SCHEMATIC CLARIFICATION FOR STRUCTURAL CHANGES IN THE INTERREGIONAL TRADE FLOWS

Hajime INAMURA
Professor
Graduate School of Information Sciences, Tohoku University
Aoba, Aoba-ku, Sendai,
980-77 Japan
Fax: +81-22-217-7494

Viroat SRISURAPANON
Graduate Student
Graduate School of Information Sciences, Tohoku University
Aoba, Aoba-ku, Sendai,
980-77 Japan
Fax: +81-22-217-7494

abstract : This paper aims to describe the structural changes in interregional trade flows by using the Transaction Structural Modeling (TSM) and the percentage deviation index. The model was applied to the technical coefficients of the interregional input-output tables. For a general view, a graphic diagram was used for presenting the overall changes of transaction structure by using TSM. Moreover, the frequency distributions of the deviations were proposed to present the variations of proportionally transacted inputs and outputs by each industry in the economy. The model was tested with the transaction from the north-eastern region to the central region of Japan.

1. INTRODUCTION

Freight transport is inherently related to trade flow. Both can be converted to each other by unit prices. In the freight transportation planning field, it is necessary to understand the structure of interregional freight flows for the projected year. This structure can be observed from the interregional trade flows which can be represented by the interregional input-output table. The technical coefficients are the principal advantage of the schematic uniformity of this table. These are usually employed to describe the structural changes of the economy.

A number of previous researches used the technical coefficients of the base year table for estimating the table for the target year. Many studies were completed with a square input-output table (Leontief model). The problems in estimating the input-output table were generally solved by two different methods, functional form and optimizing a function. The first technique, RAS, was initially applied by Stone and Brown (1962) to the input-output table. This method is a biproportional function, R and S are the diagonal matrices of multipliers in row and column for adjusting the technical coefficient matrix, A, of the base year table. Each entry of the estimated table was converged with all marginal constraints. Paelinck and Waelbroeck (1963) tested this method. It was found that the estimated table was a considerable improvement over the naive method of simply using the base year coefficients without adjustment. The deficiency of this technique was the assumption of uniform substitution and fabrication. It was assumed that each element of the input commodity I was uniformly substituted or replaced by another, and each element of the fabricated commodity J was uniformly increased or decreased. Additionally, each erroneous element of the estimated table was distributed throughout the rest of the table. Many RAS modifications were developed and tested. Paelinck and Waelbroeck also modified the RAS technique by removing entries which can be seen in advance to be troublesome. McMenamin and Haring (1974) added a change in prices to adjust the base year table before applying the RAS technique.

The second technique for estimating the input-output table is to optimize an objective function, subject to marginal constraints. For instance, Morrison and Thumann (1980) applied the Lagrangian marginal multiplier approach to estimate the input-output table. The main concept was to minimize some deviations of each entry, usually a chi-square, between the base and updated tables. It was observed that this technique was more suitable than the RAS technique in cases of additional constraints relating to blocks of cells were available.

Unfortunately, there was no generally agreed objective function and some negative values occurred in the updated table.

Various studies have been carried out in the field of the rectangular input-output model since 1953. Oosterhaven (1984) formulated a large family of different square and rectangular input-output frameworks. The rectangular members prove to have important advantages over the square members of the family. Louis (1989) made a comparative study of the methods to estimate the rectangular input-output table. The RAS, H-M (Haring/McMenamin) and LM (Lagrange Multiplier) techniques were examined by using the base year table. It was found that the results obtained for rectangular tables were generally better than those obtained for the conventional Leontief ones and the RAS method had the best performance.

All of the mentioned researches employed the base year table and marginal constraints as the inputs to formulate the projection table using mathematical techniques without considering the tendencies of each coefficient change. These tendencies are of the following five types: (1) constant, (2) increasing, (3) decreasing, (4) diminishing, and (5) generating. The model for estimating the input-output table is more attractive, if all tendencies can be added.

In this paper, the main objective is to propose two schemes for clarifying the tendencies of structural changes in the economy. The TSM is proposed to present graphically the tendencies of the technical coefficients for the interregional square input-output tables. In the other scheme, the tendencies of the technical coefficients for the rectangular input-output tables are described by a percentage deviation index. Each class of deviations is presented by the size of coefficients for quick recognition purposes.

2. INTERREGIONAL INPUT-OUTPUT TABLES

The interregional input-output table illustrates the economic structure. Two kinds of this table were employed in this study. The former one is the interregional square input-output (IRSIO) table shown in Table 1. It is based on the Chenery-Moses assumption. Each element, X_{ij}, represents the amount of each transaction of commodity I that was used for producing whichever commodity J.

Table 1 The IRSIO

	com	com			
com	X^{rr}_{ij}	X^{rs}_{ij}	f^{r}_{i}	e^{r}_{i}	q^{r}_{i}
com	X^{sr}_{ij}	X^{ss}_{ij}	f^{s}_{i}	e^{s}_{i}	q^{s}_{i}
	y^{r}_{j}	y^{s}_{j}			
	q^{r}_{j}	q^{s}_{j}			

Legend :
X: matrix with purchases of raw commodities to produce commodity
q : domestic input vector
f : final demand e : net national export
y : value added r, s : region
i : commodity I j : commodity J
com : commodities

The latter one is the interregional rectangular input-output (IRRIO) table which is shown in Table 2. This table consists of two types of matrices, the input matrix (U) and the output matrix (V). The first matrix represents inputs used by industries and the other one represents primary and secondary products produced by each industry. The table illustrates clearly the

Table 2 The IRRIO

	com	ind				com	ind				
com		U^{rr}_{ij}	f^{rr}_i	e^r_i	q^{rr}_i		U^{rs}_{ij}	f^{rs}_i		q^{rs}_i	q^r_i
ind	V^{rr}_{ij}					V^{rs}_{ij}					g^r_i
	q^{rr}_j					q^{rs}_j					
com		U^{sr}_{ij}	f^{sr}_i		q^{sr}_i		U^{ss}_{ij}	f^{ss}_i	e^s_i	q^{ss}_i	q^s_i
ind	V^{sr}_{ij}					V^{ss}_{ij}					g^s_i
	q^{sr}_j					q^{ss}_j					
		y^r_j					y^s_j				
		g^r_j					g^s_j				

Legend :
U : input matrix with purchases of commodities by industries
V : output matrix with sales of commodities by industries
g : industry output vector
i : commodity or industry I
j : commodity or industry J
ind : industries

sources and destinations of all transactions. The IRRIO model was developed by Inamura *et al* (1995).

3. UNIFORMITY OF THE INTERREGIONAL INPUT-OUTPUT TABLE

The interregional input-output table represents the economy in each situation. It is used to study economic structural changes at different points of time. The growth rate of the total input and output of the table is a simple index which is used for describing economic change. In order to ascertain the differences and similarities of the economic structures in details, some schemes are required to uniform the tables. The schematic uniformity depends on the objective of the study.

For this study, three kinds of technical coefficients are introduced. The first one is defined in Eq.(1). It is used to construct the graphic presentation for describing an overview of the economic structural system. Each coefficient A represents the ratio of amount of each transaction to all transactions from one region to another region which is different from the general definition (Leontief, 1986).

$$A^{rs}_{ij} = X^{rs}_{ij} \Big/ \sum_i \sum_j X^{rs}_{ij} \qquad (1)$$

where;

A : technical coefficient

X^{rs}_{ij} : transacted commodity I to produce commodity J from region r to region s

The others are defined in Eqs. (2) and (3). The input coefficient B represents the proportion of transacted commodity consumed by each industry while the output coefficient C represents the proportion of transacted commodity produced by each industry. Both definitions are similar to the definitions in a system of nation accounts (United Nations, 1968), but only value added is not included in the calculation of input coefficients. These coefficients were used for describing structural changes in the proportion of transacted commodities by each industry.

$$B_{ij}^{rs} = U_{ij}^{rs} \Big/ \sum_{i} U_{ij}^{rs} \tag{2}$$

$$C_{ij}^{rs} = V_{ij}^{rs} \Big/ \sum_{j} V_{ij}^{rs} \tag{3}$$

where;

B : input technical coefficient

U_{ij}^{rs} : transacted commodity I consumed by industry J from region r to region s

C : output technical coefficient

V_{ij}^{rs} : transacted commodity J produced by industry I from region r to region s

4. ECONOMIC STRUCTURAL CHANGES

The technical coefficient is the principal advantage of the schematic uniformity of the interregional input-output table. A comparison of structural properties of the economy at two different points of time is therefore reduced in this context to a comparison of each coefficient matrix. The comparison of the coefficients was performed in two techniques, by graphic presentation and percentage deviation index.

4.1 Transaction Structural Modeling

The TSM was proposed for handling the comparison of the economic structure with technical coefficient A. The differences and similarities of coefficients were illustrated by graphic presentation for quick recognizing an overview of structural changes in the economy.

An important requirement for constructing the graphic structure is an organization of relations between input and product. These relations vary from zero to one. Coefficients A were simply assumed to be the relations. Then all relations were converted to binary relations, S, by setting a threshold, P, which is shown in Eq (4). The relations which are equal to or greater than the threshold were only used to develop the graphic structure. The threshold value affects the complexity of the structural diagram. The smaller threshold value was selected so that the more complex diagram can be developed. It is noted that the diagonal elements of matrix A are generally higher than other elements. Therefore, only diagonal entries remained when a high threshold value was used.

$$\begin{aligned} A \geq P &\rightarrow S = 1 \\ \text{others} &\rightarrow S = 0 \end{aligned} \tag{4}$$

4.2 Percentage Deviation Index

The percentage deviation index, d, was used for handling the comparison of economic structure with technical coefficients B and C. The deviation of B represents the change of transacted commodity consumed by each industry while the deviation of C corresponds to the change of product mix of each industry in the economy.

$$d = ({}^{t2}D - {}^{t1}D) \Big/ {}^{t2}D \tag{5}$$

where;

D : coefficient B or C

t : point in time

5. STRUCTURAL CHANGES IN TOHOKU-KANTO TRANSACTIONS

The model was applied to ascertain the differences and similarities in the interregional transaction from the north-eastern (Tohoku) to the central (Kanto) regions of Japan between 1980 and 1985. The IRSIO and IRRIO tables were constructed from the data which was compiled by the government of Japan. The nation was divided into three regions, namely Tohoku, Kanto and other regions, which are classified in Table 3. The result of transactions from Tohoku to Kanto only is discussed. Commodities and industries were classified into twenty-six categories numbered in Table 4. The total productions of each industry, which were estimated by the IRRIO model, are also shown in the table.

Table 3 Categories of Tohoku and Kanto regions

Regions	Prefectures
Tohoku	Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima
Kanto	Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Niigata, Yamanashi, Nagano, Shizuoka

Table 4 Estimated products which were sold by each industry in Tohoku region and consumed in Kanto region

Sectors	Productions (million yens)	
	Year 1980	Year 1985
1 Agriculture & Livestock	49485	111671
2 Forestry	1652	2893
3 Fishery	6661	40208
4 Metal Mining	272	105
5 Coal Mining	4	1
6 Crude Petroleum & Gas	2	17
7 Stone & Clay Mining	2549	2062
8 Iron & Steel	359828	203802
9 Non-ferrous Metal	128714	205583
10 Metal Products	139281	232423
11 Industrial Equip. & Machinery	244595	282667
12 Electrical Equip. & Household Appliances	497062	858121
13 Motor Vehicles	316485	282414
14 Ship & Other Transports	30418	18843
15 Office & Precision Machines	99039	149902
16 Printing & Publishing & Miscel. Manufacturing	371974	263720
17 Stone & Clay Products	79138	87704
18 Petroleum & Coal Products	611441	497419
19 Chemical Products	370355	454528
20 Plastics & Synthetics & Rubber & Leather & Allied Products	73402	257036
21 Paper & Allied Products	91928	112033
22 Fabricated Textiles	116525	125429
23 Food	279358	336565
24 Drink	123871	182655
25 Lumber & Wood Products & Furniture	58608	73347
26 Services	1074418	2455816
Total	5127063	7236963

5.1 Graphic Presentation of Economic Structural Changes

Using the TSM, the overview of structural changes in transacted commodities between 1980 and 1985 from the Tohoku region to the Kanto region is graphically illustrated in Fig.1. Each block represents the transacted commodity from the Tohoku region to the Kanto region which was consumed to produce the same kind of commodity. The arrows represent the transacted commodities from the Tohoku region to the Kanto region which were consumed to produce another commodity.

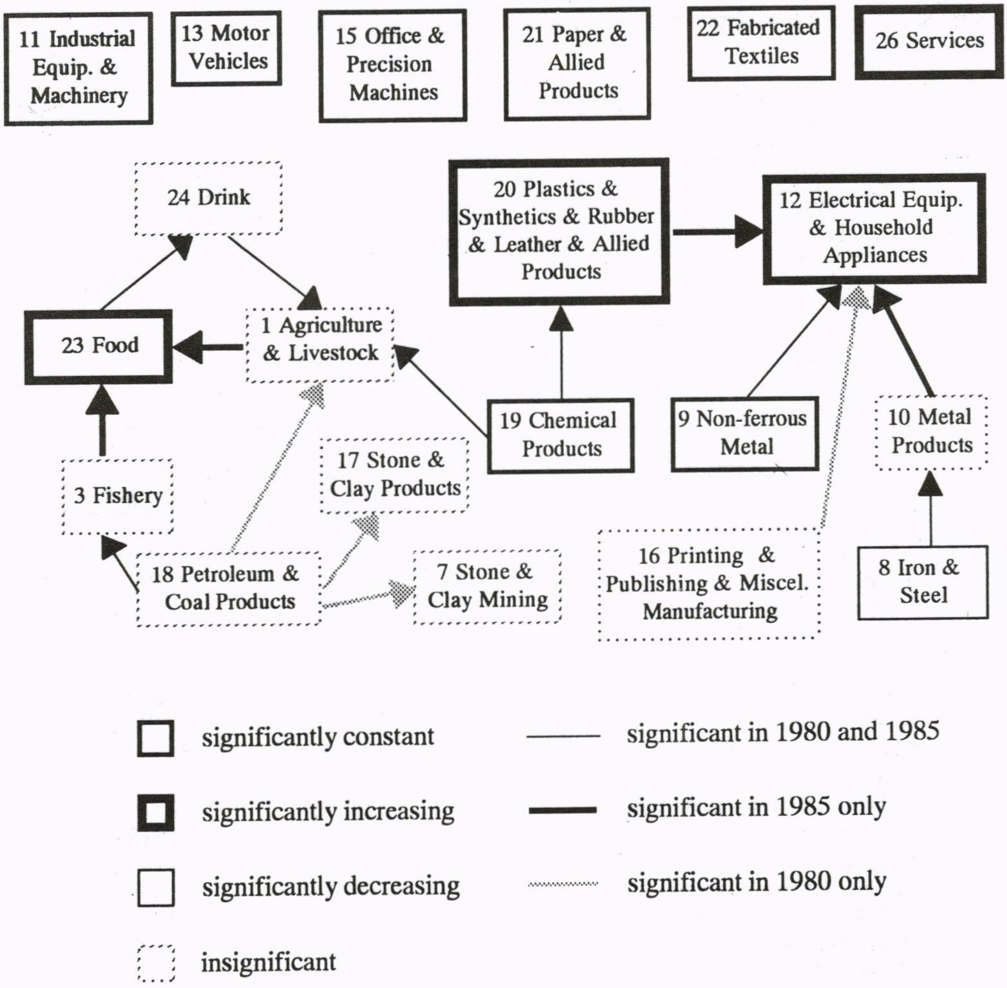


Figure 1 Transaction structural changes between 1980 and 1985 from Tohoku to Kanto, P = 0.005

For the transacted commodities which were used for producing the same kind of commodities, it is seen that the transacted commodities of non-ferrous metal, industrial equipment & machinery, motor vehicles, office & precision machines, chemical products, paper & allied products, and fabricated textiles were significantly constant in 1980 and 1985. The transacted commodities of electrical equipment & household appliances, plastics & synthetics & rubber & leather & allied products, food, and services were significantly increased while the transacted commodities of iron & steel were significantly decreased.

For the transacted commodities which were used for producing other commodities, the transactions which were significant in 1980 and 1985 were observed as follows:

- iron & steel → metal products,
- non-ferrous metal → electrical equipment & household appliances,
- petroleum & coal products → fishery,
- chemical products → agriculture & livestock,
- chemical products → plastics & synthetics & rubber & leather & allied products,
- food → drink, and
- drink → agriculture & livestock.

These transactions represent the similarities in the economy. The transactions which were significant in 1985 only were observed as follows:

- agriculture & livestock → food,
- fishery → food,
- metal products → electrical equipment & household appliances, and
- services → electrical equipment & household appliances

while the transactions which were significant in 1980 only were found as follows:

- printing & publishing & miscellaneous manufacturing → electrical equipment & household appliances,
- petroleum & coal products → agriculture & livestock,
- petroleum & coal products → stone & clay mining, and
- petroleum & coal products → stone & clay products.

These represent the differences in the economy.

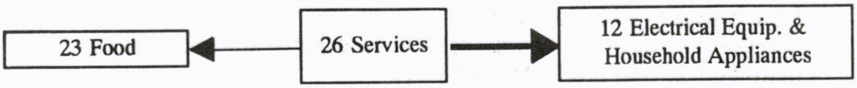
Transactions of services for producing other commodities and transaction of other commodities to produce services were separately illustrated in Fig. 2. It was found that only the transacted services for producing food were significant in 1980 and 1985 while the transacted services for producing the electrical equipment and household appliances were significant in 1985 only. For the reverse transactions, other transacted commodities for producing services, the transacted commodities which were significant in 1980 and 1985 were found as follows: iron & steel, metal products, printing & publishing & miscellaneous manufacturing, stone & clay products, petroleum & coal products, chemical products, and paper & allied products. The transacted commodities of electrical equipment & household appliances, and lumber & wood products & furniture were significant in 1980 only, while the transacted commodities of plastics & synthetics & rubber & leather & allied products were significant in 1985 only.

5.2 Frequency Distribution of Economic Structural Changes

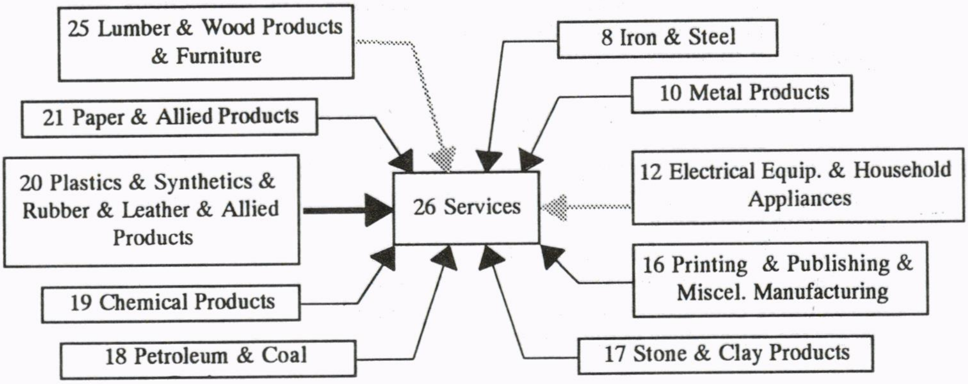
The comparisons of technical coefficients, B and C, between 1980 and 1985 are shown in Tables 5 and 6 for input and output transactions, respectively, from the Tohoku region to the Kanto region. Each bold number represents the frequency of the large coefficients which have high percentage deviations. These represent the majority of the structural changes.

Table 5. Comparison of technical coefficients of input transactions from the Tohoku region to the Kanto region between 1980 and 1985 by percentage deviation and size

Percentage Deviation	Size of Technical Coefficients in 1985					Total
	0.0005 ~ 0.0010	0.0011 ~ 0.0100	0.0101 ~ 0.1000	0.1001 ~ 0.5000	greater than 0.5000	
-100 >	6	31	**18**	**1**	**0**	56
-100 ~ -50	4	18	**19**	**10**	**0**	51
-50 ~ -20	1	15	21	**6**	**0**	43
-20 ~ -20	5	31	40	18	6	100
20 ~ 50	2	27	30	**26**	**1**	86
50 ~ 100	0	26	**36**	**8**	**0**	70
> 100	0	0	**0**	**0**	**0**	0
Total	18	148	164	69	7	406



a) Transacted services to produce other commodities



b) Other transacted commodities to produce services

significant in 1980 and 1985

significant in 1985 only

significant in 1980 only

Figure 2 Transaction structural changes of services and other commodities between 1980 and 1985 from Tohoku to Kanto, P = 0.010

Table 6 Comparison of technical coefficients of output transactions from the Tohoku region to the Kanto region between 1980 and 1985 by percentage deviation and size

Percentage Deviation	Size of Technical Coefficients in 1985					Total
	0.0005 ~ 0.0010	0.0011 ~ 0.0100	0.0101 ~ 0.1000	0.1001 ~ 0.5000	greater than 0.5000	
-100 >	12	24	2	0	0	38
-100 ~ -50	1	12	2	0	0	15
-50 ~ -20	4	10	3	0	1	18
-20 ~ -20	3	19	5	1	25	53
20 ~ 50	4	13	7	0	0	24
50 ~ 100	0	19	6	3	0	28
> 100	0	0	0	0	0	0
Total	24	97	25	4	26	176

The frequency distribution of the significant transactions in 1980 or 1985 only was shown in Tables 7 and 8, for diminishing and generating, respectively. Each bold frequency represents the majority of transaction structural change by each industry in the economy. In the input transaction respect, it is found that the commodities of ship & other transports and fabricated textiles were decreasingly consumed by industries of motor vehicles and coal mining, respectively, while there were no specific commodities increasingly consumed in 1985. In the output transaction respect, the proportion of coal mining commodity was decreasingly produced by its industry which used to produce 0.234, and the agriculture & livestock industry also decreasingly produced fabricated textiles which used to produce 0.018 in 1980 while the proportion of motor vehicle commodity was increasingly produced 0.013, 0.139 and 0.031 by industries of coal mining, crude petroleum & gas, and stone clay mining, respectively.

Table 7 The frequency distribution of technical coefficients of transactions from the Tohoku region to the Kanto region in 1980 by size in case of technical coefficients in 1985 less than 0.0005

Transaction	Size of Technical Coefficients in 1980				Total
	0.0005 ~ 0.0010	0.0011 ~ 0.0100	0.0101 ~ 0.1000	0.2340 (max.)	
Input	7	14	**2**	**0**	23
Output	3	15	**1**	**1**	20

Table 8 The frequency distribution of technical coefficients of transactions from the Tohoku region to the Kanto region in 1985 by size in case of technical coefficients in 1980 less than 0.0005

Transaction	Size of Technical Coefficients in 1985				Total
	0.0005 ~ 0.0010	0.0011 ~ 0.0100	0.0101 ~ 0.1000	0.1395 (max.)	
Input	3	10	**0**	**0**	13
Output	18	22	**2**	**1**	43

There are some relationships between the structural graphic and the structural changes in technical coefficients B and C. For instance, the total production of petroleum & coal decreased from 611441 million yen in 1980 to 497419 million yen in 1985. This amount of reduction (23 %) was related to the transacted commodity which can be observed in Fig. 1. The transacted commodity of petroleum & coal products for producing commodities of agriculture & livestock, stone & clay mining, and stone & clay products was only significant in 1980. In the other respect, these structural changes correspond to the bold numbers in Tables 5 and 6. The transacted commodity of petroleum & coal products was decreasingly consumed by the industries of agriculture & livestock, fishery, stone & clay mining, stone & clay products, and services which is shown in Table 9. Furthermore, the transacted commodity of petroleum & coal products was also decreasingly produced by the industries of coal mining, iron & steel, and chemical products which is shown in Table 10.

Table 9 Proportion of transacted commodities of petroleum & coal products consumed by each industry

Year	Industry				
	Agriculture & Livestock	Fishery	Stone & Clay Mining	Stone & Clay Products	Services
1980	0.137	0.695	0.670	0.305	0.214
1985	0.070	0.493	0.364	0.187	0.117
d (%)	-87	-40	-84	-63	-83

Table 10 Proportion of petroleum & coal products produced by each industry

Year	Industry		
	Coal Mining	Iron & Steel	Chemical Products
1980	0.705	0.154	0.048
1985	0.584	0.069	0.028
d (%)	-21	-94	-71

For the other example, the production of electrical equipment & household appliances was greatly increased by 42 %. The changes in coefficients which are the members of the bold frequencies in Table 6 and related to the transacted commodity of this production were shown in Table 11. These changes cannot be observed from the relationship in Fig. 1.

Table 11 Proportion of electrical equipment & household appliances produced by each industry

Year	Industry			
	Motor Vehicles	Ship & Other Transports	Office & Precision Machines	Miscel. Manufact-uring
1980	0.008	0.006	0.029	0.003
1985	0.014	0.012	0.118	0.012
d (%)	39	48	75	71

6. SUMMARY AND CONCLUSIONS

The differences in the economy were caused by the following two possibilities: substitution effect and fabrication effect. These effects were stimulated within the same transaction link or by a different transaction link.

In order to describe the overall structural changes of the economy, Transaction Structural Modeling (TSM) was proposed. It is practically applied to the technical coefficients of the IRSIO table. It is a method for developing a graphic diagram for quick recognition purposes. It is noted that the structure of a system can be uniquely determined depending on threshold P.

In the other respect, to describe the structural changes of transacted inputs and outputs by each industry, the percentage deviation index was proposed to apply to the technical coefficients of the IRRIO table. Some relationships between the graphic presentation and the proportionally transacted inputs and outputs have been observed and discussed.

In conclusion, in order to study the structural changes in the economy by using the technical coefficients of the interregional input-output tables, the tendencies of the changes in each group of elements need to be considered.

REFERENCES

Inamura, H., Srisurapanon, V. and Tokunaga, Y. (1995) Numerical analysis of multiregional freight flow based on rectangular modeling. presented in **The 7th WCTR**, Sydney, 16-20, July 1995.

Leontief, W. (1986) **Input-Output Economics.** Oxford University Press, New York.

Louis, L.V.St. (1989) Empirical tests of some semi-survey update procedures applied to rectangular input-output tables. **Journal of Regional Science 29**, 273-385.

McMenamin, D.G. and Haring, J.E. (1974) An appraisal of nonsurvey techniques for estimating regional input-output models. **Journal of Regional Science 14**, 191-205.
Morrison, W.I. and Thumann, R.G. (1980) A Lagrangian multiplier approach to the solution of a special constrained matrix problem. **Journal of Regional Science 20**, 279-292.
Oosterhaven, J. (1984) A family of square and rectangular interregional input-output tables and models. **Region Science and Urban Economics 14**, 565-582.
Paelinck, J. and Waelbroeck, J. (1963) Etude empirique sur l'evolution des coefficients 'input-output'. **Economic Appliquee 16**, 81-111.
Stone, R. and Brown, A. (1962) A computable model of economic growth. In **A Programme for Growth, 1**. Chapman and Hall, London.
UN (1968) **A System of National Accounts**. United Nations Studies in Methods, Series F, no.2, rev.3, New York.