Study of Regional Disparity in Indonesia Using a Multi-region CGE Model

Hiroshi SAKAMOTO
ICSEAD and Graduate School of Social System Studies,
the University of Kitakyushu

Working Paper Series Vol. 2013-01
March 2013

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

Study of Regional Disparity in Indonesia Using a Multi-region CGE Model[♦]

Abstract

This research applies the CGE model developed by Sakamoto (2012b) to analyze regional disparities and income inequalities of Indonesia. The model employs the social accounting matrix database of Resosudarmo et al. (2009), which divides Indonesia into five regions and is especially suited to analyzing regional disparities. Moreover, the database divides workers into 16 categories from which a hierarchical labor market can be constructed. Policies for reducing regional disparity are simulated through the CGE model and evaluated.

Keywords: Multi-region CGE model, Indonesia, Regional disparity
JEL Classifications: C68, D31, D58, O53

[♦] For their many useful comments the author thanks participants of the 11th IRSA International Conference at Lambung Mangkurat University (Banjarmasin, Indonesia, July 2012). The author would like to thank Prof. Suryani's helpful comments and Enago (www.enago.jp) for the English language review. The author is responsible for all remaining errors.

1. Introduction

Indonesia is a populous country of 17,500 islands accessible only by air and sea. Regional resources and economic development differ dramatically (Sakamoto, 2007), and resolving regional disparities is the key to Indonesia's economic growth. Therefore, policymakers need a tool for assessing the effects of economic policies on regional economies.

Sakamoto (2012b) developed such a tool by analyzing Indonesia's income inequality with a computable general equilibrium model (CGE) using data from a social accounting matrix (SAM) in 2005.

Because it applies general equilibrium theory to an optimization problem and is founded in microeconomics, the standard CGE model furnishes a prototype for effective model-making,[1] and SAM is often used as the database. More recently, the CGE model has been employed to evaluate economic policies quantitatively, and many multi-regional CGE models have been developed despite difficulties with data collection.

Applications of the CGE model to the Indonesian economy have already appeared. Ezaki (1990) compared the Indonesian economy between 1980 and 1985, when structural adjustment policies were implemented to reverse the decline in oil prices. Tokunaga et al. (2003) used a multiregional model to analyze the influence on Indonesia of decentralized tariff reductions and finances in regional economies. Clements et al. (2007) analyzed the economic influence of liberalizing the oil price. Although these studies corresponded to the country's current circumstances, they do not directly focus on Indonesia's income disparity. Moreover, the latter two studies use 1995 data, now considerably dated. Resosumardo has applied CGE models extensively to Indonesia (Resosudarmo, 2002, 2008; Resosudarmo et al., 1999; Yusuf and Resosudarmo, 2008), whose main topic is environmental issues. Especially, his collaboration with Arief Anshory Yusuf (Yusuf and Resosudarmo, 2008) extended the model to disaggregate household activity from SAM data. One exception to the CGE approach is the financial model employed by Azis (2000).[2] On the other hand, there are several multi-region models in international literature (for example, Böhringer and Welsch, 2004; Bröcker et al., 2010; Das et al., 2005; Horridge and Wittwer, 2008; Ishiguro and Inamura, 2005; Kim and Kim, 2002; Latorre et al., 2009; Li et al., 2009; Ueda et al., 2005 and so on). Donaghy (2009) is carrying out the surveys of the literature of this direction. Moreover, Sakamoto also has developed several multi-region models (Sakamoto, 2011; Sakamoto, 2012a; Sakamoto and Fan, 2012; Sakamoto and Yan, 2012).

Using a multi-region CGE model incorporating SAM 2005 data by Resosudarmo et al. (2009), this study examines Indonesia's regional disparities and analyzes policies to address them. Section 2 introduces the model and assumptions. Section 3 presents results of the

[1] Some small prototype CGE models were introduced by Hosoe et al. (2010).

[2] This part is quoted from Sakamoto (2012b, p82).

model simulation and evaluates several disparity reduction policies. Section 4 concludes.

2. Model and assumptions

Constructing a multi-regional CGE model for Indonesia is challenging because Indonesia's statistical authority publishes SAM data irregularly. In addition, it is necessary to estimate multi-region SAM or Input-Output tables; this work is difficult for statistical authorities, and it is rarely released. Therefore, researchers routinely estimate these tables themselves.

We constructed the CGE model using the 2005 Indonesia inter-regional social accounting matrix (IRSAM) by Resosudarmo et al. (2009) as a database. Since these data divide Indonesia into five regions of Sumatra, Java and Bali, Kalimantan, Sulawesi, and Eastern Indonesia, they are especially applicable to an analysis of regional disparities.

Moreover, the data encompass 16 labor categories (four labor sectors of Agricultural; Production, Transport Equipment Operator, and Manual; Clerical, Sales and Services Paid Rural Labor; Professional, Managerial and Non Civilians Paid Rural Labor distinguished by rural and urban categories and paid and unpaid categories), five institutions (rural households, urban households, regional government, central government, and enterprises), and 35 production sectors (Paddy; Other Food crops; Estate crops; Livestock; Forestry; Fishery; Oil, Gas, and Geothermal Mining; Coal and Other Mining; Refinery; Oil Palm; Fish Processing; Food and Drink Processing; Textiles; Foot and Leather; Wood Processing; Pulp and Paper; Rubber Processing; Petrochemical; Cement; Basic Metal; Metal Processing; Electricity Machinery; Transport Equipment; Other Industries; Electricity, Gas, and Drinking Water; Construction; Trade; Hotel and Restaurant; Land Transportation; Water Transportation; Air Transportation; Communications; Finance; Public Services; Other Services). However, since many zero data are included in the IRSAM database, we have unified four labor categories into one and aggregated 35 production sectors into 12. An attractive feature of the CGE model is that it embodies the nested production function across periods. Therefore, the formulation here is generally standard practice. The Appendix offers an explicit mathematical description. The model is used to make a final determination of consumer demand that maximizes household utility (after A-38).

We now explain the structure that produced this final determination.

First, the model aggregates a production function for paid and unpaid labor. It adopts the constant elasticity of substitution function (CES), and labor demand is established by Equation A-3. If wages for paid labor is decided, workers can establish the quantity of labor they wish to supply given the range of available wages. Therefore, wages are assumed to be fixed (A-1). Labor supply is decided endogenously by this assumption, and it is changed through a simulation. This change means adjustment of employment and implicit labor mobility in each region. On the other hand, since the wages of unpaid labor are uncertain (formal and informal workers are considered to be business proprietors), labor supply is assumed to be fixed (A-2). Wages are decided endogenously by this assumption.

Next, the production functions of rural labor, urban labor, capital, and land are set by the CES function (A-7, A-8, and A-9, respectively). The price of rural and urban labor is decided endogenously by A-4. The supply of capital is not fixed, and the price of capital is assumed to be fixed (A-5). Although this means that adjustment of capital is possible, it is better to think as actual that the operating ratio of capital is adjusted.[3] Since land is unmovable across region, the supply of land is assumed to be fixed (A-6). However, we assume land is restricted to agricultural use and does not enter the production function for other industries (see A-10a and A-10b, respectively).

Intermediate goods are comprised of three stages. The first is a composite production function of regional intermediate goods. The second is a composite production function between domestic and foreign intermediate goods. The CES function is adopted in both stages (A-12 and A-16, respectively). Domestic and foreign demands are set using the first-order condition of optimization (A-14 and A-15, respectively) as well as regional demand (A-11). The last is a composite production function among intermediate goods and value-added products by using the Leontief function (A-17 and A-18, respectively). Market equilibrium between production and demand is specified by A-21. Subsidies and taxes are added to production costs as A-20. Exports are treated as an exogenous variable.[4]

Rural and urban household incomes are shown in A-26, which includes transfers other than factor earnings between institutions. Enterprise income consists only of factor earnings and transfer income (A-27). Regional and central government revenues include these two sources plus tax revenues (A-28 and A-29, respectively). Each institution transfers part of its revenue to other institutions and saves a part (A-30–A-33). Savings by each institution are summed in A-34, A-35, and A-36 and are spent mainly on investment goods[5] and inventory (A-37). After total expenditures of each institution are set, demand for domestic and imported goods is established using this condition. A current balance is equalized initially through export and import, exogenous international transfer of capital, and exogenous international transfer of each institution.

After setting the initial equilibrium solution of various price variables to 1, we calibrate several parameters to correspond to the database. Because elasticity of substitution cannot be estimated from the database, results of previous research were used.

---

[3] If the supply of capital is fixed, the price of capital is decided endogenously. It is also possible to set this assumption. However, since capital is also adjusted in the long time, we set above mentioned assumption.

[4] It is possible to transform exports into an endogenous variable using the constant elasticity of transformation function (CET), which refers to goods other than domestic and exported goods. However, quantity exported need not be an endogenous variable if all foreign demand can be exported regardless of international price.

[5] This is a static model; therefore, total savings and total investment balance. Moreover, by considering "the purchase of investment goods," investment can use the same setup as household consumption. It adopts savings-driven closure.

3. Simulation and results

3.1. Economic conditions

Before performing the model simulation, let us examine Table 1, which shows GDP, population, and per capita GDP for each of Indonesia's five regions in 2010.[6] Java and Bali comprise about 60% of Indonesia's GDP and population. The next largest is Sumatra, accounting for around 20%. The remaining three regions comprise 10% or less. Indonesia's regional economies vary in scale, and economic structures vary regionally as reflected in differences in per capita GDP (Table 1). Kalimantan enjoys the highest per capita GDP because oil is produced on Kalimantan Island.[7] However, there are disparities within every region, and since they are averaged, the difference in per capita GDP is not large.

Table 2 shows the composition of regional industrial structures in 2010. Tertiary industries are comparatively more prominent in Java and Bali, including the capital Jakarta. Agriculture presides in Sumatra and Sulawesi. Mining is foremost in Kalimantan and Eastern Indonesia (Lainnya). Sulawesi and Eastern Indonesia lag in industrialization.

3.2. Simulation design

Table 3 shows the study's design. Simulated changes in five economic variables are considered. The first variable is increase in productivity, which corresponds to γ^{VA} of A-3 and A-4 (total factor productivity) in the model. However, this is limited to agriculture (a01 and a02) because the ratio of agriculture to GDP exceeds 10% in every region in Table 2. Improving agricultural productivity is essential to Indonesia's economic growth, so we investigate the influence of productivity increases on regional income by posting a 5% increase in agricultural sector productivity. To investigate the influence on regional income, we analyze the situation in which productivity increases in all regions and the situation in which the productivity of each region increases.

Next, we estimate the result of rural household demand rising 5% in response to government policies that encourage consumption. Successful policies to encourage consumption will increase production, and income will rise in the general equilibrium model. This is reflected in α^{XH} of A-38 by a 5% increase in the model.

The third simulation examines increased foreign demand for domestic exports. The model examines the effect of increased income resulting from increased production generated by higher external demand. The simulation considers the situation in which EX^* of A-21 increases 5%.

Finally, we investigate the effect of orthodox governmental transfer policies to ease income disparity. The model incorporates two tiers of government—regional and

---

[6] Since there were no major changes in regional economic structures between 2005 and 2010, the 2010 figure is introduced instead of 2005, which is the base year for SAM.

[7] In statistics of Indonesia, GDP without oil and gas is released simultaneously, as is per capita GDP.

central—both of which redistribute income. We consider the case in which regional governments increase transfer payments to rural households (*tgh*) in A-32 by 10%, and the central government increases transfer payments (*tch*) to rural households in A-33 by 10%. Although rural household income rises in both instances (A-26), the regional government's action affects its fiscal finances, whereas the central government's action does not affect local government.[8]

3.3. Simulation results

Tables 4, 5, and 6 summarize changes in supply of paid labor for each simulation and industry. We present the results of a macroeconomic shock affecting all regions and region-specific shocks for each region. Slightly variant results are expected for shocks to each individual region. The rise in agricultural productivity reduces agricultural employment, which is plausible if there is no major change in output. Greater rural household and export demand generate comparatively large increases in labors. However, the increase seldom changes between rural and urban. Perhaps goods that rural regions purchase are not produced exclusively in rural regions. The effects of income transfers by both regional and central government are small, possibly because the amounts transferred are small.

Tables 7, 8, and 9 show changes in wages of unpaid labor (labor price). Tables show the effect of wage changes for unpaid labor parallels the effects on labor supply changes for paid labor. There is an inverse relation between wages and labor supply.

Table 10 shows changes in regional incomes. Although the change in labor exists, we assume there is no population shift between regions, and changes in regional income correspond to those in regional disparities. Moreover, the change resulting from a shock to each region is shown beside changes resulting from a shock to all regions. A rise in agricultural productivity reduces income in all regions. However, regional income may rise if a region's productivity rises, because labor supplies (price) other than the agriculture of an individual region are increasing. Thereby, output in each industry increases, leading to an increase in regional income. Expansion of rural household demand and export demand increases regional income. Income spillovers into other regions are generally evident and are conspicuous for Java and Bali. On the other hand, the effect of government transfers has little effect on regional income and almost no spillover effect. The difference in effect of transfers by central and regional governments is insignificant.

3.4. Long-term effect of government transfers

Here, the simulation of the long-term trend at the time of repeating a policy is conducted. As an example, we discuss the situation in which the income effect brought about by transfers from central government is comparatively small. Although we assume that continuing

[8] These simulation designs arise from computability of the model, not from policies now in force in Indonesia. Therefore, a policy proposal is based on results of the simulation.

government transfers are directed at impoverished regions, the simulation measures effects on each and all regions. Figures 1 through 6 show the trend. They depict the change in income for each region after 10 consecutive periods of 10% increases transfers from the central government. When all regions received transfers from the central government, income rose in Sumatra, Java, and Bali, but seldom in other regions. It is thought that the amount of the transfer from the central government has a difference. As for it, compared with eastern Indonesia (Kalimantan; Sulawesi and Eastern Indonesia), the western Indonesia (Sumatra; Java and Bali) has many transfers from the central government according to their economic scale (Table 1). If economic development of eastern Indonesia is comparatively late, it can be said that government's transfer has not succeed in decreasing regional disparity. When it transferred to each region, the income of the region where the transfer was performed increases in all cases, and the income of the other regions decreased. This means that transfers effectively reduced income disparity in a specific region, although the size of the effect differs among regions. The effect on the western region is larger than on the eastern.

4. Conclusion

This research conducted a CGE analysis of the influence of economic policy on regional disparities in Indonesia using SAM data for five regions. The simulation produced several results. First, when productivity in the agricultural sector rises, agricultural labor must shift to other industries. Therefore, a nationwide increase in agricultural productivity will not affect national income, although there will be a regional effect. Second, rising demand prompts an increase in income, domestic demand, and foreign demand. Moreover, influencing can also be hung down to other region on a regional level. Third, although the effect of governmental transfers is small, they do reduce regional disparities.

This research shows that a policy of expanding domestic demand is the most important in resolving regional disparities. Raising productivity requires changes in industrial structure, and raising foreign demand depends on foreign economic conditions. For government transfers to be effective, large-scale transfers are needed at least and the policy depending on transfers may not be desirable. Although expanding domestic demand incurs lower relative costs, it may not be the best policy because it presents financing problems. Therefore, further analysis is required. In addition, this model ignores inter-regional population shifts; future research needs to analyze its effect on per capita income.

References

Azis, I. J. (2000), "Modelling the Transition from Financial Crisis to Social Crisis", *Asian Economic Journal*, 14(4), pp. 357–387.

Badan Pusat Statistik (2011), *Gross Regional Domestic Product (GRDP) of Provinces in Indonesia by Industrial Origin 2006-2010*, Jakarta

Böhringer, Christoph and Welsch, Heinz (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.

Clements, Benedict, Jung Hong-Sang, and Gupta Sanjeev (2007), "Real and Distributive Effects of Petroleum Price Liberalization: the Case of Indonesia", *The Developing Economies*, Vol 45, Issue 2, pp. 220–237.

Das, Gouranga G., Janaki, R. R., Alavalapati, Douglas R. Carter and Marinos, E. Tsigas (2005), "Regional impacts of environmental regulations and technical change in the US forestry sector: a multiregional CGE analysis," *Forest Policy and Economics*, 7(1), pp. 25–38.

Donaghy, Kieran, P. (2009), "CGE modeling in space: a survey," in Capello, Roberta and Nijkamp, Peter eds., *Handbook of regional growth and development theories*, Edward Elgar, Cheltenham, pp. 389–422.

Ezaki, Mitsuo (1990), "*Indonesia ni Okeru Gyaku Oiru Shokku to Kouzou Chousei Seisaku: CGE Moderu ni Motoduku 1980 Nen to 1985 Nen no Hikaku Seigaku Bunseki* (in Japanese)", Tounan Ajia Kenkyu, 27(4), pp. 389–405.

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

Hosoe, Nobuhiro, Keiji Gasawa, and Hideo Hashimoto (2010), *Textbook of Computable General Equilibrium Modeling*, Palgrave Macmillan.

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

Kim, Euijune and Kim, Kabsung (2002), "Impacts of regional development strategies on growth and equity of Korea: A multiregional CGE model," *Annals of Regional Science*, 36, pp. 165–180.

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.

Li, Na, Shi, Min-jun and Wang, Fei (2009), "Roles of Regional Differences and Linkages on Chinese Regional Policy Effect in CGE Analysis," *Systems Engineering - Theory &*

Practice, 29(10), pp. 35–44.

Resosudarmo, B. P. (2002), "Indonesia's Clean Air Program", Bulletin of Indonesian Economic Studies, 38(3): pp. 343–365.

Resosudarmo, B. P. (2008), "The Economy‐wide Impact of Integrated Pest Management in Indonesia", *ASEAN Economic Bulletin*, 25(3), pp. 316–333.

Resosudarmo, B. P., L. E. Wuryanto, G. J. D. Hewings, and L. Saunders (1999), "Decentralization and Income Distribution in the Inter‐Regional Indonesian Economy", in *Advances in Spatial Sciences: Understanding and Interpreting Economic Structure*, G. J. D. Hewings, M. Sonis, M. Madden and Y. Kimura (eds), Heidelberg, Germany: Springer‐Verlag, pp. 297–315.

Resosudarmo, Budy P., Ditya A. Nurdianto and Djoni Hartono (2009), "The Indonesian Inter-Regional Social Accounting Matrix for Fiscal Decentralization Analysis", *Journal of Indonesian Economy and Business*, 24(2), pp. 145–162.

Sakamoto, Hiroshi (2007), "The Dynamics of Inter-Provincial Income Distribution in Indonesia", ICSEAD Working Paper 2007–25.

Sakamoto, Hiroshi (2011), "CGE Analysis of Regional Policy in the Northern Kyushu Area", *Jurnal Ekonomi Malaysia* (Malaysian Journal of Economics), Vol. 45, pp. 109–121.

Sakamoto, Hiroshi (2012a), "CGE Analysis of Transportation Cost and Regional Economy: East Asia and Northern Kyushu", *Regional Science Inquiry*, Vol. 4, No. 1, pp. 121–140.

Sakamoto, Hiroshi (2012b), "A Study on Income Disparity in Indonesia Using CGE Model", in Hefrizal Handra, Budy P. Resosudarmo, Arief A. Yusuf, Elfindri and Efa Yonnedi eds., *Regional Development and Finances: Challenges for Expanding and Financing Public Services*, IRSA Book Series on Regional Development No. 10, Andalas University Press, Padang, pp. 81–102.

Sakamoto, Hiroshi and Fan, Jin (2012), "Computable General Equilibrium (CGE) Analysis of the Yangtze River Delta in China", *Journal of US-China Public Administration*, Vol. 9, No. 11, pp. 1265–1282.

Sakamoto, Hiroshi and Yan, Binjian (2012), "Income Disparity among Chinese Cities: Evidence, Decomposition, and Future Prospects", ICSEAD Working Paper 2012–09.

Tokunaga, Suminori, P. Resosudarmo Budy, Wuryanto Luky Eko, and Dung Nguyen Tien (2003), "An Inter-regional CGE Model to Assess the Impacts of Tariff Reduction and Fiscal Decentralization on Regional Economy: The Case of Indonesia", *Studies in Regional Science*, Vol 33, Issue 2, pp. 1–25.

Ueda, Takayuki, Koike, Atsushi, Yamaguchi, Katsuhiro and Tsuchiya Kazuyuki (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.

Yusuf, A. A. and B. P. Resosudarmo (2008), "Mitigating Distributional Impact of Fuel Pricing Reform: The Indonesian Experience", *ASEAN Economic Bulletin*, 25(1), pp. 32–47.

Table 1 Indonesian Regional Economies (2010)

	GDP (Billion Rupiahs)	%	Population (Thousand)	%	Per capita GDP (Million Rupiahs)
Sumatra	1,217,342	23.16	50,613	21.31	24,052
Java & Bali	3,114,840	59.27	140,455	59.13	22,177
Kalimantan	482,543	9.18	13,772	5.80	35,037
Sulawesi	238,202	4.53	17,359	7.31	13,722
Lainnya	202,525	3.85	15,356	6.46	13,189
Total of 33 Provinces	5,255,452	100.00	237,556	100.00	22,123
INDONESIA	6,422,918		237,560		27,037

Source: Badan Pusat Statistik (2011) and author's calculation

Table 2 Regional Economic Structure in Indonesia (2010)

	Agriculture, Livestock, Forestry & Fishery	Mining & Quarrying	Manufacturing Industries	Electricity, Gas & Water Supply	Construction
Sumatera	22.39	16.05	20.66	0.58	6.12
Java & Bali	10.86	1.33	27.68	1.75	6.50
Kalimantan	12.14	35.55	20.60	0.37	4.23
Sulawesi	28.96	4.91	9.82	0.83	7.72
Lainnya	18.82	38.22	6.10	0.31	7.10
Total of 33 Provinces	14.78	9.47	23.76	1.26	6.28
INDONESIA	15.34	11.15	24.82	0.78	10.29
	Trade, Hotel & Restaurant	Transport & Communication	Finance, Real Estate & Business Services	Services	
Sumatera	14.69	6.61	4.39	8.53	
Java & Bali	23.34	7.72	10.57	10.24	
Kalimantan	11.99	5.32	3.28	6.52	
Sulawesi	16.14	8.34	6.24	17.04	
Lainnya	10.11	5.67	3.06	10.61	
Total of 33 Provinces	19.46	7.19	7.98	9.82	
INDONESIA	13.72	6.50	7.21	10.19	

Source: Badan Pusat Statistik (2011)

Table 3 Simulation Designs

S1	5% increase in productivity of agricultural production	$\gamma^{VA}_{r,ja} = \gamma^{VA}_{r,ja} * 1.05$
S2	5% increase in final demand for rural household sector	$\alpha^{XH}_{rural,r,s,i} = \alpha^{XH}_{rural,r,s,i} * 1.05$
S3	5% increase in export demand	$EX^{*}_{r,i} = EX^{*}_{r,i} * 1.05$
S4	10% increase in regional government transfer to rural household sector	$tgh_{rural,r} = tgh_{rural,r} * 1.1$
S5	10% increase in central government transfer to rural household sector	$tch_{rural,r} = tch_{rural,r} * 1.1$

Note: Although it is possible to change these various values, there is no essential difference in the result.

Source: Author's calculation

Table 4 Change of Labor Supply for Paid Labor in Simulation 1 (shock to all regions)

			a01	a02	i03	i04	i05	i06
S1	Rural	Sumatra	0.9467	0.9547	1.0060	1.0161	1.0050	1.0005
		Java and Bali	0.9624	0.9607	0.9993	1.0244	1.0038	0.9989
		Kalimantan	0.9394	0.9632	0.9938	1.0208	1.0023	1.0153
		Sulawesi	0.9440	0.9571	1.0090	1.0193	1.0047	1.0060
		Eastern Indonesia	0.9636	0.9571	0.9965	1.0222	1.0152	1.0263
	Urban	Sumatra	0.9497	0.9574	1.0055	1.0145	1.0043	1.0004
		Java and Bali	0.9654	0.9637	0.9994	1.0217	1.0034	0.9990
		Kalimantan	0.9437	0.9658	0.9944	1.0186	1.0019	1.0132
		Sulawesi	0.9465	0.9597	1.0081	1.0174	1.0041	1.0053
		Eastern Indonesia	0.9651	0.9595	0.9968	1.0200	1.0131	1.0208
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	0.9995	0.9956	0.9978	0.9972	0.9963	0.9955
		Java and Bali	1.0000	1.0008	0.9964	1.0066	1.0008	1.0005
		Kalimantan	0.9996	0.9915	0.9981	0.9928	0.9962	0.9884
		Sulawesi	1.0017	0.9941	0.9997	0.9930	0.9946	0.9946
		Eastern Indonesia	1.0024	0.9947	0.9974	0.9990	0.9974	0.9986
	Urban	Sumatra	0.9995	0.9957	0.9979	0.9977	0.9967	0.9956
		Java and Bali	1.0000	1.0008	0.9964	1.0054	1.0007	1.0005
		Kalimantan	0.9997	0.9914	0.9982	0.9940	0.9967	0.9884
		Sulawesi	1.0015	0.9940	0.9997	0.9941	0.9951	0.9946
		Eastern Indonesia	1.0021	0.9948	0.9974	0.9992	0.9977	0.9986

Source: Author's calculation

Table 5 Change of Labor Supply for Paid Labor in Simulation 2 and 3 (shock to all regions)

			a01	a02	i03	i04	i05	i06
S2	Rural	Sumatra	1.1197	1.1065	1.0414	1.0873	1.0510	1.0633
		Java and Bali	1.1121	1.1018	1.0559	1.0765	1.0472	1.0519
		Kalimantan	1.1315	1.0953	1.0439	1.0772	1.0616	1.0572
		Sulawesi	1.0835	1.0839	1.0203	1.0615	1.0505	1.0521
		Eastern Indonesia	1.1040	1.0795	1.0288	1.0530	1.0642	1.0304
	Urban	Sumatra	1.1124	1.0998	1.0383	1.0784	1.0441	1.0558
		Java and Bali	1.1024	1.0935	1.0504	1.0678	1.0418	1.0456
		Kalimantan	1.1214	1.0882	1.0401	1.0689	1.0524	1.0493
		Sulawesi	1.0796	1.0787	1.0183	1.0554	1.0440	1.0465
		Eastern Indonesia	1.0994	1.0747	1.0258	1.0477	1.0551	1.0240
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	1.0430	1.0765	1.0910	1.1560	1.0721	1.1061
		Java and Bali	1.0666	1.0351	1.0842	1.1206	1.0762	1.0793
		Kalimantan	1.0672	1.0832	1.0678	1.1543	1.0869	1.1247
		Sulawesi	1.0257	1.0452	1.0591	1.1157	1.0471	1.0537
		Eastern Indonesia	1.0473	1.0591	1.0772	1.1058	1.0464	1.0385
	Urban	Sumatra	1.0383	1.0754	1.0901	1.1291	1.0649	1.1052
		Java and Bali	1.0586	1.0347	1.0834	1.0981	1.0670	1.0772
		Kalimantan	1.0595	1.0836	1.0672	1.1269	1.0751	1.1247
		Sulawesi	1.0230	1.0455	1.0586	1.0965	1.0423	1.0538
		Eastern Indonesia	1.0417	1.0583	1.0765	1.0882	1.0416	1.0386
			a01	a02	i03	i04	i05	i06
s3	Rural	Sumatra	1.1410	1.1210	1.0674	1.0930	1.0842	1.0959
		Java and Bali	1.1259	1.1104	1.0809	1.0783	1.0769	1.0846
		Kalimantan	1.1629	1.1173	1.0842	1.0968	1.0973	1.0845
		Sulawesi	1.1190	1.1002	1.0611	1.0692	1.0884	1.0767
		Eastern Indonesia	1.1168	1.1002	1.0719	1.0594	1.0868	1.0601
	Urban	Sumatra	1.1323	1.1133	1.0624	1.0834	1.0728	1.0845
		Java and Bali	1.1149	1.1014	1.0729	1.0694	1.0682	1.0744
		Kalimantan	1.1502	1.1086	1.0768	1.0864	1.0827	1.0728
		Sulawesi	1.1133	1.0939	1.0548	1.0624	1.0768	1.0684
		Eastern Indonesia	1.1117	1.0941	1.0642	1.0534	1.0744	1.0472
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	1.0826	1.0840	1.1234	1.1859	1.1017	1.1264
		Java and Bali	1.0876	1.0515	1.1132	1.1546	1.0955	1.0913
		Kalimantan	1.1011	1.1095	1.0934	1.2143	1.1222	1.1856
		Sulawesi	1.0642	1.0571	1.0804	1.1441	1.0835	1.0686
		Eastern Indonesia	1.0766	1.0678	1.1061	1.1396	1.0787	1.0489
	Urban	Sumatra	1.0734	1.0828	1.1222	1.1535	1.0915	1.1253
		Java and Bali	1.0769	1.0509	1.1121	1.1254	1.0840	1.0890
		Kalimantan	1.0894	1.1100	1.0924	1.1755	1.1053	1.1856
		Sulawesi	1.0575	1.0575	1.0797	1.1199	1.0750	1.0687
		Eastern Indonesia	1.0675	1.0669	1.1052	1.1160	1.0704	1.0490

Source: Author’s calculation

Table 6 Change of Labor Supply for Paid Labor in Simulations 4 and 5 (shock to all regions)

			a01	a02	i03	i04	i05	i06
S4	Rural	Sumatra	1.0003	1.0002	1.0000	1.0002	1.0000	0.9999
		Java and Bali	1.0001	1.0001	1.0000	1.0000	1.0000	0.9999
		Kalimantan	1.0001	1.0002	1.0001	1.0001	1.0000	0.9999
		Sulawesi	1.0002	1.0003	1.0000	1.0002	0.9999	0.9999
		Eastern Indonesia	1.0002	1.0002	1.0000	1.0003	1.0000	0.9999
	Urban	Sumatra	1.0002	1.0002	1.0000	1.0002	1.0000	0.9999
		Java and Bali	1.0001	1.0001	1.0000	1.0000	1.0000	0.9999
		Kalimantan	1.0001	1.0002	1.0001	1.0001	1.0000	0.9999
		Sulawesi	1.0002	1.0003	1.0000	1.0002	1.0000	0.9999
		Eastern Indonesia	1.0002	1.0002	1.0000	1.0002	1.0000	0.9999
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	1.0000	1.0001	0.9999	1.0001	1.0001	0.9994
		Java and Bali	1.0000	0.9999	0.9999	0.9999	1.0000	0.9992
		Kalimantan	1.0000	1.0001	0.9999	1.0001	1.0001	0.9993
		Sulawesi	1.0000	1.0001	0.9999	1.0002	1.0001	0.9993
		Eastern Indonesia	1.0000	1.0000	0.9999	1.0000	1.0001	0.9991
	Urban	Sumatra	1.0000	1.0001	0.9999	1.0001	1.0001	0.9994
		Java and Bali	1.0000	0.9999	0.9999	0.9999	1.0000	0.9992
		Kalimantan	1.0000	1.0001	0.9999	1.0001	1.0001	0.9993
		Sulawesi	1.0000	1.0001	0.9999	1.0001	1.0001	0.9993
		Eastern Indonesia	1.0000	1.0000	0.9999	1.0000	1.0001	0.9991
			a01	a02	i03	i04	i05	i06
s5	Rural	Sumatra	1.0004	1.0003	1.0001	1.0003	1.0001	1.0000
		Java and Bali	1.0003	1.0002	1.0001	1.0002	1.0000	1.0000
		Kalimantan	1.0002	1.0001	1.0000	1.0000	1.0000	1.0000
		Sulawesi	1.0001	1.0001	1.0000	1.0000	1.0000	1.0000
		Eastern Indonesia	1.0002	1.0001	1.0000	1.0000	1.0000	1.0000
	Urban	Sumatra	1.0003	1.0003	1.0001	1.0003	1.0000	1.0000
		Java and Bali	1.0002	1.0002	1.0001	1.0002	1.0000	1.0000
		Kalimantan	1.0002	1.0001	1.0000	1.0000	1.0000	1.0000
		Sulawesi	1.0001	1.0001	1.0000	1.0000	1.0000	1.0000
		Eastern Indonesia	1.0002	1.0001	1.0000	1.0000	1.0000	1.0000
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	1.0000	1.0002	1.0000	1.0003	1.0000	0.9996
		Java and Bali	1.0001	0.9999	1.0000	1.0002	1.0001	0.9997
		Kalimantan	1.0000	0.9999	1.0000	1.0000	0.9998	0.9990
		Sulawesi	1.0000	0.9999	1.0000	1.0000	0.9999	0.9995
		Eastern Indonesia	1.0000	0.9999	1.0000	1.0000	0.9999	0.9993
	Urban	Sumatra	1.0000	1.0002	1.0000	1.0002	1.0000	0.9996
		Java and Bali	1.0001	0.9999	1.0000	1.0001	1.0001	0.9997
		Kalimantan	1.0000	0.9999	1.0000	1.0000	0.9998	0.9990
		Sulawesi	1.0000	0.9999	1.0000	1.0000	0.9999	0.9995
		Eastern Indonesia	1.0000	0.9999	1.0000	1.0000	0.9999	0.9993

Source: Author’s calculation

Table 7 Change of Labor Price for Unpaid Labor in Simulation 1 (shock to all regions)

			a01	a02	i03	i04	i05	i06
S1	Rural	Sumatra	0.9553	0.9621	1.0037	1.0075	1.0027	1.0002
		Java and Bali	0.9685	0.9671	0.9996	1.0113	1.0020	0.9995
		Kalimantan	0.9493	0.9692	0.9961	1.0096	1.0012	1.0069
		Sulawesi	0.9531	0.9641	1.0056	1.0090	1.0025	1.0027
		Eastern Indonesia	0.9696	0.9641	0.9978	1.0103	1.0081	1.0119
	Urban	Sumatra	0.9579	0.9643	1.0035	1.0068	1.0023	1.0002
		Java and Bali	0.9711	0.9696	0.9996	1.0101	1.0018	0.9995
		Kalimantan	0.9529	0.9714	0.9965	1.0086	1.0010	1.0060
		Sulawesi	0.9552	0.9663	1.0050	1.0081	1.0022	1.0024
		Eastern Indonesia	0.9708	0.9662	0.9980	1.0093	1.0070	1.0094
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	0.9997	0.9973	0.9982	0.9977	0.9969	0.9963
		Java and Bali	1.0000	1.0005	0.9970	1.0055	1.0006	1.0004
		Kalimantan	0.9998	0.9947	0.9984	0.9940	0.9969	0.9904
		Sulawesi	1.0008	0.9963	0.9998	0.9942	0.9955	0.9955
		Eastern Indonesia	1.0012	0.9967	0.9978	0.9992	0.9978	0.9988
	Urban	Sumatra	0.9998	0.9973	0.9982	0.9980	0.9972	0.9963
		Java and Bali	1.0000	1.0005	0.9970	1.0045	1.0006	1.0004
		Kalimantan	0.9998	0.9946	0.9985	0.9950	0.9973	0.9904
		Sulawesi	1.0007	0.9963	0.9998	0.9951	0.9959	0.9955
		Eastern Indonesia	1.0010	0.9967	0.9978	0.9993	0.9981	0.9988

Source: Author’s calculation

Table 8 Change in Labor Price for Unpaid Labor in Simulations 2 and 3 (shock to all regions)

			a01	a02	i03	i04	i05	i06
S2	Rural	Sumatra	1.0988	1.0880	1.0257	1.0399	1.0269	1.0283
		Java and Bali	1.0926	1.0841	1.0346	1.0350	1.0249	1.0233
		Kalimantan	1.1084	1.0788	1.0272	1.0353	1.0325	1.0256
		Sulawesi	1.0691	1.0695	1.0127	1.0283	1.0267	1.0233
		Eastern Indonesia	1.0859	1.0658	1.0179	1.0244	1.0338	1.0137
	Urban	Sumatra	1.0928	1.0825	1.0238	1.0359	1.0233	1.0250
		Java and Bali	1.0846	1.0774	1.0312	1.0311	1.0221	1.0205
		Kalimantan	1.1002	1.0730	1.0249	1.0316	1.0277	1.0221
		Sulawesi	1.0659	1.0651	1.0114	1.0255	1.0233	1.0209
		Eastern Indonesia	1.0822	1.0619	1.0160	1.0220	1.0291	1.0108
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	1.0208	1.0472	1.0752	1.1284	1.0597	1.0877
		Java and Bali	1.0321	1.0218	1.0697	1.0995	1.0631	1.0656
		Kalimantan	1.0324	1.0512	1.0562	1.1270	1.0719	1.1029
		Sulawesi	1.0125	1.0280	1.0491	1.0955	1.0391	1.0445
		Eastern Indonesia	1.0229	1.0365	1.0639	1.0874	1.0386	1.0320
	Urban	Sumatra	1.0185	1.0465	1.0746	1.1065	1.0538	1.0869
		Java and Bali	1.0282	1.0215	1.0690	1.0811	1.0555	1.0640
		Kalimantan	1.0287	1.0515	1.0557	1.1047	1.0622	1.1029
		Sulawesi	1.0112	1.0282	1.0486	1.0798	1.0352	1.0446
		Eastern Indonesia	1.0202	1.0360	1.0634	1.0730	1.0345	1.0320
			a01	a02	i03	i04	i05	i06
s3	Rural	Sumatra	1.1162	1.0998	1.0416	1.0424	1.0441	1.0425
		Java and Bali	1.1039	1.0912	1.0498	1.0358	1.0404	1.0376
		Kalimantan	1.1340	1.0969	1.0518	1.0441	1.0509	1.0376
		Sulawesi	1.0982	1.0829	1.0377	1.0318	1.0463	1.0342
		Eastern Indonesia	1.0964	1.0828	1.0444	1.0273	1.0455	1.0269
	Urban	Sumatra	1.1091	1.0936	1.0386	1.0381	1.0383	1.0376
		Java and Bali	1.0949	1.0838	1.0450	1.0318	1.0359	1.0331
		Kalimantan	1.1237	1.0897	1.0473	1.0395	1.0434	1.0325
		Sulawesi	1.0936	1.0777	1.0339	1.0287	1.0403	1.0305
		Eastern Indonesia	1.0922	1.0778	1.0397	1.0246	1.0391	1.0212
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	1.0396	1.0517	1.1018	1.1527	1.0841	1.1043
		Java and Bali	1.0419	1.0319	1.0935	1.1272	1.0790	1.0755
		Kalimantan	1.0482	1.0671	1.0772	1.1757	1.1008	1.1525
		Sulawesi	1.0309	1.0353	1.0666	1.1187	1.0691	1.0568
		Eastern Indonesia	1.0368	1.0419	1.0877	1.1150	1.0652	1.0406
	Urban	Sumatra	1.0353	1.0510	1.1009	1.1264	1.0757	1.1033
		Java and Bali	1.0369	1.0315	1.0926	1.1034	1.0695	1.0736
		Kalimantan	1.0428	1.0674	1.0765	1.1442	1.0870	1.1525
		Sulawesi	1.0277	1.0356	1.0660	1.0990	1.0621	1.0569
		Eastern Indonesia	1.0325	1.0413	1.0870	1.0958	1.0583	1.0406

Source: Author’s calculation

Table 9 Change in Labor Price for Unpaid Labor in Simulations 4 and 5 (shock to all regions)

			a01	a02	i03	i04	i05	i06
S4	Rural	Sumatra	1.0002	1.0002	1.0000	1.0001	1.0000	1.0000
		Java and Bali	1.0001	1.0001	1.0000	1.0000	1.0000	1.0000
		Kalimantan	1.0001	1.0001	1.0000	1.0001	1.0000	1.0000
		Sulawesi	1.0002	1.0003	1.0000	1.0001	1.0000	0.9999
		Eastern Indonesia	1.0002	1.0002	1.0000	1.0001	1.0000	1.0000
	Urban	Sumatra	1.0002	1.0002	1.0000	1.0001	1.0000	1.0000
		Java and Bali	1.0001	1.0001	1.0000	1.0000	1.0000	1.0000
		Kalimantan	1.0001	1.0001	1.0000	1.0001	1.0000	1.0000
		Sulawesi	1.0002	1.0002	1.0000	1.0001	1.0000	1.0000
		Eastern Indonesia	1.0002	1.0001	1.0000	1.0001	1.0000	1.0000
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	1.0000	1.0001	0.9999	1.0001	1.0001	0.9995
		Java and Bali	1.0000	1.0000	0.9999	0.9999	1.0000	0.9994
		Kalimantan	1.0000	1.0001	0.9999	1.0001	1.0001	0.9994
		Sulawesi	1.0000	1.0001	0.9999	1.0001	1.0001	0.9994
		Eastern Indonesia	1.0000	1.0000	0.9999	1.0000	1.0001	0.9993
	Urban	Sumatra	1.0000	1.0001	0.9999	1.0001	1.0001	0.9995
		Java and Bali	1.0000	1.0000	0.9999	0.9999	1.0000	0.9994
		Kalimantan	1.0000	1.0001	0.9999	1.0001	1.0001	0.9994
		Sulawesi	1.0000	1.0001	0.9999	1.0001	1.0001	0.9994
		Eastern Indonesia	1.0000	1.0000	0.9999	1.0000	1.0001	0.9993
			a01	a02	i03	i04	i05	i06
s5	Rural	Sumatra	1.0003	1.0002	1.0000	1.0001	1.0000	1.0000
		Java and Bali	1.0002	1.0002	1.0000	1.0001	1.0000	1.0000
		Kalimantan	1.0002	1.0001	1.0000	1.0000	1.0000	1.0000
		Sulawesi	1.0001	1.0001	1.0000	1.0000	1.0000	1.0000
		Eastern Indonesia	1.0001	1.0001	1.0000	1.0000	1.0000	1.0000
	Urban	Sumatra	1.0003	1.0002	1.0000	1.0001	1.0000	1.0000
		Java and Bali	1.0002	1.0002	1.0000	1.0001	1.0000	1.0000
		Kalimantan	1.0002	1.0001	1.0000	1.0000	1.0000	1.0000
		Sulawesi	1.0001	1.0001	1.0000	1.0000	1.0000	1.0000
		Eastern Indonesia	1.0001	1.0001	1.0000	1.0000	1.0000	1.0000
			i07	i08	i09	s10	s11	s12
	Rural	Sumatra	1.0000	1.0001	1.0000	1.0002	1.0000	0.9997
		Java and Bali	1.0000	1.0000	1.0000	1.0001	1.0001	0.9997
		Kalimantan	1.0000	1.0000	1.0000	1.0000	0.9998	0.9991
		Sulawesi	1.0000	1.0000	1.0000	1.0000	0.9999	0.9996
		Eastern Indonesia	1.0000	0.9999	1.0000	1.0000	0.9999	0.9994
	Urban	Sumatra	1.0000	1.0001	1.0000	1.0002	1.0000	0.9997
		Java and Bali	1.0000	1.0000	1.0000	1.0001	1.0001	0.9997
		Kalimantan	1.0000	1.0000	1.0000	1.0000	0.9999	0.9991
		Sulawesi	1.0000	1.0000	1.0000	1.0000	0.9999	0.9996
		Eastern Indonesia	1.0000	0.9999	1.0000	1.0000	0.9999	0.9994

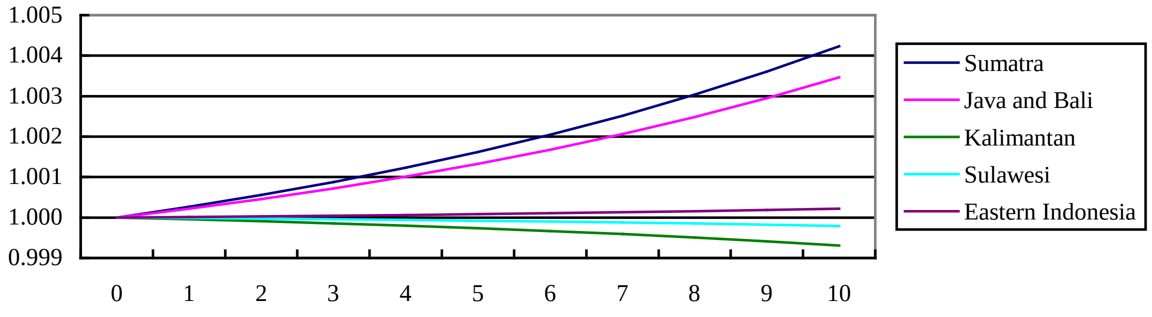
Source: Author’s calculation

Table 10 Changes in Regional Income

		Change				
	Shock region	Sumatra	Java and Bali	Kalimantan	Sulawesi	Eastern Indonesia
s1	All	0.9899	0.9986	0.9850	0.9855	0.9917
	Sumatra	0.9982	0.9960	0.9882	0.9948	0.9947
	Java and Bali	0.9965	1.0050	0.9899	0.9923	0.9944
	Kalimantan	0.9985	0.9995	1.0118	0.9981	0.9985
	Sulawesi	0.9981	0.9986	0.9970	1.0016	0.9985
	Eastern Indonesia	0.9989	0.9996	0.9986	0.9993	1.0059
s2	All	1.0826	1.0667	1.0924	1.0510	1.0416
	Sumatra	1.0335	1.0110	1.0178	1.0085	1.0076
	Java and Bali	1.0416	1.0502	1.0556	1.0282	1.0244
	Kalimantan	1.0029	1.0022	1.0127	1.0017	1.0015
	Sulawesi	1.0013	1.0011	1.0020	1.0101	1.0009
	Eastern Indonesia	1.0010	1.0008	1.0014	1.0010	1.0061
s3	All	1.1054	1.0836	1.1435	1.0701	1.0600
	Sumatra	1.0395	1.0129	1.0207	1.0096	1.0086
	Java and Bali	1.0497	1.0579	1.0652	1.0309	1.0276
	Kalimantan	1.0101	1.0076	1.0484	1.0058	1.0048
	Sulawesi	1.0028	1.0025	1.0045	1.0211	1.0019
	Eastern Indonesia	1.0033	1.0028	1.0044	1.0027	1.0170
s4	All	1.0002	1.0000	1.0003	1.0003	1.0002
	Sumatra	1.0003	1.0000	1.0001	1.0000	1.0000
	Java and Bali	0.9999	1.0000	0.9999	0.9999	0.9999
	Kalimantan	1.0000	1.0000	1.0003	1.0000	1.0000
	Sulawesi	1.0000	1.0000	1.0000	1.0003	1.0000
	Eastern Indonesia	1.0000	1.0000	1.0000	1.0000	1.0002
s5	All	1.0003	1.0002	1.0000	1.0000	1.0000
	Sumatra	1.0004	1.0000	1.0000	1.0000	1.0000
	Java and Bali	0.9999	1.0003	0.9999	0.9999	0.9999
	Kalimantan	1.0000	1.0000	1.0001	1.0000	1.0000
	Sulawesi	1.0000	1.0000	1.0000	1.0001	1.0000
	Eastern Indonesia	1.0000	1.0000	1.0000	1.0000	1.0001

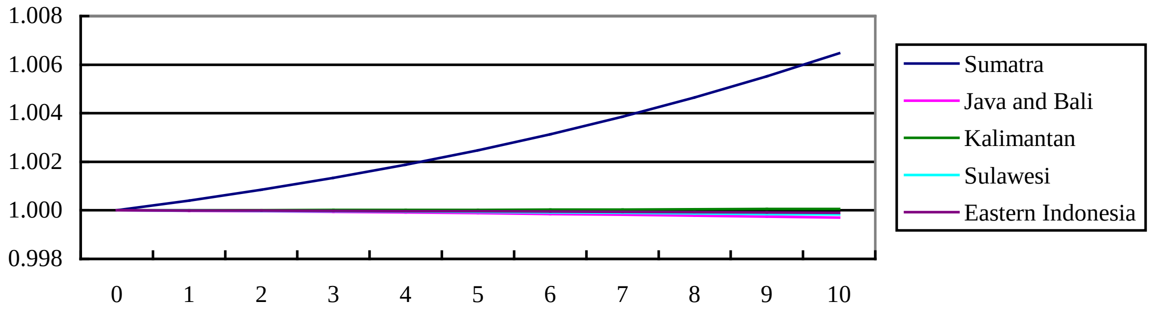
Source: Author’s calculation

Figure 1 Dynamic Change in Regional Income in Simulation 5 (shock to all regions)



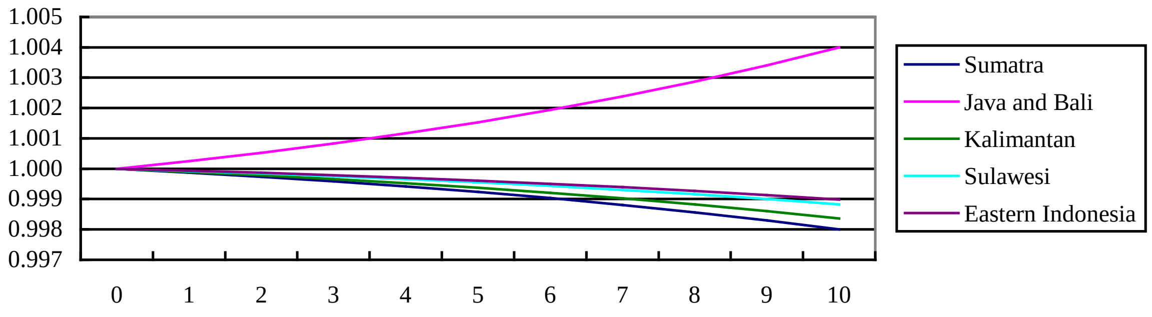
Source: Author’s calculation

Figure 2 Dynamic Change in Regional Income in Simulation 5 (shock to Sumatra)



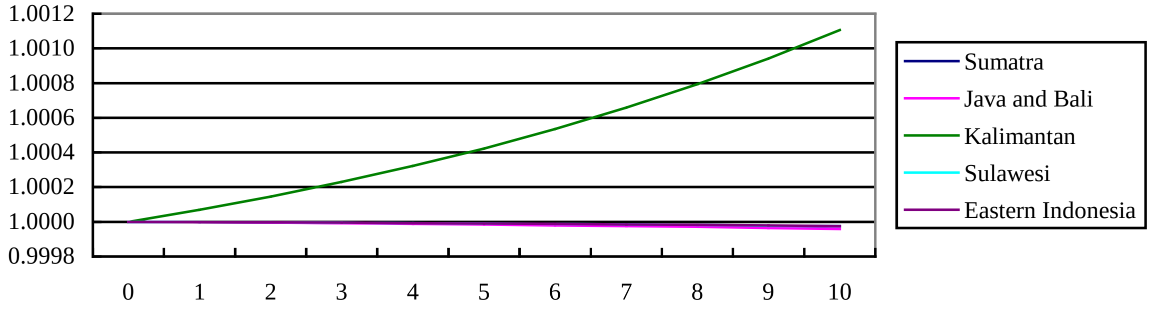
Source: Author’s calculation

Figure 3 Dynamic Change in Regional Income in Simulation 5 (shock to Java and Bali)



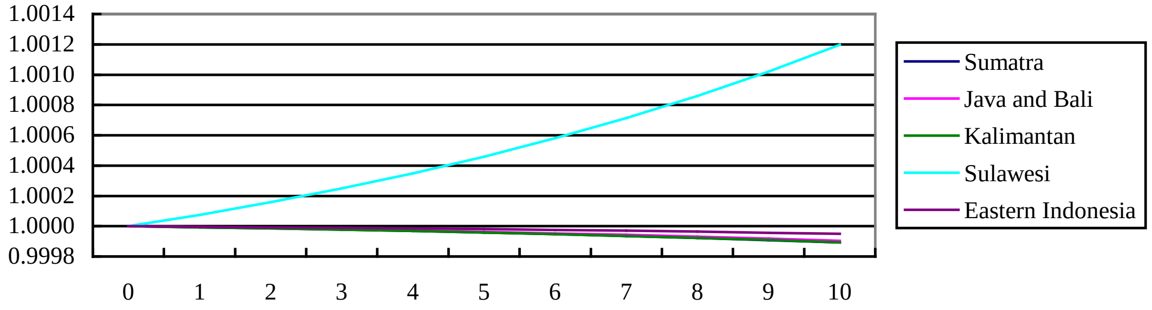
Source: Author’s calculation

Figure 4 Dynamic Change in Regional Income in Simulation 5 (shock to Kalimantan)



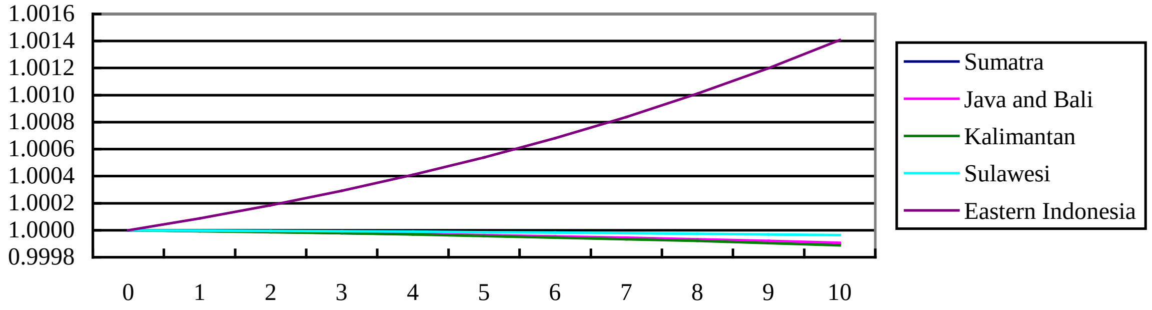
Source: Author’s calculation

Figure 5 Dynamic Change in Regional Income in Simulation 5 (shock to Sulawesi)



Source: Author’s calculation

Figure 6 Dynamic Change in Regional Income in Simulation 5 (shock to Eastern Indonesia)



Source: Author’s calculation

Appendix: Model description

A-1 Set

r (s) region (sm: Sumatra, jb: Java and Bali, ka: Kalimantan, sw: Sulawesi, ei: Eastern Indonesia)

vp labor type (paid, unpaid)

v (vv) household (rural, urban)

i (j) production sector

a01: Paddy; Other Foodcrops; Estatecrops

a02: Livestock; Forestry; Fishery

i03: Oil, Gas and Geothermal Mining; Coal and Other Mining; Refinery; Oil Palm

i04: Fish Processing; Food and Drink Processing

i05: Textiles; Foot and Leather; Wood Processing; Pulp and Paper; Rubber Processing; Petrochemical; Cement

i06: Basic Metal; Metal Processing; Electricity Machinery

i07: Transport Equipment; Other Industries

i08: Electricity, Gas and Drinking Water

i09: Construction

s10: Trade; Hotel and Restaurant

s11: Land Transportation; Water Transportation; Air Transportation; Communications

s12: Finance; Public Services; Other Services

A-2 Parameters

$rtax_{r,j}$ Regional government tax rate on domestic goods

$ctax_{r,j}$ Central government tax rate on domestic goods

$csub_{r,j}$ Central government subsidy rate on domestic sectors

imt_i Import tax revenue of central government

$hsav_{v,r}$ Saving of household

$gsav_r$ Saving of regional government

$esav_r$ Saving of enterprises

$csav$ Saving of central government

$hinvn_r$ Inventory expenditure of household

$cinvn_r$ Inventory expenditure of central government

$whinve$ Investment revenue from foreign countries to household

$wginve$ Investment revenue from foreign countries to regional government

$wcinve$ Investment revenue from foreign countries to central government

$kh_{v,r,s}$ Capital income allocation to household

$kg_{r,s}$ Capital income allocation to regional government
$ke_{r,s}$ Capital income allocation to enterprises
kc_r Capital income allocation to central government
kw_r Capital income allocation to foreign countries
wk_r Capital income from foreign countries

$th_{v,r,s}$ Land income allocation to household
$tg_{r,s}$ Land income allocation to regional government
$te_{r,s}$ Land income allocation to enterprises
tc_r Land income allocation to central government

$thh_{v,r,vv,s}$ Transfers from household to household
$thg_{v,r,s}$ Transfers from households to regional government
$thc_{v,r}$ Transfers from households to central government
$thw_{v,r}$ Transfers from households to foreign countries

$tgh_{v,r}$ Transfers from regional government to households
tgg_r Transfers from regional government to regional government
tgc_r Transfers from regional government to central government
tgw_r Transfers from regional government to foreign countries

$teh_{v,r,s}$ Transfers from enterprises to households
$teg_{r,s}$ Transfers from enterprises to regional government
$tee_{r,s}$ Transfers from enterprise to enterprise
tec_r Transfers from enterprise to central government
tew_r Transfers from enterprise to foreign countries

$tch_{v,r}$ Transfers from central government to households
tcg_r Transfers from central government to regional government
tcc Transfers from central government to central government

$twh_{v,r}$ Transfers from foreign countries to households
twg_r Transfers from foreign countries to regional government
twe_r Transfers from foreign countries to enterprise
twc Transfers from foreign countries to central government

$\alpha^{XH}_{v,r,s,i}$ Share parameter of domestic goods for household demand
$\alpha^{XG}_{r,s,i}$ Share parameter of domestic goods for regional government demand
$\alpha^{XC}_{s,i}$ Share parameter of domestic goods for central government demand
$\alpha^{HI}_{s,i}$ Share parameter of domestic goods for household investment

$\alpha^{GI}{}_{s,i}$ Share parameter of domestic goods for regional government investment
$\alpha^{CI}{}_{s,i}$ Share parameter of domestic goods for central government investment

$\alpha^{XHW}{}_{v,r,i}$ Share parameter of foreign goods for household demand
$\alpha^{XGW}{}_{r,i}$ Share parameter of foreign goods for regional government demand
$\alpha^{XCW}{}_{i}$ Share parameter of foreign goods for central government demand
$\alpha^{HIW}{}_{i}$ Share parameter of foreign goods for household investment
$\alpha^{GIW}{}_{i}$ Share parameter of foreign goods for regional government investment
$\alpha^{CIW}{}_{i}$ Share parameter of foreign goods for central government investment

$\alpha^{INVN}{}_{r,s,i}$ Share parameter of domestic goods for inventory

$\alpha^{LL}{}_{vp,v,r,,j}$ Share parameter of labor in the labor function
$\gamma^{L}{}_{v,r,j}$ Productivity parameter of the aggregate labor function

$\alpha^{L}{}_{v,r,j}$ Share parameter of labor in the production function
$\alpha^{K}{}_{r,j}$ Share parameter of capital in the production function
$\alpha^{T}{}_{r,j}$ Share parameter of land in the production function
$\gamma^{VA}{}_{r,j}$ Productivity parameter of the value added in the production function

$\alpha^{XM}{}_{r,i,s,j}$ Share parameter of regional intermediate goods in the composite production function
$\gamma^{ZM}{}_{r,i,,j}$ Productivity parameter of regional intermediate goods in the composite production function

$\alpha^{ZM}{}_{r,i,j}$ Share parameter of domestic intermediate goods in the composite production function
$\alpha^{IM}{}_{r,i,j}$ Share parameter of foreign intermediate goods in the composite production function
$\gamma^{Z}{}_{r,i,j}$ Productivity parameter of intermediate goods in the composite production

$\delta^{VA}{}_{r,j}$ Share parameter of value added for the Leontief function
$\delta^{Z}{}_{r,i,j}$ Share parameter of intermediate goods for the Leontief function

$\sigma^{LA}{}_{j}$ Elasticity of substitution between paid labor and unpaid labor
$\sigma^{VA}{}_{j}$ Elasticity of substitution among labor, capital and land
$\sigma^{XM}{}_{j}$ Elasticity of substitution between regional intermediate goods
$\sigma^{IM}{}_{j}$ Elasticity of substitution between domestic and foreign intermediate goods

A-3 Endogenous variables

$XH_{v,r,s,i}$	Demand for domestic goods by households
$XG_{r,s,i}$	Demand for domestic goods by regional government
$XC_{s,i}$	Demand for domestic goods by central government
$HI_{s,i}$	Demand for domestic goods for household investment
$GI_{s,i}$	Demand for domestic goods for regional government investment
$CI_{s,i}$	Demand for domestic goods for central government investment
$XHW_{v,r,i}$	Demand for foreign goods by households
$XGW_{r,i}$	Demand for foreign goods by regional government
XCW_i	Demand for foreign goods by central government
HIW_i	Demand for foreign goods for household investment
GIW_i	Demand for foreign goods for regional government investment
CIW_i	Demand for foreign goods for central government investment
$INVNDE_{r,s,i}$	Demand for domestic goods for inventory
$LL_{vp,v,r,j}$	Labor demand by firms
$L_{v,r,j}$	Aggregate labor demand by firms
$K_{r,j}$	Capital demand by firms
$T_{r,j}$	Land demand by firms
$VA_{r,j}$	Composite value added factor
$XM_{r,i,s,j}$	Regional intermediate goods
$ZM_{r,i,j}$	Composite intermediate goods by the domestic market
$IM_{r,i,j}$	Intermediate goods by the foreign market
$Z_{r,i,j}$	Composite goods
$Y_{r,j}$	Composite goods
VAK_r	Factor income of capital
VAT_r	Factor income of land
$PLL_{vp,v,r,j}$	Price of labor
$PL_{v,r,j}$	Price of labor
$PK_{r,j}$	Price of capital
$PT_{r,j}$	Price of land
PVA_j	Price of composite factor
$PZM_{r,i,j}$	Price of domestic intermediate goods
$PIM_{r,i,j}$	Price of foreign intermediate goods
$PZ_{r,i,j}$	Price of composite intermediate goods
$PY_{r,j}$	Price of composite goods

$P_{r,j}$	Sales price of goods
$PM_{r,j}$	Import price
PMI_j	Import price

$HINCO_{v,r}$	Household income
$EINCO_r$	Enterprise income
$GINCO_r$	Regional government income
$CINCO$	Central government income
$HINVE$	Household investment revenue
$GINVE$	Regional government investment revenue
$CINVE$	Central government investment revenue
$HEXP_{v,r}$	Household expenditures
$EEXP_r$	Enterprise expenditures
$GEXP_r$	Regional government expenditures
$CEXP$	Central government expenditures
$INVNIN_r$	Revenue for inventory

A-4 Exogenous variables

$LL0_{vp,v,r,,j}$	Initial value of labor demand by firms
$T0_{r,j}$	Initial value of land demand by firms
$PLL0_{vp,v,r,j}$	Initial value of price of labor
$PK0_{r,j}$	Initial value of price of capital
$PIM0_{r,i,j}$	Initial value of price of foreign intermediate goods
$PM0_{r,j}$	Initial value of import price
$PMI0_j$	Initial value of import price
$VAK0_r$	Initial value of factor income of capital
$VAT0_r$	Initial value of factor income of land
$HINCO0_{v,r}$	Initial value of household income
$GINCO0_r$	Initial value of regional government income
$CINCO0$	Initial value of central government income
$EX^{*}_{r,i}$	Export goods

A-5 Equations

1. Paid labor and Unpaid labor (CES)

$$PLL_{paid,v,r,j} = PLL0_{paid,v,r,j} \quad \text{(A-1)}$$

$$LL_{unpaid,v,r,j} = LL0_{unpaid,v,r,j} \quad \text{(A-2)}$$

$$LL_{vp,v,r,j} = \left(\alpha^{LL}_{vp,v,r,j} \, PL_{v,r,j} \big/ PLL_{vp,v,r,j} \right)^{-\sigma_j^{LA}} \left(\gamma^{LA}_{v,r,j} \right)^{-\sigma_j^{LA}-1} LA_{v,r,j} \quad \text{(A-3)}$$

$$PL_{v,r,j} = \left(\sum \left(\alpha^{LL}_{vp,v,r,j} \right)^{-\sigma_j^{LA}} \left(\frac{PLL_{vp.v.r.j}}{\gamma^{LA}_{v,r,j}} \right)^{1+\sigma_j^{LA}} \right)^{1/1+\sigma_j^{LA}} \quad \text{(A-4)}$$

2. Value added labor capital and land (CES)

$$PK_{r,j} = PK0_{r,j} \quad \text{(A-5)}$$

$$T_{r,j} = T0_{r,j} \quad \text{(A-6)}$$

$$L_{v,r,j} = \left(\alpha^{L}_{v,r,j} \, PVA_{r,j} \big/ PL_{v,r,j} \right)^{-\sigma_j^{VA}} \left(\gamma^{VA}_{r,j} \right)^{-\sigma_j^{VA}-1} VA_{r,j} \quad \text{(A-7)}$$

$$K_{r,j} = \left(\alpha^{K}_{r,j} \, PVA_{r,j} \big/ PK_{r,j} \right)^{-\sigma_j^{VA}} \left(\gamma^{VA}_{r,j} \right)^{-\sigma_j^{VA}-1} VA_{r,j} \quad \text{(A-8)}$$

$$T_{r,j} = \left(\alpha^{T}_{r,j} \, PVA_{r,j} \big/ PT_{r,j} \right)^{-\sigma_j^{VA}} \left(\gamma^{VA}_{r,j} \right)^{-\sigma_j^{VA}-1} VA_{r,j} \quad \text{(A-9)}$$

$$PVA_{r,j} = \left(\sum \left(\alpha^{L}_{v,r,j} \right)^{-\sigma_j^{VA}} \left(\frac{PL_{v,r,j}}{\gamma^{VA}_{r,j}} \right)^{1+\sigma_j^{VA}} + \left(\alpha^{K}_{r,j} \right)^{-\sigma_j^{VA}} \left(\frac{PK_{r,j}}{\gamma^{VA}_{r,j}} \right)^{1+\sigma_j^{VA}} + \left(\alpha^{T}_{r,j} \right)^{-\sigma_j^{VA}} \left(\frac{PT_{r,j}}{\gamma^{VA}_{r,j}} \right)^{1+\sigma_j^{VA}} \right)^{1/1+\sigma_j^{VA}}$$

(A-10a)

$$PVA_{r,j} = \left(\sum \left(\alpha^{L}_{v,r,j} \right)^{-\sigma_j^{VA}} \left(\frac{PL_{v,r,j}}{\gamma^{VA}_{r,j}} \right)^{1+\sigma_j^{VA}} + \left(\alpha^{K}_{r,j} \right)^{-\sigma_j^{VA}} \left(\frac{PK_{r,j}}{\gamma^{VA}_{r,j}} \right)^{1+\sigma_j^{VA}} \right)^{1/1+\sigma_j^{VA}} \quad \text{(A-10b)}$$

3. Composite domestic regional intermediate goods (CES)

$$XM_{r,i,s,j} = \left(\alpha^{XM}_{r,i,s,j} \, PZM_{s,i,j} \big/ P_{r,i} \right)^{-\sigma^{XM}_j} \left(\gamma^{XM}_{s,i,j} \right)^{-\sigma^{XM}_j - 1} ZM_{s,i,j} \quad \text{(A-11)}$$

$$PZM_{r,i,j} = \left(\sum \left(\alpha^{XM}_{s,i,r,j} \right)^{-\sigma^{XM}_j} \left(\frac{P_{s,i}}{\gamma^{XM}_{r,i,j}} \right)^{1+\sigma^{XM}_j} \right)^{1/1+\sigma^{XM}_j} \quad \text{(A-12)}$$

4. Composite domestic and import intermediate goods (CES)

$$PIM_{r,i,j} = PIM0_{r,i,j} \quad \text{(A-13)}$$

$$ZM_{r,i,j} = \left(\alpha^{ZM}_{r,i,j} \, PZ_{r,i,j} \big/ PZM_{r,i,j} \right)^{-\sigma^{IM}_j} \left(\gamma^{Z}_{r,i,j} \right)^{-\sigma^{IM}_j - 1} Z_{r,i,j} \quad \text{(A-14)}$$

$$IM_{r,i,j} = \left(\alpha^{IM}_{r,i,j} \, PZ_{r,i,j} \big/ PIM_{r,i,j} \right)^{-\sigma^{IM}_j} \left(\gamma^{Z}_{r,i,j} \right)^{-\sigma^{IM}_j - 1} Z_{r,i,j} \quad \text{(A-15)}$$

$$PZ_{r,i,j} = \left(\left(\alpha^{ZM}_{r,i,j} \right)^{-\sigma^{IM}_j} \left(\frac{PZM_{r,i,j}}{\gamma^{Z}_{r,i,j}} \right)^{1+\sigma^{IM}_j} + \left(\alpha^{IM}_{r,i,j} \right)^{-\sigma^{IM}_j} \left(\frac{PIM_{r,i,j}}{\gamma^{Z}_{r,i,j}} \right)^{1+\sigma^{IM}_j} \right)^{1/1+\sigma^{IM}_j} \quad \text{(A-16)}$$

5. Composite value added and intermediate goods (Leontief)

$$VA_{r,j} = \delta^{VA}_{r,j} \cdot Y_{r,j} \quad \text{(A-17)}$$

$$Z_{r,i,j} = \delta^{Z}_{r,i,j} \cdot Y_{r,j} \quad \text{(A-18)}$$

$$PY_{r,j} \cdot Y_{r,j} = PVA_{r,j} \cdot VA_{r,j} + \sum \left(PZ_{r,i,j} \cdot Z_{r,i,j} \right) \quad \text{(A-19)}$$

6. Market equilibrium: domestic goods and imported goods

$$P_{r,i} = PY_{r,i}\left(1 + rtax_{r,i} + ctax_{r,i} + csub_{r,i}\right) \quad \text{(A-20)}$$

$$\begin{aligned} Y_{r,i} = {} & \sum\sum XH_{v,r,s,i} + \sum\sum XM_{r,i,s,j} + \sum XG_{r,s,i} + \sum INVN_{r,s,i} \\ & + XC_{r,i} + HI_{r,i} + GI_{r,i} + CI_{r,i} + EX^{*}_{r,i} \end{aligned} \quad \text{(A-21)}$$

$$PM_{r,i} = PM0_{r,i} \quad \text{(A-22)}$$

$$PMI_{i} = PMI0_{i} \quad \text{(A-23)}$$

7. Factor income

$$VAK_{r} = \sum\left(PK_{r,j} \cdot K_{r,j}\right) + wk_{r} - kw_{r} \quad \text{(A-24)}$$

$$VAT_{r} = \sum\left(PT_{r,j} \cdot T_{r,j}\right) \quad \text{(A-25)}$$

8. Income of each institution

$$\begin{aligned} HINCO_{v,r} = {} & \sum\left(PL_{v,r,j} \cdot L_{v,r,j}\right) \\ & + \sum\left(kh_{v,r,s} \cdot VAK_{r}/VAK0_{r}\right) + \sum\left(th_{v,r,s} \cdot VAT_{r}/VAT0_{r}\right) \\ & + \sum teh_{v,r,s} + \sum\sum thh_{vv,r,v,s} + tgh_{v,r} + tch_{v,r} + twh_{v,r} \end{aligned} \quad \text{(A-26)}$$

$$\begin{aligned} EINCO_{r} = {} & \sum\left(ke_{r,s} \cdot VAK_{r}/VAK0_{r}\right) + \sum\left(te_{r,s} \cdot VAT_{r}/VAT0_{r}\right) \\ & + \sum tee_{r,s} + twe_{r} \end{aligned} \quad \text{(A-27)}$$

$$\begin{aligned} GINCO_{r} = {} & \sum\left(PY_{r,j} \cdot Y_{r,j} \cdot rtax_{r,j}\right) \\ & + \sum\left(kg_{r,s} \cdot VAK_{r}/VAK0_{r}\right) + \sum\left(tg_{r,s} \cdot VAT_{r}/VAT0_{r}\right) \\ & + \sum teg_{r,s} + \sum\sum thg_{v,r,s} + tgg_{r} + tcg_{r} + twg_{r} \end{aligned} \quad \text{(A-28)}$$

$$
\begin{aligned}
CINCO = & \sum \left(kc_r \cdot VAK_r / VAK0_r \right) + \sum \left(tc_r \cdot VAT_r / VAT0_r \right) \\
& + \sum \left(tgc_r + tec_r \right) + \sum \sum thc_{v,r} + tcc + twc \\
& + \sum \sum \left(PY_{r,j} \cdot Y_{r,j} \cdot \left(ctax_{r,j} + csub_{r,j} \right) \right) + \sum imt_j
\end{aligned} \quad \text{(A-29)}
$$

9. Expenditure of each institution

$$
\begin{aligned}
HEXP_{v,r} = & HINCO_{v,r} - \sum \sum thh_{v,s,vv,r} - \sum thg_{v,s,r} \\
& - thc_{v,r} - thw_{v,r} - hsav_{v,r} \cdot HINCO_{v,r} / HINCO0_{v,r}
\end{aligned} \quad \text{(A-30)}
$$

$$
EEXP_r = EINCO_r - \sum \sum teh_{v,s,r} - \sum \left(teg_{s,r} + tee_{s,r} \right) - tec_r - tew_r \quad \text{(A-31)}
$$

$$
GEXP_r = GINCO_r - \sum tgh_{v,r} - tgg_r - tgc_r - tgw_r - gsav_r \cdot GINCO_r / GINCO0_r \quad \text{(A-32)}
$$

$$
CEXP = CINCO - \sum \sum tch_{v,r} - \sum tcg_r - tcc - csav \cdot CINCO / CINCO0 \quad \text{(A-33)}
$$

10. Revenue for investment

$$
HINVE = \sum \sum \left(hsav_{v,r} \cdot HINCO_{v,r} / HINCO0_{v,r} \right) + \sum EEXP_r + whinve \quad \text{(A-34)}
$$

$$
GINVE = \sum \left(gsav_r \cdot GINCO_r / GINCO0_r \right) + wginve \quad \text{(A-35)}
$$

$$
CINVE = csav \cdot CINCO / CINCO0 + wcinve \quad \text{(A-36)}
$$

11. Revenue for inventory (exogenous)

$$
INVNIN_r = hinvn_r + cinvn_r \quad \text{(A-37)}
$$

12. Domestic goods demand (Cobb-Douglas)

$$
XH_{v,r,s,i} = \alpha^{XH}_{v,r,s,i} \cdot HEXP_{v,r} / P_{s,i} \quad \text{(A-38)}
$$

$$XG_{r,s,i} = \alpha_{r,s,i}^{XG} \cdot GEXP_r / P_{s,i} \quad \text{(A-39)}$$

$$XC_{s,i} = \alpha_{s,i}^{XC} \cdot CEXP / P_{s,i} \quad \text{(A-40)}$$

$$HI_{s,i} = \alpha_{s,i}^{HI} \cdot \left(HINVE - \sum hinvn_r \right) / P_{s,i} \quad \text{(A-41)}$$

$$GI_{s,i} = \alpha_{s,i}^{GI} \cdot GINVE / P_{s,i} \quad \text{(A-42)}$$

$$CI_{s,i} = \alpha_{s,i}^{CI} \cdot \left(CINVE - \sum cinvn_r \right) / P_{s,i} \quad \text{(A-43)}$$

13. Import goods demand (Cobb-Douglas)

$$XHW_{v,r,i} = \alpha_{v,r,i}^{XHW} \cdot HEXP_{v,r} / PM_{r,i} \quad \text{(A-44)}$$

$$XGW_{r,i} = \alpha_{r,i}^{XGW} \cdot GEXP_r / PM_{r,i} \quad \text{(A-45)}$$

$$XCW_i = \alpha_i^{XCW} \cdot CEXP / PMI_i \quad \text{(A-46)}$$

$$HIW_i = \alpha_i^{HIW} \cdot \left(HINVE - \sum hinvn_r \right) / PMI_i \quad \text{(A-47)}$$

$$GIW_i = \alpha_i^{GIW} \cdot GINVE / PMI_i \quad \text{(A-48)}$$

$$CIW_i = \alpha_i^{CIW} \cdot \left(CINVE - \sum cinvn_r \right) / PMI_i \quad \text{(A-49)}$$

14. Inventory goods demand (Cobb-Douglas)

$$INVEDE_{r,s,i} = \alpha_{r,s,i}^{INVN} \cdot INVNIN_r / P_{s,i} \quad \text{(A-50)}$$