COMPUTABLE GENERAL EQUILIBRIUM MODELS FOR DEVELOPMENT POLICY ANALYSIS IN LDCs

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Abstract. The use of CGE models has gained much popularity among policy analysts in LDCs and there is a fast growing body of literature on this area of economics. In this survey, the advantages of general equilibrium approach over partial equilibrium approach in analysing a wide range of policy issues are highlighted. The evolution of CGE modelling is discussed and more than 60 CGE applications related to different policy issues in LDCs are surveyed. This comprehensive survey shows that the CGE models have become quite popular analytical tools among policy analysts in LDCs over the last decade or so. The debate in the economic profession regarding the value and appropriateness of using CGE models for policy analysis is examined in the final section of this paper. Some of the criticisms levelled at CGE models are discussed and it is argued that despite this criticism such models are capable of providing insight into important policy problems.

Keywords. General equilibrium models; less developed countries; policy analysis.

1. Introduction

In recent years a large number of 'Computable General Equilibrium' (CGE) or applied general equilibrium models have been used to address a wide range of policy issues such as choice of development strategy, income distribution, trade policy, structural adjustments to external shocks, tax policy, and long-term growth and structural changes in both developed and less developed countries (LDCs). The use of CGE models has gained considerable popularity among policy analysts in LDCs and there is a fast growing body of literature focusing on various aspects of CGE modelling. The theoretical framework of various CGE models and their applications have been reviewed in a number of recent surveys.[1] Each of these surveys has tended to concentrate on one aspect or a few aspects of CGE modelling. The present survey has aimed at presenting an overview of CGE modelling, with emphasis on its applications to LDCs. It has four related objectives: (1) to answer the question of 'why CGE modelling?', (2) to study the evolution of CGE modelling, (3) to survey the use of CGE models in analysing various policy issues in LDCs over the last decade or so and (4) to provide an extensive list of references on CGE modelling in LDCs for the benefit of the reader.

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In order to meet the above objectives the remainder of this paper is arranged as follows. Section two discusses the question 'Why CGE modelling?'. Section three outlines the historical development of CGE models. A review of selected CGE models is presented in section four. Some limitations of CGE modelling are highlighted in section five.

2. Why CGE modelling

Partial equilibrium analysis has been the most popular approach in applied economics until quite recently. As Whalley (1975b, p. 301) points out 'partial equilibrium analysis is a way of obtaining an estimate of the impact of a change in the economy which does not require the complete solution of a new equilibrium system. Partial equilibrium is, however, loosely defined as the word *partial* refers to unspecified ceteris paribus assumptions under which different things may be held constant'.

Simplicity is the main advantage of using a partial equilibrium approach. It can be used to analyse policy issues arising from a shock whose effects are limited to a particular industry or, rather, where the impact on other industries can be considered to be small enough to be ignored in practice. It is also suitable if the results obtained from general equilibrium analysis cannot be justified in terms of the extra intellectual or computational expenses. However, this approach has limited scope to handle issues arising from general shocks which affect the outputs and prices of other industries as well. The partial equilibrium analysis is clearly unsuitable when the 'feedback' effects of a particular policy change or a shock are considered to be significant. For example, as the effects of change in trade policy or tax policy are propagated throughout the economy, the usefulness of the partial equilibrium approach is limited in analysing the effects of such policy issues. While assessing the reliability of partial equilibrium analysis as an appropriate analytical technique for assessing the impact of tax changes in the United Kingdom, Whalley (1975b, p. 302) suggests 'that although there is a considerable gain in simplicity in the use of partial equilibrium analysis, the reliability of results using more satisfactory general equilibrium techniques is considerably increased'.

In order to illustrate the importance of using general equilibrium models for analysing various policy changes, the experience of developing countries can be considered directly. Let us consider the frequently cited tariff protection issue in LDCs. In these countries, concern about the possible detrimental effects of tariff has given rise to extensive research to measure effective rates of protection within a partial equlibrium framework. However, this approach provides only limited information about the effects of tariffs on resource allocation (see Bhagwati and Srinivasan 1973; de Melo, 1977, 1980; Taylor and Black, 1974) and the costs that they induce. To analyse the detailed effects of a cut in tariffs, one must examine quantitatively the chain of events that take place when tariffs are cut, as follows. A cut in tariffs alters consumption patterns in a tariff-reducing country. Then imports rise and the relative prices of imports and domestic goods change. This has an impact on resource allocation within the tariff-reducing country. Consequently, changes in tariffs cannot be considered in isolation. Their repercussions are propagated throughout the economy as they affect production, investment and consumption decisions. Clearly a partial equilibrium approach cannot fully capture this chain of events and their interactions.

Conceptually all these interactions are capable of being captured in an economy-wide general equilibrium framework since it contains all commodities and factor markets together with decision making agents. In an economy-wide model, in which the demand and supply of each commodity depend on all relative prices, a general equilibrium analysis can take into account all those interactions explicitly. This framework provides a logically consistent way to look at policy issues, such as trade policy, which involve more than one economic agent. Consequently, the application of CGE modelling in analysing a wide range of policy issues has won worldwide recognition in the late 1970s and the early 1980s in LDCs.

At this point, it is appropriate to note the difference between theoretical general equilibrium analysis and 'computable' or 'applied' general equilibrium analysis since they are interrelated. Walras (1874) and Edgeworth (1881) are usually identified as the pioneers of general equilibrium analysis. The work of Arrow and Debreu (1954), Debreu (1959), Scarf (1967, 1973) and Arrow and Hahn (1971) represent modern contributions to the theoretical general equilibrium analysis.[2] The main focus of this theoretical literature is on the existence and uniqueness of equilibrium. The CGE modelling approach is an empirical counterpart of this well-known 'general equilibrium' analysis. As Shoven and Whalley (1984, p. 1007) point out:

> The explicit aim of this literature is to convert the Walrasian general equilibrium structure (formalized in the 1950s by Kenneth Arrow, Gerard Debreu, and others) from an abstract representation of an economy into realistic models of actual economies. The idea is to use these models to evaluate policy options by specifying production and demand parameters and incorporating data reflective of real economies.

Hence, in the CGE approach numerical experience is emphasized rather than obtaining formal analytical proofs of the existence and the uniqueness of theoretical general equilibrium analysis. In the CGE framework the main focus of the analysis is quantitative and is based on the empirical data from a particular country or group of countries being investigated. This approach offers more useful information for policy analysis than theoretical general equilibrium analysis does.

CGE analysis can be used to investigate the impacts of policy changes or external and internal shocks on macroeconomic variables and industrial structures in a developing country. Once again, as an example, consider the issue of cuts in tariffs. When a tariff cut occurs what happens to the tariff-reducing country's prospects for aggregate employment, the balance of trade, employment by occupation, and for output by industries? Although the partial equilibrium approach is not able to answer all these questions, a general equilibrium approach would be able to do so.

Furthermore, it is not necessary to assume that other policy changes do not occur in an economy while investigating any one policy change within a CGE framework. Thus, this approach can be used to analyse many policy changes simultaneously to capture their combined effects. Therefore, this framework is well suited to analysing the effects of external and internal shocks which occur simultaneously in LDCs.

3. Historical perspectives on the development of CGE models

The compilation of an input-output table for the US economy by Leontief (1936) laid the groundwork for the development of multisector models. On the basis of this input-output accounting framework, Leontief's open static input-output model was constructed. The publication of this model in 1937 (Leontief, 1937) led to the popularity of input-output models as a planning tool up until the early 1970s. The multisectoral aspects of these models were used to capture the interactions between different production sectors of the economy in the planning process. For example, assuming a fixed-coefficient-Leontief technology for each sector, and with given estimates of input-output coefficients, planners were able to forecast the required output level in each sector in order to meet a planned final consumption bundle.

The above example may be elaborated the following way. Consider **A**, an $n \times n$ matrix of fixed input-output coefficients a_{ij}. The element a_{ij} is the amount of input i necessary to produce one unit of output j. The gross output vector and the final consumption vector can be denoted as **X** and **C** respectively. Thus, the material balance equations can be written as:

$$\mathbf{X} = \mathbf{AX} + \mathbf{C}. \quad (1)$$

This equation indicates that the total gross output equals total intermediate inputs plus final consumption. If the planner sets a targeted final consumption bundle as $\bar{\mathbf{C}}$, then the output level ($\bar{\mathbf{X}}$) necessary to satisfy the target can be obtained by solving the above equation for **X** as:

$$\bar{\mathbf{X}} = (\mathbf{I} - \mathbf{A})^{-1}\bar{\mathbf{C}}. \quad (2)$$

Even the above simple material balance equation is a useful tool for policy analysis since it ensures economy-wide consistency of sectoral production plans. There are a number of extensions of this simple model (see Dervis *et al.*, 1982; Dixon *et al.*, forthcoming). In these, the input-output framework is used to address multiregional and multi-period problems as well as issues such as pollution control. All these models are capable of directly capturing inter-industry interactions, i.e., forward and backward linkages arising from the provision and purchase of intermediate inputs. Because of this ability, input-output models are commonly used in developing countries to identify 'key' sectors. Some policy analysts still use these techniques to estimate the effects of exogenous changes in final demand on employment, industry output levels and gross domestic product (see Bulmer-Thomas, 1982).

Although the input-output models are consistency models and capable of capturing major elements of interdependence in an economy, they have a number of shortcomings. These include extreme demand orientation and their unsatisfactory treatment of international trade. The input-output models tend to be completely demand driven and do not accommodate supply constraints or substitution possibilities. The fixed coefficient technology is the most important assumption of the input-output models. This indicates that fixed minimum amounts of all intermediate inputs and primary factor inputs are required in order to produce a unit of output in each industry. Therefore, the use of all these inputs expands in direct proportion to the level of output. The assumed fixed coefficient technology does not allow an industry to prevent a shortage of one input by changing its input structure. This also rules out any possibility of individual industries altering their input mixes to changes in relative prices. Industry output levels are simple linear functions of exogenously given final demand. Therefore, in input-output models an exogenous assignment of values to the elements of final demands is sufficient to determine industry output levels and hence levels of primary factor employment. This assignment can be made completely independently of the primary factor constraints. The lack of any relationship between primary factor constraints and the final demand is a major weakness of these models. This implies that the input-output models are really only appropriate to project output and employment levels in circumstances in which the demand side is completely dominant. This feature has come to be known as extreme demand orientation of the input-output modes.

In these models it is generally assumed that there is no supply side constraints in an economy. Labour and capital are available with perfect elasticity of supply. This implies that the supply curve is flat and the price of the factor is fixed. Therefore, quantity traded is determined purely by demand. There is a possibility of adding supply side constraints into input-output models (see Dixon *et al.*, forthcoming). The fixed coefficient technology and all exogenously given levels of final demand, however, limit the practicality of inclusion of supply side constraints. These two assumptions do not allow the input structures of individual industries and commodity mixes of final demand to respond to changes in relative prices. Hence, prices play only a passive role in the determination of individual behaviour of actors in input-output models and they are not influenced by changes in relative prices.

A further important shortcoming is the unsatisfactory treatment of international trade. In these models exports together with domestic final demand for domestic output are exogenous and imports are treated as non-competing. Neither exports nor imports depend on relative prices. Therefore, the crucial issue of the response of trade flows to changes in relative prices is not accommodated in these models.

The development of Linear Programming (LP) models provided another class of multisector models in the early 1960s. The LP models managed to overcome some of the shortcomings and limitations of the early input-output models by providing a methodology to introduce primary factor constraints and offering the possibility of introducing prices explicitly into the analysis. In these models, an explicit objective function is introduced which has to be optimized subject to certain (linear) constraints. A simple static LP model can be of the following form:

$$\text{Max } \gamma\mathbf{X}$$

subject to

$$\mathbf{AX} \leqslant \bar{\mathbf{F}},$$

and

$$\mathbf{X} \geqslant 0, \tag{3}$$

where γ is the vector of coefficients of the objective function, $\mathbf{X}$ is the vector of gross output and $\bar{\mathbf{F}}$ is the vector of resource constraints. If the feasible set $\mathbf{S} = [\mathbf{X} \mid \mathbf{AX} \leqslant \bar{\mathbf{F}}, \mathbf{X} \geqslant 0]$ is bounded and non-empty, then the solution vector $\bar{\mathbf{X}}$ can be obtained to the above problem given data on γ, $\mathbf{A}$ and $\bar{\mathbf{F}}$. The solution of the optimal vector of $\bar{\mathbf{X}}$ satisfies the condition of $\bar{\mathbf{X}} \in \mathbf{S}$ and $\gamma\bar{\mathbf{X}} \geqslant \gamma\mathbf{X}$ for all $\mathbf{X} \in \mathbf{S}$. Data on γ, $\mathbf{A}$ and $\bar{\mathbf{F}}$ are sufficient to obtain a solution to LP models. An important feature is that these models are associated with the duality theorem. The dual problem of a 'primal' problem as given above can be written as:

$$\text{Min } \lambda\bar{\mathbf{F}}$$

subject to

$$\lambda\mathbf{A} \geqslant \gamma;$$

and

$$\lambda \geqslant 0, \tag{4}$$

where λ is the vector of dual variables. The vector variables of λ can be interpreted as scarcity indicators or prices. Therefore, LP models are able to cope with not only quantitative aspects but also value aspects (see Dervis *et al.*, 1982, pp. 62–90).

The Evans (1972) model of the Australian economy and the Goreux (1977) model of the Ivory Coast can be regarded as excellent examples of extensions of LP models. While Evans's model provided more careful treatment of foreign trade by adding a balance of trade constraint, the Goreux model incorporated the main features of multi-level planning with a crucial role for prices (see Robinson, 1986, p. 4). LP models are treated as at least approximations to CGE models (Dervis *et al.*, 1982, p. 64). For example, although Evans (1972) set out his model in the form of a programming problem, Dixon and Butlin (1977) describe it according to the fashion of the modern general equilibrium theorists. Then they formally define an equilibrium situation (called Evans equilibrium, EE) and assess it quite independently. Despite there being no evidence for the uniqueness of this model, recomputations of Dixon and Butlin (1977) have proved the existence of an equilibrium in the model. Therefore, they noted that 'as a second best, one can compute EEs using a variety of starting points in the relevant algorithm. Convergence to a common solution is evidence (certainly not conclusive) of uniqueness' (Dixon and Butlin, 1977, p. 342). In this context, the Evans model can be said to have made good use of the general equilibrium approach. The recomputations of the Evans model by Dixon and Butlin demonstrate that LP models can be used as solution methods for CGE modelling.

Despite the fact that the LP models have been widely used in academic exercises, they have not been widely used in LDCs due to both theoretical and practical limitations. The main theoretical difficulty concerns the interpretation of micro behaviour when the LP model is solved by maximizing a well-defined welfare function for the whole society. Further, despite the fact that the LP extensions have been able to incorporate primary factor and trade constraints, they have been unsuccessful in handling these cases in a sufficiently realistic way. For example, although the Evans' model was able to incorporate balance of trade constraints, it was excessively sensitive to minor changes in relative prices. Despite those problems and limitations, LP models can be regarded as a major improvement in the area of economy-wide modelling.

The development of CGE modelling can be treated as a natural extension of input-output and LP models with the inclusion of an endogenous output and price system, neoclassical substitutability in production and demands, the optimization behaviour of individual agents and a complete treatment of income flows in an economy. As noted previously, the CGE models are empirical counterparts of the well-known 'general equilibrium' analysis of Walras, later developed by Arrow–Debreu and others. As Srinivasan and Whalley (1986, p. 4) have described, 'the major feature of the numerical general equilibrium approach is its attempt to blend theory and policy so as both to improve the analytic foundations of policy evaluation work and to bring the theoretical work that already exists in the literature more fully into the policy debate'. According to Robinson (1986, pp. 33–4), the essential components of the neo-classical approach to CGE modelling can be described as follows:

1. specification of the representative agents whose behaviour is to be analysed,
2. identification of their behavioural rules and conditions under which they operate (for example, profit maximization behaviour of producers and utility maximization behaviour of consumers),
3. specification of the signals which are used by the agents for their decisions (for example, prices are important signals in a neo-classical CGE model), and
4. identification of the 'rules of the game' (for example, assuming perfect-competition, a CGE model allows each agent to act as a price taker).

With the above specifications, a system of equations can be derived to solve simultaneously to find a general equilibrium which is just a solution of the behavioural equations. In the early 1970s efforts were made to develop solution techniques for the purpose of implementation of CGE models and at least four different approaches have been introduced (see Robinson, 1986, pp. 33–5). As a result of such advances, a large number of CGE models were developed in the 1970s.

The work by Johansen (1960) can be regarded as the seminal contribution to this new development. Bergman (1985) has discussed in detail the link between Johansen's path breaking Multi-Sectoral Growth model and the models which are nowadays labelled as CGE models. Johansen's work was not followed up until the early 1970s, when Adelman and Robinson (1978) built a model for the South Korean economy. According to Bergman (1985, p. 142), the time lag between the appearance and the full appreciation of Johansen model can be ascribed to the following reasons. Firstly, the relative importance of the sectoral dimension of economic growth was insignificant in the phase of stable conditions of economic growth in most countries during the 1960s; secondly, the development of solution algorithms and cheap software facilities were limited up until the early 1970s; and finally, contemporary policy modellers in many countries during the 1960s paid more attention to LP models which emphasized mainly resource allocation. Adelman and Robinson (1978), Dixon *et al.* (1982) and Taylor *et al.* (1980) are examples of extensive country studies which employed the CGE approach. Apart from these contributions, there are a large number of CGE models applied to developed and developing countries. Dervis *et al.* (1982) displays state-of-the-art of CGE modelling in LDCs.

All these models share the following common features. Firstly, they focus on the real side of the economy. Secondly, their supply and demand functions explicitly reflect the behaviour of profit maximizing producers and utility maximizing consumers. Finally, both the quantities and relative prices endogenous to these models, as well as the resource allocation patterns determined by them, have a strong flavour of Walrasian general equilibrium. Despite these common features, the models differ from one another quite markedly with respect to the detailed specifications and solution algorithms as noted by Bergman (1985, pp. 151–3).

CGE modelling has been widely used by policy analysts in addressing contemporary policy issues in mixed economies since the 1970s. Previous work in input-output and LP models emphasized questions such as allocation of investment. For the centrally planned economies these models had been successful to a great extent since the planner had control over the allocation of investment. However, in the context of a mixed economy, where resource allocation is largely determined by the market mechanism and independent decision making agents, the applicability of such models is debatable. It is, therefore, necessary to have an analytical framework which includes government policy variables such as taxes and subsidies. On the other hand, policy orientation in LDCs shifted towards basic needs and income distribution aspects during the early 1970s. Following the first oil shock, structural adjustments and stabilization have become important issues in these countries. With this new pattern of policy priorities, CGE modelling appears to be a better analytical framework and more suited to tackling a wide range of problems than its ancestors.

4. Experience of CGE modelling in LDCs

The interest generated by CGE modelling in LDCs over the last 15 years or so is explained by several factors. Firstly, as noted previously, this approach is appropriate when analysing various policy changes and external shocks which have economy-wide effects. On the one hand the partial equilibrium approach is not suited to examine the economy-wide effects of such changes as noted earlier. On the other, econometric techniques are not well suited in such analysis because of unavailability of reliable data for a long period, inconsistencies of available data, and frequent changes in policy regimes that require various structural models (see de Melo, 1988b). Secondly, development of the relevant statistical data bases in LDCs, for instance Social Accounting Matrices (SAMs), has facilitated the construction of CGE models. Since the first SAM of a developing country was constructed for the Sri Lankan economy in the 1970s (Pyatt *et al.*, 1977), many SAMs were developed in LDCs by the end of the 1970s and early 1980s.[3] Thirdly, advances made in efficient numerical solution techniques have removed the computational constraints on the implementation of CGE modelling. At present, there are several well developed solution techniques which are available for policy analyses in LDCs through CGE models. Hence, it is no longer necessary for policy analysts to have an expert knowledge of mathematics. Finally, the rapid growth of transferable software (for example GEMPACK, GAMS, HERCULES and OCTASOL)[4] has given rise to the widespread use of CGE models in LDCs.

By the end of 1988, at least 70 applications of CGE models to 30 LDCs could be found in the economic literature. Many of these models have been formulated on the basis of the pioneering theoretical and empirical work of Adelman and Robinson (1978), Dervis *et al.* (1982), Dixon *et al.* (1982), Johansen (1960), Leontief (1936), Scarf (1967, 1973) and Shoven and Whalley (1972). In this section an attempt is made to capture the basic features of these CGE applications. A selected list of applications is given in Table 1. These CGE applications are selected from studies published in well-known international journals, various research papers and monographs prepared by different institutions such as the World Bank and Universities around the world. This list does not cover some research work carried out for various government institutions in LDCs. Sometimes these studies are limited to particular decision making bodies. They do not like to see them in published forms for various reasons. Therefore, it is not possible to cover this type of research work in this survey. There are also some unpublished Masters and Ph.D. theses and dissertations in which CGE models have been built and applied to LDCs. In the present survey, research work of this nature is not considered. Therefore, the list shown in Table 1 is not a complete one and it does not cover many published and unpublished research work. Although this list is not a comprehensive one, it shows how CGE models can be used to address a wide range of policy issues in the LDC context.

At a glance, some common features of these CGE applications can be observed. Firstly, all these models are basically numerical applications of the Walrasian type neoclassical general equilibrium approach. Walras (1874) in his classic essay, 'The Elements of Pure Economics', provided an ideal framework for a competitive economy. Present CGE models are numerical illustrations of the Walrasian neoclassical general equilibrium approach. These models determine only relative prices and the price system has to be normalized by an appropriate selection of *numeraire*. Main equations of these models are derived from the constrained optimization of neoclassical production and utility functions. Producers choose inputs to minimize costs of a given output subject to non-increasing returns to scale industry production functions. Consumers are assumed to choose their purchases to maximize utility functions subject to budget constraints. Production factors are paid according to their marginal productivity. At the equilibrium level the model's solution provides a set of prices which clear all commodity and factor markets and make all the individual agents' optimizations feasible and mutually consistent. Although these models are based on the neoclassical general equilibrium approach some nonneoclassical features can be identified in some applications of CGE models applied to LDCs. The government sector is included and imperfect competition has been introduced via price fixing, rationing and quantitative restrictions. Therefore, the applications of CGE models to LDCs shown in Table 1 range from the extreme of strictly Walrasian approach to non-Walrasian approaches.

Secondly, many of these applications are concerned with the problems of protection, stabilization, fiscal policy, income distribution and external shocks. Foreign exchange shortages, the vulnerability of domestic economies to external shocks, primary commodity dependence, continuous external debt problems and income disparities are major problems in LDCs. Hence, the majority of applications of CGE models in Table 1 have focused on these issues.

Thirdly, as shown in column 1 of Table 1, authors of these models are related to a small number of professional groups. At least three professional groups can be identified from the list of authors. Authors like Dervis, de Melo, Robinson, Grais and Corbo are associated with more than one application and they have been linked with the World Bank. Most of their models have been developed under various research projects of the World Bank and majority of them have followed the early work of Adelman and Robinson (1978) and Dervis *et al.* (1982). The research of this group can be labelled as the 'World Bank tradition'. Another group of authors such as Serra-Puche, Kehoe, Clarete and Whalley have followed the tradition of tax policy modelling in developed countries, particularly the early work of Shoven and Whalley. This tradition has come to be known as the 'Yale Tradition' because this class of models were developed by students of Herbert Scarf or students of the students of Scarf. The work of authors like Vincent, Mayer and Gupta is located within the theoretical structure and the solution technique of the ORANI model of the Australian economy which has been developed at the 'Impact' Project.[5] This is the third group and the research of this group can be labelled as the 'Johansen tradition' because these authors have followed the Johansen's linearized solution technique (differences between solution methods are discussed below).

Finally, a small number of LDCs have become 'research laboratories' for CGE modellers. For example, a large number of CGE applications have been carried out for Turkey, Colombia, Thailand and South Korea.

There are a number of different ways in which the CGE applications can be categorized. One way is to classify them according to their theoretical structure. The solution technique used to solve the model is another. In this study we classify the CGE applications on the basis of the issues that they address. Since some of these applications deal with several different types of policy issues this classification is an imperfect one as many overlaps between categories are evident. Nevertheless, each study is included in one of the following five categories; (i) trade policy related issues, (ii) income distribution, (iii) issues related to external shocks and structural adjustments, (iv) government fiscal policy related issues and (v) choice of development strategy, long-term growth, structural changes etc.

Before turning to the nature of policy issues which these studies have addressed, it is important to identify the main structural characteristics. In order to facilitate the discussion, a summary of some of the main characteristics is given in Table 1. Let us first consider the production side. The number of production sectors varies from 2 to 65 in different models and disaggregated production structures are considered in most of the models. In all the models, at least labour and capital are identified as factors of production and, in some of them, labour has been disaggregated into occupational categories. The functional forms used to explain production technology belong to the well-known families of Leontief, Cobb–Douglas (C–D), Constant Elasticity of Substitution (CES) or Constant Ratios of Elasticities of Transformation, Homothetic (CRETH). In some of the cases, these production functions are generalized to all inputs, while in others they are distinguished between different levels as 'nested' production functions. The use of nested production functions has gained much popularity among the model builders, as suggested by Table 1. The main reason for this popularity is that it allows flexibility in introducing various behavioural features of economies into the models in simple ways. For example, the normal behaviour of non-substitutability between intermediate inputs and primary inputs can be introduced using a Leontief functional form at the first level of a given three-level production function. Using the second level CES 'nest', the substitutability among intermediate inputs from different sources (i.e., domestic and foreign) and among different primary factors (i.e., land, capital and labour) can be introduced into the model. The substitutability between different types of labour can be introduced using the third level of CES 'nest'. Furthermore, empirically estimated substitution parameters can easily be used in a CES functional form of a nested production function.

The household sector has been disaggregated into groups ranging from 1 to 200, based on income levels, skills or socio-economic factors. As in the case of the production side, the behaviour of consumers has also been specified using utility specifications that are well-known in applied economics. The selection of functional forms for the household behaviour has also to be consistent with the theoretical approach and it has to be analytically tractable. Subject to these constraints, familiar functional forms such as C–D, CES, Linear Expenditure System (LES), Extended Linear Expenditure System (ELES) and non-linear expenditure systems have been used in most CGE applications shown in Table 1 for the demand side. Apart from these, a system of expenditures with constant price and income elasticities developed by Houthakker (1960) and Sato (1972) is used in a small number of studies as shown in Table 1.

The question of how elasticity values are to be set in the model and flexibility has dominated the selection of functional forms for the demand side. For example, in many applications demands derived from C–D utility functions have been used because it is more convenient to work with them. It is not necessary to have empirically estimated elasticities in using C–D functional forms since they accommodate unitary income elasticities and uncompensated own-price elasticities. Therefore, these functional forms are more easy to use particularly in circumstances where there are no estimated elasticities. Despite the convenience of working with C–D functions, their main features such as unit income and own-price elasticities, and zero cross-price elasticities are unconvincing when empirically estimated elasticities are appropriate to any particular model. In such cases, it is necessary to have particular functional forms to relax limitations of the C–D specification. For example, the role of CES specification has played an important part in relaxing such limitations in various CGE models applied to LDCs as shown in Table 1.

As opposed to C–D specifications, the concept of unitary own-price elasticity is no longer valid with the CES specification. Empirically estimated price elasticities can be incorporated in this case. Furthermore, complexities of demand structure can be accommodated by introducing nested CES functions. The unitary income elasticities, another feature of C–D functions, can also be eased with CES functions. The most popular way of incorporating non-unitary income elasticities is to use the LES specification as shown in Table 1. For some LDCs, parameters of LES functions have been estimated (see Lluch *et al.*, 1977) and these values have been used in many CGE models. When the LES functions are not applicable, ELES, spliced LES and non-linear expenditure systems have been used.

The treatment of international trade is another important characteristic of these CGE applications. Most are based on the traditional pure theory of international trade. In some cases, imports are considered as perfect complements to national production. Then, the levels of imports of intermediate inputs are determined as fixed proportions of sectoral output and the levels of imports of final demand are determined as fixed proportions of various components of final demand (consumption, investment, etc.). Treating imports as perfect substitutes for domestic products is another way of handling imports and is done in a small number of studies. In these cases, import demand for each commodity adjusts residually to the gap between domestic supply and demand. However, most of the models have avoided those two extreme cases by using the so-called Armington (1969) assumption. This indicates that commodities of the same type, but with different countries of origin, are not perfect substitutes.

The reasons for the use of the Armington (1969) assumption are multifold 'revealing both the compromises that empirically based economic modelling involves and the realism it brings' (Srinivasan and Whalley, 1968, p. 7). Firstly, when perfect complementarity of imports to the national output is assumed, any given change in trade policy does not produce a large direct effect on the structure of the economy. This is because of the price insensitive behaviour of intermediate and final users. By contrast, a small change in trade policy may generate a large change when the perfect substitution assumption is used. To avoid this problem, imperfect substitution can be introduced by using the Armington assumption in order to restrict extreme demand responses as a result of a trade policy change. Secondly, the presence of 'cross hauling'[6] in trade data can easily be accommodated in CGE models using the Armington assumption. Finally, the model calibration (this procedure will be discussed later in this section) using econometrically estimated import and export demand elasticities is more straightforward when this assumption is used. Then, a demand function for imported goods can be identified separately from the demand for domestically produced commodities.

Next, we consider the treatment of exports. The traditional approach is to use the 'small country' assumption. Accordingly, the country's price elasticity of foreign demand is infinite and the volume of exports is the difference between domestic supply and demand for the commodity. A number of CGE applications have used this approach. However, the majority of studies have assumed price elasticity to be a positive number, rather than infinity. Some modellers argue that the small country assumption is too restrictive and that price elasticities of foreign demand for exports are different from infinity even in a small country (see Dervis *et al.*, 1982; Decaluwe and Martens, 1987).

The simple way of modelling supply of exports is to treat the supply of exports from any sector as equal to total domestic demand minus domestic consumption. As indicated in a discussion of the implications of the small country assumption for the supply side by Dervis, de Melo and Robinson (Dervis *et al.*, 1982, p. 228), this treatment is quite misleading, particularly in circumstances where a number of commodities are aggregated into large sectors. Considering the problem of modelling exports produced by aggregate sectors comprised of quite distinct products, they argue that exports may substantially differ from domestic production in the same sector. Therefore, the assumption that the supply of exports is simply the difference between total domestic production and domestic consumption greatly overestimates the possible responsiveness of export supply to the 'average' price in the aggregate sector. To overcome this problem Dervis *et al.* (1982) suggested the use of a logistic supply function determining the ratio of exports to total supply as a function of relative profitability of production. This approach has been used in many CGE models applied to LDCs for the specification of the supply of exports. However, in a number of CGE models exports are simply treated as exogenous. Study Nos. [15], [41]–[43] (hereafter, numbers in brackets refer to the individual study numbers shown in Table 1) are examples of this approach.

The majority of CGE models have been used to simulate comparative static results of a change in a particular policy or a group of policies. These simulations compare different 'states of the world', sometimes termed 'counterfactual equilibrium analysis'. It presents 'a comparison between the *status quo* and the hypothetical situation that would arise as a consequence of a substantial policy change' (Manne, 1985, p. 6). Although this counterfactual approach is useful for policy analysis purposes, some modellers feel that it is necessary to incorporate time paths of adjustment in analysing particular policy issues. Hence, some of the modellers in our list have attempted to incorporate dynamic elements into their models. As Manne (1985, p. 7) notes 'in formulating dynamic models two distinct approaches have been employed. One may be labelled *myopic* and the other *clairvoyant*. In more technical terms, the former is *recursive*, and the latter is *intertemporal* dynamics'. Usually, with intertemporal dynamics, static models are updated through a series of dynamic linkage equations. In this case, it is assumed that consistent projections of future prices are made by consumers and producers and thus the balance between supply and demand for each commodity at each point of time is maintained with an equilibrium sequence of prices. The dynamic intertemporal linkages are incorporated into this class of models by way of changing technological behavioural coefficients, mobility of capital, mobility of skilled labour or an increase in factor endowment. In our list of CGE applications in LDCs, the intertemporal approach has been widely used. For example, the research reported in studies [44], [49] and [59] belong to this class of dynamics. The recursive approach, on the other hand, deals with only one period at a time ignoring the impacts of subsequent changes in prices, tastes, technology or resource endowments. However, as Manne (1985) observed, no systematic comparison of these two approaches has yet been attempted.

Another important feature of the CGE models applied to LDCs is the usage of different 'closures' in different models. The problem of models' closures has been a major focus and a controversial subject of the theoretical aspects of CGE modelling literature (see Sen, 1963; Taylor and Lysy, 1979; Rattso, 1982; Cooper *et al.*, 1985; Dewatripont and Michel, 1987; Adelman and Robinson, 1988; Harris, 1988) and it can be traced to Sen's discussion in 1963. Although the term 'closure' is used in various ways and with varying degrees of accuracy, it can be defined as the specification of endogenous and exogenous variables in the model or assumptions about how a model is closed. A model can be closed if there is sufficient information to compute a solution. The important point is that different closure of CGE models change their qualitative characteristics. Therefore, choosing a particular closure plays an important role in CGE modelling.

At least four different macroeconomic closures, i.e., 'Keynesian', 'Kaldorian', 'Johansen' and 'Classical', have been used in CGE models applied to LDCs. The Keynesian closure allows for unemployment and a fixed nominal wage. Under this closure employment levels can increase in response to increases in aggregate demand via reduction in real wages according to the traditional Keynesian fashion. On the other hand, the Kaldorian closure is typically used in a full-employment setting and it violates the wage-marginal labour productivity relationship. Under this closure the nominal wage in the labour market is flexible in order to maintain a full employment situation. In the Johansen closure the investments are exogenous so that consumption must adjust endogenously. In this case modellers must assume a fiscal policy outside the model that makes planned savings equal to the exogenously given investments. This closure considers full employment equilibrium to be realized via adjustments of private consumption. In the Classical closure real investment is endogenous and adjusts to total available savings. In this case modellers must assume an interest-rate adjustment mechanism outside the model clearing the investment-savings market.

There is no agreement among the modellers on the selection of a particular closure. As Dewatripont and Michel (1987, p. 68) point out 'there is no clear-cut theoretical justification for the choice of a particular closure except the modeller's *general view of the world*'. All four different closures described above can be observed in different CGE models applied to LDCs. In closing these models different assumptions have been used. However, most of the modellers do not provide a convincing justification for their selection of a particular closure. The choice of a closure may depend on the modeller's 'school of economic thought'. For example, neoclassical economists tend to use Classical closure whereas 'structuralists' tend to use Keynesian closure. In the majority of studies shown in Table 1 the classical closure has been used following Dervis *et al.* (1982). However, there are some studies in which the Keynesian or Kaldorian closures have been used following Taylor and Lysy (1980). For example, some CGE models applied to Brazil have used this structuralist approach (e.g., study No. [25]). The Johansen closure has also been used in a number of studies (e.g., study Nos [10] and [11]).

Table 1 also summarizes the information on data and key parameter values used in the models. In CGE modelling, data requirements are enormous. From the early experience of LDCs in CGE modelling, it normally takes much more time to assemble an adequate set of data than it does to develop and implement a CGE model (see Adelman and Robinson, 1978; Taylor *et al.*, 1980). The selection of parameter values for the functional forms are extremely important determining the results of various policy simulations of CGE models. The procedure involved in choosing values for models' parameters is known as 'calibration' in the CGE modelling literature (see Mansur and Whalley, 1984). In general, for a given economy, an equilibrium situation is assumed that is known as 'benchmark' equilibrium. The values of the parameters of the models are chosen such that the model can replicate the benchmark data set. In general the benchmark data set is from national accounts (including input-output data) and government data sources. However, exogenously specified elasticity values are necessary when functional forms such as CES and LES are introduced. In practice the calibration procedure involves only a set of data for a particular year. This is known as base year data. Some times a 'typical year' data base is used as an average over a number of years (see Higgs, 1986). An important factor in models' calibration is that it completely depends on a single set of data as a benchmark data set.

As noted above, the calibration procedure itself determines all of the parameters in a model. This approach is quite controversial since it is not accompanied by statistical tests. As noted by Jorgenson (1984) the assumed functional forms are too restrictive in this approach and are frequently rejected by econometric tests using less restrictive functional forms. To overcome the obvious defects of the calibration approach, Jorgenson and his followers have developed CGE models based on econometrically estimated flexible functional forms for demand and supply sides. This approach has become known as the econometric approach as opposed to the calibration approach. Although the econometric approach has some obvious advantages, it has some disadvantages, particularly in relation to LDCs. Firstly, for this approach time series data are required. Secondly, flexible functional forms may not be well behaved and finally, the econometric approach may not be feasible when a large number of sectors are introduced into a model since the required number of parameters rises with the increase in number of sectors in the model. Because of these limitations many CGE models applied to LDCs have followed the calibration approach.

To calibrate a CGE model two broad categories of data are required — firstly input-output and national accounts data and secondly various elasticity estimates. To tackle issues such as income distribution and structural adjustment, the first category of data requirement goes beyond the national accounts and input-output data. The motivation underlying the development of the SAM data framework in developing countries during the 1970s was to fill that data gap. A number of the studies under review have benefited from such data bases. With flow of income and expenditure data, the value of some of the key parameters necessary for the implementation part of the models can be derived from the SAM. When fixed coefficient and C–D functional forms are used for supply and demand sides, the first category of data is sufficient. However, when functional forms such as CES and LES are introduced the second category of data, i.e., empirically estimated values for elasticities, is necessary to implement a CGE model. These values cannot be derived from the input-output or SAM data. One of the main problems that arises in CGE modelling in LDCs is the lack of empirically estimated elasticity parameters. The estimation of the necessary parameters is a difficult task due to the unavailability of data. The most common practice in selecting elasticities is the literature search. This method has been applied in many studies. Some authors, however, have derived their own estimates. Another option is to use 'best guess' values to fill data gaps. A large number of studies have followed this method.

Different solution methods are used by different analysts in solving CGE models. While some modellers prefer to solve their models in level forms (non-linear solution methods) others prefer to solve their models by using a linearized approximation method. The latter is known as Johansen's method. One group of policy analysts has used the Johansen method. This method has been used to solve the models in studies [2], [20] and [30]–[36] of Table 1. With the exception of study [2] all studies in this group have followed the ORANI model of the Australian economy (see Dixon, *et al.*, 1982) which is the best example for a traditional Johansen class CGE model. On the other hand, a large number of CGE models listed in Table 1 have been solved in level forms. These models mainly belong to the World Bank and Yale traditions. Today the non-linearized approach is probably the most commonly used in solving CGE models applied to LDCs.

Harris (1988) provides a comparison between linearized and full non-linear models focusing on the relative strengths and weaknesses of the two alternative solution methods mentioned above. Three major advantages of the linearized approach are simplicity, flexibility and transitivity of results (Harris, 1988, pp. 5–6). The apparent disadvantages of this method are: it does not reproduce a benchmark data set and involves linearization errors, so that it does not produce accurate results. In contrast, the non-linear approach has a number of advantages. It produces accurate results and benchmarking is easy. It also has an automatic procedure in checking computer codes to detect data errors. However, there are some problems with this method too including sparse knowledge of global functional forms, dimensionality restrictions on the model size and costs of theoretical consistency (see Harris, 1988, pp. 8–9). As Harris summarized, the main strength of the linearized approach is the ability to deal with large numbers of commodities and sectors, and a consequent saving in computational costs, while the main strength of the non-linearized approach is the ability to produce more accurate results for large-scale changes in a highly non-linearized model, together with an automatic procedure for checking code and data (Harris, 1988, p. 11). It is evident from the experience of CGE modelling in LDCs that the question of what solution method is used in solving a CGE model really depends on the professional group with which the model builder is associated. Policy analysts who follow the World Bank and Yale traditions tend to use the non-linearized approach whereas researchers who follow the Johansen tradition tend to use the linearized approach.

To complete the review of important characteristics of CGE models applied to LDCs it is important to recognize the manpower requirement to develop and maintain a CGE model for a LDC. The experience of CGE modelling in LDCs over the last 15 years shows that model construction and obtaining solutions are no longer constraints. However, a good deal of skill is required in a number of areas for someone to develop and maintain a CGE model. Firstly, a modeller has to know about general equilibrium theory. Secondly, he needs to have a clear idea about the policy issue which he is going to analyse using a CGE model. Thirdly, he must be able to deal with data requirements and tackle data problems that arise in LDCs. Fourthly, he must know about programming or at least must be able to communicate with a programmer. Finally, he needs to know how to interpret the results obtained from a model. When all these activities are considered it is obvious that a considerable amount of skilled manpower is needed to develop and maintain a model. From his own experience of this practical aspect Harris comments as follows: 'Having supervised a number of Ph.D. dissertations in the area, I do not think it would be unreasonable to say that it takes about two years for someone to achieve this type of competency, provided they have the right background' (Harris, 1988, p. 11). This comment clearly indicates the number of skills needed to develop a model. From the experience of CGE modelling it is evident that it is difficult for someone to become expert in all the activities mentioned above. Therefore, team work has been adopted as a successful approach. According to the present author's knowledge, the research team working on the ORANI model of the Australian economy is an excellent example of such a team effort. In this type of team one can identify specialists in a number of activities related to CGE modelling such as a theoretician, a programmer, an expert in data handling and an expert in policy issues. One problem that arises in LDCs is the difficulty in finding local experts in various activities of modelling. The common practice is developing CGE models for LDCs by international agencies such as the World Bank under their special research project. The problem of this practice is that it is very hard to train a local expert to maintain and redesign a CGE model in the long-run. These difficulties are considerable with large general purpose CGE models. The manpower requirements for this type of large models are much higher than a special purpose small model. Some modellers believe that special purpose small models are better than general purpose large models since the latter group often needs to be redesigned to investigate a specific problem.

After identifying the basic characteristics of the various CGE applications, some of the CGE applications related to different policy issues will now be discussed.

4.1. *Trade policy related issues*

Since the early days of CGE modelling work in LDCs, trade-related issues have been a major concern for policy analysts. There are two categories of CGE models in the international trade area, namely, multi-country and single country models.[7] The former are designed to analyse global issues and the latter to examine how changes in trade policy affect individual economies. In this review, only the second category is considered. The selected list of single country applications given in Table 1 shows that some studies are for general purposes but they also attempt to analyse trade policy related problems (for example study Nos. [9] and [12]). Most of these applications have been on protection, including tariff and non-tariff barriers (NTBs). Besides this, they have considered issues relating to exchange rate policy, alternative trade strategy, export subsidies or taxes and foreign capital inflows. Details of policy simulations and their results are summarized in Table 1. In this section an attempt is made to highlight the main features of CGE applications in the trade policy area by using selected studies rather than reviewing each study shown in Table 1 separately.

The main concern of earlier CGE applications (or first generation CGE applications) in LDCs has been the cost of protection, the traditional issue of the trade policy area. Taylor and Black (1974) for Chile, Staelin (1976) for Ivory Coast and de Malo (1978a, 1978b) for Colombia are examples. All these studies emphasized the shortcomings of the traditional partial equilibrium approach to the examination of effective rates of protection and domestic resource costs in predicting resource movements when tariffs are changed. Effective rates of protection have usually been estimated under the assumptions of pure competition, constant factor prices, zero substitution elasticities between inputs, infinite foreign export demand elasticities and elasticities of supply of imports. The analyses of the effects of protection within the general equilibrium framework is more realistic as it does not employ the rather restrictive assumptions used in the traditional partial equilibrium approach.

The studies of Dervis (1980), Dervis *et al.* (1982) and Grais *et al.* (1986) for the Turkish economy can be considered as extensions of their previous work on protection. Unlike the studies reviewed above, these studies have taken into account Quantitative Restrictions (QRs). Protection policy in LDCs typically includes import licensing associated with foreign exchange rationing. The Turkish economy in the 1970s was an excellent example of a restrictive trade regime with QRs. The easiest way to incorporate QRs is through *ad valorem* tariff equivalents. This is, however, not appropriate in the case of a developing country. For instance, *ad valorem* tariff equivalents do not remain constant with a change in prices in the model. State-of-the-art of incorporating QRs into CGE models is demonstrated in Dervis *et al.* (1982).

Grais *et al.* (1986) [8] provide more elaborate treatments of import rationing and rent-seeking activities. The main features of this study are discussed briefly. In their model, the rent-seeking activity has been identified as a commercial activity like any other production activity. This activity uses resources to obtain import licences granted within the limits of the quota and its value added is the scarcity rent. The import rationing is introduced in this model by dividing imports into three categories, namely (i) imports subject to tariff (mainly investment goods and government imports), (ii) imports subject to tariff and rationing which lead to rent-seeking activity (intermediate inputs) and (iii) imports subject to tariff and rationing which do not lead to rent-seeking activities (consumer goods). This classification is an approximation. The difference between (ii) and (iii) is that the modelling of QRs for consumer goods ignores the fact that commodity-specific quotas for consumer goods are mostly allocated to importers. On the other hand, the model emphasizes the rent-seeking activities generated by the commodity-specific licenses in the intermediate category of imports. In order to model import rationing, the concept of 'virtual' prices is used for both intermediate and consumer good imports that are rationed. 'Virtual' prices would induce an unrationed consumer to behave in the some manner as when faced with a given vector of ration constraints. The imports of intermediate inputs which are under commodity-specific licenses give rise to an environment in which producers can engage in rent-seeking activities in order to absorb the rents associated with the licenses. By using this approach QRs are incorporated into the model along with traditional tariff distortions. Consequently, there is a possibility for comparison between the magnitudes of the results of the effects of tariff protection and QRs. To emphasize the treatment of QRs in their model, the authors have labelled it as the TQR (Tariff Quantitative Restrictions) model. The results of these studies indicate that the costs in terms of foregone GDP resulting from import quotas in the presence of rent-seeking activities are significant, while the gains from a 50 per cent across-the-board tariff cut would be small.

Most of the CGE applications in the trade policy area belong to the World Bank tradition and are used to analyse policy issues in LDCs. The model developed by Clarete and Roumasset (1987) [15] to analyse policies in a LDC (with application to the Phillippines) following the Yale tradition is different from the above models. This model departs from the traditional World Bank models in a number of ways. The explicit modelling of a small open economy is the main feature of this study. As in theoretical trade models, it is assumed that the economy acts as a price taker in both export and import markets (exogenously given export and import prices). Imports are perfect substitutes for comparable domestic products and, therefore, the models avoids using the Armington (1969) assumption. The strategy of avoiding the complete over-specialization ('flip-flop') problem is to introduce supply elasticities through industry-specific factors. A counterfactual policy simulation was carried out using this model to analyse the effects of a complete trade liberalization, i.e., removal of all tariffs and export duties. As expected the simulation results show relatively large welfare effects of trade distortions. As noted by the authors, under fixed world prices and homogeneous products, trade distortions are fully transmitted to the domestic economy, without the cushioning effects of the terms-of-trade adjustments and the Armington assumption. Furthermore, sector-specific factors induce additional production inefficiencies (Clarete and Roumasset, 1987, p. 257). A recent study (Clarete and Whalley, 1988), has extended this model to incorporate import quotas, rent-seeking activity and urban-rural migration.

4.2. *Issues of income distribution*

As mentioned earlier, income distribution issues have been a major concern of development policy in the LDCs since the 1970s. In the 1960s and the early 1970s, rapid growth and structural changes were unable to reduce poverty and a large group of low income people did not benefit from the rapid growth in the LDCs. This has given rise to studies focusing on income distribution issues within a CGE framework. These CGE studies address issues including the distributional implications of different development strategies and designing policy packages in order to reduce poverty and income inequality associated with industrialization. The first attempt of this nature was the study by Adelman and Robinson (1978) for Korea [16]. This was followed by models of Brazil by Taylor *et al.* (1980) [17] and of Malaysia by Ahluwalia and Lysy (1981) [18]. Adelman and Robinson (1978) is a medium-term microeconomic CGE model used to examine the effects of various policies on the distribution of income among socioeconomic groups. The other two are macroeconomic CGE models. These models analyse the distributional shifts implied by the changes in real incomes induced by changes in prices and wages in an environment where some income flows are fixed in nominal terms under alternative macroeconomic closures.

In the Korean model, the policy instruments which affect income distribution have been categorized into 10 broad areas including relative factor prices, relative product prices, technology etc. The results of many simulations with the model suggest that the linkage between the functional distribution and the size distribution of income is weak. Further, the functional distribution of income is quite sensitive to policy instruments. By contrast, the Brazilian model used different macroeconomic adjustment mechanisms to address the income distribution aspects. The difference between these macro stories will be discussed in brief here because there is some controversy about these macroeconomic closures (see Ademan and Robinson, 1988). In the Korean model, the focus on income distribution is mainly based on the relative-price-adjustment mechanism allowing investment to adjust to the level of saving. The influence on distribution is an indirect one through a chain linked with commodity prices, factor prices, sectoral production structure, sectoral factor intensity and mobility. For example, assume that the equilibrium between savings and investment is disturbed due to a decline in foreign capital inflow. This leads to a change in the relative prices of goods (real exchange rate) to re-establish the equilibrium. Investment also declines because it passively adjusts to the sum of foreign and domestic savings. Relative prices of capital goods fall. Finally, changes will occur in wages and profits resulting in changes in the distribution of income.

On the other hand, two alternative macroeconomic closures are used to achieve investment-saving balance in the Brazilian model under a given level of fixed real investment. Adelman and Robinson (1988, pp. 29–30) describe these two versions of macro closure as Keynesian and Kaldorian closures. According to them, these two versions of closures differ only in the way they generate the necessary real savings to achieve exogenously given investment. Using the Brazilian model, about thirty simulations were carried out and the results indicate how income distribution in the CGE framework responds to various types of policy or institutional changes.

Apart from the traditional World Bank models, models belonging to the Johansen class have also been used to analyse distributional issues under alternative policy regimes, for example the study of Gupta and Togan (1984) [20] which includes country-specific CGE models of Turkey, Kenya and India.

The main feature of this study is that the equation systems of these country-specific models are drawn from the ORANI model of the Australian economy.

4.3. *External shocks-related issues*

Especially after the first oil shock, policy analysts in LDCs have been more concerned with the importance of structural adjustments and the choice of development strategies in coping with external shocks. Although CGE modelling with a focus on income distribution and growth continued throughout the 1970s, priority has shifted towards trade and structural adjustments in the face of external shocks including the oil-price rises.

In the face of severe external shocks suffered by LDCs, the policy analysts in the World Bank developed at least a dozen CGE models for LDCs in the late 1970s and the early 1980s to analyse these shocks and the related structural adjustment problems. Most of these studies are extensions of their early models or new models developed in the World Bank tradition. Sanderson and Williamson (1985) have reviewed some of these models.

Once again, the case of Turkey is an excellent example of analysing the effects of external shocks using the extensions of the World Bank tradition of CGE models. There are a number of studies which investigate the effects of external shocks in the Turkish economy. In order to analyse Turkey's 1978–1981 foreign exchange crises, Lewis and Urata (1984) [22] used a CGE model similar to the TQR model of the Turkish economy described earlier; QRs play a major role in this model too. The careful treatment of the foreign exchange market is one of the most important features of this model. The model was used to analyse the role of various factors which contributed to the foreign exchange crisis in Turkey during the period of 1978–1980, with emphasis on two inter-related aspects of this crisis; significant inflation differentials between Turkey and its world partners and the second oil shock. The results suggest that the failure of the exchange rate to adjust in line with its trading partners' inflation was a major reason for this crisis.

The Turkish economy is not the only economy affected by various external shocks during this period. A large number of developing countries including Thailand, Chile, Colombia, Mexico, Ivory Coast and Korea were subjected to external shocks during this period. A number of CGE models have been applied to these countries. Summaries of the structure, simulations and the results of these models are shown in Table 1. Details are not discussed here since nearly all of them take a similar form.

CGE models have also been used to analyse the effects of external shocks in a socialist economy. For example, the Robinson and Tyson (1985) model of the Yugoslav economy, which is designed to capture the behaviour of a socialist economy can be regarded as a major variant of World Bank CGE modelling [25]. For example, the neoclassical assumption of profit maximization is replaced by a complicated procedure which captures the behaviour of Yugoslav producers. In particular, the model captures stylized facts of the actual behaviour of self-managed firms in Yugoslavia. Firms are assumed to treat a part of their labour force as fixed in the short-run indicating the fact that reductions in employment are severely restricted by the rules of self-management in the economy. The other part of the labour force is treated as variable. Firms' decisions are guided by a 'planning' or 'accounting' wage. Therefore, firms decide the level of employment of variable labour by equating the value of the marginal product of labour with its accounting wage. Then, firms maximize 'accounting profits' while valuing variable labour at the accounting wage. This mechanism replaces the traditional neoclassical assumption of profit maximization. The model is used to examine the external causes of the foreign exchange crisis which occurred during 1976–80. The findings of the study indicate that internal policy errors are among the factors responsible for the crisis.

The models so far discussed in this category mainly belong to the tradition of World Bank CGE modelling. There are at least another half dozen single country CGE models developed at the Keil Institute of World Economics (Vincent, 1986) which provide another example of using country specific CGE models to analyse the effects of external shocks. These models have been used to analyse the implications of a range of shocks in the world economy and the effectiveness of alternative stabilization measures such as wage and expenditure policies, exchange rate changes and changes in trade policies in accommodating such shocks in LDCs (mainly in Chile, Colombia, India, Ivory Coast, Kenya, Mexico, South Korea and Turkey). These models belong to the traditional Johansen class and their theoretical structures have been derived from the ORANI model of the Australian economy. Since little attention has been paid to this category of models applied to LDCs in recent literature, it is important to consider some of these applications in this section. The theoretical structure, the solution method and the simulation procedure are similar in all these single country models because the same group of policy analysts has developed them following the ORANI model.

The first two studies of this category of CGE applications by Mayer (1982, 1983) ([30] and [31]) are concerned with export instability and the export diversification in the context of the Colombian economy. The treatment of the effects of uncertainty associated with export instability on the behaviour of producers, consumers, government and its impact on economic growth is the main focus of these studies. The author attempts to test two competing hypotheses: (i) that export instability deters economic growth, and (ii) that export instability is beneficial to economic growth. In order to test these hypotheses, export instability is introduced into the model as an exogenous variable. It is assumed that 'a rise of export instability by x per cent leads to an equal rise of the instability of income, the balance of trade and producers revenue (or risk) in the coffee industry' (Mayer, 1982, p. 753). The effects of these changes are transmitted throughout the economy via various linkages. The results support the proposition that export instability deters economic growth.

Using an equation system similar to the ORANI model, a CGE model has been designed for Chile to investigate various policy issues by Dick *et al.* (1984) [32]. In this study, a possible range of stabilization measures is examined in response to a reduction in world copper prices. The copper price decline during 1980 and 1981 in the Chilean economy is considered as an external shock. The objective is to explore the possible options available to the authorities in order to reach employment and current account targets in face of this shock. Using the flexibility of the Johansen solution method, a wide range of possible options are tested to find that cuts in money wages and real absorption simultaneously as a macroeconomic package would bring both external and internal equilibrium. Furthermore, the results suggest that trade policies in themselves are unable to bring about equilibrium. One of the common features of this class of CGE applications is to explore the best possible macroeconomic recovery package which would be a policy prescription for policy makers in these countries.

4.4. *Fiscal policy issues*

Over the past two and a half decades economists concerned with policy analysis have used the general equilibrium approach to investigate the issues of government tax and expenditure policies in developed countries. The applied work within a CGE framework by Shoven and Whalley (1972) on US tax policy issues is regarded as a major contribution to this area. The CGE tax policy modelling considers the impact of tax changes, tax distortions, structural characteristics of a particular tax system and welfare gains or losses of tax changes. Most of these CGE models developed for evaluation of tax policy in developed countries belong to the Yale tradition.

Some policy analysts in LDCs have also followed this Yale tradition. Particularly, they have followed the first generation of tax policy modelling in USA. For example, a CGE model called MEGAMEX has been developed for the Mexican economy following the Shoven and Whalley tradition. The main focus of this model is the tax reform in 1980 in Mexico (Serra-Puche, 1984, [37]; Kehoe and Serra-Puche, 1983, [38]; Kehoe *et al.*, 1984 [39]).

Although the MEGAMEX closely follow the work of Shoven and Whalley, structural features of the Mexican economy such as unemployment and government deficits are included. However, the basic structure of the model is firmly in the tradition of tax models applied to developed countries. Therefore, some of the features of this model are inappropriate to a developing country. As Robinson commented (Serra-Puche, 1984, pp. 482–3), there are no restrictions on labour and capital mobility across production sectors in this model. For example, the specification of freely mobile capital and the allocation of capital to equate rental rates in all sectors are clearly inappropriate for a developing country.

In the first application of the model [37], the effects of replacement of indirect turnover taxes with consumption value added tax (VAT) as introduced in 1981 have been examined (see Table 1). As an extension of this model, Kehoe and Serra-Puche (1983) [38] incorporated unemployment generated by an exogenously-specified downward-rigidity of real wages in analysing the impact of the 1980 tax reform. In another application of this model [39] the focus is on the commercial sector considering the importance of wholesaling and retailing in the Mexican economy (one-fourth of value added is governed by this sector). The distinction between this and the previous applications lies in the specification of the commercial sector which plays a crucial role in the model as an intermediation between consumers and producers. The commercial sector is disaggregated into eight subsectors and retail establishments are heterogeneous in terms of the location and prices. Consumers choose among different retail establishments when making purchases. Using the model, two policy changes were examined in this study; the impact of the 1980 fiscal reform in Mexico on the commercial sector and a subsidy aimed at the commercial sector (see Table 1).

Government expenditure policies including subsidies are another area of concern in fiscal policy modelling. In many LDCs, policies of food subsidies play a major role in the political economy. There are a number of studies concerned with this issue, for example McCarthy and Taylor (1980) [40] for Pakistan. Before a CGE application, they have developed a SAM data base for the Pakistan economy. The short-run impacts of a number of simulations are summarized in Table 1. McCarthy (1981, 1983) ([41] and [42]) investigates the impact of similar types of subsidy policies in Brazil and Egypt models. Eckaus and Mohie-Eldin (1980) [43] examine the changes in subsidy policy in Egypt. Summaries of these applications are shown in Table 1.

4.5. *Choice of development strategy, structural changes and other issues*

The failure of inward-looking strategies in many LDCs during the 1960s and 1970s has led to serious reconsideration of the implications of alternative development strategies. This debate has taken different forms such as inward-looking versus outward-looking, liberal versus interventionist, socialist versus free-economic or export-led versus domestic demand. Careful consideration of these development strategies is an essential part of the policy analysis in LDCs. CGE modelling has become a popular tool among policy analysts to focus on the implications of such strategies. Most of the models in this category also belong to the World Bank tradition.

For example, one of the recent subjects in the policy debate is export-led versus domestic demand development strategy. Yelden (1987) [47] examined the implications of these two strategies using a CGE model for the Turkish economy. The motivation behind this study is that the domestic market oriented development strategy with agriculture leading the process would be more stimulatory than the export oriented strategy in terms of Turkey's long term economic growth prospects. The model follows the earlier version of Turkish CGE models. The results support the view that the domestic demand oriented strategy with selective export promotion programs is superior to the current strategy of manufactured export-led industrialization.

Policy makers in LDCs have long been concerned with the relationships between alternative development strategies, growth and structural changes. The choice of appropriate development strategy associated with supporting policies is often debated. Issues of economic structure including the resource allocation among various sectors, inter-relationship between agriculture and manufacturing sectors, the role of foreign investment and trade have been the focus of long-run policy orientation. Some CGE applications are used to examine the relationship between growth and structural changes in developing countries over the periods under alternative development strategies. The study of Kubo *et al.* (1984) [48] investigated the macroeconomic and industry effects of alternative development strategies in the Korean economy. This study used two models; a CGE model and a dynamic input-output model. Both models were used to 'track' the historical growth path during the period 1963–1973 in Korea. Historical validation of the models was carried out by comparing the results of the simulations of the models with the actual data on the performance of the Korean economy. This validation ascertains whether the model adequately reflects the structural characteristics of a particular economy. After historical validation, the models were used to simulate the effects of alternative development strategies. Then, a comparison of the results generated by the simulations of the models was carried out. This comparison indicated that the results from both models were quite similar. However, the mechanisms by which the models capture the adjustment process are quite different. Historical experience of the Korean economy over the long-run has also been examined by Chenery *et al.* (1986) [49], Hamilton (1986) [50] and Chao *et al.* (1982) [51].

Rather than discussing similar models, a number of CGE models applied to India, which are quite different from other models in some aspects, are considered briefly in this section in order to highlight some of their important features. Narayana *et al.* (1987) [58] have developed a ten-sector sequential CGE model in order to analyse policy choices for India until the year 2000. The main distinction of this model is the estimation of a number of behavioural functions (related to demand and supply) econometrically with time series data (mostly from the period 1950–51 to 1973–75). Another important feature is that outputs, imports and exports are set equal to their actual values, and the actually observed prices are created as equilibrium prices in order to ensure the market clearing condition via stock accumulation or decumulation at these prices in running the model for the period up to 1980. The period from 1980 to 2000 is the simulation period.

The studies of Rattso (1987, 1988) ([59] and [60]) are based on a macrodynamic CGE model of India. This model is based on the experience of Dervis, *et al.* (1982). The novelty of this model is that it focuses on macrodynamic aspects of the economy in contrast with most of the CGE models which focus on allocation problems in LDCs. This model integrates a static macro model, which is based on structuralist macroeconomic theory formulated by Taylor (1983), into a CGE framework. Hence, the model is described as a combined structural and econometric model. Although there are no simultaneous estimations of the equations of the static part of the model, some of the coefficients of the model are based on econometric estimations. A clear understanding of the adjustment mechanisms at work has been described as the main strength of this model. It has been used as a supplement to the macroeconometric models available for India. Firstly, the model is implemented to reproduce the economic development from 1980/81 to 1984/85 and to describe the development path explaining the macroeconomic situation. Secondly, alternative policy experiments are performed with the model to examine alternative macroeconomic adjustment policies.

Apart from the applications of CGE models for the analysis of the choice of development strategy, growth and structural changes, there are a number of studies which investigate the 'energy-economy' interactions (see Bergman, 1988) and questions of natural resources (see Devarajan, 1988) in LDCs. For example, Blitzer and Eckaus (1986) [61] developed a CGE model for the Sri Lankan economy focusing on the impact of energy costs and prices on key variables and the industrial structure.

5. Limitations of CGE modelling

We have already considered the evolution of CGE models since the early input-output models, and the rapid development of applications of these models to LDCs in recent years. From the previous section, it was clear that these models have become quite popular among policy analysts in LDCs over the last decade or so. However, there is still considerable debate in the economic profession regarding the value and appropriateness of using CGE models for such policy analysis (see Bell and Srinivasan, 1984; Waelbrock, 1986). In this section, we outline some of the key criticisms levelled at CGE models and argue that despite these criticisms, such models are capable of providing useful insight into important policy problems.

Some critics attack CGE modelling for an alleged over reliance on unrealistic neo-classical assumptions such as perfectly competitive markets and constant returns to scale. While this may have been justified in relation to the earlier vintage of CGE models, this is less of a drawback now. It has been demonstrated that departures from such simplified assumptions can be incorporated into CGE models, when considered appropriate. Harris (1984), for example, has incorporated oligopolistic pricing and economies of scale into CGE models. Similar work has also been done by Horridge (1987).

Rigidities in markets and other 'structuralist' aspects of economies have also been incorporated into CGE models (see Taylor *et al.*, 1984; Gibson *et al.*, 1986). Once again, it should be noted that most CGE models are developed to address particular policy issues; as such they are not all-purpose composite models. These models help to identify the essential relationships which are relevant to the particular policy being analysed. Therefore, it is not always necessary to incorporate all the structural rigidities and market distortions to a CGE model to achieve its objectives. Suppose a CGE model is used to evaluate the effects of QRs in an LDC. Then, emphasis has to be placed on modelling the trade sector of the economy. There are many examples of the incorporation of 'structuralist' aspects of economies in CGE models. For example, efforts have been made to incorporate 'dualism' into these models (see Amranand and Grais, 1984). Government interventions and market distortions have been considered in CGE models. Indeed, these have provided a fruitful area of CGE applications (see Ahmed *et al.*, 1985). Recently, Clarete and Whalley (1988) have made an attempt to incorporate domestic distortions in detail into CGE models of LDCs. They have incorporated import quotas, rent-seeking activities and a Harris-Todaro type labour market distortion into their model. Clearly, all CGE models are not based on neo-classical assumptions.

Another criticism of these models is the absence of the role of money. Many extant CGE models describe the equilibrium of the real side of the economy in which only relative prices play a major role. In such CGE models, it is implicitly assumed that the monetary authorities adjust the money supply of the economy such that it is consistent with the changes in the domestic price level emerging from policy simulations. This is seen by some critics as an inadequate treatment of the important role of money (see Bell and Srinivasan, 1984). They also point to the importance of increasing monetization and, therefore, intermediate financial institutions and asset markets in LDCs. As a response to this criticism, attempts have been made to include asset markets in CGE models. For example, Lewis (1985) has attempted to incorporate money and bond markets into a stylized CGE model of Turkey. Feltenstein (1980, 1983) has included a simple monetary sector into his CGE models of Argentina. Adams (1988) has also made an attempt to incorporate a monetary sector into a Johanson class CGE model.

The particular methods used to model the long-run process of development have also been subjected to criticism. In some studies, dynamics have been included into CGE models. As noted earlier, two approaches, i.e., myopic and recursive and clairvoyant or intertemporal are used in dynamic CGE modelling. They have their own limitations and difficulties. It is appropriate to quote Manne (1985) at this point in order to have a clear idea on the limitations and difficulties of these two approaches:

> A myopic approach can easily lead to inconsistent expectations and cobweb cycles — with prices and quantities overshooting and then undershooting their long-run equilibrium levels. A clairvoyant model may avoid these difficulties, but generally requires additional data. Almost certainly there will be an increase in computing costs. These costs increase exponentially with the number of time periods. Thus, the practicality of an intertemporal model depends upon the state-of-art of numerical solution technique (Manne, 1985, p. 8).

It must be noted that the problems encountered in dealing with uncertainty about the future and expectations are not limited to CGE modelling. As Robinson (1986, p. 70) notes 'the issue of dynamics is certainly not confined to multisector models and has long been recognized as a major problem in macroeconometric models as well'. Therefore, handling dynamic issues is a difficult task in empirical work as well as in theory. With all these difficulties, however, the success of the second generation of CGE models (usually based on the first generation of comparative-static models) in capturing the time paths of adjustment can be noted as a significant improvement (see Pereira and Whalley, 1988).

Another, and perhaps the most important, criticism is related to data and parameter values. The values of major parameters in many CGE models are little more than best guesses (see Mansur and Whalley, 1984). There are many problems in relation to consistency, reality and adequacy of data in the LDCs. This issue has been raised in many international forums.[8] Therefore, one of the frontiers of research in the CGE modelling involves the data. A complete set of base-period input-output data for an economy is necessary for the use of CGE analysis. Since the initial costs and income shares are derived from the base-period input-output data set, the quality of it is critical in CGE modelling. The rapid progress in compiling input-output and income distribution data within a SAM framework in LDCs in the late 1970s and the early 1980s can be identified as an immediate response to the above requirement. As Whalley (1985b, p. 27) indicated, sometimes little is known about the numerical values of key parameters such as elasticities. Therefore, estimation of such elasticities is an important area of research required for the future development of more realistic CGE models. In the absence of such information, analysts who wish to examine the impact of policy changes and various shocks on growth, resource allocation and distribution in a logically consistent economy-wide framework are forced to rely on such best guess values. However, limitations arising from data inadequacy can be alleviated to some degree through sensitivity analysis. A systematic sensitivity analysis on the results obtained from CGE models can be carried out in order to take into account the uncertainties about key parameter values to provide an idea of the robustness of their results (see Harrison *et al.*, 1985; Pagan and Shannon, 1985).

Finally, a practical limitation can be highlighted. The major criticism in this regard is that the calculated results from CGE models are difficult to explain to policy makers. The argument is that most practicing economists and policy makers in LDCs are not convinced by the results obtained from a model with complex mathematical structures and solution techniques. In particular, they cannot understand 'where the results come from' in many of the CGE models. Sometimes these models are labelled as giant 'black boxes'. To respond to this criticism the model builders must be able to provide a detailed explanation of how their results are obtained. This is done by some CGE modellers at present. For example, the research team working on the ORANI model of the Australian economy have been able to provide a detailed explanation of many of their results using 'back-of-the-envelope' (BOTE) calculations (see Dixon, *et al.*, 1984).

The above discussion indicates that, despite certain limitations, CGE modelling has been able to confront and overcome many of its alleged weaknesses. These new developments (see Piggott and Whalley, 1985b) can be treated as the responses of modellers to earlier criticisms. As a result, CGE models are now well-suited to analyse a wide range of policy issues in LDCs in the short-run and the medium-run. They can shed considerable light on particular policy issues and generate valuable insights. They clearly illustrate the

Table 1. CGE applications in developing countries: A summary of main characteristics of

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
	(a) Trade Policy Issues					
1	Taylor & Black (1974)	Chile	Nested Cobb–Douglas production functions.	35	Addilog (Houthakker–Sato) demand system derived from CES utility functions.	1
2	Staelin (1976)	Ivory Coast	Cobb–Douglas production functions.	25	LES Demand System (Stone–Greary).	1
3	De Melo (1978a)	Colombia	Nested Cobb–Douglas/ CES production functions.	15	LES Demand System (Stone–Greary).	1
4	De Malo (1978b)	Colombia	Nested Cobb–Douglas/ CES production functions.	15	LES Demand System (Stone–Greary).	1

relevance and usefulness of economic theory. CGE models have already made useful contributions to the development of policy debate in LDCs. While much remains to be done to overcome the limitations of CGE modelling, provided that modellers themselves respond to the challengers and devote their energies to overcome existing limitations, we can expect CGE models to play an increasingly important role in the future.

models and results

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1962	Chilean Input Output (I–O) Data. Consumer demand elasticities and parameters for CES production functions were taken from available empirical studies. Data on tariffs were taken from available sources.	Reduction in tariffs by 10 to 20 per cent in general and partial equilibrium framework.	Results indicated that the study correctly predicts changing sectoral output in the general equilibrium framework compared with the under estimated results in partial equilibrium analysis.
1970	I–O Table and sectoral balance projected for the Ivorean economy. Price elasticities were calculated using Frisch formula and other elasticities from the main data base.	Elimination of tariffs under different pricing behaviours.	Different assumed pricing behaviours do lead to different resource allocations.
1970	I–O data. Parameters were taken from various studies.	Reduction in tariffs within partial and general equilibrium frameworks.	Compared with general equilibrium results, directions of changes in sectoral output are incorrectly predicted by the partial equilibrium analysis.
1970	I–O data for Colombia. Parameters were taken from various studies.	The following four main effects of protection are examined under eight different experiments: 1) the welfare costs; 2) the exchange rate adjustments required to keep the balance of payments in equilibrium; 3) distribution of income; and 4) employment.	With 1), welfare gains are determined by: (a) the factor mobility; (b) the world elasticity of demand for coffee; and (c) elasticity of supply of unskilled labour. With 2) the magnitude of the exchange rate adjustments is mainly deferred by the factor mobility. With 3), skilled and unskilled labour suffer in

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
5	De Melo & Dervis (1977)	Turkey	Cobb–Douglas production functions	3	Derived from Cobb–Douglas utility functions.	1
6	Dervis (1980)	Turkey	Nested CES production functions.	19	LES Demand System (Stone–Greary).	4
7	Dervis *et al.* (1982)	Turkey	Nested CES production functions.	19	LES Demand System (Stone–Greary).	4
8	Grais *et al.* (1986)	Turkey	Nested CES production functions.	8	LES Demand System (Stone–Greary).	1

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
			almost all cases compared with landowners and capitalists. With 4), an increase in employment can be observed in all experiments when the supply of labour is not fixed.
1967	Third Turkish five year plan. Necessary values for parameters were derived from the main data base.	Choice of alternative trade strategies.	An overall conclusion of a detailed analysis is that when labour is mobile only very strong dynamic effects can make protection a superior strategy. Whenever labour supply is very elastic in the labour intensive export sectors, free trade will be preferred.
1978	I–O data for Turkey. Trade elasticities were assumed. Other parameters were derived from data base.	1) The static resource pull effects of a devaluation under exchange control regime. 2) The longer run resource pull effects of a devaluation under exchange control regime.	The results of two simulations indicate that a devaluation leads to contraction rather than expansion in import-substitution sub-sectors.
1978	I–O data for Turkey. Sensitivity tests were carried out using guess values for various parameters.	Investigating 1977 Turkish foreign exchange crisis by setting 50 per cent tariffs on imports and giving a 50 per cent subsidy on exports.	The effects of 50 per cent exports subsidies are greater than the effects of 50 per cent import tariffs. The economy is more sensitive to export side disturbances. The results reflect that causes of the foreign exchange crisis mainly lie in domestic inflation and oil price shock.
1978	A SAM data base. Income and price elasticities and other elasticities from various studies. Guess estimates on premium generated by quotas were used.	Removal of import quotas with or without a 50 per cent tariff cut.	Gains in real GDP are large in the case of removal of quotas. Additional gains from a tariff cut are small.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
9	Keyzer (1986)	Bangladesh	Generalized Leontief production functions.	20	Fixed expenditure shares.	10
10	Feltenstein (1980)	Argentina	Generalized Leontief production functions.	23	Derived from Cobb–Douglas utility functions.	—
11	Feltenstein (1983)	Argentina	Generalized Leontief production functions.	7	Derived from CES utility functions.	3
12	Cherif (1984)	Tunisia	Nested Cobb–Douglas production function.	16	LES Demand System (Stone–Geary).	1

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1977	SAM for Bangladesh. Values for key parameters were derived from main data base.	Three policy simulations: 1) 50 per cent cut in tariffs without non-tariff barriers and upper bound on the trade deficit; 2) zero tariffs on non-agricultural imports without non-tariff barriers and upper bound on the trade deficit; 3) zero tariffs on imports of non-agricultural products without non-tariff barriers but with adjustments to meet the upper bound on the trade deficit.	GNP falls in all three simulations. However, negative effects are smaller in the first case and greater in the third. In terms of welfare, first case affects the poorest group. In the second and third cases, farmers are the main winners and others are the losers.
1978	I–O data source and other data sources. A Sam data base was used. Unit price elasticities assumed. Most of the parameters were estimated from the original data sources.	A 50 per cent cut in tariffs with 15 per cent devaluation and 12.98 per cent decrease in money supply.	Effects on balance of payments, total welfare and government revenue are negative after one quarter. After two quarters, effects on the external balance are positive.
1981	I–O data and other data sources. A SAM data base was used. Unit price elasticities assumed. Most of the parameters were estimated from the original data sources.	Calculation of quotas equivalent to a 25 per cent devaluation to be imposed on imports of industrial products.	A minimum of 39.2 per cent reduction in quotas on industrial imports is required.
1980	A SAM data base. Some of the parameters were estimated.	The effects of 4 policy shocks: 1) 20 per cent devaluation of exchange rate; 2) a uniform 10 per cent rate of customs taxation; 3) a decrease in subsidy rate from 15.5 per cent to 10 per cent for the purchase of oil and agricultural goods and a decrease in subsidy rate from 7.2 per cent to 3 per cent for the purchase of manufactured goods; 4) decline in the rate of investment from 32 per cent to 20 per cent.	If 1), an increase in domestic prices leads to a fall in consumption and investment. If 2), the current account improves and the inflation pressure is eased. If 3), GDP rises, the current account improves, and real wages rise. If 4), effects on growth and the current account are negative.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
13	Blomquist & McMahon (1984)	Kenya	Generalized CES functions.	2	LES Demand System (Stone–Greary).	2
14	Levy (1987)	Mexico	Not specified.	10	LES Demand System (Stone–Greary).	2
15	Clarete & Roumasset (1987)	Philippines	Cobb–Douglas production functions.	7	Derived from Cobb–Douglas utility functions.	1
	(b) Issues of Income Distribution					
16	Adelman & Robinson (1978)	South Korea	Nested Cobb–Douglas CES production functions.	29	LES Demand System (Stone–Greary).	15
17	Taylor *et al.* (1980)	Brazil	Nested CES production functions.	25	LES demand Systems and Addilog Systems.	4
18	Ahluwalia & Lysy (1981)	Malaysia	Generalized CES production functions.	5	Only total consumption was considered.	1

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1978	I–O data. Parameter values were chosen from various sources.	Tariff changes and removal of wage distortions.	Overall welfare benefits are larger from the removal of wage differentials than from tariff changes.
1975	Mexican system of national accounts. Trade parameters were assumed.	Changing Quantitative Restrictions (QRs).	QRs on competitive imports raise trade deficit and reduce real GDP. However, selective QRs reduce trade deficit.
1978	A 1978 benchmark data set was used (assembled by the authors). Production and consumption parameters were derived from the benchmark data set. Average tariff rates and export taxes were derived from the custom data.	A complete trade liberalization (removal of all tariffs and export taxes).	Resources are shifted from exportables to importables in a protective policy regime. Welfare costs are large, due to the trade distortions.
1968	I–O data and other government statistics. Some parameters were estimated from available data and some were obtained from other sources. Educated guesses were also used.	The effects of 26 policy experiments.	Major findings: 1) there seems to be very little connection between the distribution of income by decile (the size distribution of income) and the distribution of income by classes of recipients (functional distribution); 2) functional distribution is sensitive to policy instruments.
1959	I–O data. Key parameters were derived from main data base and other sources.	An examination of impact of a variety of policies of institutional changes on income distribution.	The improvements in income distribution resulting from fiscal measures are not radical. Direct government measures are more effective than fiscal measures.
1971	I–O data. Values for parameters were obtained from other sources.	Devaluation of exchange rate.	Adverse effects on the economy and the income distribution (given the low elasticity of supply of export commodities) are generated.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
19	De Melo & Robinson (1980)	Colombia	Nested Cobb–Douglas production functions.	8	LES Demand System.	6
20	Gupta & Togan (1984)	India, Kenya, Turkey	Nested production functions including Leontief, CES and CRESH.	4	LES Demand System (Stone–Greary).	3
21	Cole & Meagher (1984)	India	Fixed Coefficients.	3	Fixed Coefficients.	2
	(c) External Shocks and Structural Adjustments					
22	Lewis & Urata (1984)	Turkey	Nested CES production functions.	13	LES Demand System (Stone–Greary).	1
23	Condon *et al.* (1985)	Turkey	Nested CES production functions.	12	LES Demand System (Stone–Greary).	1

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
Typical year of 1970's	I–O data various sources. Some of the parameters were estimated. Guess estimates were used for others.	The impact of four alternative trade strategies on the distribution of income.	The results of four simulations indicate that, in a primary-export-oriented economy, a more open development strategy is likely to be accompanied by a worsening of the distribution of income.
Not specified	I–O tables for each country were used. Values for key parameters were taken from various empirical sources.	The effects of four alternative policies on income distribution: 1) intervenists (fixed wage and exchange rate); 2) semi-intervenists (without fixed real wage); 3) semi-liberalised (without fixed exchange rate); and 4) liberal (with 10 per cent decrease in import tariff.	In terms of GDP, the fourth policy measure is superior to other three. Specially, peasants and non-agricultural workers benefit from that policy.
1968/69	1968/69 SAM for India.	The effects of various redistribution policies considering two-way relation between growth and income distribution. For that purpose eight simulations were carried out.	Growth may give rise to significant shift in the distribution of income depending on whether or not it alters the relative scarcity of factors of production.
1978	Income and price elasticities and other elasticities from various studies. Guess estimates were used for premium.	Over-valuation of the Pound between 1978 and 1981.	The Pound would not have been over-valued, if the second oil price shock had not taken place.
1978	SAM data base. Values for various parameters were derived from base year data and guess estimates were used.	The effects of three adjustment mechanisms: 1) flexible exchange rate; 2) import premium rationing; 3) quantity rationing.	The results show that welfare losses are smallest when the exchange rate is flexible to clear the foreign exchange market and largest for quantity rationing. The costs associated with rent seeking are the most important source of welfare loss, far outweighing allocative inefficiencies arising from the use of quantity rationing.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
24	Michel & Noel (1984)	Ivory Coast	Nested Cobb–Douglas production functions.	15	Derived from Cobb–Douglas utility functions.	5
25	Robinson & Tyson (1985)	Yugoslavia	Nested Cobb–Douglas and CES functions.	18	Derived from Cobb–Douglas utility functions.	0
26	Condon *et al.* (1985)	Chile	Nested CES production functions.	5	CES Demand System (Stone–Greary).	1
27	Amranand & Grais (1984)	Thailand	Nested CES production functions.	22	LES Demand System (Stone–Greary).	7

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1980	I–O data. Elasticities were taken from various sources.	Calculation of the following, given the target of a 50 per cent reduction in current account deficit: 1) required depreciation under the existing tariff and quotas; 2) required uniform tariff and export subsidies under the existing quotas and the fixed exchange rate; 3) required fiscal surcharges with the elimination of import quotas under the fixed parity.	For 1), required devaluation of CFA franc is about 11 per cent. For 2), an overall 36 per cent export subsidy is required. For 3), fiscal surcharges ranging from 6 per cent to 36 per cent are required depending on the type of product.
1976	I–O data. Various elasticities were estimated from various sources.	Examination of the magnitude of following individual factors that account for the over-valued currency: 1) a decline in export earnings; 2) the difference between domestic and world inflation; 3) oil price shock; 4) decrease in the wage rate of migrant workers.	Calculated magnitudes of those four factors are 29.2, 44.0, 9.8 and 17 per cent of the 20.5 per cent Dinar over-valuation respectively.
1977	Chilean I–O data and other data. All parameters were best guesses.	Firstly, simulated the growth path and productivity changes. Secondly, counter-fractual simulations were carried out to assess how Chile's economic performance would have differed if (a) external events had been difficult, and (b) foreign capital inflows had been different.	Results show that the sectoral pattern of productivity growth and capacity utilization increased during 1977–81. In explaining macroeconomic imbalance of 1981, external shocks associated with copper price are important. The main determinant of imbalance is the unsustainability of capital inflows.
1975	SAM for Thailand — 1975 and various studies.	Drop in world prices of energy by allowing the domestic price to behave as before.	Growth and income distribution seem to be insensitive to alternative energy pricing policies.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
28	Devarajan & Sierra (1985)	Thailand	Nested CES production functions.	6	LES Demand System (Stone–Greary).	6
29	Benjamin & Devarajan (1985)	Cameroon	Cobb–Douglas production functions.	11	Derived from Cobb–Douglas.	1
30	Mayer (1982)	Colombia	Nested production functions including Leontief CRESH CES nests.	6	Additive utility function with CES commodity nests. Houthakker–Sato expenditure system is used.	1
31	Mayer (1983)	Colombia	Nested production functions including Leontief, CRESH CES nests.	6	Additive utility function with CES commodity nests. Houthakker–Sato expenditure system is used.	1

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1973	Main data base was a SAM for Thailand and other data sources were also used.	The basic growth path between 1973–81 and the examination of the effects of: 1) transfers from US bases; 2) increase in export prices in agricultural exports; 3) increase in the amount of level under utilization.	US transfers permitted Thailand to sustain a slightly higher growth rate and enabled to purchase more imports. The lasting effects of this 'windfall' gain appear to be minimal. The results of the effects of lower agricultural prices would have been insignificant. The counter-fractual simulations of zero growth rate of land under cultivation (compare with 4% increase in base run) yields very little difference from the basic growth path.
1980	I–O table. Key parameter values were derived from original data base.	The impact of increase in oil revenue under three scenarios: 1) an increase in oil exports revenues; 2) increased tariff on food imports; and 3) increase tariff protection for intermediate goods and construction materials to avoid de-industrialization.	The projected results produce expected 'Dutch disease' type effects including an appreciation of real exchange rate. However, some sectoral performance differs from the predicted results.
1973	I–O data. Almost all the parameter values were taken from various empirical studies.	A hypothetical 10 per cent increase in export instability.	The results of this study support the proposition that export instability is detrimental to economic development.
1973	I–O data. Almost all the parameter values were taken from various empirical studies.	A 10 per cent decrease in coffee exports in order to increase exports of processed foods and textiles.	The results show an increase in the GDP and in increase in exports of processed foods and textiles. The appropriate export diversification allows for an increase in the domestic economic stability.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
32	Dick *et al.* (1984)	Chile	Nested production functions including Leontief, CRESH CES nests.	10	Additive utility function with CES commodity nests. Houthakker–Sato expenditure system is used.	1
33	Vincent (1984)	Chile	Nested production functions including Leontief, CRESH CES nests.	10	Additive utility function with CES commodity nests. Houthakker–Sato expenditure system is used.	1
34	Vincent (1982)	South Korea	Nested production functions including Leontief, CRESH CES nests.	10	Additive utility function with CES commodity nests. Houthakker–Sato expenditure system is used.	1
35	Gupta (1983)	India	Nested production functions including Leontief, CRESH CES nests.	12	Additive utility function with CES commodity nests. Houthakker–Sato expenditure system is used.	1

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1977	I–O data. Almost all the parameter values were taken from various empirical studies.	A 25 per cent decline in world copper prices and the various subsidization policies considered to 'neutralise' the shock.	The major policy implication of the results is that the neoclassical policy package of a combined 1.9 per cent cut in real wages and 2.7 per cent reduction in real domestic absorption is sufficient to restore both the aggregate employment and the balance of trade.
1977	I–O data. Almost all the parameter values were taken from various empirical studies.	A 1 per cent increase in the nominal exchange rate, a 1 per cent increase in the domestic component of money, a 1 per cent decrease in money wages and alternative policy packages.	Results suggest the following: 1) under fixed money wages, the devaluation without accompanying contractionary monetary policies is expansionary and inflationary; 2) under fixed money wages and nominal exchange rate, contractionary monetary policy would improve balance of trade; 3) downwards flexible money wages would achieve the given improvement in balance of trade and employment with lower inflation and a smaller devaluation.
1975	I–O table. Almost all the parameter values were taken from various empirical studies.	Increase in oil prices under different scenarios.	The results indicate the importance of reduction in real labour costs to mitigate adverse effects of oil shock.
1979/ 80	I–O table. Almost all the parameter values were taken from various empirical studies.	100 per cent increase in oil prices in the short-run and the medium-run.	The short-run results show that the composition of industrial structure moves away from traded to non-traded goods and a reduction in GDP. The worst effects of GDP can be reduced in the medium-run.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
36	Dick *et al.* (1983)	Kenya, Ivory Coast & Colombia	Nested production functions including Leontief, CRESH CES nests.	12	Additive utility function with CES commodity nests. Houthakker–Sato expenditure system is used.	1
	(d) Government Fiscal Policy Related Issues					
37	Serra-Puche (1984)	Mexico	Nested production functions with Leontief and CES nests.	14	Cobb–Douglas utility functions.	10
38	Kehoe & Serra-Puche (1983)	Mexico	Nested production functions with Leontief and CES nests.	14	Cobb–Douglas utility functions.	10
39	Kehoe *et al.* (1984)	Mexico	Nested production functions with Leontief and CES nests.	21	Cobb–Douglas utility functions.	10
40	McCarthy & Taylor (1980)	Pakistan	Nested Cobb–Douglas production functions.	11	LES Demand System (Stone–Geary).	6

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1973 for Colombia & Kenya 1976 for Ivory Coast	I–O tables for each country. Almost all the parameter values were taken from various empirical studies.	A hypothetical 10 per cent increase in the world prices of coffee, cocoa and tea under fixed domestic absorption and fixed balance of trade.	The results show that the policy with fixed domestic absorption in the face of price stability can successfully isolate the effects of price shock to the relevant commodity producing sectors. The other extreme, policy with the balance of trade equilibrium, would spread the effects of price shock more evenly around the domestic economy.
1977	I–O table updated for 1977 using 1970 I–O table. Assumed production parameters for demand side were based on various surveys. Tax rates were derived from government budget data.	The effects of the substitution of a consumption value-added tax regime for a turnover indirect tax regime.	The resource allocation moves in favour of the targeted sectors such as agricultural and foodstuff and income distribution improves, reducing the disparity between urban and rural groups.
1977	I–O table updated for 1977 using 1970 I–O table. Assumed production parameters for demand side were based on various surveys. Tax rates were derived from government budget data.	Examination of the impact of 1980 tax reform which introduced the VAT.	Government revenue and the unemployment rate fall. Rich and poor classes benefit more than the middle class.
1977	I–O table updated for 1977 using 1970 I–O tables. Production parameters were assumed and parameters for demand side were estimated from various survey data. Tax rates were derived from government budget data.	An introduction of a differentiated system of value added subsidies for eight domestic trade activities and the 1980 tax reform.	Redistributive impact of subsidies on commercial activities is large compared with the tax reform which is designed for greater equality.
1977/76	SAM data and other survey data. Parameters were estimated from various survey data.	The effects of food situation under seven independent policies: 1) removal of wheat subsidy on consumption; 2) a 10 per cent increase in wages;	The most impressive redistribution measure is land reform compared to other possibilities.

(*continued*)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
41	McCarthy (1981)	Brazil	Nested Cobb–Douglas production functions.	8	LES Demand System (Stone–Greary).	2
42	McCarthy (1983)	Egypt	Nested Cobb–Douglas production functions.	12	LES Demand System (Stone–Greary).	6
43	Eckaus & Mohie-Eldin (1980)	Egypt	Nested Cobb–Douglas production functions.	12	LES Demand System (Stone–Greary).	6
	(e) Choice of Development Strategy, Growth and Other Issues					
44	De Melo (1979)	Sri Lanka	Nested Cobb–Douglas production functions.	7	Spliced LES Demand System.	6

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
		3) a comprehensive land reform; 4) a 50 per cent increase in the fertiliser subsidy; 5) a 10 per cent increase in government purchase of rural industry production; 6) a 10 per cent increase in government purchase of urban industry production; 7) removal of wheat subsidy with increase in government purchase of urban industry production.	
1975	I–O data. Key parameters from various studies.	Impact of a 20 billion increase in Cruzerios in subsidies to: 1) agriculture; 2) industry; or 3) social expenditure.	In view of the simultaneous achievement of growth, balance of payments equilibrium, employment, and budgetary equilibrium, none of the three policies can be regarded as superior.
1976	SAM of Egypt and data from various studies were used.	A reduction of subsidies to consumers or to producers of essential goods totally or partially.	Negative effects can take place in the economy as a result of increase in prices. In particular, urban poor population is severely affected.
1976	SAM of Egypt and data from various studies were used.	Partial or total removal of consumer subsidies on essential items.	Overall impacts are depressive.
1970	SAM data and values for some parameters were taken from various studies.	The effects of five different agricultural policies, namely: 1) elimination of the rice subsidy; 2) land reform; 3) increase in investment in agriculture; 4) elimination of export tax; and 5) technical change in agriculture.	The results suggest that the policies 1) and 5) have strong favourable impact on GDP and income increases in poorest groups. On the other hand, policy 4) and 3) have unfavourable effects.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
45	De Melo (1981)	Sri Lanka	Nested Cobb–Douglas production functions.	7	Spliced LES Demand System.	6
46	De Melo (1982)	Sri Lanka	Nested Cobb–Douglas production functions.	7	Spliced LES Demand System.	6
47	Yelden (1987)	Turkey	Nested Cobb–Douglas production functions.	7	Derived from Cobb–Douglas utility functions.	4
48	Kubo *et al.* (1984)	South Korea	Nested CES production functions.	8	Derived from Cobb–Douglas utility functions.	1

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1970	SAM data and values for some parameters were taken from various studies.	The effects: 1) removing rice subsidies; 2) neutral technical change; 3) land reform; and 4) flexible wage rate for unskilled labour on improving basic needs.	Although the removal of rice subsidy creates short-run adverse effects, it produces benefits in the long-run. In the long-run, land reforms may result in negative impact without complementary factors. The net effect of flexible wage rate for unskilled labour is favourable. It increases employment, stimulates growth and improves fulfilment of basic needs.
1970	SAM data and values for some parameters were taken from various studies.	The relative effects of four alternative development strategies: 1) the socialists; 2) the economic (free); 3) the green revolution; and 4) the industrialization.	The results of the simulations indicate that the green revolution strategy is the most successful strategy specially in the medium term.
1970	SAM data and other sources were used.	The effects of alternative development strategies, namely: 1) manufacturing export-led industrialization; 2) agriculture-linked manufacturing industrialization; and 3) selective agriculture-linked manufacturing industrialization.	The results of this study strongly favour a development strategy of industrialization based on domestic agriculture.
1963	1963 and 1973 I–O tables. Values for parameters were derived from the data base and other sources were used.	The effects of foreign capital inflows in a dynamic framework. 1) A smoothing of the volume of foreign capital imported with maintenance of the corresponding cumulative volume of capital between 1963–1973; and 2) a reduction of the volume of foreign capital imported 38 per cent lower than the observed volume between 1963–1973.	There are comparable effects on GDP in both cases. In the second case, there are more favourable effects on the external trade balance.

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
49	Chenery *et al.* (1986)	Korea	Nested CES production functions.	8	Derived from Cobb–Douglas utility functions.	1
50	Hamilton (1986)	South Korea	Generalized Leontief functions.	39	Fixed Co-efficient.	1
51	Chao *et al.* (1982)	South Korea	Cobb–Douglas production functions.	7	Generalized CES from yielding systems of expenditure with price and income elasticities. Addilog expenditure system.	3
52	De Melo (1977)	Colombia	Nested Cobb–Douglas production functions.	12	LES Demand System.	1

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1963	I–O data and various other data sources were used. Various sets of elasticity parameters were used from other sources.	The effects of three different strategies, namely, import substitution, balanced and export promotion over long-run.	Results show only moderate variations in aggregate growth rates under different strategies. They also indicate the importance of interactions between foreign capital inflows and domestic investment. According to results, policies designed to 'get the prices right' may be necessary to achieve growth and structural change, but there is no conclusion on their efficiency.
1966 and 1978	SAMs based on 1966 and 1978 I–O tables. Values for major parameters were derived from the base years' data.	A 20 per cent reduction in the value of competitive imports of machinery and transport equipment in the short-run and long-run.	In the short-run, import-competing activities are adversely affected and reduction in real wages and prices can be observed. In the long-run, renewal of import-competing industries can be seen.
1973	I–O data. Main parameter values were derived from the base year data.	Examination of development in South Korean economy between 1973 and 1982 using a CGE.	This model is able to reproduce the observed development of the South Korean economy except the under estimation of the growth rate and exports. This is mainly due to the fact that this model does not consider export incentives.
1970	I–O data. Values for parameters were taken from base year data base and other sources.	Removal of wage differentials among skilled and unskilled workers with or without internal labour mobility factor.	The results indicate an increase in GDP, rate of return to capital. If there is a labour mobility, some export activities move from net exporters to net importers position, and vice versa.

(*continued*)

Table 1. (*Continued*)

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
53	Grais (1981)	Thailand	Generalized Leontief functions.	4	Non-linear expenditure system developed by Carlevaro (1976)	1
54	Drub & Grais (1983)	Thailand	Generalized Leontief functions.	4	Non-linear expenditure system developed by Carlevaro (1976).	1
55	Sussangkarn (1983)	Thailand	Nested Cobb–Douglas production functions.	3	Derived from Cobb–Douglas utility functions.	1
56	Bourgeug-non *et al.* (1983)	Venezuela	'Putty clay' production functions.	65	Not specified.	200
57	Ahmed *et al.* (1985)	Egypt	Nested Cobb–Douglas production functions.	8	Non-linear expenditure system developed by Carlevaro (1979).	1
58	Narayana *et al.* (1987)	India	Not specified.	10	LES Demand System.	10

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1975	SAM of 1975. The majority of parameter values were derived from the data base and best guesses were used.	The effects of increase in indirect taxes on petroleum, export tax cut and reduction in government expenditure.	Policy of export tax cut has the strong favourable effects in terms of correcting a slowdown in agricultural activity and GDP.
1975	SAM of 1975. The majority of parameter values were derived from the data base and best guesses were used.	The impact of 5 per cent increase in the value of 12 policy instruments including various direct and indirect tax rates, public sector consumption etc. and change in the value of some of the parameters.	More efficient use of intermediate inputs is the more effective strategy in terms of growth, price and balance of payments.
1975	SAM of 1975. The majority of parameter values were derived from the data base and best guesses were used.	A 5 per cent increase in the number of civil servants.	Real wages for secondary school graduates increase.
1975	No specified data source. Estimated behavioural parameters using available data.	An examination of structural changes in the economy between two points of time.	The results prove that the CGE models are powerful tools in the analysis of structural changes and inter-sectoral linkages.
1979	A SAM for 1979. Other sources were used for the values of some parameters.	The short-run effects of an increase in public sector prices, an increase in public company investment, a reduction of public borrowing from the public sector, an increase in net foreign borrowing, devaluing the exchange rate, a combined package. The effects of similar policies in the medium term.	An increase in public sector prices tends to contract the economy. The removal of distortions yields substantial gains. The long-term growth depends on numerous government interventions in the economy.
1980	Parameters of the behavioural functions related to supply and demand were econometrically estimated and used various data sources.	1) The effects of four policies of food grains purchasing and subsidised distribution to consumers with a limited amount. 2) The effects of four foreign trade and aid policies.	The results show that the income distribution improves under-procuring and freely distributing 100 kg of grain per capita per year and financing costs through additional taxation with no reduction

(continued)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
59	Rattso (1987)	India	Not specified.	5	LES Demand System.	3
60	Rattso (1988)	India	Not specified.	5	Les Demand System.	3

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
			in growth. However, the same distributional policy has negative impact on growth if it is financed by a reduction in investment. The results of four trade policy simulations show that there is no presumption that the trade liberalization improves social welfare. The increase in aid unambiguously improves the social welfare in urban areas and worsens it in rural areas with ambiguity.
1980/81	SAM of 1980/81 and National Accounts Data from 1980/81 to 1984/85.	Three alternative policy simulations were carried out: 1) expansionary fiscal policy (by increasing government purchasing by 1 per cent); 2) an increase in food production by 1 per cent; 3) an increase in government investment by 1 per cent, which is financed by a gradual increase in profit tax.	A more expansionary fiscal policy would have stimulated both the production and inflation during 1982–85. Higher growth of agricultural production seems to have favourable macroeconomic effects in India. It reduces inflationary pressure in the economy. Increase in government investment financed by taxes may accelerate growth without inflationary pressure. In general the conclusion is that the macroeconomic development may be improved by strengthening the growth of agriculture.
1980/81	Sam of 1980/81 and National Accounts Data from 1980/81 to 1984/85.	The effects of: 1) an expansionary government demand; 2) change in investment strategy of government; 3) increase in private investment in agriculture.	The results of 1) are as above. The real location of investment in favour of agriculture affects industrial structure and the overall economic performance. It lowers inflation. An increase in investment in agriculture alone stimulates growth rate with inflationary pressure.

(*continued*)

Table 1. *(Continued)*

			SUPPLY SIDE		DEMAND SIDE	
STUDY NO.	AUTHOR(S)	COUNTRY	PRODUCTION FUNCTION	NO. OF SECTORS	DEMAND FUNCTIONS	NO. OF SECTORS
61	Blitzer & Eckaus (1986)	Sri Lanka	Cobb–Douglas production functions.	11	Extended Linear Expenditure System (LES).	2

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Notes

1. For recent surveys, see Bergman (1985, 1988), Decaluwe and Martens (1987, 1988), Devarajan (1988), Janvry and Sandoulet (1986), de Melo (1988b), Pereira and Shoven (1988), Robinson (1986), Sanderson and Williamson (1985), Shoven and Whalley (1984) and Siriwardana (1985b). The material in this paper draws on previous surveys. The surveys by Decaluwe and Martens (1987) and Robsinson (1986) are especially acknowledged.
2. See Cornwall (1984) for a lucid treatment of theoretical general equilibrium analysis.
3. See de Melo (1988a), Pyatt (1988) and Pyatt and Round (1985) for detailed discussions on SAMs and Drud *et al.* (1986) for a survey on macroeconomic modelling based on the SAM approach.
4. GEMPACK is a software package which has been developed for implementing the Johansen type CGE models. See Pearson (1988) for details. GAMS is a software package which has been used for implementing CGE models at the World Bank. See Condon *et al.* (1986) for details. HERCULES is a software package which has been used for the formulation of models based on TV (transaction value) approach. See Drud *et al.* (1986) for details. OCTASOL is a general purpose of fixed-point program for solving a system of non-linear equations. See Broadie (1983) for details.
5. Impact is an economic and demographic research project which aims to improve the publicly accessible policy information system available to government, private and academic analysts. The project is conducted by commonwealth government agencies in association with the University of Melbourne, La Trobe University, and the Australian National University.

BASE YEAR	MAIN DATA BASE AND VALUES OF KEY PARAMETERS	POLICY SIMULATIONS	RESULTS
1983	I–O data. Consumer parameters were estimated using household survey data. Other data sources and I–O data were used to estimate production parameters.	Three simulations were carried out: 1) base run assuming a 1 per cent increase in world oil prices yearly; 2) the effect of increase in world oil prices annually at a 5 per cent assuming increased oil prices are not passed on to domestic economy; 3) the effects of increase in world oil prices assuming oil prices are passed on to the domestic economy.	Base run demonstrates the inter-dependency of the economy and raises some questions about the official projections. Results of simulation 2) show some contractionary effects. In simulation 3), contractionary effects of the price rise become more pronounced.

6. The presence of 'cross hauling' in international trade data implies simultaneous import and export of a particular commodity by a certain country.
7. See Brown (1988), Shoven and Whalley (1984) and Srinivasan and Whalley (1986) for details on multi-country models. Recently, de Melo (1988) has provided a lucid survey on CGE modelling for trade policy analysis in LDCs.
8. See for example, the panel discussions of the International Conference on Trade Policy Modelling in Srinivasan and Whalley (1986).

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