Interregional Freight Flow Model Based on Interregional Rectangular Input-Output Table

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1. Introduction

Nonsurvey method for constructing the interregional freight flow (IRFF) table by using the interregional rectangular input-output (IRRIO) table is attractive because of the relatively small costs and less time consuming involved as compared with survey methods. Yet attempts at such nonsurvey technique have not been successful in the past. Recently there was no complete IRRIO table.

The purpose of this paper is to build a model to construct the IRRIO table and employ this table to construct the IRFF table. The outline of the model is represented in Fig. 1. The interregional square input-output (IRSIO) table and the national output (V) table are the exogenous data of the IRRIO model in block 1. The IRRIO table, the output of the previous model, and the price of commodity, another exogenous data, are used for the IRFF model in block 2 to estimate the IRFF table.

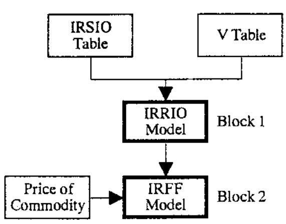

FIGURE 1: The flow of study

2. The IRRIO Model

The IRRIO and the IRSIO tables are shown in Tables 1 and 2.

TABLE 1: The IRRIO Table

	com	ind				com	ind				
com		U_{ij}^{rr}	f_i^{rr}	e_i^r	q_i^{rr}		U_{ij}^{rs}	f_i^{rs}		q_i^{rs}	q_i^r
ind	V_{ij}^{rr}					V_{ij}^{rs}					g_i^r
	q_j^{rr}					q_j^{rs}					
com		U_{ij}^{sr}	f_i^{sr}		q_i^{sr}		U_{ij}^{ss}	f_i^{ss}	e_i^s	q_i^{ss}	q_i^s
ind	V_{ij}^{sr}					V_{ij}^{ss}					g_i^s
	q_j^{sr}					q_j^{ss}					
		y_j^r					y_j^s				
		g_j^r					g_j^s				

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where; U : input matrix V : output matrix
q : domestic input vector
g : industry output vector
f : final demand e : net national export
y : value added r, s : region
i, j : commodity or industry sector
com : commodity ind : industry
B, C : matrix of coefficient

TABLE 2: The IRSIO Table

	com	com			
com	X_{ij}^{rr}	X_{ij}^{rs}	f_i^r	e_i^r	q_i^r
com	X_{ij}^{sr}	X_{ij}^{ss}	f_i^s	e_i^s	q_i^s
	y_j^r	y_j^s			
	q_j^r	q_j^s			

where; X : input matrix
A : matrix of coefficient

Hayasaka et al. (1994) used the commodity technology assumption to construct the IRRIO table. They employed the relationship of the coefficients, $B^{rs} = A^{rs}C^n$ where A^{rs} and B^{rs} are the interregional coefficients and C^n denotes the coefficient of national V, which lacks of background to frame the initial interregional input with the relationship, $U^{rs} = B^{rs}\hat{g}^s$. Additionally, there is no explanation to calculate the initial interregional output, V^{rs}. Furthermore, the relationship of value added, $y_{ind} = C^{n-1}y_{com}$ where y_{ind} denotes value added in SNA form and y_{com} denotes value added in the conventional form, has no prove which seems unreliable. However, all elements of the initial IRRIO table can be formulated to converge their constraints by iteration technique.

2.1 Methodology

The adopted IRRIO model is shown in Fig. 2. The coefficient of IRSIO table need to be estimated at first.

$$X_{ij}^{rs} = A_{ij}^{rs}\hat{q}_i^r \tag{1}$$

Secondly, the coefficient of IRRIO is transformed to the regional coefficients.

$$A_{ij}^r = \sum_s A_{ij}^{sr} \tag{2}$$

In the case of no regional survey data, nonsurvey method is usually conducted by assuming the regional coefficient of the

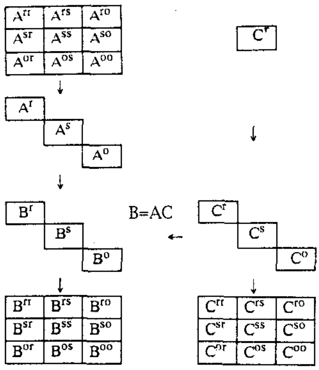

FIGURE 2: The IRRIO Model

conventional I/O table, A^r to be the same as the large regional or national coefficient, A in the empirical analyses [e.g.,Morrison and Smith(1974) , Harrigan, McGilvray, and McNicoll (1980) and Sasaki and Shibata [1984)]. Oosterhaven(1984) assumed all missing coefficient of regional input matrices and missing coefficient of regional output matrices to be the same as the national ones to frame multiregional table. In this model, it is necessary to assume the coefficient of regional output table,C^r, to be the same as the coefficient of national V table,C^n , as a third step.

The value added can be estimated as

$$y^r_{ind} = C^{r-1}(y^r_{com}+\hat{q}^r A^{r'} i - C^r \hat{g}^r C^{r'} A^{r'} i) \qquad (3)$$

where;

$$g^r = C^{r-1} q^r$$

For the regional rectangular input-output table,

$$q^r = (I - B^r C^{r-1})^{-1} (f^r + e^r) \qquad (4)$$

where;

I : the unit matrix

The regional input-output analysis (Leontief form) is based on

$$q^r = (I - A^r)^{-1} (f^r + e^r) \qquad (5)$$

With Eqs. (4) and (5), we obtain

$$A^r = B^r C^{r-1} \qquad (6)$$

Fourthly, calculate each coefficient of the regional input by using the relationship in Eq. 6. Consequently, the trade coefficient assumptions are applied to the coefficient of regional input and the coefficient of regional output to estimate the coefficient of interregional input,$T_b B$

$$T_b = \begin{bmatrix} T^{rr} & T^{rs} & T^{ro} \\ T^{sr} & T^{ss} & T^{so} \\ T^{or} & T^{os} & T^{oo} \end{bmatrix}, \quad B = \begin{bmatrix} B^r & 0 & 0 \\ 0 & B^s & 0 \\ 0 & 0 & B^o \end{bmatrix}$$

where;

$$T^{rs} = \begin{bmatrix} t^{rs}_1 & 0 & 0 \\ 0 & t^{rs}_2 & 0 \\ 0 & 0 & t^{rs}_3 \end{bmatrix}, \quad B^r = \begin{bmatrix} b^r_{11} & b^r_{12} & b^r_{13} \\ b^r_{21} & b^r_{22} & b^r_{23} \\ b^r_{31} & b^r_{32} & b^r_{33} \end{bmatrix}$$

$$t^{rs}_1 = \text{intermediate } q^{rs}_1 / \sum_i \text{intermediate } q^{is}_1$$

and the coefficient of the interregional output table, $T_c C$.

$$T_c = \begin{bmatrix} T^{rr} & T^{sr} & T^{or} \\ T^{rs} & T^{ss} & T^{os} \\ T^{ro} & T^{so} & T^{oo} \end{bmatrix}, \quad C = \begin{bmatrix} C^r & 0 & 0 \\ 0 & C^s & 0 \\ 0 & 0 & C^o \end{bmatrix}$$

where;

$$C^r = \begin{bmatrix} c^r_{11} & c^r_{12} & c^r_{13} \\ c^r_{21} & c^r_{22} & c^r_{23} \\ c^r_{31} & c^r_{32} & c^r_{33} \end{bmatrix}$$

$$t^{rs}_1 = \text{total } q^{rs}_1 / \sum_j \text{total } q^{rj}_1$$

With both interregional coefficient matrices, the IRRIO table can be calculated as follows:

$$U = T_b B \hat{g} \quad (7) \qquad V' = T_c C \hat{g} \quad (8)$$

where;

$\hat{g}$: diagonal matrix combined with $\hat{g}^r$, $\hat{g}^s$ and $\hat{g}^o$

As a result, all entries of IRRIO table were directly converged on the interregional trade flow constraints.

2.2 The Trade Flow Constraints

The IRRIO model has the advantage of taking into account the interregional trade-flow data in terms of commodity and industry.

The trade-flow in term of commodity rests on two relationships.

$$\sum_i V^{rs}_{ik} = \sum_j U^{rs}_{kj} + f^{rs}_k = q^{rs}_k \qquad (9)$$

(the interregional constraint)

The commodity k exported by the various industries in region r to region s equals that commodity k imported by various industries and final demand in region s from region r.

$$\sum_m \sum_i V^{rm}_{ik} = \sum_m \sum_j U^{rm}_{kj} + \sum_m f^{rm}_k + e^r_k \qquad (10)$$

(the regional constraint)

The supply of commodity k from various industries in region r equals the demand of that commodity k by the various industries and final demand in other regions including net national export.

With Eqs. (9) and (10), we obtain

$$\sum_i V^{rr}_{ik} = \sum_j U^{rr}_{kj} + f^{rr}_k + e^r_k = q^{rr}_k \qquad (11)$$

(the intraregional constraint)

The supply of commodity k from various industries in region r and consumed in region r equals the demand of commodity k by the various industries, final demand and net national export in region r.

The trade-flow in term of industry rests on the relationship given below.

$$\sum_{m}\sum_{j} V_{kj}^{rm} = \sum_{m}\sum_{i} U_{ik}^{mr} + y_k^r = g_k^r \qquad (12)$$

(the national constraint)

The supply of industry k in region r equals the demand of industry k in region r.

Only the constraints stated in Eq. 12 is the same as Hayasaka's constraints. Conversely, the other constraints, they stated that

$$\sum_{m}\sum_{i} V_{ik}^{mr} = \sum_{m}\sum_{j} U_{kj}^{rm} + \sum_{m} f_k^{rm} + e_k^r$$

These constraints could not be applied in this model.

3. The IRFF Model

The IRFF table is shown in Table 3.

TABLE 3: The Interregional Freight Flow Table

	com	ind				com	ind				
com		N_{ij}^{rr}	f_i^{rr}	e_i^r	q_i^{rr}		N_{ij}^{rs}	f_i^{rs}		q_i^{rs}	q_i^r
ind	M_{ij}^{rr}					M_{ij}^{rs}					g_i^r
	q_j^{rr}					q_j^{rs}					
com		N_{ij}^{sr}	f_i^{sr}		q_i^{sr}		N_{ij}^{ss}	f_i^{ss}	e_i^s	q_i^{ss}	q_i^s
ind	M_{ij}^{sr}					M_{ij}^{ss}					g_i^s
	q_j^{sr}					q_j^{ss}					

where; all entries are presented in unit of ton,

N : input matrix, M : output matrix

The price of commodity is used for converting the IRRIO table to IRFF table. There are various prices used for trade data recording. Therefore, the price convertor depends on what kind of prices is used in the IRRIO. Most of countries used producers' values which are equal to basic values plus net commodity taxes including distribution (trade and transportation) margins embodied in input.

To convert the IRRIO table which is recorded by the producers' values, transport and distribution margins (service) shown in Fig. 3, the last column of V and the bottom row of U, can be neglected because there is no volume of commodity for these margins. It is noted that Japan's margins cost about 54% of the total of transaction in 1985. Moreover, because some embodied distributor and transportation margins exist in U, therefore, each entry of the bottom row of V need to be distributed to other entries in proportion to the entries.

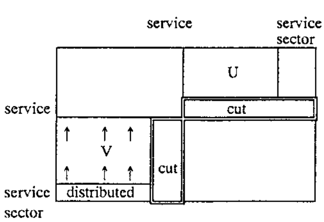

FIGURE 3: Flow of Services

4. The Real Data

The IRFF table need to be constructed from the real data, i.e. inter-city 3-days surveyed data and one-year surveyed data, for comparing with the IRFF table which is estimated by the IRFF model.

The flow of constructing of the IRFF is shown in Fig. 4. Firstly, the IRFF pattern is determined from 3-days data. Secondly, using one-year data for expanding the 3-days IRFF pattern with the IRFF constraints in Eqs. (13) and (14), the initial IRFF is determined. These constraints are similar to the trade flow constraints in Eqs. (9) and (11).

$$\sum_{i} M_{ik}^{rs} = \sum_{j} N_{kj}^{rs} + f_k^{rs} = q_k^{rs} \qquad (13)$$

$$\sum_{i} M_{ik}^{rr} = \sum_{j} N_{kj}^{rr} + f_k^{rr} + e_k^r = q_k^{rr} \qquad (14)$$

Finally, grouping the category of commodity and industry to be the same as the category which is used in the IRFF model and adjusting the unusual entries, the IRFF can be determined.

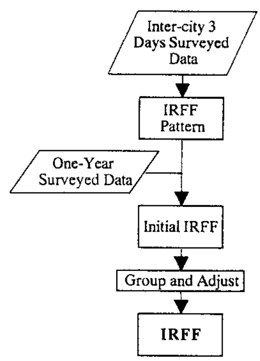

FIGURE 4: Constructing of The IRFF from The Real Data

In Japan, only these incomplete real data are available for estimating the IRFF. There are two shortcomings in the the output matrix (M) of this IRFF. First, there is no surveyed data for agriculture and fishery product. Second, some entries of this matrix are unusual [e.g. industries of food product, chemical product, etc. produced agriculture commodity]. Therefore, some regulations are established to adjust these unusual entries.

5. Case Study

The model was tested with the 1985 Japan data. The nation was divided into three regions, i.e., north-eastern (r), center (s) and others (o). Commodity and industry were classified into twenty-six. Service was classified as a last category.

The producers' prices are the most suitable convertor for IRFF model. While, imports, c.i.f. (cost, insurance &freight) are equivalent to basic values which are less than the producers' values. At present, only imports are available. In this study, using these prices to convert the IRRIO, therefore, each entry of the converted IRFF might be larger than it should be.

After processing the model, the consistency of the coefficients of both IRFF tables is tested by chi-square technique as follows:

$$\chi_j^2 = \sum_i \frac{(a_{ij}-b_{ij})^2}{a_{ij}} \qquad (15)$$

where;

a_{ij} : coefficients for the surveyed table, expressed as a percentage

b_{ij} : coefficients for the estimated table, expressed as a percentage

The results are shown in Table 4 that more than half of the estimated interregional output freight flow is consistent with real data at 0.05 significance level while the estimated interregional input freight flow is almost inconsistent with real data at the same significance level. However, it is noted that the real data is incomplete. We must not consider the test as conclusive.

6. Conclusion

The IRRIO model is applicable to construct the IRRIO table by using the IRSIO and V tables. After converting this table by the price of commodity, the IRFF table can be determined.

7. References

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TABLE 4: Industries and Commodities with Acceptable Technical Coefficients of The IRFF Table

Commodities or Industry Sectors	Output (M) Matrix																	
	Industry Base									Commodity Base								
	r r	r s	r o	s r	s s	s o	o r	o s	o o	r r	r s	r o	s r	s s	s o	o r	o s	o o
1 Agriculture	*	*	*	*	*	*	*	*	*									
2 Forestry	x									x				x				x
3 Fishery	*	*	*	*	*	*	*	*	*			x	x					
4 Metallic, Ore				x		x				x			x	x	x			x
5 Coal, Peat	x	x	x	x	x	x			x	x	x	x	x	x	x			x
6 Crude Oil, LNG	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
7 Non-Metallic	x	x			x	x	x	x	x									
8 Steel	x	x	x		x			x	x	x	x	x	x	x	x	x	x	x
9 Non-ferrous			x	x	x					x	x		x	x	x	x	x	
10 Metal Product	x	x					x			x	x							
11 Machine			x				x			x	x	x	x		x	x	x	x
12 Electric Machinery		x		x			x			x	x		x	x	x	x	x	
13 Motor Vehicle			x				x					x	x	x	x	x	x	x
14 Ship & Other Transportation **											x	x	x			x		
15 Office and Precision Machinery	x	x	x	x			x					x	x			x		
16 Printing&Other Manufactory Product	x	x	x	x	x	x												
17 Non-Metallic Product				x						x	x	x	x		x	x	x	
18 Petroleum and Coal Products	x			x	x	x	x	x	x					x			x	x
19 Chemical Product	x	x			x							x			x			
20 Plastic, Rubber&leather Materials												x				x		
21 Pulp Paper		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
22 Textile	x	x	x	x		x					x	x	x	x	x			
23 Foods	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
24 Beverage	x	x	x	x	x	x	x	x		x	x	x		x	x		x	x
25 wood&Furniture	x	x	x		x			x	x	x	x	x					x	x

Commodities or Industry Sectors	Input (N) Matrix																	
	Industry Base									Commodity Base								
	r r	r s	r o	s r	s s	s o	o r	o s	o o	r r	r s	r o	s r	s s	s o	o r	o s	o o
1 Agriculture																		
2 Forestry	x																	
3 Fishery		x			x													
4 Metallic, Ore		x	x	x		x	x	x					x		x			
5 Coal, Peat	x	x	x	x	x	x	x	x			x	x	x		x			
6 Crude Oil, LNG		x	x	x		x	x	x	x		x	x	x		x	x	x	
7 Non-Metallic			x															x
8 Steel															x			
9 Non-ferrous																x		
10 Metal Product							x											
11 Machine												x						
12 Electric Machinery												x	x			x		
13 Motor Vehicle												x						
14 Ship & Other Transportation **											x	x	x			x		
15 Office and Precision Machinery			x							x		x				x		
16 Printing&Other Manufactory Product			x				x					x				x		
17 Non-Metallic Product		x																
18 Petroleum and Coal Products		x																
19 Chemical Product																		
20 Plastic, Rubber&leather Materials																		
21 Pulp Paper																		
22 Textile												x	x					
23 Foods																		
24 Beverage												x						
25 wood&Furniture																		

x acceptable technical coefficient
* no surveyed data
** industry sector 14 is added to industry sector 13