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Abstract

This study develops a multi-region computable general equilibrium model (CGE model) that considers limited factor movement on the regional economy of the Yangtze River Delta (YRD) in China. Broadly, the YRD is composed of Shanghai City, Jiangsu province, and Zhejiang province. Over the past three decades, the YRD has achieved remarkable economic growth; the YRD 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 past achievements in economic development, but also highlights that it is integral to China's future economic development.

However, these regions face challenges to future economic growth. One major problem is the income inequality between rural and urban areas. The mobility of people is considered a solution to this problem. Therefore, this study analyzes this mobility with a CGE model. Input-output tables in these three regions are used to develop the model, and the factor market connects these three regions. Moreover, this model addresses the mobility of productive factors such as labor and capital. Concretely, we will assume four types of labor mobility: labor can move between regions, between industrial sectors, between regions and sectors, or it cannot move at all. This study simultaneously models these four types of labor mobility. Under these assumptions, the economic effect of each region (Shanghai City, Jiangsu province, and Zhejiang province) is analyzed.

JEL classification: C68, D58, O53, R13, R23
Keywords: Yangtze River Delta, Factor Mobility, Regional Economic Growth, CGE Model

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1. Introduction

This study develops a multi-region computable general equilibrium model (CGE model) that considers limited factor movement on the regional economy of the Yangtze River Delta (YRD) in China. Broadly, the YRD is composed of Shanghai City, Jiangsu province, and Zhejiang province. Over the past three decades, the YRD has achieved remarkable economic growth; the YRD 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 past achievements in economic development, but also highlights that it is integral to China's future economic development.

Since the Chinese economic reform, the YRD has played a key role in China's remarkable economic growth. Even after the government began to shift the emphasis of its economic policy to the western district after 2000, YRD still experienced economic growth.[1] According to statistics from 2010, the per capita GRP (gross regional product) is 76,074 yuan in Shanghai City, 52,840 yuan in Jiangsu province, and 51,711 yuan in Zhejiang province (*China Statistical Yearbook, 2011*). Jiangsu province and Zhejiang province are ranked fourth and fifth, respectively, among all 31 provinces (city and autonomous region) in terms of GRP, behind only Beijing City, Tianjin City, and Shanghai City, which is ranked first. Therefore, the YRD's key role in China's economic growth has remained unchanged.

Some factors of the economic growth of YRD are considerable. One such factor is the foreign-capital-funded construction of a product export base.[2] Such construction contributes to maintaining the region's infrastructure. Many YRD transit systems, including the subway system in Shanghai City, were greatly improved for the 2010 Shanghai Expo. Moreover, a rapid-transit railway from Shanghai to Nanjing (the capital of Jiangsu province) and Hangzhou (the capital of Zhejiang province) was created. The rapid-transit railway made it possible to travel between Shanghai and Nanjing in a little over an hour, a trip that had previously taken four or five hours on the limited express train. As a result, denizens of the region are expected to have increased mobility. Business opportunities are sure to expand because increased mobility provides more people with access to employment opportunities. It is expected that such opportunities will influence the regional economy.

This study aims to develop an economic model that expresses the regional economy of the three YRD provinces (Shanghai City, Jiangsu province, and Zhejiang province).[3] When developing the economic model, the availability of data and the model's context should be considered when choosing either a simple or complex model.

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[1] Research on the YRD economy is limited in China (e.g., Hong and Huang, 2010; Jin, 2010; Li and Zhou, 2007; Shi, 2010; Zhou, 2009).

[2] Foreign capital has supported the manufacturing industry using the Chinese labor force from the beginning (e.g., Shi, 2010). Then, according to development of manufacturing industry in the YRD, the Chinese labor force will be involved the global value chain (e.g. Zhou, 2009).

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

Especially, the CGE model is actively developed as a model that quantitatively evaluates economic policy.[4] This model is academically effective because it utilizes the general equilibrium theory based on optimization problems and is rooted in microeconomics theory. Because the most standard CGE model is only a prototype of the model,[5] this work will require more than the standard model. Then, this paper addresses labor mobility, such as the development of a traffic infrastructure for a standard CGE model, and it introduces the model that emphasizes this mobility.

Hereafter, the model and data are explained, and sensitivity simulations are performed. Thus, the effectiveness of the model is discussed at the end of this work.

2. Main model assumption

Quantitative analysis using the computable general equilibrium model (CGE model) proves reliable for analyzing the regional economy of 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. Moreover, because we intend to construct the multi-region CGE model,[6] the movement of the productive factor between regions becomes important. For a concrete formulation, please see the Appendix.

The model is constructed with three regions and 20 industries (A-1). A major feature of this model is an assumption concerning labor mobility: changes in policy or economic circumstances can cause the labor of a given industry in a given region to relocate. However, this relocation depends on the intentions and the ability of the labor force, and on the nature of the new employment opportunities. It is important to explain this feature concisely and plausibly. In general, if a firm attempts to optimize itself via the production function, the model can be expressed in terms of the job offer and the labor demand (amount). On the other hand, various settings exist concerning the supply of labor (amount). For instance, a worker assumes that he cannot move, and change his job. In this case, the supply of labor (amount) is fixed for each region and each industry. The labor price, that is, the wage rate at the equilibrium, changes because other supply-demand situations (e.g., production and consumption) change when the policy changes because both labor demand and supply are fixed. The method to evaluate the

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[4] Dixon et al., (1992), Ginsburgh and Keyzer (1997), and Shoven and Whalley (1992) are representative of CGE literature from the 1990s. The CGE model in China is comparatively slow, and except for Ezaki (1988), a Japanese scholar who introduced the model of Jiangsu, research began in the 1990s (e.g. Xu, 1993; 1996; Wang and Zhai, 1998; Wang, 1999). After a Chinese research document was published in 1999 (Zheng and Pan, 1999), research developed rapidly.

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

[6] It might be called a spatial CGE (SCGE) model (e.g., 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 (Hertel, 1997). Obviously, there are dozens of multi-region models that have been developed (e.g., Böhringer and Welsch, 2004; Horridge and Wittwer, 2008; and Latorre et al., 2009).

change of this wage rate is a single case.

Then, how does labor market change when the labor can move completely between regions and between industries? To answer this question, we consider two cases. One of the cases is that the total amount of labor supply does not change. In this case, only the total amount of the labor supply is fixed; that is, the total amount of the labor does not change, though the amount of labor supply and the demand of each region and each industry does change after the policy shift. Moreover, it should be noted that the wage rate is a common value and acts motivates the movement in each region and each industry in this case. That is, the labor turnover is held so that the wage rates are equal. However, the united wage rate changes at the next equilibrium because the total amount of labor supply is fixed.

In the other case, the total amount of labor supply changes. In this case, only the united wage rate is fixed. After the policy shift, the amount of labor supply and demand changes for each region and each industry because the amount of labor supply and demand is decided under the fixed wage rate. Moreover, the total amount of labor changes because it is not fixed. The policy shift allows for the possibility that labor can be procured from other regions or from previously unemployed workers. Of course, it is also possible that the total labor decreases.

In this scenario, it is possible for labor to move only between regions or only betwen industries. Therefore, the model presented here considers various settings for the labor supply.

This study assumes that the total number of workers that compose the labor force is unchanged by the policy shift. As a result, the purpose of this study is to understand the movement of these workers.[7] Therefore, four labor categories are defined based on how a worker can move. The first describes a worker who can freely move between each region and each industry (E-5 in appendix A-5). The second describes a worker who can freely move between each region but cannot change his industry (E-6). The third describes a worker who can freely move between each industry but cannot change region (E-7). The fourth describes a fixed worker, one who cannot change either his region or industry (E-8).

Next, these four labor categories are assumed to be imperfect substitutions. The composite function of the labor that combines these four labor categories under this assumption is defined (E-9). Therefore, the labor demand for the four labor categories is obtained from the above-mentioned composite CES (constant elasticity of substitution) function (E-1, E-2, E-3, and E-4).

3. Other model assumptions 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), implying that another industry's

[7] A change in total labor can be interpreted either as labor relocation or as a change in unemployment. Obviously, it is possible to develop the model that considers changes in unemployment. Moreover, a dynamic model of labor (capital) mobility is another option (e.g., Sakamoto, 2007).

goods can be produced although the capital cannot move to other regions.[8]

Intermediate goods are composed of the value-added product using the Leontief function (E-14, E-15, and E-16). In this model, we distinguish between imported goods from the domestic market (outside of each province[9]) and those from the foreign market. The goods imported from both markets are composed using the CES function (E-17, E-18, E-19, and E-20 are from the domestic market and E-21, E-22, E-23, and E-24 are from the foreign market), and the total productive structure of the nested type is completed.

The goods exported to the domestic and foreign markets are made exogenously in the study (E-28 and E-29, respectively). The goods (except exported goods) are used to satisfy each province's demand (E-25). The sales price is the sum of the government tax and the margin (E-27).

Each province's 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 from the margin and tax income from goods market (E-31).[10] The private sector pays a part of the income to the local government in the form of income tax and then consumes the final goods within the ranges of its disposable income (excluding 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 excluding (E-32). All private savings and the government savings are allocated to the investments, excluding the exogenous inventory adjustment and the domestic and foreign transfers (E-34 and E-35, respectively). The total inventory adjustment is exogenous but is allocated to each industry via the same demand function (E-36).

Other international payment balances and regional payment balances are treated as transfers, and all supplies and demands are balanced in the model.

The data used in this study are the 2007 input-output tables of Shanghai City, the Jiangsu province, and the Zhejiang province. It is necessary to integrate these tables, and, so as to examine the movement of goods between regions, construct an interregional input-output table. However, constructing this interregional input-output table is not easy. Moreover, the relationship between intermediate goods shown in the input-output analysis is not well-observed in the CGE model.[11] Then, the model to

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[8] It is possible to assume that, like labor, capital is mobile. However, it is not appropriate to move capital between regions for short time.

[9] The domestic market includes both other YRD provinces and Chinese provinces outside the YRD. These markets are combined for the sake of convenience because there are no data that distinguish the two.

[10] To join the value added incomes of each region, the commodity tax income was included in the private income. Then, the income tax including the commodity tax income becomes the income of the government.

[11] The model is often written only by using the Leontief function in the CGE model, although the relation of intermediate goods becomes the key to the analysis in the input-output analysis. It is thought that the CES function is sufficient for the

simultaneously analyze the three regions by not making the interregional input-output table in this study requires making three independent social accounting processions (SAM) from the three input-output tables.

A lack of relevant data makes it difficult to categorize labor; thus, we do so under a large assumption. The ratio of workers able to move freely was assumed to be 70% in Agriculture (a001) and 10% in other industries. The ratio of workers unable to move at all was assumed to be 10% in agriculture (a001) and 70% in other industries. The ratio of workers limited by region and the ratio of those limited by industry were each assumed to be 10% in all industries. The amount of labor was distributed according to the above-mentioned ratios, and all initial labor prices were assumed to be initially equal to 1. Few workers who specialize in technology can move. However, the large number of migrant workers suggests that agricultural workers have greater mobility. These two considerations must be kept in mind.[12]

After the initial equilibrium solution of various price variables had been set to 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. Independent local governments exist in these three regions, and there is no government that integrates them.[13] Therefore, some economic policies are independently implemented by each provincial government.[14] Because turnover is possible between regions (and between industries), the influence of the economic policy on another region is primary concern. The strengthened export (based on the reinforcement of capital stock including foreign capital) has supported the economic growth of the YRD until now, and it is thus the object of the sensitivity analysis. Moreover, the sensitivity of the agriculture problem (the problem of the growth in the future) was analyzed (see Table 1).

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intermediate goods dealings between regions in the interregional input-output table. However, the shipping in/out from/to other provinces is recorded in the input-output table of each province, 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.

[12] Of course, it may be necessary to change this ratio. However, no new implications were suggested despite different simulation results.

[13] Exceptionally, it is considerable that a central government implements special policies specific to these three regions.

[14] Because the argument may become complex, this study does not address it, 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. Dynamic game simulations among regional governments will be one option for future research.

4.1. Capital stock

The degree to which the investment rate effects the Chinese economic growth, along with the role of foreign capital, is widely discussed. Therefore, domestic capital is actually more important than is foreign capital. The investment demand in YRD nevertheless remains high. Then, the sensitivity when capital stock increases by 10% is analyzed. The policy does not specify any foreign-capital policy or corresponding infrastructure maintenance policy for the future. However, under the model's assumption, capital can be moved between industries. That is, the capital invested in specific region is distributed so that the rate (price) on capital of each industry may become equal. The industry in which the capital concentrates after increasing a capital stock under this assumption can be examined. Four simulation patterns are provided: all three regions, only Shanghai City, only Jiangsu province, and only Zhejiang province as the region(s) where capital stock increased.

4.2. Export

Exports that support the economic growth of China are primarily due to manufacturing. China also has played an important role as a production mainstay as the international specialization of manufacturing has advanced. Moreover, Chinese enterprises have a competitive edge, and as a result, China's export power has been improved even though such international specialization is primarily due the investment of enterprises from advanced countries. Sensitivity (which export increases by 10%) is analyzed. Four simulation patterns are provided: all three regions, only Shanghai City, only Jiangsu province, and only Zhejiang province as the region(s) where a capital stock increased.

4.3. Productivity

While agriculture comparatively falls behind, the YRD develops as a whole. Unlike Shanghai city (which has the economic structure of a city), the other two provinces have a large agriculture sector. Then, the economic effect of a productivity increase in agriculture is analyzed. A productivity increase corresponds to an improvement in the productivity parameter in the production function by 10%. Two regions are analyzed: all three regions and the provinces Jiangsu and Zhejiang together.

5. Results

Several tables indicate the simulation results (Table 2 through Table 8). The equilibrium solution before the simulation is assumed to be a base case solution; the results shown in the tables describe 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 labor categories exist simultaneously is complex. The initial value of the employed is small even though the labor of all categories originally concentrated on Mining (i002) in Shanghai City. Therefore, the amount of the change is small while the change rate is large. The labor of Metal products (i008) tends to concentrate in the Zhejiang province while the labor of Non-metal mineral products (i007) is concentrated in Shanghai City and the Jiangsu province. Moreover, the service industry (s018, s019, and s020) tends to concentrate in

the Jiangsu province and Zhejiang province.

Table 3 shows the change in capital (stock), the gross production, and the labor productivity in simulation 1. The distribution of capital to each industry exhibits complex movement, and the labor through 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 less than 10% (1.1000) because the increase rate is assumed to be 10%. Regarding this ratio, it is understood that an increase in the capital of agriculture is comparatively small. Conversely, there are many increases in Mining. Chemical products (i006), Electricity, and gas and water supply (i012) exhibit a comparatively small 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 further. It is understood that the agriculture of Shanghai City and the labor productivity of Mining are negative.

Table 4 shows 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 tends to move in the Agriculture and Mining industry, which has comparatively low productivity. Therefore, the labor productivity has not improved greatly. As a result, there is a possibility that the productivity differential between industries expands.

Table 5 shows the change in the main variable according to industry by the increase of the export of manufacturing. An important feature is the point that separates the industries for which the productive factor is necessary and the industries for which it is not so as export increases. Labor productivity increases primarily in agriculture, and the number of workers decreases while production increases primarily in export-oriented manufacturers, for which the productivity differential can possibly be reduced.

Table 6 shows 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 productive factors (e.g., labor and capital) to other industries via agriculture's increasing technical productivity is observed. Moreover, the effect of production on other industries also exists.

Table 7 shows the economic effects on the region from all the simulations. It is understood that the economic effect on another region is extremely small and that there is a negative effect in some cases in the table though this brings the economic effect to a concerned region when the variable in a concerned region rises. This result occurs because there exists a region that decreases and it influences the production of regions where the number of workers decreases if there is a region where the number of workers increases because the total number of workers is fixed in this model. However, the region where the number of workers decreases improves the labor productivity and the income per labor because the number of workers decreases and does not negatively affect the economy.

Table 8 presents the results for each simulation; the results are all positive because of the underlying intuition.

6. Concluding remarks

In this study, we developed a CGE model of the three regions in the YRD. Our simulations suggested that labor movement is complex because we distinguished between four types of labor. While such complexity might best reflect real-world situations, this complexity also makes it difficult to determine the underlying rules. However, the labor productivity of agriculture does not improve such that the increase of the capital by the investment may concentrate the labor on agriculture. However, there is a possibility of reducing the labor productivity difference centering on agriculture so as to increase the labor on export-oriented manufacturers. However, it is necessary to improve agriculture technical productivity to raise the productivity and to decrease the number of workers. An effect is seen when converting labor productivity difference by a unit of labor though a too large effect is not observed in the spread between regions.

Because each provincial government China is strongly independent, there tends to be little concern what influence (if any) a regional economic policy has on other regions. The model of this study described a complex setting for labor's movement, and the tendency that labor moved complexly was shown by the small regional effect on final production. In a regional economic policy, it is necessary to consider the influence on other regions because each region may suffer from the other regions' lack of consideration. Therefore, to understand such a situation, a multi-region economic model should be developed.

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Table 1 Simulation designs

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

Table 2 Result of change by region and sector for Simulation 1 (all types 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: Because the number of imperfect movable workers does not change after simulation, we will show the equilibrium price of the imperfect movable worker.

Table 3 Result of change 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 change 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 change 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 change 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 Result of change 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 Result 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)

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

$$Y_{r,j} = \left(\alpha^{QY}_{r,j} \frac{PQ_{r,j}}{PY_{r,j}} \right)^{-\sigma^{M}_{j}} \left(\gamma^{Q}_{r,j} \right)^{-\sigma^{M}_{j}-1} Q_{r,j} \quad \text{(E-22)}$$

$$M_{r,j} = \left(\alpha^{QM}_{r,j} \frac{PQ_{r,j}}{PM_{r,j}} \right)^{-\sigma^{M}_{j}} \left(\gamma^{Q}_{r,j} \right)^{-\sigma^{M}_{j}-1} Q_{r,j} \quad \text{(E-23)}$$

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

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

$$PD_{r,i} \cdot CO_{r,i} = \alpha^{CO}_{r,i} \left(1 - itax_{r} - psr_{r} \right) \cdot INCOME_{r} \quad \text{(E-30)}$$

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

9. Government consumption

$$PD_{r,i} \cdot GC_{r,i} = \alpha^{GC}_{r,i} \left(1 - gsr_{r} \right) \cdot GOINCO_{r} \quad \text{(E-32)}$$

$$GOINCO_{r} = itax_{r} \cdot INCOME_{r} \quad \text{(E-33)}$$

10. Investment

$$PD_{r,i} \cdot PI_{r,i} = \alpha^{PI}_{r,i} \left(INVEST_{r} - INVN^{*}_{r} - DTR^{*}_{r} - FTR^{*}_{r} \right) \quad \text{(E-34)}$$

$$INVEST_{r} = psr_{r} \cdot INCOME_{r} + gsr_{r} \cdot GOINCO_{r} \quad \text{(E-35)}$$

11. Inventory

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