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Critical Review of Literature on Computable General Equilibrium Models

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The Pakistan Institute of Development Economics, established by the Government of Pakistan in 1957, is an autonomous research organisation devoted to carrying out theoretical and empirical research on development economics in general and on Pakistan-related economic issues in particular. Besides providing a firm foundation on which economic policy-making can be based, its research also provides a window through which the outside world can see the direction in which economic research in Pakistan is moving. The Institute also provides in-service training in economic analysis, research methods, and project evaluation.

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1. INTRODUCTION

The paper reviews recent empirical work, which uses computable general equilibrium (CGE) framework for policy analysis. Various models have been built and applied to address a variety of policy issues. Each model has its own advantages as well as limitations. During the last two decades, there is a proliferation of general equilibrium models developed for developing as well as developed countries. CGE models are basically the modern version of Walras' model of the competitive economy. The first serious attempt to use a large CGE model to study a real economy appears to be Johansen (1960). For several years following, CGE models did not receive much attention. Then, Shoven and Whalley (1972), Whalley (1975, 1977), Shoven (1976), and Miller and Spencer (1977), were among the earliest policy-oriented computable general equilibrium studies. Subsequently, the number of CGE models of national economies exploded. Naqvi (1998) mentioned four main branches of CGE models. First, Johansen's multi-sectoral growth model. This model focuses on sectoral allocation of capital and labour and distribution of sectoral output. Second, Harberger-Scarf-Shoven-Whalley models, which have their roots in welfare economics. Third, Jorgenson approach to modeling relates to econometric estimation. Finally, Ginsburgh and Walbroek approach to modeling relates to linear programming framework.

The literature on CGE models has been surveyed by many authors. For example, Shoven and Whalley (1984) reviewed the early national CGE literature. Their review mainly focused on taxation and trade. Pereira and Shoven (1988) specifically surveyed studies related to dynamic CGE modeling of national tax issues. de Melo (1988) surveyed the contribution of CGE models to quantification of trade policy scenarios in developing countries. Decaluwe and Martens (1988) presented a comprehensive survey of CGE models. They discussed country specific economic structure of production, private consumption, external trade blocks, and type of closure rules. Devarajan (1988)

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surveyed energy CGE models and their applications. Bandara (1991) surveyed CGE studies of development policies in LDCs. Robinson (1991) surveyed "micro-macro" CGE models that incorporate assets market and product and factor markets. Kraybill (1993) compared the regional CGE approach to input-output analysis and regional issues. Bhattacharyya (1996) reviewed CGE studies of energy and environmental issues. Recently, Partridge and Rickman (1998) review regional CGE modeling to examine regional economies and regional policy issues. Other recent reviews on CGE literature are by Shoven and Whalley (1992), Dixon and Parmenter (1996), and Ginsburg and Keyzer (1997). Among others, issues of public finance and taxes, international trade policies and tariffs, regional development, energy, and environmental policies have been addressed in the context of CGE framework.

This paper attempts to focus on areas which have received relatively little attention in these surveys such as the issue of income distribution in developing economies. In addition, our main focus will be on limitations and weaknesses of CGE models developed so far. The plan of the paper is as follows. Following introduction, Section 2 discusses the need for CGE model. Section 3 describes CGE modeling and effects of adjustment programmes on income distribution. Literature on CGE models for Pakistan are discussed in Section 4. Regional CGE models developed under MIMAP projects are summarised in Section 5. Comments on CGE literature are given in Section 6. Final section gives concluding remarks.

2. NEED FOR CGE MODEL

Professionals and policy makers are commonly interested in the direct and indirect effects of specific policy measures. Often these effects are studied in partial setting. The CGE models have the advantage that specific policy measures as proposed can be accommodated without excessive simplification and aggregation. The classification can respond closely to the one the policy maker is used to. Using CGE-models not only has the advantage that general equilibrium effects are taken into account but also that the interaction of different measures can be studied. Further, the complexity of the micro-macro interrelationships can be relatively better performed through computable general

equilibrium modeling framework. In a data-rich country, macro and micro data can be combined to construct a CGE model to generate quantitative estimates of the impact of adjustment policies. Rust (1997) states the need of an economic model as follows: 'To have a complete understanding, we need to be able to calculate detailed implications and predictions of these abstract theories and determine whether the predictions of these models are consistent with what we observe in the real world. So we can not pretend to have a complete understanding of real economies until we can show that the detailed implications of our theories provide sufficiently accurate representations of the real world that we could take our models seriously for forecasting and policy analysis'. Similarly, Shoven and Whalley (1992) stated '… the virtue of using applied general equilibrium models is that, once constructed, they yield a facile tool for analysing a wide range of possible policy changes. Such analysis generates results that either yield an initial null hypothesis, or challenge the prevailing view. It may be that subsequently the conclusions from the model are rejected as inappropriate; the assumptions may be considered unrealistic, errors may be unearthed, or other factors may undermine confidence in the results. But there will be situation in which the modeler and those involved in the policy decision process will have gained new perspectives as a result of using the model'.

Recently, the introduction of economic liberalisation policies in the most developing countries has increased the need to analyse their impact in these countries, in particular, the effects of adjustment policies on welfare, equity, and income distribution. Thus, to represent the complex market-based interactions of mixed economies and the kinds of policy interventions that are feasible, economists have developed the CGE models. These models have many forms, from relatively simple models of a few equations to models as comprehensive. The key technical innovation of CGEs is that they escape the constraints of linearity. A CGE model can be much better representation of real economies than its linear predecessors. Nowadays, CGE models have become a standard tool, in particular, due to the availability of specifically designed software packages. But keeping in view the complexity of micro-macro policy issues, no one model can answer all the questions addressed in adjustment programmes.

3. CGE MODELING AND EFFECTS OF ADJUSTMENT PROGRAMMES ON INCOME DISTRIBUTION

There has been much development in "macro-micro CGE models" during the last decade. The principal impetus for development of CGE model comes from the general perspective of negative impact of adjustment programme on income distribution and poverty. In Particular, the maquette financial CGE- model developed by Bourguignon *et al.* (1989) and the extension of that model by Fargeix and Sadoulet (1990) represent significant advances in the modeling of the impact of structural adjustment policies on economic performance and distribution of income. They extended the CGE model by incorporating loanable funds market to a CGE framework, which already incorporates flow equilibria in factor and product markets.

Since 1980, a number of countries have adopted structural adjustment policies to correct the structural imbalances in the economy and to bring their derailed economies back to a sustainable growth path. Some studies show that adjustment programmes are not beneficial for the country as a whole that adopt adjustment policies. These studies also show that the programme hurts the poor segment of population the most.

de Janvry, Fargeix, and Sadoulet (1991) developed a CGE model to study the choice mix and timing of instruments for adjustment and have applied it to Ecuador. The consequences for economic growth, welfare of the poor, and political responses are examined. The model includes a financial portfolio model to endogenise the inflation rate and the interest rate. The results show that cuts in current fiscal expenditures are best for long-run growth. Monetary restraint has more diffuse income effects but is worse for growth because private investment declines as interest rate rises. In the longer-term, however, inflation control from monetary restraint has a beneficial effect on investment. These policies have different effects on sectoral poverty. Rural poverty is best aided with fiscal cuts in current expenditure, but urban poverty suffers in this scenario from the loss of public goods benefits, demand contraction, and exchange rate devaluation. But the result reveals a policy conflict: the rural poor and the state (which prefers growth) favour current fiscal cuts, and the urban poor and the politically dominant urban middle and rich prefer no adjustment in the short-run. These types of conclusions reflect the advantages of the CGE model.

Bourguignon, Branson, and de Melo (1989) developed macro model and Bourguignon, de Melo, and Suwa (1989) used it to simulate adjustment for two archetype[1] economies: a low income African country and a middle income Latin American country. The general results of the model are that devaluation helps the poor (especially in the low income country) because they are located in the exporting industry. Import rationing worsens inequality because premium accrues to capitalists, and uniform government expenditure cuts have little effect on income distribution in the low income country but are bad for the middle income modern sector workers. With real wage and price rigidity, government expenditure cuts cause a great increase in inequality and in the number of the poor because of unemployment and lower growth, and because capitalists are better able to protect their income since markup pricing protects profits. A similar model with special emphasis on distributional issues is developed by Dervis, de Melo, and Robinson (1982) and de Melo and Robinson (1982) who used a CGE model for three archetype economies: a primary exporter, a manufacturing exporter and a closed economy. They found that the distributional implications of an external shock depend on the initial structure of the economy and the choice of adjustment policies.

Adelman and Robinson (1988) investigated the issue of whether macro closure rules affect the distributional outcome of the model. They set up a CGE model and found that the size of distribution is insensitive, but functional distribution is very sensitive to macro closure rules. They also found that the balance of payments closure is at least as important as the savings-investment closure rule for the distributional outcome.

Under the OECD project, a common CGE framework was developed and applied to various countries. This framework is used by Meller (1991) for Chile, Lambert *et al.* (1991) for Cote d'Ivoire, Janvry *et al.* (1991) for Ecuador, Thorbecke (1991) for Indonesia, Demery and Demery (1991) for Malaysia, and Morrisson (1991) for Morroco. These studies used CGE model to capture the short-run and medium to long-run effects of stabilisation and structural adjustment policies on distribution of income in these

[1]Archetype models have been developed which do not describe a specific economy but are designed to explore numerically particular policy issues.

countries. The main concern in these studies is modeling the impact of adjustment policies on income distribution. These studies also help to improve the knowledge about the equity and efficiency effects of adjustment programmes. The OECD studies are summarised in Table 1 and brief description is given below.

Meller (1991) argued that the adjustment measures of the 1980s in Chile were regressive even though the government was successful in targeting its expenditures towards the very poor during the period of fiscal retrenchment. Among the regressive adjustment measures, the subsidies to holders of dollar denominated debt provided by the central bank. In addition, policies to reduce expenditures raised the unemployment rate, reduced real wages, and reduced per capita health, housing and education budgets. Finally, the required real devaluation raised the cost of living for the poor. Morrison (1991) found that the combination of a short-term stabilisation programme (devaluation, reductions in public investment, and slower growth in domestic credit and government employment) and medium-term structural adjustment measures (liberalising trade, agriculture, and financial markets) reduced internal and external deficits while maintaining economic growth and preventing an increase in poverty in Morocco. He also emphasised that the timing of the adjustment programme was suited to the exogenous shocks Morocco faced and helped to keep the social cost of adjustment low.

Demery and Demery (1991) used an applied general equilibrium model to assess three counterfactual policy packages against the chosen package in the case of Malaysia. They found that preemptive adjustment, milder fiscal restraint, and stiffer taxes to raise revenue hurt the poor most. But the government's chosen policies for cutting and switching expenditures and devaluing the exchange rate thus did much to protect the poor in Malaysia. Lambert *et al.* (1991), using the simulation CGE model, looked at the impact of three critical policy measures in Ivorian experience. Simulation results suggested that a cut in current expenditure through a reduction in the wages of public employees reduced income inequality but ineffective in reducing poverty. An increase in export taxes was distributionally regressive. Only depreciation reduced both income inequality and poverty in Cote d'Ivoire. Using a highly disaggregated CGE model for Indonesia, Thorbecke (1991) explored the impact of stabilisation and structural

Table 1

CGE Models for Developing Countries and the Impact of Adjustment Policies on Income Distribution and Poverty

Country	Author	Policies Used for Simulation	Impact on Income Distribution and Poverty
Two archetype economies	Bourguignon *et al.* (1989)	1. Devaluation 2. Government expenditure cuts	Devaluation helps the poor and expenditure cuts have little effects on income distribution but are bad for the middle income modern sector workers.
Three archetype economies	Dervis *et al.*(1982)	1. Distributional implications of external shocks	Distributional implications of external shocks depend on the initial structure of the economy and the choice of adjustment policy.
Archetype economy	Adelman and Robinson (1988)	2. Effects of macro closure rules	Size distribution is insensitive but functional distribution is very sensitive to macro closure rules.
Cote d'Ivoire	Lambert *et al.* (1991)	3. Cut in current expenditure 4. Increase in export tax 5. A currency devaluation	Simulation results suggest that a cut in current expenditure through a reduction in the wages of public employees reduces income inequality but ineffective in reducing poverty. An increase in export taxes is distributionally regressive. Depreciation reduces both income inequality and poverty.
Ecuador	Janvry *et al.* (1991)	6. Transfer of income to the poor 7. Reduce current expenditure	Reduction in current expenditure is the best for restoring growth and protecting the rural poor.
Indonesia	Thorbeck (1991)	1. Reduce expenditure 2. Increase public investment 3. Exchange rate devaluation 4. Monetary contraction 5. Monetary expansion	Results reveal that the selected adjustment package was successful in restoring equilibrium and improving income distribution.
Malaysia	Demery and Demery (1991)	6. Preemptive adjustment, milder fiscal restraint and stiffer taxes to raise revenue 7. Expenditure cutting and switching 8. Devaluation in the exchange rate	All three counterfactual analyses suggest that the poor, specially those engaged in agriculture, are hurted more under the alternative policies but cutting and switching expenditure and devaluation protected the poor.
Morroco	Morrisson (1991)	1. Devaluation 2. Reduction in public investment 3. Slower growth in domestic credit 4. Liberalising trade, agriculture, and financial markets	The adjustment policies reduced internal and external deficits while maintaining economic growth and preventing an increase in poverty.
Chile	Meller (1991)	1. Devaluation 2. Expenditure cut	Expenditure cuts hurt the poor most and devaluation raised the cost of living for the poor.

adjustment policy packages. The impact of six alternative policy scenarios (i.e. reduced aggregate expenditure, increased public investment and reduced current expenditure, reduced public investment and increased current expenditure, accelerated devaluation, monetary contraction, and monetary expansion) revealed that, by and large, the selected adjustment package was successful in restoring equilibrium and improving income distribution. Janvry *et al.* (1991), using CGE model for Ecuador, found that reduction in current expenditure is the best for restoring growth and protecting the rural poor.

In sum, simulation results of these studies vary greatly across the countries, ranging from the cases of Chile and Ecuador, where the evolution was not favorable, to the countries like Indonesia and Malaysia, where improvement occurred during adjustment. Simulating the effects of alternative policies provides rational grounds for comparing their costs and benefits. All these studies show that the distributional impact of adjustment depends on assumptions about institutional structure and market adjustment mechanism. Counter factual analysis shows that the social cost of adjustment could have been lower than those that were actually observed. Moreover, simulation of "no-adjustment" scenario resulted in much higher cost.

4. LITERATURE ON CGE MODELS FOR PAKISTAN

Unfortunately, in case of Pakistan, we have a very few studies which have used CGE models for policy analysis. Table 2 presents studies based on CGE Model for Pakistan. Naqvi (1998) developed a CGE model for the Pakistan's economy based on SAM for the year 1983-84. The model is originally intended as a tool for energy policy analysis in the general equilibrium framework. The model represents a disaggregated structure of the economy and provides interesting results. It shows that distributional effects of eliminating discriminations in taxes on energy products vary across the products. It shows that distortions in taxes on petroleum products meet social equity objective. Removal of distortions in taxes on electricity have negative effects on real per capita consumption of all urban income groups, but not for the rural region. Tax reforms for natural gas have negative impact on real per capita consumption of all households.

Table 2

CGE Models for Pakistan

Authors	Policy Focus	Main Alternative Policies	Simulation Results
Naqvi (1998)	Energy Sector	1. Tax reforms in energy sector of Pakistan	1. Results show that kerosene is the best candidate to increase tax revenues when social equity is not considered. 2. On the other hand increase in tax on kerosene is least desirable as it is not beneficial for the low income group. 3. While natural gas is the best candidate to increase tax revenue as well as has minimum welfare cost.
Vos (1998)	Dutch Disease Effect	1. Exchange rate depreciation 2. Additional foreign assistance	1. Additional exchange rate depreciation would mainly produce cost-push inflationary tendencies, erosion of real incomes and aggregate demand outfall in the medium run. 2. Additional foreign assistance would generate strong Dutch disease effects
McCathy and Desmond (1980)	Food policy issues	1. Abolition of subsidies on consumer price of rice 2. With or without increase of public expenditure on nonagricultural goods 3. Increase in nominal wages. 4. Land reforms 5. Increase in fertiliser subsidy. 6. Increase in rural and urban public expenditure	1. Largest redistributive impact is through land reforms.
Labus (1988)	Public sector enterprises	3. Fiscal incentives to promote export 4. Price liberalisation (lifting government price control)	3. Squeeze aggregate final demand. 4. Wages and rental rates decline. 5. Main result with this counterfactual analysis is that new policy measures converted losses of enterprises into their profits.

Further, removal of tax-distortions improves the balance of trade and increases real GDP. Besides certain limitations in the theoretical structure of the CGE model, it is built on old data for 1983-84 SAM and some data values are based on 'best guess', for example, for the hydro-electric industry. It assumes that supply of labour for each profession can be either horizontal or vertical. The model represents only real side of the economy. This model is only suitable for comparative static analysis and can not be used for the forecast purposes. So improved estimates of the values of the model's parameters are required to enhance the usefulness of this model.

Vos (1998), using the financial CGE model, analyses the mechanism of aid flows and Dutch disease effect in Pakistan. The simulations show that the growth of Pakistan's economy was not foreign exchange constrained during the 1980s. Rather, it indicates that additional foreign assistance would generate strong Dutch disease effects and hence would counteract structural adjustment policies in pursuit of greater competitiveness and an expansion of traded goods production. The results also show that additional exchange rate depreciation would mainly produce cost-push inflationary tendencies, erosion of real incomes and aggregate demand outfall in the medium run. Further, the model simulations also suggest across-the-board fiscal cuts are likely to be deflationary, whereas a shift from public consumption to public investment would generate positive growth effects. Due to predominance of supply constraints in the Pakistan economy, a shift from current to capital spending by the government would allow for lower inflation, crowding in of private investment and an expansion of traded goods production. Furthermore, debt reduction would have a positive impact in the medium run in Pakistan, mainly because it allows for higher investment levels as budget constraints on both private and public enterprises are lifted.

The model developed by Labus (1988) presents a behavior model of the public sector in Pakistan. Public sector is defined as a set of state owned enterprises in manufacturing and other activities. This study attempts to assess macroeconomic impact of the public enterprises in the Pakistan's economy. These enterprises are highly capital intensive with low labour capital ratios. This paper analyses the issues of price liberalisation policy and public sector price policy, using a SAM based CGE framework. This model belongs to a family of structural economy wide multi sector planning models. It disaggregates production activities for private and public sectors of the economy into analytically desirable and empirically feasible number of sectors. It also disaggregates

factors of production into labour and capital, while factor prices are flexible. The paper analyses the issue of price policy in activities where prices are under extensive government control. The key issue focused on is related to the problem of public sector enterprise losses. In the simulation exercise, it assumes that the government of Pakistan introduced a set of fiscal incentives to change supply responses of those activities and at the same time government price control is removed. Results of counterfactual analysis in this study suggest that traditional macroeconomic demand management based on fiscal policy, followed with appropriate income policy measures, could assist price liberalisation policy designed for public sector enterprises. Further, it promotes faster growth of export oriented activities and changes the losses of enterprises into profit. The results show that the first impact of squeeze in aggregate final demand is the downward adjustment of output production in affected activities. This reduction leads to a fall in wages and rent. Overall results show that liberalisation policies improve current account balance, reduce prices, and increase real GDP due to faster growth of export oriented activities. Main result is that it converts the losses of public enterprises into profits. Looking the model critically, there are only two factors of production, which are sector specific. They do not match the standards of perfect competitive factor markets, and factor mobility across sectors and activities are not significantly high. Only three types of institutions are included in this model i.e., households, enterprises, and government. Capital account reflects only the current account position of the private and public sectors. Household sector is disaggregated by region not by socioeconomic groups. CGE model developed in this study, like many others, is of " comparative static model". It does not include time dimension. This does not analyse welfare cost with the change in policy. Only one version of the model with respect to macroeconomic closure rules was developed, i.e. public investment driven model with fixed exchange rate.

CGE model developed by McCathy and Taylor (1980) focused on food policy planning. In basic needs, food comes first in priority. This study built a CGE model around SAM for the year 1975-76 to determine the impact of food policy changes in Pakistan. It is an open economy model with the government sector. In this framework, industrial sector is disaggregated into eleven sectors (i.e. wheat, rice, sugar, cotton, other agriculture, fertilisers; wheat, rice, and sugar processing into food for consumption, other rural economic activity, and other urban economic activity).

Household sector is disaggregated into 3 socio-economic classes for each rural and urban areas of Pakistan. This study focuses on how consumption pattern of households changes with the changes in price and real income. Model is simulated by eliminating subsidies on wheat, increasing government expenditure, simultaneous reduction in wheat subsidy and increase in government expenditure, wage increase, increase in fertiliser subsidy, and Land reforms. The results show largest redistributive impact with land reforms.

5. CGE MODELS DEVELOPED UNDER REGIONAL MIMAP PROJECTS

A number of CGE models have been developed under the Micro Impact of Macroeconomic Adjustment Policies (MIMAP) projects in Pakistan, Bangladesh, Philippines, and India.[2] These models are summarised in Table 3. The regional MIMAP projects are being financed by International Development Research Centre (IDRC), Ottawa, Canada. The simulation results of the impact of various adjustment policies on income distribution and poverty estimated through regional CGE models are descibed below.

MIMAP-Pakistan CGE Model

The first CGE model (with the aggregate household sector) under MIMAP project was developed by Siddiqui and Iqbal (1999) in the case of Pakistan. The simulation results show that reduction in tariff rate reduces household income through decline in wages and dividends. But percentage decline is greater in income from dividends as compared with a decline in income from wages. As higher percentage share of income from dividends goes to the rich people and higher percentage share of wages and salaries goes to the poor segment of population, this implies that the fall in income of the poor is less than the fall in income of the rich. This model has been recently extended with further disaggregation of the household sector by Siddiqui, Siddiqui, and Iqbal (1999). The simulation results with extended CGE model show that the impact of changes in relative prices is disproportionately higher for higher income groups. Further, it shows that the reduction in tariff may reduce the gap between the rich and the poor.

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[2]It is possible that some more regional CGE models are developed under the MIMAP project but in this paper we summarise CGE models that are readily available.

Table 3

CGE Models Developed under MIMAP Projects

Authors	Policy Focus	Main Alternative Policies	Simulation Results
Siddqui and Iqbal (1999)	Trade liberalisation	Reduction in tariff	Tariff reduction reduces overall household income but reduction in income of rich is greater as compared to income of the poor.
Siddiqui, Siddiqui, and Iqbal (1999)	Trade liberalisation	Reduction in tariff	Tariff reduction reduces the gap between the rich and the poor.
Mujeri and Khandaker (1998)	Trade Liberalisation	Tariff liberalisation	Tariff liberalisation appears to favour the high income household groups compared with low income household groups.
Cororaton (1998)	Trade reforms	Change in implicit tariff	The effect of a change in implicit tariff on income distribution appears to be progressive.
Pradhan and Sahoo (1998)	Tax reforms	Tax concessions and provision of subsidies	In general, tax concessions for sectors and subsidies to the food grains improve the welfare and growth.

MIMAP-Bangladesh CGE Model

Mujeri and Khandaker (1998) developed a CGE model for Bangladesh. Various simulation exercises show that tariff liberalisation appears to favour the high income household groups (e.g. professional, services, and large farm) compared with low income household groups (agricultural labour, semi-skilled and unskilled workers). The results also tend to suggest that the poverty alleviation effects under different sectors as well as under alternative poverty measures may be significantly varied.

MIMAP-India CGE Model

CGE model of India developed by Pradhan and Sahoo (1998) shows that, in general, tax concessions for sectors and subsidies to food-grains improve the welfare and growth. However, reduction in taxes on production and imports of capital goods seem to not increase the welfare of the households, particularly of rural households. Slashing of import duties on the import of commodities, in many cases, do not lead to rise in welfare

as well as growth simultaneously. The model establishes that human capital formation contributes significantly to rise in both welfare and growth. The increase in government expenditure on education and health increase the wellbeing of the households. Further, excessive expenditure on subsidies also results in the decline of welfare of the households.

MIMAP-Philippines CGE Model

The Philippines CGE model developed by Cororaton (1998) shows that the impact of a change in implicit tariff on income distribution over the period 1990-2000 is generally progressive, except on the first decile, the lowest income group. The income share of the second to the seventh income groups increased, while the share of the eighth to the tenth declined during the period under consideration. The income share of the first decile declined. However, there are differences within sub-periods.

6. COMMENTS ON CGE LITERATURE

Although, CGE models have provided unique insights into the possible effects of a variety of macroeconomic policies, as of yet, it is not clear whether the quantitative predictions of CGE models are superior to those obtained with other methods. Indeed, CGE models have raised the sophistication of the policy debate, it has not yet been demonstrated whether more credence should be given to CGE insights or quantitative predictions. CGE models are among the most influential tools in applied economics but some serious questions have been raised about the empirical validity of these models. Therefore, many issues must be addressed before more confidence can be placed in the results of CGE models. It does not mean that other modeling approaches (e.g. Input-output and SAM models, macroeconometric models, general equilibrium models) are not confronted with similar issues. Whalley (1985) viewed the criticisms aimed at CGE models as part of the larger debate concerning the contributions of empirical economics in general. For Whalley and others, the insights that CGE models provide are sufficient to merit their use. Nevertheless, given the continued demand for quantitative predictions by policy makers, we discuss below the most critical limitations that CGE models entail.

A CGE model embodies three types of information: analytical, functional, and numerical. The analytical structure is the background theoretical material which identifies the variables of interest and posits their causal relations. The functional structure of the model is the mathematical representation of the analytical material and consists of the algebraic equations which make up the actual model. The numerical structure consists of the signs and magnitudes of the coefficients in the equations which form the functional structure. The critics of CGE models mainly pose their attention to functional and numerical structure of the calibrated CGE model. Main comments on CGE framework are indicated in the following.

(i) Quality of Data: The quality of the model is partly dependent on the quality of the data for an arbitrarily chosen benchmark year. Since there are always stochastic anomalies and extraordinary economic events associated with any one year of a time series, this will detract from the validity of generalisation drawn from the model. In addition, the data matrices often go through various scaling process to force micro-consistency, introducing untraceable biases into the rows and columns. These biases will directly influence the parameters of a calibrated model.

(ii) Choice of Parameters: In the CGE model, some parameters are determined on the basis of a survey of empirical literature, some are chosen arbitrarily, and the remainder are set at values which allow the model to replicate the data of a chosen benchmark year. This approach has been criticised by, among others, Jorgesen (1984), Lau (1984), Jorgensen *et al.* (1992), Diewert and Lawrence (1994), and Mckitrick (1998), on several grounds. First, modelers often use elasticities estimated from commodity and or industry classifications which are inconsistent with those maintained in the model, and/or obsolete estimates from past literature or outright guesses when no published figures are available. These expediencies detract from the ability of the model to represent the real tastes of the economy under study. Also, users of the simulation results have virtually no way to assess the evidence supporting the choice of most parameter values.

(iii) Choice of Functional Forms: In most of the CGE models, researchers use first order functional forms, in particular, constant elasticity of substitution (CES), which embodies restrictive assumptions about the structure of the industries being modeled, by imposing a single non-negative substitution elasticity across all pairs of goods in the aggregator. Mansur and Whalley (1984) presented a comparison of a small (one consumer, two sector) CGE model where one version is calibrated and the other is estimated but each uses CES-class functional forms; estimates of tax-induced welfare losses nevertheless diverge considerably for some periods. In his recent article, Mckitrick (1998) undertakes a series of comparative simulations which show that the functional structure appears to strongly influence the results from a policy simulation at both the industry-specific and macroeconomic levels, for large and small policy shocks. In this regard, McKitrick (1998) and Perroni and Rutherford (1995) suggest that a preferred alternative would be to use flexible functional forms, such as the translog or normalised quadratic, which have enough free parameters to provide a second order approximation to any underlying preference or technology aggregator function, and consequently can represent all the relevant own- and cross-price elasticities derived from an arbitrary utility or profit function, without imposing prior constraints.

(iv) Calibration of the Model: Considerable debate exists in the CGE modeling literature regarding the appropriateness of calibrating CGE models to a benchmark year data set. As noted by Lau (1984), Hansen and Heckman (1996), and Partridge and Rickman (1998), reliance on one year data makes the system underidentified. Moreover, the benchmark year may not reflect the normal structure of the economy. Some modelers have suggested that system-wide econometric estimation of a CGE model may avoid this inconsistency by incorporating cross-equation restrictions in the estimation process. But system-wide estimation is yet more problematic, in particular, at the regional level where price and quantity data are more scarce. Another practical remedy associated with calibrating to a single benchmark year is to use averages of benchmark years as used Mansur and Whalley (1984). However, the statistical properties of this procedure are unknown as indicated by Lau (1984) and Hansen and Heckman (1996).

(v) Static CGE Model: The CGE models formulated so far are basically static (a temporal). In many applications, the models indeed apply to a single period which may range from a year to a lifetime. Static CGE models can address questions of what happens to an economy as it moves from one state of exogenous conditions to another, i.e. comparative static analysis. By design, however, comparative static analysis omits the time path of response. The introduction of dynamic behaviour in a CGE model is an attempt to incorporate the time dimension in policy analysis. Moreover, CGE model must include dynamic behaviour if they are to be used for forecasting. The most pervasive aspect of dynamic CGE models is dynamic household behaviour. Several concerns arise in the incorporation of dynamic behaviour. It has been common in the CGE literature to first calibrate to benchmark data for one year and then to simulate a balanced growth path given existing exogenous conditions. Therefore, the CGE model must be calibrated to a growth path, not just one year of data as pointed out by Pereira and Shoven (1988). Some modelers have established the time path through the "sequencing" of equilibria. That is, in each period, an equilibrium is calculated given existing supplies of capital and labour. When the supplies of capital and labour are updated, a new equilibrium is calculated. The sequence of equilibria gives the time path of the economy. Yet, the timing of factor augmentation if often arbitrary set, an equilibrium is assumed to occur in each period, rather than being empirically established. In such cases, expectations are typically assumed to be rational, which reduce to perfect foresight in nonstochastic models. Structural features are often based more on convenience than on any prior knowledge about economies. Thus, it seems advisable to choose as short a time period as the data allow and to reserve the use of static models to single, short period applications.

(vi) Neoclassical Theory: Generally, most CGE models use neoclassical specifications. Although neoclassical theory may be well known and understood, it may not necessarily be a more accurate reflection of the economy as indicated by Hanson and Heckman (1996). Extreme closure rules commonly adopted in neoclassical CGE models are proved relatively less accurate.

(vii) Sensitivity of Results: CGE applications often do not examine the sensitivity of their results to alternative parameterisations. Where performed, sensitivity analysis is usually limited to simply judgmentally changing a few key elasticities. With this procedure, however, one can never be sure that the elasticties selected are the important ones. More extensive sensitively analysis can be performed by changing each elasticity conditional upon the base values of the remaining elasticities. Yet, it is unclear whether the particular combinations of elasticity values are biased toward some outcome. Correspondingly, it is unclear how much the parameters should be changed to demonstrate the robustness of the results. To be sure, sensitivity analysis have been found to be overly optimistic about the robustness of CGE results as indicated by Wigle (1991), and Partridge and Rickman (1998). For a correct assessment of the robustness of results, all possible combinations of feasible values of elasticities should be used, i.e. unconditional sensitivity analysis. For example, McGregor *et al.*(1996) employed the unconditional sensitivity approach. They assumed uniform distribution of thirty-nine elasticities, which require the modelers to specify the range of possible values of the elasticities. Although, direct comparison of CGE predictions to econometric estimates may be problematic, some comparison should be made to assess the general reasonableness of the predictions of the CGE model. Therefore, not only should there be sensitivity analysis, there should be verification of the model properties with current econometric evidence in the literature. The verification would necessitate simulating the CGE model in a manner as consistent as possible with the framework within which the econometric estimates are obtained.

7. CONCLUSIONS

From the above review of literature, no clear idea can be drawn whether adjustment programmes have had positive impact on income distribution and poverty in developing countries. In fact, each adjustment policy behaves differently in each country. Further, the success of adjustment programmes depends on initial political and economic environments in an economy.

Despite of all criticisms and limitations mentioned above, CGE models are becoming more widely used in policy analysis. CGE models have provided unique insights into the working of economies and on the possible effects of macroeconomic policies. To this end, CGE models represent a significant advancement in economic analysis. However, it is not yet clear how accurate CGE models are quantitatively, particular in comparison to other types of models. Issues of functional form, elasticity specification, closure rules, sensitivity analysis, market structure, and dynamics need to be explored more. CGE models need to be examined whether they better explain patterns in the data than other models. Also, CGE modelers need to carefully identify why their findings differ from those produced by other types of models. Much remain to be done for CGE models to move beyond simply providing new insights, and playing more of a role in policy making. Thus, CGE modelers should pay more attention to the dynamics or time-paths of relationships in an economy.

Certainly, building, applying, evaluating, and maintaining of CGE model of an economy is a huge undertaking. To date only fractions of individual careers have been devoted to the effort. It appears that institutional effort and funding is required, both for application and theory. We suggest that joint research programmes of modelers, econometricians, theoreticians, and computational economists will be necessary to sustain effective large scale CGE model of an economy.

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