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Regional Financial CGE Model for Infrastructure Investment Policy

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Abstract. In this paper, regional financial computable general equilibrium (RFCGE) model was developed. The RFCGE model is a useful tool in the evaluation of regional fiscal policies. So far, computable general equilibrium (CGE) models have often been used to evaluate regional infrastructure investment policies. However, conventional CGE models do not consider financial assets, such as deposits, equities, and government bonds and decision-making mechanism of government. Therefore, applying CGE models might overestimate the benefit incidence of policies on the rural society. To confirm this theory, the RFCGE model was applied to regional infrastructure investment policy.

1 Introduction

Over the past decade, various tools have been used to evaluate local fiscal policies, one of the most powerful tools being the computable general equilibrium (CGE) model[1)]. CGE models make it possible to explicitly estimate the effects of policies. However, CGE models have a theoretical constraint in that they do not consider the financial economy. This means that CGE models do not consider the effects of financial assets, such as deposits, equities, and government bonds. For example, households use their assets not only for buying goods but also for buying equities, government bonds, and making deposits. In the real world, these financial assets may spill over from a local region to other regions through the financial market. Buying government bonds leads to spill-over effects. Further, if local firms borrow loans from banks in other regions, the payment of interest by the former leads to an outflow of assets. This means that the net wealth (assets of households) may spill over to other regions. Therefore, the benefit incidence on a local region owing to local fiscal policies might be overestimated by CGE models. Among policies, an infrastructure investment policy may have a major influence on the benefit incidence, because it involves a large amount of money.

In this paper, a regional financial computable general equilibrium (RFCGE) model was developed to include the financial economy in the CGE model. The RFCGE model is based on a financial computable general equilibrium (FCGE) model, which was developed by Lance Taylor (1990)[2)] and Mark Thissen (2000)[3)]. The FCGE model not only considers the real economy but also the financial economy. So far, the FCGE model has been used to

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evaluate national policy. In this paper, the FCGE model has been applied to evaluate the effect of policy on a local region. Therefore, some endogenous variables in the FCGE model have been changed to exogenous variables. Further, the RFCGE model considers inter-regional trade and asset movement between regions. In this paper, infrastructure investment policy was analyzed using the RFCGE model.

2 Model

The RFCGE model developed in this study has been presented in this section. The model consists of four economic agents—firms, households, local banks, and other regions, and six markets—the goods market, labor market, loan market, stock market, government bond market, and deposit market. The goods and labor markets are real markets. The stock market, government bond market, and deposit market are financial markets.

2.1 Schematic

2.1.1 Real side of the model

Fig. 1 shows a schematic of the real side of the model.

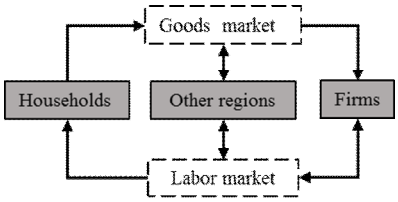

Fig. 1. Real-side schematic

2.1.2 Financial side of the model

Fig. 1 shows a schematic of the financial side of the model.

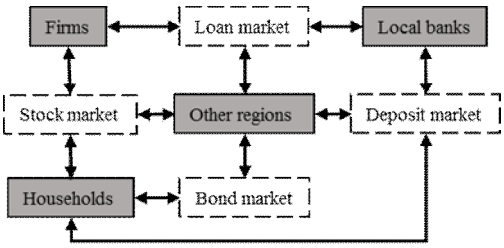

Fig. 2. Financial-side schematic

2.2 Economic agents

2.2.1 Firms

Three firms have been considered in the model: a service-sector firm, industry-sector firm, and an agricultural-sector firm. Firms receive income from the sale of goods, purchase

intermediate inputs, pay direct taxes, make wage payments and investments, distribute dividends to households, and demand bank loans. The income that remains with firms after meeting their expenses is saved. Firms finance their expenditures through retained equities and borrowings from local banks as well as banks from other regions. Production is determined by the Cobb-Douglas production function with two inputs—labor and capital. In addition, production is assumed to be carried out with constant technological growth.

2.2.3 Households

The demand for goods by households is a result of the maximization of utility, subject to a budget constraint. The utility function of households is represented by equation (1). The budget constraint is determined by activity of households in the real economy. Households receive labor income from firms and firms in other regions and profit income (dividends) from firms. The remaining income is saved post the deduction of direct taxes.

Net wealth is held in the form of currencies, deposits, government bonds, equities, and savings (for the current period). Households divide their net wealth again to currencies, deposits, government bonds, and equities in the current period. Moreover, deposits and equities are classified on the basis of region as local and other regions. Equations (2)–(15) represent the abovementioned flow of assets.

$$U = C_1^{\alpha_1^{Dem}} C_2^{\alpha_2^{Dem}} C_3^{\alpha_3^{Dem}} \tag{1}$$

$$NW_h(t) = CURR_h(t-1) + DEP_h(t-1) + P_z(t)Z_h(t-1) + GB_h(t-1) + S_h(t) \tag{2}$$

U : Utility, C_i (i = 1 - 3): Consumption, α_i^{Dem} (i = 1 - 3): Share parameter, NW_h: Net wealth of households, $CURR_h$: Currencies owed by households, DEP_h : Household deposits, P_z : Equity price, Z_h : Household equity demand (Unit : Quantity), GB_h : Government bonds owned by households, S_h : Household savings, t : Current period, $t-1$: Previous period

$$q_h = A_1^h \left(i_d / \bar{i}_{dh}\right)^{\sigma_h - 1} + A_2^h \left(r / \bar{r}_h\right)^{\sigma_h - 1} + A_3^h \left(i_g / \bar{i}_{gh}\right)^{\sigma_h - 1} + A_4^h \tag{3}$$

$$\phi_1^h = A_1^h \frac{\left(i_d / \bar{i}_{dh}\right)^{\sigma_h - 1}}{q_h} \tag{4}$$

$$\phi_2^h = A_2^h \frac{\left(r / \bar{r}_h\right)^{\sigma_h - 1}}{q_h} \tag{5}$$

$$\phi_3^h = A_3^h \frac{\left(i_g / \bar{i}_{gh}\right)^{\sigma_h - 1}}{q_h} \tag{6}$$

$$\phi_4^h = A_4^h \frac{1}{q_h} \tag{7}$$

$$DEP_h = \phi_1^h NW_h(t) \tag{8}$$

$$ZZ_h = \phi_2^h NW_h(t) \tag{9}$$

$$GB_h = \phi_3^h NW_h(t), \tag{10}$$

$$CURR_h = \phi_4^h NW_h(t) \tag{11}$$

q_h : Mean return of portfolio, $\underline{A}_i^h$: Distribution parameter in asset demand functions (I = 1– - 4), i_d: Deposit interest rate, $\bar{i}_{dh}$: Deposit interest rate (standard), r_h: Equity interest rate, $\bar{r}_h$: Equity interest rate (standard), i_g: Government interest rate, $\bar{i}_{gh}$: Government interest rate (standard), σ_h: Elasticity of substitution, ϕ_i^h : Distribution ratio (i = 1– - 4).

$$DEP_h = DEP_h^L + DEP_h^O \tag{12}$$

$$DEP_h^L = \Delta^{DEP} DEP_h \tag{13}$$

$$ZZ_h = ZZ_h^L + ZZ_h^O \tag{14}$$

$$ZZ_h^L = \Delta^{ZZ} ZZ_h \tag{15}$$

DEP_h^L : Local region deposits, DEP_h^O : Other region deposits, Δ^{DEP} : Ratio of deposit, ZZ_h^L : Equity from local firms, ZZ_h^O : Equity from firms in other regions, Δ^{ZZ} : Equity ratio.

2.2.4 Local banks

Operating expenses such as labor costs are not taken into account. Moreover, local banks do not buy or sell goods. Funds of local banks come from deposits from households and remittances from other regions. Local banks provide loans to local firms. Because other regions require banks to hold funds in the form of reserves, some funds are held for that purpose.

2.2.5 Other regions

Other regions include consumers, producers, governments, and central banks. They are involved in the exchange of money with households and local firms through various markets.

2.3 Price and interest rate

The producer price, consumer price, and intermediate price are different for each of the three firms, while the equity price and wage rate are the same for all three firms. Thus, there are eleven different prices, all of them being endogenous variables.

There are four interest rates—deposit interest rate, equity interest rate, government bond interest rate, and bank loan interest rate. The bank loan interest rate is an endogenous variable.

2.4 Markets

Endogenous variables are determined by market equilibria. Each market equilibrium has been explained in this section.

2.4.1 Goods market

The goods market equilibrium is expressed by equation (16). Producer prices are determined from the goods market equilibrium equation. Consumer prices and intermediate prices are determined from producer prices. Consumer prices take into account direct taxes.

$$X_i = \sum_{j=1}^{3} X_{ji}^{L} + C_i + IN_i^{L} + IM_i, (i = 1,2,3) \tag{16}$$

X_i : Gross production, X_{ji}^{L} : Intermediate demand, IN_i^{L} : Infrastructure investment in a local region, IM_i : Net exports.

2.4.2 Labor market

The labor market equilibrium is expressed by equation (17). The wage rate is determined from the labor market equilibrium equation.

$$\sum_{i=1}^{3} L_i = L \tag{17}$$

L_i : Labor demand by firm i (i = 1 - 3), L: Labor supply.

2.4.3 Equity market

Equity price is determined using equation (18).

$$P_z = ZZ_h \Big/ (Z_1 + Z_2 + Z_3) \tag{18}$$

P_z : Equity price, ZZ_h : Household equity demand (Unit: Monetary), Z_i : Firm i's equity supply (Unit: Quantity).

2.4.4 Loan market

Bank loan interest is determined using equation (19). This equation indicates that the assets under management of local banks are equal to the loans demanded by firms.

$$QL_B = \sum_{i=1}^{3} BLN_i^{L} \tag{19}$$

QL_B : Funds of local banks BLN_i^{L} : Bank loan demand of firm i in a local region.

3 Social accounting matrix

The numbers in a CGE model must be consistent with the national income and the input-output accounting equations the model contains. A social accounting matrix (SAM) represents the flow of all economic transactions that take place within an economy. An SAM for a local region has been developed in this paper. The SAM is based on the input-output table for Nara prefecture[4]. The exogenous variables in the model are determined by the numbers in the matrix, which have been provided in the appendix on the last page.

4 Comparative statics

This section comprises an analysis of the effect of infrastructure investment policy on a local region using comparative statics. Fig. 3 shows the result of comparative statics, which indicates that infrastructure investment policy increases the net wealth of households.

Moreover, the productivity of firms in the subsequent period improves, because the amount of funds held by the firms depends on the deposits and equity held by households. However, these comparative statics do not take into account the financial effect. The negative effect on the local region, taking the financial market into consideration, has been shown in the next subsection.

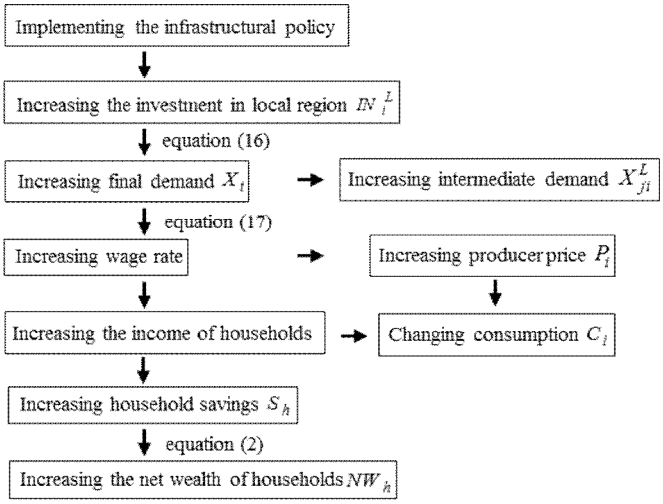

Fig. 3. Flowchart of comparative statics

4.1 Spill-over effects

In this subsection, the effects of the investment policy have been analyzed from the viewpoint of the financial economy. Fig. 3 shows that the investment policy results in increasing net wealth for households. However, there are some negative effects of the policy on the local region. These effects have been analyzed from two different viewpoints as follows:

The first viewpoint involves the outflow of households' assets. Households categorize their net wealth as deposits, government bonds, equities, and currencies. Further, deposits and equities are categorized into those from the local region and other regions. Further, funds raised by sale of government bonds to government bonds spills over to the government. The government redistributes these funds to other regions, which means that some of the increased net wealth spills over to other regions.

The second viewpoint involves the outflow of firm assets. Local firms borrow funds from local banks or banks from other regions, for which they pay interest to the banks. If the firms choose to borrow from banks from other regions, assets from the local region will spill over to other regions in the form of interest payments.

As discussed above, asset outflow can occur in two different ways. Thus, it can be observed that benefit incidence on the local region may be overestimated by CGE models owing to spill-over effects. High-cost policies, such as an infrastructure investment policy, in particular, result in such negative effects.

5 Calibration

In this section, the effect of an infrastructure investment policy on a local region has been calibrated using the RFCGE model. In this case study, we assumed a 20% increase in

infrastructure investment in the local region. Because of space limitations, only a few results have been shown. Table 1 shows that net wealth increased by 100 billion yen after the policy was implemented. However, the total amount of financial assets in the other region ($DEP_h^O + ZZ_h^O + GB_h$) increased by 14 billion yen. This implies that an amount of 14 billion yen spilled over to the other region owing to the policy.

Table 2 shows that there was an increase in producer prices. This increase was because producer prices depend on the wage rate, which rose because of the policy. Further, the increase in producer prices resulted in a decreased demand for goods.

In table 3, EV refers to equivalent variation, which is a measure of economic welfare changes associated with changes in prices. In this paper, EV represents the effect of the policy on the real economy in the local region. In addition, ΔNW represents the effect of the policy on the financial economy in the local region. Thus, EV + ΔNW represents the overall effect of the policy on the local region. EV + ΔNW is -93. This is because the demand for goods decreased owing to an increase in the prices.

Table 1. Financial assets of households

	Before	After	After/Before
NW	8710	8810	1.012
DEP_h	6200	6099	0.984
DEP_h^L	4660	4584	0.984
DEP_h^O	1540	1515	0.984
ZZ_h	2046	2255	1.102
ZZ_h^L	1632	1799	1.102
ZZ_h^O	414	456	1.102
GB_h	206	203	0.984
$CURR_h$	258	254	0.984
(Unit: Billion yen)			

Table 2. Prices of and demand for goods

	Before	After	After/Before
P1	1.00	1.39	1.39
P2	1.00	1.37	1.37
P3	1.00	1.35	1.35
C1	27	24	0.90
C2	430	391	0.91
C3	2100	1948	0.93
(Unit: Billion yen)			

Table 3. Effect of policy

	Effect of policy
EV	-193.5
ΔNW	100.5
EV + ΔNW	-93.0
(Unit: Billion yen)	

6 Conclusion

In this paper, an RFCGE model was developed to solve the theoretical issue of CGE models. The effect of an infrastructure investment policy on a local region was assessed using the RFCGE model. As a result of calibration, the net wealth of households increased. However, a portion of the increased household assets spilled over to other regions. Moreover, producer prices increased owing to an increased wage rate. Further, the demand for goods decreased due to increased prices. Thus, EV+ΔNW had a negative value. This implies that infrastructure investment policy may, sometimes, result in negative effects on the local region. In conclusion, it is difficult to explicitly evaluate the effect of policy on the local region by merely using the CGE model. Therefore, it is important to evaluate infrastructure investment policy using the RFCGE model.

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Appendix: Social Accounting Matrix

Unit: Billion yen									Portfolio																												
	Use of Incomes								Firm 1				Firm 2				Firm 3				Households				Local banks				Other regions								
	Production(1-3)			Capitalist(1-3)			Households	Investment	Physical capital	Bank borrowing	Other region borrowing	Equity	Physical capital	Bank borrowing	Other region borrowing	Equity	Physical capital	Bank borrowing	Other region borrowing	Equity	Currency	Deposit	Equity	Government bond	Loan	Reserve	Deposit	Remittance	Investment	Export/Import	Remittance	Deposit	Government bond	Equity	Loan	Reserve	Total
Initial Portfolio																																					
Capital									-23				-80				-300																				-5000
Loan										100				1000				2000							-3100												0
Reserve																										-100										100	0
Currency													0	0							-250																-250
Deposit													0									-4500					4500										0
Equity												100	0			500				1000			-1600														0
Other region																						-1500										1500					0
Other region																							-400											400			0
Other region											50				500				1000																-1550		0
Remittance																												200			-200						0
Government bond																								-200									200				0
Sales																																					
Production1	9	40	11				27	1																						-26							62
Production1	11	970	320				430	540																						-11							2,260
Production1	10	520	820				2100	86																						-756							2,780
Incomes																																					
Capitalist1	23																													15							38
Capitalist2		80																												230							310
Capitalist3			300																											250							550
Households	9	650	1329	12	120	250																								606							2,976
Other regions				4	40	125	159																														328
Flow of funds																																					
Firm1				22					-62	30	10	4																	-4								0
Firm2					150								-230	60	20	12													-12								0
Firm3						175											-335	90	30	16									24								0
Households							260														-8	-200	-46	-6													0
Local banks																									-180	-20	160	40									0
Other regions																														20	-40	40	6	14	-60	20	0
Asset balance																																					0
Loan										-130				-1060				-2090							3280												0
Equity												-104				-512				-1016			1632														0
Currency																					258																258
Reserve																										120										-120	0
Deposit																						4660					-4660										0
Other region deposit																						1540										-1540					0
Remittance																												-240			240						0
Government bond																								206									206				0
Other region equity																							414											-414			0
Other region loan											-60				-520				-1030																1610		0
Total	62	2,260	2,780	38	310	550	2976	627	-85	0	0	0	-310	0	0	0	-635	0	0	0	0	0	0	0	0	0	0	0	8	328	0	0	0	0	0		