Multiregional Input-Output Compilation Without Eliminating Cross Hauling

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Abstract

This paper describes a nonsurvey method for estimating multiregional trades without eliminating cross hauling, when a national biregional input-output table is available. Domestic outflows are assigned by interpolating the biregional trades according to the gravity ratio between the origin and the destinations with parameters estimated from the earlier survey on regional trades. The method is then applied to evaluate multiregional industrial waste abatement effect of Nagoya's waste reduction action, by estimating three-regional input-output table with and without cross hauling, by partitioning biregional table of the Aichi prefecture and the rest of Japan.

Key Words: Multiregional Input-Output Table, Cross Hauling

1 Introduction

Multiregional Input-Output (MRIO) analysis is one of the primary models to incorporate regional interdependencies into an input-output framework. In a MRIO model, the intra-regional coefficients matrices are strung in blocks along the main diagonal while another cross regional trade matrix functions to incorporate the cross-regional effects. It is said that MRIO models have the advantage over Interregional (IRIO) models of being able to use data that is more available. Despite the simplification in the MRIO models, however, real data of the cross regional trades is very costly to collect.

Preceding papers with non-survey approaches, thus, employed Location Quotients (LQ) as the primary reference to the cross regional trades. With this approach the domestic outflows and inflows (cross regional trades) are estimated independent of the other figures such as the regional control totals, final demand, and imports and exports in the multiregional table. While it is convenient to use LQ techniques, it also has some drawbacks; This methodology inevitably eliminates *cross hauling* in the cross regional trade. Without cross hauling the regional propagation effect will be underestimated.

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There is an alternative approach for estimating the cross regional trades. If we set the estimate on all the regional figures (including regional imports and exports) besides net regional trades, we can restrict to some extent the degrees of freedom in the cross regional trades estimation via the physical balance. In such cases, biproportional matrix estimation e.g., RAS technique using some given reference data can be applied. Nevertheless, the estimate will not include cross hauling unless the reference data includes cross hauling. Alternatively, if a biregional input-output table including cross hauling is available as such in the case of Japan, it is possible, as will be done in this research, to extract the cross regional trades that includes cross hauling by extrapolating the biregional trades according to the gravity ratios across the partitioned regions.

This paper thence explores to estimate the (three region and above) multiregional input-output table by partitioning the bilateral regional table without eliminating cross hauling, while utilizing the gravity ratios to redistribute the net regional trades. We also estimate the gravity parameters using the earlier nine-region multiregional table of Japan 1995 with cross regional trades based on survey,[1] along with population weighted distances.[2] As any biregional table can be partitioned in any way without eliminating cross hauling within this framework, we choose biregional table of Aichi and the rest of Japan 2000, and apply the calculation in order to split Aichi into Nagoya city and the rest of Aichi, thus producing a three-region multiregional table. We proceed to use this table for the analysis of industrial waste abatement effect of Nagoya's waste reduction action in 1998–2001.

The paper is organized as follows. In the following section we introduce models with and without cross hauling in partitioning biregional input-output models. Section 3 describes the gravity parameters estimation of cross regional trades using survey data along with the population weighted distances across the regions. In section 4 we introduce the data on regional industrial wastes generation, and perform multiregional analysis with and without cross hauling. We make some concluding remarks in section 5.

2 The model

2.1 Regional Partitioning

We consider partitioning a nation-wide input-output system into two regions. The physical equivalence in an economy can be described as follows,

$$X = AX + F + E - M \tag{1}$$

where, X is the output vector, A is the input-output coefficients matrix, F is the final demand vector, E is the export vector, and M is the import vector. Note that

[1] This survey will not be conducted any longer in Japan.

[2] Nishimura (2006) estimated cross regional trades according to physical gravity parameters.

vectors and matrices hereafter have the dimension of existing goods and services, unless indicated.

Let us partition this formula (1) into a region i and the rest of the nation. In this event, X is divided into i's proportion using amounts of shipments and employees. As for the final demand F_i, we use the value added (row) vector for the non-household expenses; for households we may divide in proportion to the number of households; for government expenses we may divide in proportion to the expenses of local governments. As for i's import M_i and export E_i we used the following estimation, wherein $\hat{M}$ and $\hat{E}$ are the diagonalized nation-wide import and export coefficient matrices, respectively:

$$E_i = \hat{E} X_i \tag{2}$$

$$M_i = \hat{M} \left[A_i X_i + F_i \right] \tag{3}$$

We must note that A_i should be estimated separately if possible, but we may assume that it is the same as the nation-wide A matrix, do to lack of information.

When these figures are all set, we are in a position to call on the *net* domestic inflows S_i as follows:

$$S_i = A_i X_i + F_i + E_i - M_i - X_i \tag{4}$$

At the same time, this must equal to the difference between the actual domestic inflows N_i and outflows H_i, that is,

$$S_i = N_i - H_i \tag{5}$$

If there are R regions the sum of the regional physical balance must coincide with the nation wide balance viz.,

$$\begin{aligned} \sum_{i=1}^{R} S_i &= \sum_{i=1}^{R} \left[A_i X_i + F_i + E_i - M_i - X_i \right] \\ &= AX + F + E - M - X = 0 \end{aligned} \tag{6}$$

As (6) is an identity, (5) will consist of $R - 1$ independent equations.

2.2 Cross Regional Trades

Cross regional trades are denoted with the amount of regional trade T_{ij} from region i to j. By definition, we have the following identities.

$$H_i = \sum_{j=1}^{R} T_{ij} \tag{7}$$

$$N_j = \sum_{i=1}^{R} T_{ij} \tag{8}$$

Note that $T_{ij} = 0$ $(i = j)$ since we exclude intra-regional trades. By Eqs. (5, 6), we have the following identity.

$$\sum_{j=1}^{R} N_j = \sum_{i=1}^{R} H_i$$

Therefore, Eqs. (8, 7) will consist of $2R - 1$ independent equations.

Let us now verify the number of unknowns and equations. The unknowns are T_{ij} $(i,\ j = 1, \cdots, R)$ while omitting the diagonal entries, H_i $(i = 1, \cdots, R)$ and N_j $(j = 1, \cdots, R)$ which sum up to $R^2 + R$ unknowns. On the other hand, independent equations are (5, 7, 8) which sum up to $3R - 2$ formulae. Therefore, we must specify the system further in order to set all the unknowns. In what follows we presuppose that a set of data on biregional trades is available. If we name this region R, we know H_R and N_R in advance. Thus, there are $3R-2$ and R^2+R-2 unknowns so that we will need $R^2 - 2R$ more independent formulae to specify the cross regional trades. We will use the following gravity ratio to have these equations.

2.3 Multiregional Outflow Ratio

In this subsection we focus on a good or a service l and save the subscript l. Let D_i be the lth entry of the region's total demand vector $A_i X_i + F_i$. Then, we have the ordinary *gravity* between region i and j with the coefficient κ and the distance d_{ij}.

$$g_{ij} = \kappa \frac{D_i D_j}{d_{ij}^2}$$

We assume that the outflow ratio[3] from region k to i and to j follows the gravity ratio of two regions i and j, from k, that is,

$$\frac{T_{ki}}{T_{kj}} = \frac{g_{ki}}{g_{kj}} = \frac{D_i}{D_j} \frac{d_{kj}^2}{d_{ki}^2}$$

We may generalize the model by introducing different parameters as follows:

$$\frac{T_{ki}}{T_{kj}} = \left(\frac{D_i}{D_j}\right)^{\alpha} \left(\frac{d_{ki}}{d_{kj}}\right)^{-\beta} \tag{9}$$

If we can estimate parameters α and β, then we will have $R - 2$ independent equations for each of the R regions. In all regions Eq. (9) sums up to $R(R-2)$ equations so we have sufficient number of equations to solve all unknowns.

2.4 Three-Region Model

In this subsection we consider partitioning one of the two regions of biregional table and thus obtain a three-region cross regional trades. The three regional trades are

[3] We may also assume that inflow ratio follows the gravity ratio, but we decided to employ the demand-pull type of model that is compatible with the ordinary input-output analyses.

illustrated in Figure 1. Note that one of the original two regions is region 3 and that the other region is partitioned into two regions 1 and 2. We also show the relationship between domestic inflows and outflows in Table 1. We note here

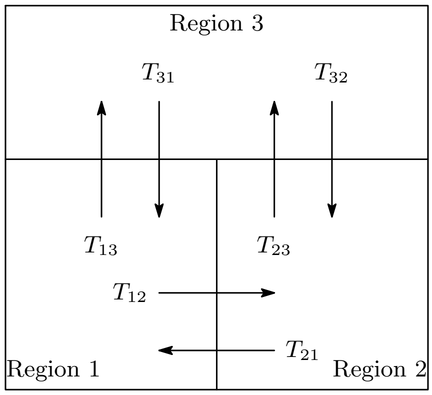

Figure 1: Trades in Three Regions

Table 1: Regional trades and domestic inflows and outflows

	T_{12}	T_{13}	H_1
T_{21}		T_{23}	H_2
T_{31}	T_{32}		H_3
N_1	N_2	N_3	

equations (5), (7, 8) and (9) in this case as below. There are 10 independent equations while there are 10 unknowns since we know N_3 and H_3. Thus, the unknowns can now be solved.

$$
\begin{array}{llll}
S_1 = N_1 - H_1, & N_1 = T_{21} + T_{31}, & H_1 = T_{12} + T_{13}, & T_{12}/T_{13} = g_{12}/g_{13} \\
S_2 = N_2 - H_2, & N_2 = T_{12} + T_{32}, & H_2 = T_{21} + T_{23}, & T_{21}/T_{23} = g_{21}/g_{23} \\
S_3 = N_3 - H_3, & N_3 = T_{13} + T_{23}, & H_3 = T_{31} + T_{32}, & T_{31}/T_{32} = g_{31}/g_{32}
\end{array}
$$

While on the subject, it is possible to determine the cross regional trades *without* cross hauling as long as there are three regions or less. If there is no cross hauling, every region is either a domestic importer or an exporter, that is, we must have

$$H_i \cdot N_j = 0 \tag{10}$$

but this can be satisfied by setting the entries (noted in lower cases) as follows.

$$n_{il} = \begin{cases} 0 & s_{il} < 0 \\ s_{il} & s_{il} \geq 0 \end{cases} \qquad h_{il} = \begin{cases} 0 & s_{il} \geq 0 \\ -s_{il} & s_{il} < 0 \end{cases} \tag{11}$$

Note that even if we have inflows and outflows including cross hauling in some region, we redefine them using (11).

Under condition (10) there will be $R-1$ independent equations and there will be at most $\frac{2R^2-1+(-1)^R}{8}$ unknowns[4] in this case. Hence, the number of independent equations and the unknowns will necessarily coincide only when $R \leq 3$. Thusly, we are able to estimate cross regional trades with and without cross hauling for the three-region models in this framework. We will accordingly compare the propagation effects later.

3 Gravity Parameters Estimation

3.1 Distances Beteween Regions

We use the nine-region multiregional table of Japan 1995 to estimate the gravity parameters for Eq. (9) in this section. Prior to regression we ought to have the distances between regions i.e., d_{ij} for all regions i and j. In this study we use the population weighted distances as described below.

Let $\delta \in i$ be a city in region i with population π_δ. Likewise let $\epsilon \in j$ be a city in region j with population π_ϵ. The distance between city δ and ϵ is $d_{\delta\epsilon}$. We define the population weighted distance d_{ij} between region i as j as follows:

$$d_{ij} = \sum_{\epsilon \in j} \sum_{\delta \in i} \frac{\pi_\delta \, \pi_\epsilon}{\sum_{\epsilon \in j} \sum_{\delta \in i} \pi_\delta \, \pi_\epsilon} d_{\delta\epsilon} \tag{12}$$

Table 2 shows the time distances measured in days across the nine regions according to the configuration of the regions of the multiregional table. Note that we estimated these numbers by limiting to three largest cities in each region with road transportation distances measured using navigation systems between the municipal offices.

Table 2: Population Weighted Distances [day]

Region	1	2	3	4	5	6	7	8
1 Hokkaido								
2 Tohoku	0.68							
3 Kanto	0.84	0.17						
4 Chubu	0.99	0.33	0.16					
5 Kinki	1.09	0.43	0.29	0.13				
6 Chugoku	1.22	0.56	0.42	0.26	0.16			
7 Shikoku	1.28	0.62	0.48	0.33	0.19	0.13		
8 Kyushu	1.40	0.75	0.60	0.45	0.33	0.14	0.31	
9 Okinawa	3.25	2.60	2.45	2.30	2.18	2.05	2.16	1.86

3.2 Gravity Parameters

Gravity parameters α and β of Eq. (9) is estimated by regression in the following loglinear form, where $x = D_i/D_j$ while D_i is the total demand in i that is $A_iX_i+F_i$,

[4] Since the proof is routine, it is omitted here.

$y = d_{ki}/d_{kj}$, and $z = T_{ki}/T_{kj}$ for all i, j, k. Note that we perform regressions for each good or service l, so we make this explicit here.

$$\log z_l = \alpha_l \log x_l - \beta_l \log y_l \tag{13}$$

The result obtained by the data (MIAC 2001) is reported in Table 3. Note

Table 3: Gravity Parameters Estimation for Each Sector

Sectors	α_l	t stat.		β_l	t stat.		obs.	R^2
Agrigulture	1.072	19.872	***	0.648	11.717	***	168	0.773
Foresty	1.514	6.261	***	0.985	9.198	***	162	0.471
Fishery	1.300	9.382	***	0.995	9.032	***	168	0.446
Mining	1.406	9.092	***	1.076	6.858	***	168	0.619
Food & Tobacco	0.944	25.216	***	0.815	18.431	***	168	0.884
Textile Prod	1.244	16.714	***	0.381	4.305	***	168	0.728
Wood Prod.	1.325	17.492	***	1.145	14.486	***	168	0.822
Furnitures	1.006	27.352	***	0.444	9.392	***	168	0.876
Pulps and Paper	1.254	23.259	***	0.915	14.093	***	168	0.864
Publishing/Printing	1.075	13.784	***	1.341	11.579	***	168	0.727
Chemical Prod	0.860	17.384	***	0.417	6.801	***	168	0.785
Oil and Coal Prod	0.469	2.769	***	1.431	7.913	***	156	0.448
Plastic Prod	0.901	12.255	***	0.649	5.675	***	168	0.640
Rubber Prod	1.038	20.717	***	0.376	5.053	***	168	0.793
Leather Prod	1.245	22.771	***	0.273	3.642	***	168	0.789
Ceramic/Soil Prod	1.004	12.980	***	0.869	9.463	***	168	0.722
Iron & Steel Prod	0.843	16.816	***	0.685	7.430	***	168	0.807
Nonferrous Prod.	0.970	15.171	***	0.548	4.503	***	168	0.712
Metal Prod.	0.944	15.313	***	0.734	9.053	***	168	0.751
General Machinery	0.903	25.034	***	0.327	6.258	***	168	0.869
Office Machinery	1.032	10.615	***	0.437	2.836	***	142	0.536
Electrical Appl	0.864	16.152	***	0.324	4.422	***	153	0.707
Electronic Appl	1.262	24.281	***	0.485	5.855	***	168	0.840
Other Electrical Appl	1.016	18.253	***	0.351	3.870	***	162	0.758
Cars and Trucks	0.996	13.303	***	0.229	1.755	*	157	0.600
Other Vehicles	1.121	11.987	***	0.538	4.848	***	168	0.590
Precision Machinery	0.919	16.144	***	0.596	7.992	***	168	0.732
Other Products	0.926	16.025	***	0.620	8.932	***	153	0.754
Electric Power	2.017	6.305	***	4.519	10.343	***	86	0.769
Gas and Heat	0.597	12.759	***	0.944	11.413	***	147	0.728
Water/Sewage	0.818	12.248	***	0.888	10.349	***	151	0.705
Commerce	0.697	40.048	***	0.609	28.251	***	168	0.952
Finance/Insurance	1.223	12.681	***	1.501	10.887	***	157	0.701
Real estate	1.567	12.910	***	1.980	10.881	***	157	0.718
Transportation	1.227	29.401	***	0.756	14.363	***	168	0.899
Broadcasting	1.118	15.238	***	0.711	7.291	***	168	0.714
Education/Research	1.159	6.014	***	0.563	2.893	***	70	0.489
Other Public Services	2.314	32.426	***	1.757	19.851	***	157	0.930
Business Services	0.968	17.917	***	1.284	16.602	***	168	0.839
Private Services	1.189	11.804	***	1.370	10.310	***	168	0.666

*** indicates significance at 1% level, ** at 5%, and * at 10% levels.

that there are 46 sectors total while the table excludes 6 sectors with trades unobserved, namely, Construction/Maintenance, Public Utilities, Other Civil Constructions, Public Services, Health care, and the rest. Also, we excluded Okinawa in this regression since this area is relatively small in scale and remote. Thus, the number of observations will be that of 8 regions with the combination of two out of regions other than the origin, that is, ${}_7C_2 \times 8 = 168$ ad extremum.

4 Application

4.1 Multiregional Analysis

Here we describe the demand-pull type of multiregional framework we use for application purposes. Let $\hat{T}_{ij}$ be the diagonalized inflow coefficients matrix from j to i such that

$$T_{ij} = \hat{T}_{ij} \left[A_j X_j + F_j \right]$$

The physical balance in i can be described by using final demand and export as exogenous as follows.

$$X_i \;=\; \left[I - \hat{M}_i \right] \left[A_i X_i + F_i \right] + E_i - \sum_{j=1}^{R} \hat{T}_{ji} \left[A_i X_i + F_i \right] + \sum_{j=1}^{R} \hat{T}_{ij} \left[A_j X_j + F_j \right]$$

This will be summarized in the following basic equation for multiregional analysis.

$$\boldsymbol{X} = \left[\boldsymbol{I} - \boldsymbol{M} - \boldsymbol{T} \right] \left[\boldsymbol{A}\boldsymbol{X} + \boldsymbol{F} \right] + \boldsymbol{E} \tag{14}$$

where, for the three-region case we write,

$$\boldsymbol{M} = \begin{bmatrix} \hat{M}_1 & & \\ & \hat{M}_2 & \\ & & \hat{M}_3 \end{bmatrix}, \quad \boldsymbol{A} = \begin{bmatrix} A_1 & & \\ & A_2 & \\ & & A_3 \end{bmatrix}, \quad \boldsymbol{X} = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix}, \quad \boldsymbol{F} = \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix}$$

$$\boldsymbol{T} = \begin{bmatrix} \hat{T}_{21} + \hat{T}_{31} & -\hat{T}_{12} & -\hat{T}_{13} \\ -\hat{T}_{21} & \hat{T}_{12} + \hat{T}_{32} & -\hat{T}_{23} \\ -\hat{T}_{31} & -\hat{T}_{32} & \hat{T}_{13} + \hat{T}_{23} \end{bmatrix}, \quad \boldsymbol{E} = \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix}$$

According to (14) the propagation effect $\Delta \boldsymbol{X}$ due to some modifications in the regional final demand $\Delta \boldsymbol{F}$ can be assessed.

$$\Delta \boldsymbol{X} = \left[\boldsymbol{I} - \left[\boldsymbol{I} - \boldsymbol{M} - \boldsymbol{T} \right] \boldsymbol{A} \right]^{-1} \left[\boldsymbol{I} - \boldsymbol{M} - \boldsymbol{T} \right] \Delta \boldsymbol{F} \tag{15}$$

Moreover, we can use regional disposal coefficient matrix $\boldsymbol{G}$ to estimate regional disposal $\boldsymbol{W}$ such that

$$\boldsymbol{G} = \begin{bmatrix} \hat{G}_1 & & \\ & \hat{G}_2 & \\ & & \hat{G}_3 \end{bmatrix}, \quad \boldsymbol{W} = \begin{bmatrix} W_1 \\ W_2 \\ W_3 \end{bmatrix}$$

The propagetion effect of which is assessed as below.

$$\Delta \boldsymbol{W} = \boldsymbol{G} \Delta \boldsymbol{X} \tag{16}$$

4.2 Multiregional Table for Aichi

There was a waste reduction action in Nagoya[5] launched by the "mayor's emergency declaration" for waste reduction in 1998. As a result, the city of Nagoya reduced 20% of its wastes and 50% of its final landfill. Preceding analyses and observations have all related to the household wastes, whereas in this study we estimate the effect on industrial waste reduction via multiregional input-output analysis.

So, first we prepare a three-region multiregional table for Nagoya (Region 1), the rest of Aich (Region 2), and the rest of Japan (Region 3), by partitioning the available biregional table of Aichi 2000 (Regions 1 and 2) and the rest of Japan (Region 3). Then we use the sectoral wastes disposal table for different regions by different types of wastes, in order to calculate the change in total landfill of industrial wastes during the time of action in Nagoya. Thus we use the change in the final demand in Nagoya (Region 1) between 1998 and 2001 and calculate the regional propagation effects using Eqs. (15) and (16).

In partitioning Aichi's table (APG 2005) we used Nagoya's share of production for the control total in each sector, while we used the same input coefficients matrix for both regions. For the final demand we used the value added (row) vector for the non-household expenses; for households we divided in proportion to the number of households; for government expenses we divided in proportion to the expenses of local governments. For fixed capital formation we used the national capital coefficients with respect to the final output. As for imports and exports we used the survey data for Nagoya.

Cross regional trades were estimated by using the model described earlier with gravity ratios estimated by the population weighted distances among three regions, namely, $d_{12} = d_{21} = 0.028$ [day], $d_{23} = d_{32} = 0.345$ [day], $d_{13} = d_{31} = 0.347$ [day]. As mentioned earlier, we naturally prepared two tables, that is, with and without cross hauling, since there are just three regions. As for the sectors that do not have cross hauling in the biregional table, we assumed to not have cross hauling also in the partitioned table.

Change in the final demand was extracted from the household consumption survey for Nagoya in 1998 and 2001 (APG 2005). According to this figure, there was a decrease in the overall consumption of about ¥100 billion. The sectoral waste generation and final landfill was extracted from the Aichi's municipal survey results (APG 2000). As for Region 3, we used the national data (MOE 2000). In Table 4 we summarize the change in the final demand, regional propagation effects considering cross hauling, and regional waste generation coefficients. The waste generation coefficients are large in Region 3. There were about ¥85 billion reduction in overall

[5] Nagoya is the largest city in the Aichi prefecture and the fourth largest city in Japan.

production in Region 1, ¥3 billion in Region 3, and ¥31 billion gain in Region 2.

Table 4: Exogenous cange $\Delta \boldsymbol{F}$ [M¥], regional propagation effects $\Delta \boldsymbol{X}$ [M¥], and waste generation coefficients $\boldsymbol{G}$ [Ton/M¥]

	Region 1			Region 2		Region 3	
Sectors	ΔF_1	ΔX_1	G_1	ΔX_2	G_2	ΔX_3	G_3
Agr Forest & Fish	-5,686	-1,454	1.865	-670	6.851	-4,550	15.372
Mining	0	31	19.343	-29	2.867	-41	28.518
Construction	-9,783	-8,184	1.015	-4,039	1.085	260	2.247
Food	-10,080	-1,283	0.083	-2,552	0.134	-7,186	1.421
Drinks & Feeds	5,457	748	0.010	741	0.188	3,458	0.626
Textiles	-4,567	-3,702	0.078	-2,183	0.072	-4,859	1.228
Clothing	-43,128	-7,852	0.000	-602	0.066	-9,088	0.079
Timber	0	15	0.130	-48	0.516	-325	1.397
Furniture	-783	-242	0.038	-204	0.089	-359	0.319
Pulps and Papers	-2,123	-807	0.599	-622	1.669	-3,615	9.349
Publish/Print	-2,983	-1,416	0.047	-595	0.155	-1,798	0.214
Chemical Prod	7,349	44	0.512	286	0.306	4,696	2.306
Oil & Coal Prod	12,099	-40,856	1.116	41,509	0.105	9,025	0.233
Plastic Prod	991	100	0.043	854	0.064	1,313	0.292
Rubber Prod	-1,569	-18	0.140	-141	0.125	0	0.353
Leather Prod	-4,797	-275	0.000	-38	0.000	-2,413	0.365
Ceramic/Soil Prod	-550	688	0.363	-1,255	1.025	-277	3.635
Iron & Steel	0	120	0.584	858	2.442	3,164	5.887
Nonferrous Prod	0	10	0.598	18	1.455	294	11.734
Metal Prod	1,082	297	0.069	-66	0.155	338	0.465
General Machin	-494	-63	0.022	56	0.052	306	0.176
Electric Machin	15,419	1,152	0.066	4,216	0.041	15,553	0.293
Cars & Trucks	68,392	-6,626	0.203	69,768	0.114	53,388	0.374
Precision Machin	-6,697	-619	0.018	-1,101	0.058	-4,453	0.108
Other Products	-13,222	-1,686	0.018	-4,340	0.020	-6,557	0.102
Electric Power	10,827	4,139	0.000	794	0.897	6,107	0.823
Gas & Heat	5,404	3,642	0.172	1,814	0.129	148	0.124
Water	-2,177	-1,745	2.812	-540	1.258	-306	36.667
Transportation	22,394	14,629	0.008	-1,983	0.006	4,306	0.041
Commerce	-2,022	-2,722	0.007	353	0.022	-1,223	0.018
Services	-6,332	-2,917	0.005	-201	0.005	-7,030	0.012
Broadcasting	17,278	19,727	0.000	-1,117	0.000	-786	0.017
Unclassified	-149,495	-47,451	0.000	-67,590	0.022	-50,821	0.000
Total	-99,794	-84,575		31,353		-3,332	

4.3 Results

Table 5 shows the result of overall changes in industrial wastes due to Nagoya's waste reduction action between 1998 and 2001. There was 9,789 tons of landfill abatement in Region 1, where the main source was from sewage reduction. We must note that the waste generation coefficient for sewage in this region's Oil & Coal Products sector, where there was a large decrease in overall production, was relatively large.[6] There was less landfill abatement in Region 2 because the propagation effect was

[6] Waste generation coefficients for different kinds of wastes is not shown in this paper.

positive and that those sectors that increased in production have relatively small generation coefficients.

Table 5: Overall changes in industrial wastes $\Delta \boldsymbol{W}$ [Ton]

	Region 1		Region 2		Region 3	
	Generated	Landfill	Generated	Landfill	Generated	Landfill
Ash	5	16	404	111	232	104
Sewage	-33,283	-8,488	-2,027	-512	-11,037	-1,027
Oil/Fat	-18,309	0	1,490	77	643	33
Acid	-167	0	428	18	419	22
Alkaline	7	0	58	3	269	15
Plastic	-310	-168	145	70	-64	-29
Paper	-278	-19	-121	-7	-576	-50
Wood	-399	-30	-191	-25	-408	-41
Fiber	-6	0	-31	-9	-68	-17
Residue	-50	-8	-31	-4	32	2
Rubber	0	0	-3	-2	-4	-3
Metal	-5,589	-633	1,539	93	2,087	335
Glass	-119	-74	-563	-249	15	9
Tailing	255	42	746	81	3,600	759
Rubble	-5,415	-431	-2,932	-255	423	71
Manure	3	3	2,197	297	-23,027	-297
Carcass	-2,712	0	-4,579	0	-41	-5
Dust	2	1	-2	-0	2,823	1,001
Total	-66,366	-9,789	-3,473	-313	-24,683	883

Finally we compare the propagation effects as well as the landfill abatement effects, with and without cross hauling, in Table 6. The exogenous change in final demand as mentioned earlier, is about ¥100 billion decline total. The propagation effects are differently distributed in the case without cross hauling although the effect in total is circa ¥57 billion decline in any case. Accordingly, the landfill abatement is assessed differently (about one-ninth for the case without) due to the waste generation coefficients as well as to the difference in the distribution of the propagation effects.

Table 6: Comparison of propagation effects with and without cross hauling

		With Cross Hauling		Without Cross Hauling	
	Exogenous	Propagation	Landfill	Propagation	Landfill
	$\Delta \boldsymbol{F}$ [M¥]	$\Delta \boldsymbol{X}$ [M¥]	$\Delta \boldsymbol{W}$ [ton]	$\Delta \boldsymbol{X}$ [M¥]	$\Delta \boldsymbol{W}$ [ton]
Region 1	-99,794	-84,575	-9,789	17,342	-353
Region 2	0	31,353	-313	-19,575	-1,126
Region 3	0	-3,332	883	-54687	195
Total	-99,794	-56,555	-9,220	-56,920	-1,284

5 Concluding Remarks

In this paper we proposed a nonsurvey method for estimating multiregional trades without eliminating cross hauling, when a national biregional input-output table is available. Domestic outflows are assigned by interpolating the biregional trades according to the gravity ratio between the origin and the destinations with parameters estimated from the survey on regional trades. The method is then applied to evaluate multiregional industrial waste abatement effect of Nagoya's waste reduction action, by estimating three-regional input-output table with and without cross hauling, by partitioning biregional table of the Aichi prefecture and the rest of Japan. The propagation effects, although coincides in total, have different distributions among regions so that different regional characteristics of industrial waste processing lead to large difference in assessing the overall landfill abatement initiated by Nagoya's waste reduction action.

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