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Conference Paper

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50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Sakamoto, Hiroshi (2010) : CGE Analysis of Regional Policy in Northern Kyushu Area, 50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

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CGE Analysis of Regional Policy in Northern Kyushu Area

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Abstract

This study develops a policy model under the hierarchical administration system of the regional economy in Japan. In case of Japan, a hierarchy of national, prefectural, and municipal (city) administration exists, and a different regional policy in these each hierarchies can be set up. Generally, the policy and its evaluation might be different whether should give priority to national interests or to each region's interests. To show such a situation, quantitatively analysis by using the computable general equilibrium model (CGE model) is examined.

Concretely, Kitakyushu City and Fukuoka City are taken up as an administrative region at the city level. Together with these two cities and surrounding areas, it becomes Fukuoka Prefecture.

On the other hand, the case of including Yamaguchi Prefecture, the adjacent prefecture, in these regions exists. In this case, it can be called Northern Kyushu Area by combining Fukuoka Prefecture and Yamaguchi Prefecture, and such a large area also becomes important in the regional policy as higher hierarchy. Five regions including the rest of Japan are focused on this study.

Moreover, due to availableness of the input-output tables of these regions, respectively, the data base to develop the CGE model is estimated after tabulating the interregional input-output table.

JEL classification: C68, D58, O53, R13

Keywords: Northern Kyushu, Hierarchy of administration, Regional policy, CGE model

2010 August

Draft version, DO NOT Quote

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1. Introduction

This study develops a policy model under the hierarchical administration system of the regional economy in Japan. In the regional analysis, the object region is often selected at the same level of hierarchical administration or economic situation.¹ However, an administrative region is also hierarchically set as well as the city exist hierarchically. Therefore, the regional analysis considering the hierarchical system is also necessary.² If data becomes 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. For solving this problem, the study provides a policy model to analyze the hierarchical administrative region.

Japan's administrative region is hierarchical as well as a lot of other countries. There is a limit in the regional policy because an administrative region of the subordinate position in the hierarchy is small the area and the population, and not diversified the industrial structure. Nevertheless, the effort for the activation of the own region is not neglected. However, the effort is the same also in an administrative region of a higher hierarchy.⁴ Therefore, it is expected that each administration compete for the policy with another region for the activation of the own region.

The Northern Kyushu area which is the object region in the study is located on the west side of Japan, and is near a Korean peninsula. The feature of this area is that it can focus on Asia including South Korea and China at the same time as considering Tokyo that is the capital as for economy and/or regional policy. Is it Tokyo or Asia? It is a big problem for this area weather is necessary to pay attention. However, it is true that there is not an idea united in the region either. One reason is that this area is not being appropriately defined. The center of the Northern Kyushu area is Fukuoka Prefecture. The Northern Kyushu area is often composed of the surrounding area with Fukuoka Prefecture (Figure 1 and Figure 2).⁵ However, because the administration is independent at the prefecture level in the surrounding

¹ For example, it is often analyzed in two regions in economic theory to make the problem simple.

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

³ For instance, because the income data of province level and prefecture (county) level available in China and Indonesia, the analysis which the income disparity among hierarchical regions is examined (for example, Akita, 2003; and Sakamoto, 2008).

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

⁵ The surrounding prefecture of Fukuoka Prefecture is Yamaguchi Prefecture, Saga Prefecture, Nagasaki Prefecture, Oita Prefecture, and Kumamoto Prefecture.

prefecture, the union of policies is quite difficult.

On the other hand, there are two government-designated major cities in Fukuoka Prefecture. One is Fukuoka City where is the central city in Fukuoka Prefecture. The other is Kitakyushu City where is a big city of about one million people in the population. The relation between Fukuoka City and Kitakyushu City is not good at all. Because two cities are becoming independent in the administration, it is possible to execute a policy in each government's profit. To express the hierarchical administration in the study, Fukuoka Prefecture is divided into Fukuoka City, Kitakyushu City, and others (Figure 3). In addition, 5 regions where it added Yamaguchi Prefecture and other prefectures of Japan are analyzed.

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

The hierarchical administration system of Japan and the feature of the object region are explained in the next section. Section 3 explains the model and data, and Section 4 explains the simulation design. The result of simulation introduces by Section 5, and the conclusion is in the last section.

2. Hierarchical administration system of Japan

First of all, we explain the hierarchical administration system of Japan by government 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 Japanese), towns (*cho*), villages (*son*) and special wards (the *ku* of Tokyo).⁷⁸

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

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").

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 which 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 fifty thousand, and a city can (but need not) be demoted to a town or village when its population decreases below fifty thousand (from Wikipedia, "Municipalities of Japan").

cabinet of Japan under Article 252, Section 19 of the Local Autonomy Law (Table 1).

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 we have 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 as the city can be done. However, this regional policy is likely a policy of the city, and the influence on another region is not considered. Therefore, it often becomes a policy competition in Fukuoka City and Kitakyushu City. For example, the international airport is in Fukuoka City, and there is an airport also in Kitakyushu City in Fukuoka Prefecture. Fukuoka City is hoping for enhancing the airport though the Fukuoka international airport may transfer a part of the function to the Kitakyushu airport because capacity is almost full.

Yamaguchi Prefecture is located next to Fukuoka Prefecture and an economic interchange among them is comparatively well. Especially, Shimonoseki City near Kyushu Island is the deepest in the economic connection 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 is very small in population and the input-output table of Shimonoseki City is not made for. Therefore, the Northern Kyushu area is made by Fukuoka Prefecture and Yamaguchi Prefecture in the study.

3. Model and Data

For analyzing the hierarchical regional system in Northern Kyushu area, quantitative analysis by using the computable general equilibrium model (CGE model) is consistent. There are dozens of models have been developed. The feature of the CGE model is to adopt the productive structure of the nested type of production function of each stage, and these structures are adopted also in the study. On the other hand, because we will construct the multi-region CGE model,⁹ the movement of the productive factor between regions becomes

⁹ It might be called 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 in the multi-region (multi-country) is GTAP (Global Trade Analysis Project) model. Of course, there are dozens of the multi-region models have been developed (for example, Böhringer and Welsch, 2004; Horridge and Wittwer, 2008; and Latorre et al., 2009).

important. Especially, because it is a model that a small region (city) exists in the prefecture, it is necessary to set the special assumption of the movement between regions. As for a concrete formulation, please see Appendix.

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

Intermediate goods are composed with the value-added product by 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 import goods from foreign countries are composed by the CES function (E-13, E-14, E-15, and E-16), and all the productive structure of the nest type is completed.

The export goods to foreign countries are made exogenously in the study (E-17 and E-18). The goods except export 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. 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 as an income tax, then, consumes the final goods within the ranges of the 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 case of Japan) to sales of the 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 the government investment (E-28 and E-29).

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

The data when the CGE model is constructed often uses the input-output table. In Japan, the input-output table at the prefecture level is also available. Therefore, regional analysis can be done by using the input-output table at the prefecture level. Two government-designated

cities, Fukuoka City and Kitakyushu City that belongs to Fukuoka Prefecture are also making the input-output table on the other hand. Therefore, the analysis that divides Fukuoka Prefecture further at the city level becomes possible. Due to availability of the input-output table of these regions, respectively, the data base to develop the CGE model is estimated after tabulating the interregional input-output table.¹⁰

Various parameters were calibrated to be corresponding to the data base after the initial equilibrium solution of various price variables had been set as one. On the other hand, because the elasticity of substitution cannot be estimated from the data base, the result of an existing research such as GTAP is used.

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 the government spending. Moreover, the adjustment of the national tax is discussed at the end. The productive factor of the Fukuoka prefecture is enabled to be moved freely in each simulation based on the assumption of the base model. As a result, the adjustment of the quantity of the productive factor within Fukuoka prefecture is expected, and the inter-regional effect on a regional economic policy is 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 (Simulation 1 and 2). The population of Japan is in the decreasing tendency, and the possibility that the number of labors also will be in the decreasing tendency is high. Therefore, the reduction in the labor stock has reality in this respect. On the other hand, an increase in a capital stock is an orthodox phenomenon seen at usual economic growth.

4.2. Local tax

There are local taxes besides the national tax, and the income tax can be collected at the prefecture level and the city level.¹¹ As a result, the various local governments can build up

¹⁰ We use following input-output tables for estimating interregional input-output table: Japan, Fukuoka Prefecture, Yamaguchi Prefecture, Fukuoka City, Kitakyushu City, and interregional table between Fukuoka Prefecture and the rest of Japan. Base year is 2000. These tables are available in their administration's website. 5 regions disaggregated interregional input-output table is estimated mechanically by using RAS method in abundance in the study.

¹¹ Other example of tax policy in Japan by the CGE model is Bessho and Hayashi (2005). Sakamoto (2009) is measuring the economic effect by the change of the tax system of Japan by the CGE model. In this case, Monte Carlo experiments under the uncertain productivity of the value-added production are examined.

the economic policy at a regional level by adjusting the local taxes rate. Then, the adjustment simulation of the local taxes rate is done as an economic policy of the local government. However, the number of capital and labor might be adjustment between three regions in Fukuoka Prefecture and because it is possible to move freely, the expected effect not be necessarily achieved. In the simulation, the income tax rate of Fukuoka City has been decreased by 10% as the local taxes rate adjustment at the city level (Simulation 3). This is also performed in Kitakyushu City (Simulation 4). Moreover, the economic policy effect at the prefecture level can be observed similarly by decreasing the income tax rate of Fukuoka Prefecture by 10% (Simulation 5).

4.3. Government expenditure

The economic policy that the local government is voluntarily enforceable is limited. Nevertheless, the local government thinks about various measures for the development of an own region. The policy of maintaining the infrastructure and attracting the enterprise that brings big employment is done in a lot of regions. Moreover, the university attracting related to this is also seen. If it is said for agriculture on the other hand, the local production for local consumption is advocated. It can be said that these are policies of sacrificing another region by moving goods and factors from other regions to own region. This model can simulate such a protectionism policy by changing the parameter. For instance, the method of buying the goods that the local government buys for consumption and the investment only in not other regions but own region is devised. It is because the increase of the production demand for the own region is expected by the change in such purchase demand. Then, we assume the case where all the government purchases are done in the own city of Fukuoka City (Simulation 6). This is also performed in Kitakyushu City (Simulation 7). These become possible to calculate by changing the goods purchasing share parameters of $\alpha_{r,s,i}^{GC}$ and $\alpha_{r,s,i}^{GI}$ from all region to the own region's purchase as a technique of the model.

4.4. National tax

The adjustment of the national tax is discussed at the end. Japan is holding big fiscal deficit by the issue of government bonds. This problem is very important for thinking about Japanese economy. However, there are only two methodologies for solving problem; one is increasing tax income and the other is government spending reductions. Then, it thinks about the tax income increase simulation. A realistic tax income increase method is only a consumption tax (value added tax). Then, the value added tax rate was doubled in the study (Simulation 8).

5. Results

There are several tables to show simulation result (Table 3, Table 4, and Table 5). The tables show: change of the movement of the productive factor within Fukuoka Prefecture and

equilibrium price of the productive factor; amount of change and price change in production caused by simulation; regional income and its real value when price are fixed at the base case level; per labor of them. When the equilibrium solution before it simulates it is assumed to be a base case solution, the result of showing in the tables show the change from the base case solution.

5.1. Sensitivity

When the labor stock reduces, the decrease rate of Fukuoka City is low, and it stays in a decrease in 4% or less. Therefore, the capital concentrates on Fukuoka City. When the capital stock is increased, the capital growth rate of Fukuoka City is low, and an increase of the capital in the other two regions is 10% or more. The labor gathers in the other two regions along with it, too.

However, the factor price (capital and labor) rises greatly in the reduction of the labor stock, and the factor price has fallen greatly in an increase of the capital stock. It can be said that the price fluctuation of this model is considerably high.

Therefore, the regional income at the nominal value has changed greatly. However, the real income is the same result as movement of productive factor. Kitakyushu City will have given the economic effects to either test most when converting it into per labor because the labor is moving within Fukuoka prefecture. Moreover, the economic effect on Yamaguchi Prefecture and other prefectures are also little, and there is an economic effect to increase the capital as a whole.

5.2. Local tax

The income tax reduction increases the capital in an own region, and decreases the labor. It is a tendency that the productive factor concentrates on Kitakyushu City in the factor movement at the tax reduction of the prefecture level. The change of the factor price is not so large. There is not necessarily economic effect when taxes is reduced at the prefecture level though the tax reduction of the income tax has brought the economic effect to the own region in the real income per labor. Therefore, even if it is effective to make the economic policy only in the own region, when it becomes a policy competition among regions there is no guarantee to obtain the economic effect.¹² Moreover, a nationwide effect of the tax reduction is small and it doesn't lead to the rise of a substantial income of the whole country.

5.3. Government expenditure

A lot of productive factors (capital and labor) can be concentrated on the own region by changing all the purchased goods of the government from the own region. However, because the factor price is a rise of about 20%, it is necessary to think about the influence of the price

¹² It can be interpreted that the tax reduction of the prefecture level is three region's simultaneous tax reduction.

fluctuation. Of course, the nominal regional income rises by the increase of prices. Because labor also increases, the economic effect per labor becomes negative though the real regional income is increasing for the region that executed a policy. The effectiveness of the policy is different depending on the standard of the policy assessment. It is substantially effectiveness though this policy also has a nationwide economic effect in the nominal value by a big rise of the price.

5.4. National tax

The factor price has greatly fallen though the productive factor tends to concentrate on Kitakyushu City as a result of a nationwide tax increase. The decrease of the capital price on other prefecture and the rise of the labor price on Yamaguchi Prefecture are remarkable on the other hand. Because the number of labor increases, economic effect is negative per labor though the real income of Kitakyushu City increases. However, the width of the minus is small in any region. It can be said that the influence of the tax increase has not been brought to economy.

From these results, a part of reason of the movement of the productive factor between regions is the difference of the parameter of the industrial structure and the production function. Moreover, various changes are expected though the movement between the industries of the productive factor is not reported because of space.

What we can learn from these results? One is that there is an economic effect when one administration goes alone in the regional policy. However, when the policy competition is done between regions, an expected effect is not necessarily achieved. Local policy authorities should note the policy trend in other regions. The other is where to put the evaluation of the policy. Whether it only has to be effective as the region or it thinks about the effect per labor or per capita? It is necessary to note this respect when there is a factor movement.

6. Concluding remarks

In this study investigates how much economic policy in the region was effective under the hierarchical administration by using the CGE model in the Northern Kyushu area. It has been understood that the policy trend in another region and how to evaluate the economic effect are important from the measurement result. Such a suggestion is not obtained easily by a theoretical analysis. On the other hand, the model is simple and there is room for enhancing depending on the availability of data. A further analysis is necessary.

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Figure 1 Fukuoka Prefecture and Yamaguchi Prefecture in Japan

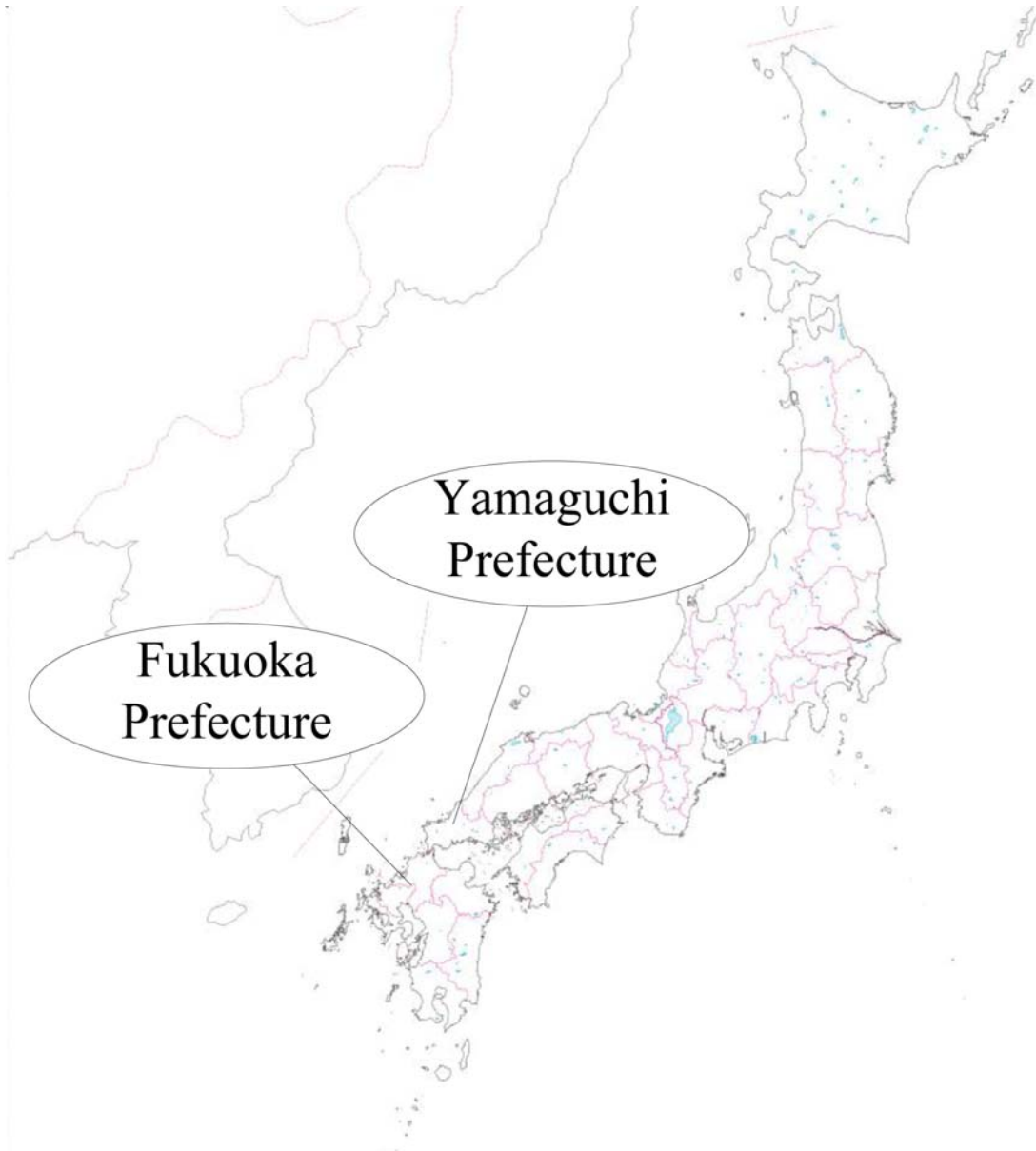


Figure 2 Fukuoka Prefecture and Yamaguchi Prefecture in Northern Kyushu Area



Figure 3 Fukuoka City and Kitakyushu City in Fukuoka Prefecture

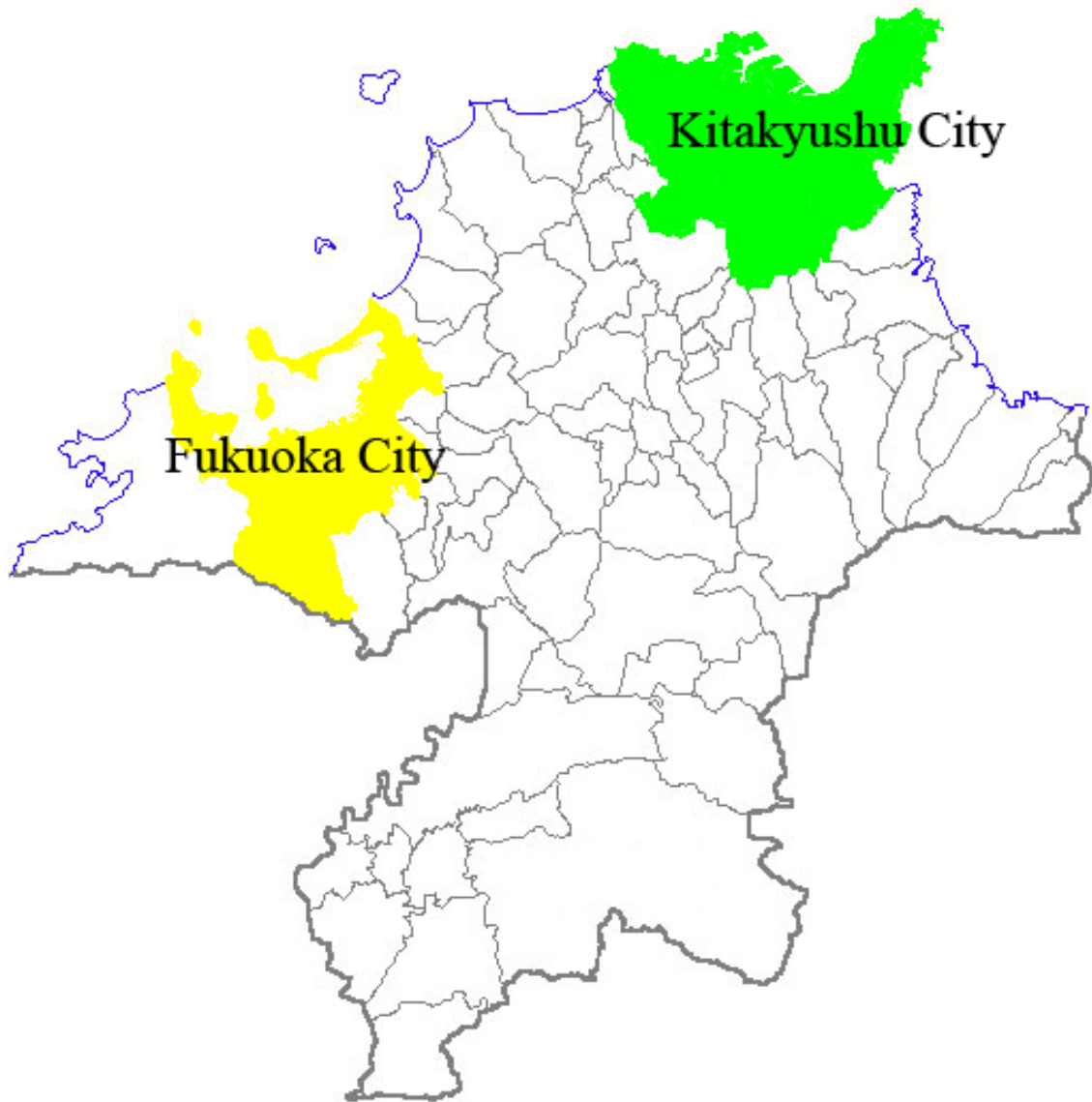


Table 1 Metropolitan cities of Japan

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”.

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 to 100% in all region	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).

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

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

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 the 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

 $\alpha_{r,s,i}^{PC}$ The share parameter of the goods for the private consumption
 $\alpha_{r,s,i}^{GC}$ The share parameter of the goods for the government consumption
 $\alpha_{r,s,i}^{PI}$ The share parameter of the goods for the private investment
 $\alpha_{r,s,i}^{GI}$ The share parameter of the goods for the government investment
 $\alpha_{r,s,i}^{IN}$ The share parameter of the goods for the inventory

$\alpha_{r,j}^{FCL}$	The share parameter of the labor in the production function
$\alpha_{r,j}^{FCK}$	The share parameter of the capital in the production function
$\gamma_{r,j}^{FC}$	The productivity parameter of the value added in the production function
$\delta_{r,j}^{FC}$	The share parameter of the composite goods for Leontief function
$\delta_{r,i,s,j}^{XM}$	The share parameter of the composite goods for Leontief function
$\alpha_{r,j}^{OY}$	The share parameter of the intermediate goods domestic
$\alpha_{r,j}^{OM}$	The share parameter of the intermediate goods import
$\gamma_{r,j}^O$	The productivity parameter of the intermediate goods
$\sigma_{r,j}^{FC}$	Elasticity of substitution between labor and capital
$\sigma_{r,j}^M$	Elasticity of substitution between composite goods and import 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 import goods
$Q_{r,j}$	The aggregate goods
$E_{r,i}$	The export goods
$D_{r,i}$	The domestic goods
PL_r	The price of the labor
PK_r	The price of the 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 by the private institution
$GOINCO_r$	The income by the 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)

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

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

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

2. Labor market

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

$$\sum L_{(yp),j} = \sum L_{(yp),j}^* \quad (E-5)$$

$$\sum L_{(op),j} = \sum L_{(op),j}^* \quad (E-6)$$

3. Capital market

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

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

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

4. Composite (Leontief)

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

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

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

5. Import (CES)

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

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

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

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

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

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

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

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

8. Private consumption

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

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

9. Government consumption

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

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

10. Private investment

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

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

11. Government investment

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

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

12. Inventory

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