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Abstract

This paper examined Japanese domestic distribution structure from the relation between industrial accumulation and transport infrastructure in order to reveal the structure of freight flow and its changes from 1980 to 2000, on the basis of the *Logistics Census*, *Census of Manufacturing*, and *Social Overhead Capital* in Japan. Our findings, as an average characteristic (evidence) of Japanese transport structure, indicate that both domestic and international freight flow are strongly linked to the scale economies emerging from industrial accumulation, and that transport infrastructure does not contribute to an increase in the overseas shipping volume; however, it does increase the volume to domestic regions. However, this suggests that transport infrastructure on the shipping to other domestic regions is maintained enough, and this has contributed to reorganization (relocation) of industrial accumulation in Japan.

JEL classification: R40, R42, R53

Keywords: International freight flow; Domestic freight flow; Transport infrastructure; Agglomeration, Distribution network;

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1. Introduction

This paper is an examination of the structure of freight flow and its changes from 1980 to 2000 in Japan. As a first step, with the data from the *Logistics Census*, *Census of Manufacturing*, and *Social Overhead Capital* in Japan, we examine the effects of industrial accumulation and transport infrastructure, i.e. social overhead capital on the shipping of physical distribution to the other domestic region and overseas region. As a second step, with the data from the *Logistics Census*, we demonstrate the transition of domestic freight flow structure.

There are fewer Japanese container ports on the major sea routes, and, as a result, Japan has become less competitive since the mid 1990s. Therefore, the Japanese container ports have become feeder ports. If this tendency continues, all Japanese container ports will function as feeder ports. In this case, Japan would completely lose its place in the global competition of ports. Japan's reduction in the global competiveness of container ports is attributed to the establishment of large-scale container ports in other parts of Asia and worldwide. For example, China, Korea, Singapore, and Taiwan have quickly established large-scale container ports because of their own rapid economic growth after 1990's. Recently, Chinese container ports, especially Shanghai and Shenzhen, have increased their overall handling capacity. As a result, China has advanced in global maritime competiveness. The growth of handling capacity of the container port in Singapore and China poses a threat to that of Japan and Korea.

It is also necessary to understand these decreases in the amount of container handling in Japanese and Korean container ports in the context of flying geese type of economic development theory, in other words, the leapfrogging theory of endogenous growth (see Brezis, Krugman, and Tsiddon, 1993). As advanced countries, Japan and Korea both have records of sustained economic growth. The rapid economic growth of Japan ended in the early 1970s, and that of Korea in the latter half of the 1980s. Since those dates, the two countries have undergone periods of low growth with the exception of their asset-inflated economies. The economic growth in Japan and Korea has been attributed to the success of building the export-led type industrial structure. During the successful years, both countries exported manufactured goods and imported raw materials and intermediate goods, which they used for the production and assembly their export products.

However, like the flying geese type of economic development, the location of major manufacturing and exporting has shifted from country that industrializes previously to country that industrializes delaying. Major manufacturing and exporting are now taking place primarily in China, whereas, in the past Japan, Korea, and the Association of Southeast Asian Nations (ASEAN), in that order, had been the hub of these activities. These shifts from Japan to Korea, Korea to the ASEAN, and ASEAN to China have picked up speed in the last few years. With some time lag, the decrease in the amount of container handling in Japan and Korea is synchronized with the change in industrial construction in each country. For the formulation of maritime policy, a thorough understanding is required of the situation changes such as history of container shipping, manufacturing, exporting, and importing in Japan, Korea, ASEAN, and China.

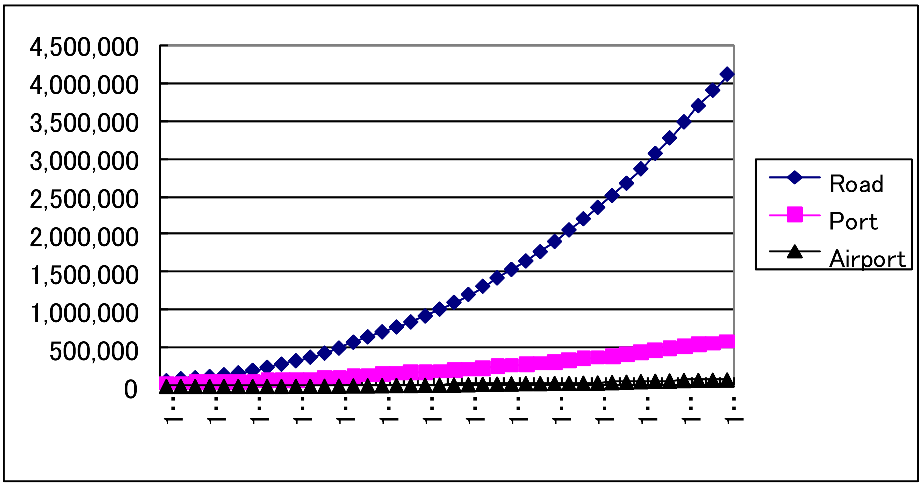
Based on such situation of overseas physical distribution, i.e. handling of container shipping, this paper examines Japanese domestic distribution structure from the relation between industrial accumulation and transport infrastructure. Then, as mentioned in opening sentence, the aim of this paper is an examination of the structure of freight flow and its changes from 1980 to 2000 in Japan. First, in Section 3, we estimate the effects of industrial accumulation and transport infrastructure, i.e. social overhead capital on the shipping volume to the other domestic regions and overseas regions. Second, following the results of this empirical work, in Section 4, we focus on the domestic freight flow. We demonstrate the transition of Japanese domestic freight flow structure in 1980 to 2000. Following this Introduction, Section 2 contains a basic description of the features of regional development and transport infrastructure improvement in Japan and a review of some previous studies for contextual background.

2. Setting the Scene: Factual and Theoretical Background

2.1. Basic Features of Transport Infrastructure Improvement and Regional Development in Japan

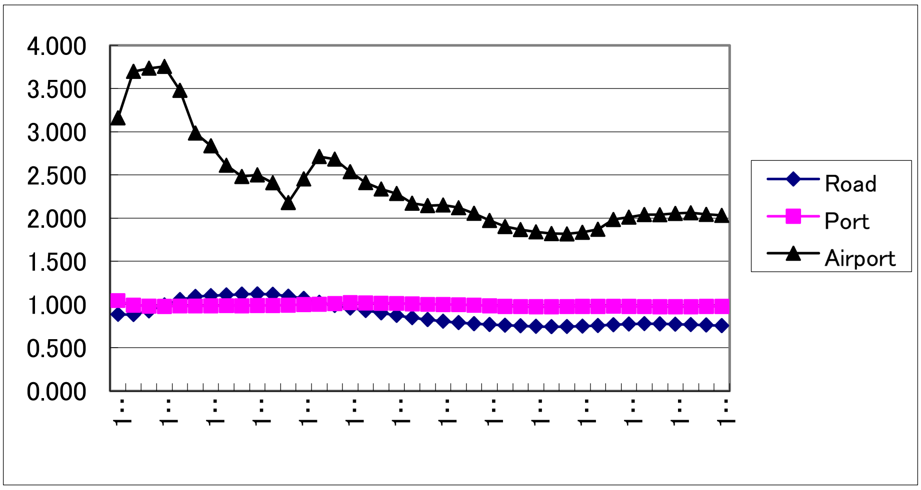
Transport infrastructure improvement has been considered a main factor of regional development. Before reviewing the related literature, we discuss the trajectory of the relationship between regional development and transport improvement in Japan. As a regional policy of Japan, the transport infrastructure, such as roads, railways, ports, and airport has been effectively maintained in order to sustain the social overhead capital. Figures 1 and 2 show the tendency of the mean value and coefficient of variation of the transport infrastructure, namely, the social overhead capital, such as roads, ports, and airports, in each prefecture.

Figure 1: Trend of the mean value of the social overhead capital of roads, ports, and airports



Note: The vertical axis shows the amount of money of social overhead capital of roads, ports, and airports
Source: *Social Overhead Capital* in Japan

Figure 2: Trend of the coefficient of variation of the transportation type of the social overhead capital

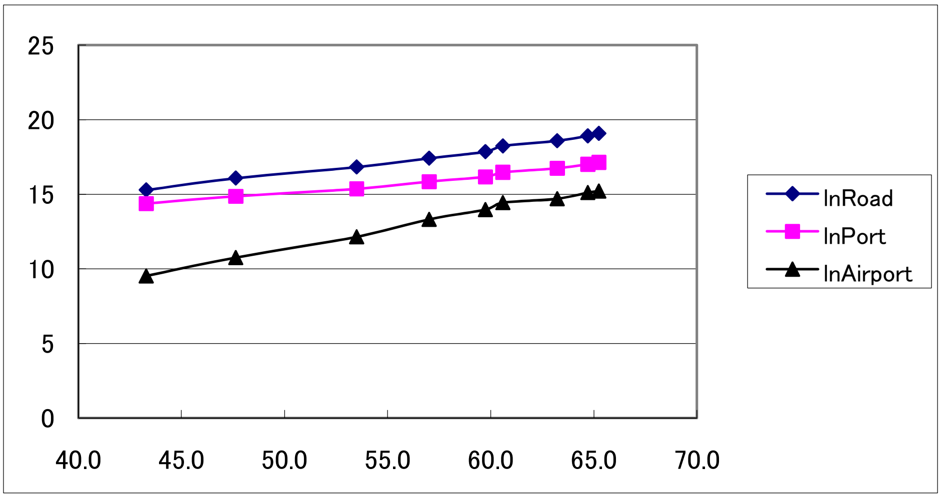


Note: The vertical axis shows the coefficient of variation social overhead capital of roads, ports, and airports
Source: *Social Overhead Capital* in Japan

The trends shown in the figures reveal that the social overhead capital required is much larger for roads than it is for ports and airports. However, the scale of port- and airport-related social overhead capital is 1/7 and 1/42 of that for roads, respectively. On the other hand, the trend of the coefficient of variation reveals that the max value for roads is about 1.12 in 1968; disparities among regions have decreased since the latter half of the 1970s. Moreover, that trend for ports was about 1.05 in 1959, and disparity among regions has remained at approximately the same lower level since the 1960s. With regard to the coefficient value for airports, about 3.75 in 1962 is recorded, and disparities among regions have decreased since the 1960s. However, the coefficient value for airports has remained at a higher figure in recent years.

The maintenance of the transport infrastructure has been affected on the transportation cost and the transit time of intra- and inter-region. The changes of those have effects on not only human and physical distribution, but also the flow of information and capital. In the process, industrial structure in regional economy has been influenced by these changes. As a result, the distribution of industry in the urban areas also changes. Then, the relationship between the maintenance of the transport infrastructure and urbanization in Japan needs to be clarified. Figure 3 illustrates the relationship between the use of social overhead capital and urbanization according to the population distribution of densely inhabited districts (DIDs) from 1960 to 2000.

Figure 3: Relationship between the social overhead capital and urbanization



Note: The vertical axis shows the social overhead capital of roads, ports, and airports with logarithmic transformation. The transverse is the share of DID population.
Source: *Population Census* (various years), *Social Overhead Capital* in Japan

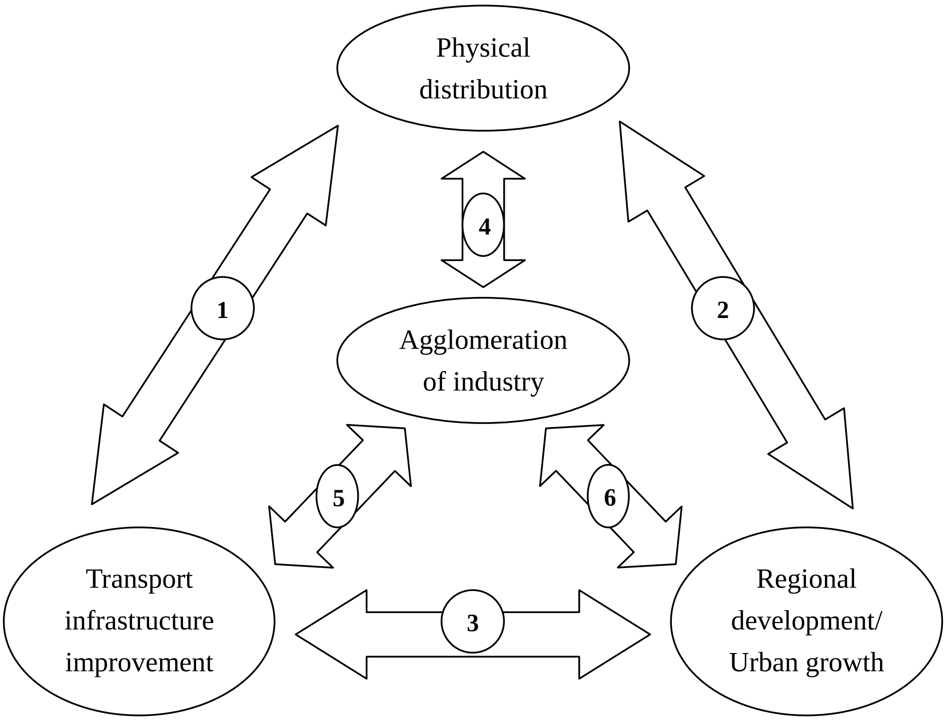
Each scatter diagram reveals that there is a positive correlation between the social overhead capital and urbanization. Actually, the development of urban industry, i.e. manufacturing industry has affected by the maintenance of the transport infrastructure that reduce the transportation cost of manufacturing goods between inter- and intra-region. As mention in Section 2.2, it is clarified that urbanization and/or industrial accumulation, in other words, the formation of agglomeration economies are determined by the variety of intermediate and/or final goods as the concentration force, and the transportation cost (including communication cost) as the dispersion force (see Fujita, Krugman and Venables, 1999). In this vain, it is thought that there is some relation between maintenance of the transport infrastructure, decrease of the transportation cost, and industrial accumulation. And, we think that that physical distribution is also affected by transport infrastructure, transportation cost, and industrial accumulation.

2.2. Previous Studies

Following the discussion, as reported above, improvements in the transport infrastructure have been considered to be a primary factor in regional development. However, this mechanism is not always explained either theoretically or in actual situations. For this reason, explanations of the mechanism are frequently provided according to discipline, such as geography, economics, civil engineering and so on. Figure 4 is an illustration of the relationships among “transport infrastructure improvement,” “physical distribution,” “regional development,” and “agglomeration of industry.” The arrows indicate the effects and/or relationships of each category. In this figure, we identify six research topics; the arrows, numbered from one to six, indicate the research topics. In many studies, the research topics have been examined individually in each discipline.

For example, with regard to Topics 1 and 2, Liew and Liew (1984) evaluated a river improvement plan from the viewpoint of the reduction of the waterborne transportation cost. Regarding Topic 3, Aschauer (1989), in a pioneering study, examined the effects of social overhead capital on output by region. Many similar studies have been conducted since this study. Garcia-Mila, McGuire, and Porter (1996) examined the effects of highways as a public capital on output by production function with U.S. state-level data and found that highways have a small, positive effect on output. Regarding Topics 4, 5, and 6, it has not inquired so much besides though Topics 6 has inquired most. Then, we point out the importance of taking up these topics at the same time. As for Topic 6, theoretical and empirical studies have been traditionally conducted in the context of research on urban economics. For this reason, there have been many previous studies. The objective of these studies has been to investigate the effects of the externalities of industrial districts on urban development.

Figure 4: Research targets of this study and related disciplines



Source: Authors own

Recently, however, the development of the theoretical framework of the Spatial Economy has made it possible to expand the research field to Topics 4 and 5 within the context of the agglomeration of industry. In the *Spatial Economy*, which started with Krugman (1991), a theoretical analysis concerning the formation of agglomeration economies has been advanced. The paradigm of this theory is constructed with Fujita, Krugman and Venables (1999). The essence of the theory is that agglomeration economies are determined by the variety of intermediate and/or final goods as the concentration force, and the transportation cost as the dispersion force. The concept of the Spatial Economy is useful to think Topics 4 and 5, because the transportation cost is affected by the transport infrastructure, on the contrary, physical distribution is affected by the transportation cost and/or the transport infrastructure. In fact, the maintenance of the transport infrastructure activates the economic activities in a region by decreasing the transportation costs and improving the transport opportunities. As a result, the volume of the physical distribution and passenger traffic increases, which promotes the agglomeration of industrial growth and yields regional development and urban growth. As a result, the theoretical framework of the Spatial Economy suggests the importance of the relationship between these topics. Regarding Topic 4, few advanced studies have been conducted until now. On the other hand, with regard to Topic 5, there have been some advanced studies, such as that by Martin and Rogers (1995), which is the most famous. Martin and Rogers (1995) theoretically clarified the relationship between public investment (public work) and industrial location within the context of the *Spatial Economy*. Martin and Rogers (1995) succeed in the theoretical explanation of the relationship between a transport infrastructure and an industrial location by distinguishing between inter- and intra-regional ones. After the study by Martin and Rogers (1995), there were no limitations for studies on transport infrastructure, and many studies have treated the relationship between investment in public works, e.g., that between the maintenance of various infrastructures and industrial accumulation. Baldwin et al. (2003) systematically combined the results and reviews of previous studies. Although these studies have pursued the formation mechanism of agglomeration economies from the viewpoint of social overhead capital, the relationship between a transport infrastructure and industrial accumulation and, furthermore, that among physical distribution, transport infrastructure, and industrial accumulation have become important. However, in previous studies, the relationship among these topics is rarely examined. From this aspect, the focus of this paper is on these relationships and the effects of the maintenance of the transport infrastructure and the level of industrial accumulation on the shipping of the freight flow.

3. Effects of Industrial Accumulation and the Improvement of the Transport Infrastructure on Freight Flow in Japan

In this section, the effects of industrial accumulation and transport infrastructure on the freight flow in Japan are examined within the traditional framework of the export equation. Throughout this analysis, facts with regard to the relationship among the industrial accumulation, the transport infrastructure, and the freight flow are revealed.

3.1. Specification of the Estimation Equation and Data Description

The industrial accumulation and transport infrastructure within an area affect the physical distribution of a regional economy. As mentioned in Section 2, it is thought that there is some relation between transport infrastructure, transportation cost, and industrial accumulation. And, we think that that physical distribution is also affected by transport infrastructure, transportation cost, and industrial accumulation. Therefore, the analysis at this point, which unites all aspects of the relationship, includes 1) the physical distribution and transport infrastructure, 2) the physical distribution and industrial accumulation, and 3) the transport infrastructure and industrial accumulation. In this section, we examine the effects of industrial accumulation and transport infrastructure on the shipping of physical distribution to the other region. The paper doesn't carry out a thorough investigation to the relation between transport infrastructure and industrial accumulation.

y is the manufacturing output of each region, w_d is the wage of manufacturing labor in a specific region, p_d is the price of production goods from one's own region to other regions, and p_m is the price of production goods from other regions to one's own. Given these conditions, we set the following production and cost functions:

$$y = A(L_d^{\alpha} q_d^{\beta} q_m^{\gamma})^s \tag{3.1}$$

$$C = w_d L_d + p_d q_d + p_m q_m \tag{3.2}$$

where L_d is the number of the labor force of one's own region, q_d is the amount of production goods from one's own region to other regions, and q_m is the amount of production goods from other regions to one's own. The cost minimum problem is as follows: $\Phi = w_d L_d + p_d q_d + p_m q_m - \lambda\left[y - A(L_d^{\alpha} q_d^{\beta_1} q_m^{\beta_2})^s\right]$. Based on the first-order condition, we obtain the following three equations:

$$y = \frac{p_d q_d}{\lambda \beta s} = \frac{w_d L_d}{\lambda \alpha s} \tag{3.3}$$

$$q_m = \frac{p_d q_d}{\lambda \beta s} \frac{\lambda \gamma s}{p_m} = \frac{\gamma p_d q_d}{\beta p_m} \tag{3.4}$$

$$L_d = \frac{p_d q_d}{\lambda \beta s} \frac{\lambda \alpha s}{w_d} = \frac{\alpha p_d q_d}{\beta w_d} \tag{3.5}$$

Using these equations, we obtain Equation (3.6) below:

$$\begin{aligned} y &= A\left(\frac{\alpha p_d q_d}{\beta w_d}\right)^{\alpha s} q_d \left(\frac{\gamma p_d q_d}{\beta p_m}\right)^{\gamma s} \\ &= A\left(\frac{\alpha p_d}{\beta w_d}\right)^{\alpha s} \left(\frac{\gamma p_d}{\beta p_m}\right)^{\gamma s} q_d^{(\alpha+\beta+\gamma)s} \end{aligned} \tag{3.6}$$

Assuming $\alpha + \beta + \gamma = 1$, we reduce Equation (3.7) with a logarithmic transformation as shown below. μ is the disturbance.

$$\ln q_d = \ln \tilde{A} - \ln \rho_1 \left(\frac{w_d}{p_d}\right) - \ln \rho_2 \left(\frac{p_m}{p_d}\right) + \ln \rho_3 y + \mu \tag{3.7}$$

After we define shift term $\tilde{A}$ as the social overhead capital G_d, we obtain the final specification.

Based on this specification, we examine the effects of the scale economies emerging from industrial accumulation and the transport infrastructure on shipping volume to other domestic regions and overseas regions in 1980, 1990 and 2000 with using the data of the *Logistics Census*, *Census of Manufacturing*, and *Social Overhead Capital* in Japan. The data description is as follows: q_d and q_m were obtained from the *Logistics Census* in 1980, 1990, and 2000. G_d was obtained from the *Social Overhead*

Capital in Japan, and G_d is regarded as the social overhead capital of roads, ports, and airports. Regarding y, value-added data from the *Census of Manufacturing* is used. The meaning of y reveals the scale economies of industrial accumulation. Moreover, q_d, q_m, and y are defined as three types of manufacturing, namely, 1) basic materials industry, 2) processing and assembly industry, and 3) manufacturing related to life. According to these industrial classifications, the data for each region are recounted. The region is based on the Japanese Prefecture and some cities, and there are 51 sample regions. The estimation results are reported in Table 1.

3.2. Estimation Results

3.2.1. The Trend of 1980

Table 1a shows the effects of industrial accumulation and transport infrastructure on the shipping volume to other regions and oversea regions in 1980. As shown in the panel of shipping volume to other regions, 1) in the basic materials industry, the effect of wage shows a significant negative sign, and that of VA, which is the proxy variable of the level of industrial accumulation (scale economies), has a significant positive sign. Investment in ports and airports has a significant positive effect, although investment in roads does not have any effect; 2) in the processing and assembly industry, the effect of wage shows a significant positive sign, and that of VA (scale economies) has a significant positive sign. No effect of investment in roads, ports, and airports was detected as an effect of the transport infrastructure; and 3) in the manufacturing related to life, the effect of wage does not show any significant sign, and that of VA (scale economies) has a significant positive sign. Investment in roads, ports, and airport has a significant positive effect.

As shown in the panel of shipping volume to other regions, 1) in the basic materials industry, no any effect was detected without the significant positive sign of VA (scale economies); 2) in the processing and assembly industry, the effect of wage shows a significant positive sign, and that of VA (scale economies) has a significant positive sign. No effect of investments in roads, ports, and airports was detected as an effect of the transport infrastructure; and 3) in the manufacturing related to life, no effect was detected.

Table 1a: Estimation results in 1980 (Shipping volume to other domestic regions)

Dependent Variable: $ln(q_d)$: Shipping volume to other domestic regions									
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
1	ln Wage-1980	-0.842	(2.920)**	-0.753	(2.570)**	-0.659	(2.380)**	-0.760	(2.85)**
	ln VA-1980	0.779	(9.980)**	0.637	(4.920)**	0.633	(6.980)**	0.774	(10.550)**
	ln Road-1977			0.264	(1.380)				
	ln Port-1977					0.284	(2.910)**		
	ln Airport-1977							0.136	(3.590)**
	Constant	2.896	(3.270)**	1.082	(0.680)	1.249	(1.210)	1.796	(2.050)**
	Adj. R2	0.674		0.680		0.733		0.747	
	Obs.	51		51		44		46	
2	ln Wage-1980	1.212	(3.230)**	1.235	(3.180)**	1.200	(3.000)**	1.239	(3.270)**
	ln VA-1980	0.994	(15.880)**	0.973	(10.260)**	0.995	(13.460)**	0.984	(15.550)**
	ln Road-1977			0.047	(0.290)				
	ln Port-1977					0.021	(0.240)		
	ln Airport-1977							0.001	(0.030)
	Constant	-4.413	(5.736)**	-4.813	(3.130)**	-4.639	(4.400)**	-4.354	(5.750)**
	Adj. R2	0.898		0.896		0.897		0.904	
	Obs.	50		50		43		45	
3	ln Wage-1980	0.161	(0.360)	0.472	(1.040)	0.251	(0.540)	0.220	(0.490)
	ln VA-1980	0.896	(9.050)**	0.529	(2.790)**	0.786	(6.880)**	0.892	(9.020)**
	ln Road-1977			0.482	(2.240)**				
	ln Port-1977					0.195	(2.240)**		
	ln Airport-1977							0.075	(2.200)**
	Constant	-1.135	(3.260)**	-3.238	(2.340)**	-2.130	(1.780)*	-1.720	(1.590)
	Adj. R2	0.784		0.800		0.795		0.806	
	Obs.	51		51		44		46	

Dependent Variable: $ln(q_m)$: Shipping volume to overseas regions									
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
1	ln Wage-1980	-0.889	(0.930)	-1.097	(1.110)	-0.534	(0.510)	-0.635	(0.630)
	ln VA-1980	1.630	(5.840)**	1.948	(4.230)**	1.384	(3.770)**	1.570	(5.240)**
	ln Road-1977			-0.580	(0.870)				
	ln Port-1977					0.378	(1.040)		
	ln Airport-1977							0.221	(1.550)
	Constant	-12.731	(4.010)**	-8.791	(1.590)	-14.304	(3.570)**	-13.959	(4.020)**
	Adj. R2	0.447		0.444		0.4274		0.453	
	Obs.	49		49		42		44	
2	ln Wage-1980	2.914	(2.650)**	2.898	(2.580)**	2.980	(2.440)**	3.068	(2.660)**
	ln VA-1980	1.010	(5.740)**	1.035	(3.760)**	1.032	(4.790)**	0.976	(5.340)**
	ln Road-1977			-0.055	(0.120)				
	ln Port-1977					-0.006	(0.030)		
	ln Airport-1977							-0.017	(0.160)
	Constant	-9.309	(4.700)**	-8.874	(2.150)**	-9.501	(3.230)**	-8.928	(3.950)**
	Adj. R2	0.5951		0.5852		0.5898		0.5942	
	Obs.	44		44		37		39	
3	ln Wage-1980	1.830	(1.040)	1.706	(0.910)	2.001	(1.040)	1.839	(1.010)
	ln VA-1980	0.341	(0.930)	0.478	(0.690)	0.293	(0.660)	0.326	(0.850)
	ln Road-1977			-0.176	(0.240)				
	ln Port-1977					0.030	(0.100)		
	ln Airport-1977							-0.047	(0.688)
	Constant	-0.732	(0.190)	0.011	(0.000)	-0.415	(0.090)	-0.013	(0.997)
	Adj. R2	0.1475		0.1263		0.122		0.122	
	Obs.	42		42		35		37	

3.2.2. The Trend of 1990

Table 1b shows the effects of industrial accumulation and transport infrastructure on the shipping volume to other regions and overseas regions in 1990. As shown in the panel of shipping volume to other regions, 1) in the basic materials industry, the effect of wage shows a significant negative sign, and that of VA (scale economies) has a significant positive sign. Investment in ports and airports has a significant positive effect, although that in roads does not have any effect. This trend is the same as that in 1980; 2) in the processing and assembly industry, only VA (scale economies) has a significant positive sign; and 3) in the manufacturing related to life, the effect of wage does not show any significant sign, and that of VA (scale economies) has a significant positive sign. Investment in ports and airports has a significant positive effect, although that in roads does not have any effect.

As shown in the panel of shipping volume to other regions, 1) in the basic materials industry, only VA (scale economies) has a significant positive sign; 2) in the processing and assembly industry, the effect of wage shows a significant positive sign, and that of VA (scale economies) has a significant positive sign. No effect of investment in roads, ports, and airports was detected as an effect of the transport infrastructure. This trend is the same as that in 1980; and 3) in the manufacturing related to life, no effect was detected. This trend is also the same as that in 1980.

Table 1b: Estimation results in 1990 (Shipping volume to other domestic regions)

Dependent Variable: *ln(q d)* : Shipping volume to other domestic regions									
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
1	ln Wage-1990	-1.805	(3.720)**	-1.529	(2.670)**	-1.451	(2.680)**	-1.617	(3.210)**
	ln VA-1990	1.005	(11.540)**	0.892	(5.900)**	0.923	(8.680)**	0.979	(10.850)**
	ln Road-1987			0.175	(0.910)				
	ln Port-1987					0.185	(1.960)*		
	ln Airport-1987							0.069	(1.860)*
	Constant	1.509	(1.820)*	0.133	(0.080)	-0.152	(0.130)	0.965	(1.060)
	Adj. R2	0.771		0.771		0.790		0.778	
	Obs.	51		51		44		47	
2	ln Wage-1990	0.182	(0.420)	0.233	(0.540)	0.238	(0.520)	0.214	(0.480)
	ln VA-1990	1.157	(19.710)**	1.112	(15.080)**	1.142	(17.350)**	1.154	(18.770)**
	ln Road-1987			0.138	(1.010)			0.023	(0.610)
	ln Port-1987					0.080	(0.940)		
	ln Airport-1987							0.023	(0.610)
	Constant	-6.146	(10.090)**	-7.590	(4.870)**	-7.009	(6.170)**	-6.374	(7.920)**
	Adj. R2	0.927		0.927		0.925		0.926	
	Obs.	51		51		44		47	
3	ln Wage-1990	-0.513	(1.050)	-0.225	(0.460)	-0.349	(0.670)	-0.430	(0.830)
	ln VA-1990	1.182	(10.240)**	0.847	(4.260)**	1.095	(8.130)**	1.167	(9.510)**
	ln Road-1987			0.453	(2.030)**				
	ln Port-1987					0.136	(1.380)		
	ln Airport-1987							0.039	(0.970)
	Constant	-4.520	(3.830)**	-6.985	(4.190)**	-5.248	(3.800)**	-4.782	(3.830)**
	Adj. R2	0.791		0.804		0.795		0.792	
	Obs.	51		51		44		47	

Dependent Variable: *ln(q m)* : Shipping volume to overseas regions									
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
1	ln Wage-1990	0.238	(0.140)	0.198	(0.100)	0.698	(0.350)	0.973	(0.540)
	ln VA-1990	1.139	(3.580)**	1.156	(2.070)**	1.018	(2.590)**	1.002	(3.050)**
	ln Road-1987			-0.027	(0.040)				
	ln Port-1987					0.205	(0.580)		
	ln Airport-1987							0.185	(1.390)
	Constant	-7.771	(2.520)**	-7.552	(1.120)	-9.151	(2.120)**	-8.611	(2.590)**
	Adj. R2	0.333		0.318		0.333		0.339	
	Obs.	49		49		42		45	
2	ln Wage-1990	2.958	(2.060)**	3.062	(2.120)**	3.215	(1.940)*	2.847	(1.880)
	ln VA-1990	1.368	(6.220)**	1.236	(4.480)**	1.291	(4.790)**	1.384	(5.890)**
	ln Road-1987			0.318	(0.800)				
	ln Port-1987					0.032	(0.140)		
	ln Airport-1987							-0.013	(0.140)
	Constant	-15.895	(7.580)**	-18.827	(4.470)**	-15.639	(4.770)**	-15.810	(6.310)**
	Adj. R2	0.741		0.739		0.712		0.737	
	Obs.	42		42		35		38	
3	ln Wage-1990	3.480	(0.710)	1.041	(0.200)	5.981	(1.020)	3.009	(0.530)
	ln VA-1990	-0.089	(0.080)	1.396	(0.910)	-0.751	(0.520)	-0.032	(0.020)
	ln Road-1987			-1.562	(1.340)				
	ln Port-1987					-0.002	(0.000)		
	ln Airport-1987							0.023	(0.110)
	Constant	2.330	(0.230)	7.972	(0.750)	8.618	(0.760)	1.783	(0.160)
	Adj. R2	0.002		0.041		-0.049		-0.070	
	Obs.	23		23		19		21	

3.2.3. The Trend of 2000

Table 1c shows the effects of industrial accumulation and transport infrastructure on the shipping volume to other regions and oversea regions in 2000. As shown in the panel of shipping volume to other regions, 1) in the basic materials industry, the effect of wage shows a significant negative sign, and that of VA (scale economies) has a significant positive sign. Investment in roads, ports, and airports has a significant positive sign. This trend is the same as that in 1980 and 1990; 2) in the processing and assembly industry, the effect of wage shows a significant positive sign, and that of VA (scale economies) has a significant positive sign. Investment in roads has a significant negative sign, although investment in ports and airports does not have any effect; and 3) in the manufacturing related to life, the effect of wage has a significant positive sign, and that of VA (scale economies) has a significant positive sign. Investment in roads and ports has a significant positive sign, although investment in airports does not have any effect.

As shown in the panel of shipping volume to other regions, 1) in the basic materials industry and 2) in the processing and assembly industry, the effect of wage shows a significant positive sign, and that of VA (scale economies) has a significant positive sign. No effect of investment in roads, ports, and airports was detected as an effect of the transport infrastructure; and 3) in the manufacturing related to life, no effect was detected. This trend is also the same as that in 1980 and 1990.

Table 1c: Estimation results in 2000 (Shipping volume to other domestic regions)

Dependent Variable: $ln(q_d)$: Shipping volume to other domestic regions									
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
1	ln Wage-2000	-1.641	(1.890)*	-0.431	(0.490)	-0.916	(0.960)	-1.097	(1.230)
	ln VA-2000	0.897	(8.270)**	0.520	(3.390)**	0.767	(5.890)**	0.840	(7.600)**
	ln Road-1997			0.624	(3.230)**				
	ln Port-1997					0.333	(2.560)**		
	ln Airport-1997							0.110	(2.250)**
	Constant	2.954	(2.550)**	-3.248	(1.480)	-0.746	(0.410)	1.751	(1.400)
	Adj. R2	0.632		0.692		0.674		0.654	
	Obs.	51		51		44		49	
2	ln Wage-2000	0.997	(2.050)**	0.709	(1.420)	1.205	(2.580)**	1.040	(2.160)**
	ln VA-2000	1.111	(16.930)**	1.220	(14.230)**	1.085	(16.500)**	1.084	(17.120)**
	ln Road-1997			-0.242	(1.910)*				
	ln Port-1997					-0.099	(1.240)		
	ln Airport-1997							-0.010	(0.280)
	Constant	-6.998	(9.750)**	-4.374	(2.830)**	-5.707	(5.000)**	-6.642	(7.790)**
	Adj. R2	0.914		0.918		0.929		0.920	
	Obs.	51		51		44		49	
3	ln Wage-2000	1.770	(2.740)**	0.778	(1.300)	1.583	(1.940)*	1.530	(2.070)**
	ln VA-2000	0.453	(4.160)**	0.139	(1.170)	0.392	(3.110)**	0.504	(4.300)**
	ln Road-1997			0.918	(4.290)**				
	ln Port-1997					0.380	(2.320)**		
	ln Airport-1997							0.037	(0.500)
	Constant	1.873	(1.300)	-6.431	(2.800)**	-2.097	(0.980)	1.083	(0.650)
	Adj. R2	0.390		0.553		0.459		0.397	
	Obs.	51		51		44		49	

Dependent Variable: $ln(q_m)$: Shipping volume to overseas regions									
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
1	ln Wage-2000	4.918	(2.330)**	4.523	(1.940)*	5.642	(2.230)**	5.610	(2.470)**
	ln VA-2000	0.472	(1.860)*	0.596	(1.510)	0.327	(0.970)	0.412	(1.540)
	ln Road-1997			-0.204	(0.410)				
	ln Port-1997					0.151	(0.450)		
	ln Airport-1997							0.166	(1.250)
	Constant	-6.049	(2.090)**	-4.028	(0.710)	-7.221	(1.520)	-8.009	(2.400)**
	Adj. R2	0.308		0.295		0.279		0.315	
	Obs.	47		47		41		45	
2	ln Wage-2000	3.443	(2.500)**	3.225	(2.260)**	3.149	(2.040)**	3.444	(2.340)**
	ln VA-2000	1.554	(8.040)**	1.696	(5.890)**	1.678	(7.050)**	1.543	(7.620)**
	ln Road-1997			-0.267	(0.670)				
	ln Port-1997					-0.312	(1.150)		
	ln Airport-1997							-0.005	(0.050)
	Constant	-19.722	(8.140)**	-17.276	(3.930)**	-16.825	(4.440)**	-19.545	(6.680)**
	Adj. R2	0.700		0.697		0.682		0.686	
	Obs.	50		50		43		48	
3	ln Wage-2000	-0.054	(0.030)	-0.294	(0.110)	-0.300	(0.120)	-0.377	(0.160)
	ln VA-2000	0.377	(1.120)	0.339	(0.830)	0.390	(1.060)	0.393	(1.140)
	ln Road-1997			0.146	(0.170)				
	ln Port-1997					0.186	(0.440)		
	ln Airport-1997							0.079	(0.410)
	Constant	-0.474	(0.120)	-1.859	(0.210)	-2.822	(0.480)	-1.110	(0.270)
	Adj. R2	-0.009		-0.056		-0.053		-0.049	
	Obs.	25		25		22		25	

3.3. Summary and Discussion based on Estimation Results

3.3.1. Regional Economy, Transport Infrastructure, and Shipping Volume to Other (Domestic) Regions

Along the time axis of our sample data, we can summarize our estimation results as follows. Regarding shipping volume to other regions, 1) in the basic materials industry, the effect of wage shows a significant negative sign, and that of VA (scale economies) has a significant positive sign in all three periods, namely, 1980, 1990 and 2000. Regarding the effects of transport infrastructure, investment in ports and airports has a significant positive influence on shipping volume to other regions in all three periods. However, investment in roads has a significant positive influence on shipping volume to other regions only in 2000; 2) in the processing and assembly industry, the effect of wage shows a significant positive sign in 1980 and 2000, and that of VA (scale economies) has a significant positive sign in all three periods. Regarding the effects of transport infrastructure, only investment in road has a significant positive sign in 2000; and 3) in the manufacturing related to life, the effect of wage shows a significant positive sign only in 2000, and that of VA (scale economies) has a significant positive sign in all three periods. Regarding the effects of transport infrastructure, investment in roads, ports, and airports has a significant positive influence on shipping volume to other regions in1980. However, only investment in roads has a significant positive influence on shipping volume to other regions in 1990. Investment in roads and ports has a significant positive influence on shipping volume to other regions in 2000.

There is resembling evidence in three types of industry in all three periods as following. Scale economies of industrial accumulation play an important role in each region, and it has increased the shipping volume to the other domestic regions. This evidence suggests that there is a strong relationship between domestic freight flow and scale economies emerging from industrial accumulation. With regard to the effects of transport infrastructure, investment in roads, ports, and airports has increased the shipping volume of the basic materials industry to other domestic regions in all three periods. Almost the same trends are shown in the manufacturing related to life. On the contrary, investment in roads harmed the shipping volume of the processing and assembly industry to other domestic regions in 2000.

3.3.2. Regional Economy, Transport Infrastructure, and Shipping Volume to Overseas Regions

As mentioned in the previous sub-section, we can summarize our estimation results about shipping volume to overseas regions as follows along the time axis of our sample data. Wage and scale economies play an important role in each region, and they have increased the shipping volume to overseas regions. This evidence suggests that both domestic freight flow and international freight flow have a strong relationship with scale economies emerging from industrial accumulation. With regard to the effects of transport infrastructure, no effect of investment in roads, ports, and airports was detected on the three types of industry in all three periods.

There is resembling evidence in three types of industry in all three periods as following. Regarding the basic materials industry and the processing and assembly industry, scale economies of industrial accumulation play an important role in each region, especially in 1980 and 1990, and it has increased the shipping volume to the overseas regions. However, it is understood that this effect has weakened gradually. With regard to the effects of transport infrastructure, no effect of the transport infrastructure was detected on the three types of industry in all three periods. Therefore, our evidence, as an average characteristic of the Japanese transport structure, revealed that the effects of transport infrastructure do not contribute to increasing the shipping volume to overseas regions, although they contribute to increasing the shipping volume to other domestic regions.

4. Transition of Freight Flow Structure in Japan

In this section, the transition of freight flow structure from 1980 to 2000 in Japan is analyzed. Three commodities are focused on in this study, namely, machinery and metal products, ceramic products, and chemical products. We obtain freight data from Japanese *Logistics Census* in 1980, 1990 and 2000. First, the inbound/outbound coefficients T_{ij} of each region are calculated using Equation 4.1.

$$T_{ij} = \min (x_{ij} / Y_i , x_{ij} / Z_j) \qquad (4.1)$$

where x_{ij} is the volume of freight flow from region i to region j, *Yi* is the total outbound volume of region i, and *Zj* is the total inbound volume of region j. The first term in parentheses on the right-hand side indicates the importance of destination region j for region i. Similarly, the second term in parentheses on the right-hand side indicates the importance of generation region i for region j. The inbound/outbound coefficient T_{ij} shows a higher level when the OD pair of region i and region j is important. The number of regions is 51 in this study; therefore, 2,601 inbound/outbound coefficients are calculated for each commodity and year. Moreover, the top 100 pairs of inbound/outbound coefficients are extracted for each commodity and year. The inbound/outbound coefficient is larger in the intra-regional flow than the inter-regional flow. A large number of intra-regional flow pairs, the maximum number is 51, are included in above top 100 pairs. The number of inter-regional pairs is shown in Table 2. The coefficient thresholds that is 100^{th}'s inbound/outbound coefficients are also shown in Table 2.

Table 2: Number of extracted inter-regional pairs and coefficient thresholds

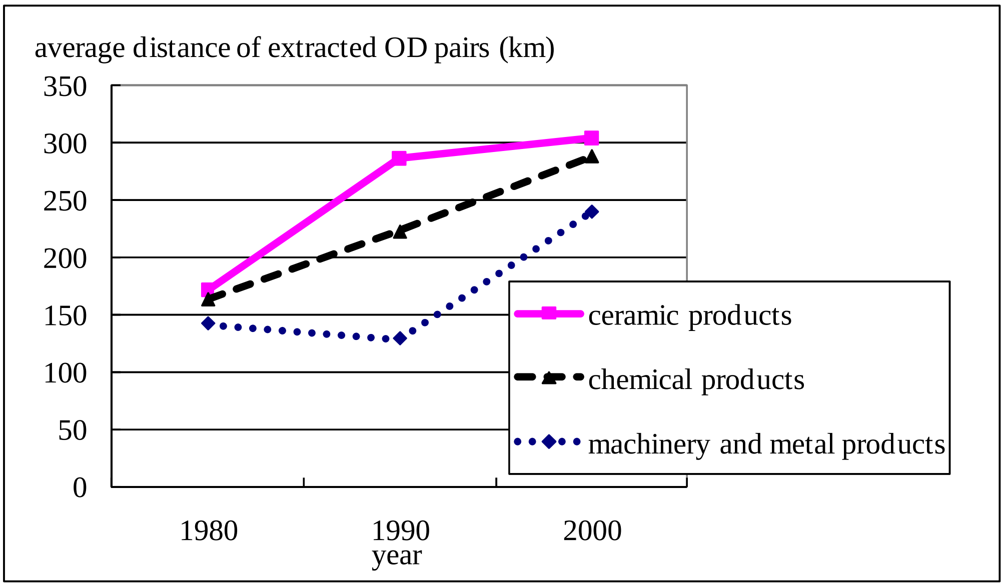
	1980	1990	2000
Machinery and metal products	49	50	50
	0.04513	0.04588	0.04889
Ceramic products	53	59	59
	0.06379	0.05264	0.05292
Chemical products	49	51	53
	0.04895	0.05589	0.04964

Note: The upper cell shows the number of extracted inter-regional pairs; the bottom cell shows the coefficient thresholds.

The number of extracted inter-regional pairs has been increasing for 20 years in all three commodities. Inter-regional freight flow has become more important, and intra-regional freight flow has lost its importance in specific regions. In case the number of extracted inter-regional pairs is 49 which are machinery and metal products in 1980 and chemical products in 1980, that means intra-regional freight flow is important in all 51 regions. On the other hand, since ceramic products in 1990 and 2000 shows 59, there are many regions which have little importance in intra-regional freight flow and inter-regional freight flow is rather important. Regarding the number of extracted inter-regional pairs has been increasing, it is speculated that the location of industry has been agglomerated supported by the transport infrastructure improvement.

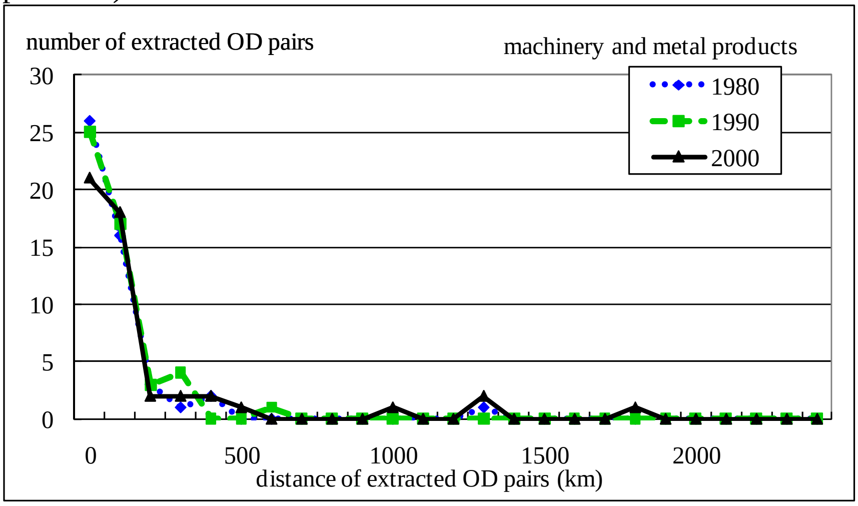
The transitions of average distances of extracted inter-regional OD pairs are shown in Figure 5. The average distances have been getting longer except in case of machinery and metal products in 1980's. It is speculated that improvements in inter-regional transport infrastructure has contributed to the transition. Each industry has been agglomerated the particular regions and the cargo has been transported longer than before.

Figure 5: Average distances of extracted inter-regional OD pairs



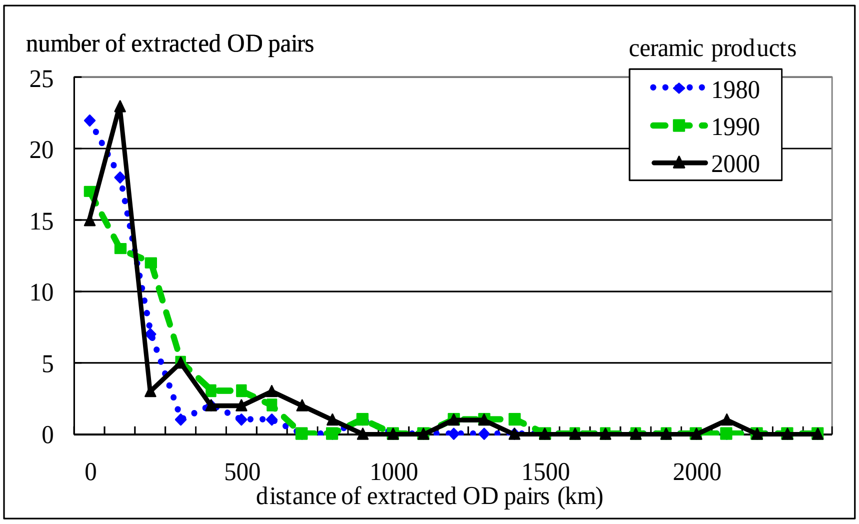
The numbers of extracted OD pairs by distance zone in each commodity are shown in Figure 6. In the case of machinery and metal products, the number of OD pairs which are within 100 km decreased from 26 in 1980 to 21 in 2000. On the other hand, that in the 100-200 km zone increased from 16 in 1980 to 18 in 2000. In the short-distance zone, it is speculated that the machinery and metal products industry has agglomerated in the period. In the long-distance zone, only one OD pair longer than 500 km is extracted in each 1980 and 1990; however, the number increased to 5 in 2000. That is further evidence of the contribution of improvements in the transport infrastructure to agglomeration of the industry.

Figure 6a: Number of extracted OD pairs by distance zone (machinery and metal products)



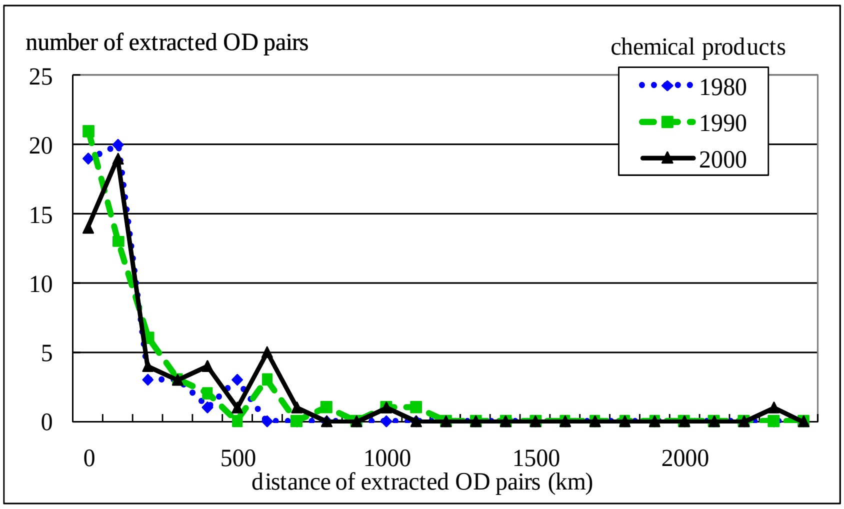
In the case of ceramic products, the number of OD pairs which are within 100 km decreased from 22 in 1980 to 15 in 2000. On the other hand, that in the 100-200 km zone increased from 18 in 1980 to 23 in 2000. In the short-distance zone, it is speculated that the ceramic products industry has agglomerated in the period, as in the case of the machinery and metal products industry. In the long-distance zone, the number of OD pairs which are longer than 500 km increased from 3 in 1980 to 11 in 2000. That is further evidence of the contribution of improvements in the transport infrastructure to agglomeration of the industry.

Figure 6b Number of extracted OD pairs by distance zone (ceramic products)



In the case of chemical products, no obvious trend can be found from the results, especially in the short-distance zone. In the long-distance zone, the number of OD pairs which are longer than 500 km increased from 3 in 1980 to 9 in 2000. That is evidence of the contribution of improvement in the transport infrastructure to agglomeration of the industry.

Figure 6c Number of extracted OD pairs by distance zone (chemical products)



This section presents a collateral evidence of the conclusion in previous section. Since average distance of major inter-regional OD pairs has been getting longer, transport infrastructure seems to have a positive influence on shipping volume to other regions. And framework of discussion is expanded to the relationship between transport infrastructure and agglomeration of the industry.

5. Concluding Remarks

This paper examined Japanese domestic distribution structure from the relation between industrial accumulation and transport infrastructure in order to reveal the structure of freight flow and its changes from 1980 to 2000 in Japan.

As a first step, we examined the effects of the scale economies emerging from industrial accumulation and the transport infrastructure on shipping volume to other domestic regions and overseas regions in 1980, 1990 and 2000 with using the data of the Logistics Census, Census of Manufacturing, and Social Overhead Capital in Japan. The estimation results revealed that scale economies of industrial accumulation play an important role in each region, and it has increased the shipping volume to the other domestic regions and overseas regions. This evidence suggests that there is a strong relationship between freight flow and scale economies emerging from industrial accumulation. With regard to the effects of transport infrastructure, investment in roads, ports, and airports has increased the shipping volume of the basic materials industry to other domestic regions in all three periods; however, no effect of the transport infrastructure was detected on the three types of industry to overseas regions in all three periods. Therefore, our evidence, as an average characteristic of the Japanese transport infrastructure, revealed that the effects of transport infrastructure do not contribute to increasing the shipping volume to overseas regions, although they contribute to increasing the shipping volume to other domestic regions.

As a second step, following the results of this empirical work, we demonstrated the transition of Japanese domestic freight flow structure in 1980, 1990 and 2000 with using the data of the Logistics Census in Japan. To calculate the inbound/outbound coefficients of each region, we revealed that average distance of major inter-regional OD pairs has been getting longer. These evidences showed that transport infrastructure has a positive influence on shipping volume to other regions and the transport infrastructure improvement has contributed to agglomeration of the industry.

Based on our analysis, as an average characteristic of the Japanese transport infrastructure, it is understand that improvements in the transport infrastructure, i.e., social overhead capital, promoted the freight flow domestically but not internationally. However, this suggests that transport infrastructure on the shipping to other domestic regions is maintained enough, and this has contributed to reorganization (relocation) of industrial accumulation in Japan. In the future, this domestic transport infrastructure should tie to the international transportation system.

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