



## **KS-CGE Model V2012 TypeIII: Mathematical settings and its applications**

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### **ABSTRACT**

Faculty of Economics, Chiang Mai University has developed its own computable general equilibrium model (CGE). This paper will reveal the settings of the so called “KS-CGE Model V2012 TypeIII”. It will also introduce the scope and limit of applications that the model can provide.

*Keywords:* Computable general equilibrium model, mathematical economics, policy modeling, macroeconomic analysis, macroeconomic policy

*JEL Classification:* C68, E60, C54

### **1. Introduction**

Computable general equilibrium model (CGE) is widely used in macroeconomic analysis. Usually schools of economics in leading universities and international institutes in the world develop their own CGE models. For example, Chulalongkorn University in Thailand has CAMGEM (Chulalongkorn And Monash General Equilibrium Model) which is developed by Professor Kwanjai Arunsmith and Professor Nuannoi Trirat (Arunsmith and Trirat, 1994; Arunsmith, 1998). Moreover, Professor Isra Sarntisart also uses his CGE for development economics analysis (Sarntisart, 1994). Massachusetts Institute of Technology (MIT) develops its CGE from microeconomic fundamentals and uses it in policy analysis (Wing, 2004). University of California at Berkeley by Professor David Roland-Holst develops his CGE and distributes it widely

to the world (Robinson and Roland-Holst, 1988). International Food Policy Research Institute (IFPRI) by Professor Hans Lofgren (Lofgren et al, 2002) has released the standard CGE model in GAM which is widely followed by scholars over the world. Professor Johannes Broecker at University of Kiel, Germany, has also developed his CGE model based on linear programming and uses intensively in regional economic policy analysis (Broecker and Korzhenevych, 2011).

Faculty of Economics, Chiang Mai University aims to create its own CGE model too. The school by Komsan Suriya and Tatcha Sudtasan (Sandy), therefore, constructs the first CGE model and gives its name “KS-CGE” which comes from Komsan and Sandy. The project begins in early 2012. The prototypes (Type I and Type II) have been improved into this version of Type III by the end of 2012. The main idea of the development is from the CGE model of Professor Johannes Broecker at University of Kiel, Germany.

## **2. Settings of the model**

The KS-CGE Model v2012 Type III is based on a system of linear equations. It forms three matrices:  $\mathbf{X}\mathbf{P}=\mathbf{Y}$ . Matrix  $\mathbf{X}$  represents the domestic economy,  $\mathbf{P}$  represents the endogenous price, and  $\mathbf{Y}$  represents the net external income. It solves the system for  $\mathbf{P}$  with Gauss-Seidel iteration method. The model applies constant elasticity of substitution (CES) technology. Input ratios change according to the change of price ratios. It applies Shephard’s lemma to calculate optimal  $\mathbf{X}$  after the price changes to reflect the structural change of the productions. The routine repeats itself until  $\mathbf{P}$  is converged.

The structure of matrix  $\mathbf{X}$  consists of the following elements:

- 1) The row of matrix  $\mathbf{X}$  presents a sector.
- 2) The diagonal values are positive and present domestic sales of related sectors.
- 3) The off-diagonal values are all negative and present intermediate inputs, factor inputs, tax and payments to institutions.
- 4) Net exports are presented in matrix  $\mathbf{Y}$ . There is no element related to imports or exports in matrix  $\mathbf{X}$ .

Matrix  $\mathbf{Y}$  presents the net external income. It combines exports, imports, remittance, capital inflow and capital outflow in all forms. The value of  $\mathbf{Y}$  is negative when it has a surplus of external income.

The idea behind  $\mathbf{X}\mathbf{P}=\mathbf{Y}$  is that the value of domestic sales plus external income equals to all inputs, payments and tax. Business profits are all translated into household income. Then every sector is under zero-profit condition. All markets will be clear when the system can find  $\mathbf{P}$  that satisfies this condition.

## **3. Applications**

The applications of the model cover the counterfactuals on external trade, government expenditure, government subsidy, taxation, household consumption, money supply, labor cost, commodity cost and capital inflow.

This CGE model works well with the social accounting matrix (SAM) in the dimension of  $16 \times 16$  sectors. The 16 sectors in the SAM are as followed:

- Sector 1: Agriculture
- Sector 2: Mining and quarrying
- Sector 3: Food manufacturing
- Sector 4: Textile industry
- Sector 5: Saw mills and food products
- Sector 6: Paper industries and printing
- Sector 7: Rubber, chemical and petroleum industries
- Sector 8: Non-metallic products
- Sector 9: Metal, metal products and industries
- Sector 10: Other manufacturing
- Sector 11: Public utilities
- Sector 12: Construction
- Sector 13: Trade
- Sector 14: Transportation and communication
- Sector 15: Services
- Sector 16: Others

The SAM may have to be manipulated when some problems occur. A problem occurs when a sector relies heavily on external capital inflow. In this case, the sector may not be able to finance itself when the related costs increase. To ease this problem, a modeler may have to combine this sector with another sector whose domestic income is high enough to cover the increasing costs of the problematic sector (Kanjanatarakul and Suriya, 2012). However, the combination should not make the meaning of the newly combined sector unclear when both sectors are totally different in the nature of business.

#### 4. Discussions

The usage of KS-CGE model needs to be careful in many dimensions. First, the KS-CGE model relies heavily on the accuracy of the SAM. The results from CGE reflect the economic structure presented by SAM. Therefore, a modeler has to be careful to use data from the latest and reliable SAM.

Second, the model needs to modify the SAM into a certain format the CGE program can understand. This requires an intensive arrangement in MS-Excel file or other equivalent spreadsheets. Along the process, the balancing of the SAM is crucial. The unbalanced SAM will cause a severe problem to the calculation of the CGE model. Therefore, before using this version of CGE, training in this specific data base arrangement is a must.

Third, the model works on MATLAB. Then the users must have MATLAB installed in their computers. Moreover, the user-interface is not like an instant program. It may be difficult for beginners to use this version of CGE model when they must find places to change variables in the model.

Fourth, there are still rooms to improve the convergence of the model. The current stopping criteria may be argued that it yields a solution that may not be converged. This can be thought of because the linear programming has a zero determinants of matrix  $\mathbf{X}$  such that Kramer's rule cannot be applied to solve the problem. It is right that, by mathematical theory, it is possible for the model to have many solutions or no solution at all. However, by the iteration method, the assigned initial value is believed to bring the model to a certain solution. Then, the question is on the appropriateness of that

initial value. Therefore, sensitivity analysis of different initial values may be a good practice when using this model.

Fifth, CGE model is time-consuming in the iteration process. Super computer may be a solution for reducing the time in doing research with this CGE model. Faculty of Economics, Chiang Mai University has invested in a super computer in 2012 and operated it in the Center for Quantitative Analysis.

## 5. Conclusions

This paper reveals the mathematical settings of a computable general equilibrium (CGE) model. The Komsan-Sandy (KS) CGE Model v2012 Type III is based on a system of linear equations. It solves the system using Gauss-Seidel iteration. The model applies constant elasticity of substitution (CES) technology. It refers to Shephard's lemma to calculate the optimum quantities of inputs to reflect the structure change of the productions. The applications of the model cover the counterfactuals on external trade, government expenditure, government subsidy, taxation, household consumption, money supply, labor cost, commodity cost and capital flow. The model works well with social accounting matrix (SAM) in the dimension of  $16 \times 16$  sectors. There are still rooms to improve the models especially for its convergence.

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