently, difference of transportation prices seldom has large effect on relative profits of firms. Third, the direct effect of transportation considerations on plant locations is further weakened by thoroughly improving the logistic system.

This discussion results that the present industrial locations or realized location pattern of industries are not necessarily determined to be efficient for transportation. Transportation condition no more seems to be a driving force of location process but to be a result of it. Although the difference of industrial specialization is usually seen as a response to the transportation condition disparities, industries in the region with higher transportation price may take other ways to conserve transportation cost. They may invest more capital on internal storage system or logistics to cut the frequencies of transportation. They may substitute other factors of production for transportation, such as "inside sourcing." They may improve efficiency by decreasing the unnecessary transportation of defects.

It is naturally questioned what part of the existing regional transportation cost difference is due to each factor as specific locality of transportation service sectors, industrial mix difference, technology difference, demand structure difference, and so forth. This question has never been well analyzed yet. You must decompose the transportation input difference into influences of several factors. The next section gives a model and method of such decomposition.

19.3 MODEL AND METHOD

Considering the aim of this study, we require a quantitative model to capture the quantitative patterns of interactions between the economic activities and transportation service in each region. Regional input output model is applicable for this type of analysis. Here, the following analyses are based on the regional input output data in 1985 which compiles monetary transaction between 49 sectors in nine regions of Japan: Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu and Okinawa.

What part of the regional difference in transportation cost is conserved by strategic location of firms or its consequence regional product mix is the main question of this study. The recent developments in the analysis of structural change in economy in the input output framework give a way to solve this question. The first application of input output model to analysis of structural change in the American economy was one by Leontief(1953). Carter(1970) used column substitution method to analyze the effect of technical changes of individual sectors, and more recently in its extended form has come to be known as "Structural Decomposition Analysis" by e.g. Skolka(1989), Kanemitsu and Ohnishi (1989). They use two sets of input-output data, one in the present and the other in the past. In Leontief input-output system, output vector is endogenously explained as a function of final demand vector, export vector, import coefficients and technical coefficients. In the model at the past year, substitution of each vector or coefficients with corresponding one in the present year gives variation in the output vector. Difference between such calculated output vector and original output vector shows the effect of each component of the changes between the time interval.

This methodology can be easily expanded to analyze regional difference. Vectors or coefficients in the regional model will be substituted by national ones, which give average picture of the nationwide economy. Actual calculation is done as following. First, the balance condition between supply and demand of the total output in region R is described as

$$X_R + m_R = A_R X_R + F_R + E_R \tag{1}$$

where,

X_R: gross regional output vector in region R (n column vector),

m_R: abroad and domestic import vector into region R (n column vector),

F_R: R region's final demand vector (n column vector),

E_R: abroad and domestic export vector out of region R (n column vector),

A_R: R region's input coefficient matrix ($n \times n$ matrix).

By introducing import coefficient matrix M_R ($n \times n$ diagonal matrix), eq.(1) is written as

$$X_R = (I - M_R)(A_R X_R + F_R) + E_R \tag{2}$$

If Matrix $[I - (I - M_R)A_R]$ is non singular, regional output vector X_R can be solved as a function of final demand F_R, inter-regional trade M_R,E_R, and regional technology A_R.

$$X_R = [I - (I - M_R)A_R]^{-1}[(I - M_R)F_R + E_R] \tag{3}$$

In order to pick up the regional differences here, let us consider an imaginary regional economy with average structure as a counterpart (region o). It has the same structure as national economy but it is the same size as the local economy of region R. Import coefficients matrix M_o and input coefficients matrix A_o of this economy are no other than what are calculated by national input output data. Final demand vector F_o and export vector E_o for this imaginary economy are corresponding national vectors but the size of them are adjusted to the total regional final demand and total regional export, respectively.

Just as eq.(3), output vector of the imaginary economy (X_o) is derived as

$$X_o = [I - (I - M_o)A_o]^{-1}[(I - M_o)F_o + E_o] \tag{4}$$

where,

X_o: output vector in the imaginal economy as large as region R (n column vector),

M_o: import coefficients matrix ($n \times n$ diagonal matrix) based on the international import and inter-regional trade vector in national economy (n column vector),

F_o: final demand vector in the imaginary economy (n column vector), calculated from the national final demand vector with size adjustment,

E_o: export demand in the imaginary economy, estimated by international export and inter regional trade vector in the national economy with size adjustment, and

A_o: national input coefficient matrix.

As shown in the following, the difference in total output vectors of the two economies can be decomposed into four components: effect of technical difference, effect of import structure difference, effect of export structure difference, and effect of final demand structure difference.

$$\begin{aligned}
dX_R &= X_R - X_o \\
&= [I-(I-M_R)A_R]^{-1}[(I-M_R)F_R+E_R] \\
&- [I-(I-M_o)A_o]^{-1}[(I-M_o)F_o+E_o] \\
&= [I-(I-M_R)A_R]^{-1}[(I-M_R)F_R+E_R] \\
&- [I-(I-M_R)A_o]^{-1}[(I-M_R)F_R+E_R] \\
&+ [I-(I-M_R)A_o]^{-1}[(I-M_R)F_R+E_R] \\
&- [I-(I-M_o)A_o]^{-1}[(I-M_o)F_R+E_R] \\
&+ [I-(I-M_o)A_o]^{-1}[(I-M_o)F_R+E_R] \\
&- [I-(I-M_o)A_o]^{-1}[(I-M_o)F_R+E_o] \\
&+ [I-(I-M_o)A_o]^{-1}[(I-M_o)F_R+E_o] \\
&- [I-(I-M_o)A_o]^{-1}[(I-M_o)F_o+E_o] \qquad (5) \\
dX_R &= dX_R(A)+dX_R(M)+dX_R(E)+dX_R(F) \qquad (6)
\end{aligned}$$

where,

$dX_R(A)$: the regional difference in output due to technical difference,

$dX_R(M)$: the regional difference in output due to import structure difference,

$dX_R(E)$: the regional difference in output due to export structure difference,

$dX_R(F)$: the regional difference in output due to structural difference in final demand.

There are 24 ways of decomposition including eq.(5) with different order of consideration, so here each of the 4 effects are derived as the average of the 24 types of calculations.

Because we are focusing on the transportation input, we picked up only the change of the production in transportation service sectors. Summation of rows of the six transportation sectors in each regional difference vector gives the difference of transportation service to carry regional economic activities.

$$\begin{aligned}
dx_o^t &= \sum_{i=transportation} dX_R(i) \\
&= dx_R^t(A)+dx_R^t(M)+dx_R^t(E)+dx_R^t(F) \qquad (7)
\end{aligned}$$

where,

dx_R^t: transportation production difference of region R,

$dx_R^t(A)$: transportation production difference due to technical difference,

$dx_R^t(M)$: transportation production difference due to import structure difference,

$dx_R^t(E)$: transportation production difference due to export structure difference, and

$dx_R^t(F)$: transportation production difference due to structural difference in final demand.

In Japan, each region of the nine has very different situation in terms of land and sea relationship, and therefore, has different share of transportation service: for example, central regions like Kanto, Chubu and Kinki have great convenience for railway transportation, regions along the Setouchi Inland Sea (Chugoku, Shikoku, Kyushu) have raised navigation service sector, while Okinawa, consisting of remote detached islands, depends on air service to the extent far beyond the national average. There are several transactions between regions to provide each type of transportation service in different share, and in some case, location of the headquarters of transportation service industry strongly skewed the domestic trades of transportation service.

For our purpose, import and export structure differences would rather be divided in more detail; trade of transportation service, trade of manufactured goods and trade of other service and elementary goods. Here, we define half localized import matrix M_P and export vector E_P from M_o and E_o, by substitution of transportation sectors' elements with those of regional data, M_R and E_R, respectively. In the same way, import matrix M_Q and export vector E_Q are defined from M_o and E_o by substitution of non manufacturing sectors' elements with those of regional data, M_R and E_R. If we consider a new decomposition using M_P, E_P;'M_R and E_R, effect of transportation transaction can be subtracted from $dX_R(M)$, $dX_R(E)$, $dx^t_R(M)$ and $dx^t_R(E)$. On the contrary, for simplicity of procedure, we combine the effects of import difference and effects of export difference, because these two structures are essentially express the difference in products mixture and the domestic division of labor, having too close relationship to investigate the results independently. Therefore, besides eq.(5), another way of decomposition is defined as follows;

$$
\begin{aligned}
dX_R &= X_R - X_o \\
&= [I-(I-M_R)A_R]^{-1}[(I-M_R)F_R+E_R] \\
&- [I-(I-M_o)A_o]^{-1}[(I-M_o)F_o+E_o] \\
&= [I-(I-M_R)A_R]^{-1}[(I-M_R)F_R+E_R] \\
&- [I-(I-M_R)A_o]^{-1}[(I-M_R)F_R+E_R] \\
&+ [I-(I-M_R)A_o]^{-1}[(I-M_R)F_R+E_R] \\
&- [I-(I-M_R)A_o]^{-1}[(I-M_R)F_o+E_R] \\
&+ [I-(I-M_R)A_o]^{-1}[(I-M_R)F_o+E_R] \\
&- [I-(I-M_Q)A_o]^{-1}[(I-M_Q)F_o+E_Q] \\
&+ [I-(I-M_Q)A_o]^{-1}[(I-M_Q)F_o+E_Q] \\
&- [I-(I-M_P)A_o]^{-1}[(I-M_P)F_o+E_P] \\
&+ [I-(I-M_P)A_o]^{-1}[(I-M_P)F_o+E_P] \\
&- [I-(I-M_o)A_o]^{-1}[(I-M_o)F_o+E_o] \qquad (8)\\
dX_R &= dX_R(A)+dX_R(F)+dX_R(TM)+dX_R(TO)+dX_R(TT) \qquad (9)
\end{aligned}
$$

where,

M_P: import coefficients matrix($n \times n$ diagonal matrix) in national economy but substituted by regional coefficients in transportation sectors (n column vector),

E_P: export demand in the imaginary economy, estimated by international export and inter regional trade vector in the national economy with size adjustment, but transportation sectors have real regional trade value,

M_Q: import coefficients matrix($n \times n$ diagonal matrix) in national economy but substituted by regional coefficients in non-manufacturing sectors (n column vector),

E_Q: export demand in the imaginary economy, estimated from national economy with size adjustment, but non-manufacturing sectors have real regional trade value,

$dX_R(TM)$: the regional difference in output due to trade structure difference of manufacturing industries,

$dX_R(TO)$: the regional difference in output due to trade structure difference of non-manufacturing industries other than transportation sectors, and

$dX_R(TT)$: the regional difference in output due to inter-regional transportation service trades.

Correspond to this decomposition, the difference of transportation service to carry regional economic activities will be decomposed as follows;

$$
\begin{aligned}
dx^t_o &= \sum_{i=transportation} dX_R(i) \\
&= dx^t_R(A)+dx^t_R(F)+dx^t_R(TM)+dx^t_R(TO)+dx^t_R(TT) \qquad (10)
\end{aligned}
$$

where,

$dx_R^t(TM)$: transportation production difference due to trade structure of manufacturing industries,

$dx_R^t(TO)$: transportation production difference due to trade structure of non-manufacturing industries other than transportation service, and

$dx_R^t(E)$: transportation production difference due to inter-regional transportation service trades.

Our purpose is therefore described as the question whether $dx_R^t(TM)$ is negative in remote region or not. If this is true, regional product mix is designed to minimize the transportation inputs for production and we can certify the explanatory power of transportation cost on industrial location in a macro way.

Furthermore, effects of each sector's location $dX_R(TMj)$, $dx_R^t(TMj)$ can be assessed in the same way. We introduce import matrix $M_R(j)$ and export vector $E_R(j)$ from M_Q and E_Q, by substitution of j sector's element with that of regional data, M_R and E_R, respectively.

$$\begin{aligned} dX_R(TMj) = \; & [I-(I-M_R(j))A_R]^{-1}[(I-M_R(j))F_R+E_R(j)] \\ & -[I-(I-M_Q)A_R]^{-1}[(I-M_Q)F_R+E_Q] \end{aligned} \quad (11)$$

where,

$dX_R(TMj)$: the regional difference in output vector due to trade structure difference of j manufacturing sector.

By adding the transportation production rows in $dX_R(TMj)$, difference in transportation service based on regional peculiar location of manufacturing sector j is derived.

19.4 DECOMPOSITION OF REGIONAL DIFFERENCE IN TRANSPORTATION INPUT

The regional input output data in 1985 which compiles transaction between 399 sectors in nine regions of Japan: Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu and Okinawa, provides empirical base for empirical analysis. At first, considering the computational capacity, transaction data were aggregation in 49 sectors input output Table, including 25 manufacturing sectors, and six transportation service sectors as railway, road transportation, navigation, airline service, storage service, and miscellaneous transportation service.

Figure 19.1 shows the difference in transportation production ($dX_R = X_R - X_o$) in each region (eq.5). Here, we confronted the unrealistic results for Okinawa region, such as tremendously large effects for railway production. This phenomena are supposed to come from that Okinawa has no railroad service while depends much on airways between remote islands, other special geographical position of Okinawa and small size economy less than 0.5 effects on railroad service is eliminated. And the following part of the analyses are focused on eight regions excluding Okinawa region. From Figure 19.1, Tohoku, Chubu, Kinki, Shikoku use less transportation service than national average, while two peripheral regions of Hokkaido and Kyushu require more transportation service than average as well as Kanto region. Items of each region reflect geographical condition; Kanto and Kinki region including metropolitan area uses more railway service than other area, while Chugoku, Shikoku and Kyushu owes more on navigation because they are in good location to use the Setonaikai Inland Sea. In peripheral region like Hokkaido, Kyushu and Okinawa, airway transportation has larger role than in regions in the central part (Tohoku, Chubu, Kinki and Chugoku). Kanto region provides larger size of miscellaneous service than any other region.

The result of the first decomposition by eq.(6) is displayed in Figure 19.2, which shows that import and export effects determine the total effects. In Kanto, Chugoku, Shikoku and Kyushu, import effect and export effect have the different sign, it implies that they make trade to exchange different types of transportation service with other region. As discussed in the last section, those trade structure need to be decomposed further for interpretation.

Figure 19.3 shows the result of the other decomposition by eq.(8). It shows that Transportation Trade effect $dx_R^t(TT)$ is largest factor to determine transportation needs and other effects possess almost similar size. If we pay attention to the manufacturing product mix effect $dx_R^t(TM)$, the main interest of this study, all of remote regions (Hokkaido, Tohoku, Chugoku, Shikoku and Kyushu)

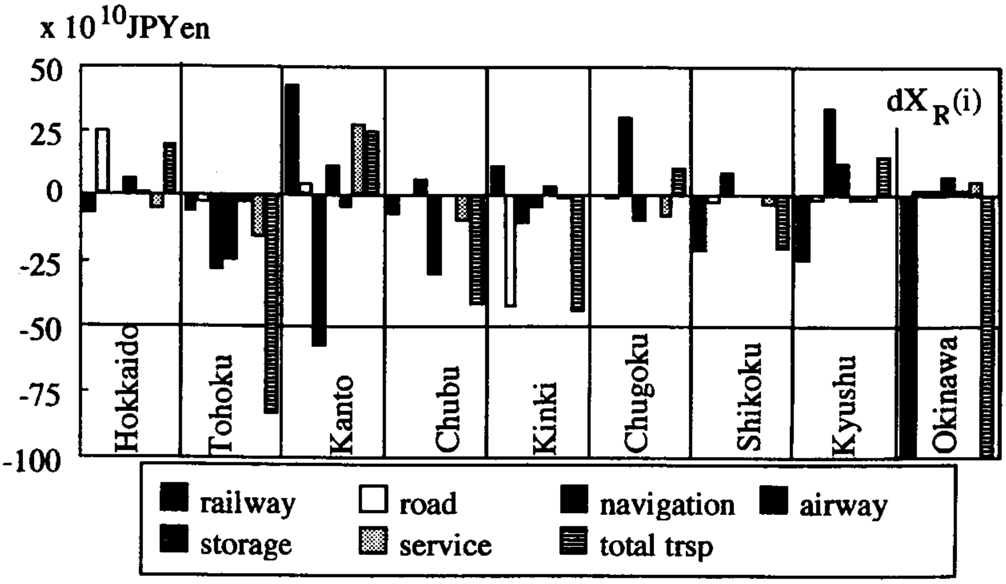

Figure 19.1: Transportation production difference in 9 regions.

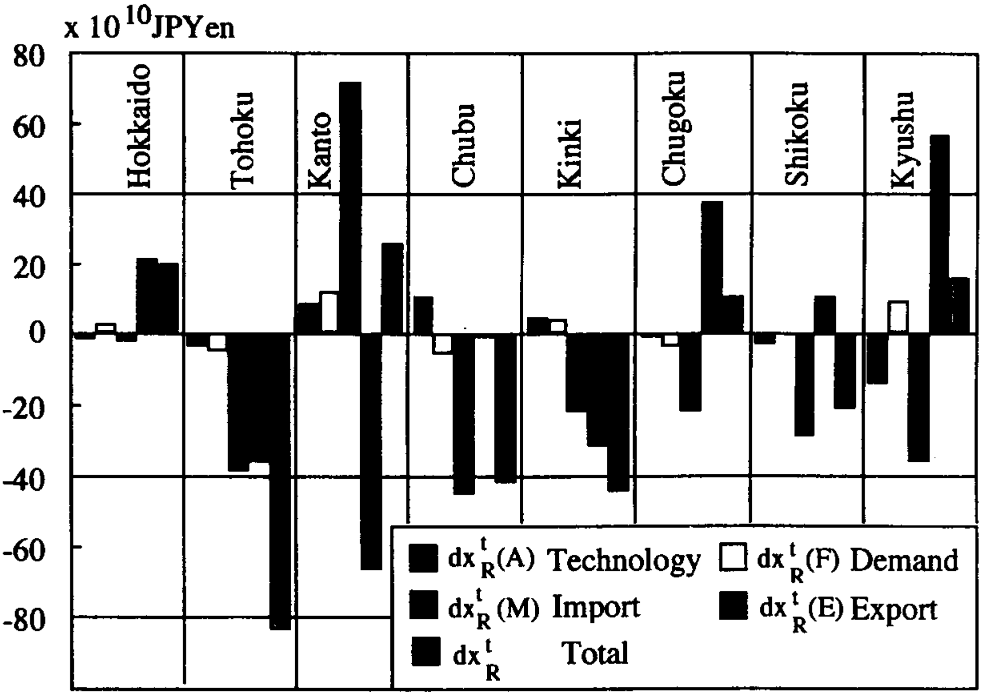

Figure 19.2: Decomposition of the transportation production difference in 8 regions.

have negative effect, which implies that the existing product mix is transportation conserving one than average product mix of Japan. On the contrary, central regions like Kanto, Chubu and Kinki have positive effect showing that transport intensive sectors are gathering in such less-remote regions. This comparison seems to prove that in macro level, industrial activities tend to decide their location considering transportation cost.

Let us investigate other effects. Non-manufacturing product mix effect $dx^t_R(TO)$ has positive sign only in Kanto metropolitan region, as well as Hokkaido, while demand effect $dx^t_R(F)$ become

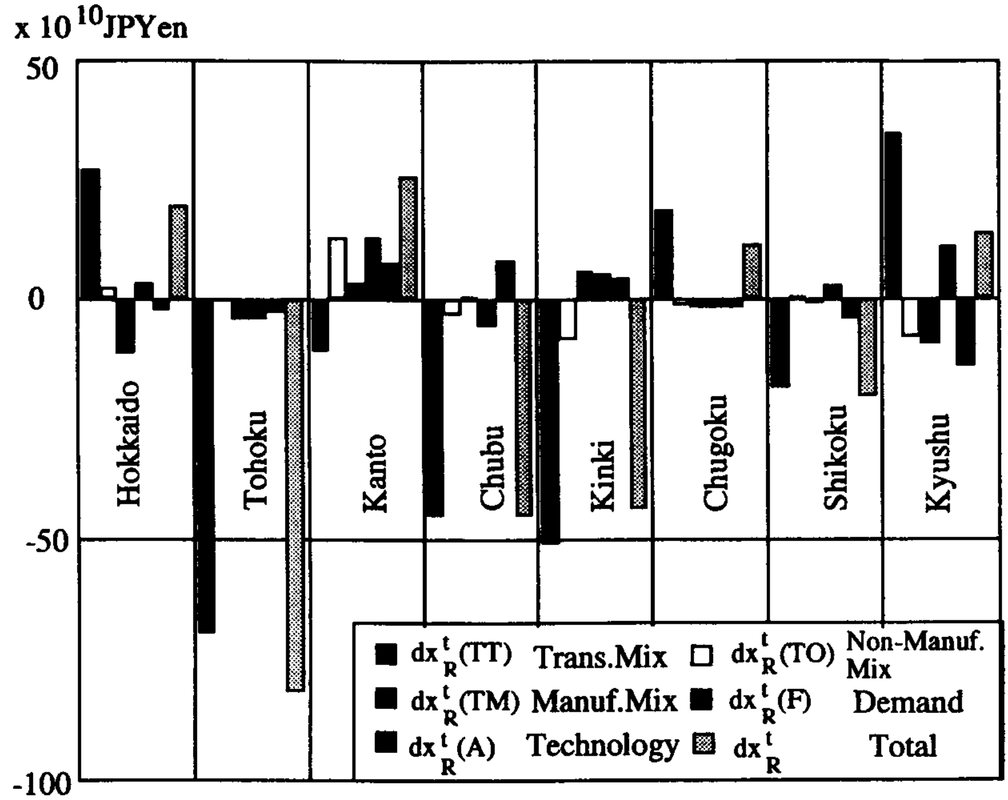

Figure 19.3: Another decomposition of the transportation production difference in 8 regions.

positive in both metropolitan areas and remote regions. The latter can be explained as follows; in metropolitan area, inhabitants needs more transportation service to take advantage to enjoy their urban life with variety, while in peripheral regions, trips to the central regions push up the transportation demand in monetary term. Technology effect $dx^t_R(A)$ shows a similar profile as the manufacturing product mix effect; negative in all peripheral regions and positive in Kanto, Chubu and Kinki. It means that in peripheral area, industrial activities try to use more transportation conservative technology than metropolitan area. Considering that this analysis is done in very coarse aggregation level, these regions may possess larger portion of less transportation intensive subsectors in each sector. Therefore, this result also strengthen the explanatory power of transportation cost for location decision.

Figure 19.4 shows that the product mix effect of individual sectors in Chugoku region calculated by eq.(11). Sixteen in twenty-two manufacturing sectors have negative effects which implies transportation saving product mix. Some transportation intensive industries like earthenware industry and wood industry are, however, exceptions to the rule. In this way, the explanatory power of transportation cost is not all mighty.

By this empirical analysis, We can conclude that transportation cost can explain the existing product mix pattern to some extent, but there are exceptions even in transportation intensive sectors.

19.5 CONCLUSION

Transportation cost has been considered as the most essential cause of industrial location, and consequently, remoteness of peripheral areas. Recent globalization of the world economy and the increase of worldwide division of labor have, however, greatly lessen the ratio of transportation cost in total cost for production, especially in developed countries like Japan. Other factors may probably determine the location more crucially than transportation cost, while some factors of then

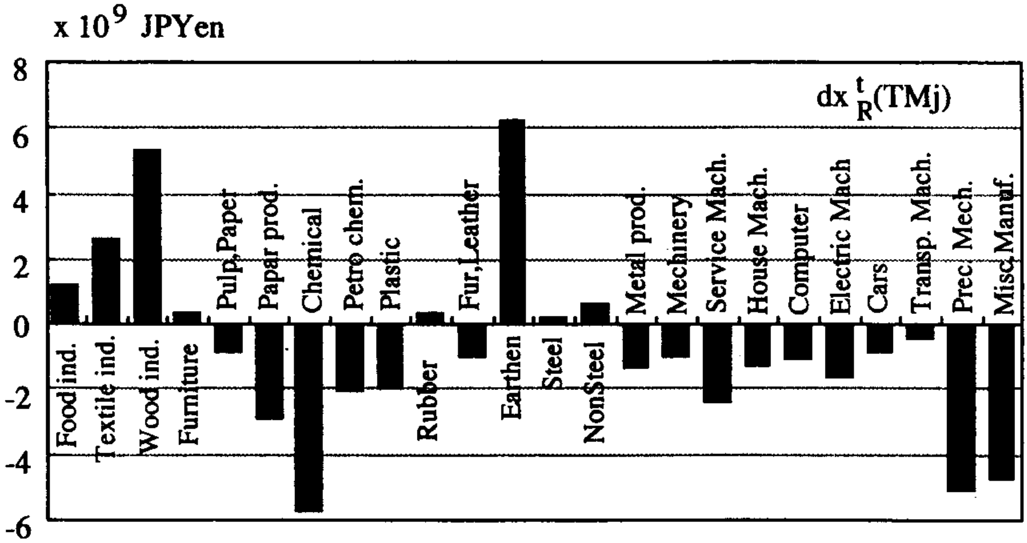

Figure 19.4: Product mix effect of each manufacturing sectors in Chugoku region.

still reflect the historical transportation gaps. This study has engaged to assess the explanatory power of transportation cost for industrial location decision and its consequence the product mix pattern. After a small conceptual consideration over the relationship between industrial structure and transportation cost in section 19.2 recent developments in regional models and methods were reviewed. The decomposition approach in the input output framework, originally used for understanding effects of technological changes along the time axis, was expanded in section 19.3, in order to identify the sources of regional difference in transportation input in Japanese economy. The technique picked up the effect of the product mix difference across regions from other effects such as difference of regional demand, peculiar existence of transportation service industry, regional technological difference. With the empirical work expressed in section 19.4, regional transportation input differences realized by product mix selection are calculated. A rough assessment shows that transportation cost can explain the existing product mix pattern to some extent, but there are exceptions even in transportation intensive sectors.

The empirical work in this study is too simple and naive, then waiting for further improvements and sophistication. The most important contribution of this study is that the input output decomposition methodology was expanded to regional or national comparison contexts, which contribution indicates a sophisticated way of comparison considering total structure of economies.

Transportation cost is no more the decisive aspects in industrial location, though, it keeps much influence to industrial activities. One of the most interesting works in future is to examine the analysis like this study at several points on the time axis and to check whether the transportation cost was neither crucial on industrial location. The methodology of this study can be easily expanded to such inter-temporal decomposition. Another one is to regress existing product mix effect on other properties of each industry to show what is actually decisive in location decision making.

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