Construction of Financial CGE Model for China–ASEAN Free Trade Area

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ABSTRACT: The establishment of China–ASEAN Free Trade Area facilitates not only free trade but also financial investment. It improves the development of financial integration within the area. The financial investment is introduced into the Computable General Equilibrium Model in this article to build a multi-nations financial CGE model, thus a basic theoretical framework is offered to further study the financial policies' effect within China–ASEAN Free Trade Area.
KEYWORD: China–ASEAN Free Trade Area; Multi-nations Financial CGE Model; Financial Investment

1 INTRODUCTION

The establishment of China–ASEAN Free Trade Area (CAFTA) was in 2002 which facilitated the financial investment and kept on strengthening the financial cooperation along with the deepening of free trade within the area (see [1]). Up to June 2014, China's total investment to ASEAN nations was nearly USD40 billion. Till the end of September 28, 2014, China had realized the public listing of exchange rate with 9 ASEAN nations. ASEAN is not only the first biggest foreign investment market for Chinese enterprises, but also a very important and active area for pushing RMB internationalization forward. The study on financial cooperation and financial integration within the area has become into a hot topic for academicians. In order to analyze chinese financial policies' influences on ASEAN nations under the present financial integration background, this article divides China–ASEAN Free Trade Area into 11 regions according to different nations, meanwhile the investment between nations is divided into financial investment and non-financial investment, thus a multi-regional China- ASEAN Financial Computable General Equilibrium Model (or CA-FCGE Model) is built up.

The model assumes the market participants of each country are facing domestic market, ASEAN market and other countries or regions in the world when making decisions.

In our multi-regional CGE model, each single region has similar structure of economic flow, and all the regions can be connected with each other via commodity flow and investment relation, see Sherman and Li [2-3]. Therefore, this article will first introduce the parts that composed the single region model, including manufacturer behavior equation, government behavior equation, investment and savings equation, resident behavior equation, international trade equation and market clearance conditions, then introduce the connections and relations between regions, including the commodity flow and capital flow between nations, and the final is the macro-closure and conclusion of the model.

2 THE FCGE STRUCTURE IN THE SINGLE REGION

The nation's manufacturer use labor, capital, intermediate input and certain imported commodities to produce commodities for export and domestic sales in the single region, like in Zhou &Deng [4]. Domestic commodity demand is mainly for enterprise's fixed asset investment, inventory increasing, resident's consumption and government consumption. The residents use production elements income to pay income taxes, consumption and domestic savings. The government income comes from direct tax, indirect tax and import tariff, and it is used for government savings and consumption. The enterprises use their sales income for fixed assets investment, inventory increasing and foreign investment except for savings and the payment of relevant taxes and fees. Here the investment includes financial investment and non-financial investment. The detailed single region FCGE economic flow chart is shown as in Figure 1.

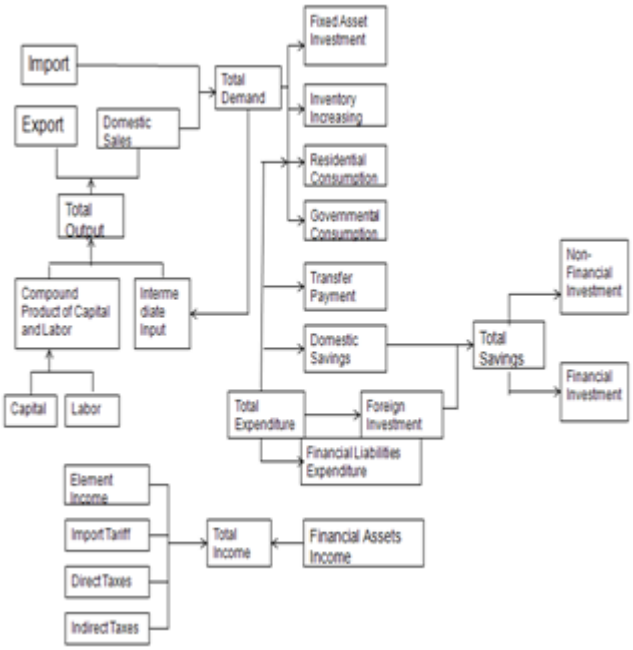

Figure 1. Economic flow for single region

2.1 *Manufacturer Behavior Equation*

Commodities produced by domestic manufacturers are used to satisfy domestic consumers' demand, export to ASEAN and other countries in the world, and the commodities exported to ASEAN nations are undifferentiated to those exported to other countries in the world. All departments' technology has a character of constant returns to scale. The manufacturer has two phases to produce the final products. The first phase, there are h kinds of fundamental production elements to produce compound element j. Based on the goal of profit maximization, the best decision making formula of the manufacturer is as follows:

$$\max_{Y_j, F_{h,j}} \pi_j^y = p_j^y Y_j - \sum_h p_h^f F_{h,j}$$

$$\text{s.t.} \quad Y_j = b_j \prod_h F_{h,j}^{\beta_{h,j}} \qquad \forall j \tag{1}$$

where π_j^y is the gained profit by the manufacturer through the compound production element j, Y_j is the compound element j produced by the manufacturer at the first phase, p_j^y is the price of the compound element, p_h^f is the price of the basic element h, $F_{h,j}$ is the quantity of basic element h that used for producing compound element j by the manufacturer at the first phase. b_j is the scale coefficient of the production function which represents the general technology level of the manufacturer, $\beta_{h,j}$ is element elasticity coefficient.

At the second phase, the manufacturer uses compound element Y_j and the intermediate inputs $X_{i,j}$ to produce the final product Z_j.

The profit maximization behavior decision making of the manufacturer at the second phase is as follows:

$$\max_{Z_j, Y_j, X_{i,j}} \pi_j^z = p_j^z Z_j - (p_j^y Y_j + \sum_i p_i^q X_{i,j})$$

$$\text{s.t.} \quad Z_j = \min\left(\frac{X_{i,j}}{\alpha x_{i,j}}, \frac{Y_j}{\alpha y_j}\right) \tag{2}$$

where π_j^z is the profit gained by the manufacturer through producing the final product, $X_{i,j}$ is the intermediate input quantity of the i product used to produce j product. p_j^z is the price of the final product, Z_j is the quantity the j product; p_j^q is the price the intermediate inputs. $\alpha x_{i,j}$ and αy_j respectively represents the element input demand coefficient when producing 1 unit final product.

Use Lagrange method of multipliers to solve the above optimization problem (1) and (2), we have:

$$F_{h,j} = \frac{\beta_{h,j} p_j^y}{p_h^f} Y_j \qquad \forall h, j \tag{3}$$

$$X_{i,j} = \alpha x_{i,j} Z_j \qquad \forall i, j \tag{4}$$

$$Y_j = \alpha y_j Z_j \qquad \forall j \tag{5}$$

$$p_j^z = \alpha y_j p_j^y + \sum_i \alpha x_{i,j} p_i^q \qquad \forall j \tag{6}$$

2.2 *Governmental Behavior Equation*

Government imposes import tariff towards imported commodities and imposes export tariff or provide subsidies to exported commodities. Government income comes from direct taxes, enterprise indirect taxes and tariffs. Government payment is for government savings and the consumption of the final products, and assumes government consumes each final product at a fixed rate of percentage. Government imposes direct taxes towards residents. The rate of the direct taxes is τ^d:

$$T^d = \tau^d \sum_h p_h^f FF_h \tag{7}$$

FF_h is the initial endowment of the basic productive element h hold by the residents.

$$T_j^z = \tau_j^z p_j^z Z_j \qquad \forall j \tag{8}$$

Government levies ad valorem duties to those products produced domestically, the rate of the indirect taxes is τ_j^z.

In order to easily find the influences on each region's economy made by the CAFTA preferential tariff policies, hereunder the sources of the imported goods are divided into 2 sources, one is imported from ASEAN nations and the other is imported from non-ASEAN nations. It is assumed that the tariff rate towards the goods imported from ASEAN nations is

τ_i^{mA} and the tariff rate towards the goods imported from non-ASEAN nations is τ_i^{mO}. Then

$$T_i^m = \tau_i^{mA} p_i^{mA} MA_i + \tau_i^{mO} p_i^{mA} MO_i \quad (9)$$

p_i^{mA} is the price of i commodity imported from ASEAN nations, MA_i means the quantity of i commodity imported from ASEAN nations, p_i^{mO} means the price of i commodity imported from non-ASEAN nations, MO_i means the quantity of i commodity imported from non-ASEAN nations.

The equation of government consumption is as follows:

$$X_i^g = \frac{\mu_i}{p_i^q}(T^d + \sum_j T_j^z + \sum_j T_j^m - S^g)$$

$$(0 \le \mu_i \le 1, \sum_i \mu_i = 1) \quad (10)$$

X_i^g is the government consumption amount of i commodity. The consumed commodities by the government have relations with the prices of commodities, μ_i means the payment percentage for i commodity paid by government. S^g is government savings.

2.3 *The Equation of Investment and Savings*

It is assumed that there is a virtual investment department which gains capital from domestic residents, its government and abroad, and then it invests to each product proportionally. The proportion coefficient is λ_i.

$$X_i^v = \frac{\lambda_i}{p_i^q}(S^p + S^g + \varepsilon S^f - I^F) \quad (11)$$

X_i^v is the expenditure of investment department towards i product. S^p is residential savings. S^f is the deficit of current account or foreign deposits. ε is exchange rate(local currency/foreign currency). ss^p is residential average propensity to save which is mutual decided by income level, price of commodity and the local deposit interest rate.

$$S^p = ss^p \sum_h p_h^f FF_h \quad (12)$$

$$S^g = ss^g (T^d + \sum_j T_j^Z + \sum_j T_j^m) \quad (13)$$

ss^g is governmental average propensity to save which is decided by domestic deposit interest rate and inflation rate. Here I^F means investment towards foreign financial assets. As in Li & Hu [5], this type of financial assets mainly includes: foreign exchange deposits, foreign exchange loans, securities and others, the above mentioned securities includes: treasury bonds, financial bonds, central banking bonds, enterprise bonds and stocks.

2.4 *Residential Behavior Equation*

The optimum decision making of residents is to maximize their own utility, hereunder the Cobb-Douglas utility function is chosen to describe it and the residential behavior equation is as follows:

$$\max_{X_i^p} UU = \prod_i X_i^{p^{\alpha_i}}$$

$$\text{s.t. } \sum_i p_i^q X_i^q = \sum_h p_h^f FF_h - S^p - T^d \quad (14)$$

X_i^q is the consumed quantity of commodity i by the residents, α_i is the shared parameters of utility function, and $(0 \le \alpha_i \le 1, \sum_i \alpha_i = 1)$.

To solve optimized problem (14), we get the demand function of commodity i as follows:

$$X_i^p = \frac{\alpha_i}{p_i^q}(\sum_h p_h^f FF_h - S^p - T^d) \quad (15)$$

2.5 *International Trade Equation*

The small country assumption is adopted for the international trade among countries,:

$$p_i^e = \varepsilon p_i^{we} \qquad \forall i \quad (16)$$

$$p_i^m = \varepsilon p_i^{wm} \qquad \forall i \quad (17)$$

p_i^e is the price of the export commodity i whose invoicing currency is domestic currency, p_i^{we} is the price of the export commodity i whose invoicing currency is foreign currency, p_i^m is the price of the import commodity i whose invoicing currency is domestic currency, p_i^{wm} is the price of the import commodity i whose invoicing currency is foreign currency.

Under the binding condition of a balance between economic receipts and payments, the balance equation between capital account and current account calculated based on foreign currency is as follows:

$$\sum_i p_i^{we} E_i + S^f = \sum_i p_i^{wm} M_i \quad (18)$$

E_i is the total export quantity of commodity i, M_i is the total import quantity of commodity i.

Under open economic body, it is assumed that the manufacturer allocate its products in both domestic and foreign markets, and the commodity produced and consumed domestically with the imported and exported commodity are in imperfect substitute, i.e.

has Armington assumption

$$\max_{Q_i,M_i,D_i} \pi_i^q = p_i^q Q_i - [(1+\tau_i^m) p_i^m M_i + p_i^d D_i]$$

$$\text{s.t.} \quad Q_i = \gamma_i (\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i})^{1/\eta_i} \tag{19}$$

Q_i is residents and manufacturers' total demand quantity of Armington compound commodity i, γ_i is the convertible proportion coefficient, δm_i and δd_i is the input allocation coefficient and $0 \le \delta m_i \le 1, \quad 0 \le \delta d_i \le 1, \delta m_i + \delta d_i = 1$

η_i is the parameter defined by commodity substitution elasticity during the process of consuming compound commodity i, ($\eta_i = \frac{\sigma_i - 1}{\sigma_i}$, $\eta_i \le 1$); σ_i is the commodity substitution elasticity :

$$\sigma_i = -\frac{d(M_i / D_i)}{M_i / D_i} \Big/ \frac{d(p_i^m / p_i^d)}{p_i^m / p_i^d}$$

To solve optimized problem (19) to get:

$$\mathrm{M_i} = [\frac{\gamma_i^{\eta_i} \delta m_i p_i^q}{(1+\tau_i^m) p_i^m}]^{\frac{1}{1-\eta_i}} Q_i \qquad \forall i \tag{20}$$

$$\mathrm{D_i} = [\frac{\gamma_i^{\eta_i} \delta d_i p_i^q}{p_i^d}]^{\frac{1}{1-\eta_i}} Q_i \qquad \forall i \tag{21}$$

The best decision making of export enterprise is:

$$\max_{Z_i,E_i,D_i} \pi_i = (p_i^e E_i + p_i^d D_i) - (1+\tau_i^z) p_i^z Z_i$$

$$\text{s.t.} \quad Z_i = \theta_i (\xi e_i E_i^{\varphi_i} + \xi d_i D_i^{\varphi_i})^{\frac{1}{\varphi_i}} \tag{22}$$

θ_i is the convertible proportion coefficient during home and abroad allocation period of final commodity i, ξe_i and ξd_i is the allocation coefficient during home and abroad allocation period of final commodity i, and

$0 \le \xi e_i \le 1, 0 \le \xi d_i \le 1, \xi e_i + \xi d_i = 1;$

φ_i is the parameter defined by convertible elasticity, $\varphi_i = \frac{\psi_i + 1}{\psi_i}$, $\psi_i \le 1$; ψ_i is the commodity substitution elasticity during home and abroad allocation period of final commodity i. Solve optimized problem (22), we get:

$$E_i = [\frac{\theta_i^{\varphi_i} \xi e_i (1+\tau_i^z) p_i^z}{p_i^e}]^{\frac{1}{1-\varphi_i}} Z_i \tag{23}$$

$$D_i = [\frac{\theta_i^{\varphi_i} \xi d_i (1+\tau_i^z) p_i^z}{p_i^{de}}]^{\frac{1}{1-\varphi_i}} Z_i \tag{24}$$

2.6 *Market Clearance Condition*

Commodity market equilibrium:

$$Q_i = X_i^p + X_i^g + X_i^v + \sum_j X_{i,j} \qquad \forall i \tag{25}$$

Element market equilibrium:

$$\sum_j F_{h,j} = FF_h \qquad \forall h \tag{26}$$

3 THE CONNECTIONS BETWEEN NATIONS

3.1 *The Commodity Flow between Nations*

In the model, the commodity flow between nations includes the flow of intermediate input products between nations, and the flow of final consumption commodity, includes: residential consumption, government consumption, fixed assets investment, inventory increasing etc. Both intermediate input demand and the commodity demand of residential consumption, governmental consumption, and enterprise investment can both adopt domestic and imported products, can also adopt commodity produced abroad, their substitution relations can be described by CES function (Constant Elasticity of Substitution). The products produced by each nation can both meet its domestic demand for residents, government and enterprises and be exported to other nations, as shown in figure 2.

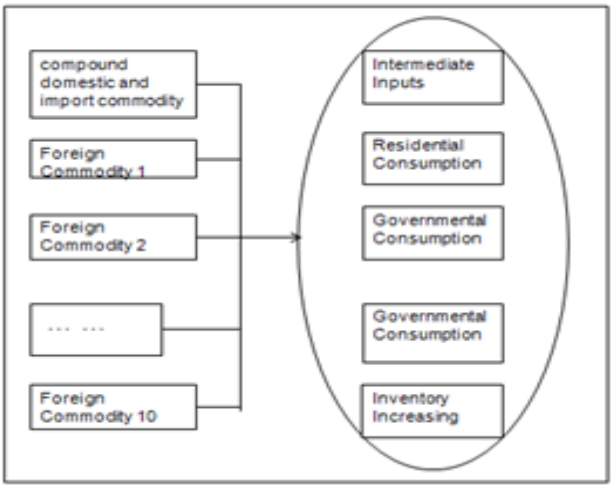

Figure 2 Scheme of Commodity Flow between Nations

3.2 *The Investment Allocation between Nations*

The return on investment (ROI) has differences between nations within China–ASEAN Free Trade Area. The capital will flow from low ROI nations to high ROI nations. But in the long run, the expected ROI will decrease along with the increasing of the capital supply in high ROI nations, at last the expected ROI of each nation will be the same as the average expected ROI of China–ASEAN Free Trade Area, see Wang et.al [6]. According to the equalization of expected ROI allocation pattern, it is

assumed the investment amount in each nation is endogenous variable, if the actual investment amount of each nation is IT_r, the stock of capital at the beginning of the period is KB_r, the stock of capital at the end of the period is KE_r, the stock of capital at the end of the period can be defined as:

$$KE_r = IT_r + KB_r \tag{27}$$

r=0,1,2,…,10, means there are 11 nations within China–ASEAN Free Trade Area. It is assumed that the capital rent price in nation r is $RENTK_r$, the average price of investment projects is PRI_r the inflation rate is $depre_r$, then nation r's net ROI, $RORK_r$ is as follows:

$$RORK_r = RENTK_r / PRI_r - depre_r$$

$rorex_r$ is the elasticity value of ROI regarding the ratio of stock of capital, aex_r is scale parameter, then nation r's expected ROI, $RORK_r$ is defined as follows:

$$RORE_r = aex_r \cdot (KE_r / KB_r)^{-rorex_r} \cdot RORK_r$$

each nation's expected ROI , $RORE_r$ equals to the average ROI, $RORG_r$, of the China–ASEAN Free Trade Area:

$$RORE_r = RORG_r \tag{28}$$

4 MACRO-CLOSURE

The equilibrium between investment and savings is cleared by adjustable mechanism interest which is outside of the model, see Liu [7]. Governmental savings and residential savings are exogenous, governmental consumption and the investment in each nation is endogenous. The exchange rate is exogenous and the proportion of foreign savings to domestic GDP is endogenous. The binding condition of labor is all the labors in all the industries of each nation equals to the total quantity of its national labor, the binding condition of capital is all the capital in all the industries of each nation equals to the total amount of its national capital, the condition of macro equilibrium is the total savings equals to the total investment. Please refer to (29)-(31).

$$TQL_r = \sum_i QL_{i,r} \tag{29}$$

$$TQK_r = \sum_i QK_{i,r} \tag{30}$$

$$\sum_r (S_r^p + S_r^g) + \sum_r \varepsilon_r S_r^f = \sum_r IT_r \cdot PRI_r + \sum_r \sum_i (Q_{i,r} \cdot P_{i,r} + Q_{i,r,h} \cdot P_{i,r,h}) \tag{31}$$

TQL_r is the total labor quantity of nation r, TQK_r is the total capital amount of nation r,

$QL_{i,r}$ is the labor quantity in nation r's i industry, $QK_{i,r}$ is the capital amount in nation r's i industry, S_r^p is residential savings of nation r, S_r^g means governmental savings of nation r, S_r^f means foreign savings of nation r, IT_r is the total investment amount of nation r, PRI_r is the average investment price of nation r, $Q_{i,r}$ is nation r's i commodity's investment amount used for domestic savings, $P_{i,r}$ is nation r's i commodity's investment price used for domestic savings, $Q_{i,r,h}$ is the inventory investment quantity of commodity i from nation r to h, $P_{i,r,h}$ is the inventory investment price of commodity i from nation r to h.

5 CONCLUSION

The financial investment is introduced to the investment allocation of each nation's savings within China–ASEAN Free Trade Area in the article, the financial CGE model for China–ASEAN Free Trade Area is built based on the general equilibrium principal, then a theoretical framework is offered to further study and analyze the China financial policies' influences on the economic growth of other nations within China–ASEAN Free Trade Area ever since its establishment.

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REFERENCES

[1] Jianbo Chen, Liequ Hu. 2012. *The Regional Financial Cooperation Process and Prospects of China–ASEAN*. Cooperation of Economy and Technology, 4: 50-51.

[2] Sherman, R. 1991. *Macroeconomics, Financial Variables and Computable General Equilibrium models*. Word Development. 11: 1509-1525.

[3] Hongxin Li. 2008. *Computable General Equilibrium Model——Model Construction and Simulation*. Beijing: China Machine Press

[4] Chifei Zhou, Shuhui Deng. 1998. *China Finance Computable General Equilibrium Model.* Systems Engineering-Theory & Practice, 4: 8-17.

[5] Li Li, Liequ Hu.2014. *The Study and Application of China Financial CGE Model*. Finance, 4: 41-46.

[6] Huifang Wang, Qin Bao, Shanying Xu. 2013. *China Financial Computable General Equilibrium Model and its Application to the Study on Deposit Reserve Policy*. Management Review, 25(8): 3-9.

[7] Bin Liu. 2011. *The Study on Central Banking Macro Economic Model based on CGE Framework*. Journal of Financial Research, 6: 1-17.