THE MODIFIED RAS METHOD FOR UPDATING RECTANGULAR INPUT-OUTPUT TABLE -EXPECTATION MODEL- *

by Viroat SRISURAPANON** and Hajime INAMURA***

1. Introduction

The iteration technique, RAS, is generally employed to forecast the input-output table. This technique is a biproportional function, R and S are the diagonal matrices of multipliers in rows and columns for adjusting the technical coefficient matrix, A, of the base year table. This technique requires a recent input-output table as the base data, and intermediate inputs and intermediate outputs as the marginal constraints. It is assumed that each element of the input commodity is uniformly substituted or replaced by another, and each element of the fabricated commodity is uniformly increased or decreased.

The RAS technique was initially applied by Stone and Brown (1962) to the input-output table. Paelinck and Waelbroeck (1963) tested this method. It was found that the estimated table shown a considerable improvement over the naive method by simply using the base year coefficients without adjustment. The deficiency of this technique was the assumption of uniform substitution and fabrication. Additionally, each erroneous element of the estimated table was distributed throughout the rest of the table. Subsequently, 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 problematic.

All of the mentioned researches employed the base year table and marginal constraints as the inputs using the iteration technique to formulate the projection table. It is well known that a direct application of the RAS method deduces a significant bias in some industrial sectors which have fast growth or decline.
Main problem was the lack of historical data. For this study, the tendency of changing two recent input-output tables are observed and used as historical data. Moreover, the intermediate inputs and the intermediate outputs are utilized as current information in a more effective way. The historical data and the current information are the focus area of the expectation model introduced in this paper. The objective of this paper is to verify the performance of expectation model for updating of the interregional rectangular input-output table.

2. Expectation Model

(1) Base Year Table

For the conventional technique, a base year table is required for estimating the input-output table. Intermediate inputs and intermediate outputs of the target table are used as constraints for this estimation. In this case, it is noted that the solution of $n \times n$ input-output table with $2n$ constraints is not unique since the degree of freedom equals $n^2 - 2n$.

Many researchers employed the RAS technique for solving this kind of problem. They usually assumed the most recent table with or without a change in prices as a base table before applying the RAS technique (McMenamin and Haring, 1974). Hence, all elements of the base year table can be assumed as follows:

$$X_{ij}^{base} = X_{ij}^{recent} \qquad (1)$$

where;

X_{ij}^{recent} : $n \times n$ recent input-output transactions

With the above deduction, the solution can be various. The base year table is directly related to the solution. A more realistic model consistent with historical tendencies is one which allows possibility of change in the base year table (Lawson, 1980). The change of each element, V_{ij}, is expressed as follows:

$$X_{ij}^{base} = X_{ij}^{recent} + V_{ij} \qquad (2)$$

The direction and size of this change are totally leading to the improvement on the base year elements. For this study, the changes are observed from the trends of each transaction changed from 1980 to 1985. These trends are used to adjust each

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entry of the base year table for estimating the 1990 input-output table.

(2) Uniformity of Input-Output Table

To ascertain the similarities and differences of the economic structures in details, some techniques are required to unify the input-output tables. The schematic uniformity depends on the purpose of the study. For this study, a coefficient is specially introduced to uniform the table as shown in Eq.(3). Each coefficient K_{ij} represents the ratio of amount of each transaction to the summation of all transactions which is different from the common definition (Leontief, 1986).

$$K_{ij} = X_{ij} / \sum_i \sum_j X_{ij} \tag{3}$$

where;

K : coefficient matrix

To estimate the expected size of changes in each coefficient K_{ij}, three types of expected weight, W, are employed as defined in Eqs.(4)-(6).

$$W_i = \sum_j X_{ij} / \sum_i \sum_j X_{ij} \tag{4}$$

$$W_j = \sum_i X_{ij} / \sum_i \sum_j X_{ij} \tag{5}$$

$$W_{ij} = W_i \times W_j \tag{6}$$

where;

W_i : expected weight of the intermediate output of commodity i

W_j : expected weight of the intermediate input of commodity j

W_{ij} : expected weight of commodity i which is consumed to produce commodity j

(3) Expected Changes

In general, the expectation technique is not only based on the previous observed data but also encompassed current information and knowledge. For this model, historical trends of change in each transaction are extracted from the two recent tables. Intermediate inputs and intermediate outputs of the target table are used as the current information. These are used for estimating the expected change in each transaction for the target year. The direction and size of the expected changes are described as follows:

(a) Expected Direction of Change

The expected direction of change is observed from the trends of the expected weight given below:

$$W_i^{1980} \text{--->} W_i^{1985} \text{--->} W_i^{1990}$$

$$W_j^{1980} \text{--->} W_j^{1985} \text{--->} W_j^{1990}$$

$$W_{ij}^{1980} \text{--->} W_{ij}^{1985} \text{--->} W_{ij}^{1990}$$

If the patterns of the given references are the same, the direction of the expected change in coefficient K_{ij}, U_{ij}, are certainly predicted which is explained by:

$$K_{ij}^{1980} \text{--->} K_{ij}^{1985} \text{--->} K_{ij}^{1985} + U_{ij}$$

(b) Expected Value of Change

The expected initial value of U_{ij} can be calculated by the following three ways: (1) change in the weight of intermediate output, W_i; (2) change in the weight of intermediate input, W_j; and (3) change in the expected transaction weight, W_{ij}; as shown in Eqs.(7)-(9) respectively. In order to realize the most probable estimate, one of three equations have to be chosen which shows the least error considering an expected value of changes by the initial values. A guideline of chosing procedure is expressed in the next chapter.

$$U_{ij} = \frac{(W_i^{1990} - W_i^{1985})}{(W_i^{1985} - W_i^{1980})} \times (K_{ij}^{1985} - K_{ij}^{1980}) \tag{7}$$

$$U_{ij} = \frac{(W_j^{1990} - W_j^{1985})}{(W_j^{1985} - W_j^{1980})} \times (K_{ij}^{1985} - K_{ij}^{1980}) \tag{8}$$

$$U_{ij} = \frac{(W_{ij}^{1990} - W_{ij}^{1985})}{(W_{ij}^{1985} - W_{ij}^{1980})} \times (K_{ij}^{1985} - K_{ij}^{1980}) \tag{9}$$

3. Characteristics between Adjusting Base Data and Errors of Updated Data

To observe the characteristics between expected values and errors of updated data, the analysis is confined to Japan national data for 1985 and 1990, as published by the Management and Coordination Agency of Japan (1995). These tables were linked and aggregated to 32-sector level.

The target year's input-output table is estimated by using an iterative technique. The data required for iteration are as follows: 1) the 1985 base-year input-output table, 2) the intermediate input sums, and 3) the intermediate output sums. The last two types of data are fixed as the margins of the projected table for the year 1990.

The standardized total percentage error (STPE) is used to verify the updated data. This measure has been recommended by several authors (Miller and

Blair, 1983; Szyrmer, 1989) which is defined in Eq.(10).

$$\mathrm{STPE} = \left[\sum_i \sum_j \left| X^*_{ij} - X_{ij} \right| / \sum_i \sum_j X_{ij} \right] \times 100 \qquad (10)$$

where;

X : observed data matrix

X^* : projected data matrix

A diagonal base entry of the transport machinery sector has selected as an example, because a diagonal ellement has larger value and affect much than those of the others. When this base entry is varied, the input-output table is updated using the RAS method.

The variation of STPE with various values of the base data is shown in Fig. 1. (the lower curve) The value of the base data is varied from 10 to 30 million yen with 0.1 million yen interval. The estimated values have changed between 17.6 and 19.7 million yen. (the upper curve)

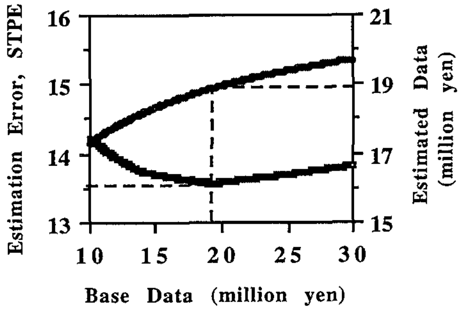

Figure 1 Variations of STPE and estimated value (transport machines sector)

From this figure, it is observed that the estimated data increases when the base data increases. For the STPE value, it decreases with increase in base data until reaching a minimum point. The minimum value at the base data takes the value of 19.3 million yen and 18.9 million yen upon projecting to estimated data. After this point, the estimated error increase.

The formula which estimates the value nearby the minimum pointis of STPE must be chosen among three Eqs. (7)-(9). Since the study chooses almost forty ellements among more than six thousand ellements of a matrix for adjustment, this guideline, of course, does not give a guarantee of optimaization but gives an approximation of it.

4. Updating Interregional Rectangular Input-Output Table

To verify the proposed expectation model, it is used to update the 1990 interregional rectangular input-output (IRRIO) table for Japan. The nation is divided into three regions, i.e., north-eastern (r), center (s) and others (o). Commodity and industry were classified into twenty-six. The overview of IRRIO model (Srisurapanon and Inamura, 1995) is illustrated in Fig. 2. The interregional square input-output table or regional square input-output (X) tables, and the national output (V) table are the exogenous data of this model. Each table is converted to technical coefficient matrix. Regional coefficient A matrices are estimated from the interregional square input-output table while regional coefficient C matrices are assumed to be the same as the national output coefficient. Relying on the trade coefficient assumptions, the interregional input and output coefficient matrices are consequently estimated. Finally, all input and output matrices of IRRIO table can be calculated from these coefficient matrices.

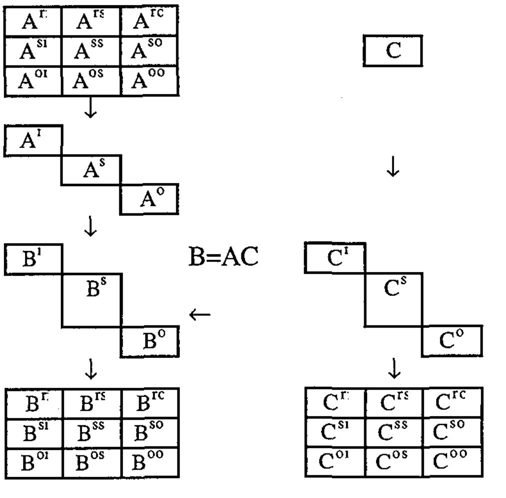

Figure 2 The IRRIO model

For the analysis of IRRIO table, it requires two types of matrices, the regional coefficient A and the national coefficient C, as the input data for the IRRIO model.

Two methods, namely, conventional RAS method and modified RAS method, are used to forecast these input data. The difference between the conventional method and modified RAS method is that using the first method each entry of the base year matrix can directly be used without any adjustments while using the second method each entry of the base year matrix is adjusted in conjunction with an expectation model.

(1) The Conventional RAS Method

This conventional RAS method is used to forecast each regional technical coefficient matrix, A, and a national technical coefficient matrix, C, for the year 1990 by using the data for the year 1985 as the base year. The input data required for this RAS method are as follows:

(a) the base matrices, 1985 regional I/O and 1985 national V matrices;
(b) the intermediate input and output vectors for the year 1990 (for estimating A); and
(c) the total input and output vectors for the year 1990 (for estimating C).

Using the RAS method with these input data, each regional I/O and national V tables can be estimated. The number of iterations are 22 times for Tohoku I/O table, 21 times for Kanto I/O table, 25 times for other regions, and 1375 times for national output table.

Using the updated matrices and apply to the IRRIO model, estimation of the interregional rectangular input-output table is obtained.

The main process is illustrated in Fig. 3. This process can be carried out by using the technical coefficient matrices as shown in Figure 2.

Where, $\oplus$ means that considering two tables

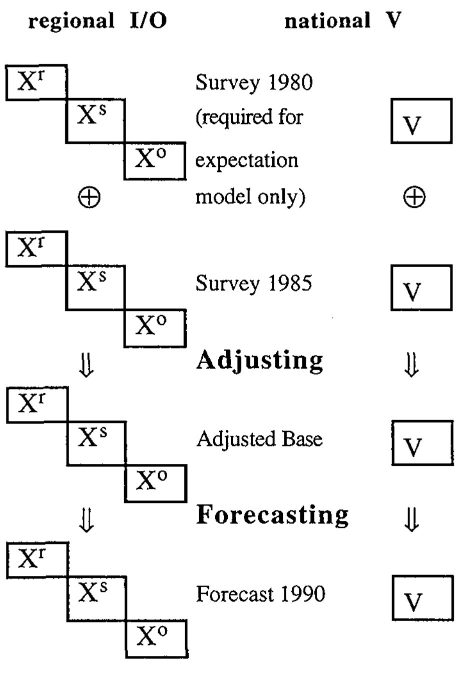

Figure 3 The main process for updating input data of the IRRIO model

(2) The Modified RAS Method

This method encompasses the expectation model and all the process of the conventional RAS method. Only one diffrence is that the expectation model is used to adjust the selected entries of the base year matrices.

5. Comparing the Performance of Forecasting Methods

Comparisons were made between the interregional input-output coefficients of the forecast tables and the ones that were directly constructed by the 1990 survey data. These were done by the absolute error index.

The absolute error is defined as follows:

$$d_{ij} = |X_{ij} - X'_{ij}| \qquad (11)$$

where;

X_{ij} : each entry of the observed input, U_{ij}, or the observed output, V_{ij}

X'_{ij} : each entry of the forecast U_{ij} or V_{ij}

Considering the magnitude of effects by each entry, the criterion in selecting the entries to be adjusted are illustrated in Table 1. Here, concrete figures in the table are given a prio ri taking acount of number of entry to be adjusted. A part of the candidates for adjustment are shown in Table 2.

Table 1 Criteria in selecting the entries

Tables	$\lvert K^{85}_{ij} \rvert$ * × 0.00001	PDI ** (%)
Regional Intermediate I/O	> 97	> 20
National Output	> 97	> 10

* absolute of technical coefficient for the year 1985 defined in Eq.(3)

** absolute percentage deviation $= \dfrac{|K^{85}_{ij} - K^{80}_{ij}|}{K^{85}_{ij}} \times 100$

The average of these absolute errors is obtained from:

$$\bar{d} = \sum_{ij} d_{ij} / t \qquad (12)$$

where; t : total number of entries

Table 2 Adjusted entries using the expectation model

Tables	entries (i,j)	K_{ij}^{80} × 0.00001	K_{ij}^{85} × 0.00001	K_{ij}^{90} × 0.00001	Adjusted K_{ij} × 0.00001
Tohoku	(18,7)	260	97	56	56
Intermediate	(9,9)	1051	509	863	647
I/O	(18,1)	245	153	78	62
	(25,25)	592	350	484	374
	(7,26)	745	381	455	406
Kanto	(2,25)	408	174	131	155
Intermediate	(18,8)	502	300	151	92
I/O	(6,18)	4129	2374	1073	1312
Other regions	(18,17)	250	165	79	142
Intermediate	(18,8)	856	524	345	237
I/O	(9,9)	983	647	766	697
	(6,18)	3921	2595	1191	1430
	(10,12)	81	162	191	184
	(13,13)	1885	4057	5219	5180
National	(2,2)	303	201	156	167
output	(7,7)	389	205	218	209
	(16,16)	2551	1755	1938	1890
	(20,20)	851	2014	1954	1949

The standard deviation of these absolute errors is given by:

$$s_d = \sqrt{\frac{\sum_{ij} d_{ij}^2}{t} - \left(\frac{\sum_{ij} d_{ij}}{t}\right)^2} \qquad (13)$$

The results computed are as shown in the Tables 3 to 6.

Table 3 demonstrates the comparison of technical coefficients of the estimated interregional input table using the conventional RAS method and the technical coefficients of the observed table, by absolute percentage deviation and absolute size. It is obvious that smaller size of technical coefficients have more error than those of the larger one. And the larger absolute percentage deviation can be found more in the smaller size of technical coefficients. Only twenty entries out of 341 technical coefficients with more than 2.5% of size (from the column fifth to eighth and from the row fifth to eighth) have more than 40% of percent deviation. Table 4 shows the comparison of technical coefficients of the estimated interregional input table using the modified RAS method and the technical coefficients of theobserved table, by absolute percentage deviation and absolute size. The total standard deviation reduces from 171 to 166. Number of technical coefficients with relative large error which have more than 40% of percent deviation reduce from twenty to eighteen (see from the column fifth to eighth and from the row fifth to eighth of the Table 3 and 4).

Table 5 and 6 show the comparison of technical coefficients of the estimated and the observed interregional output table using the conventional RAS method and the modified RAS method. They are also compared by absolute percentage deviations and absolute sizes. Generally speaking, the results of the both methods is much beter than those of input coefficient.because of much greater number of zero entries in the original tables. Number of zero entries of the Table 3 and 5 are 2393 and 4049 respectively. However the standard deviation of other entries do not different so much, and they are 171 and 158 respectively.

Table 3 Comparison of technical coefficients of the estimated interregional input table using the conventional RAS method

Absolute Percentage Deviation	Absolute Size of Observed Technical Coefficients x 0.01 0.01 ~ 0.10	0.11 ~ 0.50	0.51 ~ 1.00	1.01 ~ 2.50	2.51 ~ 5.00	5.01 ~ 10.0	10.0 ~ 20.0	Greater than 20.0	Total	Observed Coeff. x.0.001	Observed Coeff. (%)	Cumulative (%)
0-10	336	356	131	152	58	49	68	24	1174	26622	60	60
10.1-20	260	213	70	94	41	24	22	3	727	9884	22	82
20.1-30	207	173	63	50	13	11	4	1	522	3686	8	90
30.1-40	117	101	22	14	2	0	1	0	257	854	2	92
40.1-50	112	83	22	15	6	2	3	0	243	1329	3	95
50.1-70	119	105	25	20	2	3	0	0	274	1042	3	98
70.1-100	95	59	13	6	3	1	0	0	177	540	1	99
>100	124	30	1	2	0	0	0	0	157	143	1	100
Total	1370	1120	347	353	125	90	98	28	3531	44101	100	
Observed coefficients and estimated coefficients=0									2393			
Total Coefficients									5924			
Mean	84	30	23	19	15	14	9	5	28			
Standard Deviation	346	47	27	31	16	15	9	5	171			

Table 4 Comparison of technical coefficients of the estimated interregional input table using the modified RAS method

Absolute Percentage Deviation	Absolute Size of Observed Technical Coefficients x 0.01 0.01 ~ 0.10	0.11 ~ 0.50	0.51 ~ 1.00	1.01 ~ 2.50	2.51 ~ 5.00	5.01 ~ 10.0	10.0 ~ 20.0	Greater than 20.0	Total	Observed Coeff. x 0.001	Observed Coeff. (%)	Cumulative (%)
0-10	337	346	129	148	60	50	67	24	1161	26736	61	61
10.1-20	256	221	72	94	36	21	23	3	726	9441	21	82
20.1-30	207	171	58	52	10	13	4	1	516	3737	8	90
30.1-40	111	107	26	16	9	1	1	0	271	1219	3	93
40.1-50	122	84	21	13	5	2	3	0	250	1269	3	96
50.1-70	129	104	24	22	2	2	0	0	283	1006	2	98
70.1-100	85	58	16	6	3	1	0	0	169	552	1	99
>100	123	29	1	2	0	0	0	0	155	141	1	100
Total	1370	1120	347	353	125	90	98	28	3531	44101	100	
Observed coefficients and estimated coefficients = 0									2404			
Total Coefficients									5935			
Mean	83	30	23	19	15	14	9	5	28			
Standard Deviation	336	48	27	31	17	15	9	6	166			

Only eleven entries out of 237 technical coefficients with more than 2.5% of size (from the column fifth to eighth and from the row fifth to eighth) have more than 40% of percent deviation.

Table 6 shows the comparison of technical coefficients of the estimated interregional output table using the modified RAS method and the technical coefficients of theobserved table, by absolute percentage deviation and absolute size. The total standard deviation reduces from 158 to 155. Number of technical coefficients with relative large error which have more than 40% of percent deviation does not change btween two methods. (see from the column fifth to eighth and from the row fifth to eighth of the Table 5 and 6).

Table 5 Comparison of technical coefficients of the estimated interregional output table using the conventional RAS method

Absolute Percentage Deviation	Absolute Size of Observed Technical Coefficients x 0.01								Total	Observed Coeffi. x 0.001	Observed Coeff.i (%)	Cumulative (%)
	0.01 ~ 0.10	0.11 ~ 0.50	0.51 ~ 1.00	1.01 ~ 2.50	2.51 ~ 5.00	5.01 ~ 10.0	10.0 ~ 20.0	Greater than 20.0				
0-10	184	107	19	33	34	13	46	119	555	74333	95	95
10.1-20	142	71	23	5	3	2	2	0	248	913	1	96
20.1-30	106	57	14	5	0	0	0	0	182	340	1	97
30.1-40	82	48	10	15	5	2	0	0	162	689	1	98
40.1-50	103	42	10	2	1	0	0	0	158	267	0	98
50.1-70	97	26	8	5	2	0	0	0	138	286	0	98
70.1-100	133	53	12	15	5	0	0	0	218	641	1	99
>100	121	30	9	2	0	0	3	0	165	497	1	100
Total	968	434	105	82	50	17	51	119	1826	77965	100	
Observed coefficients and estimated coefficients = 0									4049			
Total Coefficients									5875			
Mean	100	43	51	32	17	6	8	1	21			
Standard Deviation	374	63	81	32	27	10	23	2	158			

Table 6 Comparison of technical coefficients of the estimated interregional output table by the modified RAS method

Absolute Percentage Deviation	Absolute Size of Observed Technical Coefficients x 0.01								Total	Observed Coeff. x 0.001	Observed Coeff. (%)	Cumulative (%)
	0.01 ~ 0.10	0.11 ~ 0.50	0.51 ~ 1.00	1.01 ~ 2.50	2.51 ~ 5.00	5.01 ~ 10.0	10.0 ~ 20.0	Greater than 20.0				
0-10	203	115	22	33	34	13	46	119	585	74375	95	95
10.1-20	120	67	20	8	3	2	2	0	222	931	1	96
20.1-30	106	51	12	6	1	2	0	0	178	466	1	97
30.1-40	105	61	12	11	4	0	0	0	193	533	1	98
40.1-50	81	34	11	2	1	0	0	0	129	254	0	98
50.1-70	105	38	13	7	2	0	0	0	165	382	0	98
70.1-100	141	38	6	13	5	0	0	0	203	531	1	99
>100	107	30	9	2	0	0	3	0	151	494	1	100
Total	968	434	105	82	50	17	51	119	1826	77965	100	
Observed coefficients and estimated coefficients =0									4055			
Total Coefficients									5881			
Mean	98	41	50	32	17	5	8	1	21			
Standard Deviation	368	58	76	32	27	8	23	2	155			

The mean and standard deviation of the absolute errors are summarized in Table 7. It is found that the mean of the absolute errors for the input coefficients is larger than the one for the output transactions while the standard deviation of the absolute errors for the input transactions is smaller for both methods. Furthermore, it can be concluded that the modified RAS method generally has better performance but difference between both methods is not so large. However, it is noted that the forecast IRRIO table using the modified RAS method can be varied depending on the criteria in selecting the entries for adjusting the base tables.

Table 7 Summary of mean and standard deviation for the absolute errors

(unit: x0.01)

Transaction Matrices	Input coefficients		Output coefficients	
Methods	Simple RAS	Modified RAS	Simple RAS	Modified RAS
Mean	28	28	21	21
S. T. D.	171	166	158	155

6. Conclusion

To forecast the IRRIO table, the main process involved the prediction of the regional input-output and national output tables to serve as the input data for the analysis of IRRIO model. The RAS method is generally applied to update the input-output tables. The RAS method produced a unique solution. However, the deficiency of this method is generally known for relying on the assumptions of substitution and fabrication. The other technique, modified RAS method, was introduced in this research to dissolve these assumptions. It required two recent input-output tables and intermediate input and output vectors for the target year as the input data. The difference from the conventional RAS method is that some entries of the base matrix need to be adjusted. In this technique, the historical data from the two input-output tables were added and the current data, intermediate input and output vectors, can be used in a more effective way using the expectation model.

The expectation model used in this study to adjust the base matrix is different from the rational expectation model introduced by Lawson (1980). He suggested to correct each coefficient with the assumption that the change of each coefficient was a normally distributed random variable with mean zero while this research, some entries of the base matrix, which have large sizes and changed sensitively, were only adjusted and then balanced by the RAS method to converge to the intermediate input-output vectors. This was demonstrated and proven implying that the accuracy of the RAS estimation can be improved.
The deficiency of the expectation model is that it consumes more data resulting to the requirement of another I/O table. Moreover, it has been noted that it cannot apply to all entries of the base matrix. Only the entries, which have large sizes and change sensitively, are preferable to be considered.

Nevertheless, the developed model is by no means final. Further development and improvement can be insinuated. In creating the adjusted base matrix, several entries from the base matrix were selected and using the expectation model, they are adjusted and formed the adjusted base matrix. It is noted that, the summation of weights defined in Eq.(3) for the base matrix is 1 which is desirable but not in the case for the adjusted matrix ($\neq 1$). This indifference perhaps can be overcome using 'distribution techniques' to adjust the weights accordingly.

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ＳＮＡ産業連関表の改定のための修正ＲＡＳ法
期待値モデル

ウイロート　シースラパノン・稲村　肇

ＲＡＳ法はレオンチェフ型産業連関表の投入代替変化と加工過程変化を取り入れ、投入係数の改定を行うものである。このＲＡＳ法を産業連関表に直接適用すると技術進歩の著しい産業分野の変化が大きく他の部門へも影響し不安定な結果を生じることは良く知られている。本研究はＲＡＳ法を従来ほとんどなされてこなかったＳＮＡ型産業連関表に適用するために、変化の激しい投入要素の初期値を時系列データから推計する期待値モデルを提案し、その修正ＲＡＳ法の精度を検討するものである。本研究により提案した方法は従来のＲＡＳ法の精度を向上できることが明らかとなった。

The modified RAS method for updating rectangular input-output table -Expectation model-

Viroat SRISURAPANON and Hajime INAMURA

The RAS method aims to update a technical coefficient matrix of Leontief type input-output table based on the assumptions of substitution and fabrication effects. It is well known that a direct application of the RAS method deduces a significant bias in some industry sectors which have fast growth. This paper proposes an expectation model to adjust initial values of selected elements from base matrix based on historical data, and applies it to the modified RAS method for updating of Japan interregional rectangular input-output table. The accuracy and validity of the model were confirmed through a case study.