□ 論 文 □

Development of Nonsurvey Method of Input-Output Analysis for Production and Attraction Freight Flow Estimation According to Region

지역별 발생집중 화물량 추정을 위한 산업연관분석의 Nonsurvey법 개발에 관한 연구

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목 차

요 약

교통계획의 수립은 사람과 화물의 이동상태에 대한 파악으로부터 시작되며, 화물이동상태를 파악하기 위한 가장 기본적인 데이터는 지역별 발생집중 화물량일 것이다. 이러한 지역별 발생집중 화물량의 추계방법중 추계의 간편성과 경제상황변화의 반영이 용이하다는 점에서, 최근 학자들의 상당한 주목을 받으며 연구되고 있는 것이 産業聯關分析을 응용한 물류해석방법이다. 그러나 이방법은 대상지역의 산업연관표를 기본 data로 하기때문에 해당지역의 산업연관표의 존재여부에 따라서 그 적용범위가 제한된다. 이러한 문제점을 해결하기 위해서 연구되고 있는 방법이 Nonsurvey법이다. Nonsurvey법은 대지역의 산업연관표로부터 그 지역에 포함된 소지역의 산업연관표를 여러 가지 보조적인 데이터를 이용해서 간접적으로 추계하는 방법이다.

본 연구에서는 이러한 Nonsurvey법의 하나로서, 대지역의 산업연관표와 地域分割된 각 소지역의 산업부문별 생산량만을 이용해서 각 소지역의 발생집중화물량을 추계하는 방법을 제안했다. 그리고 日本의 近畿(긴키, Kinki)地域과 이에 속하는 4부현을 대상으로 본 연구의 방법으로 추계된 移出入量과 실제의 産業聯關表상의 移出入量을 비교·분석함으로써 본 연구의 방법에 대한 검증을 실시했다. 본 연구에서 제안한 지역별 발생집중 화물량 추계방법의 특징은 다음과 같다. 첫째, 대지역내 각 소지역간의 移出入量이 分配係數라고 하는 産業聯關表의 행방향의 합에 대한 비율을 사용함으로서 간단히 추계가능하다. 둘째, 추계된 소지역의 産業聯關表는 대지역에 대한 시스템전체의 整合性이 유지된다. 셋째, 分割되는 소지역의 數에 관계없이 각 소지역의 移出入量에 대한 추계가 가능하다.

I. Introduction

To develop a transportation plan, one has to understand the movement of the persons and freight which are the subject of the traffic generation. Data obtained from regional Production and Attraction Freight Flow (PAFF) analysis is generally used to understand the freight movement in a given region. Three methods have been used primarily in the past to estimate PAFF within a specific region.

The first method employs a neoclassic economic aggregate model which is based on a variety of economic indicators in the pertinent region. However, this method uniformly applies the parameters that express the relationship between the general economic indicator of the independent variable and the PAFF of the subordinate variable in the model equation. Therefore, it is difficult for the existing model to reflect any future changes in the economic frame and/or industrial structure.

The second method determines the amount of freight by surveying logistics agents. The objects of the survey are transportation companies that actually take charge of the freight transportation, and shipping offices where the demand for the freight transportation is generated. There are two data collection methods used it' s conduct the survey, complete enumeration and partial enumeration. Complete enumeration is labor-, time, and cost-intensive. Consequently, partial enumeration is generally used whereby a sample is extracted and assumed to reflect the entire population. However, it is difficult to obtain a high degree of accuracy using this method due to the complex and non-uniform attributes of the shipper, freight lots and transportation forms, freight articles, and freight patterns.

The third method updates the input-output tables (I-O tables) of each target region using an economic frame in the future and converting to units of weight (ton). This method is seperior to the above methods in that any future changes in the economic frame and/or industrial structure can be reflected. In addition, this method can be handled more easily than the above methods. However, the logistics movement estimation is based on the I-O table of the object region. Therefore, it is not possible to use this method for a region where the I-O table is not given.

This study considers an alternative nonsurvey method that indirectly converts the I-O table of a large region into I-O tables of its component small regions[1] using supplementary data. Nonsurvey method has been reviewed by Round (1983), Richardson (1985), and Ando (1989). Sasaki et al. (1983) proposed a method that combines the industrial system of a small region, the industry-location quotient of the small region, and the RAS method, which mechanically revises the input coefficients in the time direction applied widely to small regions. Previous nonsurvey methods assume that the industrial structure of the large region and the small regions are closely related.

Previous nonsurvey methods require improvement. Until now, nonsurvey studies have introduced input coefficients as an index to provide an industrial relation. However, the extent of the relationship between the input coefficients of the large region and the small regions is not clear. Second, the correspondence of the entire system ($X_{ij} = \sum_r x_{ij}^r$)[2] between the total production of the small regions and the production of the large region has not been considered carefully. In addition, these nonsurvey methods

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1) This study is performed using the regional index of a large and a small region.

2) x_{ij}^R (amount of input from section *i* to j in large region R) is a total of x^r_{ij} (amount of input from section *i* to *j* in small region r where the large region was divided). If this condition is met for all cells of the I-O table, it can be said that the correspondence of the I-O table is maintained.

estimate only two items with respect to the flow[3] (outflow and inflow) in various small regions. Moreover, the number of regions is limited to two or three and may not be applicable to additional regions.

The study proposes a nonsurvey method whereby the PAFF of each small region can be estimated with a good correspondence between the large region and the divided small regions. This study uses input coefficients and sharing coefficients whereas previous nonsurvey methods introduced input coefficients and location quotients. Sharing coefficients are introduced to show to which industry a product is distributed. To prove the validity of sharing coefficients, a comparative analysis of input coefficients and sharing coefficients is performed. The proposed method is applied to the Kinki region in Japan (Kinki) which is divided into five small regions, and the total flow and PAFF are estimated. Finally, the total flow estimations are compared with the amount of flow of the I-O tables for the 1990 term and the results are reported.

II. Estimation assumptions

2.1 General assumptions of I-O analysis.

To estimate the PAFF of a small region using I-O analysis the following assumptions are introduced.

- The goods are measured over a set period of term usually by a yearly base.
- The goods produced by each industry are used as intermediate goods demand or final goods demand.
- Each industry produces a single good at one to one correspondence ratio (assumption of non-uniting production).
- Only one method (technology) for production exists in each industrial section (assumption of one industry conducting one activity).
- The input coefficients are fixed regardless of the amount of production, as long as the production technology of each industry is not changed (fixed input coefficients assumption).

These assumptions might not be strictly satisfied. For example, some goods must be produced by one industry and the production methods will vary slightly depending on the production technology. To allow comparision with similar studies, these assumptions will be strictly adapted in the study .

2.2 Estimate assumptions.

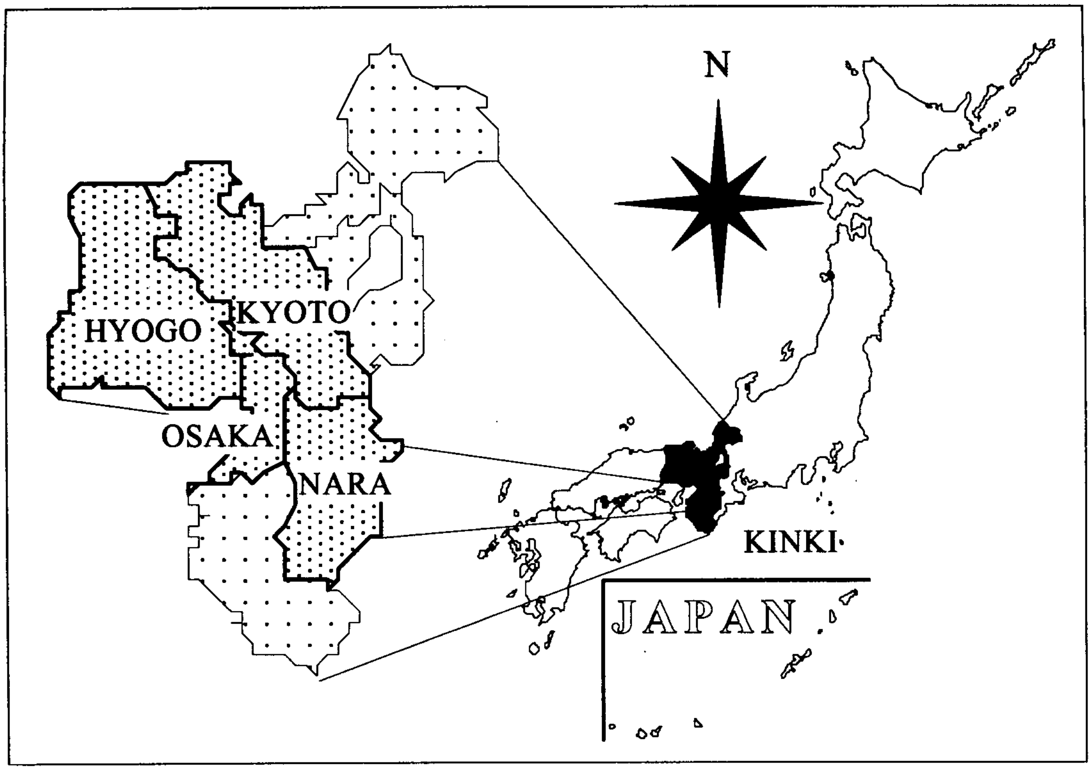
2.2.1 Regional range of study and integration of industrial sections.

This study uses 1990 data of the nation, Kinki region and five small regions of Kinki in Japan (Figure 1). Five small regions are Osaka Pref. (Prefecture), Kyoto Pref., Hyogo Pref., and Nara Pref., and the rest prefectures of Kinki region. This study uses the I-O tables of these regions and of the nation. The prefecture tables are generally based on the Bulletin (bulletin of I-O table of the nation)[4].

Many industrial sections have been united in the prefecture tables. The intermediate demand section consistes of 91 categories for the nation, 91 in the Bulletin, 46 in Kinki, 91 in Osaka Pref., 90 in Kyoto Pref., 94 for Hyougo Pref., and 91 in Nara Pref. In this study, the intermediate demand section has been intergated into 44 sections as shown in Table 1. These are based on the 46 sections of

3) Flow (outflow and inflow) refers to goods movement generated from a given region. Outflow means export and shipping-out. Inflow means import and shipping-in. The export and import refer to international movement. Shipping (shipping-out and shipping-in) refers to intranational movement.

4) The Bulletin is a subsidiary I-O table of the complete I-O table of the nation and is announced earlier than the complete table.



〈Figure 1〉 Study area

the I-O table of the Kinki region. In addition, steel products and nonferrous metals products have been integrated into steel nonferrous metal products, 17th intermediate demand. Furthermore, public civil engineering works and private civil engineering works have been integrated into civil engineering works, 29th intermediate demand.

The fixed gross capital formation of public and private sectors has been integrated into one in the final demand section. As the export, shipping-out, import, and shipping-in sections in regions, these are defined as the following: export, shipping-out, total of export and shipping-out, import, shipping-in and total of import and shipping-in.

2.2.2 Basic I-O table.

The I-O tables used in this study are based on the form shown in Table 2. The expression of the sign of each section corresponds to the notation in Table 2. The expressions for the shipping-out and the shipping-in sections are different from the standard I-O table, to distinguish between flow in small regions in a region and that between small regions and other regions.

2.2.3 Input coefficients and sharing coefficients

Input coefficient (a_{ij}) is the ratio between each industrial product (x_{ij}) and the total (X_j) in column j, defined as eq. [1]. It is defined as a coefficient by which the product composition is input for each industry. This shows the production technology of each industry.

$$a_{ij} = x_{ij} / X_j \qquad [1]$$

where, a_{ij} : Input coefficients.

x_{ij} : Each industrial product.

X_j : the total of x_{ij} in column

〈Table 1〉 Two-digit classifications of input-output table used in this study.

	Intermediate demand section		
1	Agriculture	37	Communication and broadcasting
2	Forestry	38	Official duties
3	Fishing	39	Education and research
4	Mining	40	Medical treatment, insurance, and social security
5	Food and tobacco	41	Other public service
6	Fiber goods	42	Service to office
7	Wood and products	43	Service to individual
8	Furniture and equipment goods	44	Uncertain classification and others
9	Pulp, paper, and paper processing goods	45	Total of intermediate demand section
10	Newspaper, printing, and publishing		Value added section
11	Chemical industrial products	46	Consumption expenditure of outside households (line)
12	Oil and coal products	47	Compensation of employees
13	Plastic products	48	Operating surplus
14	Rubber products	49	Capital consumption
15	Leather and products	50	Indirect tax (except tariff)
16	Ceramic products	51	Current subsidies(deduction)
17	Steel and nonferrous metals products	52	Total of value added section
18	Metallic goods	53	Gross production(gross output in region)
19	General machinery		The final demand section
20	Official machinery	46	Consumption expenditure of outside households (row)
21	Electric machine for public welfare	47	Private consumption expenditure
22	Electronic machinery	48	General government consumption expenditure
23	Other electrical machinery	49	Fixed gross capital formation in region
24	Automobiles	50	Inventory
25	Other transport equipment	51	Total of final demand sections in region
26	Precision machinery	52	Total of demand in region
27	Other manufacturing	53	Export
28	Construction	54	Shipping-out
29	Civil engineering works	55	Total of export and shipping out
30	Electric power	56	Total of final demand
31	Gas and heat supply	57	Demand total
32	Water service and waste processing	58	Import
33	Commerce	59	Shipping-in
34	Finance and insurance	60	Total of import and shipping in
35	Real estate	61	Total of final demand
36	Transportation	62	Gross production(gross output in region)

〈Table 2〉 Basic form and sign definition of input-output table.

		Inter-mediate demand		Final demand in small region		Shipping-out		Export	Shipping-in		Import	Amount of production
			Sum		Sum	To same large region	To other large region		From same large region	From other large region		
Intermediate demand		x_{ij}	X_{it}	f_{ij}	F_i	$T_i^{r\rightarrow}$	$S_i^{r\rightarrow}$	E_i	$T_i^{\rightarrow r}$	$S_i^{\rightarrow r}$	M_i	X_i
	Sum	X_{tj}	X_{tt}	F_j	F_t	$T^{r\rightarrow}$	$S^{r\rightarrow}$	E_t	$T^{\rightarrow r}$	$S^{\rightarrow r}$	M_t	X_t
Value added		v_{ij}	V_i									
	Sum	V_j	V_t									
Amount of production		X_j	X_t									

Sharing coefficient (h_{ij}) is the ratio between each industrial product (x_{ij}) and the total (X_i) of x_{ij} in row i and is given by eq. [2]. The sharing coefficient defines how one unit of a product by a industry is distributed to another industry as either a raw material or finished product. It is believed that the sharing coefficients represent the distribution route of the product.

$$h_{ij} = x_{ij} / X_i \qquad [2]$$

where, h_{ij} : Sharing coefficients.

X_i : the total of x_{ij} in row

2.2.4 Regional supply and demand

The amount and direction of product flow in a certain region is dependent upon the amount of supply and demand for that product in the region. If supply is larger than demand for a product in a region, outflow is generated from the region. Conversely, if the amount of demand in the region is greater than supply, inflow is generated. Thus, product flow activity is performed by transportation which entails a cost. The proposed method minimizes transportation costs assuming that transportation cost and distance are directly proportional and that the transportation distance of the internal product flow within a region is shorter than that of any external flow between the region and another region. Therefore, the demand for a product in a certain region is supplied by the amount produced in that region. Thus, any demand or supply surplus flows and outflows.

III. Sharing coefficients

In many studies, only input coefficients have been used and their stability is generally accepted. In this study, sharing coefficients have been introduced to represent the relationship between industries. This chapter describes the relationship between input coefficients and sharing coefficients, and considers the stability of the sharing coefficients.

The relationship between a_{ij} and h_{ij}, x_{ij} is expressed by eq's. [3] and [4].

$$x_{ij} = a_{ij} \times X_j \qquad [3]$$

$$x_{ij} = h_{ij} \times X_i \qquad [4]$$

If these equations are expressed by the matrix shown in eq's. [5] and [6], they can be rearranged as shown in eq. [7].

$$[x_{ij}] = A\hat{X} \qquad [5]$$

$$[x_{ij}] = \hat{X}H \qquad [6]$$

$$A\hat{X} = \hat{X}H \qquad [7]$$

where, A : Input coefficients matrix.

H : Sharing coefficients matrix.

$\hat{X}$: Diagonal matrix containing elements X_i of vector X representing amount of production.

If the input coefficients are fixed for the same production vector (X), it is believed that the sharing coefficients are used in fixed.

Until now, I-O analysis has been based primarily on input coefficients. This phenomenon is related to the assumption of the fixed input coefficients in the section 2.1 and is based on the following statement: "Because the input coefficients used by I-O analysis show a technological structure unique to each industry in a given region. Furthermore, technology does not differ remarkably between regions, this input coefficients are stable." (Niida, H. 1992)

This statement is based on the assumption of the technology of industry, at making I-O table. Namely, when certain commodities are produced, it is assumed that the composition of industry which supply them is fixed. However, the technology in this assumption is to represent how and at what composition the products from other industry are combined when a certain industry does the production activity. Therefore, technology is input coefficient from the side of industry to which the goods are delivered. In contrast, technology is sharing coefficient from the side of industry which distributes the goods.

The input coefficients remain stable as long as the technology does not change because:

- Physical input coefficients (a_{ij}) must not change rapidly even if the price of the goods changes.
- Input coefficients (a_{ij}) must not change rapidly even if the demand for the goods changes.

In contrast, the sharing coefficients remain stable as long as the technology does not change because:

- Sharing coefficients (h_{ij}) of a material base in the I-O tables must not change rapidly, even if the price of the goods changes;
- Sharing coefficients (h_{ij}) must not change rapidly even if the composition of the value added of the goods (wage, operating surplus, and indirect taxes, etc.) changes.

Stability may be obtainable for not only the input coefficients but also the sharing coefficients based on these above assumption.

The majority of the current I-O analysis has been performed using input coefficients. However, because the input coefficients are ratios of column total (X_j) in the I-O table, I-O analysis related to the final demand sections may be difficult to relate between the various industries For example, it may be difficult represent the relationship between the value added sections and the final demand sections when the production (X_i) is unknown.

This issue can be solved by using the sharing coefficients as in eq. [8].

$$D = (I-A)(I-H')^{-1}V' \quad [8]$$

where, D : Final demand vector.

V′ : Transposed vector of value added.

H′ : Transposed matrix of sharing coefficient matrix.

When the sharing coefficients are used, the analysis of the cost change of all industries in a region as a result of the additional cost generation of a certain industry is also possible. That is, when a new cost is generated in a certain industry, the cost is distributed to all industries in the region associated with production. The cost distributed in this way is a repercussion cost newly generated in each industry. The repercussion cost of these industries is self-perpetrating for all industries in the regions. The total of all repercussion costs generated by this process and the first generation cost is the total generation cost in a given region. We can calculate this using the sharing coefficients in eq. [9].

$$C_e = [I-H']^{-1}C \quad [9]$$

where, C_e : Vector of Total cost vector in region which includes repercussion cost.

C : Cost vector given first.

Ⅳ. Comparative analysis of input and sharing coefficients between regions

In chapter 3, we introduced the possibility of using sharing coefficients in I-O analysis. In order to estimate the regional PAFF using input coefficients and sharing coefficients, it is necessary to clarify how closely related the input coefficients and sharing coefficients are between a large and small region. The relationship of each coefficient between regions is confirmed by conducting a comparative analysis using the average and deviation, and by conducting a correlation analysis. These coefficients represent only the intermediate demand sections (first quadrant of I-O table). However, by applying the same concept to the final demand section (second quadrant of I-O table) and the value added section (third quadrant of I-O table), we can define similar coefficients in order to perform comparative analysis. The coefficients in eq's. [10]~[13] are defined in this study as,

$$av_{ij} = v_{ij} / X_j \quad [10]$$

$$af_{ij} = f_{ij} / F_j \quad [11]$$

$$hf_{ij} = f_{ij} / X_i \quad [12]$$

$$hv_{ij} = v_{ij} / V_i \quad [13]$$

where, f_{ij} : Final demand.

F_j : Column total of final demand according to sections.

v_{ij} : Value added.

V_i : Row total of value added according to sections.

4.1 Comparative analysis using average and deviation of comparative value.

4.1.1 Calculation of comparative value.

The input coefficients, sharing coefficients and coefficients given by eq's. [10]~[13] are compared by the same method. In order to simplify the notation of numerical formula, the comparative element c^k_{ij} defined in Table 3 is used.

This comparative analysis is performed for the following regions: the nation, the Bulletin, Kinki, Osaka Pref., Kyoto Pref., Hyougo Pref., and Nara Pref. The comparative value L^k_{ij} of a small region to a large region is calculated by eq. [14]. The logarithm of c^k_{ij} and the calculated L^k_{ij} are introduced in order to reduce the analysis error to the scale of the amount of production.

$$L^k_{ij} = \log|c^{k(r)}_{ij}| / \log|c^{k(R)}_{ij}| \quad [14]$$

if, $c^{k(r)}_{ij} = c^{k(R)}_{ij} = 0$ or $c^{k(r)}_{ij} = c^{k(R)}_{ij} = 1$

then $L^k_{ij} = 1$

if, $c^{k(r)}_{ij} \neq 0$ and $c^{k(R)}_{ij} = 0$

then exclude from calculation.

〈Table 3〉 Definition of comparative element.

	Intermediate demand	Sum	Final demand	Sum	Amount of Production
Intermediate demand	x_{ij} $\cdot k=1 : c^k_{ij} = a_{ij}$ $\cdot k=2 : c^k_{ij} = h_{ij}$	$X_{i●}$	f_{ij} $\cdot k=4 : c^k_{ij} = af_{ij}$ $\cdot k=6 : c^k_{ij} = hf_{ij}$	F_i	X_i
Sum	$X_{●j}$	$X_{●●}$	F_j		X
Value added	v_{ij} $\cdot k=3 : c^k_{ij} = av_{ij}$ $\cdot k=5 : c^k_{ij} = hv_{ij}$	V_i	$\cdot c^k_{ij}(R)$:coefficients of large region $\cdot c^k_{ij}(r)$:coefficients of small region		
Sum	V_j				
Amount of Production	X_j	X			

●: represents total of only intermediate sections.

if, $c_{ij}^{k(r)} = 0$ and $c_{ij}^{k(R)} \neq 0$

then $L_{ij}^{k} = 0$

if, only one of $c_{ij}^{k(r)}$ and $c_{ij}^{k(R)}$ is Minus or 1

then exclude from calculation.

4.1.2 Average, standard deviation, and deviation from 1 of comparative value.

Each L_{ij}^{k} becomes mutually independent as opposed to a set with a certain probability distribution. Therefore, comparative analysis of each coefficient between two regions is performed for the average (M^k) and the standard deviation (SM^k) of L_{ij}^{k}. When the average of L_{ij}^{k} approaches 1 and SM^k becomes small, the c_{ij}^{k} in two regions becomes approximately equal, and the relationship of each coefficient between regions is thought to be high.

To confirm how far L_{ij}^{k} deviates from 1, the deviation from 1 ($S1^k$) is calculated. If $S1^k$ is large, the deviation in c_{ij}^{k} between two regions is high.

$$M^k = \left(\sum_i \sum_j L_{ij}^{k} \right) / N \qquad [15]$$

$$SM^k = \sqrt{\left(\sum_i \sum_j (L_{ij}^{k} - M^k)^2 \right) / (N-1)} \qquad [16]$$

$$S1^k = \sqrt{\left(\sum_i \sum_j (L_{ij}^{k} - 1)^2 \right) / (N-1)} \qquad [17]$$

where, N : Frequency of L^{k}_{ij} included in calculation.

k : Division of coefficient.

4.1.3 Import, export and shipping analysis considerations

When a large region is divided into small regions, the freight flow in the small regions becomes that shown in Figure 2. T_i^r is included in the intermediate demand in the large region (*R*), but is only included in the flow of a small region (*r*) after the large region is divided. The flow in small region (*r*) is the total of T_i^r and S_i^r. The ratios of T_i^r and X_i, and , S_i^r and X_i, produce very high results in the I-O table.

We believe that the flow sections have a large influence on the comparative analysis of each coefficient between regions especially in the calculation of the sharing coefficients, the ratio of x_{ij} and the row total X_i. Therefore, in order to compare the flow sections and the other sections, we perform a comparative analysis betweenjegions for the export, import, and shipping sections, represented by the flow sections of the I-O tables. at_{ij} and ht_{ij} are defined in eq's. [18] and [19], and the comparative analysis methods described in sections 4.1.1 and 4.1.2 are applied.

$$at_{ij} = t_{ij} \ / \ T_j \qquad [18]$$

$$ht_{ij} = t_{ij} \ / \ X_i \qquad [19]$$

where, t_{ij} : Export and import and shipping.

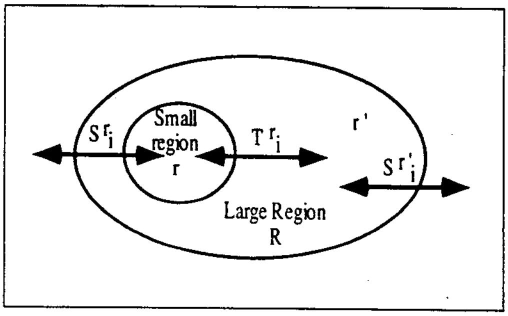
T_j : Column total of t_{ij} according to section.

To confirm how much influence t_{ij} exerts on the comparative analysis of the sharing coefficients, the ratio of x_{ij} and the column total X_i (given by eq's. [20] and [21]) are compared, where t_{ij} is excluded from X_i.

$$h_{ij}^{-t} = x_{ij} \ / \ (X_i - T_i) \qquad [20]$$

$$hf_{ij}^{-t} = f_{ij} \ / \ (X_i - T_i) \qquad [21]$$

where, T_i : Row total of t_{ij} according to section.



〈Figure 2〉 Freight flow after large region was divided.

4.1.4 Results of comparative analysis and considerations.

The relationship between the results of the industrial structure of a large region and small regions are considered based on the comparative analysis methods used in this study (Table4). M^k between the nation and Kinki approaches 1; SM^k and $S1^k$ are also small when compared to other regions results. Therefore, the industrial relation structure of the nation and Kinki is similar. However, the industrial relation structure between the nation and each prefecture, and between Kinki and each prefecture differed somewhat when compared to the relationship between the nation and Kinki.

A comparison of the input coefficients between regions shows that the majority of M^k values approach 1 and the deviation is also small, thus confirming that a very close

〈Table 4〉 Result of Comparatire analysis

Index		Ratio to total of ROW (input coefficient, etc.)			Ratio to total of LINE (sharing coefficient, etc.)						
					Include export, import and shipping				Exclude export, import and shipping		
		All k=1,3	Inter-mediate demand k=1	Value added k=3	All k=2,6	Inter-mediate demand k=2	Final demand k=6	Export, import and shipping	All k=2,6	Inter-mediate demand k=2	Final demand k=6
Kinki / WN*	M	1.002	1.002	1.006	1.029	1.009	1.119	1.088	1.010	1.012	0.995
	SM	0.047	0.045	0.057	1.441	0.242	2.180	2.002	0.114	0.115	0.113
	S1	0.047	0.045	0.057	1.441	0.242	2.183	2.004	0.114	0.115	0.114
Osaka / WN*	M	1.015	1.009	1.047	1.014	1.024	1.190	0.923	1.040	1.041	1.041
	SM	0.151	0.153	0.137	2.604	0.672	1.991	1.468	0.294	0.292	0.335
	S1	0.152	0.153	0.145	2.604	0.673	2.000	1.470	0.297	0.295	0.338
Kyoto / WN*	M	1.008	1.007	1.015	1.067	0.975	1.185	0.885	1.026	1.026	1.030
	SM	0.143	0.134	0.182	2.724	1.119	1.800	0.999	0.212	0.218	0.183
	S1	0.143	0.134	0.183	2.725	1.119	1.809	1.006	0.214	0.220	0.185
Hyougo / WN	M	1.008	1.008	1.002	0.963	1.000	1.338	0.977	1.021	1.027	0.979
	SM	0.081	0.079	0.089	3.530	0.472	4.149	2.838	0.159	0.163	0.130
	S1	0.081	0.080	0.089	3.531	0.472	4.162	2.838	0.160	0.166	0.131
Nara / WN*	M	1.019	1.020	1.010	1.101	1.008	0.928	1.303	1.055	1.065	0.997
	SM	0.119	0.112	0.150	4.020	1.240	3.579	5.551	0.288	0.284	0.330
	S1	0.120	0.114	0.150	4.021	1.240	3.579	5.559	0.293	0.291	0.330
Kinki / Bulleti	M	1.002	1.001	1.002	1.023	1.007	1.122	0.995	1.008	1.010	0.995
	SM	0.067	0.066	0.072	1.351	0.245	2.181	0.183	0.122	0.121	0.138
	S1	0.067	0.066	0.072	1.351	0.245	2.184	0.183	0.122	0.122	0.139
Osaka / Bulleti	M	1.013	1.008	1.044	1.005	1.022	1.180	1.048	1.038	1.039	1.037
	SM	0.153	0.155	0.136	2.518	0.666	1.915	0.544	0.292	0.291	0.323
	S1	0.153	0.155	0.143	2.518	0.667	1.923	0.546	0.295	0.294	0.325
Kyoto / Bulleti	M	1.006	1.005	1.009	1.044	0.974	1.177	1.052	1.023	1.024	1.027
	SM	0.134	0.127	0.171	2.709	1.133	1.722	0.406	0.207	0.213	0.176
	S1	0.134	0.127	0.171	2.710	1.134	1.732	0.410	0.208	0.214	0.178
Hyougo / Bulleti	M	1.005	1.007	0.998	0.963	0.998	1.339	0.969	1.018	1.024	0.980
	SM	0.076	0.073	0.094	3.482	0.475	4.156	0.208	0.158	0.160	0.152
	S1	0.077	0.073	0.094	3.482	0.475	4.169	0.210	0.160	0.162	0.153
Nara / Bulleti	M	1.017	1.019	1.006	1.093	1.008	0.936	0.000	1.052	1.062	0.995
	SM	0.120	0.114	0.148	3.948	1.274	3.471	0.000	0.281	0.277	0.328
	S1	0.121	0.116	0.148	3.949	1.274	3.472	0.000	0.286	0.283	0.328
Osaka / Kinki	M	1.013	1.007	1.041	0.994	1.032	0.943	0.828	1.028	1.027	1.043
	SM	0.145	0.148	0.127	2.799	0.433	0.927	4.431	0.216	0.202	0.312
	S1	0.146	0.148	0.134	2.799	0.435	0.929	4.435	0.217	0.204	0.315
Kyoto / Kinki	M	1.007	1.006	1.009	0.938	0.947	0.953	0.864	1.023	1.020	1.050
	SM	0.139	0.133	0.169	2.168	1.162	1.417	0.895	0.217	0.216	0.242
	S1	0.139	0.133	0.169	2.168	1.164	1.418	0.905	0.219	0.217	0.247
Hyougo / Kinki	M	1.006	1.007	0.996	1.013	0.987	0.908	0.899	1.012	1.015	0.992
	SM	0.077	0.078	0.069	1.531	0.365	1.973	1.271	0.126	0.126	0.136
	S1	0.077	0.078	0.069	1.531	0.365	1.975	1.275	0.127	0.127	0.136
Nara / Kinki	M	1.018	1.020	1.004	0.891	0.966	0.899	0.785	1.048	1.054	1.009
	SM	0.112	0.106	0.137	2.620	0.936	1.064	1.540	0.245	0.227	0.359
	S1	0.113	0.108	0.137	2.623	0.937	1.069	1.555	0.249	0.234	0.359

Note : * WN in this table is nation.
Comparative value of at least two quadrants is analyzed for average and deviation of comparative value of all quadrants that become objects.

relationship exists between regions.

A different tendency is seen in the case of L_{ij}^{k} for the sharing coefficients in which export, import and shipping are included together with the input coefficients : L_{ij}^{k} of the sharing coefficients (including export, import and shipping). Although the M^k values tended to approach 1, the standard deviation was remarkably higher. If we compare the sharing coefficients according to each quadrant, the final demand section (second quadrant) including export, import and shipping show a low relationship in comparison with the intermediate demand sections (first quadrant). These results show that the influence of these flow sections, as described in 4.1.3, is large in the comparative analysis of the sharing coefficients between regions. This is probably due to the inclusion of the internal flow of a large region in the denominator X_i in the calculation of the sharing coefficient in a small region, resulting in the creation of a new item associated with shipping in the final demand sections. Comparative analysis was also performed using the ratio of rows for which these sections were excluded from X_i. M^k was found to approach 1 and the corresponding deviation was also very small. Thus, the proposed comparative analysis method results in a very close relationship between regions.

The comparative analysis results are not recorded for the flow sections between the Bulletin and Nara Pref, because the form representing these sections is different from the other sections.

4.2 Correlation analysis.

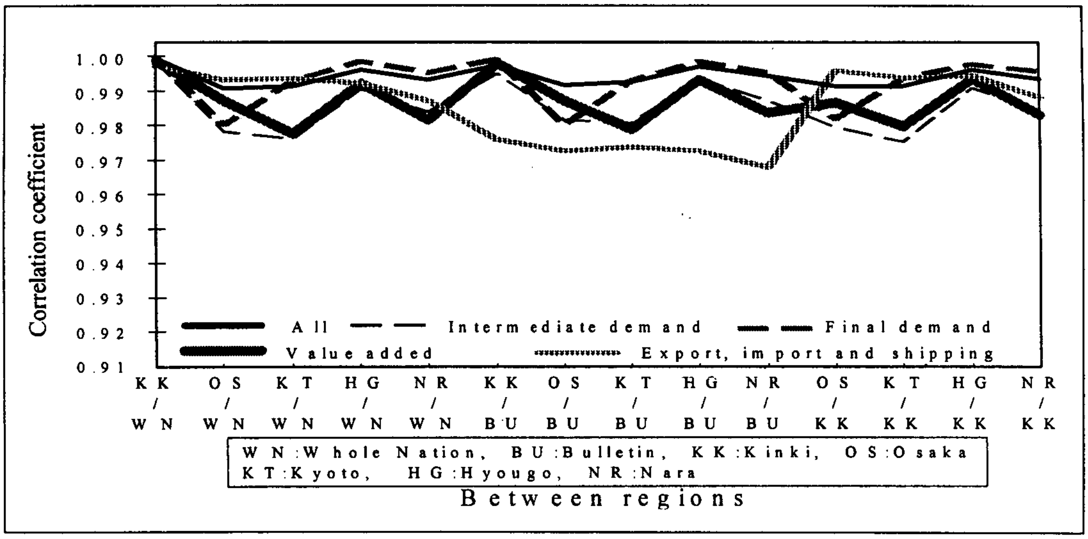
4.2.1 Analysis method.

In the proposed method, strong correlation is assumed for industrial structures between regions. We attempt to confirm the correlation between large region *R* and small region *r* for various coefficients, including the input coefficients and sharing coefficients. These coefficients are calculated from the data contained in the Bulletin and the tables for the nation, Osaka Pref., Kyoto Pref., Hyogo Pref., Nara Pref. and remaining Kinki prefectures combined (Kinki). Bivariate correlation analysis is applied to $c_{ij}^{k(R)}$ and $c_{ij}^{k(r)}$ for each quadrant and region. The results are represented by c_{ij}^{k} (Table 3). Pearson' s correlation coefficient is used for analysis.

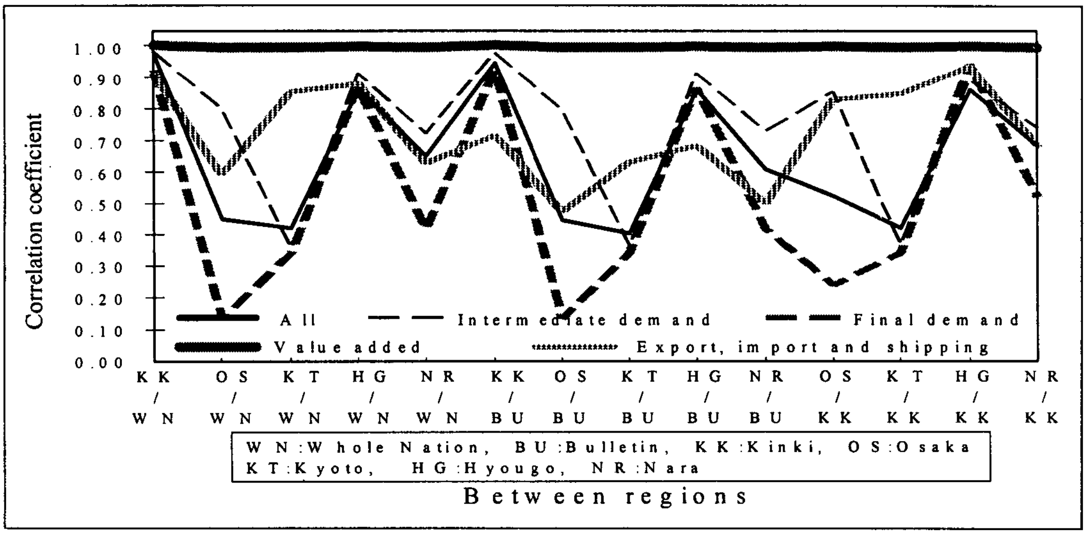
4.2.2 Results of analysis and considerations.

First, the correlation of the input structure of each industry between regions was considered by applying the correlation analysis method to the column total coefficients (input coefficients, etc.). The results are shown in Figure3. For all sections, the correlation coefficient was at least 0.99 for all regional combinations. According to quadrant, the correlation coefficients between Osaka Pref. and all other regions for the value added section (third quadrant), and between Kyoto Pref. and all other regions for the final demand section (the second quadrant) are lower than those between other regions. These regions show a similar tendency with respect to the intermediate demand section (first quadrant). However, a correlation coefficient of at least 0.9 or larger was obtained between most regions. The input structure of each industry between region *R* and region *r* is believed to have a close regional relationship.

The correlation results of the row total coefficients (sharing coefficients, etc.), between regions are shown in Figure 4. Only for the value added section was a high correlation coefficient of 0.9 or larger found for all regional combinations. The other sections produced very low correlation coefficients for the majority of regional combinations. This is due to the influence of flow (export, import and shipping) on all sections except the value added sec-



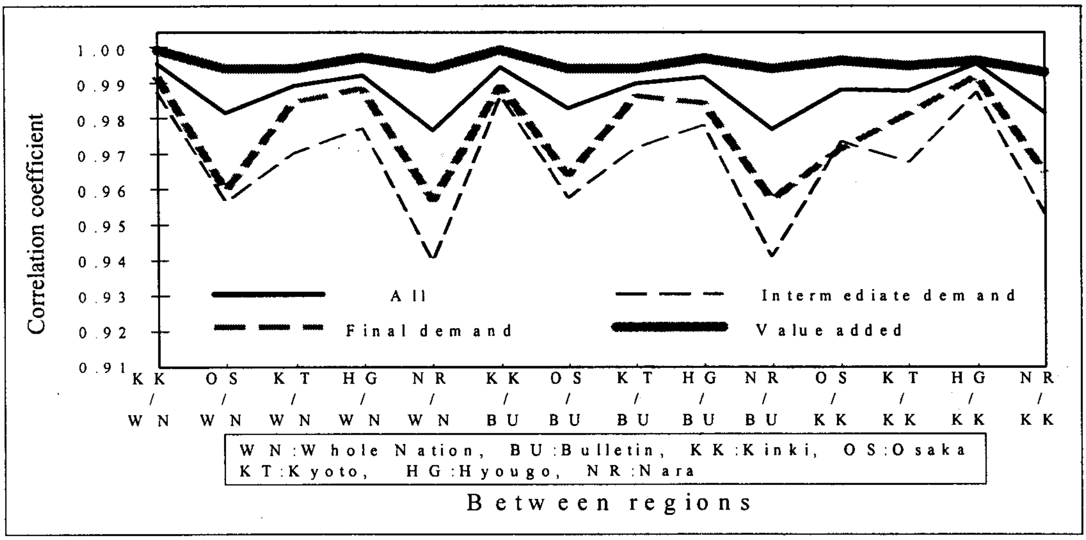
〈Figure 3〉 The result of Correlation analysis by input coefficients, etc. (the coefficients to row total)



〈Figure 4〉 The result of Correlation analysis by sharing coefficients, etc.
(the coefficients to line total including T_i)

tion when these coefficients are calculated.

In order to determine how much influence the flow sections exert on the sharing coefficients, correlation analysis between region R and regions r for h^{-t}_{ij} and hf^{-t}_{ij} given by eq' s. [20] and [21] was performed. h^{-t}_{ij} and hf^{-t}_{ij} are the ratios to the row total where the flow sections are excluded from X_i. The results are shown in Figure 5. All the correlation coefficients between regions for the coefficients were



〈Figure 5〉 The result of Correlation analysis by sharing coefficients, etc. (the coefficients to line total excluding T_i)

at least 0.9 for all regional combinations.

Thus, the flow sections, including the internal flow in region *R* (generated when a large region is divided), appear to exert a large influence on the calculation of the row total coefficients (sharing coefficients, etc.). Moreover, due to the the high correlation coefficients for the coefficients when the flow sections are excluded from the calculation, we can conclude that there is a high regional relationship for the distribution structure of industries between region *R* and the divided region *r*.

V. Estimation of PAFF according to region

This chapter, we proceed to explain the method of estimates PAFF according to region using the input and sharing coefficients. From the analysis results in Chapter 4, this method is assumed that the industrial relation structure of a large region and a small region is the same.

5.1 Derivation of temporary input-table and temporary sharing-table.

Estimation of PAFF of a small region (*r*) using the poposed method requries the amount of production in the I-O table of large region (*R*) before regional division and the amount of production according to each industrial section in each small region (*r*).

The input and sharing coefficients for region *R* are calculated using the I-O table of region *R*. Based on Amano's assumption of a uniform technological structure in a metropolitan area, as well as our data, the input and sharing coefficients in small region *r* are assumed to be the same as those in large region *R* (Amano,1978). Thus, the input coefficients (a_{ij}^r) and the sharing coefficients (h_{ij}^r) in small region (*r*) can be expressed by in eq's. [22] and [23].

$$a_{ij}^r = a_{ij}^R = x_{ij}^R / X_j^R \quad [22]$$

$$h_{ij}^r = h_{ij}^R = x_{ij}^R / X_i^R \quad [23]$$

where, R : Index of large region before division.
r : Index of small region after division.

The temporary input-table and temporary sharing-table of small region r are constructed using a^r_{ij} and h^r_{ij}. The amount of temporary input (x^{rI}_{ij}) which is the amount of production input from industry i in the large region, into industry j in small region r; and the amount of temporary sharing (x^{rO}_{ij}) which is the amount of production shared by industry j in the large region from industry i in region r. We derive the temporary input-matrix (I^r) and the temporary sharing-matrix (O^r) using a diagonal matrix $\hat{X}^r$ containing x^{rI}_{ij} and x^{rO}_{ij} as given by eq's. [24] and [25]. These two matrices are the temporary input-table and temporary sharing-table.

$$I^r = A^r \hat{X}^r \quad [24]$$

$$O^r = \hat{X}^r H^r \quad [25]$$

where, I^r : Temporary input-matrix in small region r $[x^{rI}_{ij}]$

O^r : Temporary sharing-matrix in small region $r\,[x^{rO}_{ij}]$

A^r : Input coefficients matrix in small region r

H^r : Sharing coefficients matrix in small region r

$\hat{X}^r$: Diagonal matrix containing amount of production X^r_i or X^r_j in small region r

5.2 Calculation of Shipping in I-O table.

We calculate the amount of shipping created in small region r that is performed in large region R (internal flow in region R) using the temporary input-table and temporary sharing-table. The amount of shipping in region r is summed up to the intermediate demand section for region R, where as the sum is taken to the shipping section for region r. The following assumptions are made: the amount of temporary input in a small region r is the total amount of input from region r and another small region r', and the amount of temporary sharing in region r is the total amount of sharing between region r and region r'. The input and sharing generated among regions r and r', which is the amount of shipping in small region r performed in large region R, is calculated. If we then apply the transportation cost minimizing condition assumed in section 2.2.4 to the amount of temporary input and temporary sharing in region r, we are able to calculate the amount of the shipping in region r using the difference between the amount of temporary input and temporary sharing according to each industrial section. Note that the shipping matrix (K^r) in region r is arrived at by calculating the temporary input-matrix and the temporary sharing-matrix in region r as in eq. [26].

$$O^r - I^r = K^r \quad [26]$$

where, K^r : Matrix of k^r_{ij} (amount of shipping-in or shipping-out according to each industrial section in small region r).

We believe that shipping-out occurs when each element of the shipping matrix is greater than 0, and shipping-in occurs when each element is less than 0. We calculate the amount of shipping for section i of small region r that is performed in large region R by calculating these elements (k^r_{ij}) in eq. [27] in order to find the amount of shipping-out and shipping-in for row i.

$$\text{If } k^r_{ij} < 0 \text{ then } T_i^{\rightarrow r} = \sum_j k^r_{ij}$$

$$\text{If } k^r_{ij} > 0 \text{ then } T_i^{r\rightarrow} = \sum_j k^r_{ij} \quad [27]$$

where, $T_i^{\rightarrow r}$: Amount of shipping-in from section i of another small region r' to small region r in same large region.

$T_i^{r\rightarrow}$: Amount of shipping-out from section i of small region r to another small region r' in same large region.

When considering the intermediate demand section (x^r_{ij}) for region r, we substitute the temporary input-table, whereas the value added section (v^r_{ij}) is calculated using eq. [29] after defining av^r_{ij} as in eq. [28].

$$av^r_{ij} = av^R_{ij} = v^R_{ij} \,/\, X^R_j \quad [28]$$

$$v^r_{ij} = av^r_{ij} \times X^r_j \quad [29]$$

The final demand section (f^r_{ij}) for region *r*, the shipping section between region *r* and another large region ($S_i^{r\rightarrow}$, $S_i^{\rightarrow r}$), export (E^r_i) and import (M^r_i), etc. are calculated similarly. D^r_{ij} represents the elements of the final demand section, and is calculated by hD^r_{ij} (the ratio to X^r_i) as shown in eq's. [30] and [31].

$$hD^r_{ij} = hD^R_{ij} = D^R_{ij} \,/\, X^R_i \quad [30]$$

$$D^r_{ij} = hD^r_{ij} \times X^r_i \quad [31]$$

Each value estimated in this way is used to construct a Yen-base I-O table for region *r*, based on the form of Table 2. The amount of shipping-out of industry *i* in region *r* is the total of $T_i^{r\rightarrow}$ and $S_i^{r\rightarrow}$, and the amount of shipping-in of industry *i* in region *r* is the total of $T_i^{\rightarrow r}$ and $S_i^{\rightarrow r}$.

The I-O tables of regions *r′* in region *R* can be estimated using the same method. I-O tables in small regions estimated in this way maintain correspondence ($X_{ij} = \sum_r x^r_{ij}$) over the entire system for all cells.

5.3 Amount of freight flow in small region r.

The I-O table derived in 5.2 shows the transaction process between industries in small region *r*. The actual amount of freight flow generated in small region r is limited only by the shipment of freight involved in this transaction process. The freight shipped due to the following industrial sections construction, transportation and communication, official duties, and other service industries are excluded from the estimate because the amount of freight shipped by these industries is not zero. However, if the estimate is restricted to the shipment of freight involved in the transaction activity, this amount is negligible. Thus, the following are excluded from the estimate object:

- Shipment from industries in which shipment of freight is not involved.
- Transportation of construction materials from the construction industry.
- Waste from each industry.
- Household generated freight (Freight to be moved, Home-delivery, etc.).

Thus, the amount of freight flow in small region r is estimated by the amount of shipping-out, shipping-in, export, and import generated by <u>industry *i* with a shipment of freight.</u>[5)]

Ⅵ. Sample application : Kinki

Kinki was divided into 5 smaller regions: 4 prefectures (Osaka Pref., Kyoto Pref., Hyougo Pref., and Nara Pref.) and the other remaining Kinki prefectures combined. The amount of flow was estimated according to the industrial section for each of these small regions. This was to allow comparison betwen the estimated flow (t^e_{ij}) and the actual flow (t^s_{ij}) listed in the I-O tables which have already been announced for the 4 prefectures. The PAFF in each small region is calculated according to industry using the method described in section 5.3. The object term for this estimate is the 1990 term using the latest I-O table data for the Kinki region and the 4 prefectures.

The input data of the model is the I-O table for the Kinki region and the amount of production according to industrial section for the 4 prefectures. The amount of production according to industrial section (X^r_i) for the 4 prefectures uses X^r_i from the I-O tables which have already been announced for the 4 prefectures.

X^r_i for Another region is used to calculate the difference

5) In general, 1~3999 of the section codes of the I-O table are classified into the manufacturing shipment section.

between the total of X^r_i in the four prefectures and X^R_i in the I-O table of the Kinki region. The I-O table for each small region is of the modified form 44 sections shown in Table 1.

The flow according to industrial section and according to region is calculated based on an I-O table containing 44 sections for the intermediate demand section. The totals for each flow item and region are shown in Table 5. Osaka Pref., which has the largest amount of production in the Kinki region also has the largest flow; 40% or more of the total flow in Kinki. Furthermore, the amount of shipping-out is large in Osaka Pref. and Another region. Shipping-out is approximately 1.5 times greater than shipping-in for Osaka Pref. In contrast, shipping-in is approximately 1.9 times greater than shipping-out in Kyoto Pref., 1.5 times in Hyogo, and 1.7 in Nara.

For each of the 44 industrial sections, comparative analysis was performed between the estimated flow and the reported flow according to region. First, the comparative value (α_{ij}) of the ratio between the estimated flow and the roported flow was claculated by eq. [32]. α_{ij} (comparative value by simple division) is very large when the roported flow is comparatively smaller than the estimated flow. Based on this inconsistency, β_{ij} (comparative value by which the common logarithm of the amount of each flow is by the eq. [33]) was also calculated.

$$a_{ij} = t^e_{ij} / t^s_{ij} \qquad [32]$$

$$\beta_{ij} = \log | t^e_{ij} | / \log | t^s_{ij} | \qquad [33]$$

If, $t^e_{ij} = t^s_{ij} = 0$ then $\alpha_{ij} = \beta_{ij} = 1$

If, $t^e_{ij} = 0$ and $t^s_{ij} \neq 0$ then $\alpha_{ij} = \beta_{ij} = 0$

If, $t^e_{ij} \neq 0$ and $t^s_{ij} = 0$ then exclude from calculation.

where, t^e_{ij} : Estimated flow.

t^s_{ij} : Reported flow.

i : Index of industrial section (44 sections).

j : Index of export, shipping-out, import, and shipping-in.

The average (m_j) and standard deviation (S_j) of α_{ij} and β_{ij} are calculated by eq' s. [34] and [35]: The deviation ($S1_j$) from 1 is also calculated by eq. [36].

$$m_j = \sum_i r_{ij} / n \qquad [34]$$

$$s_j = \sqrt{\sum_i (r_{ij} - m_j)^2 / n} \qquad [35]$$

$$s^1_j = \sqrt{\sum_i (r_{ij} - 1)^2 / n} \qquad [36]$$

where, γ_{ij} : α_{ij} or β_{ij}

n : Frequency of α_{ij} or β_{ij} included in calculation.

The results of comparative analysis are shown in Table 6. The results for Nara Pref. show the overall outflow and inflow, because the export and shipping-out, and the import and shipping-in are not dealt with separately in the I-O table for the 1990 term. The I-O tables of the 4 prefectures showed no correspondence with the Kinki region. Therefore Another region is excluded from comparative analysis. α_{ij} analysis revealed that the average m_j value deviates is somewhat from 1. Furthermore, standard deviation s_j and the deviation from 1 s^1_j were also large. This difference is very large in the shipping-in of Osaka Pref. and Kyoto Pref., as well as the outflow of Nara Pref. Examination of each industrial section showed that m_j for the majority of α_{ij} approached 1, but α_{ij} of 2 or 3 industrial sections was 10 or more. In one case, this value exceeded 100. One cause of this may be the use of simple division.

The β_{ij} results show that mj approaches 1 for all items, and s_j and s^1_j are also very small. Thus, the estimated flow according to industrial section using the proposed method differs little from the roported flow .

The industrial sections involving shipment of freight are sections 1~27 in Table1. The PAFF according to region can be estimated by calculating the flow for the industries that involve freight shipment using the flow amounts in Table5. The results are shown in Table7. PAFF estimation shows that the flow tendency of the freight flow does not differ largely from the flow tendency of the total flow. However, the shipping tendency in the

Kinki region is very different from that of Osaka Pref. and Another region. In the case of Osaka Pref., the ratio of shipping-in to shipping-out was 0.7 for the total flow, but the ratio of shipping-in to shipping-out for the freight flow was 1.9. This is probably due to a large surplus production of a third industry in which freight shipment is not involved. Actually, a large proportion of the industrial structure of Osaka Pref. consists of industries not involving freight shipment including commerce, finance, transportation, and communication. This tendency is reversed in the case of Another region.

〈Table 5〉 Total flow according to flow item and region.

Unit:billion Yen

Prefecture		Osaka	Kyoto	Hyougo	Nara	Another
Shipping-out	In Kinki	4,969	1,013	2,292	546	3,892
	Excluding Kinki	17,375	4,445	9,560	1,522	6,186
Export		3,579	873	2,175	325	1,161
Shipping-in	In Kinki	-3,344	-1,929	-3,328	-945	-3,165
	Excluding Kinki	-15,118	-4,421	-9,116	-1,475	-6,281
Import		-2,870	-874	-2,003	-333	-2,217

〈Table 6〉 Results of comparative analysis.

Index		α_{ij}				β_{ij}			
		Export	Shipping-out	Import	Shipping-in	Export	Shipping-out	Import	Shipping-in
Osaka	m	1.370	1.854	1.838	3.425	1.005	1.020	1.045	1.037
	S	1.834	4.371	1.253	8.062	0.108	0.263	0.097	0.118
	S^1	1.871	4.453	1.507	8.419	0.108	0.263	0.107	0.123
Kyoto	m	1.839	1.699	1.366	2.490	1.049	1.023	1.008	1.034
	S	2.012	2.051	1.055	6.033	0.185	0.079	0.087	0.103
	S^1	2.180	2.167	1.117	6.214	0.192	0.082	0.087	0.109
Hyougo	m	1.210	1.527	0.857	1.190	0.996	1.031	0.976	1.001
	S	0.709	2.645	0.415	0.750	0.092	0.273	0.053	0.051
	S^1	0.739	2.697	0.439	0.774	0.092	0.274	0.058	0.051
Nara	m	5.434		1.845		1.303		1.035	
	S	13.608		2.150		1.389		0.107	
	S^1	14.312		2.310		1.421		0.113	

〈Table 7〉 Production and attraction freight flow according to region.

Unit:billion Yen

Prefecture		Osaka	Kyoto	Hyougo	Nara	Another
Shipping-out	In Kinki	1,331	524	1,424	344	2,791
	Excluding Kinki	11,578	3,228	7,597	1,224	5,673
Export		2,618	683	1,748	270	1,148
Shipping-in	In Kinki	-2,477	-1,170	-1,482	-505	-780
	Excluding Kinki	-10,006	-3,335	-7,201	-1,199	-5,771
Import		-1,820	-645	-1,533	-270	-2,114

VII. Conclusions

The proposed nonsurvey method estimates PAFF of each small region created when a large region is divided using only the I-O table of the large region and the amount of production according to industrial section of each small region. In general, the method chosen for estimating PAFF in a certain region is dependent on the amount of information that can be obtained, and the required accuracy of the estimate. Therefore, when the information which can be obtained is limited to the amount of production according to industrial section, the proposed method should be considered as a useful estimation method.

The proposed method offer the following advantages:

- The amount of shipping between each divided small region in a large region can be easily and accurately estimated using sharing coefficients.
- Correspondence of the entire system between total production of the large region and the total production of the small regions is maintained when estimating the I-O tables of each divided small region.
- The amount of shipping in each small region can be estimated, regardless of the number of divided small regions.

The data presented in the I-O tables and the amount of shipping estimated using this method are in Yen[6]. It is necessary to convert these data into Tonnes[7] in order to apply an actual logistics analysis. The method of Kashima(1989) was generally used for converting Yen into Tonnes, but this method has the problem in the application of small regions. Therefore, an accurate and reliable method of conversion must be established.

Because this study was intended to estimate the freight flow, shipping of the final demand sections and the value added sections were not considered. Future studies should investigate differences in consumption expenditure of outside households between row total and column total.

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