CGE Analysis of Regional Policy in the Northern Kyushu Area

Hiroshi Sakamoto
The International Centre for the Study of East Asian Development (ICSEAD)

Working Paper Series Vol. 2011-03
February 2011

The International Centre for the Study of East Asian Development, Kitakyushu

CGE Analysis of Regional Policy in the Northern Kyushu Area*

Hiroshi Sakamoto◆

Abstract

This study develops a policy model in the context of the hierarchical administration system of the regional economy in Japan. In the case of Japan, a hierarchy of national, prefectural, and municipal (city) administration exists, and a different regional policy may be established for each level of the hierarchy. Generally, the policy and its evaluation might differ according to whether priority is given to national interests or to each region's interests. To examine such a situation, quantitative analysis is conducted using the computable general equilibrium model (CGE model).

Concretely, Kitakyushu City and Fukuoka City constitute an administrative region at the city level. These two cities and the rest of Fukuoka Prefecture together make up Fukuoka Prefecture.

On the other hand, there is a case for including Yamaguchi Prefecture, the adjacent prefecture, in these regions. In that case, it can be called Northern Kyushu Area by combining Fukuoka Prefecture and Yamaguchi Prefecture. Such a large area then becomes important in the regional policy because of being placed higher in the hierarchy. Five regions including the rest of Japan are focused on in this study.

Moreover, due to the availability of the input-output tables of these regions, the database to develop the CGE model can be estimated after tabulating the interregional input-output table.

JEL classification: C68, D58, O53, R13
Keywords: Northern Kyushu, Hierarchy of administration, Regional policy, CGE model

---

* This paper was presented at the 5th Annual International Symposium on Economic Theory organized by the Athens Institute for Education and Research (ATINER) (Athens, Greece in 2010) and the 50th Anniversary European Congress of the Regional Science Association International (Jönköping University, Sweden in 2010). The author wishes to express gratitude for the many helpful comments. All remaining errors are entirely the responsibility of the author.

◆ Research Associate Professor
The International Centre for the Study of East Asian Development, Kitakyushu (ICSEAD)
11-4 Otemachi, Kokurakita, Kitakyushu 803-0814, JAPAN
Tel: +81 93 583 6202; Fax: +81 93 583 4602 E-mail address: sakamoto@icsead.or.jp

1. Introduction

This study develops a policy model in the context of the hierarchical administration system of the regional economy in Japan. In the regional analysis, the regions selected for consideration are often at the same level of hierarchical administration or economic development.[1] However, both an administrative region and a city are established hierarchically. Therefore, a regional analysis considering the hierarchical system is also necessary.[2] Once data are complete, of course, empirical analysis considering the hierarchical system is possible.[3] However, few studies have ever tried to analyze the hierarchical regional system in economic policy. To solve this problem, this study provides a policy model to analyze the hierarchical administrative region.

Japan's administrative regions are hierarchical as in some other countries. There is a limit regarding regional policy because an administrative region holding a subordinate position in the hierarchy is small in area and in population, and not diversified industrially. Nevertheless, efforts to activate such a region are not neglected. However, the same effort takes place in an administrative region of a higher hierarchy.[4] Therefore, it is expected that each administration will compete with another region for a policy to activate its own region.

The Northern Kyushu area which is the focal region in this study is located on the west side of Japan, and is near the Korean peninsula. This area's features allow us to focus on Asia including South Korea and China, while at the same time considering the capital Tokyo with regard to economic and/or regional policy. A big problem for this area is whether to focus on Tokyo alone or on Asia as well. However, it is true that there is not a unified idea for the region either. One reason is that this area has not been

[1] For example, two regions are often analyzed in economic theory to simplify the problem.

[2] Numerous attempts have been made by scholars to show the hierarchical system of the city in the field of urban economics (for example, Fujita et al., 1999; and Fujita et al., 2004).

[3] For instance, because the income data at the provincial level and prefectural (county) level are available in China and Indonesia, it is possible to analyze the income disparity among hierarchical regions (for example, Akita, 2003; and Sakamoto, 2008).

[4] An administrative region that is high in the hierarchy can execute regional policy by wider eyes. For instance, when infrastructure such as airports and harbors is maintained at the country level, the national government may decide the location point for such infrastructure. Therefore, the location point that maximizes the national interest is selected. On the other hand, for lower administrative regions, the treatment afterwards will change whether the location point (political importance) is chosen from a higher administration.

properly defined. The center of the Northern Kyushu area is Fukuoka Prefecture. The Northern Kyushu area is typically composed of the surrounding area including Fukuoka Prefecture (Figure 1 and Figure 2).[5] However, because the administration is independent at the prefectural level, it is difficult to have a unified policy for the area.

On the other hand, there are two government-designated major cities in Fukuoka Prefecture. One is Fukuoka City, which is the central city in Fukuoka Prefecture. The other is Kitakyushu City, which is a big city with a population of about one million. The relationship between Fukuoka City and Kitakyushu City is not without problems. Because the two cities are independently administered, each government can execute the policy that best suits its own interest. To express the hierarchical administration in this study, Fukuoka Prefecture is divided into Fukuoka City, Kitakyushu City, and others (Figure 3). In addition, five regions including Yamaguchi Prefecture and other prefectures of Japan are analyzed.

The policy analysis employs the CGE (computable general equilibrium) model, which can be used for quantitative analysis. The economic effect of the regional policy is analyzed by using the CGE model.

The hierarchical administration system of Japan and the features of the region under consideration are explained in the next section. Section 3 explains the model and data, whereas Section 4 explains the simulation design. Section 5 gives the results of the simulation, and the last section concludes.

2. Hierarchical administration system of Japan

First, we explain the hierarchical administration system of Japan using the government's definition. Japan has three levels of government: national, prefectural, and municipal. The nation is divided into 47 prefectures.[6] Each prefecture consists of numerous municipalities. There are four types of municipalities in Japan: cities (*shi* in

[5] The prefectures surrounding Fukuoka Prefecture are Yamaguchi Prefecture, Saga Prefecture, Nagasaki Prefecture, Oita Prefecture, and Kumamoto Prefecture.

[6] The prefectures of Japan are the country's 47 subnational jurisdictions: one "metropolis (*to* in Japanese)", Tokyo; one "circuit (*do*)", Hokkaido; two urban prefectures (*fu*), Osaka and Kyoto; and 43 other prefectures (*ken*). Prefectures are governmental bodies larger than cities, towns, and villages (from Wikipedia, "Prefectures of Japan").

Japanese), towns (*cho*), villages (*son*), and special wards (the *ku* of Tokyo).[7][8]

A city designated by government ordinance (*seirei shitei toshi*), also known as a designated city (*shitei toshi*) or government ordinance city (*seirei shi*), is a Japanese city that has a population greater than 500,000 and has been designated as such by an order of the cabinet of Japan under Article 252, Section 19 of the Local Autonomy Law (see Appendix Table).

Designated cities are delegated many of the functions normally performed by prefectural governments in fields such as public education, social welfare, sanitation, business licensing, and urban planning. The city government is generally delegated the various minor administrative functions in each area, while the prefectural government retains authority over major decisions. Designated cities are also required to subdivide themselves into wards (*ku*), each of which has a ward office conducting various administrative functions for the city government, such as resident registration and tax collection. In some cities, ward offices are responsible for business licensing, construction permits, and other administrative matters. The structure and authorities of the wards are determined by municipal ordinances.

As mentioned before, there are two government-designated major cities in Fukuoka Prefecture. One is Fukuoka City and the other is Kitakyushu City. Because these two cities are government-designated major cities, an original regional policy can be implemented for each of them. However, this regional policy is likely a policy designed specifically for one city, and its influence on another region is not considered. This often leads to policy competition between Fukuoka City and Kitakyushu City. For example, the international airport is in Fukuoka City, and there is an airport in Kitakyushu City in Fukuoka Prefecture. Fukuoka City is hoping to enhance its international airport and transfer some of its functions to the Kitakyushu airport because it has reached almost

[7] Under the current Local Autonomy Law, each prefecture is further subdivided into cities (*shi*) and districts (*gun*). Each district is further subdivided into towns (*cho* or *machi*) and villages (*son* or *mura*). For example, Hokkaido has 14 subprefectures that act as branch offices (*shicho*) of the prefecture. Some other prefectures also have branch offices, which carry out prefectural administrative functions outside the capital (from Wikipedia, "Prefectures of Japan").

[8] The status of a municipality, if it is a village, town, or city, is decided by the prefectural government. Generally, a village or town can be promoted to a city when its population increases above 50,000, and a city can (but need not) be demoted to a town or village when its population decreases below 50,000 (from Wikipedia, "Municipalities of Japan").

peak capacity.

Yamaguchi Prefecture is located next to Fukuoka Prefecture and there is a fair amount of economic interchange between them. Especially, Shimonoseki City near Kyushu Island has the deepest economic ties with Kyushu though the prefectural government in Yamaguchi Prefecture is Yamaguchi City. Therefore, Shimonoseki City is often included in the Northern Kyushu area. However, Shimonoseki City has a very small population and no input-output table is made for it. Therefore, the Northern Kyushu area comprises Fukuoka Prefecture and Yamaguchi Prefecture in this study.

Table 1 shows some basic statistics on the Northern Kyushu area. In 2007, the 2000 price of gross regional product (GRP) of Fukuoka Prefecture accounted for about 3.5% of Japan's total GRP, whereas Yamaguchi Prefecture accounted for only 1.1%. Moreover, the GRP of Yamaguchi Prefecture is less than that of Fukuoka City. The GRP of Kitakyushu City is half or more than half that of Fukuoka City. Yamaguchi Prefecture's GRP per capita is below the national average, but is higher than Fukuoka Prefecture's. That of Kitakyushu City is lower than that of Yamaguchi Prefecture though Fukuoka City's is higher than Yamaguchi Prefecture's. On the other hand, Fukuoka Prefecture's population shows an increasing tendency and that of Yamaguchi Prefecture a decreasing tendency. However, the increasing tendency of the population of Fukuoka Prefecture differs greatly between Fukuoka City and Kitakyushu City. The trends of workers are also similar. In Fukuoka City, the ratio of manufacturing is extremely low and indicates an economic structure of the city type. That of Kitakyushu City is the same as that of the national economy, and Yamaguchi Prefecture's ratio of manufacturing is higher than that of the national economy. It is understood that there are some differences in the economic structure.

3. Model and Data

Quantitative analysis using the computable general equilibrium model (CGE model) proves reliable for analyzing the hierarchical regional system in the Northern Kyushu area. Dozens of models have been developed. The CGE model adopts the productive structure of the nested type of production function at each stage, and these structures are

adopted in this study. On the other hand, because we intend to construct the multi-region CGE model,[9] the movement of the productive factor between regions becomes important. Especially, because a small region (city) exists in the prefecture, it is necessary to make the special assumption of movement between regions for the model. For a concrete formulation, please see the Appendix.

The model is constructed using 5 regions and 18 industries (A-1). The productive factor produces the value-added products by using the CES (constant elasticity of substitution) function for capital and labor (E-1, E-2, and E-3). On the other hand, the following assumption is made about the factor market. First, the factor market enables the free movement between industries. Second, free movement within the prefecture is possible though the factor market cannot move between the prefectures. It means that because Fukuoka Prefecture comprises Fukuoka City, Kitakyushu City, and the rest of Fukuoka Prefecture, the capital and labor movement between these three regions becomes free. When free movement is possible, the factor price of Fukuoka Prefecture becomes equal at the equilibrium. Therefore, the factor price is different in the three regions of Fukuoka Prefecture, Yamaguchi Prefecture, and other prefectures (E-4, E-5, E-6, E-7, E-8, and E-9).

Intermediate goods are composed with the value-added product using the Leontief function. In this case, the intermediate goods between regions are included in this function (E-10, E-11, and E-12). Moreover, the goods imported from foreign countries are composed using the CES function (E-13, E-14, E-15, and E-16), and the total productive structure of the nested type is completed.

The goods exported to foreign countries are made exogenously in the study (E-17 and E-18). The goods except exported goods are used for the domestic demand (E-19 and E-20).

The domestic demand is divided into private consumption, private investment, government consumption, government investment, and the inventory adjustment.

[9] It might be called a spatial CGE (SCGE) model (for example, Bröcker et al., 2010; Ishiguro and Inamura, 2005; and Ueda et al., 2005). The representative of the CGE model for multi-region (multi-country) analysis is the GTAP (Global Trade Analysis Project) model. Of course, there are dozens of multi-region models that have been developed (for example, Böhringer and Welsch, 2004; Horridge and Wittwer, 2008; and Latorre et al., 2009).

Although the inventory is made exogenously, the other demands are distributed according to the demand function of the Cobb-Douglas type. This demand function extends between industry and the region.

The income of the private sector is based on the price (wage) and the amount of the productive factor obtained from the factor market (E-23). The private sector pays a part of the income to the local government in the form of income tax, then consumes the final goods within the ranges of its disposable income, except private savings (E-22). All private savings are allocated to the investments excluding the exogenous inventory adjustment (E-26, E-27, and E-30). The income of the government sector is a private income tax and a value added tax (E-21, consumption tax in Japan's case) on the sale of goods (E-25). A part of the government revenue is saved, and the government consumes the final goods besides (E-24). All the government savings are allocated to government investment (E-28 and E-29).

Other balance of international payments and balance of regional payments are properly treated as transfers, and all supply and demand are corresponding in the model.

The data from which the CGE model is constructed often come from the input-output table. In Japan, the input-output table at the prefectural level is also available. Therefore, regional analysis can be done by using that input-output table. Two government-designated cities, Fukuoka City and Kitakyushu City that belong to Fukuoka Prefecture, also provide an input-output table. Therefore, analysis that divides Fukuoka Prefecture further at the city level becomes possible. Due to the availability of the input-output table of these regions, the database to develop the CGE model is estimated after tabulating the interregional input-output table.[10]

After the initial equilibrium solution of various price variables had been set as 1, various parameters were calibrated to correspond to the database. On the other hand, because the elasticity of substitution cannot be estimated from the database, the results of existing research were used.

[10] We use the following input-output tables for estimating the interregional input-output table: Japan, Fukuoka Prefecture, Yamaguchi Prefecture, Fukuoka City, Kitakyushu City, and an interregional table comparing Fukuoka Prefecture and the rest of Japan. Base year is 2000. These tables are available on their administration's website. The disaggregated interregional input-output table of five regions is estimated mechanically by using the RAS method in the study.

4. Simulation

In the study, we assume the simulation in four directions (see Table 2). One is to discuss the increase and decrease of the productive factor in the sensitivity test. The second is the adjustment of local income taxes and the third is an adjustment of government spending. Moreover, an adjustment of the national tax is discussed at the end. The productive factor of the Fukuoka Prefecture can be moved freely in each simulation on the basis of the assumption of the base model. As a result, an adjustment of the quantity of the productive factor within Fukuoka Prefecture is expected, and the interregional effect on regional economic policy can be expected.

4.1. Sensitivity

We assume about 10% reduction in the labor stock of Fukuoka Prefecture and 10% increase in the capital stock, respectively, as a sensitivity test (Simulations 1 and 2). The population of Japan shows a decreasing tendency, and the possibility that the amount of labor also will show a decreasing tendency is high. Therefore, the reduction in the labor stock is real in this respect. On the other hand, an increase in capital stock is an orthodox phenomenon seen with usual economic growth.

4.2. Local tax

There are local taxes besides the national tax, and income tax can be collected at both the prefectural level and the city level.[11] As a result, the various local governments can bolster the regional economic policy by adjusting the local tax rate. Then, the adjustment simulation of the local tax rate is done as part of the economic policy of the local government. However, the amount of capital and labor might be adjusted between the three regions in Fukuoka Prefecture and, because it is possible to move freely, the expected effect might not necessarily be achieved. In the simulation, the income tax rate of Fukuoka City has been decreased by 10% due to an adjustment at the city level

[11] Another example of analyzing tax policy in Japan using the CGE model is that of Bessho and Hayashi (2005). Sakamoto (2009) measures the economic effect of the change in the tax system of Japan using the CGE model. In this case, Monte Carlo experiments under the condition of uncertain productivity of the value-added production are examined.

(Simulation 3). This was also done in Kitakyushu City (Simulation 4). Moreover, the economic policy effect at the prefectural level can similarly be observed by decreasing the income tax rate of Fukuoka Prefecture by 10% (Simulation 5).

4.3. Government expenditure

The economic policy that the local government may voluntarily enforce is limited. Nevertheless, the local government considers various measures for the development of its region. The policy of maintaining infrastructure and attracting enterprises that offer large-scale employment is pursued in many regions. Moreover, attracting the new university related to this is also seen. If the policy emphasizes agriculture on the other hand, local production for local consumption is advocated. It can be said that these policies involve sacrificing another region by moving the goods and factors from other regions to one's own region. The model can simulate such a protectionist policy by changing the parameters. For instance, the approach wherein the local government buys goods for consumption and makes investment only in its own region, not other regions, can be devised. This is because production demand in its own region is expected to increase with such a change in purchase demand. Then, we assume the case where all the government purchases are done in its own city, Fukuoka City (Simulation 6). This is also done in Kitakyushu City (Simulation 7). Calculating the effects of these changes becomes possible by changing the goods purchasing share parameters of $\alpha^{GC}_{r,s,i}$ and $\alpha^{GI}_{r,s,i}$ from all regions to the particular region's purchases, as a technique of the model.

4.4. National tax

The adjustment of the national tax is discussed at the conclusion. Japan is running a large fiscal deficit due to the issue of government bonds, which is a serious problem for the Japanese economy. However, there are only two methodologies for solving the problem: one is increasing tax income and the other is reducing government spending. Thus, a tax income increase simulation is of interest. The only realistic tax income increase method is through a consumption tax (value added tax). Hence, the value added tax rate was doubled in the study (Simulation 8).

5. Results

There are several tables to show the simulation results (Table 3, Table 4, and Table 5). The tables show the following: change of the movement of the productive factor within Fukuoka Prefecture and the equilibrium price of the productive factor; amount of change and price change in production caused by simulation; regional income and its real value when prices are fixed at the base case level; per labor unit of them. The equilibrium solution before the simulation is assumed to be a base case solution; the results shown in the tables show the change from the base case solution.

5.1. Sensitivity

When the labor stock reduces, the decrease rate of labor of Fukuoka City is low, and it remains at 4% or less. Therefore, the capital tends to be concentrated on Fukuoka City. When the capital stock increases, the capital growth rate of Fukuoka City is low, and the increase of capital in the other two regions is 10% or more. The labor migrates to the other two regions along with the capital, too.

However, the factor price (capital and labor) rises greatly with the reduction of the labor stock, and the factor price falls greatly with an increase of the capital stock. It can be said that this model shows considerable price fluctuation.

Therefore, the nominal value of the regional income has changed greatly. However, the real income is in keeping with the movement of the productive factor. Kitakyushu City will have given the economic effects to either simulation most in terms of per labor unit due to the labor is moving within Fukuoka prefecture. Because the ratio of manufacturing in Kitakyushu City is comparatively high as shown in Table 1, it appears that Kitakyushu City has received a significant share of the change of the productive factor in Fukuoka Prefecture. Moreover, the economic effect on Yamaguchi Prefecture and other prefectures is also small, and the economic effect has increased the capital as a whole.

5.2. Local tax

Income tax reduction increases the capital in a particular region, and decreases the

labor. The productive factor shows a tendency to be concentrated in Kitakyushu City due to the factor movement resulting from the tax reduction at the prefectural level. The change of the factor price is not very large. Reducing taxes at the prefectural level does not necessarily induce an economic effect, though reduction of the income tax has induced an economic effect on the particular region doing the reduction in terms of the real income per labor. Therefore, even if it is effective for regions to implement an economic policy only in their own region, when policy competition is aroused among regions there is no guarantee of obtaining an economic effect.[12] Moreover, a nationwide effect due to tax reduction is small and does not lead to a substantial rise in the income of the whole country.

5.3. Government expenditure

The government can concentrate a lot of the productive factors (capital and labor) in its own region by making all the purchases of goods from its own region. However, because the factor price rises by about 20%, the influence of price fluctuation should be considered. Of course, the nominal regional income rises with an increase of prices. Because labor also increases, the economic effect per labor becomes negative, although the real regional income is increasing for the region that executed the policy. The effectiveness of the policy is different depending on the standard of the policy assessment. It may be substantially effective if this policy also has a nationwide economic effect on the nominal value of income leading to a steep rise in prices.

5.4. National tax

The factor price has fallen greatly though the productive factor tends to be concentrated on Kitakyushu City as a result of a nationwide tax increase. The effect of the decrease of the capital price on other prefectures and the rise of the labor price on Yamaguchi Prefecture is remarkable on the other hand. Because the amount of labor increases, the economic effect is negative per labor though the real income of Kitakyushu City increases. However, the size of this negative is small in any region. It

[12] Tax reduction at the prefectural level may be interpreted as being equivalent to three regions' simultaneous tax reduction.

can be said that the tax increase has not had an influence on the economy.

From these results, it can be seen that part of the reason for the movement of the productive factor between regions is the difference of the parameters of the industrial structure and the production function. Moreover, various changes are expected though the movement of the productive factor between the industries is not reported because of space constraints.

What can we learn from these results? One is that there is an economic effect when one administration unilaterally implements a regional policy. However, when policy competition erupts between regions, the expected effect is not necessarily achieved. Local policy authorities should note the policy trend in other regions. A further consideration is how to evaluate the policy. Does it need to be effective only at the regional level or should the effect per labor or per capita be taken into account as well? It is necessary to note this aspect when there is a factor movement.

6. Concluding remarks

This study investigates how effective the economic policy in the region was in the context of the hierarchical administration by using the CGE model in the Northern Kyushu area. The results have shown that the policy trend in another region and the method of evaluating the economic effect are important. Such a conclusion is not arrived at easily by theoretical analysis. On the other hand, the model is simple and there is room for enhancement depending on the availability of data. Further analysis is necessary.

References

Akita, Takahiro. (2003). "Decomposing regional income inequality in China and Indonesia using two-stage nested Theil decomposition method," *Annals of Regional Science*, 37, pp. 57-77.

Bessho, Shun-ichiro and Masayoshi Hayashi. (2005). "Economic studies of taxation in Japan: The case of personal income taxes," *Journal of Asian Economics*, 16(6), pp. 956-972.

Böhringer, Christoph and Heinz Welsch. (2004). "Contraction and Convergence of carbon emissions: An intertemporal multi-region CGE analysis," *Journal of Policy Modeling*, 26(1), pp. 21-39.

Bröcker, Johannes, Artem Korzhenevych, and Carsten Schürmann. (2010). "Assessing spatial equity and efficiency impacts of transport infrastructure projects," *Transportation Research Part B: Methodological*, 44(7), pp. 795-811.

Fujita, Masahisa, Paul Krugman, and Anthony J. Venables. (1999). *The Spatial Economy: Cities, Regions, and International Trade*. Cambridge, MIT Press.

Fujita, Masahisa, Tomoya Mori, J. Vernon Henderson, and Yoshitsugu Kanemoto. (2004). "Spatial distribution of economic activities in Japan and China," in *Handbook of Regional and Urban Economics*, Vol. 4, edited by J. Vernon Henderson and Jacques-Francois. Thisse, Amsterdam: North-Holland, pp. 2911-2977.

Horridge, Mark and Glyn Wittwer. (2008). "SinoTERM, a multi-regional CGE model of China," *China Economic Review*, 19(4), pp. 628-634.

Ishiguro, Kazuhiko and Hajime Inamura. (2005). "Identification and Elimination of Barriers in the Operations and Management of Maritime Transportation," *Research in Transportation Economics*, 13, pp. 337-368.

Latorre, María C., Oscar Bajo-Rubio, and Antonio G. Gómez-Plana. (2009), "The effects of multinationals on host economies: A CGE approach," *Economic Modelling*, 26(5), pp. 851-864.

Sakamoto, Hiroshi. (2008). "Economic development and regional disparity in Yangzi River Delta (in Japanese)," *Journal of Applied Regional Science*, 13, pp. 69-80.

Sakamoto, Hiroshi. (2009). “Uncertainly of productivity and effect of tax system change: Monte Carlo experiment by CGE model (in Japanese),” *Studies in Applied Economics*, 3, pp. 59-73.

Ueda, Takayuki, Atsushi Koike, Katsuhiro Yamaguchi, Kazuyuki Tsuchiya. (2005). “Spatial benefit incidence analysis of airport capacity expansion: Application of SCGE model to the Haneda Project,” *Research in Transportation Economics*, 13, pp. 165-196.

Figure 1 Fukuoka Prefecture and Yamaguchi Prefecture in Japan

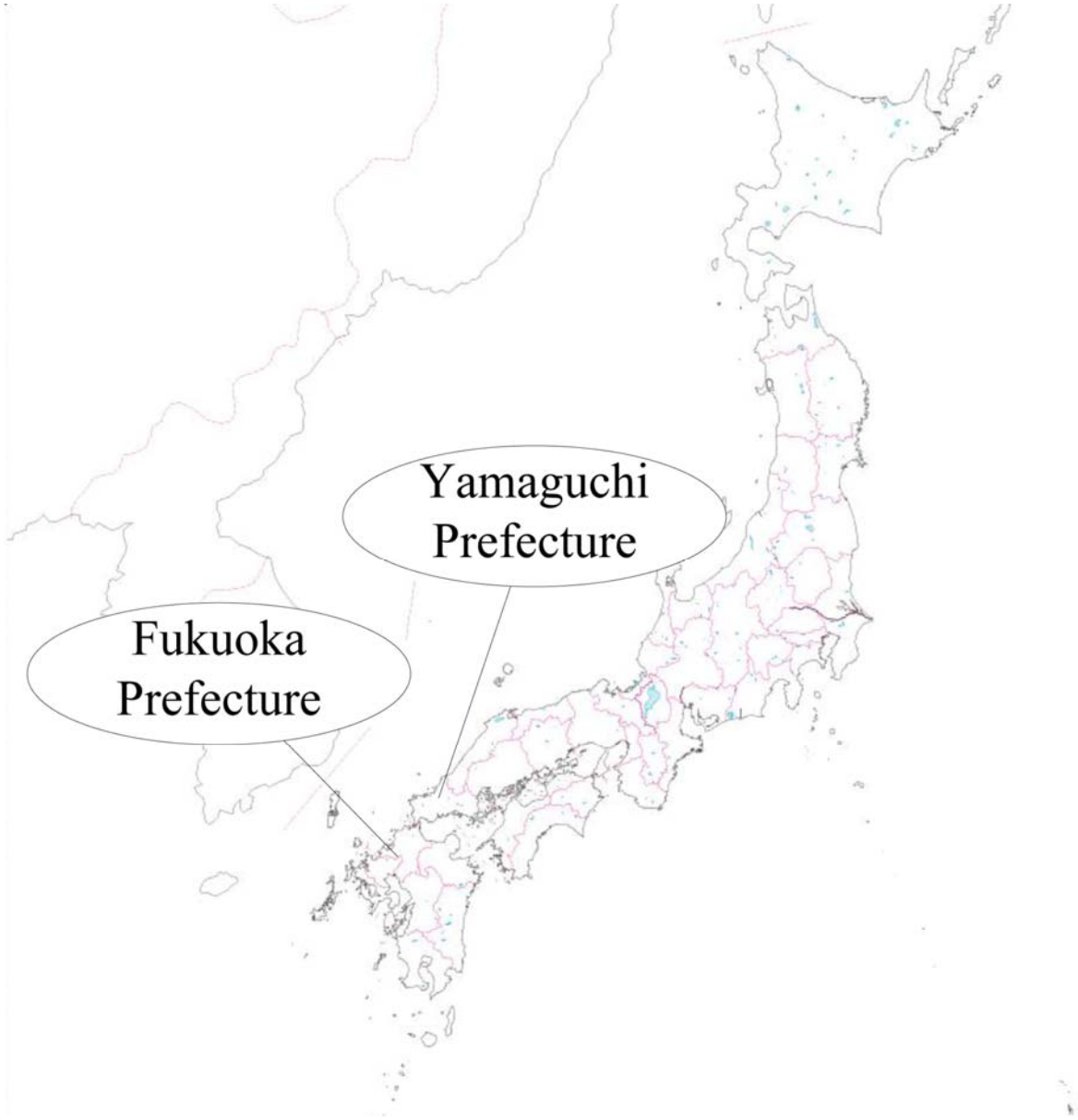

Figure 2 Fukuoka Prefecture and Yamaguchi Prefecture in Northern Kyushu Area

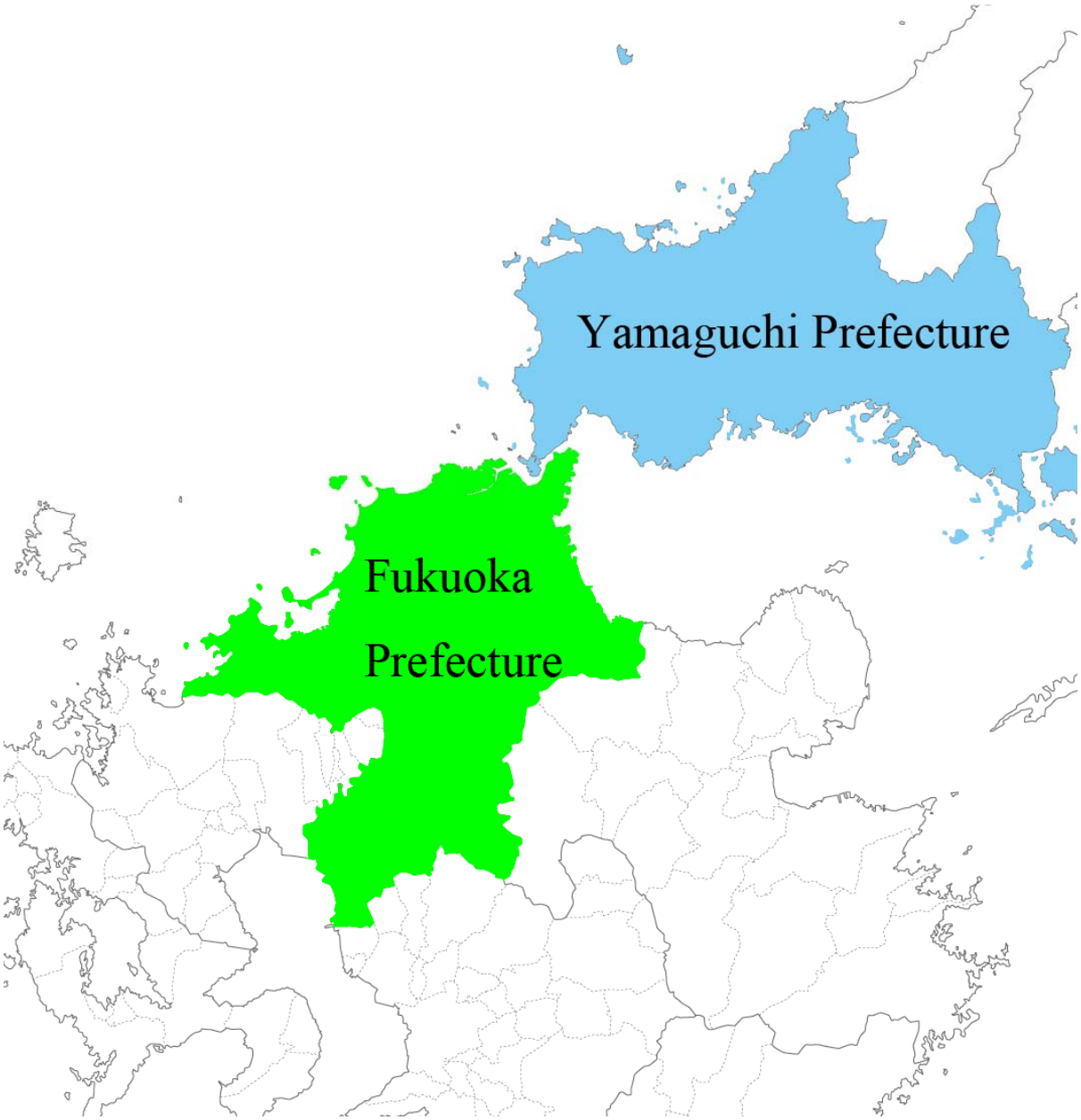

Figure 3 Fukuoka City and Kitakyushu City in Fukuoka Prefecture

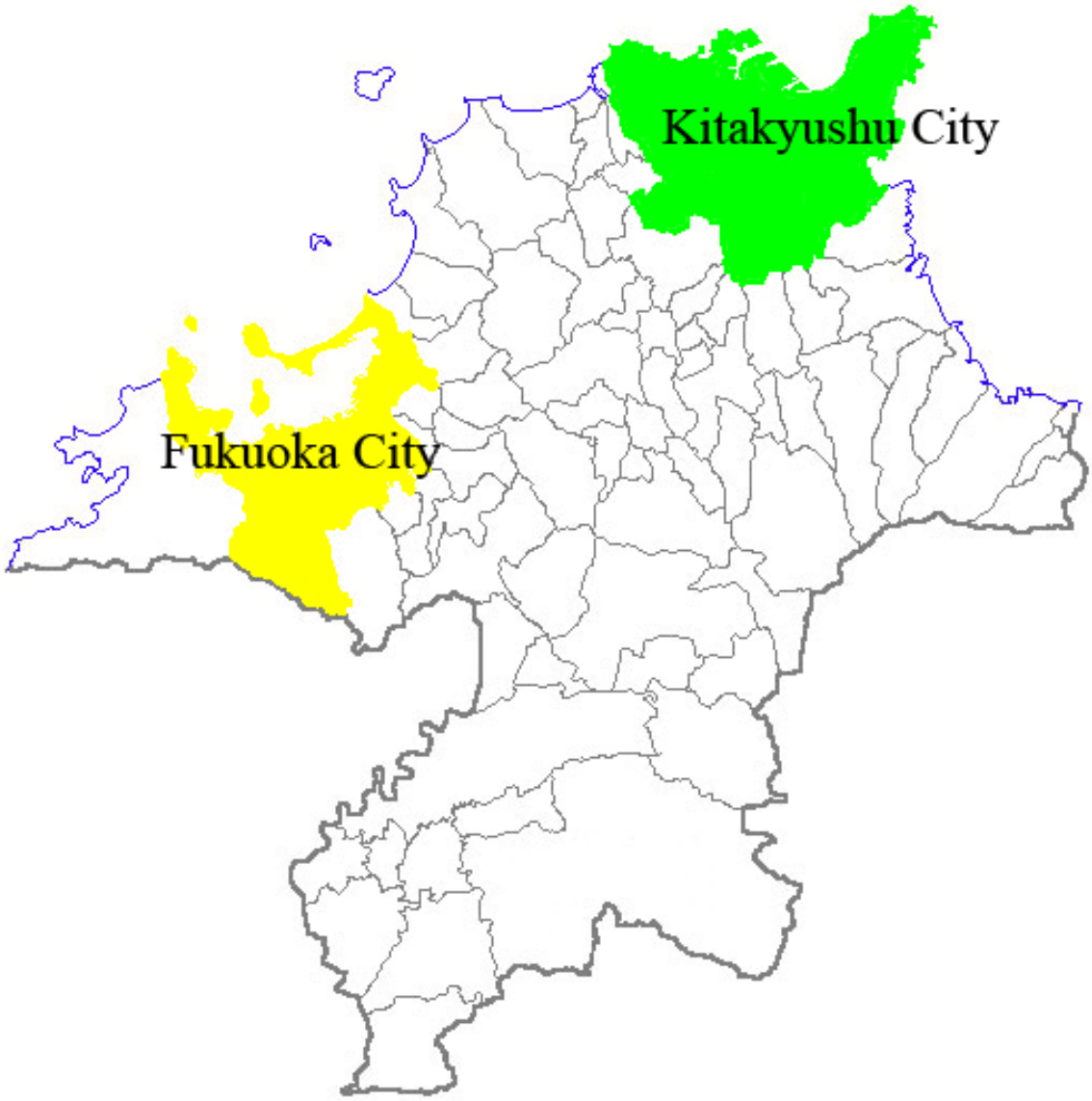

Table 1 Economy of Northern Kyushu Area

2000 price GRP (Billion yen)								
	2000	2001	2002	2003	2004	2005	2006	2007
Fukuoka	18,062	17,837	18,105	18,512	18,774	19,208	19,473	19,717
Fukuoka	6,943	6,840	6,863	6,885	7,026	7,237	7,127	7,270
Kitakyushu	3,682	3,606	3,613	3,668	3,685	3,803	3,780	3,865
Yamaguchi	5,788	5,687	5,892	5,836	5,942	6,165	6,122	6,252
All pref.	522,030	515,897	521,556	529,949	539,189	552,666	562,455	567,833
per capita GRP (Thousand yen)								
	2000	2001	2002	2003	2004	2005	2006	2007
Fukuoka	3,601	3,546	3,593	3,669	3,718	3,804	3,853	3,900
Fukuoka	5,176	5,051	5,016	4,989	5,053	5,165	5,039	5,095
Kitakyushu	3,640	3,575	3,590	3,656	3,684	3,828	3,816	3,915
Yamaguchi	3,788	3,733	3,884	3,864	3,955	4,131	4,127	4,243
All pref.	4,113	4,052	4,091	4,150	4,219	4,326	4,402	4,444
Population (10 thousand persons)								
	2000	2001	2002	2003	2004	2005	2006	2007
Fukuoka	502	503	504	504	505	505	505	506
Fukuoka	134	135	137	138	139	140	141	143
Kitakyushu	101	101	101	100	100	99	99	99
Yamaguchi	153	152	152	151	150	149	148	147
All pref.	12,693	12,732	12,749	12,769	12,779	12,777	12,777	12,777
Workers (10 thousand persons)								
	2000	2001	2002	2003	2004	2005	2006	2007
Fukuoka	239	237	234	233	234	236	237	238
Fukuoka	83	83	83	83	84	84	82	82
Kitakyushu	49	48	48	47	47	46	46	46
Yamaguchi	76	75	74	74	73	73	72	73
All pref.	6,435	6,389	6,342	6,303	6,278	6,276	6,284	6,294
Share of secondary industry (percent)								
	2000	2001	2002	2003	2004	2005	2006	2007
Fukuoka	21.83	20.51	20.33	20.23	20.01	20.05	20.18	20.22
Fukuoka	10.01	9.22	9.57	8.53	8.85	8.78	8.56	7.87
Kitakyushu	28.84	27.78	25.89	25.41	25.41	26.62	25.98	25.97
Yamaguchi	35.69	34.67	36.09	35.09	35.40	36.55	35.96	36.17
All pref.	27.49	25.87	25.52	25.40	25.58	25.44	25.65	25.32

(Source) *Kenmin Keizai Keisan*, Cabinet Office, Government of Japan.

Table 2 Simulation Design

	Purpose	Detail	Model
Simulation 1	Sensitivity	Exogenous labor stock is decreased by 10% in Fukuoka Prefecture	LS (fc, kc, of)*0.9
Simulation 2	Sensitivity	Exogenous capital stock is increased by 10% in Fukuoka Prefecture	KS (fc, kc, of)*1.1
Simulation 3	Local tax	Local income tax rate is reduced by 10% in Fukuoka City	itax (fc)*0.9
Simulation 4	Local tax	Local income tax rate is reduced by 10% in Kitakyushu City	itax (kc)*0.9
Simulation 5	Local tax	Local income tax rate is reduced by 10% in Fukuoka Prefecture	itax (fc, kc, of)*0.9
Simulation 6	Government expenditure	Fukuoka City's government buys the goods from Fukuoka City	α_{gc} (fc), α_{gi} (fc)
Simulation 7	Government expenditure	Kitakyushu City's government buys the goods from Kitakyushu City	α_{gc} (kc), α_{gi} (kc),
Simulation 8	National tax	National consuming tax rate is raised by up to 100% in all regions	ntax (fc, kc, of, yp, op)*2

Table 3 Change of Capital and Labor

		S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8
Capital growth	fc	1.0654	1.0427	1.0026	0.9981	0.9950	1.0587	0.9973	0.9962
	kc	0.9313	1.1201	0.9986	1.0050	1.0035	0.9668	1.0646	1.0089
	of	0.9850	1.1354	0.9987	0.9988	1.0021	0.9708	0.9663	0.9982
Labor growth	fc	0.9643	0.9494	0.9980	1.0007	0.9983	1.0694	0.9967	0.9924
	kc	0.8285	1.0168	1.0014	0.9967	1.0042	0.9613	1.0920	1.0034
	of	0.8828	1.0318	1.0009	1.0010	0.9994	0.9636	0.9600	1.0044
Capital price	fp	1.5332	0.5987	0.9998	0.9992	0.9787	1.1663	1.1917	0.8315
	yp	0.9974	0.9933	0.9999	1.0001	0.9995	0.9964	1.0004	0.9826
	op	0.9925	1.0028	1.0000	1.0000	1.0004	0.9973	0.9973	0.9373
Labor price	fp	1.8691	0.6762	0.9953	0.9943	0.9565	1.1828	1.2052	0.8735
	yp	0.9949	0.9940	0.9998	0.9999	0.9987	0.9949	0.9970	1.0618
	op	0.9919	1.0031	1.0000	1.0000	1.0002	0.9970	0.9970	0.9929

(Note) fc: Fukuoka City; kc: Kitakyushu City; of: other region in Fukuoka Prefecture (rest of Fukuoka Prefecture); fp: Fukuoka Prefecture; yp: Yamaguchi Prefecture; op: other Prefectures (rest of Japan).
(Source) Author's calculation

Table 5 Change of Total Macro Value

	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8
Output total	0.9986	1.0005	1.0000	1.0000	1.0000	1.0002	1.0003	0.9915
Income total	1.0151	0.9908	0.9999	0.9999	0.9990	1.0036	1.0045	0.9671
Real income total	0.9978	1.0014	1.0000	1.0000	1.0000	1.0000	1.0000	0.9946

(Source) Author's calculation

Table 4 Change of Regional Macro Value

		Output	Income	Real income	Output / Labor	Income / Labor	Real income / Labor
S 1	fc	1.0443	1.7304	1.0057	1.0829	1.7944	1.0429
	kc	0.9178	1.4916	0.8739	1.1078	1.8004	1.0549
	of	0.9302	1.5813	0.9219	1.0537	1.7912	1.0443
	yp	1.0005	0.9976	0.9999	1.0005	0.9976	0.9999
	op	0.9999	0.9925	1.0000	0.9999	0.9925	1.0000
S 2	fc	0.9537	0.6382	0.9835	1.0045	0.6722	1.0359
	kc	1.0252	0.6842	1.0582	1.0083	0.6729	1.0407
	of	1.0535	0.6991	1.0707	1.0210	0.6776	1.0377
	yp	0.9991	0.9932	1.0000	0.9991	0.9932	1.0000
	op	1.0000	1.0028	1.0000	1.0000	1.0028	1.0000
S 3	fc	0.9993	0.9972	1.0001	1.0013	0.9992	1.0021
	kc	1.0001	0.9975	1.0003	0.9987	0.9961	0.9988
	of	1.0001	0.9972	1.0001	0.9992	0.9963	0.9992
	yp	1.0000	0.9998	1.0000	1.0000	0.9998	1.0000
	op	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
S 4	fc	0.9995	0.9959	0.9997	0.9987	0.9952	0.9990
	kc	0.9995	0.9969	1.0005	1.0029	1.0002	1.0039
	of	1.0002	0.9964	1.0002	0.9992	0.9954	0.9992
	yp	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	op	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
S 5	fc	0.9944	0.9629	0.9973	0.9961	0.9645	0.9990
	kc	1.0010	0.9703	1.0042	0.9969	0.9663	1.0000
	of	1.0009	0.9671	1.0014	1.0015	0.9677	1.0021
	yp	0.9999	0.9990	1.0000	0.9999	0.9990	1.0000
	op	1.0000	1.0003	1.0000	1.0000	1.0003	1.0000
S 6	fc	1.0820	1.2512	1.0657	1.0118	1.1699	0.9965
	kc	0.9779	1.1314	0.9644	1.0172	1.1769	1.0032
	of	0.9721	1.1333	0.9667	1.0088	1.1761	1.0033
	yp	1.0000	0.9961	1.0000	1.0000	0.9961	1.0000
	op	0.9999	0.9972	1.0000	0.9999	0.9972	1.0000
S 7	fc	1.0109	1.1946	0.9978	1.0143	1.1986	1.0011
	kc	1.0871	1.2923	1.0800	0.9955	1.1834	0.9890
	of	0.9691	1.1510	0.9629	1.0095	1.1990	1.0031
	yp	1.0012	0.9992	1.0003	1.0012	0.9992	1.0003
	op	0.9999	0.9972	1.0000	0.9999	0.9972	1.0000
S 8	fc	0.9805	0.8521	0.9867	0.9880	0.8586	0.9943
	kc	0.9935	0.8644	1.0013	0.9902	0.8614	0.9979
	of	0.9921	0.8611	0.9918	0.9878	0.8574	0.9875
	yp	0.9895	1.0292	0.9906	0.9895	1.0292	0.9906
	op	0.9916	0.9705	0.9948	0.9916	0.9705	0.9948

(Source) Author's calculation

Appendix: Model description

A-1. Set

r, s, u Region

fc: Fukuoka City
kc: Kitakyushu City
of: other Fukuoka Prefecture
yp: Yamaguchi Prefecture
op: other Prefectures

i, j Industry

a001: Agriculture
i002: Food products
i003: Textile, wearing apparel and wooden products
i004: Chemical products
i005: Metal products
i006: Machinery
i007: Electronic products
i008: Transport equipment
i009: Other manufacturing (including mining)
i010: Construction
s011: Electricity, gas and water supply
s012: Trade
s013: Banking
s014: Real estate
s015: Transport
s016: Telecommunication
s017: Public services
s018: Other services

A-2. Parameters

$ntax_{r,i}$ The value added tax rate on goods
$itax_r$ The income tax rate of the private institution
psr_r The saving rate of the private institution
gsr_r The saving rate of the government

$\alpha^{PC}_{r,s,i}$ The share parameter of the goods for private consumption
$\alpha^{GC}_{r,s,i}$ The share parameter of the goods for government consumption
$\alpha^{PI}_{r,s,i}$ The share parameter of the goods for private investment
$\alpha^{GI}_{r,s,i}$ The share parameter of the goods for government investment
$\alpha^{IN}_{r,s,i}$ The share parameter of the goods for inventory
$\alpha^{FCL}_{r,j}$ The share parameter of labor in the production function
$\alpha^{FCK}_{r,j}$ The share parameter of capital in the production function
$\gamma^{FC}_{r,j}$ The productivity parameter of the value added in the production function

$\delta^{FC}_{r,j}$ The share parameter of the composite goods for the Leontief function

$\delta^{XM}_{r,i,s,j}$ The share parameter of the composite goods for the Leontief function

$\alpha^{QY}_{r,j}$ The share parameter of the intermediate goods produced domestically
$\alpha^{QM}_{r,j}$ The share parameter of the intermediate goods imported
$\gamma^{Q}_{r,j}$ The productivity parameter of the intermediate goods

$\sigma^{FC}_{r,j}$ Elasticity of substitution between labor and capital
$\sigma^{M}_{r,j}$ Elasticity of substitution between composite goods and imported goods

A-3. Endogenous variables

$PC_{r,s,i}$ The consumption demand by the private institution
$GC_{r,s,i}$ The consumption demand by the government
$PI_{r,s,i}$ The investment demand by the private institution
$GI_{r,s,i}$ The investment demand by the government
$IN_{r,s,i}$ The inventory

$L_{r,j}$ The labor demand by firm
$K_{r,j}$ The capital demand by firm
$FC_{r,j}$ The composite factor
$XM_{r,i,s,j}$ The intermediate goods
$Y_{r,j}$ The composite goods
$M_{r,j}$ The imported goods
$Q_{r,j}$ The aggregated goods
$E_{r,i}$ The exported goods
$D_{r,i}$ The domestic goods

PL_r The price of labor
PK_r The price of capital
$PFC_{r,j}$ The price of the composite factor
$PY_{r,j}$ The price of the composite goods
$PM_{r,j}$ The import price of the intermediate goods
$PQ_{r,i}$ The goods price
$PE_{r,i}$ The export price of the goods
$PD_{r,i}$ The domestic price of the goods

$INCOME_r$ The income of the private institution
$GOINCO_r$ The income of government
$INVEST_r$ The investment by the private institution
$GOINVE_r$ The investment by the government

A-4. Exogenous variables

$L^{*}_{r,j}$ The labor supply
$K^{*}_{r,j}$ The capital supply
$E^{*}_{r,i}$ The export goods
$PM^{*}_{r,j}$ The import price of the intermediate goods

$PE^{*}_{r,i}$	The export price of the goods
$INVN^{*}_{r}$	The inventory transfer
$RTR^{*}_{r,s}$	The regional transfer
FTR^{*}_{r}	The foreign transfer

A-5. Equations

1. Value added (CES)

$$L_{r,j} = \left(\alpha_{r,j}^{FCL} \, PFC_{r,j} \Big/ PL_r \right)^{-\sigma_j^{FC}} \left(\gamma_{r,j}^{FC} \right)^{-\sigma_j^{FC}-1} FC_{r,j} \qquad \text{(E-1)}$$

$$K_{r,j} = \left(\alpha_{r,j}^{FCK} \, PFC_{r,j} \Big/ PK_r \right)^{-\sigma_{r,j}^{FC}} \left(\gamma_{r,j}^{FC} \right)^{-\sigma_j^{FC}-1} FC_{r,j} \qquad \text{(E-2)}$$

$$PFC_{r,j} = \left(\left(\alpha_{r,j}^{FCL} \right)^{-\sigma_j^{FC}} \left(\frac{PL_r}{\gamma_{r,j}^{FC}} \right)^{1+\sigma_j^{FC}} + \left(\alpha_{r,j}^{FCK} \right)^{-\sigma_j^{FC}} \left(\frac{PK_r}{\gamma_{r,j}^{FC}} \right)^{1+\sigma_j^{FC}} \right)^{1/1+\sigma_j^{FC}} \qquad \text{(E-3)}$$

2. Labor market

$$\sum L_{(fc),j} + \sum L_{(kc),j} + \sum L_{(of),j} = \sum L^{*}_{(fc),j} + \sum L^{*}_{(kc),j} + \sum L^{*}_{(of),j} \qquad \text{(E-4)}$$

$$\sum L_{(yp),j} = \sum L^{*}_{(yp),j} \qquad \text{(E-5)}$$

$$\sum L_{(op),j} = \sum L^{*}_{(op),j} \qquad \text{(E-6)}$$

3. Capital market

$$\sum K_{(fc),j} + \sum K_{(kc),j} + \sum K_{(of),j} = \sum K^{*}_{(fc),j} + \sum K^{*}_{(kc),j} + \sum K^{*}_{(of),j} \qquad \text{(E-7)}$$

$$\sum K_{(yp),j} = \sum K^{*}_{(yp),j} \qquad \text{(E-8)}$$

$$\sum K_{(op),j} = \sum K^{*}_{(op),j} \qquad \text{(E-9)}$$

4. Composite (Leontief)

$$FC_{r,j} = \delta_{r,j}^{FC} \cdot Y_{r,j} \qquad \text{(E-10)}$$

$$XM_{r,i,s,j} = \delta_{r,i,s,j}^{XM} \cdot Y_{s,j} \qquad \text{(E-11)}$$

$$PY_{r,j} \cdot Y_{r,j} = PFC_{r,j} \cdot FC_{r,j} + \sum PD_{u,i} \cdot XM_{u,i,r,j} \qquad \text{(E-12)}$$

5. Import (CES)

$$PM_{r,j} = PM^{*}_{r,j} \qquad \text{(E-13)}$$

$$Y_{r,j} = \left(\alpha_{r,j}^{QY} \frac{PQ_{r,j}}{PY_{r,j}} \right)^{-\sigma_j^{M}} \left(\gamma_{r,j}^{Q} \right)^{-\sigma_j^{M}-1} Q_{r,j} \qquad \text{(E-14)}$$

$$M_{r,j} = \left(\alpha_{r,j}^{QM} \frac{PQ_{r,j}}{PM_{r,j}} \right)^{-\sigma_j^{M}} \left(\gamma_{r,j}^{Q} \right)^{-\sigma_j^{M}-1} Q_{r,j} \qquad \text{(E-15)}$$

$$PQ_{r,j} = \left(\left(\alpha_{r,j}^{QY}\right)^{-\sigma_j^M} \left(\frac{PY_{r,j}}{\gamma_{r,j}^{Q}} \right)^{1+\sigma_j^M} + \left(\alpha_{r,j}^{QM}\right)^{-\sigma_j^M} \left(\frac{PM_{r,j}}{\gamma_{r,j}^{Q}} \right)^{1+\sigma_j^M} \right)^{1/1+\sigma_j^M} \quad \text{(E-16)}$$

6. Export (exogenous)

$$PE_{r,i} = PE_{r,i}^{*} \quad \text{(E-17)}$$

$$E_{r,i} = E_{r,i}^{*} \quad \text{(E-18)}$$

7. Market clearing

$$D_{r,i} = Q_{r,i} - E_{r,i} \quad \text{(E-19)}$$

$$D_{r,i} = \sum \left(PC_{r,s,i} + GC_{r,s,i} + PI_{r,s,i} + GI_{r,s,i} + IN_{r,s,i} \right) + \sum\sum XM_{r,i,s,j} \quad \text{(E-20)}$$

$$PD_{r,i} = PQ_{r,i}\left(1 + ntax_{r,i}\right) \quad \text{(E-21)}$$

8. Private consumption

$$PD_{s,i} \cdot PC_{s,r,i} = \alpha_{s,r,i}^{PC}\left(1 - itax_r - psr_r\right) \cdot INCOME_r \quad \text{(E-22)}$$

$$INCOME_r = \sum \left(PL_r \cdot L_{r,j} + PK_r \cdot K_{r,j} \right) \quad \text{(E-23)}$$

9. Government consumption

$$PD_{s,i} \cdot GC_{s,r,i} = \alpha_{s,r,i}^{GC}\left(1 - gsr_r\right) \cdot GOINCO_r \quad \text{(E-24)}$$

$$GOINCO_r = itax_r \cdot INCOME_r + \sum \left(ntax_{r,j} \cdot PQ_{r,j} \cdot D_{r,j} \right) \quad \text{(E-25)}$$

10. Private investment

$$PD_{s,i} \cdot PI_{s,r,i} = \alpha_{s,r,i}^{PI}\left(INVEST_r - INVN_r^{*} - \sum RTR_{r,u}^{*} + FTR_r^{*} \right) \quad \text{(E-26)}$$

$$INVEST_r = psr_r \cdot INCOME_r + \sum RTR_{u,r}^{*} \quad \text{(E-27)}$$

11. Government investment

$$PD_{s,i} \cdot GI_{s,r,i} = \alpha_{s,r,i}^{GI} \cdot GOINVE_r \quad \text{(E-28)}$$

$$GOINVE_r = gsr_r \cdot GOINCO_r \quad \text{(E-29)}$$

12. Inventory

$$PD_{s,i} \cdot IN_{s,r,i} = \alpha_{s,r,i}^{IN} \cdot INVN_r^{*} \quad \text{(E-30)}$$

Appendix Table Metropolitan cities of Japan

Tokyo Metropolis	Special wards of Tokyo (Adachi, Arakawa, Bunkyo, Chiyoda, Chuo, Edogawa, Itabashi, Katsushika, Kita, Koto, Meguro, Minato, Nakano, Nerima, Ota, Setagaya, Shibuya, Shinagawa, Shinjuku, Suginami, Sumida, Toshima, Taito)
Designated cities	Chiba, Fukuoka, Hamamatsu, Hiroshima, Kawasaki, Kitakyushu, Kobe, Kyoto, Nagoya, Niigata, Okayama, Osaka, Sagamihara, Saitama, Sakai, Sapporo, Sendai, Shizuoka, Yokohama
Core cities	Akita, Amagasaki, Aomori, Asahikawa, Fukuyama, Funabashi, Gifu, Hakodate, Higashiosaka, Himeji, Iwaki, Kagoshima, Kanazawa, Kashiwa, Kawagoe, Kochi, Koriyama, Kumamoto, Kurashiki, Kurume, Maebashi, Matsuyama, Miyazaki, Morioka, Nagano, Nagasaki, Nara, Nishinomiya, Oita, Okazaki, Otsu, Shimonoseki, Takamatsu, Takatsuki, Toyama, Toyohashi, Toyota, Utsunomiya, Wakayama, Yokosuka
Special cities	Akashi, Atsugi, Chigasaki, Fuji, Fukui, Hachinohe, Hirakata, Hiratsuka, Ibaraki, Ichinomiya, Isesaki, Joetsu, Kakogawa, Kasugai, Kasukabe, Kawaguchi, Kishiwada, Kofu, Koshigaya, Kumagaya, Kure, Matsumoto, Mito, Nagaoka, Neyagawa, Numazu, Odawara, Ota,·Sasebo, Soka, Suita, Takarazuka, Takasaki, Tokorozawa, Tottori, Toyonaka, Tsukuba, Yamagata, Yamato, Yao, Yokkaichi
Prefectural capitals (not included above)	Fukushima, Tsu, Naha, Saga, Matsue, Tokushima, Yamaguchi

(Note 1) A core city (*Chukakushi*) is a class of Japanese city created by the first clause of Article 252, Section 22 of the Local Autonomy Law of Japan. Core cities are delegated many functions normally carried out by prefectural governments, but not as many as designated cities. To become a candidate for core city status, a city must satisfy the following condition: A population greater than 300,000.
(Note 2) Special Cities (*Tokureishi*) of Japan are cities with populations of at least 200,000, and are delegated a subset of the functions delegated to core cities. This category was established by the Local Autonomy Law, article 252 clause 26. They are designated by the Cabinet after a request by the city council and the prefectural assembly.
(Source) Wikipedia, “City designated by government ordinance.”