

**UNIVERSITA' CATTOLICA DEL SACRO CUORE
MILANO**

**Dottorato di ricerca in
Modelli Quantitativi per la Politica Economica
ciclo XIX**

S.S.D: SECS-P/01, SECS-P/02, SECS-P/06

**LINKING CGE AND MICROSIMULATION MODELS:
METHODOLOGICAL AND APPLIED ISSUES**

Tesi di Dottorato di: Giulia Colombo

Matricola: 3280098

Anno Accademico 2006/2007



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ABSTRACT

After an introduction to CGE (Computable General Equilibrium) models and to Microsimulation techniques, this thesis wants to give an assessment and a detailed description of how CGE and MS models can be linked together, taking inspiration from the current literature, with a special focus concerning the literature on developing countries. The main goal for which these two models are linked together is to try to take into account full agents' heterogeneity and the complexity of income distribution, while being able at the same time to consider the macroeconomic effects of the policy reforms. In current literature there are two main trends in the approach to linking: one that tries to fully integrate the two models, or better the CGE model and a micro dataset or survey (integrated model), while the other develops separately the CGE and the microsimulation models and then links them together through a set of equations and parameters (layered models). We will make a detailed comparison of the two approaches.

In the last chapter, we build a CGE-microsimulation model for the economy of Nicaragua, following the Top-Down approach (see Bourguignon *et al.*, 2003), that is, the reform is simulated first at the macro level with the CGE model, and then it is passed onto the microsimulation model through a vector of changes in some chosen variables, such as prices, wage rates, and unemployment levels. The main reason for this choice is that with such an approach, one can develop the two models (CGE and microsimulation) separately, thus being able to make use of behavioural micro-econometric equations, which are instead of more difficult introduction into a fully integrated model. Moreover, the so called top-down approach appears to be particularly suited to the policy reform we are willing to simulate with the model: the Free Trade Agreement of Central America with the USA is mainly a macroeconomic reform, which on the other hand can have important effects on the distribution of income. With such a model we try to study the possible changes in the distribution of income deriving from the Free Trade Agreement with USA. Our analysis finds only small changes both in the main macroeconomic variables and in the distribution of income and poverty indices.

RIASSUNTO

Dopo aver introdotto i modelli CGE (Computable General Equilibrium, Equilibrio Generale Computazionale) e le tecniche di microsimulazione, questa tesi offre una descrizione dettagliata di come i modelli CGE ed i modelli di microsimulazione possano essere utilizzati congiuntamente, partendo dalla letteratura piú recente sull'argomento, e focalizzando in particolare l'attenzione sulla letteratura riguardante i paesi in via di sviluppo. Lo scopo principale dell'utilizzo di questi due modelli in maniera congiunta é quello di voler tenere in considerazione l'eterogeneità degli agenti economici e la complessità della distribuzione del reddito, e di essere in grado allo stesso tempo di valutare gli effetti macroeconomici delle riforme.

Nella letteratura attuale troviamo due tendenze principali: la prima cerca di integrare completamente i due modelli, o meglio il modello CGE ed il dataset microeconomico (modello integrato), mentre la seconda sviluppa separatamente i due modelli per poi collegarli attraverso un insieme di equazioni e di parametri (modelli stratificati). Eseguiamo un confronto dettagliato dei due approcci sopra descritti.

Nell'ultimo capitolo costruiremo un modello CGE-microsimulazione per l'economia del Nicaragua, seguendo l'approccio cosiddetto Top-Down (si veda Bourguignon *et al.*, 2003) che simula la riforma dapprima ad un livello macro con il modello CGE, e poi passa i risultati di questo al modello di microsimulazione attraverso un vettore di variazioni di prezzi, salari e livello di disoccupazione. La ragione principale per la quale è stato scelto questo approccio è che grazie ad esso è possibile sviluppare i due modelli separatamente, potendo così fare libero uso di equazioni comportamentali che sarebbero invece di difficile implementazione in un modello pienamente integrato. Inoltre, l'approccio Top-Down è particolarmente adatto alla riforma di politica economica che vogliamo simulare con il modello: l'accordo di libero scambio commerciale tra i paesi dell'America Centrale e gli Stati Uniti è una riforma di tipo macroeconomico, che potrebbe tuttavia avere effetti significativi sulla distribuzione del reddito. Con questo modello proveremo infatti ad analizzare gli effetti derivanti dall'accordo commerciale con gli Stati Uniti sulla distribuzione del reddito. I risultati dell'analisi dimostreranno che tale accordo commerciale porterá soltanto a piccole variazioni sia delle principali variabili macroeconomiche che della distribuzione del reddito e degli indici di povertá.

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Giulia Colombo

INTRODUCTION

Computable General Equilibrium (CGE) models are multi-sector numerical models based on concepts associated with Walrasian general equilibrium theory. They are designed to analyze the effects of policy reforms or of economic shocks on the economy in a national, multi-national or global economy. Major fields of application include fiscal policy and optimal taxation, trade policy and international trade regimes, income distribution, sector development, and the economic impact of technological change. In addition, CGE models have been fruitfully used for analyses of environmental and natural resource problems and policies¹. CGE models have proved to be useful instruments for studying the effects of a reform or of a shock on the whole economy, especially when a simultaneous change of more than one parameter is necessary. Anyway, one of the limits of CGE models is that, as they generally follow the representative household approach, they are often unable to capture within-group inequality and some specific individual agents' behaviour. This is particularly important when we want to carry on income inequality and poverty analysis².

¹ The earliest CGE models of developing countries were designed to examine issues of income distribution. Adelman and Robinson (1978) analysed the case of South Korea, and Lysy and Taylor (1980) built a model for Brazil. For applications concerning optimal taxation, see for instance Ballard *et al.* (1985) and Ballard and Medema (1993). CGE models about trade policies are very numerous. For example, on the occasion of the negotiations for the North American Free Trade Agreement (NAFTA) among the United States, Canada and Mexico (1993), there appeared several studies relying on CGE models, surveyed by Brown (1992). CGE on environmental issues include measurements of intergenerational and multisectoral effects of policies such as cutting tolerated toxic emissions levels, raising green taxes, etc. See for example Bohringer and Rutherford (1997), Rutherford (2000) and Bohringer *et al.* (2000 and 2003).

² After Mookherjee and Shorrocks' (1982) study of UK, there are now other examples of "within/between" decomposition analysis of changes in inequality that indicate that changes in overall inequality are usually due at least as much to changes in within-group inequality as to changes in the between-group component. Among the applications to developing countries, see Ahuja *et al.* (1997), who applied this decomposition analysis to the case of Thailand, and Ferreira and Litchfield (2001) for Brazil.

Microsimulation (MS) models are instead tools that allow the simulation of the effects of a policy on a sample of economic agents (individual, households, firms) at the individual level. Usually, MS models are based on two fundamental elements: a micro dataset containing the economic and socio-demographic characteristics of a sample of individuals or households (household surveys), and the rules of the policies to be simulated, and especially their impact on the budget constraint faced by each agent. Their field of application ranges among the ones included in the broader area of redistribution policies: indirect and direct taxation, social security system reforms, etc.

Microsimulation (MS) techniques are accurate instruments for studying the effects on individual behaviour (such as labour supply or consumption) of a change in the tax-benefit system at a very detailed level. In this respect, microsimulation models are very useful and precise when studying income distribution and poverty issues, as they work at the level of the individual or of the single household. However, the main drawback of these models is that they are just a partial equilibrium analysis, and they are not able to capture the general equilibrium impact of a reform. However this could be significant in the case we are analysing a reform or a shock that could have important effects on the structure of the economy under study.

In principle, the idea of linking CGE and MS models looks as the best solution to overcome the limits of both models, as they are somehow complementary. The CGE model will provide the macro structure of the economy, while the MS model is providing a detailed micro dataset at the individual and household level. This way, the new modelling tool resulting from the link of the two models should be able to consider full agents' heterogeneity and general equilibrium effects at the same time. In particular, recent literature has focused on the possibility of combining these two types of models in order to account simultaneously for structural changes of the economy, general equilibrium effects of economic policies, and for their impacts on households' welfare, income distribution and poverty³. This way, the modeller will be able to implement

³ The literature that follows this approach is quite flourishing in recent years: there are, among others, the important contributions by Decaluwé *et al.* (1999a) and (1999b), Cogneau and Robilliard (2000), Agénor *et al.* (2001), Cockburn (2001), Cogneau (2001), Bourguignon, Robilliard and Robinson (2003), Boccantuso *et al.* (2003a) and Savard (2003).

structural or macroeconomic policies/shocks while taking into account their effects on microeconomic behaviour (at the individual or household level).

This thesis wants to give an assessment and a detailed description of how CGE and MS models can be linked together, taking inspiration from the current literature (with a special focus concerning the literature on developing countries).

In particular, one could think of introducing thousands of individuals/households taken from a household survey directly into the CGE model. We will call this an integrated approach. Another way would be to develop the two models separately, and then link them in a layered fashion through a vector of changes in some important variables (prices and/or quantities). Of course the main disadvantage or drawback of this approach is that it requires much more time and effort in the building of the entire model, as one has to go through two completely different modelling techniques and two different databases, the national accounts and the household survey.

But a question arises at this point: in which direction should go the link? Or better, should the link be in one direction only (for instance, from the macro onto the micro level of analysis), or the feedback effects (from the micro to the macro level) are also important for the final general equilibrium results?

In this work we will make a first attempt in trying to answer to some of these questions, and we will compare the three main approaches used in the literature to link CGE and MS models: the integrated approach, which uses thousands of households as agents in a standard CGE framework; the so called Top-Down approach, which imposes the results of a CGE model onto the microsimulation model, and draws from the latter poverty and inequality analysis; the Top-Down/Bottom-Up (TD/BU) approach, as it was developed by Savard (2003). This approach, after the injection of macroeconomic changes from the CGE onto the MS model, tries to take into account also the feedback effects from the micro to the macro level of analysis.

In linking these two types of models we encounter several difficulties, one of which is of course the problem of data inconsistency between the two datasets. This problem is openly faced by modellers that build integrated models, through the so-called “data reconciliation process”, but has not been treated so far in the other two approaches. This will be of particular relevance for the TD/BU approach.

In general, however, when building such models one has also to take into account other possible advantages and drawbacks of the various approaches: for instance, the layered approach requires time and effort in the building of the entire model, as one has to go through two different modelling techniques and two different databases. On the other side, one of the main advantages of the integrated approach is its simplicity and easiness of implementation. Its easiness allows what is instead still missing in the framework of a layered approach: dynamics. Indeed, while with integrated models dynamics is already introduced in a few examples⁴, one of the main things still missing up to now in a layered framework is a dynamic featuring, which in the future will need further effort⁵.

The work is organized as follows.

In the **first chapter**, after an introduction to microsimulation techniques, we will give a technical and detailed overview on how to link CGE to microsimulation models, describing in detail the practical implementation of the three main approaches cited above.

In the **second chapter** we investigate further the three approaches, and build three models for the same economy to compare and investigate results from the three different models. We will go in special detail with the TD/BU approach and draw some conclusions on its possible drawbacks. We will also propose an alternative way of taking into account feedback effects from the micro to the macro level of analysis.

Finally, in the **last chapter**, we will apply the technique to a real economy: we will study the effects that the introduction of the Free Trade Agreement of Central America with USA will have on poverty and inequality in Nicaragua. For this we have built a CGE-MS model for the Nicaraguan economy using a Top-Down approach. We will analyse both the macroeconomic effects and the changes in poverty and inequality that will take place after the introduction of the Treaty in Nicaragua.

⁴ See for instance the integrated dynamic model of Annabi *et al.* (2005) for Senegal, and the model for Philippines developed by Corong (2005). Other information about this approach can be found in Cockburn and Decaluwé (2006).

⁵ A first attempt in this direction was made by Bibi and Chatti (2006) with their dynamic layered model for Tunisia.