Paper submitted to The 20th International Input-Output Conference, Bratislava, Slovakia, 26-29 June 2012

CGE Analysis of Yangtze River Delta in China

Dr. Hiroshi SAKAMOTO

Research Associate Professor

The International Centre for the Study of East Asian Development (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

Dr. FAN Jin♦

Professor

Research Centre for Jiangsu Applied Economics, Jiangsu Administration Institute

49 Shuizuogang, Nanjing, 210009, China

Tel: +86 25 85013353; Fax: +86 25 84201784

E-mail: jfan@mx.cei.gov.cn

♦ Corresponding author.

The authors would like to thank for their useful comments the participants of abc where this paper was presented. Sakamoto's research was supported by grant number 21530247, financed by the Japanese Ministry of Education, Culture, Sports, Science and Technology. Fan's research was supported by grant number 70873052 financed by the Natural Science Foundation of China. Of course, all remaining errors and omissions are the responsibility of the authors.

CGE Analysis of Yangtze River Delta in China

Abstract

This study develops a multi-region computable general equilibrium model (CGE model) with considering limited factor movement on the regional economy of Yangtze River Delta (YRD) in China. In broadly, YRD is composed of Shanghai City, Jiangsu province, and Zhejiang province. It has been achieved remarkable economic growth in the recent three decades. It was identified as a national-level regional economic circle in the "People's Republic of China national economic and social development 11th Five-Year Plan." This not only reflects the region's economic strength and its tremendous achievements in economic development in the past, but also highlights that it is integral to China's future economic development.

However, these regions will not go well with economic growth in the future. One of the big problems is an income inequality between rural and urban. The liquidity of people is thought as this problem solving method. Therefore, this study analyzes this liquidity by using CGE model. Input-output tables in these three regions are used to developing the model and the factor market connects these three regions. Moreover, it paid attention to the mobility of the productive factor like labor and the capital, etc. in the model. Concretely, we will assume four types of labor mobility: it can move between regions, it can move between industrial sectors, it can move between regions and sectors, and it cannot move any place. This study models four types of labor mobility at the same time. Under these assumptions, the economic effect of each region which is Shanghai City, Jiangsu province and Zhejiang province of the model is analyzed.

JEL classification: C68, D58, O53, R13, R23

Keywords: Yangtze River Delta, Factor Mobility, Regional Economic Growth, CGE Model

1. Introduction

This study develops a multi-region computable general equilibrium model (CGE model) with considering limited factor movement on the regional economy of Yangtze River Delta (YRD) in China. In broadly, YRD is composed of Shanghai City, Jiangsu province, and Zhejiang province. It has been achieved remarkable economic growth in the recent three decades. It was identified as a national-level regional economic circle in the "People's Republic of China national economic and social development 11th Five-Year Plan." This not only reflects the region's economic strength and its tremendous achievements in economic development in the past, but also highlights that it is integral to China's future economic development.

YRD has played the center role since the reform opening while China is accomplishing remarkable economic growth. After the government comes to move the emphasis of the economic policy to the western district after 2000, YRD still accomplishes with economic growth well. According to statistics in 2009, per capita GRP (gross regional product) is 78,989 yuan in Shanghai City, Jiangsu province is 44,744 yuan and Zhejiang province is 44,641 yuan (*China Statistical Yearbook, 2010*). Jiangsu province and Zhejiang province is the 4th place and the 5th place next to Beijing City and Tianjin City while Shanghai City is the top in 31 provinces (city and autonomous region). Therefore, a center role in the economic growth of YRD does not change for a while.

Some factors of the economic growth of YRD are considerable. The construction of the product export base using the foreign capital is the one. It makes efforts to the infrastructure maintenance in the region on the other hand. The subway system for the Shanghai City has been greatly maintained to one of the emphases by transport links starting with the Shanghai Expo. Moreover, the rapid-transit railway from Shanghai to Nanjing (the capital of Jiangsu province) and Hangzhou (the capital of Zhejiang province) was maintained. It became possible to move with the rapid-transit railway by one hour and some minutes though it had taken 4 or 5 hours from Shanghai to Nanjing up to now in the limited express train. As a result, it is expected that the movement of people in the region becomes active more than before. The business opportunity is sure to expand, and to expand if the movement becomes active the starting work possibility. And, it is expected that the influence on the regional economy by this is also enough.

This study is to develop the economic model who expresses the regional economy of such three provinces (Shanghai City, Jiangsu province and Zhejiang province) in YRD.[1] In the economic model's development, it is possible to think from an easy model to a complex model comparatively by the availability of data and the model setting. Especially, the CGE model is actively developed as a model by which the economic policy is quantitatively

[1] Sakamoto (2008) and Sakamoto and Fan (2010) investigated regional disparity in YRD using county data.

evaluated recently.[2] It is an academically effective because it has the general equilibrium theory based on optimization problem and has the foundation of microeconomics by this model. Because the most standard CGE model has "proto-type" of the model making,[3] reader's concern will not be obtained only by a standard model construction. Then, this paper pays attention to the mobility of the labor by such as the development of a traffic infrastructure for a standard CGE model, and it introduces the model by whom the idea is put a little on this point.

Hereafter, the model and data are explained, and sensitivity simulations are performed, as a result, we want to discuss the effectiveness of the model at the end.

2. Main model assumption

Quantitative analysis using the computable general equilibrium model (CGE model) proves reliable for analyzing the regional economy in the YRD. 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,[4] the movement of the productive factor between regions becomes important. For a concrete formulation, please see the Appendix.

The model is constructed using three regions and 20 industries (A-1). A big feature in this model is assumption concerning the mobility of the labor. The labor which belongs in some region's some industry with initial stage is engaged enables to move to the different location by the policy turnaround or the change of economic circumstances. However, the locomotion strategy acts greatly the intention and the ability of the labor furthermore by the degree of the job offer. It is important to explain this feature concisely and plausibly. In general, if the optimization of the firm is attempted by using the production function, the model can be expressed about the job offer and the labor demand (amount). On the other hand, various settings exist about the supply of labor (amount). For instance, the labor assumes that he or she cannot move, and change his job. In this case, the supply of labor (amount) is fixed by each region and each industry. The labor price, that is, the wage rate at the equilibrium changes because other supply-demand situations like production and consumption, etc. change when the policy change is done though the labor demand (amount)

---

[2] Dixon et al., (1992), Ginsburgh and Keyzer (1997), and Shoven and Whalley (1992) are representative of CGE literature in 1990s.

[3] Some small proto-type CGE models are introduced by Hosoe et al., (2004).

[4] It might be called a spatial CGE (SCGE) model (for example, Bröcker et al., 2010; Ishiguro and Inamura, 2005; Sakamoto 2011a; Sakamoto 2011b; 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).

comes to fixation because the supply of labor (amount) is fixation, too. The method of evaluating the change of this wage rate is one setting.

Then, how does it become it when the labor can move completely between regions and between industries? As for this, two settings are considerable. One of the cases is that it does not change the total amount of the labor supply. In this case, only the total amount of the labor supply is set fixing. In a word, the total amount of the labor does not change though the amount of the labor supply and demand of each region and each industry changes after changing the policy. Moreover, it should be focused on that the wage rate is a common value as the motive of such movement in each region and each industry in this case. That is, the turnover is held so that the wage rates are united. However, the united wage rate changes at the next equilibrium because the total amount of the labor supply is fixed.

The other case is changes the total amount of the labor supply. In this case, it only has to fix the united wage rate. The amount of the labor supply and demand after the policy is changed changes by each region and each industry because the amount of the labor supply and demand is decided under the fixed wage rate. Moreover, the total amount of the labor changes because it does not fix the total, too. The interpretation that the labor is procured from the other region or the unemployed in certain region start work becomes possible by the policy turnaround. There is a possibility of becoming it of course inversely, too.

The setting that reflects the characteristic of a more detailed labor that the only between regions can move or the only between industry can move becomes possible, too, if coming here. Therefore, various settings are considerable for the labor supply.

The total amount of labors is assumed to be not changeable by the policy turnaround in this study. As a result, the purpose is to understand the movement situation of labor.[5] Therefore, four labor categories of the following are set based on the movement possibility of the labor. One is a labor who can freely move between each region and each industry (E-5 in appendix A-5). Second is a labor who can freely move between each region though cannot changed one's job (E-6). Third is a labor who can freely move between each industry though cannot move other region (E-7). The last one is a fixed labor who cannot move between each region and each industry (E-8).

Next, these four labor categories are assumed to be imperfect substitution. The composite function of the labor which aggregates four labor categories by this assumption can be set (E-9). Therefore, the labor demand for four labor categories is requested from the above-mentioned composite CES (constant elasticity of substitution) function (E-1, E-2, E-3, and E-4).

[5] When the total amount of labor changes, it is possible to interpret as not the turnover but the unemployment of starting work or its inverse. Of course it is possible to develop the model that considers this feature. Moreover, dynamic model of labor (capital) mobility is another option (for example Sakamoto, 2007).

3. Other model assumption and data

The productive factor produces the value-added products by using the CES function for capital and aggregated labor (E-10, E-11, and E-13). The capital market enables the free movement between industries (E-12). It means another industry's goods can be produced though the capital cannot move to other regions.[6]

Intermediate goods are composed with the value-added product using the Leontief function (E-14, E-15, and E-16). In this model, we distinguish imported goods from domestic market (outside of each province[7]) or foreign market. The goods imported from both market are composed using the CES function, respectively (E-17, E-18, E-19, and E-20 are from domestic market and E-21, E-22, E-23, and E-24 are from foreign market), and the total productive structure of the nested type is completed.

The goods exported to domestic (outside of each province) and foreign markets are made exogenously in the study, respectively (E-28 and E-29). The goods except exported goods are used for each provincial demand (E-25). The sales price is added up by government tax and margin (E-27).

The each provincial demand is divided into private consumption, government consumption, investment, inventory adjustment and the intermediate goods (E-26). Each demand is distributed according to the demand function of the Cobb-Douglas type.

The income of the private sector is based on the price (wage) and the amount of the productive factor obtained from the factor market and margin and tax income from goods market (E-31).[8] 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-30). The income of the government sector is a private income tax (E-33). A part of the government revenue is saved, and the government consumes the final goods besides (E-32). All private savings and the government savings are allocated to the investments excluding the exogenous inventory adjustment and domestic and foreign transfer (E-34 and E-35). The total inventory adjustment is exogenous but it is allocated to each industry by using the same demand function (E-36).

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.

Data used the input-output table of the Shanghai City, Jiangsu province, and Zhejiang province in 2007. It is necessary to make the interregional input-output table to have to

[6] It is possible to assume capital mobility like the labor, but it is not appropriate to move it between regions for short time.

[7] It means of outside of each province. It might reflect other YRD province or might reflect China's province other than YRD. It brings it together in one for convenience sake because there is no data that concretely distinguishes this.

[8] To bring the value added incomes of each region together in one, the commodity tax income was included in a private income. Then, the income tax including the commodity tax income becomes the income of the government.

examine the movement of the goods between regions, and to integrate these tables. However, making the interregional input-output table is not easy. Moreover, the relation of intermediate goods shown in the input-output analysis is not so valued in the CGE model.[9] Then, the model to analyze three regions at the same time by not making the interregional input-output table in this study, making three independent social accounting processions (SAM) from three input-output tables, and connecting this by labor market is constructed.

It is a problem how to set the labor to four categories. The material to distinguish data does not exist about this. Therefore, it sets it by strong assumption here. The ratio of the labor that was able to move freely was assumed to be 70% in Agriculture (a001) and assumed to be 10% in other industries. The ratio of the labor that was not able to move at all was assumed to be 10% in agriculture (a001) and assumed to be 70% in other industries. The itinerant labor of the limitation between industry and limiting between regions assumed to be 10% as the initial value in all industries, respectively. The amount the labor is distributed according to the above-mentioned proportional distribution ratio because it makes it to relativity, and all initial values of the labor price are assumed to be one as an initial value. There are not a lot of labors who can move in view of the specialty of the technology. However, agricultural labor is seemed starting work degree of freedom as the migrant worker is high. These two are put on the mind.[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.

4. Simulation

The simulation is assumed to be a sensitivity analysis. An independent local government exists in these three regions, and the government that integrates these does not exist.[11] Therefore, some economic policies are done by each provincial government independently.[12]

---

[9] The model is often written only by usually using the Leontief function in the CGE model though the relation of intermediate goods becomes the key to the analysis in the input-output analysis. It is thought enough to use the CES function for the intermediate goods dealings between regions in the interregional input-output table. However, the shipping in/out from/to other provinces are recorded in input-output tables of each provinces, and it can be written to exchange the goods between regions by applying the CES function by the above-mentioned model setting even if it is uncertain at the import origin and shipping out destination.

[10] Of course, it is necessary to change this ratio. However, the important suggestion was not seen though the simulation result was different.

[11] Exceptionally, it is considerable that a central government does a special policy to these three regions for some reason.

[12] Because the argument may become complex, this study does not take it up though it is considerable repeated game simulation to which the region where the disadvantage by it was put out because a certain region does the economic policy does the opposing economic policy.

Because the turnover is possible between regions (and between industry), the influence on another region by the economic policy is main concern. Then, strengthening export based on the reinforcement of a capital stock including the foreign capital that has supported the economic growth of YRD up to now and it is made the object of the sensitivity analysis. Moreover, sensitivity of the agriculture problem that had to be called the problem of the growth in the future was analyzed (see Table 1).

4.1. Capital stock

As for essence, the height of the investment rate supports economic growth though the role of the foreign capital in the economic growth of China is widely discussed. Therefore, the domestic capitals are actually more important than foreign capitals. The investment demand in YRD is still high anyway. Then, sensitivity when a capital stock increases by 10% is analyzed. The policy is not especially specified though a further introduction policy of the foreign capital and the policy for further infrastructure maintenance correspond in the policy. However, the capital is enabled to be moved between industries by the model's assumption. In a word, the capital invested in a region concerned is distributed so that the rate (price) on capital of each industry may become equal. On which industry the capital concentrates after increasing a capital stock by this assumption can be examined. Four simulation patterns are provided: the entire three regions, only Shanghai City, only Jiangsu province and only Zhejiang province as a region where a capital stock increased.

4.2. Export

Export that supports the economic growth of China is mainly due to manufacturing. China also has played an important role as a production foothold while the international specialization of manufacturing is advanced. Moreover, the enterprise in China applies competitive edge, and, as a result, the export power has been improved though such an international specialization has been mainly done by the investment of the enterprise in the advanced country. Sensitivity which export increases by 10% is analyzed. Four simulation patterns are provided: the entire three regions, only Shanghai City, only Jiangsu province and only Zhejiang province as well as the region where a capital stock increased.

4.3. Productivity

Agriculture falls behind relatively though YRD is a region that develops comparatively. As for the other two provinces, still a lot of agriculture is held, and the conversion of the industrial structure is requested though there is not too much agriculture in Shanghai City because he is an economic structure of the city type. Then, the economic effect by a productivity increase in agriculture is analyzed. A productivity increase corresponds by improving the productivity parameter in the production function by 10%. The object region

---

Dynamic game simulation among regional government will be one option for future research.

analyzed two: the entire three regions and two provinces of Jiangsu and Zhejiang are improved productivity at the same time.

5. Results

There are several tables to show the simulation results (from Table 2 to Table 8). 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.

Table 2 is a summary of the change of the labor of each category (a part of labor price) in simulation 1. The labor's change when four category labors exist at the same time is very complex. An initial value of employed is considerably little though the labor of all categories has concentrated on Mining (i002) of Shanghai City originally. Therefore, the amount of the change is a little though the change rate is large. The labor of Metal products (i008) tends to concentrate on the Zhejiang province though the labor of Non-metal mineral products (i007) is concentrated tendency in Shanghai City and Jiangsu province. Moreover, the labor of service industry (s018, s019, and s020) tends to concentrate on the Jiangsu province and Zhejiang province.

Table 3 is showing of the change in capital (stock), gross production and the labor productivity in simulation 1. The distribution of the capital to each industry does complex movement as well as the labor though the capital stock in all regions and industries increase because the capital stock is increased in all regions in simulation 1. It can be thought that the capital is used for other industries when it is smaller than 10% (1.1000) because increase rate is assumed to 10%. Regarding to this ratio, it is understood that an increase the capital of agriculture is comparatively little. There are oppositely a lot of increases of Mining. Chemical products (i006), Electricity, and gas and water supply (i012) are comparatively little an increase. It can be understood that the capital is redistributed again. An increase of the capital is connected with the production increase. However, the labor productivity decreases when labor is distributed any more. It is understood that the agriculture of Shanghai City and the labor productivity of Mining are negative as long as the table is seen.

Table 4 is showing of the change in the main variable according to industry in the increase of a capital stock. Production increases simply so that a capital stock may increase. However, the labor has the movement tendency in industry named Agriculture and Mining with comparatively low productivity. Therefore, the labor productivity has not improved so much. As a result, there is a possibility that the productivity differential between industries expands.

Table 5 is showing of the change in the main variable according to industry by the increase of the export of manufacturing. The point that divides into industry for which the productive factor is necessary and industry not so as export increases is a big feature. The labor productivity increases mainly Agriculture that the number of labors decreases though production increases mainly export-oriented manufacturers, and the productivity differential

has the possibility of the reduction.

Table 6 is showing of the change in the main variable according to industry by the increase of the TFP (total factor productivity) of Agriculture. The effect of moving the productive factor like the labor and the capital, etc. to other industries by agriculture's technically increasing productivity is invented. Moreover, the effect of production to other industries exists, too.

Table 7 is showing of the economic effect on the region respectively at all the simulations. It is understood that the economic effect to another region is extremely small and there is the negative effect in some case in the table though it brings the economic effect to a concerned region when the variable in a concerned region rises. It is because the region that decreases without fail exists, and it influences the production of regions where the number of labors decreased if the region where the number of labors increases appears because this is fixed of the total of the labor by the entire model. However, the region where the number of labors decreased improves the labor productivity and the income per labor because the number of labors decreased, and does not affect economy negatively.

Because it is the one for each simulation to bring the economic effect intuitively, the figure of this Table 8 is result of all positive.

6. Concluding remarks

In this study, we developed the CGE model of three regions in the YRD. It found that labor movement after simulations is the very complex because we assume to distinguish four categories as for the labor. Catching the law becomes difficult though such a complexity might be good to express plausibility. However, the labor productivity of agriculture does not improve so that the increase of the capital by the investment may concentrate the labor on agriculture. There is a possibility of reducing the labor productivity difference centering on agriculture for the increase of export to concentrate the labor on export-oriented manufacturers on the other hand. However, it is necessary to improve agriculture own, technical productivity to raise the productivity, and to decrease the number of employed besides. The effect is seen when converting it by the unit of the labor though a too big effect is not seen about the spread between regions.

Because the independence of each provincial government is high in China, there tends to be no for the concern whether and what influence a regional economic policy gives to other regions. The model of this study installed a complex setting for the labor's movement, and the tendency that the labor moved complexly was shown though a regional effect to final production was small. In a regional economic policy, it is necessary to consider the influence on another region. It is because there is a possibility of receiving the disadvantage for doing of other regions the regional policy oppositely if it is not so. Therefore, to understand such a situation beforehand, the economic model in a multi region like this study should be developed, and be analyzed.

References

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.

Dixon, P. B., B. R. Parmenter., A. A. Powell., and P. J. Wilcoxen. (1992). *Notes and problems in applied general equilibrium economics*, Amsterdam: North–Holland.

Ginsburgh, V. and M. A. Keyzer. (1997) *The structure of applied general equilibrium models*, Cambridge and London: MIT Press.

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

Hosoe, Nobuhiro, Keiji Gasawa, and Hideo Hashimoto. (2004). *Handbook of Computable General Equilibrium Modeling* (in Japanese), University of Tokyo Press, Tokyo, Japan.

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. (2007). "Regional Income Disparity and Provincial Migration in China: Simulation Model of 31 Provinces (in Japanese)," *Studies in Regional Science*, 37(3), pp. 679–692.

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. (2011a). "CGE Analysis of Regional Policy in the Northern Kyushu Area," ICSEAD Working Paper 2011–03.

Sakamoto, Hiroshi. (2011b). "CGE Analysis of Transportation Cost and Regional Economy: East Asia and Northern Kyushu," ICSEAD Working Paper 2011–04.

Sakamoto, Hiroshi and Jin Fan. (2010). "Distribution Dynamics and Convergence among 75 Cities and Counties in Yangtze River Delta in China: 1990-2005," *Review of Urban & Regional Development Studies*, 22(1), pp.39–54.

Shoven, J. B. and J. Whalley. (1992). *Applying general equilibrium*, Cambridge university press.

Ueda, Takayuki, Atsushi Koike, Katsuhiro Yamaguchi, and 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.

Table 1 Simulation designs

	Purpose	Detail	Model
Simulation 1	Capital stock	10% increasing of capital stock for all region	KS^{*}_{r}
Simulation 2		10% increasing of capital stock for Shanghai	$KS^{*}_{Shanghai}$
Simulation 3		10% increasing of capital stock for Jiangsu	$KS^{*}_{Jiangsu}$
Simulation 4		10% increasing of capital stock for Zhejiang	$KS^{*}_{Zhejiang}$
Simulation 5	Export	10% increasing of manufacturing export for all region	$E^{*}_{r,i003\text{-}i011}$
Simulation 6		10% increasing of manufacturing export for Shanghai	$E^{*}_{Shanghai,i003\text{-}i011}$
Simulation 7		10% increasing of manufacturing export for Jiangsu	$E^{*}_{Jiangsu,i003\text{-}i011}$
Simulation 8		10% increasing of manufacturing export for Zhejiang	$E^{*}_{Zhejiang,i003\text{-}i011}$
Simulation 9	Productivity	10% increasing of productivity of agriculture for all region	$\gamma^{FC}_{r,a001}$
Simulation 10		10% increasing of productivity of agriculture for Jiangsu and Zhejiang	$\gamma^{FC}_{Jiangsu,a001}$ $\gamma^{FC}_{Zhejiang,a001}$

Table 2 Result of changing by region and sector for Simulation 1 (all type of labor)

		LP	*LR*	*LS*	*PLI*			*LP*	*LR*	*LS*	*PLI*
sh	a001	1.0155	0.9977	1.0283	1.0179	js	i011	0.9676	1.0047	0.9746	0.9923
sh	i002	1.2475	1.1247	1.2791	1.1019	js	i012	0.9370	1.0029	0.9438	0.9801
sh	i003	0.9808	1.0064	1.0057	0.9969	js	i013	1.0163	1.0100	1.0242	1.0108
sh	i004	1.0044	1.0162	1.0321	1.0066	js	s014	0.9542	1.0308	0.9632	0.9912
sh	i005	0.9810	1.0161	1.0081	0.9976	js	s015	0.9251	0.9545	0.9317	0.9753
sh	i006	0.9398	0.9837	0.9656	0.9812	js	s016	1.0197	0.9976	1.0271	1.0125
sh	i007	1.0020	1.0105	1.0296	1.0057	js	s017	0.9548	1.0027	0.9616	0.9872
sh	i008	0.9491	0.9581	0.9753	0.9849	js	s018	1.0046	1.0221	1.0119	1.0067
sh	i009	0.9688	0.9939	0.9955	0.9928	js	s019	1.0166	1.0106	1.0239	1.0113
sh	i010	0.9833	1.0043	1.0104	0.9984	js	s020	1.0036	0.9989	1.0108	1.0063
sh	i011	0.9393	0.9753	0.9651	0.9810	zj	a001	1.0181	1.0004	1.0249	1.0201
sh	i012	0.9491	1.0158	0.9752	0.9849	zj	i002	1.1136	1.0040	1.1284	1.0510
sh	i013	0.9881	0.9819	1.0174	1.0006	zj	i003	0.9690	0.9942	0.9818	0.9918
sh	s014	0.8853	0.9564	0.9173	0.9696	zj	i004	1.0012	1.0130	1.0156	1.0054
sh	s015	1.0176	1.0501	1.0457	1.0117	zj	i005	0.9572	0.9914	0.9710	0.9882
sh	s016	1.0189	0.9968	1.0469	1.0122	zj	i006	0.9518	0.9963	0.9655	0.9860
sh	s017	0.9699	1.0185	0.9966	0.9932	zj	i007	0.9600	0.9682	0.9738	0.9893
sh	s018	0.9541	0.9707	0.9804	0.9869	zj	i008	1.0163	1.0259	1.0309	1.0112
sh	s019	0.9878	0.9820	1.0150	1.0002	zj	i009	0.9583	0.9831	0.9720	0.9886
sh	s020	0.9933	0.9887	1.0206	1.0023	zj	i010	0.9556	0.9760	0.9694	0.9875
js	a001	1.0177	0.9999	1.0211	1.0197	zj	i011	0.9683	1.0055	0.9822	0.9926
js	i002	1.1054	0.9967	1.1128	1.0478	zj	i012	0.9213	0.9861	0.9346	0.9738
js	i003	0.9751	1.0005	0.9816	0.9944	zj	i013	1.0030	0.9968	1.0186	1.0060
js	i004	0.9704	0.9818	0.9774	0.9934	zj	s014	0.9248	0.9991	0.9423	0.9821
js	i005	0.9683	1.0029	0.9753	0.9926	zj	s015	0.9227	0.9522	0.9360	0.9743
js	i006	0.9625	1.0074	0.9694	0.9903	zj	s016	1.0283	1.0060	1.0431	1.0158
js	i007	1.0099	1.0185	1.0172	1.0088	zj	s017	0.9241	0.9705	0.9375	0.9749
js	i008	0.9877	0.9971	0.9948	1.0002	zj	s018	0.9958	1.0131	1.0101	1.0033
js	i009	0.9941	1.0198	1.0013	1.0026	zj	s019	1.0067	1.0008	1.0212	1.0075
js	i010	0.9996	1.0210	1.0068	1.0048	zj	s020	1.0102	1.0056	1.0248	1.0089

Note: Since the number of the imperfect movable labor is not change after simulation, we will show the equilibrium price of the imperfect movable labor.

Table 3 Result of changing by region and sector for Simulation 1 (capital and output)

		capital	output	output/labor			capital	output	output/labor
sh	a001	1.0704	1.0064	0.9930	js	i011	1.0972	1.0117	1.0171
sh	i002	1.2822	1.0326	0.9694	js	i012	1.0762	1.0337	1.0458
sh	i003	1.1024	1.0076	1.0084	js	i013	1.1401	1.0173	1.0121
sh	i004	1.1289	1.0096	1.0043	js	s014	1.1278	1.0253	1.0306
sh	i005	1.1131	1.0072	1.0067	js	s015	1.0654	1.0317	1.0515
sh	i006	1.0830	1.0167	1.0281	js	s016	1.1319	1.0234	1.0188
sh	i007	1.1270	1.0141	1.0099	js	s017	1.0884	1.0350	1.0434
sh	i008	1.0880	1.0181	1.0302	js	s018	1.1231	1.0222	1.0182
sh	i009	1.1035	1.0075	1.0117	js	s019	1.1305	1.0174	1.0122
sh	i010	1.1139	1.0068	1.0070	js	s020	1.1211	1.0157	1.0143
sh	i011	1.0822	1.0090	1.0212	zj	a001	1.0755	1.0174	1.0022
sh	i012	1.0912	1.0278	1.0341	zj	i002	1.1951	1.0348	1.0099
sh	i013	1.1261	1.0101	1.0114	zj	i003	1.0985	1.0133	1.0189
sh	s014	1.0822	1.0129	1.0379	zj	i004	1.1320	1.0133	1.0103
sh	s015	1.1397	1.0232	1.0117	zj	i005	1.1007	1.0137	1.0219
sh	s016	1.1375	1.0145	1.0082	zj	i006	1.0973	1.0190	1.0279
sh	s017	1.1056	1.0180	1.0195	zj	i007	1.1014	1.0155	1.0256
sh	s018	1.0922	1.0142	1.0239	zj	i008	1.1429	1.0199	1.0125
sh	s019	1.1158	1.0090	1.0105	zj	i009	1.1010	1.0091	1.0179
sh	s020	1.1198	1.0079	1.0076	zj	i010	1.0988	1.0061	1.0161
js	a001	1.0699	1.0164	1.0019	zj	i011	1.1091	1.0111	1.0156
js	i002	1.1781	1.0336	1.0119	zj	i012	1.0756	1.0339	1.0505
js	i003	1.0926	1.0168	1.0212	zj	i013	1.1430	1.0110	1.0091
js	i004	1.0978	1.0082	1.0154	zj	s014	1.1202	1.0205	1.0344
js	i005	1.0976	1.0182	1.0237	zj	s015	1.0747	1.0272	1.0470
js	i006	1.0939	1.0210	1.0272	zj	s016	1.1499	1.0154	1.0076
js	i007	1.1265	1.0209	1.0162	zj	s017	1.0767	1.0319	1.0496
js	i008	1.1104	1.0239	1.0260	zj	s018	1.1283	1.0176	1.0157
js	i009	1.1159	1.0183	1.0168	zj	s019	1.1350	1.0143	1.0114
js	i010	1.1197	1.0199	1.0171	zj	s020	1.1377	1.0075	1.0034

Table 4 Result of changing by sector (Simulation 1 to Simulation 4)

	labor				capital			
	S 1	S 2	S 3	S 4	S 1	S 2	S 3	S 4
a001	1.0147	1.0014	1.0082	1.0051	1.0722	1.0028	1.0391	1.0303
i002	1.0228	1.0013	1.0161	1.0053	1.1952	1.0310	1.0938	1.0702
i003	0.9962	1.0004	0.9973	0.9985	1.0960	1.0170	1.0488	1.0302
i004	0.9989	1.0007	0.9968	1.0014	1.1163	1.0100	1.0436	1.0625
i005	0.9945	1.0004	0.9975	0.9966	1.1010	1.0155	1.0441	1.0414
i006	0.9923	0.9986	0.9960	0.9977	1.0927	1.0163	1.0480	1.0285
i007	0.9996	1.0012	1.0010	0.9974	1.1154	1.0215	1.0497	1.0442
i008	0.9993	0.9993	0.9984	1.0016	1.1107	1.0213	1.0633	1.0260
i009	0.9963	0.9996	0.9997	0.9970	1.1072	1.0200	1.0459	1.0414
i010	0.9972	1.0004	1.0001	0.9967	1.1114	1.0386	1.0437	1.0291
i011	0.9938	0.9986	0.9965	0.9987	1.0960	1.0181	1.0577	1.0203
i012	0.9881	0.9992	0.9935	0.9953	1.0794	1.0215	1.0268	1.0312
i013	1.0027	1.0002	1.0015	1.0010	1.1388	1.0201	1.0676	1.0508
s014	0.9870	0.9943	0.9962	0.9964	1.1084	1.0307	1.0466	1.0314
s015	0.9957	1.0046	0.9956	0.9956	1.0868	1.0356	1.0282	1.0230
s016	1.0058	1.0019	1.0016	1.0024	1.1390	1.0203	1.0654	1.0530
s017	0.9922	0.9996	0.9969	0.9956	1.0862	1.0129	1.0458	1.0276
s018	0.9982	0.9975	1.0004	1.0003	1.1101	1.0398	1.0470	1.0232
s019	1.0027	1.0004	1.0013	1.0010	1.1275	1.0331	1.0572	1.0370
s020	1.0023	1.0005	1.0002	1.0016	1.1232	1.0163	1.0874	1.0194
	output				output/labor			
	S 1	S 2	S 3	S 4	S 1	S 2	S 3	S 4
a001	1.0149	1.0015	1.0089	1.0045	1.0002	1.0002	1.0007	0.9993
i002	1.0338	1.0071	1.0153	1.0114	1.0108	1.0058	0.9992	1.0060
i003	1.0136	1.0021	1.0073	1.0042	1.0175	1.0017	1.0100	1.0057
i004	1.0108	1.0009	1.0034	1.0065	1.0119	1.0002	1.0066	1.0051
i005	1.0138	1.0018	1.0062	1.0058	1.0194	1.0014	1.0088	1.0092
i006	1.0193	1.0038	1.0084	1.0071	1.0272	1.0052	1.0124	1.0095
i007	1.0176	1.0034	1.0088	1.0054	1.0180	1.0023	1.0077	1.0080
i008	1.0213	1.0041	1.0102	1.0070	1.0220	1.0049	1.0118	1.0053
i009	1.0124	1.0022	1.0072	1.0030	1.0161	1.0026	1.0075	1.0060
i010	1.0103	1.0030	1.0055	1.0018	1.0131	1.0027	1.0054	1.0051
i011	1.0107	1.0029	1.0057	1.0021	1.0170	1.0043	1.0092	1.0035
i012	1.0325	1.0063	1.0126	1.0136	1.0449	1.0071	1.0192	1.0184
i013	1.0132	1.0024	1.0062	1.0046	1.0105	1.0022	1.0047	1.0036
s014	1.0185	1.0061	1.0075	1.0049	1.0320	1.0119	1.0114	1.0085
s015	1.0257	1.0140	1.0061	1.0056	1.0302	1.0094	1.0106	1.0100
s016	1.0176	1.0044	1.0071	1.0062	1.0117	1.0025	1.0055	1.0038
s017	1.0268	1.0082	1.0109	1.0077	1.0349	1.0085	1.0140	1.0122
s018	1.0180	1.0060	1.0080	1.0040	1.0198	1.0085	1.0076	1.0037
s019	1.0140	1.0031	1.0068	1.0041	1.0113	1.0027	1.0055	1.0031
s020	1.0107	1.0020	1.0056	1.0032	1.0084	1.0015	1.0054	1.0015

Table 5 Result of changing by sector (Simulation 5 to Simulation 8)

	labor				capital			
	S 5	S 6	S 7	S 8	S 5	S 6	S 7	S 8
a001	0.9781	0.9945	0.9916	0.9914	0.9744	0.9971	0.9872	0.9901
i002	0.9620	0.9964	0.9747	0.9888	0.8838	0.9849	0.9361	0.9600
i003	0.9893	0.9986	0.9946	0.9956	0.9685	0.9951	0.9840	0.9885
i004	1.0075	0.9986	1.0069	1.0024	1.0264	0.9993	1.0249	1.0030
i005	1.0079	1.0031	0.9988	1.0062	1.0227	1.0065	1.0031	1.0130
i006	0.9956	1.0004	0.9977	0.9974	0.9897	1.0013	0.9924	0.9959
i007	0.9938	0.9984	0.9959	0.9994	0.9861	0.9959	0.9902	1.0000
i008	0.9941	0.9997	0.9982	0.9959	0.9885	1.0021	0.9925	0.9937
i009	1.0118	1.0033	1.0016	1.0073	1.0384	1.0085	1.0088	1.0215
i010	1.0065	1.0013	1.0025	1.0031	1.0187	1.0026	1.0099	1.0069
i011	1.0113	1.0027	1.0066	1.0023	1.0365	1.0105	1.0183	1.0078
i012	0.9913	0.9985	0.9958	0.9967	0.9759	0.9950	0.9893	0.9912
i013	1.0284	1.0025	1.0122	1.0142	1.0857	1.0092	1.0428	1.0343
s014	0.9911	0.9998	0.9955	0.9957	0.9777	0.9935	0.9918	0.9925
s015	0.9914	0.9964	0.9957	0.9990	0.9920	0.9896	1.0012	1.0009
s016	0.9954	0.9985	1.0020	0.9947	0.9883	0.9964	1.0069	0.9850
s017	0.9984	1.0021	0.9965	0.9999	0.9959	0.9993	0.9957	1.0009
s018	0.9992	1.0029	0.9978	0.9986	1.0015	1.0025	0.9985	1.0008
s019	0.9982	1.0004	0.9983	0.9995	0.9971	0.9988	0.9983	1.0003
s020	1.0038	1.0007	1.0011	1.0022	1.0125	1.0023	1.0062	1.0042
	output				output/labor			
	S 5	S 6	S 7	S 8	S 5	S 6	S 7	S 8
a001	1.0079	1.0027	1.0060	0.9990	1.0305	1.0082	1.0145	1.0077
i002	0.9935	1.0002	0.9959	0.9971	1.0328	1.0039	1.0218	1.0084
i003	1.0114	1.0033	1.0053	1.0027	1.0224	1.0047	1.0107	1.0072
i004	1.0383	1.0020	1.0198	1.0166	1.0305	1.0034	1.0128	1.0141
i005	1.0358	1.0133	1.0090	1.0135	1.0278	1.0101	1.0102	1.0073
i006	1.0073	1.0031	1.0009	1.0031	1.0117	1.0028	1.0032	1.0057
i007	1.0206	1.0049	1.0082	1.0077	1.0270	1.0065	1.0123	1.0082
i008	1.0183	1.0055	1.0065	1.0063	1.0243	1.0058	1.0082	1.0104
i009	1.0320	1.0099	1.0097	1.0125	1.0200	1.0066	1.0081	1.0052
i010	1.0313	1.0174	1.0082	1.0058	1.0246	1.0161	1.0057	1.0027
i011	1.0416	1.0142	1.0213	1.0061	1.0299	1.0115	1.0147	1.0038
i012	0.9986	1.0015	0.9970	0.9999	1.0074	1.0030	1.0012	1.0032
i013	1.0320	1.0049	1.0131	1.0142	1.0035	1.0024	1.0009	1.0000
s014	1.0031	1.0015	1.0018	0.9998	1.0122	1.0017	1.0063	1.0042
s015	1.0071	1.0080	0.9991	1.0001	1.0159	1.0116	1.0034	1.0011
s016	1.0080	1.0026	1.0020	1.0033	1.0126	1.0040	1.0000	1.0087
s017	1.0065	1.0041	1.0024	0.9999	1.0081	1.0020	1.0059	1.0001
s018	1.0087	1.0032	1.0042	1.0013	1.0095	1.0003	1.0064	1.0027
s019	1.0116	1.0041	1.0055	1.0019	1.0134	1.0038	1.0072	1.0024
s020	1.0046	1.0015	1.0002	1.0029	1.0008	1.0008	0.9991	1.0007

Table 6 Result of changing by sector (Simulation 9 and Simulation 10)

	labor		capital		output		output/labor	
	S 9	S 10	S 9	S 10	S 9	S 10	S 9	S 10
a001	0.9821	0.9817	0.9739	0.9731	1.0299	1.0284	1.0486	1.0476
i002	0.9967	0.9969	0.9845	0.9851	1.0005	1.0005	1.0038	1.0036
i003	1.0212	1.0209	1.0613	1.0605	1.0167	1.0161	0.9956	0.9953
i004	1.0039	1.0041	1.0047	1.0048	1.0023	1.0024	0.9984	0.9983
i005	1.0029	1.0031	1.0032	1.0034	1.0020	1.0021	0.9991	0.9990
i006	1.0026	1.0027	1.0011	1.0011	1.0024	1.0023	0.9998	0.9997
i007	1.0011	1.0012	0.9969	0.9971	1.0026	1.0025	1.0015	1.0013
i008	0.9999	1.0001	0.9936	0.9938	1.0002	1.0002	1.0002	1.0001
i009	1.0017	1.0017	0.9988	0.9988	1.0022	1.0022	1.0006	1.0005
i010	1.0012	1.0014	0.9977	0.9981	1.0014	1.0013	1.0002	0.9999
i011	1.0004	1.0005	0.9945	0.9946	1.0004	1.0004	1.0000	0.9999
i012	1.0016	1.0017	0.9984	0.9983	1.0015	1.0012	0.9999	0.9995
i013	1.0046	1.0046	1.0067	1.0062	1.0045	1.0043	0.9999	0.9997
s014	1.0020	1.0020	0.9987	0.9987	1.0021	1.0020	1.0001	0.9999
s015	1.0009	1.0012	0.9998	1.0003	1.0006	1.0006	0.9998	0.9994
s016	1.0037	1.0037	1.0050	1.0048	1.0030	1.0028	0.9993	0.9991
s017	1.0015	1.0015	0.9999	0.9999	1.0016	1.0015	1.0001	1.0000
s018	1.0024	1.0024	1.0022	1.0019	1.0033	1.0032	1.0009	1.0008
s019	1.0016	1.0016	0.9988	0.9987	1.0025	1.0023	1.0009	1.0007
s020	1.0018	1.0018	0.9982	0.9980	1.0014	1.0014	0.9996	0.9996

Table 7 Results of changing by region

		labor	output	income	real income	output/labor	income/labor	real income/labor
S 1	sh	0.9969	1.0131	1.0025	1.0193	1.0162	1.0056	1.0225
	js	1.0015	1.0190	1.0078	1.0249	1.0174	1.0062	1.0234
	zj	0.9997	1.0166	1.0028	1.0218	1.0169	1.0031	1.0220
S 2	sh	0.9977	1.0133	1.0025	1.0197	1.0157	1.0048	1.0221
	js	1.0006	1.0003	1.0001	1.0004	0.9997	0.9995	0.9997
	zj	1.0005	1.0002	1.0000	1.0003	0.9998	0.9995	0.9998
S 3	sh	0.9991	0.9997	1.0000	0.9995	1.0006	1.0009	1.0004
	js	1.0014	1.0188	1.0077	1.0248	1.0174	1.0063	1.0234
	zj	0.9987	0.9995	0.9999	0.9992	1.0008	1.0012	1.0006
S 4	sh	1.0001	1.0001	1.0000	1.0001	1.0000	0.9999	1.0000
	js	0.9995	0.9999	0.9999	0.9997	1.0003	1.0004	1.0002
	zj	1.0006	1.0169	1.0029	1.0223	1.0163	1.0023	1.0216
		labor	output	income	real income	output/labor	income/labor	real income/labor
S 5	sh	0.9987	1.0241	1.0388	1.0083	1.0254	1.0401	1.0096
	js	0.9996	1.0216	1.0489	1.0093	1.0220	1.0493	1.0097
	zj	1.0012	1.0190	1.0481	1.0076	1.0178	1.0468	1.0064
S 6	sh	1.0149	1.0301	1.0387	1.0174	1.0150	1.0235	1.0026
	js	0.9961	0.9983	0.9994	0.9977	1.0023	1.0033	1.0016
	zj	0.9966	0.9985	1.0001	0.9979	1.0019	1.0035	1.0013
S 7	sh	0.9909	0.9966	1.0001	0.9948	1.0058	1.0093	1.0039
	js	1.0120	1.0269	1.0509	1.0166	1.0146	1.0384	1.0045
	zj	0.9894	0.9951	0.9998	0.9934	1.0058	1.0105	1.0041
S 8	sh	0.9932	0.9975	1.0002	0.9961	1.0043	1.0070	1.0030
	js	0.9913	0.9964	0.9989	0.9949	1.0051	1.0076	1.0036
	zj	1.0153	1.0254	1.0486	1.0162	1.0099	1.0328	1.0009
		labor	output	income	real income	output/labor	income/labor	real income/labor
S 9	sh	0.9995	1.0001	1.0015	0.9998	1.0007	1.0020	1.0004
	js	1.0011	1.0047	1.0078	1.0023	1.0035	1.0066	1.0011
	zj	0.9988	1.0030	1.0051	1.0007	1.0042	1.0063	1.0019
S 10	sh	0.9985	0.9995	1.0001	0.9991	1.0009	1.0015	1.0006
	js	1.0014	1.0048	1.0078	1.0024	1.0034	1.0064	1.0010
	zj	0.9990	1.0030	1.0051	1.0008	1.0040	1.0061	1.0018

Table 8 Results of total change

	S 1	S 2	S 3	S 4	S 5
output	1.0167	1.0037	1.0076	1.0054	1.0214
income	1.0050	1.0006	1.0035	1.0009	1.0465
real income	1.0227	1.0045	1.0111	1.0072	1.0086
	S 6	S 7	S 8	S 9	S 10
output	1.0067	1.0088	1.0060	1.0030	1.0028
income	1.0079	1.0234	1.0154	1.0056	1.0053
real income	1.0020	1.0044	1.0021	1.0012	1.0012

Appendix: Model description

A-1. Set

r, s, u Region

sh: Shanghai City

js: Jiangsu province

zj: Zhejiang province

i, j Industry

a001: Agriculture

i002: Mining

i003: Food products

i004: Textile, wearing apparel

i005: Wooden products

i006: Chemical products

i007: Non-metal mineral products

i008: Metal products

i009: Machinery and equipment

i010: Transport equipment

i011: Electronic products

i012: Electricity, gas and water supply

i013: Construction

s014: Transport

s015: Telecommunication

s016: Trade

s017: Banking

s018: Research and technology

s019: Other services

s020: Public services

A-2. Parameters

$mar_{r,i}$ The margin rate on goods

$ntax_{r,i}$ 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

$\alpha^{CO}_{r,i}$ The share parameter of the goods in the utility function for private consumption

$\alpha^{GC}_{r,i}$ The share parameter of the goods in the utility function for government consumption

$\alpha^{IV}_{r,i}$ The share parameter of the goods in the utility function for investment
$\alpha^{IN}_{r,i}$ The share parameter of the goods for inventory

$\alpha^{LLP}_{r,j}$ The share parameter of the perfect movable labor in the labor function
$\alpha^{LLR}_{r,j}$ The share parameter of the region movable labor in the labor function
$\alpha^{LLS}_{r,j}$ The share parameter of the sector movable labor in the labor function
$\alpha^{LLI}_{r,j}$ The share parameter of the imperfect movable labor in the labor function
$\gamma^{LL}_{r,j}$ The productivity parameter of the labor function

$\alpha^{FCL}_{r,j}$ 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 value added for the Leontief function
$\delta^{XM}_{r,i,j}$ The share parameter of the intermediate goods for the Leontief function

$\alpha^{YZ}_{r,j}$ The share parameter of the composite goods
$\alpha^{YM}_{r,j}$ The share parameter of the import goods from domestic market
$\gamma^{Y}_{r,j}$ The productivity parameter of the composite goods

$\alpha^{QY}_{r,j}$ The share parameter of the composite goods
$\alpha^{QM}_{r,j}$ The share parameter of the import goods from foreign market
$\gamma^{Q}_{r,j}$ The productivity parameter of the goods

$\sigma^{L}_{r,j}$ Elasticity of substitution among four category labor
$\sigma^{F}_{r,j}$ Elasticity of substitution between labor and capital
$\sigma^{D}_{r,j}$ Elasticity of substitution between composite goods and imported goods from domestic market
$\sigma^{M}_{r,j}$ Elasticity of substitution between composite goods and imported goods from foreign market

A-3. Endogenous variables

$CO_{r,i}$ The consumption demand by the private institution
$GC_{r,i}$ The consumption demand by the government
$IV_{r,i}$ The investment demand
$IN_{r,i}$ The inventory

$LP_{r,j}$ The perfect movable labor demand by firm
$LR_{r,j}$ The region movable labor demand by firm
$LS_{r,j}$ The sector movable labor demand by firm

$LI_{r,j}$ The imperfect movable labor demand by firm
$L_{r,j}$ The labor demand by firm
$K_{r,j}$ The capital demand by firm
$FC_{r,j}$ The composite factor
$XM_{r,i,j}$ The intermediate goods
$Z_{r,j}$ The composite goods
$Y_{r,j}$ The composite goods
$DM_{r,j}$ The imported goods from domestic market
$M_{r,j}$ The imported goods from foreign market
$Q_{r,j}$ The aggregated goods
$DE_{r,i}$ The exported goods to domestic market
$E_{r,i}$ The exported goods to foreign market
$D_{r,i}$ The domestic goods

PLP The price of perfect movable labor
PLR_j The price of region movable labor
PLS_r The price of sector movable labor
$PLI_{r,j}$ The price of imperfect movable labor
$PL_{r,j}$ The price of labor
PK_r The price of capital
$PFC_{r,j}$ The price of the composite factor
$PZ_{r,j}$ The price of the composite goods
$PDM_{r,j}$ The import price from domestic market
$PY_{r,j}$ The price of the composite goods
$PM_{r,j}$ The import price from foreign market
$PQ_{r,i}$ The goods price
$PD_{r,i}$ The domestic price of the goods

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

A-4. Exogenous variables

LPS^* Supply of the perfect movable labor
LRS^*_j Supply of the region movable labor
LSS^*_r Supply of the sector movable labor
$LIS^*_{r,j}$ Supply of the imperfect movable labor
KS^*_r The capital supply
$DE^*_{r,i}$ The export goods to domestic market
$E^*_{r,i}$ The export goods to foreign market

$PDM^*_{r,j}$	The import price from domestic market
$PM^*_{r,j}$	The import price from foreign market
$INVN^*_r$	The inventory transfer
DTR^*_r	The domestic transfer
FTR^*_r	The foreign transfer

A-5. Equations

1. Labor aggregation (CES)

$$LP_{r,j} = \left(\alpha_{r,j}^{LLP} \, PL_{r,j} \Big/ PLP \right)^{-\sigma_j^L} \left(\gamma_{r,j}^{LL} \right)^{-\sigma_j^L - 1} L_{r,j} \quad \text{(E-1)}$$

$$LR_{r,j} = \left(\alpha_{r,j}^{LLR} \, PL_{r,j} \Big/ PLR_j \right)^{-\sigma_j^L} \left(\gamma_{r,j}^{LL} \right)^{-\sigma_j^L - 1} L_{r,j} \quad \text{(E-2)}$$

$$LS_{r,j} = \left(\alpha_{r,j}^{LLS} \, PL_{r,j} \Big/ PLS_r \right)^{-\sigma_j^L} \left(\gamma_{r,j}^{LL} \right)^{-\sigma_j^L - 1} L_{r,j} \quad \text{(E-3)}$$

$$LI_{r,j} = \left(\alpha_{r,j}^{LLI} \, PL_{r,j} \Big/ PLI_{r,j} \right)^{-\sigma_j^L} \left(\gamma_{r,j}^{LL} \right)^{-\sigma_j^L - 1} L_{r,j} \quad \text{(E-4)}$$

$$\sum\sum LP_{r,j} = LPS^* \quad \text{(E-5)}$$

$$\sum LR_{r,j} = LRS_j^* \quad \text{(E-6)}$$

$$\sum LS_{r,j} = LSS_r^* \quad \text{(E-7)}$$

$$LI_{r,j} = LIS_{r,j}^* \quad \text{(E-8)}$$

$$PL_{r,j} = \left(\begin{array}{l} \left(\alpha_{r,j}^{LLP} \right)^{-\sigma_j^L} \left(\dfrac{PLP}{\gamma_{r,j}^{LL}} \right)^{1+\sigma_j^L} + \left(\alpha_{r,j}^{LLR} \right)^{-\sigma_j^L} \left(\dfrac{PLR_j}{\gamma_{r,j}^{LL}} \right)^{1+\sigma_j^L} \\ + \left(\alpha_{r,j}^{LLS} \right)^{-\sigma_j^L} \left(\dfrac{PLS_r}{\gamma_{r,j}^{LL}} \right)^{1+\sigma_j^L} + \left(\alpha_{r,j}^{LLI} \right)^{-\sigma_j^L} \left(\dfrac{PLI_{r,j}}{\gamma_{r,j}^{LL}} \right)^{1+\sigma_j^L} \end{array} \right)^{1/1+\sigma_j^L} \quad \text{(E-9)}$$

2. Value added (CES)

$$L_{r,j} = \left(\alpha_{r,j}^{FCL} \, PFC_{r,j} \Big/ PL_{r,j} \right)^{-\sigma_j^F} \left(\gamma_{r,j}^{FC} \right)^{-\sigma_j^F - 1} FC_{r,j} \quad \text{(E-10)}$$

$$K_{r,j} = \left(\alpha_{r,j}^{FCK} \, PFC_{r,j} \Big/ PK_r \right)^{-\sigma_{r,j}^F} \left(\gamma_{r,j}^{FC} \right)^{-\sigma_j^F - 1} FC_{r,j} \quad \text{(E-11)}$$

$$\sum K_{r,j} = KS_r^* \quad \text{(E-12)}$$

$$PFC_{r,j} = \left(\left(\alpha_{r,j}^{FCL} \right)^{-\sigma_j^F} \left(\frac{PL_{r,j}}{\gamma_{r,j}^{FC}} \right)^{1+\sigma_j^F} + \left(\alpha_{r,j}^{FCK} \right)^{-\sigma_j^F} \left(\frac{PK_r}{\gamma_{r,j}^{FC}} \right)^{1+\sigma_j^F} \right)^{1/1+\sigma_j^F} \quad \text{(E-13)}$$

3. Composite (Leontief)

$$FC_{r,j} = \delta_{r,j}^{FC} \cdot Z_{r,j} \quad \text{(E-14)}$$

$$XM_{r,i,j} = \delta_{r,i,j}^{XM} \cdot Z_{r,j} \quad \text{(E-15)}$$

$$PZ_{r,j} \cdot Z_{r,j} = PFC_{r,j} \cdot FC_{r,j} + \sum PD_{r,i} \cdot XM_{r,i,j} \quad \text{(E-16)}$$

4. Import from domestic market (CES)

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

$$Z_{r,j} = \left(\alpha_{r,j}^{YZ} \frac{PY_{r,j}}{PZ_{r,j}} \right)^{-\sigma_j^D} \left(\gamma_{r,j}^{Y} \right)^{-\sigma_j^D - 1} Y_{r,j} \quad \text{(E-18)}$$

$$DM_{r,j} = \left(\alpha_{r,j}^{YM} \frac{PY_{r,j}}{PDM_{r,j}} \right)^{-\sigma_j^D} \left(\gamma_{r,j}^{Y} \right)^{-\sigma_j^D - 1} Y_{r,j} \quad \text{(E-19)}$$

$$PY_{r,j} \cdot Y_{r,j} = PZ_{r,j} \cdot Z_{r,j} + PDM_{r,j} \cdot DM_{r,j} \quad \text{(E-20)}$$

5. Import from foreign market (CES)

$$PM_{r,j} = PM_{r,j}^* \quad \text{(E-21)}$$

$$Y_{r,j} = \left(\alpha_{r,j}^{QY} \frac{PQ_{r,j}}{PY_{r,j}} \right)^{-\sigma_j^M} \left(\gamma_{r,j}^{Q} \right)^{-\sigma_j^M - 1} Q_{r,j} \quad \text{(E-22)}$$

$$M_{r,j} = \left(\alpha_{r,j}^{QM} \frac{PQ_{r,j}}{PM_{r,j}} \right)^{-\sigma_j^M} \left(\gamma_{r,j}^{Q} \right)^{-\sigma_j^M - 1} Q_{r,j} \quad \text{(E-23)}$$

$$PQ_{r,j} = \left(\left(\alpha_{r,j}^{QY}\right)^{-\sigma_j^M} \left(\frac{PY_{r,j}}{\gamma_{r,j}^{Q}} \right)^{1+\sigma_j^M} + \left(\alpha_{r,j}^{QM}\right)^{-\sigma_j^M} \left(\frac{PM_{r,j}}{\gamma_{r,j}^{Q}} \right)^{1+\sigma_j^M} \right)^{1/1+\sigma_j^M} \quad \text{(E-24)}$$

6. Market clearing

$$D_{r,i} = Q_{r,i} - E_{r,i} - DE_{r,i} \quad \text{(E-25)}$$

$$D_{r,i} = CO_{r,i} + GC_{r,i} + IV_{r,i} + IN_{r,i} + \sum XM_{r,i,j} \quad \text{(E-26)}$$

$$PD_{r,i} = PQ_{r,i}\left(1 + mar_{r,j} + ntax_{r,i}\right) \quad \text{(E-27)}$$

7. Export (exogenous)

$$DE_{r,i} = DE_{r,i}^{*} \quad \text{(E-28)}$$

$$E_{r,i} = E_{r,i}^{*} \quad \text{(E-29)}$$

8. Private consumption

$$PD_{r,i} \cdot CO_{r,i} = \alpha_{r,i}^{CO}\left(1 - itax_r - psr_r\right) \cdot INCOME_r \quad \text{(E-30)}$$

$$INCOME_r = \sum \left(PL_{r,j} \cdot L_{r,j} + PK_r \cdot K_{r,j} + PQ_{r,j} \cdot Q_{r,j}\left(mar_{r,j} + ntax_{r,j}\right) \right) \quad \text{(E-31)}$$

9. Government consumption

$$PD_{r,i} \cdot GC_{r,i} = \alpha_{r,i}^{GC}\left(1 - gsr_r\right) \cdot GOINCO_r \quad \text{(E-32)}$$

$$GOINCO_r = itax_r \cdot INCOME_r \quad \text{(E-33)}$$

10. Investment

$$PD_{r,i} \cdot PI_{r,i} = \alpha_{r,i}^{PI}\left(INVEST_r - INVN_r^{*} - DTR_r^{*} - FTR_r^{*}\right) \quad \text{(E-34)}$$

$$INVEST_r = psr_r \cdot INCOME_r + gsr_r \cdot GOINCO_r \quad \text{(E-35)}$$

11. Inventory

$$PD_{r,i} \cdot IN_{r,i} = \alpha_{r,i}^{IN} \cdot INVN_r^{*} \quad \text{(E-36)}$$