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Construction of a Multi-regional Input-Output Table for Nagoya Metropolitan Area, Japan

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Abstract

Japan has many input-output tables, national and regional. We focus our attention to Nagoya metropolitan area, in which the headquarter office of Toyota Motors is located and many manufacturing industries of transport equipment and other machinery are concentrated. This area is included in the region covered by three prefectures; Aichi, Gifu, and Mie. To construct a multi-regional input-output table from these prefecture tables, at first, we break down each prefecture table with 186 sectors to several smaller sub-regional tables. Then we combine each table to one multi-regional input output table, which consists of 14 sub regions. Transaction values among sub-regions of each sector are estimated by the gravity-RAS method, in which the initial values are obtained by the gravity model. Using the multi-regional table, we discuss the structural characteristics of Nagoya metropolitan area. We could show a way to cope with the inconsistency of regional definitions, administrative and economic, in the input-output analysis.

Key Words: Multi-regional input-output table, Gravity-RAS method, Average Propagation Lengths, Nagoya metropolitan area,

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1. Introduction

After 1990, all of 47 prefectures have released their input-output tables (hereafter IOTs) for every five years in Japan. The prefectures' IOTs have been frequently used for the evaluation of many events, the policy evaluation of local government, and the economic planning of the regions. Recently the prefectures' tables are recompiled to an multi-regional IOT, which covers several prefectures or all of Japan. This tendency stems from the recognition that multi-regional input-output analysis becomes more important, because the regional economies are strongly connected domestically and internationally.

In this paper, using three prefectures' IOTs for Aichi, Gifu, and Mie, we recompile one type of a multi-regional IOT for Tokai region, which is a name usually used as a region covering those prefectures. For this purpose firstly we decompose each prefecture's table to tables for several small areas. Then the commodity flows among areas are estimated by the Gravity-RAS method, in which the initial values for RAS iterative calculation are reduced from the estimated Gravity model. Finally we integrate all tables to a multi-regional IOT, using the estimated transaction shares. This multi-regional IOT for Tokai region consists of 186 sectors for each of 14 areas.

Such decomposition of the prefecture's IOT to those of several small areas and the integration of the small areas' IOTs might bring possibility to solve the analytical problem that the region identified in term of economic activity is not same as the administrative region.

Nagoya metropolitan area is the third largest metropolitan area, following Tokyo and Osaka. Nagoya City is the capital city of Aichi prefecture, and is an economic center not only of Aichi prefecture but also of Gifu and Mie prefectures. However, each surrounding area is not equally connected to Nagoya City. Generally speaking, the closer the distance between them, the stronger their economic connection. So, using the multi-regional IOT for Tokay region, we investigate such relation by the Average Propagation Lengths (APL) index proposed by Dietzenbacher *et al.* (2005).

In section 2 the preceding studies in Japan is briefly discussed. Then in Section 3, we introduce the method to recompile our multi-regional IOT of Tokai region. Section 4 discuss the structural characteristics of Tokai region, and in section 5 two applications are conducted. One is the interregional impacts of the Motor Vehicle Sector on the Value Added, and the other is the characteristics of Nagoya metropolitan area in term of the APL index. Finally, section 6 concludes.

2. Background

There are several multi-regional IOTs based prefecture's tables; Osaka-Kinki-Japan regional IOT (Ito et al. (1997)), Mie-Japan regional IOT (Yamada and Asahi(1999), Kansai multi-regional IOT (Kansai Institute for Social and Economic Research (2008)), Tohoku multi-regional IOT (Tohoku Development and Research Center (2009)), Tokai multi-regional IOT (Yamada(2010)), Chubu Multi-regional IOT (Chubu Region Institute for Social and Economic Research (2011)). These tables were made to investigate some particular region in Japan, and their sector size is commonly about ninety.

The multi-regional IOT covering all of 47 prefectures in Japan has been conducted. Ishikawa and Miyagi (2003) compiled a 1995 multi-regional IOT for Japan with 45 sectors. Hitomi (2008) compiled a 2000 multi-regional IOT for Japan with 59 sectors. Hagiwara (2012) conducted a 1990-2000-2005 linked multi-regional IOT with 59 sectors. Because the number of prefectures increased, the sector size was decreased to around fifty.

Ishikawa and Miyagi (2003) used RAS method with the survey statistics of domestic net freight flows (MLIT[1]) to estimate the inter-prefectural transaction flows. Hitomi (2008) estimated the gravity model using the same freight flow data of MLIT for the goods sectors and the commodity flow data of METI[2] for the tertiary sectors. Hagiwara (2012) applied an extended-RAS method, that utilize the net freight flow data of MLIT, employees' commuting flow of the Census, and the communication traffic data of MIC[3] as initial values.

On the other hand, there are several multi-regional IOTs covering small areas within the prefectures. Ehime prefecture made an intra-prefectural multi-regional IOT (Tsubouchi (1991)) with 50 sectors for each of 6 areas. Takahata (1991) compiled 4 areas by 61 sectors multi-regional IOT for Hokkaido. Yamada (1996) decomposed Mie prefecture to 5 areas and made a multi-regional IOT for Mie with 84 sectors. Recently, Ishikawa (2004) tried to compile an 1995 Aichi multi-regional IOT with 3 areas (Nagoya City, the rest of Aichi, and the rest of Japan) by 46 sectors. Nakano and Nishimura (2007) brought another trial for Aichi prefecture, in which the definition of areas and sectors are same. Nomura et al. (2011) broke down Yamaguchi prefecture to 3 areas (Yamaguchi City, Hagi City, and the rest of the prefecture) and made a multi-regional

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1 Ministry of Land, Infrastructure, Transport and Tourism, Japan
2 Ministry of Economy, Trade, and Industry, Japan
3 Ministry of internal affairs and communications

IOT for Yamaguchi with 3 areas and 104 sectors.

In Hokkaido, there were some statistics on the freight flow and passenger flow within the prefecture, which are used for the estimation of commodity flows among areas. However, because there were seldom such statistics in other prefectures, Ehime conducted some special survey on the commodity flow of the goods produced in Ehime prefecture and others. For the estimation of commodity flow within Mie prefecture, Yamada (1996) applied the RAS method with the survey data of freight flow as initial values of the iterations. Nakano and Nishimura (2007) applied the gravity model. Nomura et al. (2011) used the Location Quotient (LQ) method, which estimate the net transaction between two areas by the relative advantage measures.

Yamada and Owaki (2012) developed a 2005 Aichi prefecture's multi-regional IOT table, in which there were four areas; Nagoya, Owari, Nishi-mikawa, and Higashi-mikawa. This table had 186 sectors for each area. The transaction flows were estimated by the Gravity-RAS method, in which the gravity model was used to get initial values of the RAS iterations.

Here we extend the IOT to cover three prefectures; Aichi, Gifu, and Mie (See Figure 1). This region is called Tokai region, whose core city is Nagoya. Using this IOT with 14 areas and 186 sector for each area, we are going to investigate the economic structure of Nagoya metropolitan area, which is included in Tokai region. How close each area is to Nagoya City would be discussed.

Table 1 shows the area and population of Tokai region. More than 11 million persons live in this region. The population of Nagoya City is 2.2 million persons, and it has the highest population density, about 6,900 persons per square Km, in this region. Owari surrounding Nagoya City has the second highest density, about 2,000 persons per square Km. In Gifu prefecture, Gifu area has the highest density, 814 persons per square Km, and Hokusei area is the highest, 759 persons per square Km, in Mie prefecture.

Figure 1 The Location of Tokai Region, Fourteen Areas

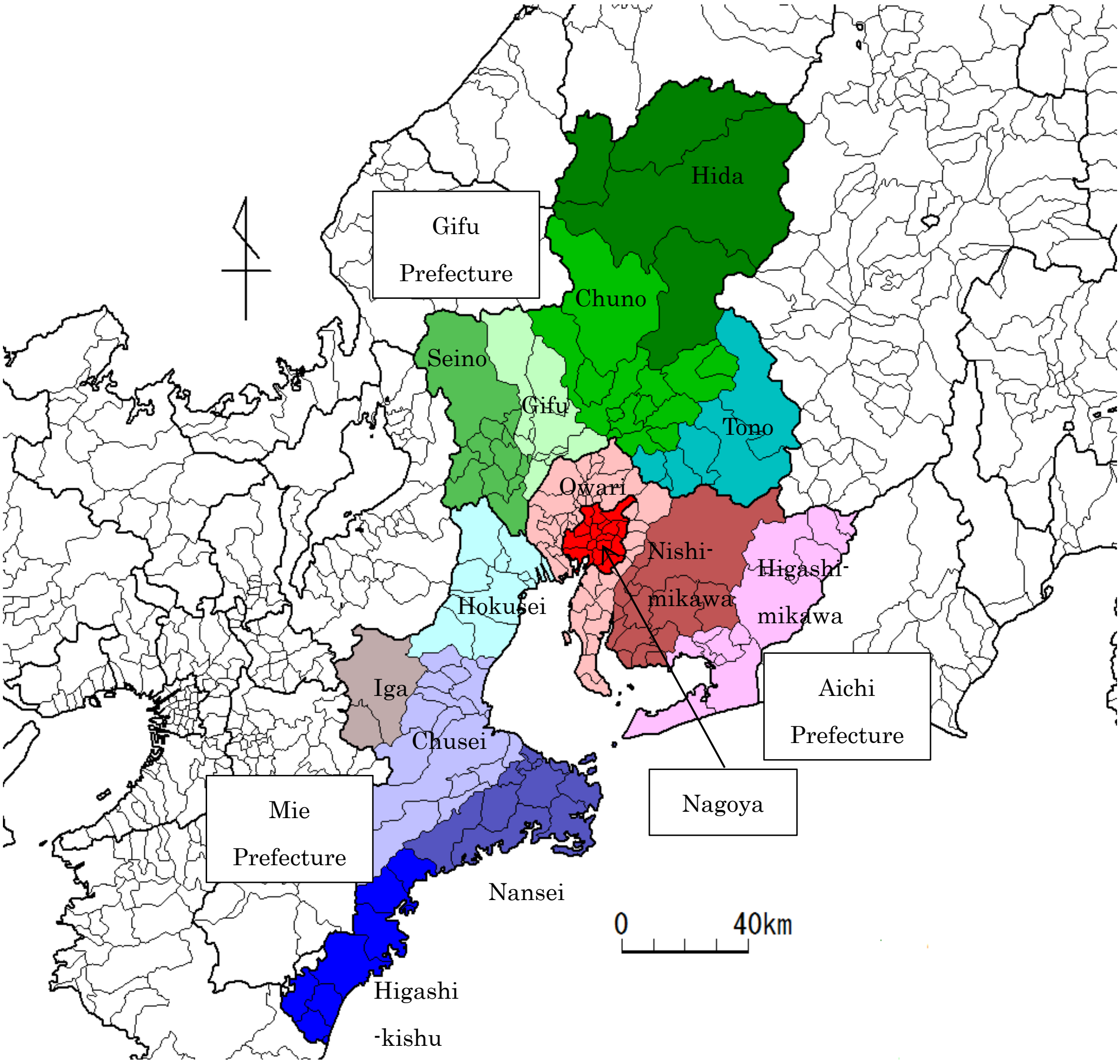

Table 1 Area and Population of Tokai region

	Area	Population in 2005	Population in 2010	Population Density in 2010
	Km^2	Thousand	Thousand	Person/Km^2
Aichi Prefecture	5,163.9	7,254.7	7,410.7	1,435.1
1 Nagoya	326.4	2,215.1	2,263.9	6,935.3
2 Owari	1,393.0	2,806.9	2,875.2	2,064.0
3 Nishi-mikawa	1,724.5	1,466.0	1,506.0	873.3
4 Higashi-mikawa	1,720.0	766.8	765.7	445.2
Gifu Prefecture	10,621.2	2,107.2	2,080.8	195.9
5 Gifu	992.5	802.2	807.6	813.6
6 Seno	1,433.4	391.6	385.0	268.6
7 Chuno	2,454.9	388.9	382.6	155.8
8 Tono	1,562.8	358.9	348.1	222.7
9 Hida	4,177.6	165.6	157.5	37.7
Mie Prefecture	5,777.3	1,867.0	1,854.7	321.0
10 Hokusei	1,107.3	823.6	840.2	758.7
11 Chusei	1,841.6	507.0	502.5	272.8
12 Nansei	1,148.7	267.7	255.0	222.0
13 Iga	687.9	182.8	177.5	258.0
14 Hgashi-kishu	991.7	85.8	79.6	80.2
Tokai Region	21,562.3	11,228.9	11,346.2	526.2

3. Construction of a multi-regional input-output table

In this section, we explain the outline to construct a multi-regional IOT of Tokai region, which consists of three prefectures; Aichi, Gifu, and Mie. Firstly each prefecture's table is decomposed to several areas' IOT of 186 sectors. These tables are imperfect in the sense that they include intra-prefectural transaction as net values. Secondly, we estimate transaction values among areas in two steps; the transactions within each prefecture, and the transactions among areas of different prefectures. The stepwise estimations are adopted to keep the consistency with the domestic trade of each prefecture's table.

3.1 Regional decomposition

Here we explain the method to decompose a prefecture's IOT to several IOTs of the smaller areas.

1) Output values

We estimate the output values of each smaller area by multiplying appropriate ratio to the prefecture's value by sector as follows.

$$X_i^s = r_i^s X_i \ ,$$

where X_i^s is the output value of the i-th sector in the s-th area, and r_i^s denotes the decomposing index of the i-th sector in the s-th area, and X_i means the output vale of the i-th sector in a prefecture. In the manufacturing sectors, for example, the product values of each municipal are added up to that of each area, the area's share of which is used as the dividing index.

2) Intermediate input and value added

Assuming that the inputs coefficient and value added ratios to the outputs are same for each area within the prefecture, the intermediate input values and value added of each sector are estimated as follows.

$$X_{ij}^s = a_{ij} X_i^s ,$$

$$V_{ij}^s = v_{ij} X_i^s ,$$

where X_{ij}^s is the intermediate input of the i-th commodity for the j-th sector in the s-th area, a_{ij} denotes the input coefficient of the i-th commodity for the j-th sector in the prefecture, V_{ij}^s means the i-th value added of the j-th sector in the s-th area, and v_{ij} is the i-th value added ratio of the j-th sector in the prefecture.

3) Domestic final demand

The domestic final demand consists of private consumption, government consumption, private investment, public investment, and change of inventory.

The private consumption of each area is estimated by multiplying appropriate ratio to the prefecture's value by sector as follows.

$$C_i^s = \gamma_i^s C_i \ ,$$

where C_i^s is the consumption of the i-th commodity in the s-th area, and γ_i^s denotes the decomposing index of the i-th sector in the s-th area, and C_i means the consumption of the i-th commodity in the prefecture. The decomposing factor is estimated as follows.

$$\gamma_{ij}^s = c_{i1} n_{j1}^s + c_{i2} n_{j2}^s ,$$

where c_{i1} and c_{i2} are per capita consumption of the i-th commodity in the prefecture, for two-or-more-person households and one-person households respectively, which are obtained from the National Survey of Family Income and Expenditure, MIC. n_{j1}^s and n_{j2}^s means the number of households; two-or-more-person and one-person respectively.

The estimation of government consumption, private investment, and public investment were conducted in the almost same way to divide them into those of the areas by using the appropriate dividing shares.

For the change of inventory, we estimate them assuming that the inventory change's ratio to the output in an area is same in the prefecture.

$$J_i^s = (J_i \ / \ X_i \ ) X_i^s$$

where J_i^s is the inventory change of the i-th sector in the s-th area, and J_i is the corresponding value of the prefecture.

4) International Trade

Here we have to estimate the values of export and import for each small area. We assume that the export ratio to the output for each sector is same within the prefecture. Then the export for each area is reduced as follows,

$$E_i^s = e_i \, X_i^s \ ,$$

where E_i^s means the export of the i-th commodity in the s-th area, and e_i denotes the export ratio to output by sector in the prefecture, that is $e_i = E_i / X_i$. Here E_i is the export of the i-th sector in the prefecture.

Assuming that the import coefficient for each area is same within the prefecture, the import of the area is reduced as follows,

$$M_i^s = m_i D_i^s ,$$

where M_i^s means the import of the i-th commodity in the s-th area, m_i denotes the import coefficient by sector in the prefecture, and D_i^s shows the domestic demand of the i-th commodity in the s-th area. The import coefficient of the prefecture is defined as $m_i = M_i / D_i$, where M_i is the import of the i-th sector and D_i is the domestic demand of the i-th sector in the prefecture.

5) Internal Trade with the Outside of the Prefecture

We estimate the values of export and import with the rest of Japan for each area. Assuming that the export ratio to the output for each sector is same for the internal trade with the rest of Japan, the export for each area is reduced as follows,

$$E_i^{*s} = e_i^* X_i^s ,$$

where E_i^{*s} means the i-th commodity's export to the rest of Japan in the s-th area, and e_i^* denotes the corresponding export ratio to output by sector in the prefecture, $e_i^* = E_i^* / X_i$. Here E_i^* is the export of the i-th sector in the prefecture.

For the import, we assume that the import coefficient from the rest of Japan is same for each area within the prefecture. Then the import of the area is reduced as follow,

$$M_i^{*s} = m_i^* D_i^s ,$$

where M_i^{*s} means the i-th commodity's import in the s-th area, and m_i^* denotes the import coefficient by sector in the prefecture. The import coefficient of the prefecture is defined as $m_i^* = M_i^* / D_i$, where M_i^* is the i-th commodity's import from the rest of Japan.

6) Balancing equation

After estimating each items by sector, the total demand have to be equal to the total supply. Then the following equation is to be hold for each sector in each area.

$$D_i^s + E_i^s + E_i^{*s} - M_i^s - M_i^{*s} + \Delta N_i^s = X_i^s ,$$

where $D_i^s = \sum X_{ij}^s + F_i^s$.

Here D_i^s denotes the total domestic demand of i-th commodity in the s-th area, which consists of the intermediate demands $\sum X_{ij}^s$ and the final demand F_i^s. The variable ΔN_i^R means the net export to the other areas within the prefecture, which works as the balancing factor after estimating all the other items independently.

3.2 Estimation of Transaction Flows between areas

Here we use the gravity-RAS method that the estimates from the gravity model are used as the initial values for the RAS iterations to obtain the commodity flow among areas.

Table 1 shows the illustrative flows of the i-th commodity among four areas, two of which are included in each of two prefectures, respectively. Two regions, the rest of Japan and the rest of the world, are appears in the table to capture the domestic and international transaction. T_i^{rs} shows the transaction of the i-th commodity from the r-th area to the s-th area, and $T_i^{R\cdot}$ denotes the total values of transaction of the i-th commodity from the r-th area, and $T_i^{\cdot S}$ means the total values of transaction of the i-th commodity to the s-th area. E_i^s and M_i^s are export and import with the world, respectively, and E_i^{*so} and M_i^{*os} are export and import with the rest of Japan, which is defined the region excluded the two prefectures from Japan in this case.

Table 1 Inter-regional flows of the i-th commodity

Destination ＼ Origin		Prefecture-1 Area-1	Prefecture-1 Area-2	Prefecture-2 Area-3	Prefecture-2 Area-4	Rest of Japan	Rest of the World	Total
Prefecture-1	Area-1	T_i^{11}	T_i^{12}	T_i^{13}	T_i^{14}	E_i^{*1o}	E_i^1	$T_i^{1\cdot}$
	Area-2	T_i^{21}	T_i^{22}	T_i^{23}	T_i^{24}	E_i^{*2o}	E_i^2	$T_i^{2\cdot}$
Prefecture-2	Area-3	T_i^{31}	T_i^{32}	T_i^{33}	T_i^{34}	E_i^{*3o}	E_i^3	$T_i^{3\cdot}$
	Area-4	T_i^{41}	T_i^{42}	T_i^{43}	T_i^{44}	E_i^{*4o}	E_i^4	$T_i^{4\cdot}$
Rest of Japan		M_i^{*o1}	M_i^{*o2}	M_i^{*o3}	M_i^{*o4}	-	-	$M_i^{*\cdot}$
Rest of the World		M_i^1	M_i^2	M_i^3	M_i^4	-	-	$M_i^{\cdot}$
Total		$T_i^{\cdot 1}$	$T_i^{\cdot 2}$	$T_i^{\cdot 3}$	$T_i^{\cdot 4}$	$E_i^{*\cdot}$	$E_i^{\cdot}$	$T_i^{\cdot\cdot}$

The following equations have to be considered.

$$\sum_s T_i^{rs} + E_i^{*ro} + E_i^r = T_i^{r\cdot} \qquad \text{for r=1,2,3, and 4,} \qquad (1)$$

$$\sum_r T_i^{rs} + M_i^{*os} + M_i^s = T_i^{\cdot s} \qquad \text{for s=1,2,3, and 4.} \qquad (2)$$

In this table, the following variables and relations are known from each of the decomposed IOTs.

1) Export E_i^s and Import M_i^s are known for s=1, 2, 3, and 4.

2) Domestic transaction E_i^{*s} and M_i^{*s} with the rest of Japan are known with the relations,

Prefecture-1: $\sum_{s\neq 1} T_i^{rs} + E_i^{*ro} = E_i^{*r}$ for r=1, 2 (3)

Prefecture-2: $\sum_{s\neq 2} T_i^{rs} + E_i^{*ro} = E_i^{*r}$ for r=3, 4. (4)

3) The total value supplied from the r-th area to all areas and regions $T_i^{r\cdot}$ is equal to the output of the area X_i^r, and the total value received from all area and regions to the r-th area $T_i^{\cdot s}$ is same as the total demand of the s-th area, D_i^s, that is,

$$T_i^{r\cdot} = X_i^r, \qquad (5)$$

$$T_i^{\cdot s} = D_i^s . \qquad (6)$$

Here, X_i^r and D_i^s are obviously obtained from the decomposed IOT.

Considering the above restrictions, we have to determine the transaction values T_i^{rs} in an appropriate way. To solve this model, we take the strategy of two-step estimation that distinguishes the intra-prefectural transaction to the transactions between prefectures in estimation.

3.2.1 Estimation of the intra-prefectural flows

Table 2 shows the intra-prefectural flows of the i-th commodity, and the row-sum values and column-sum values are obtained from each decomposed IOT. Holding the following equations, we are able to determine the values of intra-prefectural transaction T_i^{rs}.

$$\sum_{s=1,2/3,4} T_i^{rs} = X_i^r - E_i^{*r} - E_i^r \qquad (7)$$

$$\sum_{r=1,2/3,4} T_i^{rs} = D_i^s - M_i^{*s} - M_i^s \qquad (8)$$

Then we apply the RAS method with appropriate initial values. In this table, we apply the gravity model, which is to be explained in section 3.3.3, to obtain the initial values.

Table 2 Intra-prefectural flows of the i-th commodity

Destination		Prefecture-1		Prefecture-2		Total
Origin＼		Area-1	Area-2	Area-3	Area-4	
Prefec-ture-1	Area-1	T_i^{11}	T_i^{12}	-	-	X_i^1-E_i^{*1}-E_i^1
	Area-2	T_i^{21}	T_i^{22}	-	-	X_i^2-E_i^{*2}-E_i^2
Prefec-ture-2	Area-3	-	-	T_i^{33}	T_i^{34}	X_i^3-E_i^{*3}-E_i^3
	Area-4	-	-	T_i^{43}	T_i^{44}	X_i^4-E_i^{*4}-E_i^4
Total		D_i^1-M_i^{*1}-M_i^1	D_i^2-M_i^{*2}-M_i^2	D_i^3-M_i^{*3}-M_i^3	D_i^4-M_i^{*4}-M_i^4	

3.2.2 Estimation of the inter-prefectural flows

After estimating the intra-regional commodity flows, we have to determine the values of inter-prefectural commodity flows, as shown in Table 3.

Table 3 Inter-prefectural flows of the i-th commodity

Destination ＼ Origin		Prefecture-1		Prefecture-2		Total
		Area-1	Area-2	Area-3	Area-4	
Prefecture-1	Area-1	-	-	T_i^{13}	T_i^{14}	$E_i^{*1}-E_i^{*1o}$
	Area-2	-	-	T_i^{23}	T_i^{24}	$E_i^{*2}-E_i^{*2o}$
Prefecture-2	Area-3	T_i^{31}	T_i^{32}	-	-	$E_i^{*3}-E_i^{*3o}$
	Area-4	T_i^{41}	T_i^{42}	-	-	$E_i^{*4}-E_i^{*4o}$
Total		$M_i^{*1}-M_i^{*o1}$	$M_i^{*2}-M_i^{*o2}$	$M_i^{*3}-M_i^{*o3}$	$M_i^{*4}-M_i^{*o4}$	

In the following equations to be hold, both export and import with the outside of the region that excludes both prefectures E_i^{*ro} and M_i^{*os} are not known, though export and import with the rest of Japan, E_i^{*r} and M_i^{*s}, are obtained from the IOT.

$$\sum_{s=1,2/3,4} T_i^{rs} = E_i^{*r} - E_i^{*ro} \tag{9}$$

$$\sum_{r=1,2/3,4} T_i^{rs} = M_i^{*s} - M_i^{*os} \tag{10}$$

To obtain their values, we multiply the predicted share by the gravity model to total values as follows.

$$\hat{E}_i^{*ro} = \frac{\hat{E}_i^{*ro}}{\sum_s \hat{T}_i^{rs} + \hat{E}_i^{*ro}} E_i^{*r}, \tag{11}$$

$$\hat{M}_i^{*os} = \frac{\hat{M}_i^{*os}}{\sum_r \hat{T}_i^{rs} + \hat{M}_i^{*os}} M_i^{*s}, \tag{12}$$

where the variables with hats denote the predicted ones by the gravity model with some modification to fill the condition that the sum of “total” column is equal to that of “total” row[4]. This condition means that the sum of export within prefectures concerned is equal to the sum of import within the same prefectures. Here we apply the gravity-RAS method to obtain the transaction values T_i^{rs}, that keep the condition expressed by the

[4] Here we adopted the adjusting rule that the larger sum is adjusted to the smaller sum by decreasing each item proportionally. As a result, either export shares or import shares are modified from the estimated values.

equation (9) and (10), within the concerned prefectures.

3.2.3 The modified gravity model

The gravity model shows that the volume of transaction from region r to region s T_i^{rs} is proportionally related to the total volumes of both the origin $T_i^{r\cdot}$ and the destination $T_i^{\cdot s}$ and disproportionally to the distance between the regions[5] $\bar{L}^{rs}$ as follows.

$$T_i^{rs} = k_i^{rs} \frac{\left(T_i^{r\cdot}\right)^{\alpha}\left(T_i^{\cdot s}\right)^{\beta}}{\left(\bar{L}^{rs}\right)^{\gamma}},$$

where α, β, and γ are parameters of two volume variables and distance variable respectively. The parameters are estimated from the transaction data between 9 regions of 2005 METI inter-regional IOT for each of 186 sectors. Generally speaking, the transactions within each region are not included in the gravity model. However, we estimated the model with the transaction data not only between regions but also within each region, because we needed some estimates for the transaction within region.

For our purpose, we applied the gravity model asymptotically to induce the transaction coefficients $\hat{t}_i^{rs}$ between areas of our IOT, and the estimates were used as initial values for the RAS iterative method to estimate the transaction values T_i^{rs}.

$$\hat{t}_i^{rs} = \frac{\hat{T}_i^{rs}}{\sum_r \hat{T}_i^{rs}},$$

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5 There are some varieties of distance between regions: geographical distance, time distance, and cost distance, and so on. Yamada and Owaki (2012) adopted the geographical distance. They measured the distance L^{rs} between two points, each of which belongs to the different regions to be measured, by the root searching in the Google website. Then they calculated the average distance $\bar{L}^{RS}$ with the weight of the employment number as follow.

$$\bar{L}^{RS} = \frac{\sum_{r \in R}\sum_{s \in S} L^{rs} E^r E^s}{\sum_{r \in R}\sum_{s \in S} E^r E^s}$$

$$\hat{T}_i^{rs} = \hat{k}_i^{rs} \frac{\left(\hat{T}_i^{r\cdot}\right)^{\hat{\alpha}} \left(\hat{T}_i^{\cdot s}\right)^{\hat{\beta}}}{\left(\hat{\bar{L}}^{rs}\right)^{\hat{\gamma}}}$$

where $\hat{\alpha}$, $\hat{\beta}$, $\hat{\gamma}$, and $\hat{k}_i^{rs}$ are the estimated parameters. The variables $\hat{T}_i^{r\cdot}$, $\hat{T}_i^{\cdot s}$, and $\hat{\bar{L}}^{rs}$ are corresponding values for the multi-regional IOT compiled here. The average distances were calculated from the distance between municipals that belonged to each area with employment weights.

Table 4 the estimated transaction matrix

Unit: 10 billion Yen, %

	Transaction Flows (->)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Nagoya	Owari	Nishi-mikawa	Higashi-mikawa	Gifu	Seno	Chuno	Tono	Hida	Hokusei	Chusei	Nansei	Iga	Hgashi-kishu	Export to the ROJ	Export, International	Total
1	Nagoya	10949	4091	2129	586	129	74	87	49	12	324	105	38	51	6	2876	1932	23438
2	Owari	2516	8891	2517	667	245	128	161	80	18	435	155	41	62	8	4767	2235	22925
3	Nishi-mikawa	768	1493	8824	1223	154	78	134	58	15	578	1	43	59	8	4819	5356	23608
4	Higashi-mikawa	249	409	831	2653	35	21	27	16	5	99	52	20	16	4	1744	1628	7809
5	Gifu	129	166	164	34	2896	315	257	140	46	28	16	2	3	0	737	140	5074
6	Seno	81	115	133	28	187	1100	136	85	24	31	8	2	3	0	486	210	2629
7	Chuno	118	185	161	78	164	96	1127	113	29	29	10	3	5	1	538	261	2920
8	Tono	48	70	96	19	63	58	104	968	21	10	6	2	2	0	377	110	1953
9	Hida	13	16	21	6	56	41	60	42	552	10	5	2	2	0	152	25	1003
10	Hokusei	444	544	635	143	26	30	18	11	3	3764	333	139	116	51	2544	1163	9966
11	Chusei	85	104	135	39	11	9	8	5	2	297	1640	99	62	22	1047	421	3988
12	Nansei	37	43	46	21	4	2	3	2	0	82	106	748	20	13	424	125	1677
13	Iga	58	67	79	20	4	2	3	2	0	85	49	18	526	7	485	138	1544
14	Hgashi-kishu	7	10	7	3	1	0	0	0	0	54	35	12	28	272	71	10	511
15	The Rest of Japan	3848	4510	4615	1626	718	412	472	324	183	2734	1138	470	434	169	0	0	21652
16	Import	1308	2075	1389	499	249	155	169	110	49	948	453	192	156	50	0	0	7800
17	Total	20658	22792	21781	7646	4941	2521	2767	2004	959	9508	4110	1831	1545	612	21066	13755	138497

	Share of Origins	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Nagoya	Owari	Nishi-mikawa	Higashi-mikawa	Gifu	Seno	Chuno	Tono	Hida	Hokusei	Chusei	Nansei	Iga	Hgashi-kishu	Export to the ROJ	Export, International	Total
1	Nagoya	53.0	17.9	9.8	7.7	2.6	2.9	3.1	2.4	1.3	3.4	2.6	2.1	3.3	1.1	13.7	14.0	16.9
2	Owari	12.2	39.0	11.6	8.7	5.0	5.1	5.8	4.0	1.9	4.6	3.8	2.3	4.0	1.3	22.6	16.2	16.6
3	Nishi-mikawa	3.7	6.5	40.5	16.0	3.1	3.1	4.8	2.9	1.5	6.1	0.0	2.3	3.8	1.2	22.9	38.9	17.0
4	Higashi-mikawa	1.2	1.8	3.8	34.7	0.7	0.8	1.0	0.8	0.5	1.0	1.3	1.1	1.1	0.6	8.3	11.8	5.6
5	Gifu	0.6	0.7	0.8	0.4	58.6	12.5	9.3	7.0	4.8	0.3	0.4	0.1	0.2	0.1	3.5	1.0	3.7
6	Seno	0.4	0.5	0.6	0.4	3.8	43.6	4.9	4.3	2.5	0.3	0.2	0.1	0.2	0.1	2.3	1.5	1.9
7	Chuno	0.6	0.8	0.7	1.0	3.3	3.8	40.7	5.7	3.0	0.3	0.2	0.2	0.3	0.1	2.6	1.9	2.1
8	Tono	0.2	0.3	0.4	0.3	1.3	2.3	3.8	48.3	2.1	0.1	0.1	0.1	0.1	0.1	1.8	0.8	1.4
9	Hida	0.1	0.1	0.1	0.1	1.1	1.6	2.2	2.1	57.5	0.1	0.1	0.1	0.1	0.1	0.7	0.2	0.7
10	Hokusei	2.1	2.4	2.9	1.9	0.5	1.2	0.7	0.5	0.3	39.6	8.1	7.6	7.5	8.4	12.1	8.5	7.2
11	Chusei	0.4	0.5	0.6	0.5	0.2	0.3	0.3	0.2	0.2	3.1	39.9	5.4	4.0	3.7	5.0	3.1	2.9
12	Nansei	0.2	0.2	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.9	2.6	40.9	1.3	2.2	2.0	0.9	1.2
13	Iga	0.3	0.3	0.4	0.3	0.1	0.1	0.1	0.1	0.0	0.9	1.2	1.0	34.1	1.1	2.3	1.0	1.1
14	Hgashi-kishu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.8	0.6	1.8	44.4	0.3	0.1	0.4
15	The Rest of Japan	18.6	19.8	21.2	21.3	14.5	16.4	17.1	16.1	19.1	28.8	27.7	25.7	28.1	27.6	0.0	0.0	15.6
16	Import	6.3	9.1	6.4	6.5	5.0	6.1	6.1	5.5	5.1	10.0	11.0	10.5	10.1	8.1	0.0	0.0	5.6
17	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

	Share of the Destinations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Nagoya	Owari	Nishi-mikawa	Higashi-mikawa	Gifu	Seno	Chuno	Tono	Hida	Hokusei	Chusei	Nansei	Iga	Hgashi-kishu	Export to the ROJ	Export, International	Total
1	Nagoya	46.7	17.5	9.1	2.5	0.6	0.3	0.4	0.2	0.1	1.4	0.4	0.2	0.2	0.0	12.3	8.2	100.0
2	Owari	11.0	38.8	11.0	2.9	1.1	0.6	0.7	0.3	0.1	1.9	0.7	0.2	0.3	0.0	20.8	9.7	100.0
3	Nishi-mikawa	3.3	6.3	37.4	5.2	0.7	0.3	0.6	0.2	0.1	2.4	0.0	0.2	0.3	0.0	20.4	22.7	100.0
4	Higashi-mikawa	3.2	5.2	10.6	34.0	0.4	0.3	0.4	0.2	0.1	1.3	0.7	0.3	0.2	0.0	22.3	20.8	100.0
5	Gifu	2.5	3.3	3.2	0.7	57.1	6.2	5.1	2.8	0.9	0.5	0.3	0.0	0.1	0.0	14.5	2.8	100.0
6	Seno	3.1	4.4	5.1	1.1	7.1	41.8	5.2	3.2	0.9	1.2	0.3	0.1	0.1	0.0	18.5	8.0	100.0
7	Chuno	4.1	6.3	5.5	2.7	5.6	3.3	38.6	3.9	1.0	1.0	0.3	0.1	0.2	0.0	18.4	8.9	100.0
8	Tono	2.5	3.6	4.9	1.0	3.2	3.0	5.3	49.5	1.1	0.5	0.3	0.1	0.1	0.0	19.3	5.6	100.0
9	Hida	1.3	1.6	2.1	0.6	5.6	4.1	6.0	4.2	55.0	1.0	0.5	0.2	0.2	0.0	15.1	2.5	100.0
10	Hokusei	4.5	5.5	6.4	1.4	0.3	0.3	0.2	0.1	0.0	37.8	3.3	1.4	1.2	0.5	25.5	11.7	100.0
11	Chusei	2.1	2.6	3.4	1.0	0.3	0.2	0.2	0.1	0.0	7.4	41.1	2.5	1.5	0.6	26.2	10.6	100.0
12	Nansei	2.2	2.6	2.7	1.3	0.2	0.1	0.2	0.1	0.0	4.9	6.3	44.6	1.2	0.8	25.3	7.4	100.0
13	Iga	3.7	4.4	5.1	1.3	0.2	0.1	0.2	0.1	0.0	5.5	3.2	1.2	34.1	0.5	31.4	8.9	100.0
14	Hgashi-kishu	1.4	1.9	1.4	0.7	0.2	0.1	0.1	0.1	0.1	10.6	6.8	2.3	5.4	53.1	14.0	2.0	100.0
15	The Rest of Japan	17.8	20.8	21.3	7.5	3.3	1.9	2.2	1.5	0.8	12.6	5.3	2.2	2.0	0.8	0.0	0.0	100.0
16	Import	16.8	26.6	17.8	6.4	3.2	2.0	2.2	1.4	0.6	12.2	5.8	2.5	2.0	0.6	0.0	0.0	100.0
17	Total	14.9	16.5	15.7	5.5	3.6	1.8	2.0	1.4	0.7	6.9	3.0	1.3	1.1	0.4	15.2	9.9	100.0

Table 4 show the estimated transaction matrix among areas for all commodities. In this table, there are export and import, international and domestic with the outside of the Tokai region. The export shares and import shares are also calculated. The shaded sell means the area, whose transaction share has 5 percent and more. Looking these shares, four areas in Aichi prefecture has strong relation among them. Also there appears strong interdependence among Gifu, Seino, Chuno, and Tono areas in Gifu prefecture, though Hida area seems to have a little bit weak relation to them. In Mie prefecture, Hokusei and Chusei area has relatively strong links.

There are relatively strong relation between Owari area in Aichi prefecture and three areas in Gifu Prefecture: Gifu, Seino, and Chuno. Hokusei area in Mie prefecture and Nishi-mikawa area in Aichi prefecture are also linked.

Table 5 The estimated input-output table for Tokai region,

14 areas and one sector

Unit: 10 billion Yen

		Intermediate Demand														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Nagoya	Owari	Nishi-mikawa	Higashi-mikawa	Gifu	Seno	Chuno	Tono	Hida	Hokusei	Chusei	Nansei	Iga	Hgashi-kishu	Intermediate Demand
1	Nagoya	3994	2304	1405	349	78	51	64	31	7	248	72	24	39	3	8670
2	Owari	1509	3280	1996	501	188	104	137	62	13	342	113	28	49	5	8328
3	Nishi-mikawa	466	1100	5484	1022	125	65	119	45	10	480	1	24	45	3	8988
4	Higashi-mikawa	127	256	665	1039	26	17	23	12	4	74	33	12	12	2	2300
5	Gifu	73	112	143	28	848	162	151	59	23	13	5	1	2	0	1621
6	Seno	49	87	119	24	113	384	83	44	13	21	6	1	3	0	948
7	Chuno	67	142	135	71	99	50	350	71	16	20	7	2	4	0	1034
8	Tono	25	50	82	15	29	33	68	260	11	8	4	1	1	0	589
9	Hida	7	10	18	4	28	21	34	26	167	8	3	1	1	0	329
10	Hokusei	260	401	542	118	16	24	15	8	2	1768	132	55	57	18	3415
11	Chusei	52	75	116	32	7	8	7	4	1	197	489	47	37	9	1081
12	Nansei	16	23	31	13	2	2	2	1	0	50	55	189	12	6	403
13	Iga	28	44	60	14	3	2	2	1	0	60	30	10	166	3	424
14	Hgashi-kishu	5	7	5	2	1	0	0	0	0	40	24	7	19	62	173
15	The Rest of Japan	2157	2980	3541	1176	476	300	353	218	121	2206	784	300	315	104	15032
16	Import	782	1602	1087	373	154	114	128	75	31	577	253	94	85	15	5371
17	Intermediate Input	9617	12472	15428	4784	2194	1337	1536	918	421	6110	2012	799	848	230	58705
18	Value Added	13821	10453	8180	3025	2880	1293	1384	1035	582	3855	1977	878	696	281	50339
19	Total Input	23438	22925	23608	7809	5074	2629	2920	1953	1003	9966	3988	1677	1544	511	109044

		Final Demand																
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
		Nagoya	Owari	Nishi-mikawa	Higashi-mikawa	Gifu	Seno	Chuno	Tono	Hida	Hokusei	Chusei	Nansei	Iga	Hgashi-kishu	Export to the ROJ	Export, International	Import, Domestic and International	Output
1	Nagoya	6955	1788	723	237	51	23	23	18	5	76	33	13	12	3	2876	1932	0	23438
2	Owari	1007	5611	521	165	57	23	25	18	5	93	41	13	12	4	4767	2235	0	22925
3	Nishi-mikawa	302	393	3339	201	29	13	15	13	4	98	1	18	14	5	4819	5356	0	23608
4	Higashi-mikawa	122	153	165	1614	9	4	5	4	2	25	19	8	4	2	1744	1628	0	7809
5	Gifu	56	54	21	6	2048	153	106	80	23	15	11	1	1	0	737	140	0	5074
6	Seno	32	28	14	4	74	715	53	41	11	10	1	1	1	0	486	210	0	2629
7	Chuno	51	44	27	7	65	46	777	42	13	10	2	1	1	0	538	261	0	2920
8	Tono	23	21	14	4	34	25	36	708	9	2	1	1	0	0	377	110	0	1953
9	Hida	6	6	4	1	28	20	26	16	385	2	1	1	1	0	152	25	0	1003
10	Hokusei	184	144	93	25	9	6	4	3	1	1996	202	85	58	34	2544	1163	0	9966
11	Chusei	34	30	19	7	4	1	2	1	1	100	1151	52	25	13	1047	421	0	3988
12	Nansei	21	20	15	8	2	0	1	1	0	31	51	559	8	8	424	125	0	1677
13	Iga	30	23	19	6	1	0	1	1	0	25	19	8	361	4	485	138	0	1544
14	Hgashi-kishu	3	3	2	1	0	0	0	0	0	15	11	4	8	210	71	10	0	511
15	The Rest of Japan	1690	1530	1074	449	241	113	119	106	62	529	353	170	119	65	0	0	−21652	0
16	Import	526	473	302	126	95	41	41	35	18	371	199	98	71	34	0	0	−7800	0
17	Total	11041	10320	6353	2862	2748	1184	1232	1086	538	3398	2098	1032	697	382	21066	13755	−29453	109044

3.3 The compiled multi-regional input-output table

We divide three prefectures' IOTs with 186 sectors to fourteen areas' IOTs, and estimate the transaction flows among areas and the outside regions, domestic and international for each sector. Here we are able to combine the fourteen tables to one multi-regional IOT using the sectoral transaction flow matrices. Table 5 shows the compiled fourteen regions IOT, which is integrated one sector.

4. Comparison of output structures

In this section we integrate the multi-regional IOT with 14 areas and 186 sectors for each area to that with 14 areas and 40 sectors, and discuss about the characteristics of the output structures in Table 6, 7, and 8. Those tables have the sectoral outputs and the revealed comparative advantage (RCA) indices of output.

Table 6 shows that Nagoya City has the relative advantage in “Information and communications,” “Commerce,” “Finance and insurance,” “Real estate,” and “Business services,” that are strongly related to the core industries in the metropolitan area. On the other hand, Owari area has the advantage in “Petroleum and coal products,” “Pottery, china and earthenware,” “Aircrafts and repair of air crafts,” and “Miscellaneous manufacturing products.” Nishi-mikawa area, where there are the headquarter office and factories of Toyota Motor Co. and the group companies, has the advantage in ”Information and communication electronics equipment,” “Electronic components,” and “Motor vehicle.” Higashi-mikawa area has the advantage in “Agriculture,” “Motor Vehicle,” “Other transportation equipment,” and “Precision instruments.”

Table 7 shows the output structures of five areas in Gifu prefecture. Gifu area, where the capital city of Gifu prefecture is located, has strong industries in ”Aircrafts and repair of air crafts,” and “Textile products.” Historically textile industries were in prosperity. Seino area, located west of Gifu area, has the advantage in the manufacturing industries as “Other Ceramic, stone and clay products,” “Metal products,” “Electrical machinery,” “Precision instruments,” “Textile products,” and “Plastic products” in addition to the ”Mining.” Tono area, in the east part of Gifu prefecture, has advantage in the manufacturing industries like “Pulp, paper and wooden products,” “Metal products,” “General machinery,” and “Information and communication electronics equipment,” with “Forestry.” On the other hand, Hida area, located in northern part of Gifu prefecture and having much nature resources, has superiority in ”Forestry,” “Fishery,” “Mining,” ”Pulp, paper and wooden products,” and ”Electricity, gas and heat supply,” that generates by the hydropower stations.

Table 6 Output Structure of Aichi Prefecture

		Output(10 Billion Yen)					Revealed Comaprative Advantage			
		Nagoya	Owari	Nishi-mikawa	Higashi-mikawa	Aichi Pref.	Nagoya	Owari	Nishi-mikawa	Higashi-mikawa
01	Agriculture	12.7	103.9	63.4	192.9	372.9	0.090	0.758	0.449	4.133
02	Forestry	0.0	0.5	2.5	3.0	6.1	0.004	0.045	0.221	0.801
03	Fishery	0.0	20.5	8.4	4.4	33.3	0.000	0.940	0.371	0.589
04	Mining	0.5	5.4	9.9	5.6	21.5	0.035	0.363	0.647	1.110
05	Beverages and Foods	388.4	936.9	426.9	217.8	1,970.0	0.609	1.503	0.665	1.026
06	Textile products	48.3	196.6	149.2	91.3	485.5	0.298	1.242	0.915	1.694
07	Pulp, paper and wooden products	94.1	506.4	103.7	91.6	795.7	0.310	1.705	0.339	0.905
08	Chemical products	192.4	609.1	182.2	82.2	1,065.9	0.338	1.093	0.317	0.433
09	Petroleum and coal products	6.6	474.4	32.5	4.5	518.1	0.019	1.363	0.091	0.038
10	Plastic products	145.6	702.3	483.7	271.3	1,603.0	0.297	1.462	0.978	1.658
11	Pottery, china and earthenware	39.3	185.3	7.4	3.4	235.4	0.459	2.213	0.086	0.118
12	Other Ceramic, stone and clay products	72.7	305.6	143.4	45.9	567.6	0.311	1.337	0.609	0.590
13	Iron and steel	282.1	1,653.6	555.1	179.5	2,670.2	0.455	2.724	0.888	0.868
14	Non-ferrous metals	200.3	121.7	93.7	117.8	533.5	0.923	0.574	0.429	1.630
15	Metal products	252.5	695.2	321.4	102.3	1,371.4	0.583	1.641	0.737	0.709
16	General machinery	802.1	1,744.3	956.0	204.5	3,707.0	0.698	1.553	0.826	0.535
17	Electrical machinery	262.8	693.1	417.2	154.3	1,527.4	0.501	1.352	0.790	0.884
18	Information and communication electronics equipment	24.9	282.1	629.4	46.3	982.7	0.077	0.894	1.937	0.431
19	Electronic components	13.6	283.2	706.0	25.7	1,028.5	0.025	0.538	1.303	0.143
20	Motor vehicle	415.6	1,631.1	11,175.1	2,681.3	15,903.0	0.104	0.416	2.768	2.008
21	Aircrafts and repair of air crafts	121.2	188.6	0.1	0.1	309.9	1.170	1.860	0.001	0.002
22	Other Transportation equipment	33.8	120.0	164.1	122.9	440.8	0.298	1.082	1.437	3.253
23	Precision instruments	13.1	47.5	86.9	70.6	218.1	0.241	0.895	1.592	3.910
24	Miscellaneous manufacturing products	116.7	807.8	283.8	196.1	1,404.4	0.277	1.960	0.669	1.397
25	Construction	1,369.5	1,304.3	804.9	346.3	3,824.9	1.066	1.038	0.622	0.809
26	Electricity, gas and heat supply	479.0	491.6	251.2	84.8	1,306.6	1.133	1.189	0.590	0.603
27	Water supply and waste disposal business	101.7	223.0	110.6	44.7	480.0	0.658	1.475	0.711	0.868
28	Commerce	5,691.7	1,467.1	1,016.3	428.4	8,603.5	2.501	0.659	0.443	0.565
29	Finance and insurance	1,203.0	517.3	413.8	243.2	2,377.3	1.631	0.717	0.557	0.990
30	Real estate	1,975.1	1,276.4	726.1	345.8	4,323.4	1.495	0.988	0.546	0.786
31	Transport	1,239.3	1,116.4	342.2	167.2	2,865.0	1.475	1.358	0.404	0.597
32	Information and communications	1,918.1	160.6	115.5	71.3	2,265.5	3.046	0.261	0.182	0.340
33	Public administration	406.7	401.2	228.1	125.2	1,161.3	1.022	1.030	0.569	0.944
34	Education and research	679.0	814.1	764.7	219.2	2,477.0	0.971	1.190	1.085	0.941
35	Medical service, health, social security and nursing care	1,060.1	898.5	477.0	255.8	2,691.4	1.181	1.023	0.528	0.855
36	Other public services	92.9	58.5	34.8	23.2	209.3	1.069	0.689	0.397	0.801
37	Business services	2,263.8	848.6	679.4	222.9	4,014.7	2.104	0.806	0.627	0.622
38	Personal services	1,303.9	932.8	547.1	283.1	3,067.0	1.354	0.990	0.564	0.882
39	Office supplies	44.1	30.9	24.2	8.8	108.0	1.282	0.918	0.700	0.769
40	Activities not elsewhere classified	70.5	68.4	70.5	23.4	232.7	0.849	0.842	0.844	0.846
41	Total of intermediate sectors	23,437.8	22,924.7	23,608.5	7,808.5	77,779.5	1.000	1.000	1.000	1.000

Table 7 Output Structure of Gifu Prefecture

		Output(10 Billion Yen)						Revealed Comaprative Advantage				
		Gifu	Seino	Chuno	Tono	Hida	Gifu Pref.	Gifu	Seino	Chuno	Tono	Hida
01	Agriculture	30.6	29.6	25.7	26.6	25.3	137.7	1.008	1.881	1.474	2.275	4.221
02	Forestry	4.0	0.1	8.1	1.4	14.5	28.1	1.637	0.072	5.773	1.448	29.929
03	Fishery	0.6	1.6	0.8	0.2	2.1	5.3	0.121	0.642	0.289	0.105	2.182
04	Mining	4.7	13.0	1.0	8.2	2.2	29.2	1.435	7.645	0.532	6.454	3.418
05	Beverages and Foods	148.4	104.7	41.3	31.2	36.1	361.7	1.076	1.464	0.520	0.587	1.322
06	Textile products	107.6	69.7	22.3	2.8	3.7	206.1	3.069	3.839	1.104	0.209	0.536
07	Pulp, paper and wooden products	82.5	47.5	173.7	88.7	45.8	438.2	1.255	1.393	4.593	3.503	3.528
08	Chemical products	192.9	55.7	22.6	17.2	11.4	300.0	1.565	0.872	0.318	0.363	0.470
09	Petroleum and coal products	2.3	1.5	2.4	1.1	1.0	8.4	0.030	0.038	0.055	0.036	0.067
10	Plastic products	71.7	144.9	92.0	62.3	4.2	375.1	0.675	2.629	1.503	1.523	0.199
11	Pottery, china and earthenware	0.8	10.2	14.2	114.3	2.1	141.7	0.044	1.065	1.332	16.020	0.584
12	Other Ceramic, stone and clay products	52.2	102.5	28.1	39.1	9.4	231.4	1.032	3.910	0.967	2.011	0.944
13	Iron and steel	34.0	8.0	57.0	21.3	1.0	121.3	0.253	0.115	0.738	0.412	0.039
14	Non-ferrous metals	16.0	19.6	13.8	18.3	21.9	89.6	0.341	0.804	0.509	1.014	2.361
15	Metal products	67.7	108.0	165.4	31.6	8.9	381.6	0.722	2.222	3.065	0.875	0.480
16	General machinery	136.9	136.6	326.4	73.6	17.1	690.6	0.551	1.060	2.282	0.769	0.348
17	Electrical machinery	28.2	65.8	54.3	121.8	0.4	270.5	0.248	1.119	0.832	2.788	0.020
18	Information and communication electronics equipment	2.2	5.0	205.1	49.3	8.0	269.5	0.031	0.137	5.105	1.833	0.577
19	Electronic components	1.6	228.7	30.7	18.0	8.5	287.5	0.014	3.788	0.458	0.401	0.369
20	Motor vehicle	295.1	120.9	297.8	67.3	20.6	801.7	0.340	0.269	0.597	0.201	0.120
21	Aircrafts and repair of air crafts	142.9	6.9	5.0	0.8	0.0	155.5	6.370	0.595	0.384	0.088	0.000
22	Other Transportation equipment	12.0	6.0	1.1	0.0	0.1	19.2	0.489	0.469	0.079	0.002	0.015
23	Precision instruments	3.7	0.9	7.6	15.8	0.0	27.9	0.312	0.148	1.128	3.490	0.000
24	Miscellaneous manufacturing products	63.8	64.5	38.0	18.5	20.8	205.7	0.699	1.365	0.725	0.526	1.156
25	Construction	417.0	194.2	201.3	158.7	88.5	1,059.6	1.499	1.347	1.257	1.482	1.609
26	Electricity, gas and heat supply	39.3	37.8	78.4	26.1	91.5	273.1	0.429	0.797	1.490	0.741	5.062
27	Water supply and waste disposal business	45.0	19.2	20.2	16.4	11.1	112.0	1.346	1.110	1.051	1.271	1.686
28	Commerce	599.5	166.5	135.5	159.9	79.4	1,140.8	1.217	0.652	0.478	0.843	0.816
29	Finance and insurance	245.3	98.6	75.2	73.8	58.6	551.6	1.536	1.191	0.819	1.201	1.855
30	Real estate	355.9	167.8	171.8	163.5	75.1	934.1	1.245	1.132	1.044	1.486	1.328
31	Transport	181.8	88.8	56.9	74.0	34.7	436.2	0.999	0.942	0.544	1.057	0.966
32	Information and communications	251.9	38.6	12.4	16.9	10.5	330.3	1.848	0.547	0.158	0.321	0.392
33	Public administration	190.9	52.5	58.1	50.6	35.1	387.2	2.214	1.175	1.172	1.526	2.062
34	Education and research	219.0	71.2	89.4	68.4	29.1	477.2	1.446	0.908	1.027	1.174	0.973
35	Medical service, health, social security and nursing care	363.5	135.2	136.7	107.0	62.4	804.9	1.870	1.342	1.223	1.431	1.626
36	Other public services	39.6	21.4	16.8	10.1	9.7	97.6	2.109	2.197	1.553	1.394	2.608
37	Business services	295.0	72.2	73.4	68.1	48.4	557.0	1.267	0.598	0.547	0.760	1.051
38	Personal services	290.7	96.3	139.2	116.4	96.2	738.9	1.394	0.891	1.160	1.449	2.334
39	Office supplies	9.8	4.5	4.7	3.8	1.9	24.7	1.314	1.162	1.100	1.330	1.279
40	Activities not elsewhere classified	27.2	12.8	14.8	10.2	5.2	70.1	1.514	1.370	1.428	1.473	1.451
41	Total of intermediate sectors	5,073.8	2,629.5	2,919.5	1,953.0	1,002.9	13,578.7	1.000	1.000	1.000	1.000	1.000

Table 8 shows the output structures of five areas in Mie prefecture. Hokusei area, the northern parts of Mie prefecture and next to Owari area, has the advantage in the industries of "Chemical products," "Petroleum and coal products," "Iron and steel," "Non-ferrous metals," "Information and communication electronics equipment," and "Motor vehicle." Contrarily, Chusei area, located in the central part of Mie prefecture, not only the manufacturing industries like "Electronic components," "Miscellaneous manufacturing products," and "Other Ceramic, stone and clay products," but also the tertiary sectors as "Information and communications," and "Public administration," are observed to have the relative advantage. In Nansei area, "Aircrafts and repair of air crafts" sector is one of the competitive industries, though the production of this sector is not so large. "Fishery" is also large sector in this area. Iga area, the inner part of Mie prefecture, is relatively close to Kansai region and has prosperity in "Pottery, china and earthenware," "Plastic products," "Pulp, paper and wooden products," and "General machinery." In Higashi-kishu area, "Forestry," and "Fishery" sectors have relative advantage, and relatedly "Pulp, paper and wooden products" sector has relatively larger production. In this area there are thermal power plants, so the production of "Electricity, gas and heat supply" sector is also large.

Table 8 Output Structure of Mie Prefecture

		Output(10 Billion Yen)						Revealed Comaprative Advantage				
		Hokusei	Chusei	Nansei	Iga	Higashi-kishu	Mie Pref.	Hokusei	Chusei	Nansei	Iga	Higashi-kishu
01	Agriculture	58.0	42.0	18.1	15.5	7.7	141.2	0.973	1.760	1.806	1.679	2.522
02	Forestry	4.5	6.2	2.4	0.8	4.6	18.5	0.935	3.235	2.901	1.106	18.525
03	Fishery	7.7	4.8	41.4	0.3	11.3	65.3	0.807	1.257	25.899	0.184	23.103
04	Mining	7.8	1.0	6.4	4.1	0.8	20.1	1.202	0.387	5.903	4.089	2.512
05	Beverages and Foods	294.8	170.4	73.1	77.4	18.2	633.9	1.088	1.571	1.602	1.843	1.310
06	Textile products	35.6	17.5	3.4	4.5	0.4	61.5	0.518	0.636	0.297	0.425	0.121
07	Pulp, paper and wooden products	46.9	38.7	7.0	49.9	36.5	179.0	0.363	0.749	0.323	2.495	5.506
08	Chemical products	1,088.5	46.2	15.4	134.1	0.0	1,284.2	4.494	0.476	0.378	3.575	0.000
09	Petroleum and coal products	1,123.3	0.4	1.0	3.7	0.6	1,128.9	7.425	0.006	0.038	0.157	0.072
10	Plastic products	167.7	40.1	3.8	91.5	4.0	307.0	0.803	0.479	0.107	2.828	0.376
11	Pottery, china and earthenware	10.3	0.7	1.8	8.5	0.0	21.3	0.282	0.045	0.296	1.512	0.020
12	Other Ceramic, stone and clay products	128.4	128.1	3.5	24.9	3.0	288.0	1.293	3.221	0.212	1.618	0.592
13	Iron and steel	78.7	6.8	2.2	8.1	0.2	96.0	0.298	0.065	0.050	0.197	0.014
14	Non-ferrous metals	296.2	64.1	2.0	23.7	0.0	386.0	3.211	1.738	0.129	1.659	0.000
15	Metal products	110.5	68.3	39.0	43.3	1.2	262.4	0.600	0.927	1.258	1.517	0.126
16	General machinery	522.6	90.0	79.5	253.0	0.1	945.3	1.070	0.460	0.968	3.346	0.004
17	Electrical machinery	400.6	119.2	59.6	57.7	3.2	640.3	1.798	1.336	1.591	1.673	0.277
18	Information and communication electronics equipment	211.9	4.4	29.0	0.6	2.5	248.4	1.545	0.080	1.255	0.028	0.357
19	Electronic components	373.6	699.6	97.0	11.2	6.1	1,187.4	1.633	7.641	2.518	0.315	0.517
20	Motor vehicle	1,659.1	175.8	22.6	86.2	0.3	1,943.9	0.973	0.258	0.079	0.326	0.003
21	Aircrafts and repair of air crafts	2.0	0.0	14.7	0.0	0.0	16.7	0.045	0.000	1.986	0.000	0.000
22	Other Transportation equipment	10.5	36.7	19.6	0.5	0.1	67.5	0.219	1.901	2.417	0.069	0.058
23	Precision instruments	2.8	1.6	1.0	0.7	0.0	6.2	0.123	0.178	0.260	0.198	0.000
24	Miscellaneous manufacturing products	103.1	97.9	83.6	61.8	4.0	350.4	0.575	1.366	2.772	2.228	0.434
25	Construction	503.5	295.4	138.7	93.0	64.4	1,094.9	0.921	1.351	1.508	1.098	2.296
26	Electricity, gas and heat supply	156.4	53.9	85.0	7.7	83.6	386.6	0.870	0.749	2.810	0.276	9.073
27	Water supply and waste disposal business	60.1	32.5	16.7	12.5	5.3	127.1	0.915	1.234	1.506	1.224	1.582
28	Commerce	393.3	258.4	103.2	62.7	26.6	844.0	0.406	0.667	0.634	0.418	0.535
29	Finance and insurance	185.8	185.5	69.1	35.4	27.6	503.4	0.592	1.478	1.309	0.729	1.713
30	Real estate	373.9	244.8	134.9	83.3	51.7	888.7	0.666	1.089	1.427	0.958	1.794
31	Transport	350.2	125.8	76.2	43.2	12.2	607.7	0.980	0.880	1.268	0.781	0.668
32	Information and communications	93.4	164.7	33.5	16.5	25.5	333.6	0.349	1.537	0.744	0.397	1.855
33	Public administration	87.2	128.9	45.4	25.0	17.4	303.9	0.515	1.903	1.592	0.954	2.003
34	Education and research	143.9	86.2	38.2	24.1	7.2	299.6	0.484	0.724	0.763	0.523	0.472
35	Medical service, health, social security and nursing care	291.7	189.4	99.4	66.0	33.8	680.3	0.764	1.240	1.548	1.116	1.726
36	Other public services	29.4	38.8	14.3	8.7	5.8	97.1	0.796	2.625	2.307	1.528	3.068
37	Business services	204.0	128.4	50.7	33.7	16.2	433.1	0.446	0.701	0.659	0.476	0.691
38	Personal services	294.3	166.0	132.2	58.6	24.9	676.0	0.718	1.013	1.918	0.924	1.183
39	Office supplies	12.7	7.7	3.3	2.6	0.9	27.3	0.870	1.315	1.343	1.160	1.249
40	Activities not elsewhere classified	40.6	21.6	9.2	8.6	3.4	83.3	1.150	1.527	1.543	1.576	1.862
41	Total of intermediate sectors	9,965.6	3,988.2	1,677.0	1,543.7	511.3	17,685.8	1.000	1.000	1.000	1.000	1.000

5. Some Applications

5.1. Interregional impacts of the Motor Vehicle Sector on the Value Added

In this section, we discuss the interregional impacts of the motor vehicle sector, calculating the induced value added, by sector and region, of one-unit increase of the motor vehicle sector's final demand for each area. Tokai inter-regional IOT with 40 sectors by 14 areas are used. Table 9 shows the results. Nagoya, Owari, and Nishi-mikawa are the areas where the motor vehicle sector is concentrated. The headquarter office of Toyota Motors Co. is located in Nishi-mikawa area. We observe that those areas gains relatively high share in the value added. Gifu area in Gifu prefecture and Hokusei area in Mie prefecture obtain also high share in the Value added. The factory of Honda Motor Co. is located in Hokusei area.

Table 9 Induced VA and Import of One-Unit increase of Final Demand, Motor Vehicle sector

	Aichi Prefecture				Gifu Prefecture					Mie Prefecture					The Rest of Japan	Import	Total
	Nagoya	Owari	Nishi-mikawa	Higashi-mikawa	Gifu Prefecture	Seno	Chuno	Tono	Hida	Hokusei	Chusei	Nansei	Iga	Higashi-kishu			
Nagoya	0.333	0.093	0.091	0.014	0.008	0.005	0.012	0.003	0.001	0.017	0.004	0.001	0.002	0.000	0.321	0.094	1.000
Owari	0.090	0.324	0.099	0.016	0.008	0.005	0.012	0.003	0.001	0.016	0.004	0.001	0.002	0.000	0.323	0.094	1.000
Nishi-mikawa	0.071	0.073	0.349	0.022	0.007	0.005	0.006	0.003	0.001	0.019	0.005	0.001	0.002	0.000	0.340	0.095	1.000
Higashi-mikawa	0.062	0.068	0.130	0.238	0.006	0.005	0.010	0.003	0.001	0.015	0.005	0.002	0.002	0.000	0.356	0.097	1.000
Gifu	0.052	0.073	0.113	0.017	0.284	0.018	0.022	0.007	0.004	0.009	0.003	0.001	0.001	0.000	0.296	0.100	1.000
Seino	0.052	0.070	0.101	0.015	0.042	0.288	0.016	0.008	0.005	0.008	0.003	0.001	0.001	0.000	0.292	0.098	1.000
Chuno	0.051	0.068	0.102	0.015	0.037	0.014	0.287	0.015	0.007	0.008	0.003	0.001	0.001	0.000	0.296	0.096	1.000
Tono	0.049	0.063	0.108	0.015	0.026	0.013	0.028	0.286	0.008	0.008	0.002	0.001	0.001	0.000	0.297	0.095	1.000
Hida	0.036	0.046	0.085	0.013	0.024	0.011	0.021	0.012	0.291	0.006	0.002	0.001	0.001	0.000	0.368	0.083	1.000
Hokusei	0.052	0.056	0.099	0.015	0.003	0.003	0.004	0.002	0.001	0.275	0.019	0.005	0.007	0.002	0.352	0.107	1.000
Chuseu	0.045	0.055	0.027	0.021	0.002	0.002	0.004	0.001	0.001	0.037	0.276	0.008	0.009	0.002	0.416	0.094	1.000
Nansei	0.042	0.042	0.071	0.017	0.002	0.002	0.003	0.001	0.001	0.036	0.032	0.254	0.009	0.002	0.387	0.097	1.000
Iga	0.048	0.046	0.073	0.013	0.003	0.002	0.003	0.001	0.001	0.034	0.020	0.005	0.271	0.004	0.377	0.098	1.000
h¥Higashi-kishu	0.034	0.037	0.061	0.014	0.002	0.002	0.003	0.001	0.001	0.044	0.029	0.010	0.013	0.236	0.421	0.093	1.000

Figure 2 draws the geographical diffusion of the induced value added for one-unit increase of the motor vehicle sector in Nishi-mikawa area. Nishi-mikawa area has the highest contribution in the value added. Owari area, that is adjacent to Nishi-mikawa area, receives relatively higher value added, then another neighboring Higashi-mikawa area and Hokusei area in Mie prefecture follow it. Gifu, Seino and Chuno in Gifu prefecture and Chusei in Mie prefecture receives some gains, though the induced value added for each is not so much. Roughly speaking, the gains in value added are inversely correlated the distance from the Nishi-mikawa area.

Figure 3 shows the similar geographical diffusion for one-unit increase of the motor vehicle sector in Hokusei area, which is one of integrated areas of the motor vehicle industry. Hokusei area is connected strongly to Nagoya, Owari, and Nishi-mikawa, where many motor vehicle industries are located. However, it has little economic connection to areas in Gifu prefecture, at least via the motor vehicle industry.

The similar geographical diffusion for one-unit increase of the motor vehicle sector in Gifu area appears in Figure 4. In this case, Nishi-mikawa area gains the highest among the neighboring areas, and Owari and Nagoya follow it. Chono, Seino, and Higashi-mikawa obtain some gains. Tono and Hokusei have a little share. Gifu area is connected Nishi-mikawa area stronger than the adjoined areas. Also we are able to observe the relation with Hokusei area in Mie prefecture, which is asymmetrical to the case of Figure 3.

Figure 2 Geographical diffusion of the induced value added,
motor vehicle sector in Nishi-mikawa area

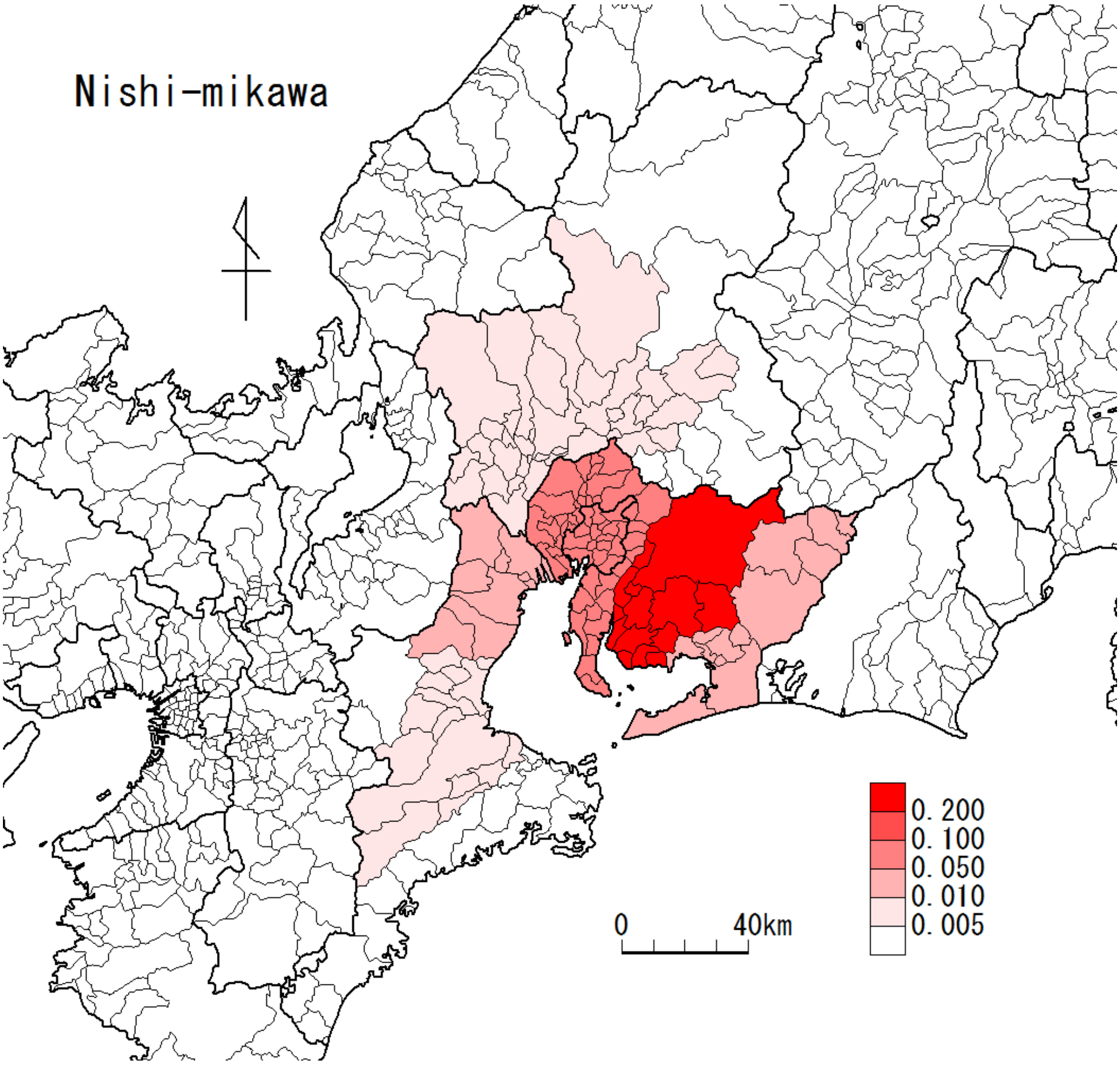


Figure 3 Geographical diffusion of the induced value added,
motor vehicle sector in Hokusei area

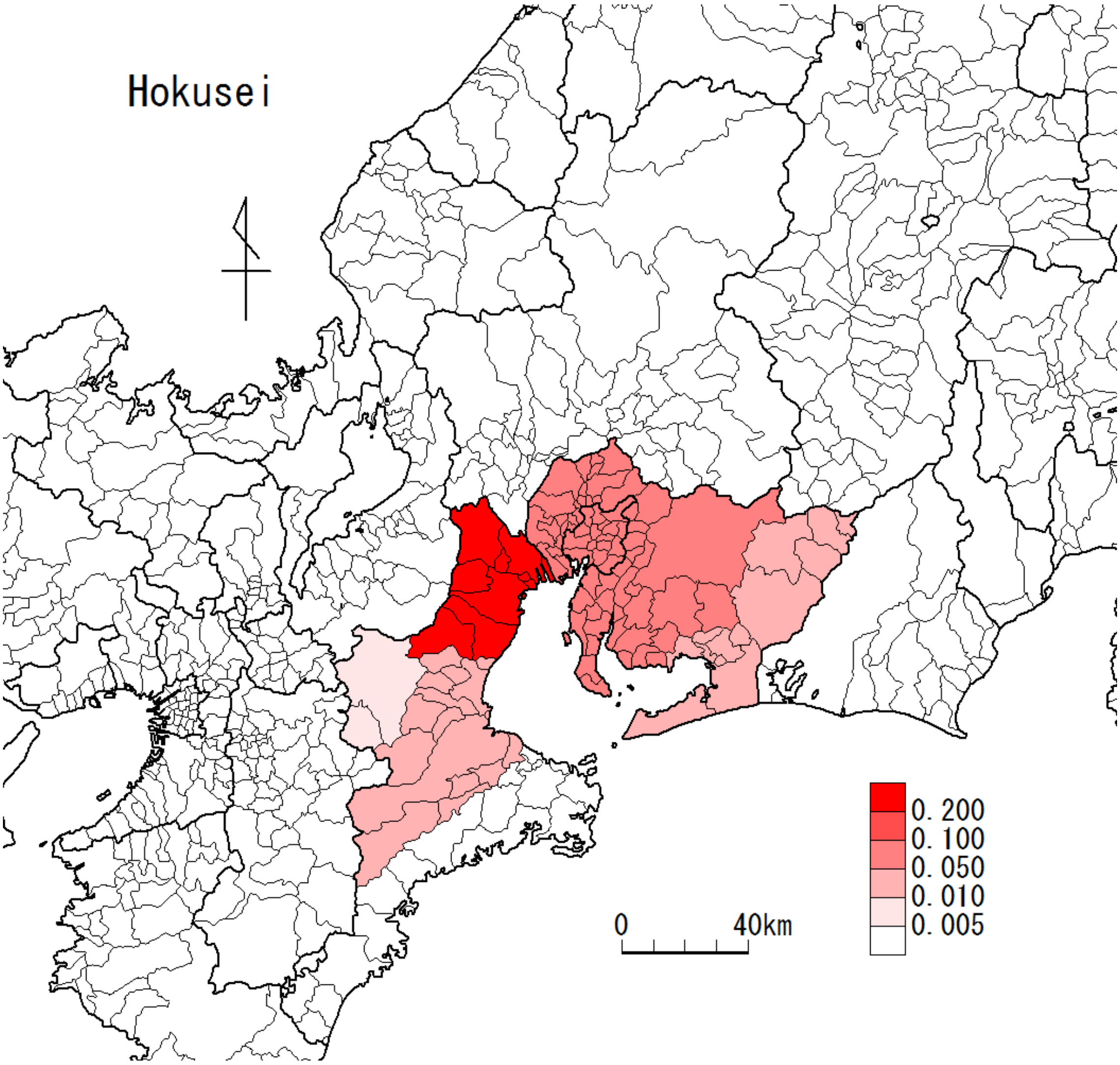
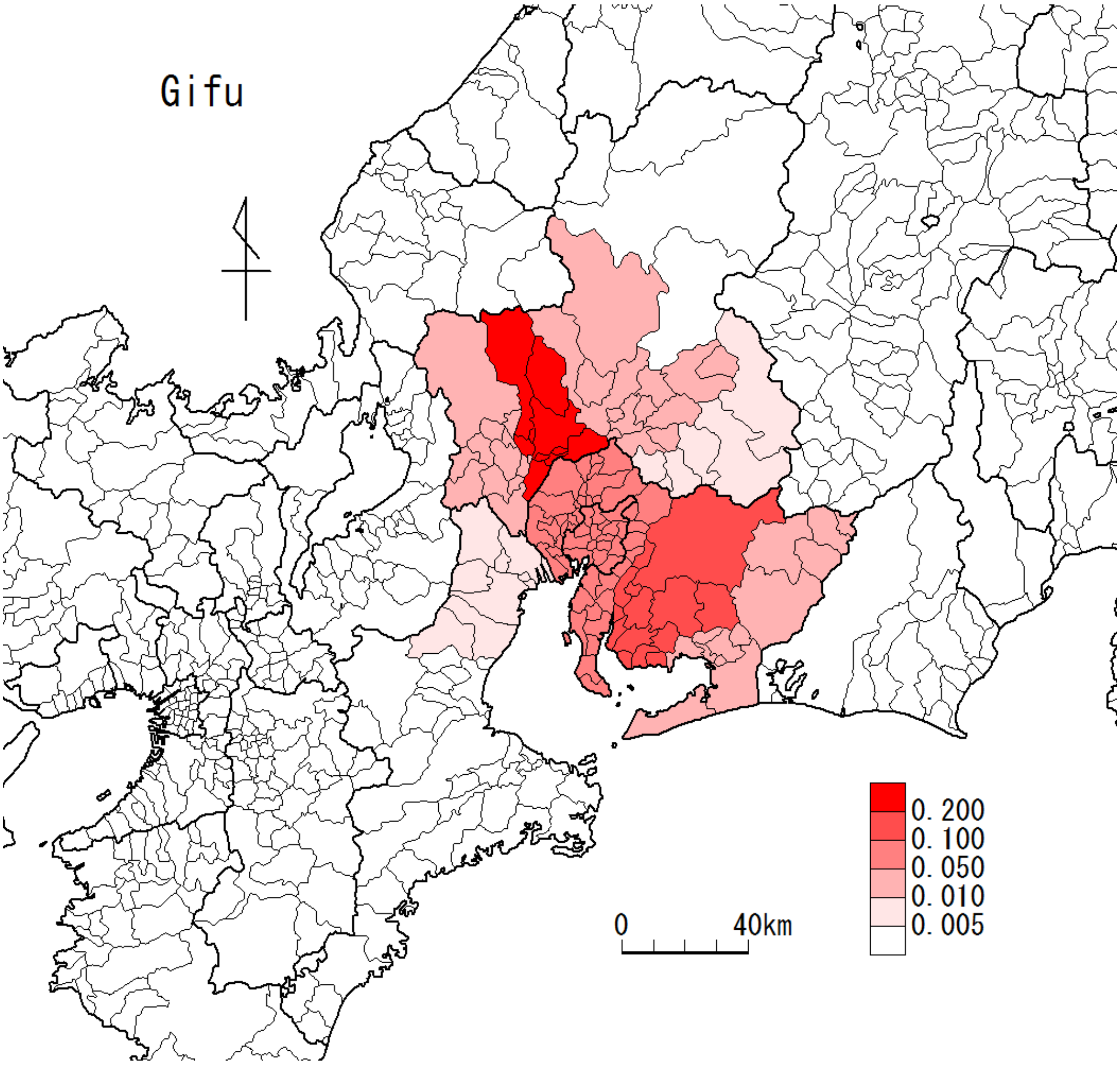


Figure 4 Geographical diffusion of the induced value added, motor vehicle sector in Gifu area



5.2 Average Propagation Lengths

The Average Propagation Lengths (APL) index, developed by Dietzenbacher at al. (2005), is used to measure the economic distances between industries. This index is defined as follows.

When we express the Leontief inverse matrix $\mathbf{L}$ for the standard Leontief quantity model is denoted as follows,

$$\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1} = \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \cdots$$

where $\mathbf{A}$ means the input coefficient matrix of the model, the overall indirect effects is expressed as

$$\mathbf{L - I = A + A^2 + A^3 + A^4 + \cdots}.$$

On the other hand, we can define the weighted sum of the intermediate input, with the number of each diffusion stage as the weight, as follows.

$$\mathbf{\Phi = A + 2A^2 + 3A^3 + 4A^4 + \cdots = L(L - 1)}$$

Then the average propagation lengths (APL) $\mathbf{APL_{ij}}$ from the j-th sector to i-th sector in the model is defined as

$$\mathbf{APL_{ij} = [L(L - I)]_{ij} / [L - I]_{ij}}$$

where $\mathbf{[L - I]_{ij}}$ denotes the i-j element of the matrix $\mathbf{L - I}$.

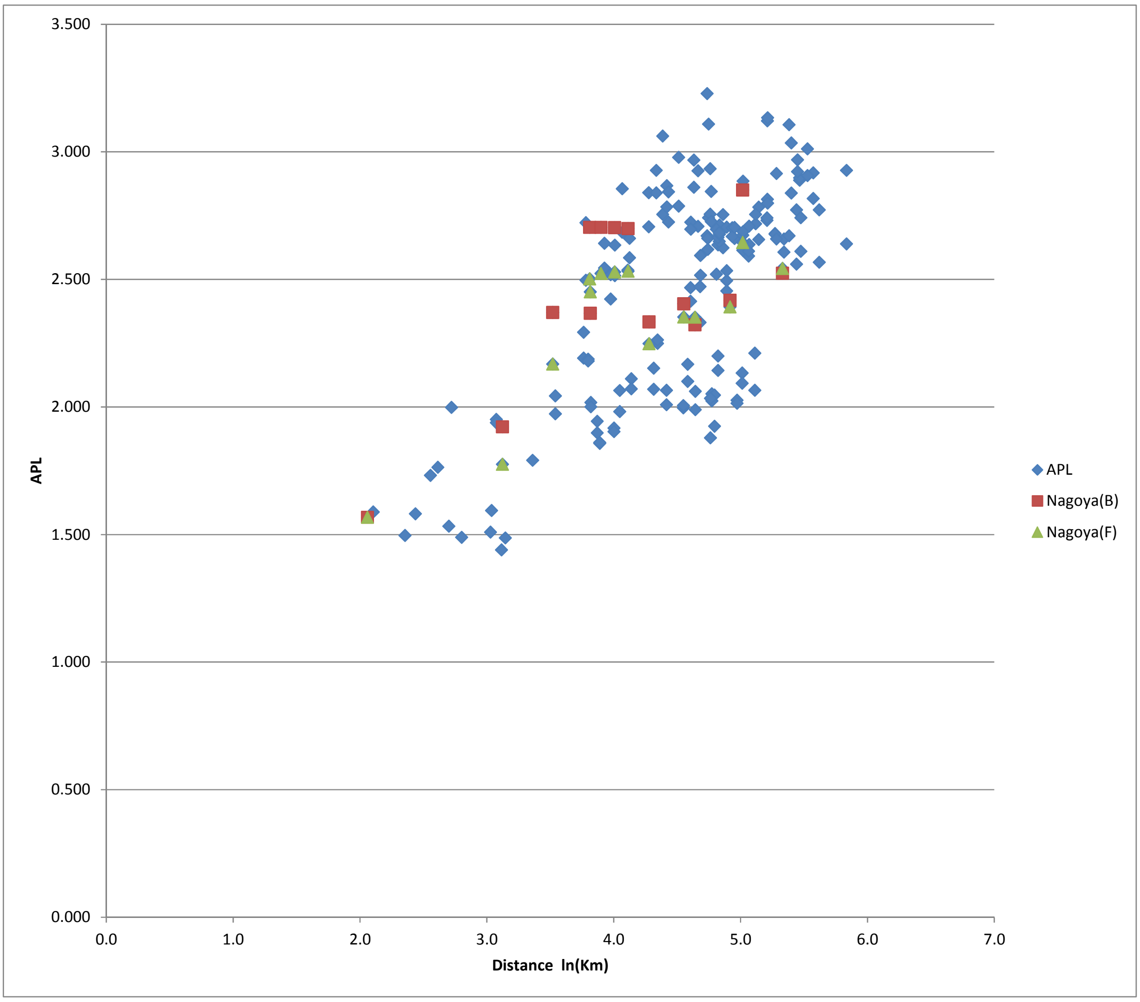
Calculated the APL from the j to i for the model with 40 sectors for each of 14 areas, we have integrate them as the index form r-th area to s-th area, $\mathbf{APL^{rs}}$,

$$\mathbf{APL^{rs}} = \sum_{i \in r} \sum_{j \in s} \mathbf{v_i^r APL_{ij} f_j^s},$$

where $\mathbf{v_i^r}$ is the share vector of the value added in region r and $\mathbf{f_j^s}$ is the share vector of the final demand in region s. The APL index is usually interpreted the distance between industries, as originally Diezenbacher et al. (2005) applied to a regional IOT. Here we are able to obtain APL with respect to the regions, and examine it as the index to measure the spatial distance. The regional comparison of the APL index appears in the analysis using international input-output model (Dietzenbacher et al.(2007)). However, we compare the APL with respect to areas to the geographical distance to measure the relation between the core city and the surrounding areas in the multi-regional IOT.

Figure 5 show the relation between the average propagation Lengths and the logarithm of the geographical distance. The positive relation is observed with the correlation coefficient 0.681. The triangle points in Figure 5 denotes the APL distance of Nagoya City to the other areas in forward direction, and the square points shows those in backward direction. Both show that the APL distance of Nagoya City becomes larger as the geographical distance becomes longer. The area cross to Nagoya City has deeper connection with Nagoya City and the transaction between them becomes higher, which makes the APL distance lower.

Figure 5 The Average Propagation Lengths and the Distance



We estimate the regression of the APL on the logarithm of the distance with some prefectural dummies from 196 samples. The estimated equation is

$$APL^{rs} = \alpha + \beta \ln(\mathrm{D}^{rs}) + \gamma_G^F D_G^F + \gamma_G^B D_G^B$$

$$+\gamma_M^F D_M^F + \gamma_G^B D_G^B + \gamma_N^F D_N^F + \gamma_N^B D_N^B ,$$

where D^{rs} is the geographical distance between r and s. D_G^F and D_G^B denote the dummy variables of Gifu prefecture, in the forward direction and the backward direction respectively. D_M^F and D_M^B are also the dummy variables for Mie prefecture, and D_N^F and D_N^B are for Nagoya City. The estimated results are shown in Table 10. The relation is significant in the sense of relatively high determinant coefficient, 0.5706. The APL index is positively correlated to the logarithm of the geographical distance. Among the prefectural dummy variables, the Dummy of Gifu prefecture in the forward direction is not significant, though the others are significant. The prefectural dummies are negative, which means that the industries of Aichi prefecture are concentrated more crossly than the other two prefectures. Nagoya Dummy is also not significant, which means there is no difference to Aichi prefecture.

Table 10 Regression result of the APL on the logarithm of the distance

Dependent Variable: APL

Method: Least Squares

Sample: 1 196

Included observations: 196

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.907905	0.124932	7.267164	0.0000
LOG(DISTANCE)	0.403806	0.026481	15.24903	0.0000
GIFUF	-0.078902	0.052282	-1.509181	0.1329
GIFUB	-0.170883	0.052282	-3.268515	0.0013
MIEF	-0.202266	0.052698	-3.838196	0.0002
MIEB	-0.280918	0.052698	-5.330704	0.0000
NAGOYAF	-0.063877	0.082821	-0.771270	0.4415
NAGOYAB	-0.029044	0.082821	-0.350683	0.7262

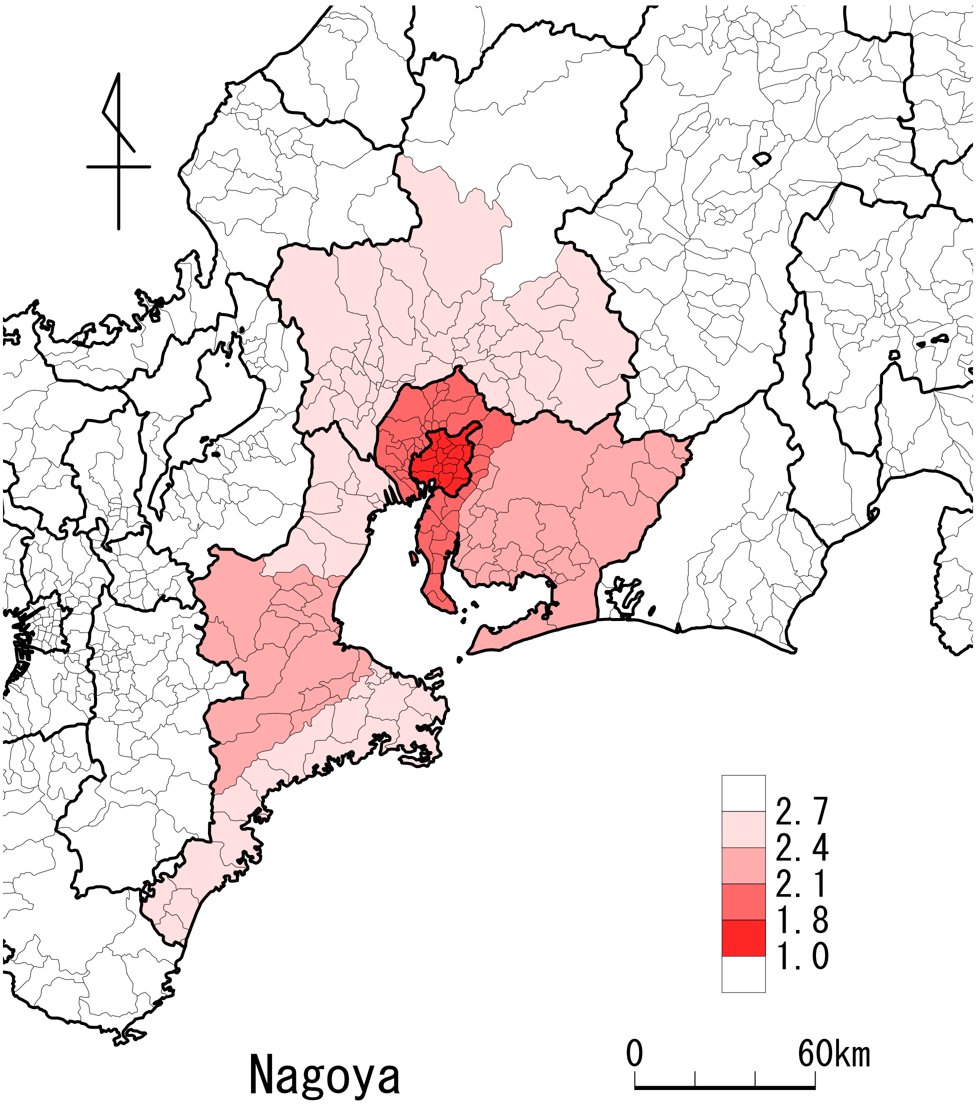
R-squared	0.570567	Mean dependent var	2.452842
Adjusted R-squared	0.554577	S.D. dependent var	0.400440
S.E. of regression	0.267254	Akaike info criterion	0.238724
Sum squared resid	13.42782	Schwarz criterion	0.372525
Log likelihood	-15.39495	Hannan-Quinn criter.	0.292893
F-statistic	35.68379	Durbin-Watson stat	1.110952
Prob(F-statistic)	0.000000		

Figure 6 shows the APL distance from Nagoya City. Here the APL distance is defined the average of two variations; the forward direction and the backward direction.

$$\mathbf{APL}^{*rs} = \frac{1}{2}\left(\mathbf{APL}^{rs} + \mathbf{APL}^{sr}\right)$$

Looking this figure, relatively wide areas surrounding Nagoya City have linked to Nagoya City. Among them, Hida area in Gifu prefecture has little connection to Nagoya City. Owari, Nishi-mikawa, and Higashi-mikawa in Aichi prefecture are strongly connected to Nagoya City. Chusei in Mie prefecture also has relatively stronger linkage to Nagoya City than Hokusei, though the geographical distances are in reverse order. The APL index is useful to measure the degree of linkage among areas.

Figure 6 APL distance from Nagoya City



6. Concluding Remarks

In this paper, we recompiled three prefectures' IOTs to a multi-regional IOT, to discuss the regional structure of Nagoya metropolitan area. Firstly the original table with 186 sectors for each prefecture was decomposed to several tables of smaller areas. Then the commodity flows among areas in three prefectures were estimated by the gravity-RAS method for each sector. Finally we compiled one multi-regional IOT from tables of each area and the commodity flow matrix of each sector.

Using the estimated multi-regional IOT of Tokai region, we compared the output structures of each area by revealed comparative advantage index. Nagoya City has advantage in the tertiary industries as the core city of the region. Owari and Nishi-mikawa in Aichi prefecture flourish in machinery industries, especially motor vehicle and electric industries. So we secondly examined the linkage strength among areas in term of the induced value added, which stems from one-unit increase of final product of motor vehicle sector in Nishi-mikawa, Hokusei, and Gifu. We found that those areas strongly connected to Nishi-mikawa each other, though the linkage between Hokusei and Gifu is week.

Thirdly we investigate the characteristics of economic linkage among areas in term of the Average Propagation Lengths index, to measure the regional linkage strength. A simple regression of the APL index on the geographical distance shows a good positive correlation. We found that relatively wide areas surrounding Nagoya City have some linkage to Nagoya City, though Hida area in Gifu prefecture has little connection to Nagoya City. The APL index showed the usefulness to measure the degree of spatial linkage among areas.

We are able to show that decomposing the prefecture's IOT to those of several small areas and integrating them to a multi-regional IOT brings an analytical tool to solve that the region identified in term of economic activities is not necessary same as the administrative region.

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