Computable General Equilibrium Models for Trade Policy Analysis in Developing Countries: A Survey

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This paper surveys the contributions of computable general equilibrium (CGE) simulation models designed to quantify the implications of alternative trade policy scenarios in developing countries. The paper starts with a review of the basic structure of CGE models, using a one-sector model with product differentiation on the import and export side. The basic properties of CGE models are established and a series of applications to trade policy, internal–external balance and growth, and intertemporal issues are discussed.

INTRODUCTION

The use of computable general equilibrium (CGE) models for policy analysis has become widespread for both developed and developing economies. For developed economies, with a few notable exceptions, applications have focused on microeconomics with the analysis concentrating on estimating the welfare impact of alternative tax structures or energy policies.[1] In developing countries, CGE models have been used for a wider range of issues, from medium- to long-term macroeconomic policy analysis to the more traditional microeconomic issues analyzed in developed countries as well.[2] Several reasons account for this wider range of applications, particularly the fact that notwithstand-

[1]Applications to international trade and taxation issues are surveyed in Shoven and Whalley (1984). For models with a focus on energy policies, see Hudson and Jorgenson (1978). An exception is Dixon et al. (1982), who use a CGE model for Australia to analyze a wide range of macroeconomic and microeconomic issues.

[2]Robinson (1988) surveys CGE applications for developing countries with an emphasis on macroclosure and applications rather than on international trade. The two surveys are therefore complementary.

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ing the use of econometric models in the framework of LINK, developing countries are usually not well suited to economy-wide policy analysis relying on econometric techniques. This is so for three reasons. First, reliable time-series data for sufficiently long periods are usually not readily available; second, when available, the data are often not appropriate for standard econometric analysis without considerable further preparation to remove inconsistencies; and third, significant changes in policy regimes often take place, calling for different structural models, thereby reducing the time span available for hypothesis testing with a selected model.

CGE models have been used frequently for medium- to long-term policy analysis in developing countries. The policy applications have ranged from long-run issues such as the the impact of alternative development strategies on growth and resource allocation or on policy concerning exhaustible resources, to medium-run issues such as rural–urban migration, labor markets and employment, the functional and size distribution of income, and tax reform. Because foreign exchange has great scarcity value in most developing countries, the issue of foreign trade policy has occupied center place in the majority of applications. Even in the applications that do not have a foreign trade focus, the way the foreign trade sector is modeled has a decisive influence on the outcome of policy simulations. For example, in a model focusing on income distribution, changes in the equilibrium value of the agricultural terms of trade in response to a change in policy will depend on assumptions about the behavior of exports and imports. The issue of foreign trade policy and the interaction between the domestic economy and the foreign trade sector is also particularly well suited for general equilibrium rather than partial equilibrium policy analysis because of the sensitivity of domestic resource allocation to developments in the external sector. The extent to which the scarcity value of foreign exchange is affected by a change in policy cannot be easily estimated in partial equilibrium analysis because of the difficulty of estimating excess demand functions for tradables and nontradables without specifying the appropriate economy-wide budget constraint.

This survey reviews the contributions made to the modeling of foreign trade and provides examples from numerical applications. Deliberately, the focus is on policy issues and how to model them, rather than on an exhaustive review of contributions in each policy area.[3]

[3]Devarajan, Lewis, and Robinson (1986) and Decaluwe and Martens (1986) provide bibliographic surveys.

Section 2 presents the simplest model for dealing with external–internal balance. This one-sector model is then extended to a multisectoral version in section 3. The discussion of policy applications starts in section 4, which examines the impact of tariffs and quantitative restrictions on welfare and resource allocation, as well as the design of tariff policy when the government has a revenue constraint. Model extensions for dealing with a growing economy are surveyed in section 5, with applications to problems of external–internal balance in the medium run. Finally, applications that deal with policy choice when the economy faces an intertemporal budget constraint are raised in section 6.

2. A ONE-SECTOR MODEL

It is widely accepted that for medium-run issues, the Salter–Swan dependent economy model is the most appropriate specification for representing the external sector in a developing economy. In that specification, foreign prices are given and hence the external terms of trade are exogenous and domestically produced tradable goods are perfect substitutes for foreign-produced goods. In applied work, however, with the exception of a few homogeneous primary commodities, the implication of this specification—namely, that changes in foreign prices or trade policy are entirely passed through to competing domestic traded goods—is unrealistic for most traded goods. Indeed, the empirical evidence at the most disaggregated levels (see, for example, Isard 1977; Aspe and Giavazzi 1982) shows that the pass-through of exchange rate changes on domestic prices is small.[4] In addition, trade statistics indicate significant cross-hauling even at a very disaggregated commodity level, also suggesting the inappropriateness of the perfect substitution assumption of the Salter–Swan framework.

The alternative, now found in most CGE models, is to assume that foreign goods and domestic import-competing goods are imperfect substitutes in use. This specification, which is used on the import side, should also be incorporated on the export side for similar reasons. Then domestically produced goods for export sale

[4]A recent example of a pass-through, although for a developed economy, is that of the dollar appreciation during 1981–85. Dornbusch (1987) observes that a 20 percent appreciation in the dollar resulted in only a five percent increase in the index for manufactured imports. He goes on to show that this relative price behavior among traded goods is consistent with a number of competing hypotheses about firm behavior and product characteristics, including the one presented here. Krugman (1986c) develops other pricing models that are consistent with this observation.

are imperfect substitutes for domestically produced goods for sale on the domestic market. This assumption, while appropriate for economy-wide models that are fairly aggregated, is not without drawbacks. As Dixon (1977) has convincingly argued, empirical estimates of the costs of protection that are not sufficiently disaggregated to accommodate both economies of scale at the product level and the appropriate degree of complementarity/substitutability in use are likely to seriously understate the costs of protection. This criticism thus applies to the models that use the product differentiation assumption presented here when the models are used to give welfare estimates of the cost of protection.

A one-sector full employment model with symmetric product differentiation is presented in Table 1 and analyzed in Figure 1.[5] Because of Walras' law, the economy-wide budget constraint is omitted. Because of homogeneity of demand and supply functions, only relative prices are determined. Let $e=1$ be the numeraire. Then the model determines the following 10 endogenous variables: X, E, D^d, D^s, M, p^m, p^e, p^d, Q, p^x. In numerical applications, the functions $G(\ )$ and $F(\ )$ are usually given by constant elasticity of transformation (CET) and constant elasticity of substitution (CES) functions.[6]

The equilibrium in this stylized economy is represented in Figure 1. The external constraint for $\bar{B}=0$ is given in quadrant 1, and the full-employment transformation frontier represented by the CET is shown in quadrant 4. By choice of units, let $\bar{\pi}^e=\bar{\pi}^m=1$. Then the economy's consumption possibility frontier, which is given by CC in quadrant 2, is symmetric with the production possibility frontier in quadrant 4. Finally, II represents the indifference map. It is easy to see that equilibrium in the economy is characterized by the following familiar condition:

$$\frac{\delta Q/\delta D}{\delta Q/\delta M}=\frac{\bar{\pi}^e}{\bar{\pi}^m}=\frac{\delta G/\delta D}{\delta G/\delta E}=\frac{p^d}{p^m}=\frac{p^d}{p^e}, \tag{1}$$

which states that the marginal rate of transformation in production is equal to the marginal rate of substitution in consumption at equilibrium. Furthermore, when there are no trade or consumption taxes, these

[5]The presentation here follows de Melo and Robinson (1986).

[6]The CET and CES formulations in this context were first introduced by Powell and Gruen (1967) and Armington (1969), respectively.

Table 1: A One-Sector Small-Country Model With Differentiated Trade

(1) $Q = F(M,D^d)$	Import aggregation function
(2) $X = G(E,D^s)$	Export transformation function
(3) $p^m = e\,\bar{\pi}^m$	Import price
(4) $p^e = e\bar{\pi}^e$	Export price
(5) $p^q = f_1(p^m,p^d)$	Consumer price
(6) $p^x = g_1(p^e,p^d)$	Producer price
(7) $\frac{M}{D^d} = f_2(p^m,p^d)$	Import demand equation
(8) $\frac{E}{D^s} = g_2(p^e,p^d)$	Export supply equation
(9) $\bar{\pi}^m M - \bar{\pi}^e E = \bar{B}$	Balance of trade constraint
(10) $D^d - D^s = 0$	Domestic demand–supply equilibrium

where:

M,E	= Imports, exports
D^d,D^s	= Demand and supply of the domestic good
Q	= Composite consumer good
X	= Composite production
$\bar{\pi}^m$	= World price of imports
$\bar{\pi}^e$	= World price of exports
e	= Numeraire
p^m	= Domestic price of imports, M
p^e	= Domestic price of exports, E
p^d	= Domestic price of domestic sales, D
p^q	= Domestic price of composite consumer good, Q
p^x	= Domestic price of composite output, X
$\bar{B}$	= Exogenous balance of trade, or net foreign capital inflow (or outflow for negative $\bar{B}$)

marginal rates are equal to the foreign rate of transformation and Pareto efficiency occurs.

The equilibrium in Figure 1 is given by A and B. This apparatus is useful for examining the effects of terms of trade shifts and changes in the (exogenous) level of foreign transfers $\bar{B}$ and ad valorem trade taxes (tariffs and subsidies are not incorporated in the equation summary of Table 1). Several characteristics of this model are worth noting. First, the sign of the slope of the domestic offer curve—obtained by perturbing the terms of trade—is determined by the value of the elasticity of substitution in use, σ, between imports and domestically produced goods. As shown by de Melo and Robinson (1989), the domestic offer curve is upward (backward) sloping when σ is greater (less) than one. This is an important point in numerical applications

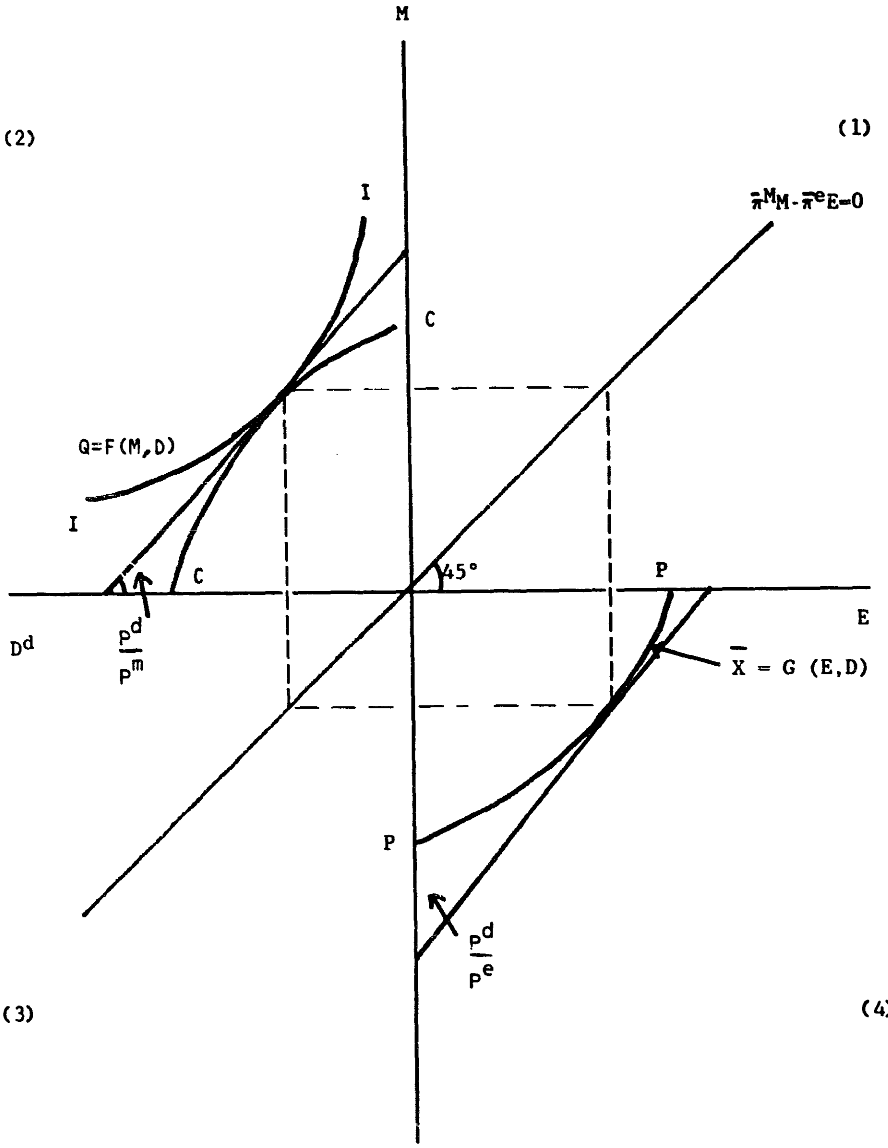

Figure 1. A one-sector full employment model.

since it will determine whether a policy change will cause a real exchange rate appreciation or depreciation.

Second, the model determines an equilibrium real exchange rate, e^r, which is the relative price of the foreign-produced and the domestically produced goods. Note that for the selected numeraire, $e = 1$, the real exchange rate is defined as $e^r = 1/p^d$. However, the computed value of e^r will differ according to the choice of weights in defining the price index for the domestically produced good. Thus, results from multisectoral simulations computing the percentage change in the equilibrium real exchange rate from a policy scenario can be used to determine how sensitive the values of e^r are to the selection of weights in defining the price indices that enter into the definition of the real exchange rate.[7]

3. THE DOMESTIC PRICE SYSTEM IN MULTI-SECTOR MODELS

The stylized model above is too simple in structure for policy analysis, although it contains the elements necessary to expand the dependent-economy model. The first extension that adds structure to the model is the inclusion of sectors and intermediate goods. The implications of this extension for the effects of trade policy changes on resource allocation are discussed next. The analysis is partial equilibrium.[8]

To start out, consider the problem of specialization in production in response to trade policy change when the perfect substitution assumption ($p^m = p^d = p^e$) is joined to the small country assumption. Suppose the economy has n sectors, of which $i, j = 1, \ldots, m$ are traded and the remainder $k = m+1, \ldots, n$ are nontraded. Following most CGE applications, technology is described by a separable function between value added and intermediates. A Leontief production function describes the fixed input/output coefficients for value added and the aggregate of intermediates, as well as the substitution possibilities within intermediates.

To illustrate the specialization problem, assume that nontraded intermediates do not enter into traded goods production. As before, by choice of units, $\bar{\pi}^m = \bar{\pi}^e = 1$. Suppose there are $1 = 1, \ldots, s$ intersectorally mobile factors of production with unit input coefficients k_l under cost minimization. Then the zero- profit condition of perfect competition for traded sectors implies that unit value added prices will just cover unit costs when production takes place. If t_i denotes the ad valorem tariff/subsidy rate, the zero-profit condition is:

$$PN_i \leq \sum_s k_s w_s \qquad \begin{array}{l} i,j = 1, \ldots, m \\ s = 1, \ldots, s \end{array} \tag{2}$$

where $PN_i = 1 + t_i - \sum_j a_{ji} t_i$. It is immediately evident that the system of equations described in equation 2 is underdetermined for a change in tariff/subsidy rates if $m > s$, that is, if there are more traded

[7]Edwards and Ng (1985) discuss alternative definitions of the real exchange rate and of the indices used in computing it.

[8]The analysis below draws on de Melo and Robinson (1985).

sectors than primary factors of production. This is of course the case in most empirical applications. Allowing for nontraded intermediate inputs to enter into traded goods production will help somewhat, but not much, unless they weigh heavily and cross-price effects are strong enough within the nontraded sectors that relative prices change considerably when tariff/subsidy rates are altered. An obvious solution is to add primary factors; however, this approach is not entirely satisfactory because one quickly runs out of information for disaggregating labor categories. The alternative is to assume decreasing returns to scale (e.g., land as a naturally fixed factor or entrepreneurial talent that is sector specific).[9]

Another alternative is to return to the product differentiation assumption presented in section 2, which has the added advantages of allowing for cross-hauling and of leading to a characterization of sectors by their degree of tradability, as will be shown shortly. Define

$$E^m \equiv \frac{dp^d}{dp^m}\frac{p^m}{p^d} \text{ and } E^e \equiv \frac{dp^d}{dp^e}\frac{p^e}{p^d},$$

the elasticities of the domestic price response to a change in the domestic currency price of imports and exports, respectively (sector subscripts are omitted to save on notation). It is clear that under the assumption of perfect substitution, $E^e = E^m = 1$, an increase of say 10 percent in the domestic currency price of imports or exports (due to a change in their world price, a change in the exchange rate, or a change in the trade tax) will lead to a 10 percent increase in the price of the domestically traded sector. However, for the model introduced in section 2, it can be shown that

$$E^m = \frac{(\sigma - \epsilon^q)\,\theta^m}{(1 - \theta)\,\epsilon^x + \epsilon^q + \theta^e\Omega + (\sigma^q - \epsilon^m)\,\theta} \tag{3}$$

$$E^e = \frac{(\Omega - \epsilon^x)\,\theta^e}{(1 - \theta^e)\,\epsilon^x + \epsilon^q + \theta^e\Omega + (\sigma - \epsilon^q)\,\theta^m}, \tag{4}$$

where $\theta^e = p^e \cdot E/P^x \cdot X$, $\theta^m = P^m \cdot M/P^q Q$, $\epsilon^q \equiv \dfrac{dQ}{dP^q}\dfrac{P^q}{Q} < 0$, ϵ^x is the elasticity of supply of X, and σ and Ω are the elasticities of substitution and transformation for the CES and CET trade aggregation functions

[9] This was done by Taylor and Black (1974) in one of the first trade policy simulations with a CGE model.

introduced in section 2.[10] Clearly, dropping the assumption of perfect substitution between imports and domestic goods solves the specialization problem noted above. Furthermore, this formulation is well suited for addressing empirically the arguments raised in the development literature between "structuralists" who maintain that developing countries are characterized by low elasticities, and "neoclassicists" who maintain that elasticities are high.[11] When σ, $\Omega \rightarrow \infty$, the domestic price system loses its independence, and we are back to the traditional trade theoretic model.

Once intermediates are included, the formulation acquires quite a degree of realism for studying the impact of trade policy changes on resource allocation. A four-part classification of sectors according to their degree of tradability follows naturally: (1) nontradables are sectors with low export (θ^e) and import (θ^m) shares; (2) exportables are sectors with high export and low import shares; (3) importables must be distinguished according to two subgroups, depending upon whether they are substitutes ($\sigma > \epsilon^q$) or complements ($\sigma < \epsilon^q$); and (4) import-dependent sectors are the sectors, like construction, that may be nontradable on the final demand side but that have a high ratio of imported intermediate inputs to total intermediate inputs.

This formulation has a number of desirable attributes due to the relatively small number of parameters and elasticities required for its implementation. Furthermore, equations like (3) and (4), once augmented for oligopolistic pricing possibilities, can be used for interpretation of microeconometric estimates of the link between exchange rate movements and producer prices.[12] When applied to simulations of the effects of changes in trade taxes on resource allocation, however, this formulation's reliance on constant elasticities may overestimate the degree of autonomy of the domestic price system, especially when simulations involve large changes in relative incentives.

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[10]These expressions are derived in de Melo and Robinson (1985), who compute values of E^e and E^m for different parameter configurations in equations (3) and (4). They also show that this formulation can easily be extended to accommodate a less than infinitely elastic foreign demand for exports, with or without product differentiation on the export side, thereby extending the analysis for homogeneous primary commodities.

[11]Chenery (1975) reviews the structuralist debate.

[12]Feinberg (1986a,b) uses the model presented here and augments it by a term that captures the presence of oligopolistic interactions on the price-cost margin. He uses a Cournot model to estimate econometrically the pass-through of changes in the real value of the dollar to relative producer prices at the microeconomic level.

4. APPLICATIONS TO TRADE POLICY

The model structure outlined in sections 2 and 3 reflects the essential characteristics of the trade policy reform simulations carried out in practice. Three examples of model-based simulations are presented in the following subsections.

4.1. The Welfare Costs of Quantitative Restrictions and Rent-Seeking Activities[13]

The foreign trade regimes in many developing countries are rife with quantitative restrictions. For example, import programs in Turkey in the late 1970s were issued semiannually, with imported commodities classified under three main lists: a liberalization list, consisting essentially of raw materials and spare parts not in competition with domestic production, for which importation was free; a restricted list, consisting of intermediate and final goods most of which were manufactured in Turkey, for which an import license was required; and a quota list, with commodity-specific quotas further allocated between industrialists and importers.

Students of Turkey's foreign trade regime have noted that industrialists have responded to these extensive quantitative restrictions with rent-seeking activity.[14] Grais, de Melo, and Urata (1986) draw on the concept of "virtual" prices introduced by Neary and Roberts (1980) to estimate the welfare costs of rationing in Turkey, using an eight-sector CGE model calibrated to 1978 Turkish data. The use of virtual prices (prices that would induce an unrationed household or firm to behave in the same manner as when faced with a vector of ration constraints) allows reoptimization over unrationed quantities, thereby allowing for spillover into other markets when adjustment to the quota is by quantity rather than price.

In the simulations, consumers are rationed in their purchases of imports of final goods, and producers are rationed in their purchases of imports of intermediates.[15] Furthermore, producers are assumed to

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[13]This application was formulated in the transactions value (TV) approach to modeling (see Drud, Grais, and Pyatt 1986, and Pyatt 1987).

[14]Krueger's (1974) is the original work in this area. Bhagwati and Srinivasan (1980) and Dervis, de Melo, and Robinson (1982) add to the discussion. Lewis and Urata (1984), Ahmed et al. (1985), Robinson and Tyson (1985), Clarete and Whalley (1986), and Ahmed and Grais (1987) also provide estimates of the costs of quantitative restrictions and rent-seeking activities.

[15]The specification of foreign trade in this application is close to the one in Table 1, although final demand is broken down into investment and public and private consumption.

engage in rent-seeking activity. The approach to implementing rent-seeking behavior is to assume that the production function for rent seeking is the same as that for what the authors refer to as "traditional" output. Producers, however, must purchase both the traditional and the rent-seeking commodities. Furthermore, the authors assume that the entire value of the rents, R, is spent on the production of the rent-seeking activity. At equilibrium the following will hold (sector subscripts have been dropped to simplify the notation):

$$X_t^d(p^d) + X_r^d(p^d) = X^s(p^d,p^v;\bar{k}) \tag{5}$$

$$X_r^d \cdot p^d = M(p^v - p^m) = R, \tag{6}$$

where p^d, p^v, and p^m are, respectively, the domestic, virtual, and import prices; M is the volume of rationed intermediate imports; X_t^d, X_r^d are the demand for traditional and rent-seeking output; and X^s is short-run output supply, given capital stock. Thus the effect of rent seeking is to reduce the supply of the traditional output and to raise the price to the final user. In the spirit of the literature on directly unproductive activities, rent seeking creates income since more output is produced, but at the same time the output generated by rent seeking, X_r^d, does not enter the utility function since it does not appear as an element of final demand.

The loss to the economy from rationing and rent seeking is summarized in Figure 2, which conveniently aggregates the economy into one sector. Because producers purchase imported intermediates, any rationing of these intermediates will raise the marginal costs of production. This is shown in Figure 2 by the leftward shift of XX_0s to XX_1s beyond X_0, the point at which rationing becomes effective. As a result of rationing, there is a deadweight loss, ADE. The effect of rent seeking is to push the supply curve up even further to $X_2^s = X_1^s - X_R^d$ because of the diversion of output toward rent seeking. The result is to raise the price (in terms of the numeraire) to PD_2. The area $HBCI$ is equal to the value of the rents, and the horizontal distance between $X_1{}^s$ and $X_2{}^s$ shows the output of rent-seeking activity. The extra deadweight loss from rent seeking is given by ABD. At the new equilibrium, FG and BF are the additional costs due to rationing and rent seeking, respectively.

The welfare benefits resulting from the removal of quantitative restrictions are reported in Table 2. Measured in terms of GDP, the welfare costs of quantitative restrictions in Turkey in 1978 were estimated at over five percent of GDP. Most of the costs come from quotas on intermediates since consumer imports had a small share in

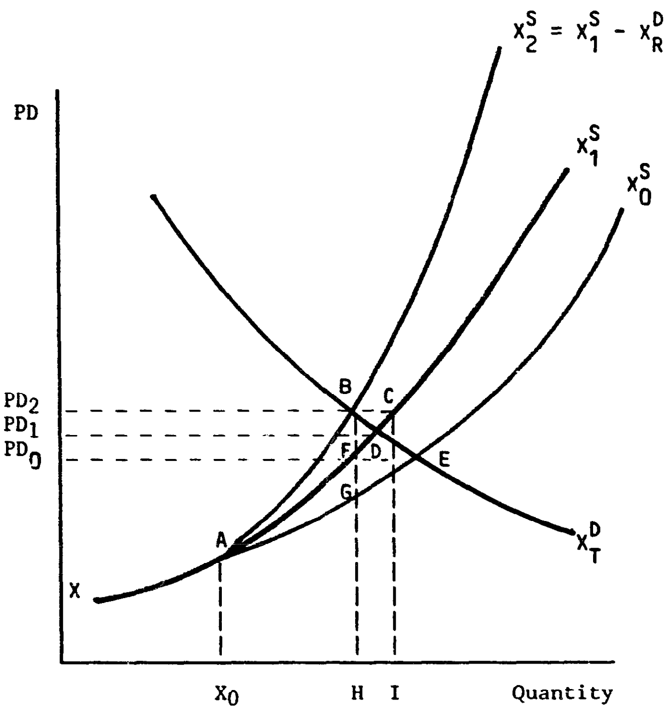

Figure 2. Welfare cost of rationing and rent seeking.

overall imports. Of course, the magnitude of the results is driven by the assumed rent-seeking behavior and by the estimated value of the premium rates incorporated in the calibrated solution for the base simulation. The results are thus only indicative, but they help to focus on the costs in terms of foregone consumption and, more important, foregone growth due to reduced real investment caused by quantitative restrictions and rent-seeking behavior.

Table 2: Welfare Benefits Resulting From the Removal of Quotas in Turkey (Ratio to Base Simulation Value)

	Removal of Quotas on Intermediate Imports Removed	**Removal of Quotas on Intermediate and Consumer Imports**
Real GDP	1.052	1.054
Real Household Consumption	1.038	1.042
Real Investment	1.112	1.110

Source: Grais, de Melo, and Urata (1986, Table 7).

4.2. Interactions Between Quantitative Restriction-Based Foreign Trade Regimes and Industrial Organization

Rent-seeking activity under foreign trade regimes based on quantitative restrictions is only one aspect of the potential welfare costs that extend beyond the standard welfare costs of protection. Another and potentially more costly aspect of such trade regimes derives from the noncompetitive behavior made possible by the market structure in many developing countries. In the following application, a quantitative restriction-based trade regime does not give rise to rent seeking.

Students of industrial organization in developing countries have often noted that concentration is high in the manufacturing sector and that these high concentration ratios probably understate the extent of market power enjoyed by leading oligopolists.[16] This is so because entry is restricted by industrial policies that regulate investment through complex licensing procedures and because credit incentives are exhausted among incumbent firms. Likewise, weak capital markets imply that investment funds are internally generated, which also restricts entry. Most important, the widespread use of quantitative restrictions eliminates foreign competition. Furthermore, exit from the market is also difficult because of the lack of bankruptcy legislation. As a result, markets in these countries are often characterized by both market power and an ossified industrial structure. When restrictiveness on investment licensing is not too great, too many firms operate. This has become known as the *excessive entry problem*, reflecting the observation that too many firms have typically coexisted behind protective walls despite official licensing policies.[17]

Condon and de Melo (1986), starting from the analysis by Harris (1985) and Cox and Harris (1985) for Canada, illustrate the costs of quantitative restriction-based protection in a semi-industrial economy. They use several variants of a model in which economies of scale and oligopolistic behavior interact when rationing of consumer and intermediate imports takes place. Although expressed in dual rather than primal form, the model is similar to the model presented in Table 1

[16]The evidence on market structure and performance in developing countries is surveyed in Kirkpatrick, Lee, and Nixson (1984). Krugman (1986a,b) reviews the issues raised here along the same lines. Stewart (1984) takes an opposing view, claiming that the literature on trade and industrial organization provides new arguments for protection.

[17]The excessive-entry problem was first noted by Eastman and Stykolt (1960) for Canada. A well-known example of excessive entry is that of the automobile industry in developing countries.

in its specification of the foreign trade sector since it assumes symmetric product differentiation on the import and export sides.

Before examining the welfare costs of rationing, it is instructive to indicate how the standard costs of protection are modified by the presence of economies of scale and by the departure of pricing from average cost implied by noncompetitive behavior. Let the consumer side be represented by a single consumer with expenditure function $E(P_1, \ldots P_n, W)$, where W is a welfare index. Let sectoral production take place in identical firms ($X_i = n_i x_i$), with unit cost functions $c_i(w, X_i)$, where w is the vector of factor prices, x_i is firm output, and $\theta_i = c_i[\delta(c_i x_i)/\delta\ x_i]$ is the ratio of average to marginal cost (i.e., the inverse of the scale elasticity). Then, as shown by Rodrick (1987), the wlefare effect of a change in trade policy can be decomposed into the following expression:

$$E_u dW = \underset{(1)}{\sum_i (P_i - \pi_i^*) dC_i} - \underset{(2)}{\sum_i (c_i - \pi_i^*) dX_i} + \underset{(3)}{n_i c_i} \left[1 - \frac{1}{\theta_i}\right] dX_i, \tag{7}$$

where P_i is the domestic price and π_i^* is the corresponding world price.

Equation (7) decomposes the welfare change into three terms. The first term is the familiar consumption effect, which states that consumption should be expanded wherever marginal value exceeds marginal cost. The second term departs from the traditional costs of production and states that output should contract whenever unit domestic price exceeds world price because of the effects of imperfect competition. The degree of monopoly is represented by the extent to which $P_i > c_i$. Whenever $P_i > c_i$, the correct policy goal should be to expand output to remove monopoly power. In the end, the second term states that output should contract if $c_i > \pi_i^*$. Thus, for a given degree of oligopoly, the production costs of protection are less than under perfect competition. Finally the third term states that, for a fixed number of firms, production should be expanded whenever there are unexploited economies of scale.

Table 3 reports the welfare cost calculations obtained from a stylized three-sector model (primary, manufacturing, and nontraded activities) in which only the manufacturing sector is characterized by economies of scale and noncompetitive behavior. The welfare costs of rationing are obtained by starting from a free trade situation and then rationing consumer and intermediate imports, first by 20 percent and then by 50 percent (that is, reducing the volume of imports by 20 percent and 50 percent). Rationing is modeled as in the previous example, but there is no rent seeking.

Table 3: A Comparison of the Welfare Costs of Rationing Under Alternative Market Structures

	Rationing rate (M_0/M_1)	Variant 1:[a] CRTS	Variant 2: IRTS	Variant 3: IRTS; Firm Entry, No Collusive Behavior	Variant 4: No Entry, IRTS; Collusive Behavior
Welfare Costs:[b] (% of base national income)	0.8	1.7	6.1	6.5	6.5
	0.5	13.0	16.0	16.7	17.1
Profits (P/AC-1)	0.8	0	0	0	6.6
	0.5	0	0	0	25.7
Number of firms (ratio to base)	0.8	1	1	107	1
	0.5	1	1	124	1

Source: Condon and de Melo (1986, Table 5).

Notes: The calibration of the parameters determining the extent of economies of scale in manufacturing are from Cox and Harris (1984). Profits and firm entry are calibrated so as to replicate the change in price–cost margin and number of firms in the Chilean manufacturing sector after trade liberalization (see de Melo and Urata 1986). In the base simulation, foreign trade is 40 percent of GDP with 5% in consumer goods.

CRTS = Constant returns to scale.

IRTS = Increasing returns to scale.

[a]Variants are discussed in the text.

[b]Computed as the Hicksian compensation variation from the Linear Expenditure System (LES) indirect utility function representing consumer expenditure choice.

Variant 1 gives the cost of rationing with constant returns to scale. Variant 2 gives the cost of rationing when there are economies of scale in manufacturing. Variant 3 captures the excessive-entry phenomenon observed in the manufacturing sector of developing countries by incorporating the assumption that the number of firms in a sector is an increasing function of the rents in manufacturing arising from rationing. Variant 4 captures the fact that rationing provides opportunities for manufacturing firms to depart from average cost pricing in the domestic market. Rents accruing from rationing are used as the proxy for entry barriers (since imports are restricted), and the departure of unit domestic price, p^d, from unit average cost is an increasing function of the per unit rents conferred by rationing.[18] Table 3 shows that the

[18]Calibratrion procedures are described in Table 3.

welfare costs of excessive entry or collusive pricing can be well over 10 percent of national income. These calculations are only suggestive because more disaggregation would be desirable to better distinguish sectors that are subject to economies of scale and noncompetitive behavior. Nonetheless, the calculations are suggestive of the potential costs of quantitative restrictions when interaction is specified between the trade regime and the industrial organization structure.

4.3 Optimal Trade Policy in the Presence of a Government Revenue Constraint

With limited administrative capacity to raise taxes, developing countries often have a government revenue constraint. Some sectors in the economy (e.g., agriculture) or some categories of demand (e.g., consumer goods) cannot be taxed, and rampant tax evasion for certain kinds of taxes, such as income taxes, forces the government to rely on trade and producer taxes as its main source of revenue. The policy issue then is how to raise a given amount of revenue at minimum distortionary cost, given the presence of nonremovable distortionary taxes and the further constraint that trade taxes are needed to raise revenue.[19]

Dahl, Devarajan, and van Wijnbergen (1986) and Mitra (1986) derive conditions for optimal tariff structures for raising government revenue at minimum distortionary cost under the conditions specified above. They derive a number of rules analogous to those derived in the optimal taxation literature. For example, they show that in the absence of cross-price effects, the optimal tariff rate is inversely proportional to the import demand elasticity. Furthermore, when there is cross-elasticity of import demand with respect to the export price, account must be taken of the fact that a tariff acts as an export tax, so that imports that are the closest substitutes for export goods should be taxed the least. These theoretical results imply that the recommendation for uniform nominal (and hence effective) tariffs advocated in the literature on trade liberalization should be revised to take into account the inherent weaknesses of developing country fiscal systems.

Dahl, Devarajan, and van Wijnbergen (1986) incorporate these features in a CGE model similar to the one outlined in Table 1 except that their eight-sector model for Cameroon also includes uniform less-

[19]As shown by Dixit (1985), in the absence of nondistortionary taxes, consumer taxes should be used to raise revenue.

Table 4: Actual and Optimal Revenue-Constrained Tariff Rates

	Indirect Production Tax Rate	Actual Tariff Rates	Optimal Revenue-Constrained Rates	
			Ind. Taxes > 0	Ind. Tax = 0
Food Crops	0.02	0.22	−0.06	0.09
Cash Crops	0.19	0.23	−0.28	0.13
Forestry	0.06	0.28	9.31[a]	0.12
Food Processing	0.04	0.35	0.27	0.11
Consumer Goods	0.10	0.38	0.28	0.11
Intermediate Goods	0.03	0.18	0.22	0.15
Services	0.00	0.00	0.04	0.19
Uniform Rate			0.16	0.15

Source: Dahl, Devarajan, van Wijnbergen (1986, Table 2).

Note: The simulations assume zero export taxes.

[a]The 931 percent tariff on forestry is due to the fact that imports in this sector are minuscule.

than-infinitely-elastic demand for sectoral exports ($\zeta = -20$). Table 4 presents the results from a model run using optimal tariffs to raise the same level of government revenues as was collected in Cameroon during 1979. Although similar in structure to the prevailing tariff structure (in column 1), the optimal tariff structures (in columns 2 and 3) are far from uniform. Note in particular the results in column 2 for the case in which the prevailing set of indirect taxes is kept at its existing level: the optimal tariff for food and cash crops is negative. Because virtually all output of the cash crop sector is exported, the production tax acts like an export tax. The negative optimal tariff dampens the effect of this tax, which is excessive given the high elasticity of demand for exports.

Of course, as with the other empirical exercises, greater disaggregation would help in the design of trade reform packages, but the essential message of this analysis would remain, namely that uniform protection is not optimal in the presence of fiscal (or other) constraints.

5. APPLICATIONS TO INTERNAL-EXTERNAL BALANCE AND GROWTH

I now turn to issues of internal–external balance in a growing economy. Table 5 augments the skeleton model presented in Table 1 to deal with a growing economy. Neither the process of growth nor the

Table 5: A One-Sector Small-Country Growth Model

(1)	$Q = F(M,D^d)$	Import Aggregation Function
(2)	$X = G(E,D^s)$	Export Transformtion Function
(3)[a]	$X = A(t)\, H\, (L_t;\, \bar{K}_t)$	Production Function
(4)[a]	$\underline{W} = P^s\, \delta H/\delta L_t$	Labor Demand
(5)[a]	$K_t = K_{t-1} + I_{t-1}$	Capital Accumulation
(6)[a]	$L_t = L_{t-1}(1+g_l)$	Labor Accumulation
(7)	$p^m = e\bar{\pi}^m$	Import Price
(8)	$p^e = e\bar{\pi}^e$	Export Price
(9)	$p^q = f_1(p^m,p^d)$	Consumer Price
(10)	$p^s = g_1(p^e,p^d$	Producer Price
(11)[a]	$p^I = k_1(p^m,p^d)$	Investment Price
(12)	$\frac{M}{D^d} = f_2(p^m,p^d)$	Import Demand
(13)[a]	$\frac{I^d}{I^m} = k_2(p^m,p^d)$	Investment Demand
(14)	$\frac{E}{D^s} = g_2\,(p^e,p^d)$	Export Supply
(15)	$\bar{\pi}^m I^m + \bar{\pi}^m M - \bar{\pi}^e E = \bar{B}$	Balance of Trade constraint
(16)[a]	$Y = p^s X + e\bar{B}$	Income
(17)[b]	$p^q Q = p^d D^d + P^m M + P^I I$	Absorption
(18)[a]	$p^q C = P^s X^d - S(Y)$	Consumtion
(19)[a]	$P^I I = S(Y) + e\bar{B}$	Investment

[a]Equation was not included in Table 1.

[b]This absorption equation replaces equation 10 in Table 1.

A time subscript is included only for the factor accumulation and factor demand equations to save on notation. $A(t)$ is the exogenous rate of disembodied technical progress, and g_l is the exogenous rate of growth of the labor force. Also to save on notation, it is assumed that domestic and foreign investment goods have the same prices as their final demand counterparts.

interaction between growth and policy is addressed in the model, except in a very limited sense, as discussed further on.

The distinguishing feature of the augmented model is the presence of a more complete production side, which includes factor allocation and factor accumulation equations. Here the capital stock is assumed to be immobile across sectors, whereas labor migrates to equate the value of marginal products across sectors. This specification is common in many applications where limited within-period factor mobility is handled in this manner. For example, rural and urban labor are often distinguished, with limited rural–urban migration in response to wage differences. The model also assumes that all of the resource gap $e\bar{B}$ is invested and that investment includes a domestic and an imported

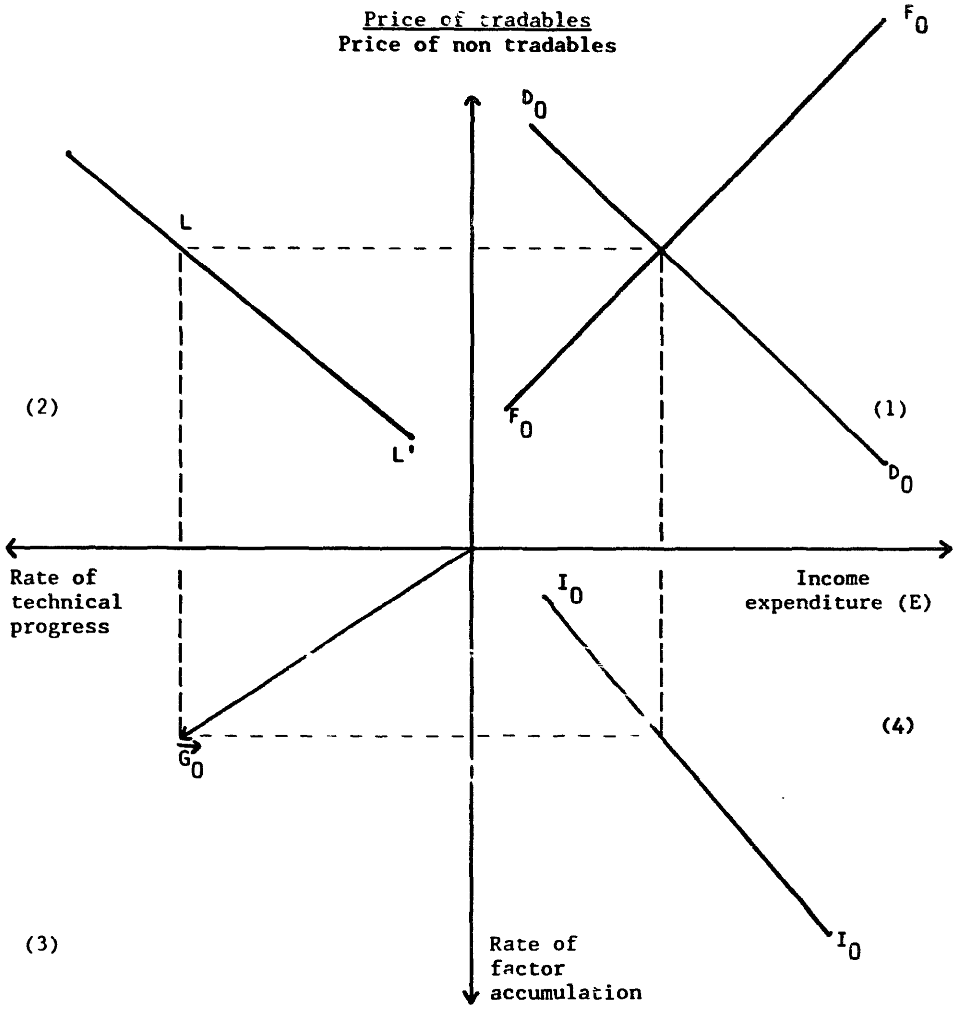

Figure 3. Internal-external balance and growth.

component; therefore, any change in the equilibrium value of relative prices will have an impact on the amount of real investment forthcoming from a given savings effort.

To see more clearly how external–internal balance and factor accumulation interact to determine growth in this augmented model, consider the simple case with no differences in factor intensities across sectors but with greater technical progress in tradables than in nontradables (perhaps because of learning by doing). The contribution of technical progress to growth can be related to the structure of production, as shown by line LL' in Figure 3, quadrant 2. Internal–external balance for a given level of exogenous capital inflow ($\bar{B}_0$) is given by F_0F_0 in quadrant 1. The internal balance is downward sloping because, starting from an equilibrium position, expenditure exceeds income and the relative price of home-produced goods must rise to eliminate excess demand. By the same line of reasoning, the external balance schedule is upward sloping because the excess demand for tradables caused by an excess of expenditure over income requires an increase in the relative price of tradables (i.e., a depreciation of the real exchange rate) to eliminate the excess demand.[20] The model is closed in quadrant 4 by the assumption that a constant fraction of income is invested. The rate of growth is measured by the vector $\overrightarrow{OG_0}$ in quadrant 3. The model closure assumes that investment is determined by savings. As Dewatripont and Michel (1987) show, other closures are possible. One such example is the application reported in section 5.2.

The apparatus can be used to examine the effects on growth resulting from a change in the terms of trade, in the exogenous level of foreign transfers (a shift in the F_0F_0 schedule), or in the relative price of investment goods (a shift in the investment schedule I_0I_0). The simulations reported below involve applications that amount to either exogenous or policy-induced shifts in the schedules of quadrants 1 and 4. A typical exercise with a model of the type described in Table 5 starts with a validation of the model from historical data; the modeler chooses a plausible set of parameters and elasticities that produce a base run scenario close to the observed aggregate and sectoral growth rates. No formal econometric procedures are used to test the validity of the chosen model structure.[21] After satisfactory validation, counterfactual simulations are undertaken to examine the likely evolution of equilibrium values of relative prices and medium-term adjustments under different policy scenarios.

5.1 Causes of Turkey's Foreign Exchange Crisis in 1977

The modern theory of exchange rate determination recognizes that the equilibrium exchange rate is determined by a combination of monetary and real factors, going beyond differences in inflation rates of the economy and the rest of the world as advocated by the strictest version of purchasing power parity (PPP). To show this, we assume following Dornbusch (1976), that there is goods arbitrage, so that for tradables

[20]The slopes of the internal and external balance schedules reflect the assumption of gross substitutability between tradables and nontradables in demand. See, for example, Dornbusch (1980, chapter 6) for a fuller derivation.

[21]CGE models have been described so far as though relative prices were always assumed to adjust to clear markets. In practice, all models rely on a mix of price and quantity clearing assumptions in product and factor markets.

$$P_T = e\,P_T^*, \tag{8}$$

where subscript T refers to a tradable sector. Let P denote the price level and θ, θ^* the equilibrium relative price of traded goods, so that

$$P_T = \theta P; \quad P_T^* = \theta^* P^*, \tag{9}$$

where the asterisk denotes a variable for the rest of the world. In introducing the monetary sector, assume monetary equilibrium where L and L^* denote domestic and foreign demand for real balances

$$M/P = L(\ ); \quad M^*/P^* = L^*(\ ). \tag{10}$$

By combining equations (8)–(10) and taking log differentials, it can be shown that the determinants of the equilibrium exchange rate combine real and monetary aspects according to the following:

$$\hat{e} = (\hat{M} - \hat{M}^*) + (\hat{L} - \hat{L}^*) + (\hat{\theta} - \hat{\theta}^*), \tag{11}$$

where the first term captures the effect of different rates of monetary growth and the second and third terms capture the effects of real money demand and changes in relative price structure, respectively. In the exercise to be described, the monetary sector is treated rudimentarily, as it is assumed that the monetary authorities effectively control the domestic price level, which is set exogenously in the model. The analysis concentrates on decomposing the role of the various real factors that contribute to the equilibrium value of the real exchange rate.[22]

Following a successful devaluation in 1970, accompanied by a set of macro policies to correct imbalances, Turkey achieved a $0.5 billion current account surplus in 1973. By 1978, however, Turkey had a deficit of $3 billion, or nine percent of GDP. With its foreign reserves exhausted, Turkey only postponed the crisis by massive foreign borrowing. As is often the case in such circumstances, Turkey did not devalue sufficiently during the post-1973 period to correct for the differential in inflation so the real exchange rate was back to its pre-1970 value by 1976 (the differential in inflation between Turkey and OECD countries was eight to 10 percentage points while devaluations averaged five percent).

What were the causes of this foreign exchange crisis? More specif-

[22]More precisely, values for $\hat{P}$ and $\hat{P}_T^*$ are taken exogenously where $\hat{P}$ is Turkey's inflation rate and $\hat{P}_T^*$ is the OECD's rate of inflation. The exercise thus assumes equilibrium in the money market, with the government having full control over the money supply. In terms of the results in Table 6, the effects of differential inflation are captured by the first two terms on the right side of equation 11.

Table 6: Factors Contributing to the Change in the Equilibrium Real Exchange Rate in Turkey in 1977 (%)

Differential Inflation	37
Oil Price Rise	21
Higher OECD Export Prices	11
Lower Remittances	18
Other Factors (residual)	13
	100

Source: Dervis and Robinson (1982, Table 5)

ically, what were the contributions of the inflation differential, the rise in oil prices of 1973, the massive foreign borrowing in 1976 and 1977, the rise in the index of OECD-country export prices, and the unexpected fall in worker remittances (which had been financing half of imports by 1973)? Dervis and Robinson (1982) used a 15-sector CGE model similar to the one described in Table 3 to assess the relative impact of each of these effects.[23]

After validating their model over the period 1973–77, Dervis and Robinson performed a set of cumulative experiments (adding one new factor after another). They sought to determine what the equilibrium real exchange rate would have been had inflation in Turkey equaled OECD inflation, had external borrowing been equal to GDP growth, had there been no rise in oil prices or OECD-country export prices beyond the rise in world prices in Turkey's export markets, and had workers' remittances grown at the same rate as GDP.

The results of the contribution of each element of this counter-factual history are reported in Table 6. The exercise shows that differential inflation was only a small part of the story. Of course the model structure was imposed rather than tested, and there was certainly interaction among some of the variables that were treated exogenously or feedback from endogenous to exogenous variables. But it remains that in a world in which economies are exposed to multiple exogenous shocks, partial equilibrium analysis or simplistic calculations are likely to be misleading.

[23]The numerical results are from Dervis and Robinson (1982), who summarize the full structure of the model and recent Turkish economic history.

5.2. Absorption Under Disequilibrium Exchange Rates: Chile, 1979–1981

A second application dealing with internal–external balance illustrates the difficulty in modeling agents' expectations and incorporates a practical— albeit not entirely satisfactory—way of overcoming the difficulty. The model follows the recent contributions to the analysis of the current account that emphasize the role of expectations and the usefulness of modeling the adjustments in savings and investment behavior (see, for example, Sachs 1981; Svensson and Razin 1983). Studies of the implications for the current account of a temporary disequilibrium in exchange rates have also focused on savings and investment behavior (see, for example, Dornbusch 1985). In great part, these contributions have been inspired by country experiences, some involving unsustainable current account deficits fostered by protracted periods of low real exchange rates resulting from "excessive" capital inflows. These contributions drawn from intertemporal models show that expenditure smoothing takes place to offset temporary changes in purchasing power.

A vivid example of this smoothing effect is the consumption increase that followed the 25 percent appreciation of the real exchange rate in Chile between 1979 and 1981. The problem was exacerbated by the pegging of the peso to the dollar in mid-1979 while the minimum wage was fully indexed to past inflation and domestic inflation exceeded world inflation. Capital inflows averaged five percent of GDP between 1977 and 1979 and jumped to an average of nine percent during 1979–81, with the current account deficit reaching 15 percent of GDP in 1981. With no public sector deficit, this increase in capital inflows (induced by the fixed exchange rate coupled with unregulated domestic interest rates) resulted in an expenditure boom. During 1977–79 private consumption grew at a rate that was one percent less than the growth in GDP, but during 1979–81 it grew at an average annual rate of 11 percent, while GDP was growing at the rate of seven percent. The crisis emerged when the capital inflows necessary to finance the deficit ceased.

Condon, Corbo, and de Melo (1986) use a simulation model similar to the one presented in Table 3 to ask what might have happened had Chile not followed the fixed exchange rate policy that led to the surge in capital inflows described above. The mechanism leading to capital inflows is not modeled explicitly; rather, the exercise consists of asking what would have been the absorption and real exchange rate trajectories had capital inflows been lower during 1979–81. Their model departs from the one described in Table 3 to allow for a rising real consumption wage that reflects the wage indexation mechanism then prevailing in

Chile. In addition, private savings behavior is modified to incorporate expenditure smoothing by considering savings as a positive function of real income and a negative function of (exogenously determined) real capital inflows, $e\bar{B}$, with coefficients drawn from econometric estimation with Chilean data.[24]

This model closure applied to a five-sector model for Chile during 1977–81 fits well with the adjustment patterns in production, relative price, and expenditure that occurred in Chile during that period. The authors then use the model to ask how the Chilean economy would have adjusted to lower capital inflows during 1979–81, taking as given the wage indexation mechanism prevailing in Chile. The model is used to trace the combination of real exchange rate depreciation and increases in unemployment caused by real wage rigidity. By taking into account different factor intensities across sectors, the model also captures the effect on GDP of compositional shifts in demand induced by expenditure switching and by expenditure reductions.

Figure 4 shows the predicted tradeoffs from lower capital inflows during 1979–81 with reductions in capital inflows of 10 percent, 25 percent, and 50 percent (E–1, E–2, E–3) during both 1980 and 1981. Elasticities of the real exchange rate with respect to the equilibrium expenditure levels range between 0.6 and -0.8 for 1980, and -0.5 and -0.7 for 1981. In addition, the model shows that much of the adjustment to lower capital inflows could have been achieved by expenditure switching, in spite of the institutionally determined real wage rigidity, because of the positive effect on employment of compositional shifts in demand. Again, these counterfactual simulations are only indicative, but as in the preceding exercises, the addition of structure (in the labor market and in the composition of demand) to an otherwise standard dependent-economy model, provides an enhanced tool for policy analysis.

5.3. Simulating Alternative Development Strategies[25]

The last application is a long-run exercise using CGE simulation analysis to distill the growth implications of alternative foreign trade

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[24]The counterfactual is well visualized in terms of Figure 3 since, during 1977–81, total factor productivity growth patterns induced by the trade reforms corresponded to those shown in Figure 3. Reducing capital inflows (with a fixed real wage) results in an upward shift of the F_0F_0 schedule, an inward shift of the D_0D_0 schedule, and a leftward kink in the I_0I_0 schedule for expenditure levels below the initial equilibrium.

[25]The specifics of the model are reported in Chenery et al. (1986).

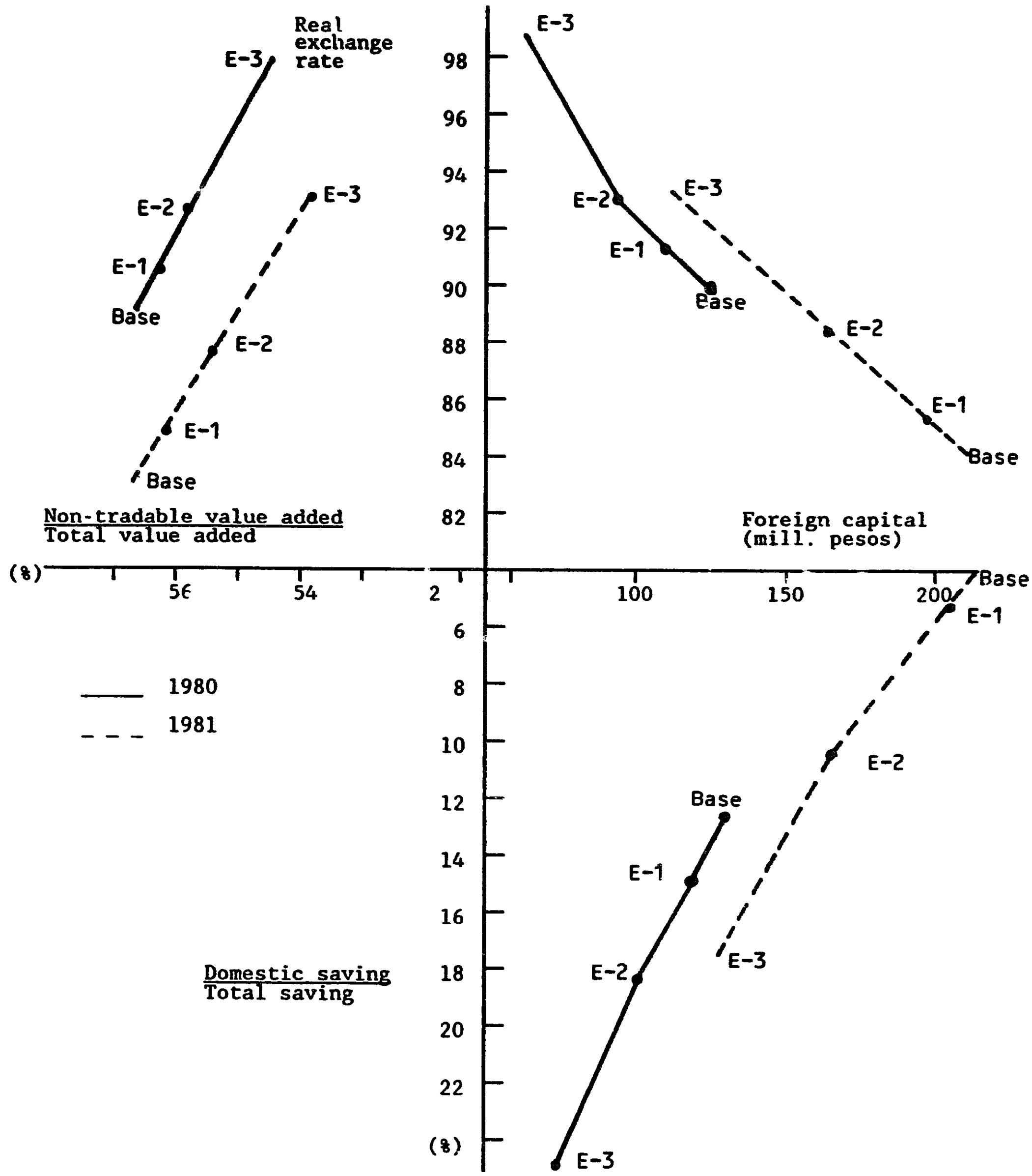

Figure 4. Model predicted tradeoffs from lower capital inflows.

strategies. The results of the exercise, consisting of 20-year simulation runs, are sensitive to the linkages built into the (mostly) exogenous determinants of growth. Again, the model structure corresponds quite closely to that described in Table 3 and Figure 3. Three new features, however, deserve attention. First, exogenous trends have to be imposed on the parameters describing the response of imports and exports to relative price shifts (See table 7); otherwise, the model is not capable of reproducing the development patterns that result from the selection of alternative trade strategies (described below).[26] This is a serious shortcoming of the functional forms advocated in section 2, at least for long-run applications, and suggests that the foreign trade specifications adopted in applied general equilibrium analysis need improvement. Second, as indicated in Table 7, the inward-looking (IS) strategy is modeled by assuming that macroeconomic adjustment comes entirely on the import side via rationing of imports when there is excess demand for imports, rather than by a real exchange rate devaluation, which would also relieve the foreign exchange constraint by stimulating exports. The implication of this adjustment mechanism is that a premium on imports develops in the IS strategy, resulting in the strong bias against exporting in the trade regime shown in Table 7. The third new feature is the significant effect on the relative price of capital goods. This effect, equivalent to an upward shift of the I_0I_0 schedule in Figure 3, results in less real investment from a given savings rate. Thus, policy choices affect growth via the bias in the trade regime and the cost of capital goods.

Table 7 reports the results of simulations designed to provide rough bounds on the extent to which the choice of development strategy is likely to affect growth. Although not reported here, the model was also used to examine the marginal productivity of foreign aid under different trade strategies. Based upon extensive sensitivity analysis to key parameters in the model, the exercise suggests that up to one percent of average annual growth (over a 20-year period) can be explained by the mechanisms incorporated in the model to describe alternative trade strategies.

6. APPLICATIONS TO INTERTEMPORAL ISSUES[27]

Although the role of forward-looking decisions was alluded to in the application to Chile for absorption under a disequilibrium real exchange rate (see section 5.2), all the models considered so far have been intertemporally decomposable. That is, the solution values for endogenous variables in period t depended only on the solution values of endogenous variables in previous periods. For the problems examined, this assumption was adequate, although the example for Chile

[26]This led the authors to update exogenously the trade share parameters in the import demand and export supply equations. Analytical expressions are provided by de Melo and Robinson (1985) that show such a procedure is necessary to diminish the degree of independence of the domestic price system from foreign prices.

[27]See Devarajan (1987), who covers intertemporal issues in greater depth.

Table 7: Representative Trade Strategies and Macroeconomic Indicators

Components	**Import Substitution (IS)**	**Balanced (B)**	**Exort Promotion (EP)**
Trade Policy/Trends			
Sectoral trends (i.e., exogenous variation in trade shares)	Low/falling	Constant	Rising
Macroeconomic policy instruments	Tariffs/import rationing[a]	Real echange rate adjustment[b]	Real exchange rate adjustment[b]
Productivity growth	Low/intermediate	Intermediate	High
Macroeconomic Indicators[c]			
Incremental capital-output ratio, terminal, year	3.26	3.02	2.95
Export growth rate	7.9	10.3	14.1
Import growth rate	4.5	6.4	9.3
GDP growth rate	5.7	6.2	6.5
Bias of the trade regime in terminal year[d,e]	200	100	95
Relative price of capital goods in terminal year[d]	120	105	95

Source: Chenery et al. (1986, Chapter 4).

[a]Import rationing implies that ex ante excess demand for foreign exchange is eliminated by endogenously determining the premium on foreign exchange.

[b]No rationing of imorts.

[c]Level of cumulative capital inflow is \$1,900 million in 1964 dollars.

[d]Index = 100 in initial year.

[e]The bias of the trade regime is defined as $B = EER_M/EER_X$, where EER is the effective exchange rate (inclusive of tariffs, subsidies, and premiums on foreign exchange), and subscripts refer to imports and exports respectively.

points out that such an assumption is not tenable when the economy is in strong macroeconomic disequilibrium. The assumption of intertemporally decomposable growth paths is also inadequate for inherently forward-looking policy issues such as the optimal extraction rate for an exhaustible resource, or decisions about external borrowing strategy. In such circumstances a forward-looking intertemporal model is the appropriate framework.

This section briefly reviews the equilibrium properties of the two-sector tradable/nontradable dependent-economy model in a two-period framework, and then illustrates results from an application to optimal borrowing strategies for Thailand derived from a five-sector, seven-period model. The intertemporal aspects of the two-period model carry over to the multiperiod model.

Following Glick and Kharas (1986), consider a small open economy that can borrow any amount, D, in the first period at a fixed world interest rate, r. The country's welfare maximization problem consists of choosing consumption and investment levels for traded and non-traded goods that maximize discounted utility:

$$W = \sum_{t=1}^{2} C_t^{1-b}/[(1-b)(1+\delta)^{t-1}], \tag{12}$$

where $C_t \equiv C_{Tt}^{a}\, C_{Nt}^{1-a}$; $b>0$, $0<a<1$.

Subject to the intertemporal budget constraint

$$\begin{aligned} &C_{T1} + p_1 C_{N1} + I + (C_{T2} + p_2 C_{N2})/(1+r) \\ &\quad - Q_{T1} - p_1 Q_{N1} - (Q_{T2} + p_2 Q_{T2})/(1+r) = 0, \end{aligned} \tag{13}$$

where $P_t \equiv \dfrac{P_{Nt}}{P_{Tt}}$ is the relative price of nontraded goods or the inverse of the real exchange rate. Subscripts T and N distinguish tradables from nontradables, and Q refers to output. Note that investment, I, is all in tradables. In this formulation, δ is the pure rate of time preference, and the utility function is assumed to be intertemporally separable, with a constant intertemporal elasticity of substitution $1/b$, as in the simulation exercise below. As $b \rightarrow \infty$, greater smoothing of consumption is desired. Let $\rho_2 \equiv \delta Q_{T2}/\delta k_2 + p_2\, \delta Q_{N2}/\delta k_2$ represent the return to capital in period 2. Then the first-order conditions to the maximization problem are:

$$(1+\delta)(C_2/C_1)^b = (1+r)(p_2/p_1)^{1-a} = \rho_2 (p_2/p_1)^{1-a}. \tag{14}$$

This familiar condition from intertemporal models states that the real social discount rate in equilibrium is set equal to the real cost of foreign borrowing and the real rate of return on capital, all rates and costs being expressed in terms of the aggregate consumption bundle. The real cost of foreign borrowing and the real return to capital depend on two factors: (1) the cost (return) in terms of traded goods, and (2) changes in the aggregate consumer price index over time. Thus changes in relative prices over time are an important determinant of intertemporal substitution.

With no investment, given supply functions, borrowing (lending) will occur for $\delta > r$ ($\delta < r$) because there is a fall (rise) in consumption of tradables and nontradables in the second period. With positive investment—the case relevant to the CGE applications—Glick and Kharas show that borrowing not only affects production and consumption through relative prices, but also through factor intensities in each sector. Only for the case of $\upsilon = 0$ (that is, when consumption is perfectly substitutable across time periods) are relative price movements independent of investment. Otherwise, the relative factor intensity in production will influence the outcome. Thus, while it is possible to isolate the factors that determine whether borrowing or lending will take place, it is difficult to derive analytical results, even in the simple case in which all investment goods are produced in the tradable sector. Also, the outcome is quite sensitive to the value assumed by the intertemporal elasticity of substitution, a parameter for which it is difficult to give an intuitively satisfying value.[28]

6.1. Optimal Foreign Borrowing Strategies: A Case Study of Thailand, 1985–1992

As the recent debt repayment difficulties of developing countries have shown, it is critical that external borrowing be conducted within a consistent macroeconomic policy environment, lest capital flight occur when credibility wanes. The debt crisis of the early 1980s also showed creditors the fragility of sovereign borrowing and debtors the realities of credit rationing. For example, the empirical evidence shows that lenders' willingness to lend is positively related to the borrower's fiscal position (Kharas and Shishido 1984). This suggests that borrowers will find it appropriate to achieve high fiscal savings in order to reduce the probability of being cut off from credit.

Kharas and Shishido (1986) use a model similar to the one described above to examine optimal borrowing strategies for Thailand over the period 1985–92. In addition to the intertemporal equilibrium conditions described in equation 14, their multisectoral model captures some aspects of uncertainty insofar as the expected terminal year fiscal surplus is a parameter that depends on the weight attached by the borrower to the possibility of losing creditworthiness. To ensure smooth in-

[28]Glick and Kharas (1986) also study the properties of the model when the economy no longer faces a perfectly elastic supply of foreign funds. They do so by incorporating an endogenous lending constraint whereby lenders limit the credit extended below the worth of the "collateral" given by the penalties of default proxied by a given loss of tradable goods production. In particular they show that the presence of a lending constraint provides a case for subsidizing tradable goods production.

vestment and borrowing paths, the model postulates an absorptive capacity constraint on investments in each period so that there is a diminishing marginal efficiency of investment within any period. Likewise, the more the country borrows relative to outstanding loans in each period, the more costly the loans become, reflecting the assumption that the borrower must shift to new lenders and more expensive financial instruments. Finally, as in the applications discussed in section 5, technology is putty-clay with new investment being directed to sectors with the highest profit rates and capital being removable from a sector only through depreciation.[29] The model is solved numerically by resorting to the turnpike theorem (Burmeister and Dobell 1970), so that a balanced growth state is reached by the end of the simulation, with all real values growing at the same rate in the post-terminal period.[30] This implies that the model evaluates the penalty for the outstanding debt and the premium for the existing capital stocks in the terminal year by calculating the impact of these on future consumption.[31]

After calibrating the model on historical data for the period 1975–85, Kharas and Shishido use it to determine optimal borrowing and investment strategies after a policy change when the economy is subjected to external or internal shocks. As in the other simulation exercises, the model determines the equilibrium real exchange rate and other relative prices and quantities; but in these dynamic simulations, the model also determines the borrowing and investment paths that maximize welfare subject to the constraints discussed above.

As an example, consider the implications of a tariff reform that would reduce the average tariff on manufactured imports from 16 percent to 10 percent. The dashed and solid line simulation paths in

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[29]This implies that profit rates are not equalized within period, although there is a tendency toward equalization within period. Note that these adjustment costs on investment and borrowing and partial capital mobility are necessary in dynamic multi-period models to avoid extreme behavior (e.g., all investment or borrowing in one period).

[30]The transversality condition requiring that the net present value of post-terminal debt service payments be equal to the debt outstanding is incorporated in the model by insuring that the balanced-growth increase in the stock of debt is less than the interest rate. The additional constraint (mentioned above) requiring that a predetermined fiscal surplus be maintained in the post-terminal year, ensures that funds will always be available along the transition path during the simulation period.

[31]The specification of the foreign trade sector is akin to that discussed earlier, although exports from the primary sector are modeled exogenously and manufactures exports have a less than infinitely elastic demand. Imports have either a zero elasticity of substitution (i.e., are noncompetitive) or a positive elasticity, as in Tables 1 and 2.

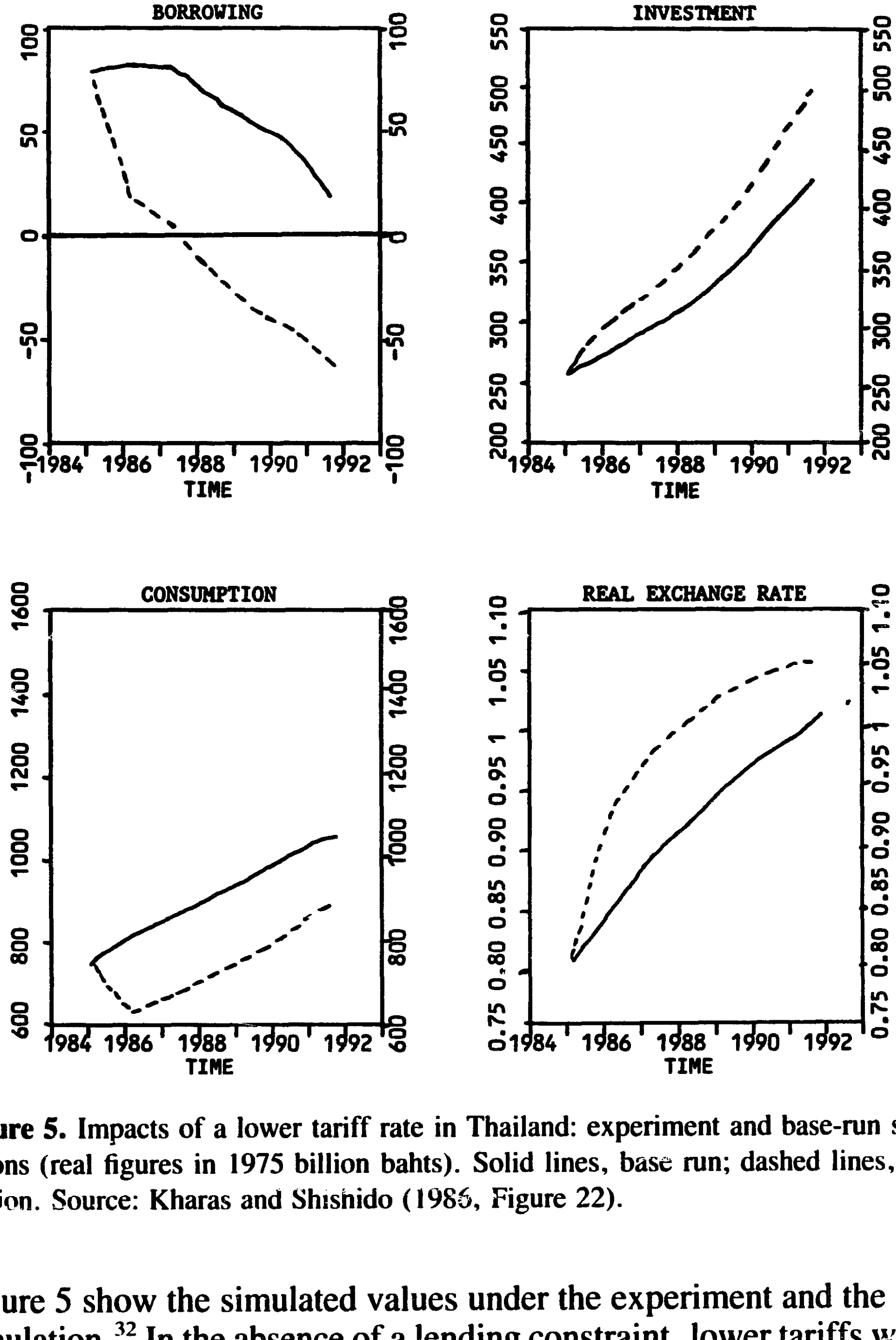

Figure 5. Impacts of a lower tariff rate in Thailand: experiment and base-run simulations (real figures in 1975 billion bahts). Solid lines, base run; dashed lines, simulation. Source: Kharas and Shishido (1986, Figure 22).

Figure 5 show the simulated values under the experiment and the base simulation.[32] In the absence of a lending constraint, lower tariffs would generate positive effects on growth because of reduced distortions. With a lending constraint, however, the situation is quite different.

[32]Similar paths arise from an increase in the world interest rate or lower world demand for Thai exports. The relative position of the base and simulation paths is reversed for simulations that raise the rate of technical progress or the domestic supply of natural gas.

The loss in public revenue (24 percent) increases the risk of debt repudiation, so lenders reduce credit lines and borrowing is only 19 percent of what would be available without the policy change. As shown in Figure 5, consumption must fall and the real exchange rate depreciate so as to achieve the required reduction in the current account deficit forced by the borrowing constraint. Investment, however, rises because of the improved returns in the economy associated with the real exchange rate depreciation.

The results presented here are of course even more tentative than those drawn from the simulations reported in section 5 because they rely on parameters whose values are even harder to obtain, such as the intensity of the lending constraint or the intertemporal elasticity of substitution. Nevertheless, the simulations point out the need to take macroeconomic considerations into account while undertaking microeconomic reforms, and the advisability of not postponing adjustment in the face of an adverse change in external or internal conditions.

7. CONCLUSIONS

This paper has surveyed recent contributions in foreign trade-focused applied general equilibrium analysis for developing countries. The structure and properties of the models commonly employed have been analyzed and numerical exercises have been reviewed to show how simulation analyses can provide a useful tool for policy analysis. The strengths and weaknesses of the models were clear from their theoretical properties and implementation methods. It is evident that there is room for much improvement, especially in the area of parameter estimation and in the development of more formal methods of testing model validity. Nonetheless, it is hoped that the variety of applications illustrated in this paper show the range of foreign trade policy issues in developing countries for which CGE models can be used.

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