Chukyo University Institute of Economics

Discussion Paper Series

November 2014

No. 1406

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for Nagoya Metropolitan Area, Japan

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Abstract

Japan has many input-output tables, national and regional. We focus on the Nagoya metropolitan area, in which Toyota Motors is headquartered along with many industries manufacturing transport equipment, machine tools and other machinery. 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 prefectures, we first break down each prefecture table with 186 sectors into several smaller sub-regional tables. Then we combine each table into one multi-regional input output table, consisting 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 the Nagoya metropolitan area. We then show a way to cope with the various inconsistencies 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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† The original version of this paper was presented at the 22nd International Input-Output Conference held in Lisbon, Portugal, from 15th to 18th July 2014. This study was financially supported by a Chukyo University Grant for Special Research Projects (No. 1410813).

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1 Introduction

In Japan all of 47 prefectures have released their input-output tables (hereafter IOTs) for every five years beginning with 1990. The prefectures' IOTs have been effectively used for the evaluation of many events, the policy evaluation of local governments, and the economic planning of the regions. Recently, the prefectures' tables are applied to compile them into a multi-regional IOT (hereafter MRIOT). This tendency stems from the recognition that the multi-regional input-output analysis becomes more important, because the regional economies are strongly connected domestically and internationally.

In this paper, using the IOTs for the three prefectures of Aichi, Gifu, and Mie, respectively, we recompile them into one type of MRIOT for the Tokai Region covering those prefectures. For this purpose, we first break down each prefecture's table into the tables for several small areas. Then the commodity flows among the areas for each sector 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 the small area tables into a MRIOT, using the estimated transaction shares of the commodity flows. This MRIOT for the Tokai Region consists of 186 sectors for each of the 14 areas.

Breaking down the prefecture IOTs into those of several small areas and the integration of the small area IOTs into one MRIOT may make it possible to solve the analytical problem that a region identified in terms of economic activity is not necessarily the same as the administrative region.

Nagoya is the third largest metropolitan area in Japan, following Tokyo and Osaka. Nagoya City, the capital city of Aichi Prefecture, is the economic center of the Tokai Region. However, each surrounding area is not equally connected to Nagoya City. Generally speaking, the closer the distance between areas, the stronger their economic connection. Thus, using the MRIOT for the Tokai Region, we investigate such relations by the Average Propagation Lengths (APL) index proposed by Dietzenbacher *et al.* (2005).

In Section 2, the related preceding studies in Japan are briefly discussed. Then in Section 3, we introduce a method to recompile our MRIOT of the Tokai Region. Section 4 discusses the structural characteristics of the 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 the Nagoya metropolitan area in terms of the APL index. Finally, Section 6 provides concluding remarks.

2 Background

In Japan, there are several MRIOTs-based prefecture tables. Table 1 shows the typical experiences related to such issues in three groups. The first one is the inter-prefectural MRIOTs for specific regions in Japan, which includes Kansai Region MRIOT (Kansai Institute for Social and Economic Research (2008)), Tohoku Region MRIOT (Tohoku Region Advancement (2011)), Tokai Region MRIOT (Yamada (2010)), and Chubu Region MRIOT (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 commodity flows between prefectures were estimated essentially by the RAS method with different statistical sources for the initial values.

The second group is the inter-prefectural MRIOT covering overall the 47 prefectures in Japan, including Ishikawa and Miyagi (2003) for the 1995 Table, Hitomi (2008) for the 2000 Table, and Hagiwara (2012) for the 1990-2000-2005-linked MRIOT. Because the number of prefectures has increased, the sector size was decreased to around fifty. The estimation of commodity flows among prefectures also depends on the RAS method. As the initial values of the RAS method, the authors used the data of survey statistics of domestic net freight flows (MLIT[1]), the commodity flow data of METI[2], employees' commuting flow of the Census, and the communication traffic data of MIC[3].

The third group is the intra-prefectural MRIOT for the specific prefecture. The Ehime Prefecture MRIOT (Tsubouchi (1991)), Hokkaido Prefecture MRIOT (Takahata (1991)), and Mie Prefecture MRIOT (Yamada (1996)) were the pioneering studies. After 2000, several new studies appeared such as the 1995 Aichi MRIOT (Ishikawa (2004)), 2000 Aichi Prefecture MRIOT (Nakano and Nishimura (2007)), Yamaguchi Prefecture MRIOT (Nomura et al. (2011)), and 2005 Aichi Prefecture MRIOT (Yamada and Owaki (2012) and Yamada (2013)).

1 Ministry of Land, Infrastructure, Transport and Tourism, Japan
2 Ministry of Economy, Trade, and Industry, Japan
3 Ministry of Internal Affairs and Communications, Japan

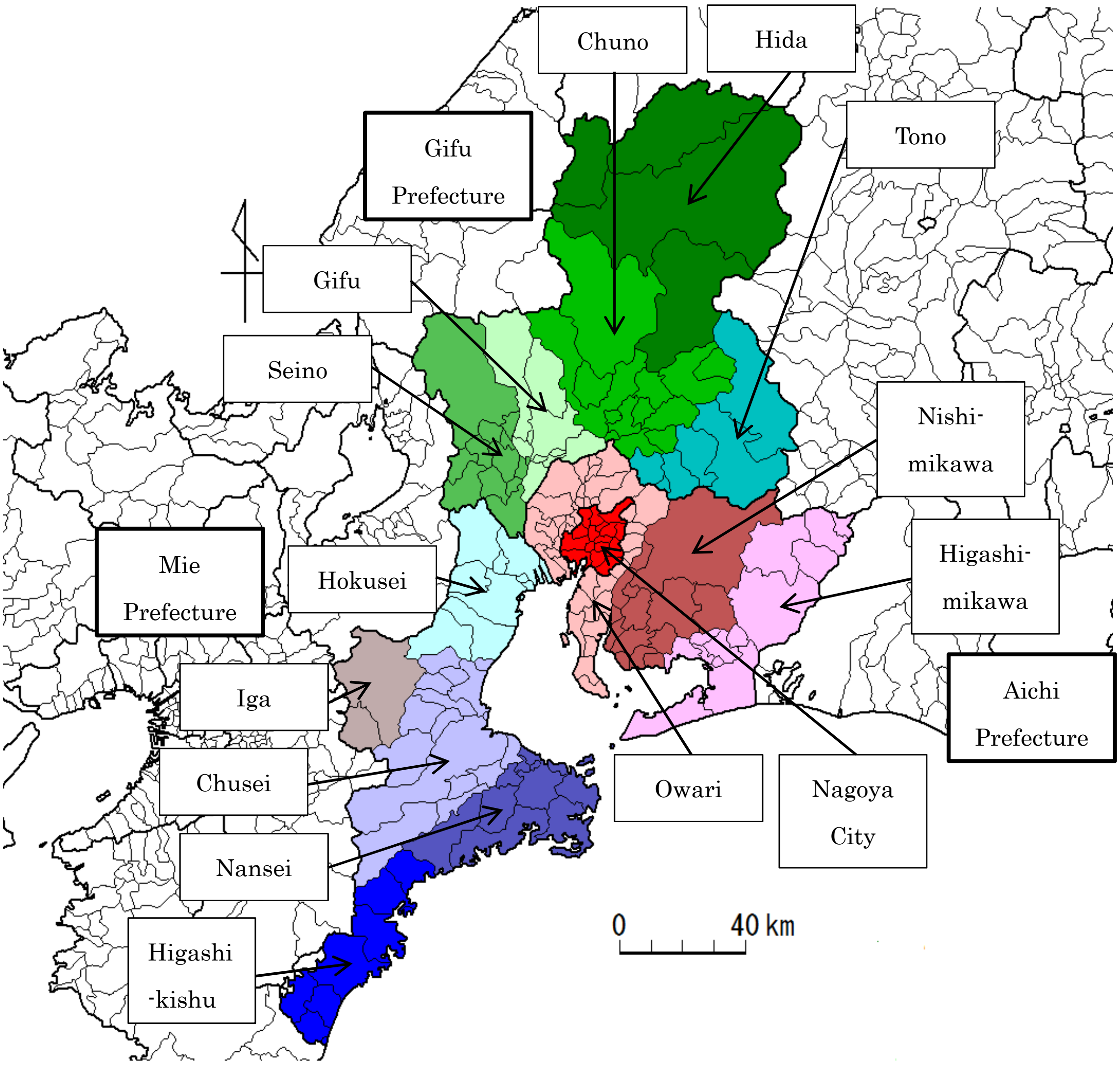
Table 1 Multi-Regional Input Output Tables in Japan

Types of RIO	Authors	Table name	Sectors	Estimation of Commodity flow
1) Inter-prefectural MRIOT for the specific region within Japan	Kansai Institute for Social and Economic Research (2008)	2000 Kansai Interregional IOT	7 prefectures/100 sectors	Special survey data on commodity flow (METI)
	Asia Pacific Institute of Research (2012)	2005 Kansai Interregional IOT	7 prefectures/104 sectors	RAS method with the survey statistics of domestic net freight flows (MLIT) and employees' commuting flow of the Census (MIC), and others
	Tohoku Region Advancement Center (2011)	2005 Tohoku Region MRIOT	6 prefectures/43 sectors	Special survey data on commodity flow (METI)
	Yamada(2010)	2000 Tokai Region MRIOT	3 prefectures/185 sectors	RAS method with the special survey data of commodity flow (METI)
	Chubu Region Institute for Social and Economic Research (2011)	2005 Chubu Region MRIOT	10 prefectures/95 sectors	RAS method with the survey statistics of domestic net freight flows (MLIT)
2) Inter-prefectural MRIOT covering Japan overall	Ishikawa and Miyagi (2003)	1995 MRIOT for Japan	47 prefectures/45 sectors	RAS method with the survey statistics of domestic net freight flows (MLIT)
	Hitomi (2008)	2000 MRIOT for Japan	47 prefectures/59 sectors	Gravity model using the freight flow data of MLIT and the commodity flow data of METI
	Hagiwara (2012)	1990-2000-2005-linked MRIOT	47 prefectures/59 sectors	Extended-RAS method with the net freight flow of MLIT, employees' commuting flow of the Census, and the communication traffic data of MIC
3) Intra-prefectural MRIOT for the specific prefecture	Tsubouchi (1991)	1988 multi-regional IOT of Ehime Prefecture	6 areas/50 sectors	Special survey data on the commodity flow in Ehime
	Takahata (1992)	1985 multi-regional IOT of Hokkaido Prefecture	4 areas/61 sectors	Statistics on the freight flow and passenger flow
	Yamada (1996)	1985 Mie Prefecture MRIOT	5 areas/84 sectors	RAS method with the survey data of freight flows
	Ishikawa (2004)	1995 Aichi Prefecture MRIOT	3 areas/46 sectors	Location Quotient (LQ) method
	Nakano and Nishimura (2007)	2000 MRIOT for Aichi Prefecture	3 areas/46 sectors	Gravity model estimated using the commodity flows of METI MRIOT
	Nomura et al. (2011)	2000 a MRIOT for Yamaguchi Prefecture	3 areas/104 sectors	Location Quotient (LQ) method
	Yamada and Owaki (2012), Yamada (2013)	2005 Aichi Prefecture MRIOT	4 areas/186 sectors	Gravity-RAS method

For the estimation of commodity flows within a prefecture, the pioneering works depended on the statistics regarding the freight flow and passenger flow within the prefecture, or on special surveys conducted on the commodity flow of the goods produced if there were no statistics for flows within the prefecture. In the case of Mie Prefecture, Yamada (1996) applied the RAS method with the survey data of freight flow as the initial values of the iterations. Nakano and Nishimura (2007) applied the gravity model. Ishikawa (2004) and Nomura et al. (2011) used the Location Quotient (LQ) method, which estimates the net transaction between two areas by the relative advantage measures[4]. Yamada (2013) developed the Gravity-RAS method, in which a gravity model was used to obtain initial values of the RAS iterations.

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

Figure 1 Location of the Tokai Region (Fourteen Areas)



[4] There are several variations of the Location Quotient model for the estimation of the export and import of the region (See Miller and Blair (2009)).

Table 2 shows the area and population of the Tokai Region. More than 11 million persons live in this region. The population of Nagoya City itself is 2.2 million, 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, the Gifu area has the highest density, 814 persons per square km, and the Hokusei area has 759 persons per square km in Mie Prefecture.

Table 2 Area and Population of the 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 Higashi-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 the Tokai Region, which consists of three prefectures; Aichi, Gifu, and Mie. First, each prefecture's table is divided into several areas' IOT of 186 sectors. These tables are imperfect in the sense that they include intra-prefectural transaction as net values. Second, we estimate the transaction values of commodity flows among the areas in two steps; the transactions within each prefecture, and the transactions among areas of different prefectures. The two-stepwise estimations are adopted for the consistency with the domestic trade of each prefecture's table.

3.1 Regional decomposition of each prefecture's IOT

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

1) Output values

The output values of each smaller area are estimated by multiplying the 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, r_i^s denotes the dividing index of the i-th sector in the s-th area, and X_i means the output value of the i-th sector in a given prefecture. In the manufacturing sectors, for example, the product values of each municipal are added 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[5], government consumption, private investment, public investment, and change of inventory.

The private consumption of each area is estimated by multiplying the 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 dividing 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 dividing 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 the consumptions for each household 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

[5] Japanese IOTs, national and regional, include "consumption expenditure outside households" as the exogenous sector, in both value-added parts and final demand parts. We estimate them in the value-added part assuming that the ratio to output for each sector is the same as those of the prefecture. We are able to acquire the total value in the final demand part by summing the sectoral values in the value-added part. Then each value of the item in the final demand part is estimated by multiplying the total value by the corresponding share value, assuming the share values are the same for all areas in the prefecture.

investment is conducted in almost the same way so as to divide them into those of the areas by using the appropriate dividing shares.

The change of inventory is estimated 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 must estimate the export and import values for each small area. We assume that the export ratio to the output for each sector is the 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 the 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 outside of the prefecture

We estimate the export and import values 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 the same for each area within the prefecture. Then the import of the area is reduced as follows:

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

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 item by sector, the total demand must be equal to the total supply. Then the following equation holds 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 the 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 commodity flows between areas

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

Table 3 shows the illustrative flows of the i-th commodity among four areas, two of which are included in each of two prefectures, respectively[6]. Two regions, the rest of Japan and the rest of the world, appear in the table to capture the domestic and international transactions. T_i^{rs} shows the transaction of the i-th commodity from the r-th area to the s-th area, $T_i^{r\cdot}$ 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 respective exports and imports to and from the world, and E_i^{*so} and M_i^{*os} are exports and imports to and from the rest of Japan, which is defined as the region excluding the two prefectures in Japan in this case.

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

Destination ＼ Origin		Prefecture-1		Prefecture-2		Rest of Japan	Rest of the World	Total
		Area-1	Area-2	Area-3	Area-4			
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 must be considered.

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

[6] Actually, there are not two areas for two prefectures but fourteen areas for three prefectures in all.

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

In this table, the values of the following variables 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,

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

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

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 divided IOT.

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

3.2.1 Estimation of intra-prefectural flows

Table 4 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}.

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

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

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 4 Intra-prefectural flows of the i-th commodity

Destination / Origin		Prefecture-1		Prefecture-2		Total
		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 inter-prefectural flows

After estimating the intra-regional commodity flows, we must determine the values of inter-prefectural commodity flows, as shown in Table 5.

Table 5 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, both exports and imports to and from the region outside of both prefectures E_i^{*ro} and M_i^{*os} are not known, though exports and imports 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 the 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 fulfill the condition that the sum of the “total” column is equal to that of the “total” row[7]. This condition means that the sum of the exports within prefectures concerned is equal to the sum of the imports 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 equation (9) and (10), within the concerned prefectures.

3.2.3 The modified gravity model

The gravity model shows that the volume of transactions 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[8] $\bar{L}^{rs}$ as follows:

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[7] 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.

[8] There are some variations to show the 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

$$T_i^{rs} = k_i^{rs} \frac{\left(T_i^{r\cdot}\right)^{\alpha} \left(T_i^{\cdot s}\right)^{\beta}}{\left(\overline{L}^{rs}\right)^{\gamma}}, \tag{13}$$

where α, β, and γ are parameters of the two volume variables and distance variable, respectively. Taking the logarithm on both sides of the equation (13), the parameters are estimated from the transaction data among 9 regions of the 2005 METI MRIOT for each of 186 sectors. Because some sectors have no transaction with the other regions, 153 sectors are estimated. 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.

Table 6 describes the characteristics of the estimated parameters. Almost all of the parameters are estimated to be statistically significant. The average values of the volume parameters for the origin and the destination are 0.99 and 0.74, respectively. The average of distance parameters is 1.29. The distance average of the commodity sectors is 1.12, which is lower than that of the service sectors, 1.77, as expected. Figure 2 shows the distribution of each estimated parameter. We are able to confirm that the distance parameters are scattered wider than the two volume parameters, and that distance parameters of service sectors are more widely dispersed than those of commodity sectors.

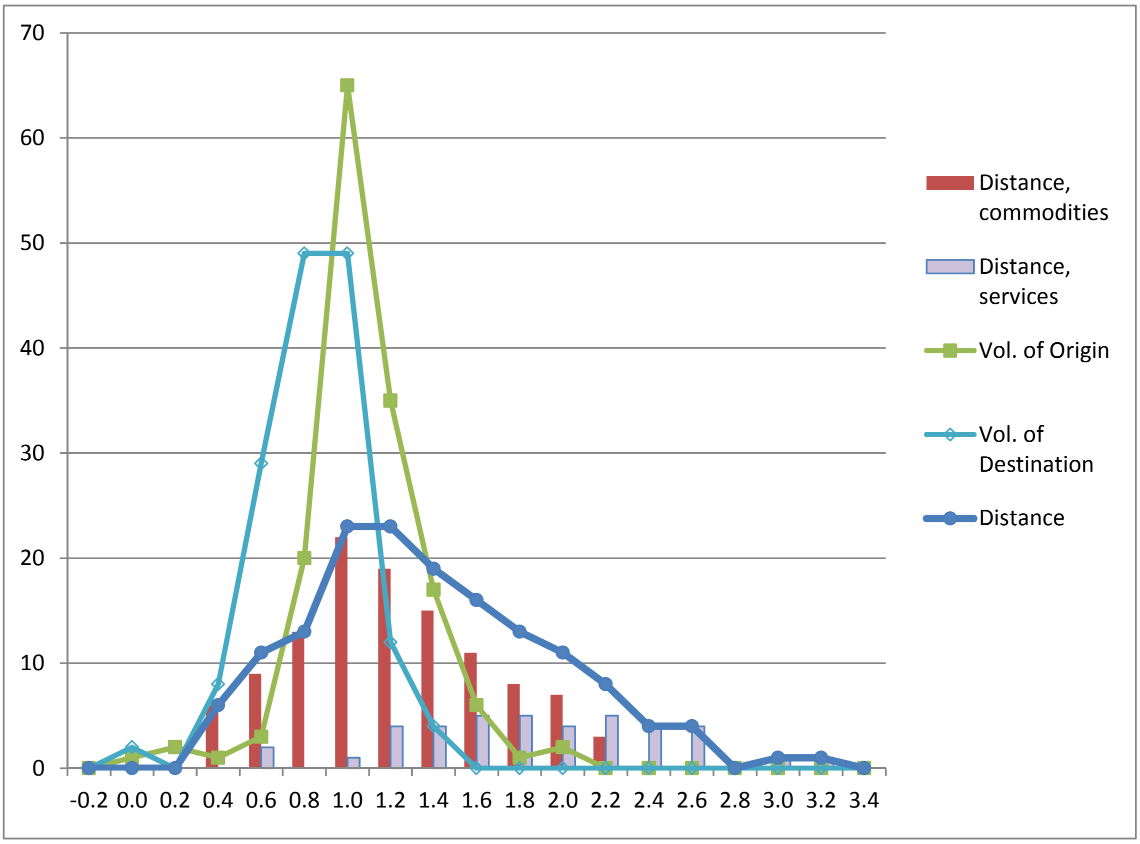
Table 6 Characteristics of the estimated parameters

	Total volume of the origin	Total volume of the destination	Distance
Maximum Value	1.92	1.27	3.08
Minimum Value	−0.02	−0.08	0.20
Average	0.99	0.74	1.29
of Commodity sectors	0.96	0.75	1.12
of Service Sectors	1.06	0.70	1.77
Standard Deviation	0.28	0.23	0.57
No. of Equations	153	153	153
No. of Significant Values	150	149	149

$\overline{L}^{RS}$ with the weight of the employment number as follows:

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

Figure 2 Distribution of the estimated parameters



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}.

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

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

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 $\hat{\bar{L}}^{rs}$ [9] are values corresponding to the MRIOT compiled here.

[9] The average distances were calculated from the distance between municipals that belonged to each

Table 7 The estimated transaction matrix

Unit: 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	Higashi-kishu	Export to the ROJ	Export, Inter-national	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	Higashi-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	Higashi-kishu	Export to the ROJ	Export, Inter-national	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	Higashi-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	Higashi-kishu	Export to the ROJ	Export, Inter-national	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	Higashi-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 7 shows the estimated transaction matrix among areas for all commodities. In this table, there are exports and imports, international and domestic, of the Tokai region. The export shares and import shares are also calculated. The shadow cells mean the areas whose transaction share has amounts to 5 percent and more. Looking at these shares, we note that four areas in Aichi Prefecture have strong relations among them. Also there appears to be strong interdependence among Gifu, Seino, Chuno, and Tono areas in Gifu Prefecture, though the Hida area seems to have a slightly weak relation to them. In Mie Prefecture, the Hokusei and Chusei areas have relatively strong links.

area with employment weights.

There are relatively strong relations between the Owari area in Aichi Prefecture and three areas in Gifu Prefecture; Gifu, Seino, and Chuno. The Hokusei area in Mie Prefecture and Nishi-mikawa area in Aichi Prefecture are also linked.

3.3 The compiled multi-regional input-output table

We divide three prefectures' IOTs with 186 sectors into 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 into one multi-regional IOT using the sectoral transaction flow matrices. Table 8 shows the MRIOT compiled for the Tokai Region with fourteen areas, in which 186 sectors are integrated into one sector.

Table 8 The estimated IOT for Tokai Region
14 areas and one sector

Unit: 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	Higashi-kishu	Inter-mediate Demand, Total
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	Higashi-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	Higashi-kishu	Export to the ROJ	Export, Inter-national	Import, Domes-tic and Inter-national	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	Higashi-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

4 Comparison of output structures

In this section, we integrate the MRIOT with 14 areas and 186 sectors for each area to that with 14 areas and 40 sectors, and discuss the characteristics of the output structures in Table 9, 10, and 11. Those tables contain sectoral outputs and the Revealed Comparative Advantage (RCA) indices of output in the Tokai Region.

Table 9 Output Structure of Aichi Prefecture

		Output (Billion Yen)					Revealed Comparative Advantages			
		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 wood 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	Aircraft and repair of aircraft	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 manufactured 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	Sectors, total	23,437.8	22,924.7	23,608.5	7,808.5	77,779.5	1.000	1.000	1.000	1.000

Table 9 shows that Nagoya City has relative advantages in “Information and communications,” “Commerce,” “Finance and insurance,” “Real estate,” and “Business services.” Those sectors are strongly related to the core industries in the metropolitan area. On the other hand, the Owari area has advantages in “Petroleum and coal products,” “Pottery, china and earthenware,” “Aircraft and repair of aircraft,” and “Miscellaneous manufactured products.” The Nishi-mikawa area, where Toyota Motor Co. is headquartered along with its factories and group companies, has advantages in "Information and communication electronics equipment," "Electronic components," and "Motor vehicles." The Higashi-mikawa area has advantages in "Agriculture," "Motor Vehicles," "Other transportation equipment," and "Precision instruments."

Table 10 shows the output structures of five areas in Gifu Prefecture. The Gifu area, where the capital city of the prefecture is located, has strong industries in "Aircraft and repair of aircraft," and "Textile products." Historically, textile industries prospered in this area. The Seino area, located west of the Gifu area, has advantages in its 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." The Tono area, in eastern Gifu Prefecture, has advantages in manufacturing industries like "Pulp, paper and wood products," "Metal products," "General machinery," and "Information and communication electronics equipment," along with "Forestry." On the other hand, the Hida area, located in northern Gifu Prefecture has much natural resources, superiority in "Forestry," "Fishery," "Mining," "Pulp, paper and wood products," and "Electricity, gas and heat supply," that is generated by hydropower stations.

Table 10 Output Structure of Gifu Prefecture

		Output (Billion Yen)						Revealed Comparative Advantages				
		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 wood 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	Aircraft and repair of aircraft	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 manufactured 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	Sectors, total	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 11 Output Structure of Mie Prefecture

		Output (Billion Yen)						Revealed Comparative Advantages				
		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 wood 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	Aircraft and repair of aircraft	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 manufactured 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	Sectors, total	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

Table 11 shows the output structures of five areas in Mie Prefecture. Hokusei area, the northern parts of Mie Prefecture and next to the Owari area, has advantages in its “Chemical products,” “Petroleum and coal products,” “Iron and steel,” “Non-ferrous metals,” “Information and communication electronics equipment,” and “Motor vehicles.” Contrarily, the Chusei area, located in the central part of Mie Prefecture, has advantages in not only manufacturing industries like ”Electronic components,” “Miscellaneous manufactured products,” and “Other ceramic, stone and clay products,” but also the tertiary sectors such as “Information and communications,” and “Public administration.” In the Nansei area, “Aircraft and repair of aircraft” sector is one of the competitive industries, though its production is not so large. “Fishery” also has a large sector in this area. The Iga area, deep in Mie Prefecture, is relatively close to the Kansai Region and boasts of “Pottery, china and earthenware,” “Plastic products,” “Pulp, paper and wood products,” and “General machinery.” In the Higashi-kishu area, “Forestry” and “Fishery” sectors have relative advantages, and the “Pulp, paper and wood products” sector also has relatively larger production. In this area there are thermal power plants, so the production of “Electricity, gas and heat supply” sector is also extensive.

5 Some applications

5.1. Interregional impacts of the motor vehicle sector on 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 MRIOT with 40 sectors by 14 areas is used. Table 12 shows the results. Nagoya, Owari, and Nishi-mikawa are the areas where the motor vehicle sector is concentrated. Toyota Motor Co. is headquartered in the Nishi-mikawa area. We observe that those areas gain a relatively high share in value added. The Gifu area in Gifu Prefecture and the Hokusei area in Mie Prefecture also obtain a high share of value added. The Honda Motor Co. main factory is located in the Hokusei area.

Table 12　Induced VA and import of one-unit increase of final demand, motor vehicle sector

	Aichi Prefecture				Gifu Prefecture					Mie Prefecture					Rest of Japan	Import	Total
	Nagoya	Owari	Nishi-mikawa	Higashi-mikawa	Gifu	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
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 3 indicates the geographical diffusion of the induced value added for one-unit increase of the motor vehicle sector in the Nishi-mikawa area, which has the largest gain in the value added. The Owari area, adjacent to the Nishi-mikawa area, has a relatively higher value added, and the other neighboring Higashi-mikawa and Hokusei areas are not far behind. Gifu, Seino and Chuno in Gifu Prefecture and Chusei in Mie Prefecture show some gains, though the effect for each is not so much. Roughly speaking, the gains in value added are inversely correlated with the distance from the Nishi-mikawa area.

Figure 3 Geographical diffusion of induced value added, motor vehicle sector in the Nishi-mikawa area

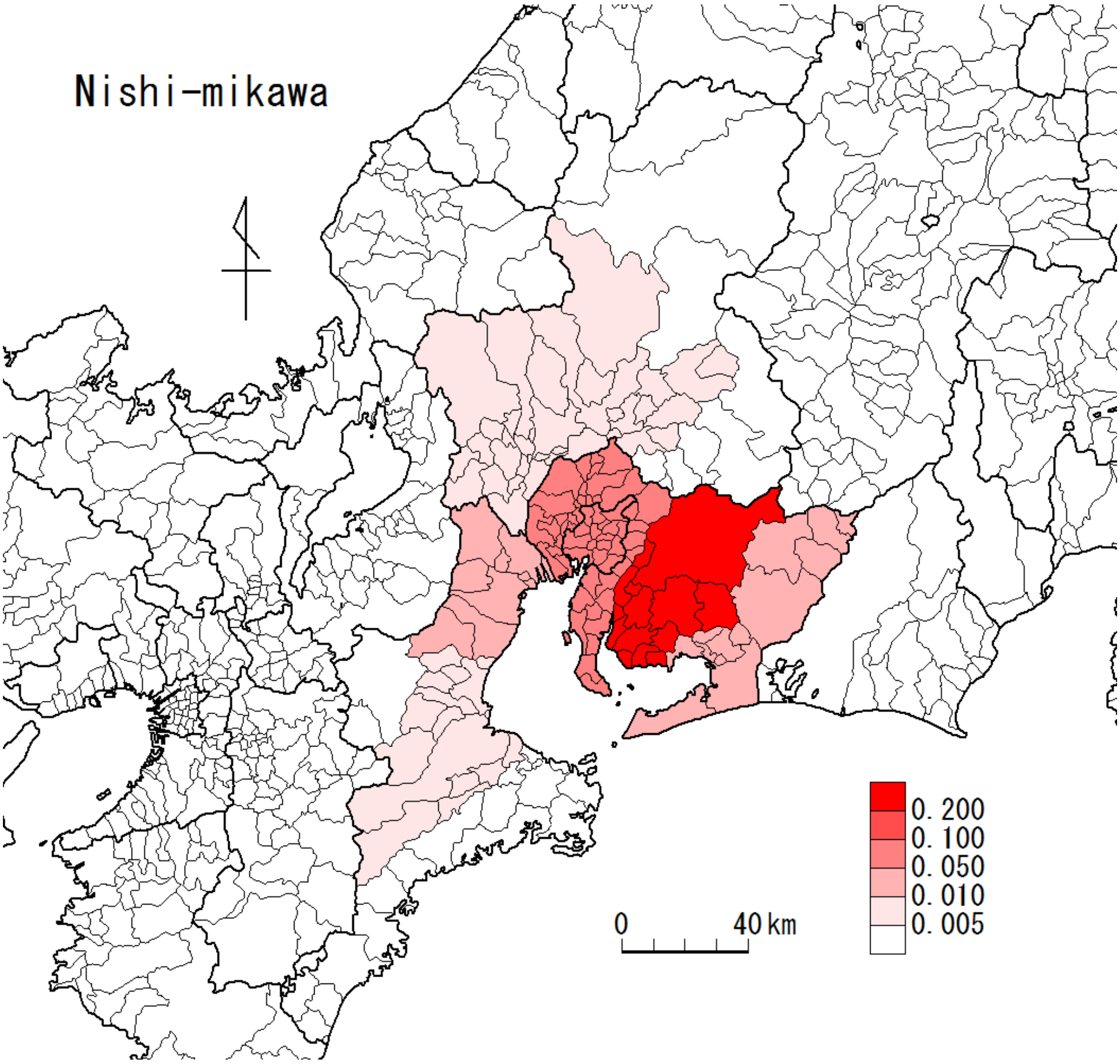


Figure 4 shows a similar geographical diffusion for the one-unit increase of the motor vehicle sector in the Hokusei area, which is another integrated area of the motor vehicle industry. The Hokusei area is connected strongly to Nagoya, Owari, and Nishi-mikawa, where many motor vehicle industries are 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 the Gifu area appears in Figure 5. In this case, the Nishi-mikawa area gains are the largest among the neighboring areas, and Owari and Nagoya are close behind. Chono, Seino, and Higashi-mikawa obtain some gains. Tono and Hokusei have a little share. The Gifu area is connected more closely to the Nishi-mikawa area than the adjoining areas. Also, we are able to observe the relation with the Hokusei area in Mie Prefecture, which is asymmetrical to the case of Figure 4.

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

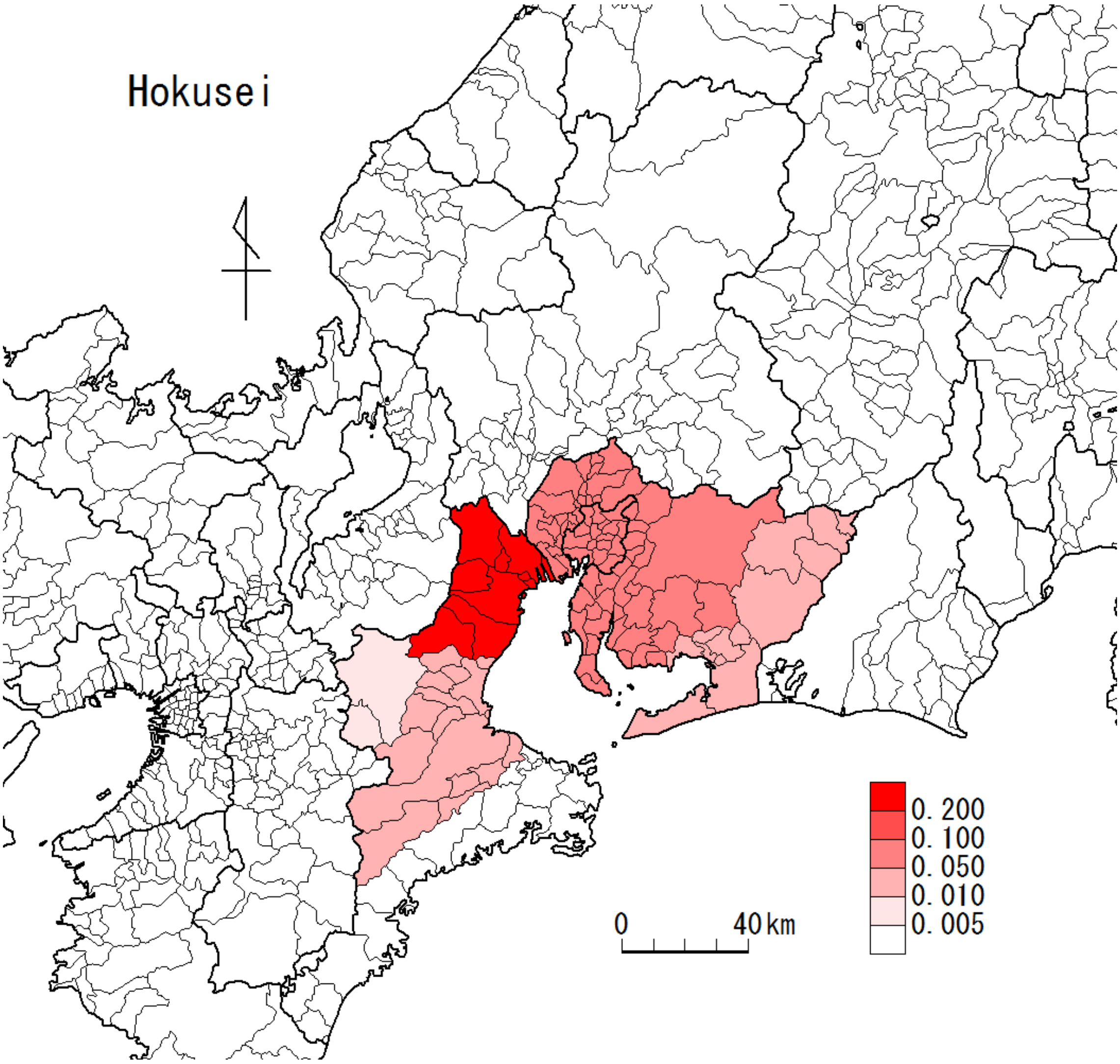
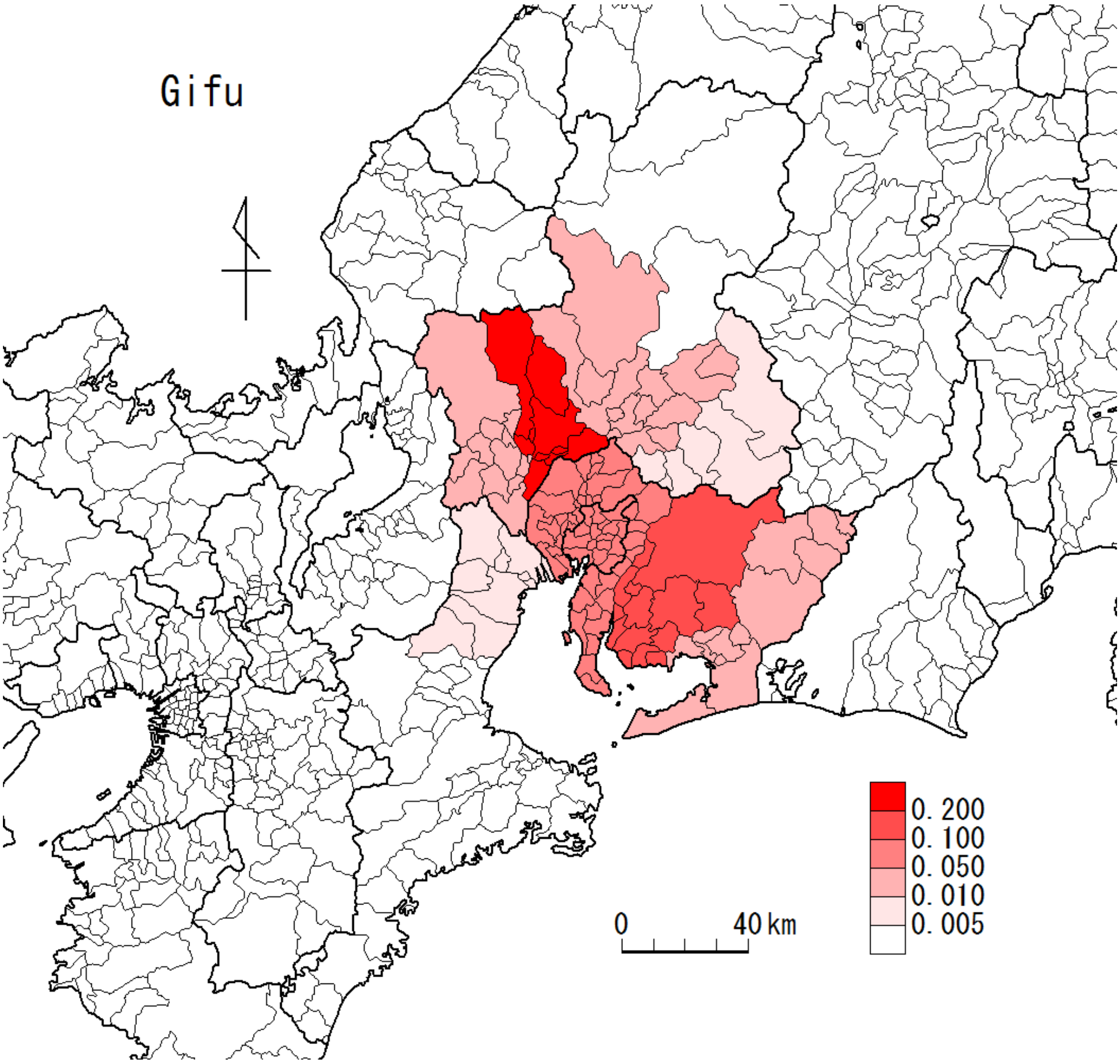


Figure 5 Geographical diffusion of induced value added, motor vehicle sector in the Gifu area



5.2 Average Propagation Lengths

The Average Propagation Lengths (APL) index, proposed 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 are expressed as

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

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:

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

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

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

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

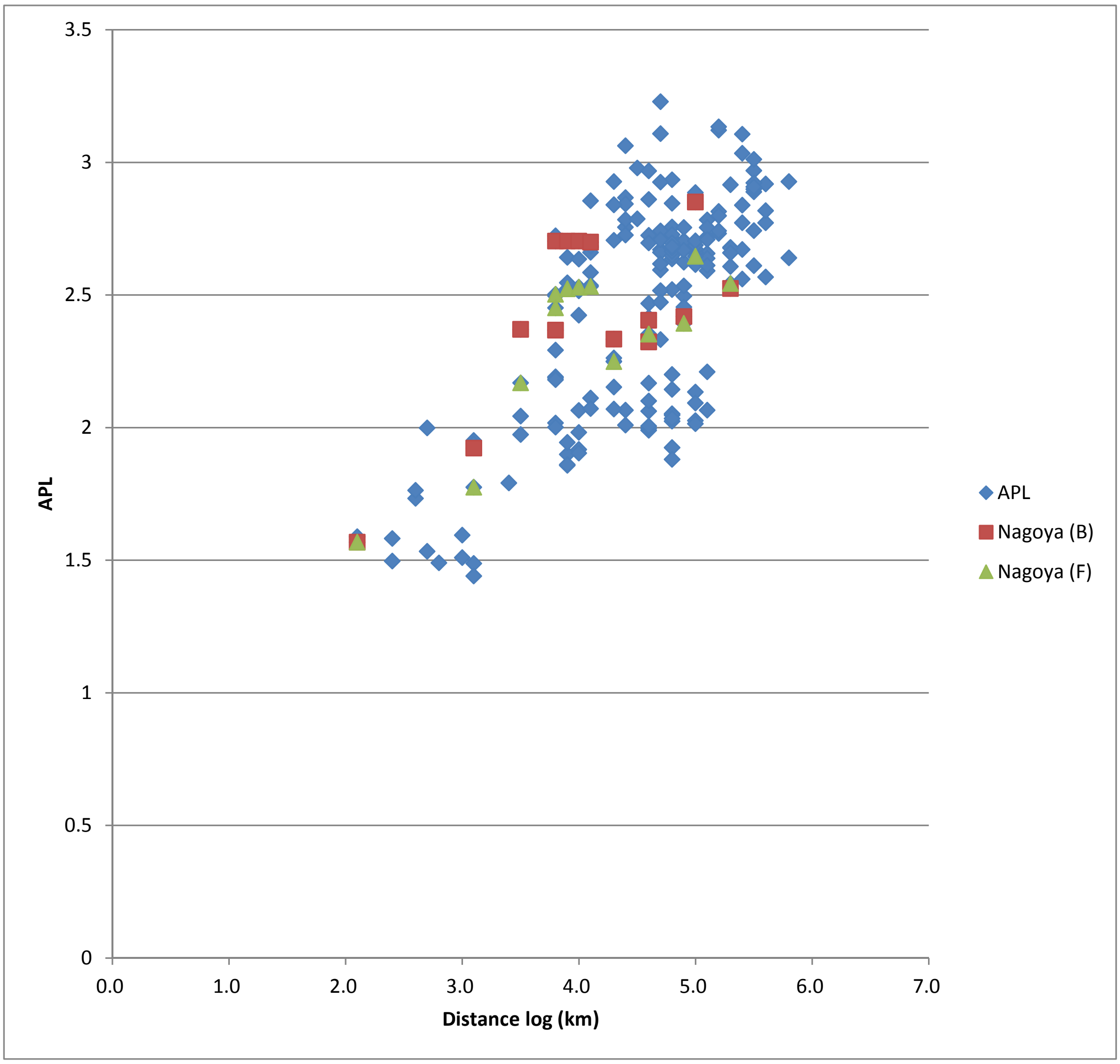
Calculating the APL between the j and i for the model with 40 sectors for each of 14 areas, we have integrated them as the index between the r-th area and s-th area, $\mathbf{APL^{rs}}$,

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

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 Diezenbacher *et al.* (2005) originally 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 the 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 MRIOT.

Figure 6 shows the relation between the APL and the logarithm of the geographical distance. The positive relation is observed with the correlation coefficient 0.681. The triangle points in Figure 6 denote the APL distance of Nagoya City to the other areas in the forward direction, and the square points show them in the backward direction. Both show that the APL distance of Nagoya City becomes larger as the geographical distance becomes longer. The area closer to Nagoya City has deeper connections with the city and the transaction between them becomes larger, which makes the APL distance lower.

Figure 6 Average propagation lengths and 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 dummy variables of Gifu Prefecture, in the forward and backward direction, respectively. D_M^F

and D_M^B are also dummy variables for Mie Prefecture, and D_N^F and D_N^B are for Nagoya City. The estimated results are shown in Table 13. The relation is significant in the sense of a 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. The prefectural dummies are negative, which means that the industries of Aichi Prefecture are more closely concentrated than the other two prefectures. Nagoya Dummy is also not significant, which means there is no difference to Aichi prefecture.

Table 13 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

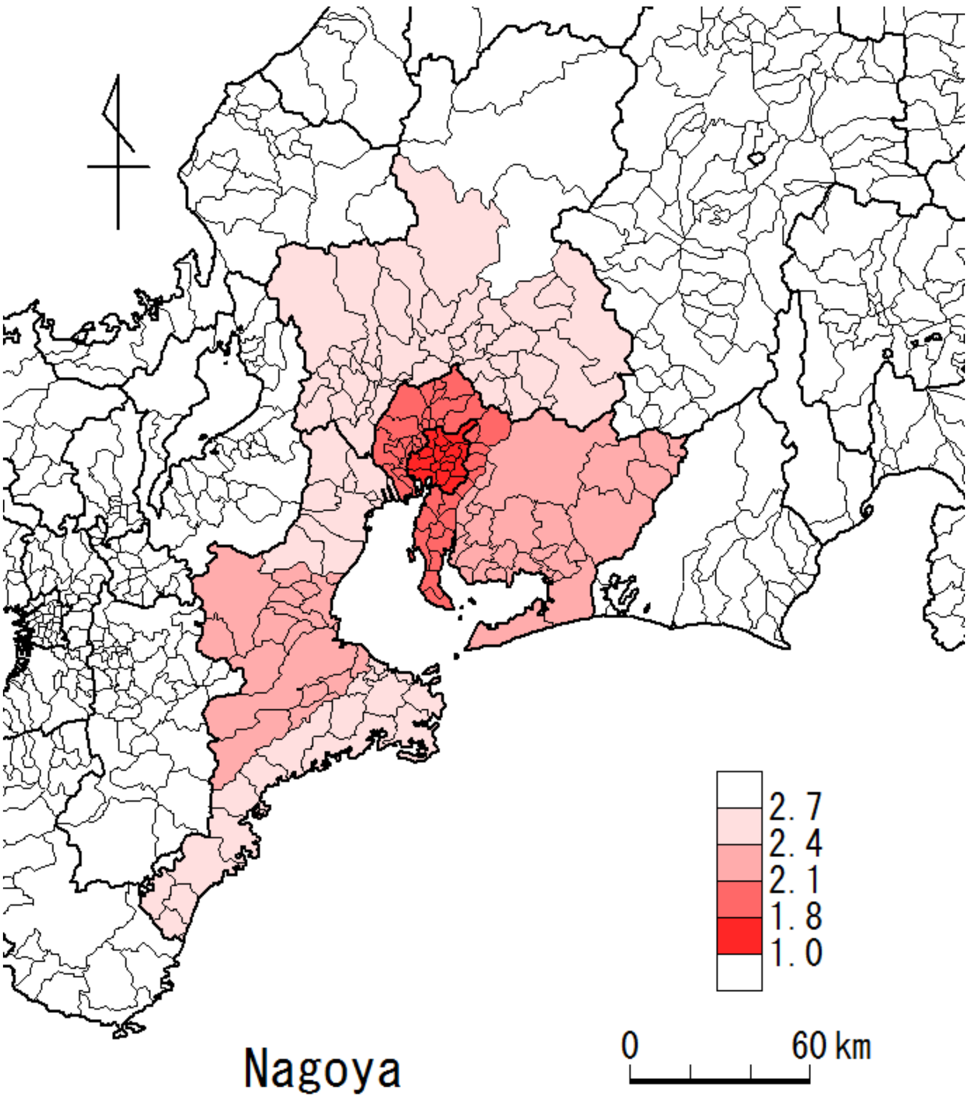
R-squared	0.570567	Mean dependent var	2.452842
Adjusted R-squared	0.554577	S.D. dependent var	0.400440
S.E. of regression	0.267254	Akaike info criterion	0.238724
Sum squared residuals	13.42782	Schwarz criterion	0.372525
Log likelihood	-15.39495	Hannan-Quinn criter.	0.292893
F-statistic	35.68379	Durbin-Watson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

Figure 7 shows the APL distance from Nagoya City, which is here defined as the average of two variations; the forward and backward direction:

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

In this figure, relatively wide areas surrounding Nagoya City are linked to Nagoya City. Among them, the Hida area in Gifu Prefecture has little connection to Nagoya City. The Owari area is strongly connected to Nagoya City, and Nishi-mikawa, and Higashi-mikawa in Aichi Prefecture also have connections. Chusei and Iga in Mie Prefecture also have 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 7 APL distance from Nagoya City



6 Concluding remarks

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

Using the estimated MRIOT of the Tokai Region, we compared the output structures of each area by an RCA index. Nagoya City has the edge in tertiary industries as the core city of the region. Owari and Nishi-mikawa in Aichi Prefecture are well-known for their machinery industries, especially motor vehicle and electric industries. Second, we examined the linkage strength among areas in terms of the induced value added, which stems from one-unit increase of the final product of the motor vehicle sector in Nishi-mikawa, Hokusei, and Gifu. We found that those areas are strongly connected to the Nishi-mikawa area, though the linkage between Hokusei and Gifu is weak.

Third, we investigated 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 the Hida area in Gifu Prefecture has little connection to it. The APL index showed its usefulness to measure the degree of spatial linkage among areas.

We were able to show that subdividing the prefecture's IOT to those of several small areas and integrating them into a MRIOT yields an analytical tool to solve how the region may be identified in terms of economic activities is not necessarily the same as for an administrative region.

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