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COMPUTABLE GENERAL EQUILIBRIUM MODELS OF DEVELOPING COUNTRIES: STRETCHING THE NEOCLASSICAL PARADIGM

by

Sherman Robinson

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

BERKELEY

CALIFORNIA AGRICULTURAL EXPERIMENT STATION

University of California

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Sherman Robinson
Department of Agricultural and Resource Economics
University of California, Berkeley

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Introduction

In both developed and developing countries, computable general equilibrium (CGE) models have become part of the standard tool kit of policy analysts. However, the two strands of work have been differently motivated. Past work in developed countries, with a few exceptions, has focused on efficiency questions in neoclassical welfare analysis --what might be called triangle counting. These models, by design, have stayed close to the neoclassical paradigm. What are the efficiency losses due to distortionary tax systems? What are the efficiency gains from pursuing different trade policies? By contrast, past work on developing countries has focused on structural issues. What is the impact of different choices of development strategy on growth, structural change, and the distribution of income? Given macroeconomic shocks, how do different choices of "structural adjustment" policies affect the economy? Given various rigidities, distortions, and market imperfections characteristic of developing countries, how do these countries react to different policy instruments.

In recent years, there has been a fair amount of movement across these two strands of analysis. Many developed countries have undergone macro shocks that raise issues of structural adjustment and require multisectoral models for adequate analysis.[1] Also, the current round of multilateral trade negotiations, the Uruguay Round of the GATT, has focused policy interest on questions of the structural impact of different trade regimes in developed countries. Given that the GATT negotiations, at the request of the U.S., started with agriculture, there has been active work using CGE models to explore the impact of different domestic and international agricultural policy regimes on various economies.[2]

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[1]See, for example, Goulder and Eichengreen (1989a) and Adelman and Robinson (1988a).

[2]This work is surveyed by Hertel (1989).

As the Uruguay Round continues, there will be many more such applications, including models that focus on industrial sectors.[3]

In recent years, there has also been work on welfare analysis in CGE models of developing countries, focusing largely on issues of trade and indirect taxation.[4] More generally, CGE models are starting to be used to analyze issues of optimal policy choices in developing countries characterized by various structuralist rigidities, imperfect competition, and/or the presence of externalities.[5]

In this paper, I review some of the recent work using CGE models to address issues concerning the appropriate choice of policies in developing countries. Given the importance of trade in developing countries over the past 10-20 years, much of this work focuses on trade policy. Since many developed countries are currently facing similar problems, the review will be more issue-centered than country-centered and will mention work on developed countries where appropriate. I shall, however, limit myself to single-country models.

In the next section, I present a simple analytic model that captures the essential features of many of the single-country, trade-focused CGE models developed over the past decade. I then review recent work with CGE models, focusing on empirical work with optimizing models and on models that seek to incorporate macro features. The review is selective, discussing examples of recent work rather than trying to provide a broad survey.[6]

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[3]Work is underway on these issues at the U.S. International Trade Commission and the OECD. Earlier trade-focused CGE models of developed countries are surveyed by Shoven and Whalley (1984). Recent models are surveyed by Whalley (1989).

[4]Some specific examples will be discussed below. For general surveys, see Newbery and Stern (1987) and Heady and Mitra (1987).

[5]One impetus for this work has been the development of the General Algebraic Modelling System (GAMS) software, which can be used to solve CGE models within an optimizing framework. See Brooke, Kendrick, and Meeraus (1988).

[6]Robinson (1989) provides a general survey of work with multisector models of developing countries. De Melo (1988) provides a complementary but selective survey of trade-focused CGE models of developing countries. Devarajan (1989) surveys CGE models of taxation and natural resources applied to developing countries.

A Two-Sector, Three-Good, Trade Model

De Melo and Robinson (1989a) present a simple two-sector, three-good model that can be seen as a CGE representation of the Salter-Swan (or Australian) trade model. The model has three goods and no factor markets. The country produces two commodities: (1) an export good, E, which is sold to foreigners and is not demanded domestically, and (2) a domestic good, D, which is only sold domestically. The third good is an import, M, which is not produced domestically. The country is small in world markets, facing fixed world prices for exports and imports.

The model can be presented as a standard CGE model by writing out the supply and demand equations for each market, with prices explicitly included as endogenous variables. It is also useful to write the model as a maximization problem whose solution generates a set of shadow prices that, taken with the primal, represent a competitive market equilibrium. Such a presentation, which expresses the model as a special kind of nonlinear programming problem, provides the foundation for later discussing models that can be solved for optimal policies.[7]

Programming Model Formulation

Define a composite commodity, Q, made up of domestic goods and imports and which is consumed by a single consumer. In CGE models, Q is usually a constant elasticity of substitution (CES) function of D and M.[8] Assuming that the consumer gains utility from Q, welfare is maximized when the amount of Q in

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[7]See Ginsburgh and Waelbroeck (1981) for a comprehensive discussion of the relationship between programming models and CGE models. Ginsburgh and Robinson (1984) provide a brief discussion. The models described below are available as GAMS programs. See Robinson, Hanson, and Kilkenny (1989).

[8]In a multisector model, we disaggregate by sectors and assume that imports and domestic goods in the same sector category are imperfect substitutes, following Armington(1969).

the economy is maximized. In this model, Q defines total absorption.[9] The economy faces two constraints. First, there is a production possibility frontier defining achievable combinations of D and E. Second, there is a balance of trade constraint requiring that the value of exports is adequate to pay for imports at fixed world prices. The resulting programming model is given in Table 1.

Table 1: Two-Sector, Three-Good, CGE Model as a Programming Model

Maximize $Q = F(M, D^D)$ (absorption)

with respect to: M, E, D^D, D^S

subject to:

			Shadow Price
(1)	$G(E, D^S) \leq \bar{X}$	(technology)	λ^x
(2)	$\pi^m \cdot M \leq \pi^e \cdot E$	(balance of trade)	λ^b
(3)	$D^D \leq D^S$	(domestic supply and demand)	λ^d

where:

π^m and π^e are fixed world prices of the import and export commodities,

$F(M, D^D)$ is the import aggregation function defining total absorption,

$G(E, D^S)$ is the production possibility frontier with fixed output $\bar{X}$.

Constraint equation 1 defines the domestic production possibility frontier and gives the maximum achievable combinations of E and D that the economy can supply. The function is assumed to be concave. In multisector CGE models, it is specified as a constant elasticity of transformation (CET) function for each sector. The constant $\bar{X}$ defines aggregate production and is assumed fixed. Since there are no intermediate inputs, $\bar{X}$ also corresponds to real GDP. The

[9]The model would be unchanged if we defined a utility function with total absorption, Q, as the only argument.

assumption that $\bar{X}$ is fixed is equivalent to assuming full and efficient employment of all primary factor inputs in a model with factor markets.[10]

Constraint equation 2 defines the balance of trade constraint with no foreign borrowing. The value of imports in world prices cannot exceed the value of exports. Constraint equation 3 states that demand for the domestic good, D, cannot exceed supply.

The shadow prices associated with the three constraints in the solution to the program can be shown to be equivalent to market prices in the associated CGE model which explicitly writes out the budget constraints of the various actors and all the supply and demand equations. The CGE model will have four prices: P^q, P^x, P^d, and R. These are the prices of Q, X, and D, and the exchange rate. The programming model has only three constraints and three shadow prices. Given that shadow prices are in units of the maximand, the programming model is using Q as the numeraire good and solves for three relative prices, implicitly setting P^q equal to one. The relationship between shadow prices and CGE solution prices, regardless of choice of numeraire, is given by:

$$\lambda^x = P^x/P^q \qquad \lambda^b = R/P^q \qquad \lambda^d = P^d/P^q.$$

De Melo and Robinson (1989a) analyze the properties of this model in some detail and argue that it is a good stylization of most recent single-country, trade-focused, CGE models. The assumption of product differentiation on both the import and export sides is very appealing for applied models, especially at the levels of aggregation typically used. The specification is a theoretically clean extension of the Salter-Swan model and gives rise to normally shaped offer curves.[11] The exchange rate is a well-defined relative price (the shadow price on the balance of trade constraint). If the domestic good is chosen as numeraire, setting P^d equal to one, then the exchange rate variable, R, corresponds

[10]Indeed, it can be shown that if we were to specify separate Cobb-Douglas production functions for D and E which depend on, say, capital and labor, then the implied production possibility frontier is locally a CET function. See Devarajan, Lewis, and Robinson (1989).

[11]This model, and applied CGE models that follow this general specification, certainly do not suffer from any of the problems discussed by Whalley and Yeung (1984).

to the "real" exchange rate of neoclassical trade theory: the relative price of tradables (E and M) to non-tradables (D). Trade theory models often set R to one, with P^d then defining the real exchange rate. For other choices of numeraire, R is a monotonic function of the real exchange rate.[12]

The CGE model can also easily accommodate a downward-sloping world demand curve for exports by adding an equation specifying a functional relationship between E and π^e.[13] For the programming model, however, the problem is a bit more difficult. A world demand function for exports adds a new constraint to the model and changes the solution shadow prices. They will no longer be interpretable as market prices. In this particular case, the shadow prices will implicitly include an optimal export tax to exploit market power in the world market for exports.

This example illustrates a general problem with the programming approach. While it provides a very compact way to present a general equilibrium model and is also a feasible solution approach, it is delicate. A programming model cannot easily simulate non-competitive behavior. More importantly, it cannot easily be adapted to handle price-distorting policy instruments or constraints expressed in terms of "nominal" flows (e.g., prices times quantities). In practice, most modelers have written down the supply and demand equations of their CGE models explicitly, including income-expenditure constraint equations for the various actors, and have used various techniques for solving them directly.

An approach which is starting to be used in some applications is to write out the CGE model equations explicitly, but embed them in a programming model. For example, we can add as constraint equations in Table 1 the export-supply and import-demand equations that arise from utility and profit maximization behavior. The resulting model will include market prices and the exchange rate as endogenous variables. In this model, the resulting set of constraint equations will

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[12]Dervis, de Melo, and Robinson (1982), Chapter 6, discuss this relationship in detail.

[13]This approach can be seen as a reasonable approximation for a single-country model. In multi-country models, of course, endogenizing world prices presents a number of problems.

have a unique solution. At that solution, the shadow prices on the material balance equations (the first two constraint equations in Table 1) and the trade balance constraint (the third constraint) will equal the endogenously solved market prices (if P^q is chosen as the numeraire price), and the additional equations defining the CGE model are redundant.

So far, we have not added much of interest to the CGE model except to cast it into a form suitable for solution by nonlinear programming packages.[14] The point is to add interesting choice variables to the CGE model and then use the programming approach to solve for optimal policy choices. I will discuss some recent examples of papers using this approach.

CGE Model Formulation

Table 2 presents essentially the same model as a CGE model, including prices as endogenous variables and explicit income and expenditure constraints for the single household, government, and the rest of the world. To complete the macro specification, the model adds savings and investment, with all savings done by the single household. The CGE model also adds three price-wedge tax instruments. The government collects indirect taxes and tariffs, pays export subsidies, and transfers any net balance in a lump-sum fashion to or from the single household.

Equations 4 and 5 give the efficient export and import ratios as functions of relative prices. Equations 13 and 14 define the corresponding prices (P^x and P^q) of aggregate output X and the composite good Q. They are the cost-function duals to the first-order conditions embodied in equations 4 and 5. P^x essentially defines the GDP deflator, while P^q defines the consumer price index for the CES composite good, which will also be a CES function.

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[14]Using such an approach would be useful if one wished to add inequality constraints to the CGE model.

Table 2: Two-Sector, Three-Good, CGE Model

Real Flows

(1) $\overline{X} = G(E, D^S)$

(2) $Q^S = F(M, D^D)$

(3) $Q^D = \tilde{C}/P^q + \tilde{Z}/P^q$

(4) $E/D^S = g_2(P^e, P^d)$

(5) $M/D^D = f_2(P^m, P^t)$

Nominal Flows

(6) $\tilde{T} = t^m \cdot R \cdot \pi^m \cdot M + t^d \cdot P^d \cdot D^D - t^e \cdot R \cdot \pi^e \cdot E$

(7) $\tilde{Y} = P^x \cdot \overline{X} + R \cdot \overline{B} + \tilde{G}$

(8) $\tilde{C} = \overline{s} \cdot \tilde{Y}$

(9) $\tilde{S} = \tilde{Y} - \tilde{C}$

Prices

(10) $P^m = (1 + t^m) \circ R \circ \pi^m$

(11) $P^e = (1 + t^e) \circ R \circ \pi^e$

(12) $P^t = (1 + t^d) \circ P^d$

(13) $P^x = g_1(P^e, P^d)$

(14) $P^q = f_1(P^m, P^t)$

(15) $P^x = \overline{P}$

Equilibrium Conditions

(16) $D^D - D^S = 0$

(17) $Q^D - Q^S = 0$

(18) $\pi^m \cdot M - \pi^e \cdot E = \overline{B}$

(19) $\tilde{Z} - \tilde{S} = 0$

(20) $\tilde{T} - \tilde{G} = 0$

Accounting Identities

(i) $P^x \cdot \overline{X} \equiv P^e \cdot E + P^d \cdot D^S$

(ii) $P^q \circ Q^S \equiv P^m \cdot M + P^t \cdot D^D$

(iii) $P^q \circ Q^D \equiv \tilde{Y}$

Endogenous Variables:

E: Export good
M: Import good
D^S: Supply of domestic good
D^D: Demand for domestic good
Q^S: Supply of composite good
Q^D: Demand for composite good
P^e: Domestic price of export good
P^m: Domestic price of import good
P^d: Producer price of domestic good
P^t: Consumer price of domestic good
P^x: Price of aggregate output
P^q: Price of composite good
R: Exchange rate
$\tilde{T}$: Net government revenue
$\tilde{G}$: Net government expenditure
$\tilde{Y}$: Total income
$\tilde{C}$: Aggregate consumption
$\tilde{S}$: Aggregate savings
$\tilde{Z}$: Aggregate investment

Exogenous Variables:

π^m: World price of import good
π^e: World price of export good
t^m: Tariff rate
t^e: Export subsidy rate
t^d: Indirect tax rate
$\overline{s}$: Average savings rate
$\overline{X}$: Aggregate output
$\overline{P}$: Numeraire price index
$\overline{B}$: Balance of trade

Equation 3 defines consumer and investment demand for the composite good. In this model, it merely states that all income is spent on the single composite good, and could be omitted. However, in a multisector model, this equation defines how consumers allocate consumption expenditure across goods and how aggregate investment is spent on capital goods. There is a vast literature on systems of consumer demand as functions of relative prices and income. In the simple model, equation 3 can stand in for a more complex system of expenditure equations and does reflect an important property of all complete systems --the value of the goods demanded must equal aggregate expenditure.

Equations 6 to 9 determine the income flows in the economy. The model has four actors: a producer, a household, government, and the rest of the world. Equation 6 determines government revenue and Equation 7 determines household income. Equations 8 and 9 divide household income between consumption and savings. The nominal flows among the actors can be tabulated in a Social Accounting Matrix (or SAM), which is presented in Figure 1.[15] The SAM shows the circular flow of income and expenditure in the economy. Each cell represents a payment from a column account to a recipient in a row account. The SAM is square and, following the conventions of double-entry bookkeeping, each actor's accounts must balance --income must exactly equal expenditure. Thus, column sums in the SAM must equal the corresponding row sums.

The SAM defines six accounts, one for each actor, one for savings and investment, and an additional "commodity" account. The commodity account keeps track of absorption, which equals the value of domestic products sold on the domestic market, D, and imports, M. The producer account pays out total revenue to households and government down the column and sells goods on the domestic and foreign markets along the row. The column sum equals gross domestic product (GDP) at market prices, which includes indirect taxes. GDP at factor cost equals $P^x \cdot X$. Export subsidies are seen as a payment by government to producers.

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[15]Pyatt and Round (1985) provide a good introduction to SAM's and a number of examples of their uses.

Figure 1: Social Accounting Matrix for the CGE Model

Receipts:	Expenditures: Commod-ity	Pro-ducer	House-hold	Govern-ment	Capital Account	Rest of world	Total
Commodity			$\tilde{C}$		$\tilde{Z}$		$P^q \cdot Q^D$
Producer	$P^t \cdot D^D$			$\tilde{T}^e$		$\tilde{E}$	$P^t \cdot D^D + P^e \cdot E$
Household		$P^x \cdot \overline{X}$		$\tilde{G}$		$R \cdot \overline{B}$	$\tilde{Y}$
Government	$\tilde{T}^m$	$\tilde{T}^d$					$\tilde{T}^m + \tilde{T}^d$
Capital			$\tilde{S}$				$\tilde{S}$
World	$\tilde{M}$						$\tilde{M}$
Total	$P^q \cdot Q^S$	GDP	$\tilde{Y}$	$\tilde{G} + \tilde{T}^e$	$\tilde{Z}$	$\tilde{E} + R \cdot \overline{B}$	

Definitions:

$\tilde{M} = R \cdot \pi^m \cdot M$ $\quad$ $\tilde{T}^d = t^d \cdot P^d \cdot D^d$

$\tilde{E} = R \cdot \pi^e \cdot E$ $\quad$ $\tilde{T}^e = t^e \cdot R \cdot \pi^e \cdot E$

$\tilde{T}^m = t^m \cdot R \cdot \pi^m \cdot M$ $\quad$ $GDP = P^x \cdot \overline{X} + \tilde{T}^d$

All other variables are defined in Table 2.

Exports and imports in the account for the rest of the world are valued in world market prices times the exchange rate.

In Table 2, the price equations define relationships among eight prices. There are fixed world prices for E and M; domestic prices for E and M; producer and consumer prices for D; and prices for the two composite commodities, X and Q. Equations 1 and 2 are linearly homogeneous, as are the corresponding dual price equations, 13 and 14. Equations 3, 4, and 5 are homogeneous of degree zero in prices --doubling all prices leaves real demand and the desired export and import ratios unchanged.[16] Since only relative prices matter, it is necessary to define a numeraire good whose price is set exogenously. Equation 15 defines the numeraire price as the GDP deflator.

Equations 16 to 20 define the market-clearing equilibrium conditions. Supply must equal demand for D and Q, the balance of trade constraint must be satisfied, aggregate savings must equal aggregate investment, and the government account must balance. The complete model has 20 equations and 19 endogenous variables. The five equilibrium condition equations, however, are not all independent. The model satisfies Walras' Law and it can be shown that if any four of the five equations are satisfied, then the fifth must also hold. So, any one of them can be dropped, and the resulting model is exactly identified.

Extending the CGE model to include many sectors, sectoral production functions, intermediate goods, factor markets, many consumers, and macro balances is relatively straightforward. For example, to move to many sectors, just add sector subscripts to all the output and price variables. The CET production possibility frontier is now interpreted as a sectoral export transformation function describing the relative degree of difficulty in producing goods for the domestic market versus the export market. Similarly, the import aggregation function describes the degree of substitution in demand between imports and domestically produced goods within the same sectoral category.

[16]For the demand equation, one must show that nominal income doubles when all prices double, including the exchange rate. Tracing the elements in Equations 6 and 7, it is easy to demonstrate that nominal income goes up proportionately with prices.

Given that each sector has eight associated prices, the model provides for a lot of product differentiation. The specification started with CGE models of developing countries in order to capture the fact that, at aggregation levels typically used, the law of one price clearly does not hold. Changes in the prices of imports and exports are not completely "transmitted" to the prices of domestic goods in the same sector categories. Also, two-way trade (cross hauling) is observed in almost all sectors. For a single-country model, the CES and CET functions capture the reasonable notion that it is not "easy" to shift trade shares in either export or import markets.

The specification has been criticized in the context of multi-country models because it implies that every country has market power, leading to the potential for national welfare gains from imposing trade restrictions. What is a reasonable approximation for a single-country model has become something of an embarrassment in multi-country models which were designed to analyze the gains from trade liberalization. While attention has focused on the elasticities of substitution, the share parameters in the CES functions are really at the root of the problem. In a multi-country model, the assumption of fixed sectoral share parameters in every country largely determines the volume and direction of world trade, with price changes only affecting shares at the margin. It is probably more correct to view trade shares as evolving over time in response to shocks and policy changes, with short-run import aggregation functions sliding along long-run functions that have much higher substitution elasticities. The problem for multi-country models is to understand why and how these shares change over time in ways that do not depend only on shifts in relative prices.

In single-country models, the CES formulation for the import-aggregation function has been criticized on econometric grounds.[17] It is certainly a restrictive form. For example, it constrains the income elasticity of demand for imports to be one in every sector. In both single-country and multi-country models, it is probably time to explore other formulations, while maintaining the

[17]See, for example, Allston et al. (1989).

fundamental assumption of imperfect substitutability. Other functional forms are certainly available. For example, Hanson, Robinson, and Tokarick (1989) estimate sectoral import demand functions based on the almost ideal demand system (AIDS) formulation. They find that sectoral expenditure elasticities of import demand are generally much greater than one in the U.S., results consistent with estimates from macroeconometric models. Factors other than relative prices appear to affect trade shares, and it is important to start doing research on what they might be and how they operate.

Trade Policy and Welfare

Since Adam Smith, much of the literature in trade theory has explored the benefits of free trade and the welfare costs of protection. The development of CGE models permitted the empirical estimation of the welfare costs of protectionist policies in a general equilibrium framework. One of the intriguing results from the now rather large body of empirical work is that the costs of engaging in protectionist policies, or the gains from removing them, are relatively small. For example, Harrison and Rutstrom (1989) have used a world model developed by Whalley to generate a pay-off matrix for multi-country trade policy games. They compute Nash equilibria and show that it is relatively easy to generate a nasty trade war. However, examining the pay-off matrix indicates that the aggregate welfare differences between various solutions to the game for the major players are really quite minor --hardly worth fighting over.

In a recent conference volume, Srinivasan and Whalley (1986) compare studies of trade liberalization in a variety of single-country and multi-country models. In their summary, they note that the welfare gains from trade liberalization are relatively small, seldom amounting to as much as one percent of GNP. They cite Harberger's discussion of the welfare costs of distortions, which can be summarized in the often-quoted proposition that "triangles are smaller than rectangles." They also note that, at least in developed countries, the reforms being modelled are not really dramatic. In the conference volume, for example, each paper explored the impact of a fifty percent cut in tariffs. Since the initial levels of tariffs in many countries such as the U.S. are fairly low, one might expect that aggregate welfare effects of halving them would be small. However, more dramatic changes in protection also yield small welfare effects. In a recent thirty-sector CGE model of the U.S., Hanson, Robinson, and Tokarick (1989) explore the impact of a protectionist policy where the U.S. adds an across-the-board fifty percent tariff to existing tariffs in all sectors. The experiment is designed to measure the impact of a complete failure of the current round of GATT talks, with the U.S. imposing protection similar to the 1930 Smoot-Hawley tariff. The structural results are dramatic, but aggregate GDP falls by only about 0.25 percent.

The result that the static welfare costs from misallocation of resources due to price-wedge distortions are small in a competitive general equilibrium model represents one of the robust properties of CGE models. Substitution possibilities in production, consumption, and trade endow the economy with a great deal of adjustment flexibility. When markets work and factors are fully employed, even large price-wedge distortions can be vitiated by substitution possibilities, with little effect on aggregate welfare.

Two points should be noted about this result. First, the term "small" must be evaluated in terms of the problem being analyzed. Work with CGE models focusing on tax issues indicates that welfare losses from "inefficient" tax systems can be a large share of total tax revenue. Consider a "project" which involves redesigning the tax system to raise the same amount of revenue more efficiently --that is, with less dead-weight losses. Such a project can easily have a social rate of return of 20-50 percent, where the denominator is aggregate tax revenue. For the U.S., such welfare gains amount to billions of dollars, which should certainly justify work with CGE models in the U.S. Treasury.

Second, while price-wedge distortions may generate small aggregate welfare losses, their impacts on the sectoral structure of resource allocation, production, and trade tend to be more significant. In general, political pressure groups are organized by sector and care about the impact of policy on the relative position of their sector in the economy.[18] The closer one gets to actual policy makers, the more evident is the interest in measures of the structural impact of policies, rather than measures of aggregate welfare. Any positive analysis of policy needs to take this concern into account.

Especially in developing countries, much of the work with CGE models evaluating the impact of policies in an operational environment has tended to reflect these concerns about structure. For example, the extensive work on CGE models of "structural adjustment" at the World Bank has tended to focus on issues of resource allocation and "expenditure switching" rather than aggregate welfare. This concern for analyzing the structural impact of policy changes is also evident in the recent work on trade liberalization in developed countries.

Optimal Tariff Policy

Some of these problems with neoclassical CGE models are nicely illustrated by work on optimal tariff policy in the presence of a government revenue constraint. A standard rule of thumb in development policy is that developing countries should equalize their tariff rates across sectors. A policy of equal tariffs across sectors is best, getting the prices right and yielding a level playing field. Given the existence of differentiated tariffs and a revenue constraint, it is desirable to move in the direction of equalizing tariffs. This "uniformalist" position certainly represents the conventional wisdom at the World Bank and has been forcefully advocated by writers such as Harberger (1988), Balassa et al. (1982), and Krueger (1985).

From the public finance literature, we know that in the presence of non-removable distortionary taxes, equalizing tariff rates is not optimal. Chambers

[18]Recent work with "specific factors" models in international trade also tends to support this view. See, for example, Magee (1978) who argues that political pressure for import protection in the U.S. is organized along industry lines rather than, say, by ownership of factor of production (as would be predicted by the Stolper-Samuelson model). Work with CGE models supports this view. Empirically, even large shocks tend to have little effect on economywide wage-rental ratios, but large effects on the sectoral composition of value added. Hanson, Robinson, and Tokarick (1989) discuss the issue in a model of the U.S.

(1989) provides a good survey of the theoretical arguments.[19] Dahl, Devarajan, and van Wijnbergen (1986) discuss a theoretical model of the issue and provide an empirical application with an eight-sector CGE model of Cameroon. Devarajan and Lewis (1989) discuss a similar application using a thirteen-sector CGE model of Indonesia and Devarajan, Lewis, and Robinson (1989) illustrate the empirical issues using an extension of the two-sector, three-good model described above that includes a fourth good, an imported intermediate input.

In these models, the method used is to include the CGE model as constraint equations in the planning model presented in Table 1. The objective function is the utility function of the single consumer and is defined to be consistent with the expenditure functions in the CGE model. Then, various tax instruments are specified as variables rather than fixed parameters, so the CGE model no longer has a unique solution. The programming problem is solved by finding the set of tax instruments that yields a market equilibrium with maximum welfare.

From these studies, the answer is that, in a second-best world, a policy of equal tariffs across sectors is not optimal. The results from the theory of public finance carry over into empirical models. Moreover, a policy of moving toward equal tariffs from an existing situation of unequal tariffs is not generally welfare improving. Based on the empirical results from the latter two studies, a better rule of thumb would be to recommend that tariff rates for intermediate and capital goods be very low or zero, and certainly much less than the tariff rates for consumer goods.[20]

These empirical results do not imply that the World Bank should cease recommending that countries move toward equalizing tariff rates. In a world of rent seeking and administrative capacity constraints, it is probably a good idea to simplify tariff rate structures. However, tariff equalization cannot be justified on the basis of static efficiency gains in the neoclassical model, either

[19]He is the one that used the term "uniformalist." Dixit (1985) and Mitra (1986) also discuss the theory as applied to trade policy in open economies.

[20]This particular result depends on the nature of the second-best initial situation. In the small model, we assume that the indirect tax rate on the domestic good is less than optimal.

theoretical or empirical, once realistic second-best constraints are introduced. The neoclassical competitive general equilibrium model is a powerful tool, but it is also important to describe how the world actually works, not just how it would work in some first-best Platonic form.

In these optimal-policy applications, large variations in policy instruments yield small changes in aggregate welfare. While it is clearly optimal to use differentiated tariffs, the improvement in aggregate welfare is not all that large. One might argue that simplifying the structure of tariffs would save a lot of administrative costs and reduce rent seeking, and that the resulting benefits might well exceed the welfare losses arising from tariff equalization. While persuasive, this argument turns the neoclassical model on its head and would probably not appeal much to the proponents of uniform taxation. It would appear that they are being hoist on their own petard.

In spite of all these caveats, one is still left with an uneasy feeling that CGE models, and the theoretical neoclassical general equilibrium model on which they are based, are missing some important effects. Empirical work, especially in developing countries, indicates that countries which pursue "good" trade and tax policies perform better, much better. The neoclassical model correctly predicts the sign, but not the magnitude of the potential gains from "correct" policies. There is clearly a need to look further for large effects that are being missed in existing models.

Import Restrictions, Rents, and Rent Seeking

Quantitative controls on imports have been a characteristic feature of trade regimes in many developing countries. The seminal article on rent seeking by Krueger (1974) was motivated by her experience in Turkey, where pervasive quantitative controls generated enormous gains to particular groups. Those developing trade-focused CGE models of developing countries were strongly influenced by these "stylized facts." The first of the World Bank "structural adjustment" CGE models, the Dervis-Robinson model of Turkey, incorporated quantity rationing of imports and rent-seeking behavior.[21] In the last decade, the majority of CGE models applied to developing countries have focused on issues of trade and structural adjustment, and many of them have incorporated quantitative restrictions and rent seeking.

The empirical results from this literature indicate that the rents generated by policies to restrict imports are indeed large, sometimes amounting to 10-15 percent of GDP.[22] These results raise a number of issues for policy analysis and modelling: (1) Who gets the rents?; (2) How do we model the trade regime?; and (3) What are the efficiency losses due to rent seeking?

The first two questions are closely related. Dervis, de Melo, and Robinson (1981) compare the distributional impact of two import rationing regimes: a fixprice regime where import demanders receive a direct allocation of imports which they cannot sell and a flexprice regime where there is, in effect, a market in quota certificates.[23] In their model, typical of semi-industrial countries, imports consist largely of intermediate inputs and capital goods, with very few consumer goods. Thus, producing sectors are the agents most directly affected by the trade regime. Under fixprice rationing, sectors receive fewer imported intermediate inputs and capital goods than they desire, but get them at far lower prices than they would be willing to pay. Producers thus receive the rents, since they pay less than market-clearing prices for the imports they use, and so are subsidized by the trade regime. In an environment where imports must be reduced (say, in response to a decline in foreign investment or a balance of payments crisis), import-dependent producers will tend to favor quantity ration-

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[21]That model was developed in 1978 for a World Bank mission to Turkey, and is described in Dervis, de Melo, and Robinson (1982).

[22]Representative studies include: Dervis, de Melo, and Robinson (1982) (Turkey); Lewis and Urata (1984) (Turkey); Condon, Robinson, and Urata (1985) (Turkey); Grais, de Melo, and Urata (1986) (Turkey); Ahmed et al. (1985) (Egypt); Clarette and Whalley (1986) (Philippines); Kis, Robinson, and Tyson (1989) (Hungary); and Robinson and Tyson (1985) (Yugoslavia). See also de Melo (1988).

[23]In their model, the fixprice regime is modelled directly, not by using an ad valorem equivalent.

ing over a flexible exchange rate regime because they gain a great deal from the implicit subsidies.

Under flexprice rationing, all users are assumed to pay the premium-ridden price for imports, so rationed imports are efficiently allocated across competing uses. The rationing is implemented by an ad valorem equivalent premium. However, the allocation of the premia rents must be handled separately. In a CGE model, they appear as an explicit flow which must be allocated to agents in the economy. They are computed by applying a supplemental tariff whose proceeds must be allocated to agents other than the government. Figuring out who gets these rents in the first instance is important for policy analysis, since it largely determines the impact effect of any change in policy. The CGE model also traces out the indirect effects, which will work themselves out through changes in equilibrium prices and quantities.

The existence of quantitative restrictions raises the issue of spillover effects. How do agents in the economy behave, given the quantity rationing? Is the rationing scheme incentive compatible? Dervis, de Melo, and Robinson (1982) note the problem and argue that because of the special characteristics of their model it is relatively unimportant in their case. Grais, de Melo, and Urata (1986), drawing on the notion of "virtual prices" introduced by Neary and Roberts (1980), solve explicitly for the agents' behavior on the non-rationed markets. By "reoptimizing" given the quantity constraints, their model captures the spillover effects in a theoretically satisfying way.

The final question is whether the existence of "chaseable rents" induces efficiency losses through rent-seeking behavior. Bhagwati and Srinivasan (1980) generalize the notion, using the term "revenue seeking," and argue that the magnitude of the efficiency losses will equal the value of the rents. Grais, de Melo, and Urata (1986) make this assumption, and find that rent-seeking efficiency losses amounted to over five percent of GDP in Turkey in 1978, in the midst of their foreign exchange crisis. In the references cited in footnote 22, a variety of assumptions are made about efficiency losses as a share of total rents. There is no obvious answer, since one can easily think of quota allocation schemes that will generate no rent seeking. In general, one would expect that there would be an initial period of intensive rent seeking while the institutional rules determining the allocation of rents are settled.[24] After that, there should be no more efficiency losses from rent seeking associated with import quotas than with any other government entitlement program.[25]

The literature on rents and rent seeking when there is extensive import rationing has certainly identified an effect where the numbers are large. Pervasive import rationing, however, occurs rarely. In the studies cited earlier, such rationing was usually a short to medium-term policy response to a crisis situation. More common, in developing and developed countries, is sectoral protection over a long period which is intended to restrict foreign competition. In this environment, there are potential welfare losses because protection induces non-competitive behavior. If, in addition, the affected industries are subject to scale economies, then potential welfare losses from protection can be quite large.

The interaction between oligopolistic behavior, scale economies, and import protection in developed countries is an area of active research in trade theory. There are some CGE models of developed countries incorporating these effects.[26] Work in developing countries is surveyed by de Melo (1988) and Devarajan and Rodrik (1989). Condon and de Melo (1986) build a stylized three-sector CGE model loosely based on Chile to illustrate the potential effects. In their model, with import rationing, scale economies in manufacturing, and imperfect competition (but no rent seeking), the welfare costs of import rationing in the manufacturing

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[24]Robinson and Tyson (1985) argue that the disruption caused by the introduction of extensive import rationing in Yugoslavia may well have led to short-term efficiency losses that exceeded the value of the rents.

[25]Note that one has to be careful in defining what constitutes an efficiency loss. A bribe is a lump-sum transfer and involves no efficiency loss. When James Watt lobbied HUD, some part of his fee represented a bribe. The only efficiency loss was the social opportunity cost of his time, which was probably not that large.

[26]See Harris (1985), Cox and Harris (1985), de Melo and Tarr (1989), and work in progress by Burniaux and Waelbroeck (1989). Dixon (1978) was an early contributor to this literature and provided some suggestive calculations for Australia, although not in a full CGE model.

sector amount to 13-17 percent of national income. In a similar, but more disaggregated, model of Cameroon, Devarajan and Rodrik (1989) generate a much smaller number for welfare costs, around 2-3 percent of GDP.

The models appear to provide a reasonable description of parts of the manufacturing sector in a number of developing countries. In addition to coexisting firm-level scale economies and imperfect competition, many developing countries are also characterized by scale economies that appear to be external to the firm. There is some very recent work with theoretical long-run growth models incorporating Marshallian externalities that attempt to explain long-run development. See, for example, Lucas (1985) and Romer (1986). These models, in effect, introduce increasing returns to scale at the economywide level, while maintaining constant returns to scale at the level of the firm. They thus do not require any assumptions about imperfect competition to generate equilibrium growth paths.[27] While much of this literature appears to be inspired by long-run historical industrialization in the currently developed countries, some of the externality mechanisms they discuss are potentially relevant for developing countries, especially when considering the role of manufacturing exports.[28]

Externalities and Export-Led Growth

As noted earlier, a number of developing countries which have pursued "good" trade policies and an open development strategy have achieved remarkable growth. While the "gang of four" (Korea, Taiwan, Hong Kong, and Singapore) are the leaders, a number of other semi-industrial countries have also achieved rapid

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[27]Although see Romer (1988) who specifies a model with imperfect competition and externalities arising from investment in R&D. See also the survey by Krugman (1989).

[28]Helpman (1988) surveys some of the externality models and relates them to recent work in trade theory.

growth led by manufactured exports.[29] There has been an active debate about what policies are required to promote export-led growth (or ELG). One school argues that the removal of distorting protectionist polices and the achievement of neutral trade policies --a level playing field-- are needed and will suffice to start the process.[30] A second school argues that interventionist policies are required, including selective export subsidies, infant-industry protection, industry-wide assistance in marketing, and efforts to pick winners.[31] The empirical evidence is that these countries did, in fact, provide a variety of subsidies to support manufactured exports and to favor imports of capital goods and intermediate inputs.

The first school largely bases its arguments on the neoclassical model, with references to efficiency gains from removing distortions, although there are also some references to exploiting economies of scale, eliminating rent seeking, and reducing x-inefficiency. The implicit view is that achieving non-distorting policies will permit these effects to emerge, and so promote growth. The second school refers explicitly to externalities, total factor productivity (TFP) growth, and technology transfer arising from export and import activities.

Existing CGE models cannot capture the major features of growth and structural change in countries pursuing a successful ELG strategy. Again, when distortionary policies are eliminated, the neoclassical model gets the right sign on the effect, but greatly underestimates the magnitude. For example, Chenery et al. (1986) use a dynamic CGE model of Korea to analyze the impact that the shift in trade regime in the mid-1960s to an "open" development strategy had on growth and structural change. They manage to track the major aggregate changes, but only after adding a large exogenous increase in total factor productivity

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[29]Chenery, Robinson, and Syrquin (1986) describe the growth experience of the semi-industrial countries in the post-Korean-War period.

[30]See, for example, Balassa et al. (1982) and Krueger (1985).

[31]See, for example, Westphal (1978) and Westphal et al. (1985).

growth.[32] Their model also understates the structural change that is a characteristic part of ELG. Assuming that ELG leads to high TFP growth, which appears to be empirically valid, really only emphasizes the limitations of the neoclassical model in explaining the process.

In a recent paper, de Melo and Robinson (1989b) incorporate trade-related externalities in a stylized CGE model designed to replicate the experience of semi-industrial countries which have pursued a successful strategy of export-led growth. They present two models. The first starts from the model presented in Table 2 and adds an export externality to the export transformation function. Equation 1 is replaced by:

(1a) $\bar{X} = A \cdot G(E, D^S)$ where $A = (E/E_0)^{-\eta}$ when $E \geq E_0$ and 1 otherwise.

The effect is that any increase in exports shifts the production possibility frontier outward. In a region, the curve actually bows outward, effectively incorporating scale economies.[33] The export supply function given in equation 4, however, is left unchanged since the externality is assumed not to be seen by individual producers. The model is then embedded in the optimization framework of Table 1, maximizing absorption, with the export subsidy rate included as an endogenous instrument.

In a second model, the CGE model is expanded to include four sectors (agriculture, light manufacturing, heavy manufacturing, and services) and factor markets. It is designed to represent an archetype semi-industrial country.[34] In this model, the export externality is assumed to apply only to the manufacturing sectors, with most exports coming from light manufacturing. In addition, there is assumed to be an import externality. Imported capital goods are assumed to be more productive than domestically produced capital goods. The aggregate

[32]Their model also includes rent seeking and associated costs, so goes well beyond the standard neoclassical competitive model.

[33]The shape of the resulting curve depends on the CET transformation elasticity and on the export-externality elasticity η.

[34]The data come from Chenery, Robinson, and Syrquin (1986).

amount of "effective" capital in the economy is specified as a function of the import ratio in the heavy manufacturing sector.

The second model is also embedded in the optimization framework, and is solved by maximizing the utility of a single consumer. The CGE model includes investment and a set of consumer expenditure functions. The expenditure functions are given by the extended linear expenditure system (ELES), which explicitly includes investment and the price of capital goods. The corresponding utility function is a CES function that also includes savings. An additional price-wedge instrument is included, a tariff (or subsidy) on imports of heavy manufacturing.

In both models, the balance of trade is fixed exogenously and the government serves only to impose price-wedge taxes and subsidies. Any net government revenue is transferred to the single consumer in a lump sum. The only policy distortions allowed in the models are the price-wedge instruments, although a variant of the second model also allows pre-existing distortions in factor markets.

A number of numerical experiments are run with the two models to test how well the stylization replicates the experience of semi-industrial countries pursuing a strategy of export-led growth. In the experiments, the programming model was solved to determine optimal tariffs and subsidies, given the trade externalities. The models were also run with additional instruments and a government revenue constraint. Various second-best scenarios were also tried.

The empirical results are encouraging. The models appear to capture well the stylized facts characterizing growth and structural change in semi-industrial countries pursuing export-led growth. The working out of the externalities also generates measured TFP increases that are quite close to those observed in semi-industrial countries such as Korea. The optimal subsidy rates for exports are also in line with empirical evidence on subsidy policies pursued in countries such as the gang of four. In the second model, optimal export subsidy rates for light manufacturing were around 40-45 percent, depending on the strength of the export externality. Optimal import subsidy rates for heavy manufacturing ranged from 25 to 50 percent.[35]

De Melo and Robinson conclude that, from a theoretical perspective, the approach to modelling trade externalities appears to be fruitful. The models provide a first step toward endogenizing major driving forces generating measured TFP growth and structural change in countries pursuing ELG. There are also some policy lessons. In the presence of externalities, the simple policy rules arising from the neoclassical general equilibrium model are no longer valid. Policy rules that seek to minimize static efficiency losses may miss potential gains arising from policy links to externalities. The empirical results from these models indicate that, if there are externalities to be exploited, policy makers should pursue them aggressively and not worry overmuch about getting the instruments just right. When there are rectangles to be gained, an economy can easily afford to lose some triangles along the way.

Modelling Macroeconomic Adjustment

The macro properties of CGE models of developing countries have provided a topic for much debate and controversy. The discussion has focused on what has come to be called the macro "closure" of an economywide model.[36] The CGE model in Table 2 and Figure 1 contains the three basic macro balances: balance of trade, savings-investment, and government deficit. In this model, all income accrues to the single household which then splits it between savings and consumption. Aggregate investment is thus savings determined, and savings are determined by a simple average savings rate out of income. This savings-driven macro specification is called "neoclassical closure."

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[35]Note that these represent first-best policies in the presence of externalities, with no other distortions in the model economy.

[36]The seminal work on macro closure is Sen (1963). The development literature is surveyed by Robinson (1989) and Rattso (1982).

In addition, the model assumes full employment, so aggregate real income is fixed. The government really only represents a pass-through account, with net government revenue being transferred to the single household. The balance of trade is specified exogenously and is also given to the household. While all the macro balances are in the model, there is no room for any interesting macro behavior. There is no possible feedback from changes in macro aggregates to GDP and little scope for variation in the macro aggregates themselves. Given the assumed savings behavior, no special equilibrating variable is required to achieve savings-investment equilibrium. The model is specified in terms only of current flows and flow-equilibrium conditions. There are no assets, no asset markets, no expectations, and no dynamics.

The toy model in Table 2 represents a clean version of a Walrasian CGE model. While it contains macro aggregates, as must any economywide model, it is best seen as a neoclassical general equilibrium model of production and exchange. The additions of government, savings-investment, and the balance of trade are done in ways that retain the notion of flow equilibria and do not strain the Walrasian paradigm. However, as the development literature illustrates, it is possible to bring in a lot of macro effects while remaining within the framework of a CGE model which includes only flow variables.

Macro Closure

The earliest CGE models of developing countries --the Adelman-Robinson model of Korea and the Taylor-Lysy model of Brazil-- were designed to study the impact of alternative policy choices on the distribution of income. Much of the debate about these models centered on their macro features. How did their choice of macro closure affect the results?[37] In the late 1970s, policy concern shifted to problems of structural adjustment. How should developing countries adjust to changes in the international environment, including increases in the price of oil and declines in the availability of foreign borrowing? Starting with the

[37]See Taylor and Lysy (1979) and Adelman and Robinson (1988b) for discussions of the macro properties of the two models.

Dervis-Robinson model of Turkey, CGE models were developed to address such issues. Again, macro features of the models are important, since a major transmission mechanism by which the external shocks affect the economy is through changes in macro balances. Recently, policy concern has come full circle, focusing on the impact of macro stabilization and structural adjustment packages proposed by the IMF and World Bank on poverty and the distribution of income.[38]

The literature on macro closure has followed two different approaches to bringing macro features into a CGE model. In the first approach, relationships are specified among the macro aggregates, but their justification is based on macroeconomic theory outside of the CGE model. At one extreme, all the macro variables are specified as exogenous to the CGE model.[39] In a second approach, the CGE model is extended to include variables typically found in macro models (such as money, assets, and interest rates) and to expand the notion of equilibrium to incorporate asset markets and expectations. The intent is to build CGE models which move beyond the Walrasian paradigm and directly incorporate macro phenomena.

In the first approach, in effect, the CGE model is forced to interact with a macro model, but the two models are kept as separate as possible. The macro model may not even be fully spelled out. The basic credo of this approach might be described as "Render unto Walras that which belongs to Walras, and ditto for Keynes." This approach has been widely used in CGE models of developing countries and in a few models of developed countries.[40]

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[38]See Scobie (1989) for a review of recent work on this issue.

[39]Or almost all. The CGE model still must satisfy Walras' Law and the various equilibrium conditions are not all independent. For an example of a CGE model which draws on a separate macro model to determine the macro aggregates, see Hanson, Robinson, and Tokarick (1989). See also Robinson and Roland-Holst (1988) who discuss macro multipliers in CGE models.

[40]See Powell (1981) who describes how the Orani model of Australia was linked to a separate small macro model. Robinson and Tyson (1984) formally describe the notion of linking macro and CGE models and relate the idea to the literature on macro closure. Many of the structural adjustment models that trace their roots to Dervis, de Melo, and Robinson (1982) are in this tradition.

A recent example that illustrates how this approach can be fruitful is provided by Devarajan and de Melo (1987) who discuss a CGE model applicable to Franc-zone African countries. In these countries, the local currency is tied to the French Franc, so they have no independent monetary authority. In addition, it is reasonable to assume that real government expenditure and aggregate real investment are fixed exogenously. Given fixed tax rates, government revenue and private savings may not suffice to finance government expenditure and real investment. For these countries, it is assumed that any shortfall is financed by foreign borrowing. In effect, the French Central Bank finances the sum of the twin deficits.[41]

The CGE model can be extended to capture these assumptions. Since real investment and government expenditure are fixed, the model is "investment driven" rather than savings driven. The balance of trade is now treated as an endogenous variable. It is, in effect, the macro equilibrating variable which will vary to equilibrate savings (the sum of private, government, and foreign savings) and investment. The nominal exchange rate is chosen as numeraire, reflecting the fact that the exchange rate in these countries is tied to the French Franc. The domestic price level will vary to achieve a real exchange rate that generates a balance of trade that achieves macro balance. The CGE model will thus solve for a flow equilibrium that is consistent with the assumed macro behavior. The CGE model reflects the macro rigidities, in particular the government revenue constraint.

Given the macro assumptions, this model indicates that these countries might well react in a counterintuitive way to some standard policy packages. Consider, for example, the imposition of an export subsidy. The direct effect is to encourage exports, which should improve the balance of trade. However, the subsidy represents expenditure by the government and, without any increase in taxes, will increase the government deficit. The increased deficit is

[41]Such a view may seem extreme. However, consider recent U.S. history. While the macro story is more complex, the effect may well be the same. In effect, the U.S. has financed the federal deficit by foreign borrowing, with the Japanese playing the role of the French Central Bank.

financed by foreign borrowing, which will lead to a revaluation of the real exchange rate, and so counteract the effect of the subsidy. The net effect will certainly worsen the balance of trade and may actually reduce exports. The adverse revenue effect of the subsidy can easily overwhelm the beneficial relative price effect.

In the Devarajan-de Melo model, the macro effects are purely structural. Given the maintained assumption that factors are fully employed and that factor markets clear, the changes in macro aggregates will have little or no affect on aggregate GDP. Many of the structural adjustment models maintain the assumption of full employment. There is, however, also a strand of work with CGE models that incorporate mechanisms that permit changes in macro aggregates to generate unemployment. These "macro structuralist" models all have in common the assumption that at least some factor and product markets do not clear.[42] They postulate various rigidities, such as sectorally immobile capital, fixed wages, mark-up pricing, a fixed exchange rate, and/or various kinds of rationing in product and factor markets. They can generate Keynesian unemployment (or Keynesian closure) and so postulate strong links between macro balances and the real side of the economy.

The literature on macro closure demonstrates that neoclassical CGE models which contain no assets or money can still be useful in analyzing the impact of changes in macro aggregates on the economy. However, the marriage is an uneasy one. A macro model or scenario is forced onto the CGE model, which then traces out the structural implications of the assumed macro behavior. There are no optimizing agents at work that generate the macro behavior. In addition, the macro structuralist models further strain the neoclassical paradigm since they assume that various markets do not clear and/or that certain agents do not optimize.

[42]Lance Taylor is a leader in this strand of work, arguing for the general applicability of Latin American structuralist models. See Taylor (1983). Recent CGE models in this tradition with a focus on agriculture are surveyed by de Janvry and Sadoulet (1987).

Assets and Dynamics

The second approach to bringing macro features into CGE models has sought to expand the CGE model to include features of macro models. The obvious first step in this direction is to introduce assets and asset markets into CGE models. There are a few examples of such CGE models of developing countries. Lewis (1985) has a stylized model of Turkey that includes money and bonds, as well as a segmented loanable funds market that can capture elements of financial repression. Feltenstein (1984) has a model of Argentina that also includes money and bonds. Benjamin (1989), Feltenstein (1986), and Feltenstein and Morris (1988) add simple dynamics. The first two use a two-period model and the third is a three-period model with perfect foresight and provision for the post-plan period. All these models introduce an interest rate as an equilibrating variable. They do not include any uncertainty and their specification of portfolio behavior on the part of asset holders is very simple.[43]

Bourguignon, Branson, and de Melo (1989) is a recent example of a CGE model which incorporates asset behavior and dynamics. The model is designed to explore the distributional impact of alternative stabilization and structural adjustment policy packages.[44] It is run for seven periods, although it is dynamically recursive, with exogenous expectation variables. The model has six different household types and solves for their income and wealth in every period. Changes in asset prices and real returns on financial assets thus affect household incomes and are determined endogenously. Financial assets include money, government debt, domestic bonds, foreign bonds, and working capital (held by firms).

The real side of the model follows the CGE model in Table 2 in its trade specification. It also incorporates some structuralist rigidities. Sectoral

[43]There are some CGE models which incorporate uncertainty, but not in the context of macro models. See Adelman, Sarris, and Roland-Holst (1987) and Adelman and Berck (1989). These models explore the choice of appropriate policies in the face of price uncertainty on international markets.

[44]The model was developed as part of a project at the OECD Development Centre on "Adjustment Programs and Equitable Growth." Variations of their model will be applied to a few countries covered in the project.

capital is fixed within each period and the nominal wage is fixed in the modern and government sectors. In a variant of the model, the exchange rate is fixed. Thus, there are feedbacks from shifts in macro variables to aggregate employment and output. Over time, changes in investment affect the growth of the capital stock.

The model is benchmarked to a data set for a representative low-to-middle income country that earns most of its foreign exchange by exporting primary goods and light manufactures. The model economy is then "shocked" with an increase in the foreign interest rate and a rise in the world price of imports (a deterioration in the international terms of trade). Various policy responses to this shock are then simulated that capture the major features of World Bank and IMF structural adjustment and stabilization packages. Components include a reduction in foreign borrowing, a cut in government expenditures, a wage and credit squeeze, and, finally, a mix of adjustment policies including targeted expenditure cuts and subsidies designed to help the poor.

The empirical results indicate that, in the short run, a contractionary policy package severely worsens the distribution of income in the early years. Such shifts are likely to make the package politically unsustainable, even though the distribution improves in the later years after the economy returns to a sustainable growth path. The mixed package, which is designed to minimize the impact of adjustment on the poor during the adjustment period, works well. Through year five, its distributional impact dominates the other packages. However, by the end of year seven, the improvement is eroded since the subsidy components are assumed to cease after year five. The authors conclude that "stabilization packages which do not have specific components targeted towards the poor will have a noticeable adverse effect on the distribution of income, which is likely to result in some form of permanent damage for those below the poverty line."

Among the CGE models which incorporate assets and asset markets, Bourguignon, Branson, and de Melo (1989) is unique in that it carefully sorts out the ownership patterns of the assets, and hence is able to track the distributional impact of changes in asset returns and prices. The other models all introduce assets in order to capture interest-rate and inflation effects, and hence to endogenize the determination of important macro aggregates such as foreign borrowing, aggregate savings, and aggregate investment within the structure of the CGE model. While some of the models incorporate intertemporal utility functions to determine savings behavior, none of them have a very sophisticated model of portfolio choice by the various agents. They simply assume that different assets are imperfect substitutes.

The models also incorporate fairly rudimentary dynamic behavior. Bourguignon, Branson, and de Melo use a time-recursive, adaptive dynamics that is common in earlier CGE models of developing countries. Feltenstein and Morris (1988) have forward-looking consumers who maximize intertemporal utility functions which include expectations of future exchange rates. They state that their model incorporates perfect foresight, so it is presumably solved so that consumers correctly forecast future exchange rates for the three periods within the plan horizon.[45] Desired private investment is also a function of expected future returns to capital and interest rates, which are also presumably solved to be dynamically model consistent.[46] These are essentially short-term models, seeking to track the impact of stabilization and structural adjustment policies instituted in response to external shocks. They are not seeking to solve for long-run, steady-state growth paths.

In the developed countries, macroeconomic theory in the 1980s has moved away from a concern with short-run cycles and unemployment, and has focused more on long-run dynamic models. The Lucas critique and the rise of rational expectations models have led to the development of macro models which seek to incorporate representative agents who maximize intertemporal objective functions subject to budget constraints. Assets and asset markets, of course, are an important part of the story. Parsell, Powell, and Wilcoxen (1989) discuss the implications

[45]The dynamic behavior thus exhibits "model consistent" expectations.

[46]They also include an infinite-horizon, post-plan period for which investors assume a constant, exogenous, real rate of return on capital.

of this shift in theoretical focus for those wishing to incorporate macro phenomena in CGE models. They note that these new macro models can easily be placed within the theoretical framework of dynamic CGE models extended to include assets and asset markets. Dewatripont and Michel (1987) also suggest the need for such an approach and argue that it is the appropriate theoretical way to sort out the macro closure issue in CGE models of developing countries.

Currently, there are no long-run dynamic CGE models of developing countries along the lines suggested by Parsell, Powell, and Wilcoxen. Goulder and Eichengreen (1989a, 1989b) have developed a stylized long-run dynamic CGE model of the U.S. which can be seen as being in this tradition. The Goulder-Eichengreen model is quite small, but is run for many periods and does solve for steady-state growth paths. To date, they have used it to analyze the long-run impact of trade liberalization on the U.S. economy.

From the macro side, Parsell, Powell, and Wilcoxen take two empirical macro models of Australia and demonstrate how they can be seen as dynamic CGE models.[47] With both models, they simulate the effect over thirty years of a macro shock consisting of a reduction in the share of government expenditure in GDP maintained for five years.[48] The initial shock is assumed to be unexpected, but the resumption of government spending after five years is assumed to be correctly anticipated by all agents. Both models take about 10-15 years to settle down on a new stable long-run growth path. They differ in their short-run behavior, largely because of differences in lag structures.[49] Their long-run behavior, however, is very similar and reflects their common roots in long-run, rational-expectations models.

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[47]The two models are described in Murphy (1988) and McKibbin and Sachs (1989).

[48]They in fact solve the two models using CGE solution software developed for the Orani model.

[49]As Parsell, Powell, and Wilcoxen note, these lag structures involve a number of essentially ad hoc specifications, similar to standard econometric models which estimate reduced-form lag structures.

As Parsell, Powell, and Wilcoxen interpret the results, the long-run impact of a cut in government spending in the two models works almost entirely through changes in the long-run stock of domestic debt held by foreigners. While this result is captured in the two models through changes in asset markets, it can also be interpreted in terms of macro closure. In effect, these models have a long-run version of the macro closure used by Devarajan and de Melo (1987) in their model of Franc Zone countries, which was discussed above. In the long run, the reduction in government interest payments to foreigners (which fall because of the reduction in the government deficit over the first five years leads to lower total government debt, part of which is held by foreigners) leads to an improvement in the balance of payments. In the steady state, exports are lower and domestic consumption is higher. One could have achieved the same effect in a CGE model without assets, but which assumed that a fraction of the government deficit was borrowed abroad. The point, however, is that this closure can be derived endogenously in a dynamic CGE model that draws from modern macro theory.

While suggestive, these long-run macro models are of limited use in developing countries. Much of the current work with CGE models of developing countries is concerned with issues of short-run stabilization and structural adjustment. Long-run models which assume full employment and embody steady-state equilibria with rational (or model consistent) expectations will miss most of the action. However, it should prove valuable to be able to use CGE models to provide a laboratory for testing the empirical implications of new theoretical models. For this purpose, stylized numerical models may well prove useful in determining what theoretical effects are, in fact, empirically important and worth pursuing.

Conclusion

This selected survey has concentrated on CGE models which have sought to extend the neoclassical paradigm to capture phenomena thought to be important in developing countries. The core of most single-country, trade-focused CGE models can be seen as an extension of the Salter-Swan "Australian" model of a small, open economy producing both tradables and non-tradables. The addition of assumptions about imperfect substitution and transformability between goods produced for the domestic and world markets represented a considerable advance, certainly in empirical realism. The resulting model is still theoretically very much in the neoclassical paradigm.

While these CGE models have proven useful in policy analysis, they have also demonstrated the limitations of the underlying paradigm. Empirical work has indicated differences in performance across developing countries, and in countries over time, of magnitudes that cannot be captured in models which stick close to the paradigm. In addition, the Walrasian general equilibrium model of production and exchange cannot easily capture the sorts of macro phenomena that have become increasingly important in the analysis of performance in developing countries over the past decade. The observed gap between stylized facts and model results has led to a healthy tension, with modelers seeking to incorporate new forces in their models. I have discussed CGE models that have drawn on theoretical work on optimal taxation, imperfect competition, scale economies, externalities, and macroeconomics. These topics hardly exhaust the theoretical inventory, but have provided examples of the need for, and potential benefits from, expanding the paradigm on which CGE models of developing countries are based.

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