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A Classification of Empirical CGE Modelling

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Abstract

In the existing literature on CGE modelling there is still much discussion about a definition and classification of CGE models. Different names like Transaction Value models, Computable General Equilibrium models, Applied General Equilibrium models and SAM-based general equilibrium models have been used, without giving a proper classification of models. In this paper a definition and classification of CGE modelling will be given, based on the historical development of empirical CGE analysis, the chosen model specification and the determination of parameters.
1. Introduction

Since the beginning of the 1980s Computable General Equilibrium (CGE) models have become increasingly popular to analyze the consequences of macroeconomic policy choices and the allocation of resources in developing as well as in developed countries. CGE models are preferred over partial equilibrium models because complex interdependencies are included in the analysis. That is, if a policy instrument is used to achieve a change in an economic target variable, other economic variables than those targeted will be affected. The resulting final economic outcomes may well differ adversely from the intention of the policy makers and the direct effects predicted by partial equilibrium models. In other words, there are many instances where the implied ceteris paribus assumptions do not apply for successive sector-by-sector partial equilibrium analyses (see also Willenbockel (1994a, pp. 13-28)).

However, there is still much discussion about a definition of empirical CGE models. For instance, empirical CGE models have been presented in the literature using various names such as Transaction Value models, Computable General Equilibrium models, Applied General Equilibrium models and SAM-based general equilibrium models. The difference between these terms, if existing, has never been made clear and the purpose of this paper is, therefore, to give a definition and classification of CGE modelling, based on the historical development of empirical CGE analysis, the specification of different models and the determination of parameters.

2. Definition

A CGE model may be defined as the fundamental macroeconomic general equilibrium links among incomes of various groups, the pattern of demand, the balance of payments and a multisector production structure. Moreover, the model incorporates a set of behavioural equations describing the economic behaviour of the agents identified in the model and the technological and institutional constraints facing them. The model is in general equilibrium, because a set of prices and quantities exists, such that all excess demands for commodities and services, in nominal as well as in

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1 This definition, combines and narrows the definitions of Dixon, Parmenter, Powell and Wilcoxen (1992, p. 70) and of Dervis, De Melo and Robinson (1982, pp. 132-133).

2 The agents identified by the model may be representative agents like a typical household with a given socio-economic background, or a typical producer in a particular industrial sector operating on a specific market. It is also possible that the behavioural equations describe the behaviour of larger entities like social groups.
real quantities, are zero. It should be noted that, as was also mentioned by Bergman (1990, p. 4), CGE models are not true general equilibrium models if the latter is reserved for models devoted to the interaction of utility maximizing micro units in the economy.

2.1 Confining the definition

Unfortunately, this definition encompasses models that are generally not seen as CGE models. But, although many numerical multisector models are usually referred to as being ‘CGE models’, there exists no consensus on a precise and excluding definition of a CGE model. As a second best solution to this definition problem, I follow Bergman (1990) in narrowing the definition of CGE models by describing their common and distinct characteristics.

CGE models are aggregate representations of the economy and are based on the flow equilibrium in product and factor markets in real as well as in nominal values. Opposite to input-output analysis, both quantities and relative prices are endogenous, while consumption is no longer exogenous but linked to income. The general equilibrium approach, opposite to partial equilibrium models which analyze the different sectors separately under ceteris paribus assumptions, intends to model all links within the economy that represent a transaction of money or goods. The analysis is usually based on comparative numerical static analysis of changes in exogenous conditions. Thus, the base equilibrium situation is compared with the new equilibrium after the exogenous shocks or the policy measures have taken place.

In general, the aim of CGE modelling is to build a model with a relative transparent structure in order to clarify the mechanism with which policy measures or exogenous shocks affect the economy within a multisector framework. Given the existing limitations in parameter estimation and, therefore, also the model structure, it is often not the objective to forecast the exact outcome of policy measures as with, for instance, a reduced form forecasting model (Adelman and Robinson, 1978, pp. 6) but to give only an indication for the direction and size of the effects. Usually the model is build for one country, focusing on income distribution or resource allocation within the country. However, also multi-country models about regional or global perspectives exist and are becoming increasingly popular.

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3 So, the law of Walras should be valid and the equilibrium price vector should not be equal to the zero price vector. In mathematical terms: \( p \cdot z(p) = 0 \) and \( z(p^*) = 0 \), with \( z \) equal to the excess demand function, \( p \) equal to the price-vector and \( p^* \) equal to the equilibrium price vector.
3. A classification of CGE models

There are three different classification of CGE models given in the literature. An introduction to these three classifications and how they are interrelated will be given in this section and is graphically sketched in Figure 3.1. In the following three subsection these three classifications will be thoroughly discussed.

Figure 3.1: Classification of CGE modelling

<table>
<thead>
<tr>
<th>Computable General Equilibrium Models</th>
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<tr>
<td>Macro</td>
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<tr>
<td>Walrasian</td>
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<tr>
<td>other closures</td>
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The main classification of CGE models is based on both the historical development of CGE modelling and the intended purpose of the CGE models. The following two lines of development may be distinguished. The first type of CGE models evolved from multisector analysis and the macro models of the 1970s. These macro CGE models became especially popular for policy analysis in developing countries. The second type of CGE models, Walrasian CGE models, evolved from the general equilibrium framework of Walras and the pioneering work of Scarf (1967) on the numerical solution of a Walrasian system.

Among the researchers working on macro CGE models, it has become common to classify their models based on so called ‘closure rules’. This second classification is based on the main theoretical differences in the earlier macro models. Often these authors base their choice of ‘closure rule’ on the debate among economists which dominated economics in the 1960s and 1970s. They consider the Walrasian models as a specific subgroup of all CGE models, namely those with a neoclassical closure.

Besides this theoretical classification of CGE models, there exists also a third classification based on the technique used to determine the parameters. This classification distinguishes between models with parameters based on the calibration technique and
models with parameters based on econometric estimation. It should however be noted that, although most CGE models use some parameters which are econometrically estimated, almost all models are based on the calibration technique.

3.1 Macro and Walrasian CGE models

Along the lines of Robinson (1989) and Willenbockel (1994a) we may make a distinction within CGE analyses based on their origins, purposes and theoretical background. One group of CGE modellers tries to make the general equilibrium framework of Walras operational and has its roots in applied welfare economics. As such, these models are the numerical counterparts of Walrasian general equilibrium models. Walrasian CGE models, being based on the optimizing behaviour of representative agents, are extensions of the basic competitive equilibrium as defined by Ginsburgh and Keyzer (1997) with utility maximizing consumers and profit maximizing producers. The second line of thought, macro CGE modelling, is a logical extension of Leontief’s input-output analysis and linear programming models often applied in development economics.

3.1.1 Walrasian CGE models

Walrasian CGE modelling started with the work of Harberger (1962) on the incidence of taxation within the framework of a numerical two sector model. The work of Scarf (1973) made the determination of the equilibrium of a Walrasian system possible. Especially the pioneering work of Shoven and Whalley (Scarf and Shoven, 1984; Shoven and Whalley, 1992) and recently the work in the context of the Global Trade Analysis Project (GTAP) of Hertel (1997) as well as the work of Ginsburgh and Keyzer (1997) has further elaborated this category of CGE models.

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4 Robinson’s distinction is between micro- and macrostructuralist models, while Willenbockel makes a distinction between orthodox and less orthodox models

5 The General Competitive Equilibrium is defined as:

Every producer \( j \), solves \( \max_{y_j} \{ p^* y_j | y_j \in Y_j \} \), where \( y_j \) are production plans, \( Y_j \) is the set of feasible production plans and \( p^* \) is the equilibrium price vector.

Every consumer \( i \), solves \( \max_{x_i} \{ u_i(x_i) | p^* x_i \leq h_i^* \} \), where \( u_i(x_i) \) is utility derived from the non-negative consumption plan \( x_i \) and subject to the budget constraint for equilibrium income \( h_i^* \) which is equal to its receipt from selling endowments \( o_i \) and shares \( \theta_{ij} \) in distributed profits: \( h_i^* = p^* o_i + \sum_j \theta_{ij} p^* y_j^* \).

All markets are in equilibrium: \( \sum_i x_i^* - \sum_j y_j^* = \sum_i o_i \leq 0 \), where \( x_i^* \) and \( y_j^* \) are respectively the equilibrium consumption and production plan. See Ginsburgh and Keyzer (1997)

6 See Blitzer, Clark and Taylor (1975) for a first attempt at integrating both input-output and macro modelling for developing countries.
The objective of Walrasian CGE analysis is to analyse the quantitative effects of exogenous changes on the optimal allocation of resources, on efficiency and on welfare. Although debatable, it is argued by, among others, Willenbockel (1994b) and Bergman (1990) that Walrasian CGE models do not have the intention to give a description of actual economies but to construct a ‘mental organizing framework’ capable of analysing policy issues. During the last decade Walrasian CGE modelling has become less strict in applying Walrasian general equilibrium theory. To make the model more realistic, adjustments are made to the Walrasian theoretical framework.

These models are comparable to the neoclassical macro CGE models discussed below. Although it is impossible to make a strict distinction, it may be argued that Walrasian CGE models are generally still completely based on optimizing representative agents and markets are cleared by endogenous prices without quantity clearing markets. For instance, a CGE model where certain production sectors are not modelled by use of a production function (see for instance Taylor (1990a)) are generally not seen as belonging to this group of Walrasian CGE models.

3.1.2 Macro CGE models

Macro CGE modelling evolved from input-output analysis and the short run macro models which are commonly used for policy analysis since the 1930s. In macro CGE models the input-output analysis is extended with endogenous quantities and prices while consumption is related to income, thereby, closing the flow of money within the economy. Johansen’s (1960) model with simultaneous determination of quantities and prices on sectoral aspects of growth with sectoral reallocation of labour and capital, is generally seen as the first model in this category of CGE modelling. These type of models are further extended with the ORANI/MONASH models of Australia (Powell and Lawson, 1990; Vincent, 1990) and numerous models of developing countries (Decaluwé and Martens, 1988; Bandara, 1991). Leading authors in this field of CGE models for developing countries are Taylor (1990a) and Robinson (1989).

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7 Especially the effects of national tax and international trade policies have received much attention and are still popular (see for some recent work Harrison, Rutherford and Tarr (1997), Markusen, Rutherford and Hunter (1995) and Lopez-de Silanes, Markusen and Rutherford (1996)). Recently the field is extended with environmental policy issues (see for instance Böhringer and Rutherford (1997)).

8 An example is the model of Feltenstein and Shah (1995) incorporating financial markets. Shoven and Whalley (1992) describe this type of modelling as follows: ‘The central idea underlying this work is to convert the Walrasian general equilibrium structure from an abstract representation of an economy into realistic models of actual economies. Numerical empirically based general equilibrium models can then be used to evaluate concrete policy options by specifying production and demand parameters incorporating data reflecting real economies’.
The objective within this field of research is rather to quantify short run income distribution consequences, sectoral growth and trade balance effects, than to elucidate resource allocation effects of exogenous shocks or policy alternatives. To describe the economy at hand, the macro CGE models, opposite to Walrasian CGE models, may include ad-hoc elements while behaviour of economic agents may not be derived from optimizing behaviour. Thus, it may be argued that these models trade off internal rigour for increases in empirical relevance resulting in models that are often impossible to solve analytically and, on the aggregate level, these models are comparable to the short run macro models of the previous decades with an extensive multisector input-output submodel.

3.2 A classification of macro CGE models

The discussion about macro-closures, initiated by Sen (1963), was revived by Taylor and Lysy (1979) who found that the choice of macro-closure to a large extent affected the policy simulation results obtained with a CGE model. The closure rule problem was prominent in the field of short-run macro CGE modelling because these models often deviated from the Walrasian paradigm and the neoclassical closure. The existing macro CGE models are classified by their respective closure because of the above mentioned importance of the closure rule for the results obtained with the model. The classification is based on the main closure that describes the fundamental equilibrating mechanisms on which the larger CGE models are based. In the tradition of Sen’s original paper are the closure rules usually associated with specific economic theories and ‘schools’. The following most important closures and associated ‘schools’ are discussed below:

- The neoclassical closure
- The neo-Keynesian or forced savings closure
- The Keynes closure
- The Johansen closure
- The Kaleckian or structuralist closure
- The loanable funds closure
- The Pigou or real balances closure

There are two ways to interpret and define the closure rule problem. In mathematical terms, the problem boils down to the simple notion that the model should consist of an equal number of equations and endogenous variables. Thus, the closure rule prob-

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lem is the decision the model builder has to make on which variables are endoge-
nous and which variables are exogenous. Alternatively, if the model is build in the
Walrasian tradition and all decisions are based on optimizing behaviour, the closure
rule problem is the introduction of macroeconomic constraints that inflict upon the
microeconomic behaviour of individual agents and which introduce the need for an
additional endogenous variable that balances this constraint (see, for instance, Gins-
burgh and Keyzer (1997, pp. 111-112)). In general a closure rule is determined by the
personal theoretical preferences of the model builder and the, in his view, empirically
most plausible adjustment processes.\textsuperscript{10}

3.2.1 Sen’s base model

The problem of closure rules was introduced by Sen (1963) who showed that the fol-
lowing short-run macro model with an independent investment function (equation 5)
where investment $I$ is equal to some level $I^*$ based on, for instance, ‘animal spirits’,
good $X_s$ produced by a neoclassical production function $f_p$ homogeneous of the first
degree (equation 1) and production factors, labour $L$ and capital $K$ payed according
to their marginal productivities with wage rate $w$ and total capital income $\pi$ (equa-
tions 2 and 3) is over-determined if the savings-investment balance (equation 6) with
total savings $S$ determined by the savings ratios $s_w$ and $s_p$ out of, respectively, wage
and capital income (equation 4) is added to the model:

$$X_s = f_p(L, K) \tag{1}$$

$$w = \frac{\partial X_s}{\partial L} \tag{2}$$

$$X_s = \pi + wL \tag{3}$$

$$S = s_p\pi + s_w wL \tag{4}$$

$$I = I^* \tag{5}$$

$$S = I \tag{6}$$

endogenous variables: $X_s, I, S, w, \pi$

\textsuperscript{10} For instance Taylor (1991, p. 41) formulates this as follows: ‘...the closure question ... transforms itself to one of empirically plausible signs of ‘effects’ and -more important- a perception of what are the driving macroeconomic forces in the system’, while Decaluwé and Monette (1988) add that ‘there is no rigorous criterion for choosing the ‘right’ macroclosure, besides the modeller’s intimate conviction of how the economy functions’.

8
This single production sector model is capable of explaining the closure rule problem without going into unnecessary details. Because the production function is homogeneous of degree one, equation 3 may also be replaced by:

\[ \pi = \frac{\partial X}{\partial K} K \quad (3.3a) \]

Clearly, this model is overdetermined as it consists of 6 equations and 5 endogenous variables. Therefore, it should be closed by either adding an endogenous variable or skipping an equation.

3.2.2 The neoclassical closure

The most common way to close the model is by use of the neoclassical closure. In the neoclassical model (equations 1, 2, 3, 4 and 6) equation 5 is dropped from the above system of equations. It is assumed that a mechanism exists such that investment is brought into equilibrium with savings at a level that guarantees full employment in the economy, or, in the words of Swan (1970), it is assumed that whatever is saved is invested. This mechanism is often assumed to be an interest rate, although, like in the standard Solow (1956) model, this is generally not modelled explicitly.\(^1\) The neoclassical closure is fundamental to Walrasian CGE models though only seldom used in macro CGE models.

3.2.3 The neo-Keynesian or forced savings closure

Alternatively, in the neo-Keynesian model (equations 1, 3, 4, 5 and 6) equation 2 is dropped. This is based on the forced savings models of Kaldor (1956) and Pasinetti (1962). The forced savings mechanism is created by fixing the nominal wage rate, while production is still determined by the supply of labour and capital. This is implicit in the model if equation 2 is skipped and may be made explicit by rewriting equation 4 as:

\[ S = s_p \pi + s_n \frac{W_n}{p} L \quad (3.4a) \]

\(^1\) Only in the extensions of Solow’s seminal paper it is explained how the interest rate may operate to make investment equal to a level of available savings.
With \( W_n \) the exogenous nominal wage rate and \( p \) the endogenous price level that brings about the equality between investment and savings by a change in the income distribution. The well-known neo-Keynesian equation for profit income, which may be derived from this model is:

\[
\pi = \frac{I^*}{s_p - s_w} - \frac{s_w}{s_p - s_w}X
\]

3.2.4 The Keynes and Johansen closure

The closure associated by Sen with Keynes’s (1936) General Theory is endogenizing labour in the above system of equations. By introducing unemployment in this model (consisting of all the equations 1, 2, 3, 4, 5 and 6) it is assumed possible for investment to be different from its full-employment level. This brings us to the role of the government who may intervene to bring about full-employment. In CGE models this is achieved by endogenous government spending or taxes (the Johansen (1960) closure), and boils down to dropping equation 4 in the model described above. To model the government more explicitly in this model (equations 1, 2, 3, 5 and 6) it is possible to include equation 4 by rewriting it as:

\[
S = s_p \pi + s_w \omega L + G_s
\]

or as:

\[
S = s_p (1 - t) \pi + s_w (1 - t) \omega L
\]

With \( G_s \) equal to the endogenous government savings (the government expenditure minus government income) in equation 3.4b, or \( t \) equal to the endogenous tax rate in equation 3.4c.\(^{12}\)

3.2.5 The Kaleckian or structuralist closure

A closure often used in structuralist models (Taylor, 1990b) is based on the work of Kalecki (1976). In Kalecki’s model (equations 3.1a, 3, 3.3b, 4, 5 and 6) it is assumed

\(^{12}\) It is important to note that the goods markets is cleared via the law of Walras. On the goods market it is here implicitly assumed that the amount \( G_s \) in the case of equation 3.4b, or the total tax receipts in the case of equation 3.4c are used for expenditures on the good \( X_s \).
that firms operate with excess capacity, therefore demanding labour as a function $f_i$ of supply (equation 3.1a) and have market power on an oligopolistic market to set prices as a markup $\tau$ over costs (equation 3.3b).

$$L = f_i(X)$$  \hspace{1cm} (3.1a)  

$$\pi = (1 + \tau)wL$$  \hspace{1cm} (3.3b)

Equation 3.2 is left out of the model because real wages are no longer assumed to be equal to the marginal productivity of labour. Wages are now determined by equation 3.3 such that total income is equal to total value added while $L$ is endogenous and unemployment exists. Also in this model it is easy to show that profit income is equal to:

$$\pi = \frac{I^*}{s_p - s_w} - \frac{s_w}{s_p - s_w}X$$

Therefore it is not surprising that this model, at full capacity with an endogenous markup rate $\tau$ and exogenous production, gives comparable results to the neo-Keynesian model.\(^{13}\) In multisector models, especially if supply is fixed in certain sectors of the economy (often the agricultural sector), one obtains mixed results with strong redistributive effects among the different social classes distinguished in the model.

3.2.6 The loanable funds closure

The central issue in this discussion on closure rules is the mechanism that brings investment and savings into equilibrium, or the implicit modelling of financial markets. A more explicitly modelling of financial markets is required to enlarge the available equilibrating mechanisms, or create mechanisms that are a mixture of several others. The most straightforward closure in this respect is the loanable funds closure as explained in Taylor (1991) where savings are the supply of loanable funds and investment is the demand for loanable funds. Both supply and demand for loanable funds are balanced by an additional variable being the interest rate. Thus, in the small model presented above this would imply a substitution of the equations 4 and 5 with the following two equations:

\(^{13}\) The occurrence of a change in the equilibrating mechanism of the model if full capacity is reached can be seen as a regime switch.
with $i$ representing the endogenous interest rate, $f_{sp}$ and $f_{sn}$ respectively the interest dependent savings functions of those earning wage and those earning profit income and $f_i$ the investment function which depends on an exogenous level $I^*$ and the interest rate. For the loanable funds model (equations 1, 2, 3, 4d 5a and 6) to be stable the interest elasticities with respect to savings and investment have to be opposite in sign.\(^\text{14}\)

If the elasticity of savings with respect to the interest rate is zero (and the elasticity of investment with respect to the interest rate deviates from zero), the model is comparable to the Solow model. In the opposite situation the model becomes comparable to the Johansen model with the main difference that the change in savings is brought about by a change in the savings rate and not a change in the tax rate (savings of wage and profit earners adjust, while in the Johansen model the savings of the government adjust).

### 3.2.7 The Pigou or real balances closure

The introduction of financial stocks in the model introduces possible other equilibrating mechanisms such as the Pigou or real balance effect. Equation 4 may now be presented as:

\[
S = f_{sp}(\frac{M}{p})\pi + f_{sn}(\frac{M}{p})\omega L
\]

(3.4e)

where $M$ is an exogenous money supply, $f_{sp}$ and $f_{sn}$ the savings functions and $p$ the endogenous price level. So, if in this real balance model (equations 1, 2, 3, 4e, 5 and 6) excess demand exists, the prices will increase causing economic agents to reduce their consumption and increase their savings to make up for the loss in real balances.

Extending the loanable funds approach by taking into account wealth effects, such as the Pigou effect, interest payments and interest clearing stock markets for financial

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\(^{14}\) An objection to this approach, already mentioned by Taylor (1991), is that the rate of return on assets ought to clear the stock market and not the flow market for these assets.
assets, a fully developed Tobin’s (1971) style portfolio model is needed. Of course ‘empirical’ models may combine several of the above mechanisms by, for instance, using a portfolio approach and fixing the nominal wage rate. This may result in a model where adjustments may cause a mixture of portfolio allocation, wealth effects and forced savings mechanisms to generate a new equilibrium after a policy shock. Extending the model with explicit modelling of expectations may further complicate the adjustment mechanisms. However, because CGE models often not capture financial markets explicitly, the closure question is usually restricted to the straightforward non-financial closures.

3.3 SAM-based versus econometric approach

An alternative classification of empirical economic models is based on the determination of the parameters of the model (see, for instance, Bergman, Jorgenson and Zalai (1990)). The parameters of CGE models are generally determined by a calibration technique. This is, obviously, different from the econometric methods used in large scale econometric macro economic models. The few existing econometrically specified CGE models are due to the work of Jorgenson (1984). To avoid the difficulty of full stochastic specification of a CGE model, he builds a general equilibrium model with stochastically specified submodels.

The reason for using a calibration technique instead of stochastic estimation in CGE modelling, is the need for a simultaneous equations system estimation approach, which is considered infeasible for larger CGE models. Next to the needed sophistication of techniques is this supposed infeasibility also caused by degrees of freedom problems and the scarcity of data and time (Lau, 1984; Mansur and Whalley, 1984). However, also the structure of the model is affected by using the calibration approach. The model builder can only use relatively simple structures because the number of parameters that can be determined by calibration is limited. This limitation is usually circumvented by using parameters from other (econometric) research.

The major advantages of the calibration method are the ease of determining parameters, while only little data is needed as the parameters can be specified using only

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15 According to Bergman (1990) there may be some discussion on whether the models of Jorgenson and associates are ‘complete’ general equilibrium models. The Hudson and Jorgenson (1975) model has, for instance, no endogenous mechanisms ensuring the equality of aggregate demand and supply of capital and labour services at the given prices. Subsequent work in this field by Jorgenson and associates has, according to Bergman, not led to any major revision of the basic structure of the original Hudson and Jorgenson (1975) model.

16 Normally the elasticities are obtained from secondary sources while the scale and share parameters are obtained from the SAM.
one observation. Significant changes in the economic structure of developing countries may be an other reason to use calibration instead of econometric estimation to determine the parameters of CGE models for developing countries. Particularly if the directions of causality in the economy changes, it is difficult to link figures of a few years ago with the present situation. Estimation of parameters, using figures for many years with all having equal weights, may therefore not give sensible results (Taylor, 1990b). In such cases it may be preferable to use a calibration approach based on data for the period after the structural changes.

Apart from the limited reliability of parameters, estimated using data for only one point in time, the method of calibration has some additional drawbacks. For instance, in econometric models stochastic disturbances are introduced to capture the effect of variables omitted in the model, and errors in the measurement of exogenous and endogenous variables. If calibration is used to determine the parameters this stochastic disturbance term is assumed to be equal to zero, which implies that no factors other than those included in the model affected, or are expected to affect, the endogenous variables. A justification may be found in the focus of CGE models, which attempt to clarify economic mechanisms with an indication of the qualitative effects, while it is not the intention to give precise forecasts.17

Another problem associated with the calibration method is the absence of measures of reliability of the model and its parameters. According to Lau (1984) forecasts may give some indication of the reliability. An indication of reliability can also be given by the use of systematic sensitivity analysis as proposed by Harrison, Jones, Kimbell and Wigle (1993), although this method is not widely used, probably because of the large amount of simulations that is required.18 A few studies which do a less comprehensive sensitivity analysis show that at the very least initial conditions significantly matter for CGE analysis (Wiese, 1995; Roberts, 1994). Furthermore, it seems likely that results obtained with CGE analysis will be more seriously affected by parameter errors if the period under investigation increases. Improvement of the reliability of parameter estimates, such that the dynamic behaviour of the model better describes

17 For dynamic models it is obvious that some form of forecasting is needed to compare simulation results with the reference path.

18 An interesting attempt for sensitivity analysis of the base-year of the SAM has been done by Roberts (1994). She finds that the model is not very sensitive to the usage of a specific base-year. However, it is not clear what is actually tested by using different base years. An economy develops and changes over time, so the structure of the economy and thereby the SAM and the parameters are expected to change over time. So, what is really tested in this way? It might be just as useful to test the model result with randomly changed SAM-entries with a specified probability like in the systematic sensitivity analyses of parameters proposed by Harrison. However, this would again request numerous simulations.
the actual economic developments, is therefore crucial for especially long term CGE analysis.

4. Concluding remarks

It has been shown that it is possible to classify the different CGE models in several groups based on their purposes, the historical development in CGE modelling, and the technique used to determine the model parameters. Walrasian CGE models are the numerical counterparts of the theoretical Walrasian general equilibrium models and as such often used for welfare analysis and the quantitative analysis of the optimal allocation of resources. The macro CGE models are generally used to elucidate the economic mechanisms that operate in a specific country with its own economic structure. Besides the analysis of sectoral growth, these models often focus on the distribution of income and trade balance effects. It was shown that these models could be further divided into different groups based on the closure rule on which the model is based. Finally, a classification of CGE models was given based on the different approaches used to determine the model parameters.

It may be concluded that a Walrasian CGE model is suitable to analyse the effects of policy measures on the optimal allocation of resources, efficiency and welfare in an economy without too many rigidities. A macro CGE model with many structural equations is appropriate to elucidate economic mechanisms or predict possible outcomes of economic policies given the present or an alternative economic structure in the short run. Moreover, the point estimates obtained from the ‘normal’ procedure of calibrating the model using a SAM for one ‘base-year’ are good enough for the analysis of impact effects of different policies, but they are inadequate for long run analysis. Improvement of the reliability of parameter estimates, such that the dynamic behaviour of the model better describes the actual economic developments, is crucial for long term CGE analysis. An econometric approach is therefore more appropriate if long run analysis is the purpose of the model and there are no significant structural changes in the economy over the period the parameters are estimated.

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