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A COMPUTABLE GENERAL EQUILIBRIUM MODEL OF NEPAL

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I. Introduction

Multisector Computable General Equilibrium (CGE) models provide an attractive alternative to econometrically based macro models. First, they allow the establishment of a very direct and transparent link between the economic structure as embodied in a Social Accounting Matrix (SAM) and the results provided by the CGE model simulation. Second, CGE models have in general a more limited data requirement than econometric models; CGE models do not require long time series and are calibrated around a base year SAM with a small amount of additional data used to estimate parameters and elasticity of substitutions/transformation. Third, CGE models are by construction better suited than econometric models in analyzing the impact of structural reforms implying changes in relative prices. The scope of this paper is to illustrate the steps taken in deriving a CGE model after constructing a SAM for Nepal. The model is then used to analyze the macroeconomic impact of the ongoing trade liberalization.

The organization of the paper is as follows. First, after referring to the abundant literature on CGE models, the development of the SAM for fiscal year 1990/1991 for Nepal that forms the heart of the CGE model used in the paper is reviewed. Second, the structure of the CGE model for Nepal is discussed. Third, the model to examine the macroeconomic impact of reductions in tariffs and other nontariff trade barriers is used. Finally, conclusions are drawn from the analysis and avenues for additional research are suggested.

II. The Use of Computable General Equilibrium Models for Policy Analysis

General equilibrium analysis has increasingly been utilized as a tool of applied policy work particularly for less developed countries. Since the pioneering work by Adelman and Robinson (1978) on a model for the Republic of Korea, CGE models have been constructed for many of the less developed countries as reported by the many surveys available (Shoven and Whalley 1984; Manne 1985; Devaraj et al. 1986; Decaluwe and Martens 1989, and Robinson 1989. The principles of constructing general equilibrium models are discussed in Dixon et al. (1992) and Shoven and Whalley (1992). Kehoe (1991) gives an excellent treatment of the theoretical and computational aspects of CGE modeling. Brooke et al. (1988) and Codsi et al. (1992) document two useful software packages (Gams and Gempack).

Summarizing very briefly the results of this voluminous literature, one can say at this stage that the use of CGE models rather than other types of models is mainly driven by two factors: the usefulness of the link between structure and results in CGE models and the limited data requirements of CGE models. The link between structure and outcomes comes about since a properly formulated CGE model contains a complete specification of the optimization problems facing all of the actors in the economy, to the degree of disaggregation used. This makes it possible to trace all results to the responsible structural features. Thus, the careful modeler can examine the importance of the various assumptions in the model on the results and to specify the mechanism by which the results are obtained.

The limited data requirements of CGE models in comparison to econometric models is also important. CGE models are calibrated around a base year SAM with a small amount of additional data used to estimate certain parameters. Depending on the functional forms chosen,
nearly all of the parameters of a model can be calibrated without reference to additional data. When additional data are required, it is often in the form of elasticities of substitution and transformation which either can be estimated for a given country or adopted based on the results from countries with a similar industrial structure.

III. A Social Accounting Matrix for Nepal

In developing a CGE model for any economy, one should start an accurate social accounting matrix for a base year. A SAM is similar to the standard input/output tables that most countries maintain, but it also incorporates the basic idea from national accounting that an expenditure by one actor in the economy is the income of another. The basic structure of a SAM is set out in Table 1.

<table>
<thead>
<tr>
<th>Table 1: A Typical Social Accounting Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Receipts</strong></td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>Activities</td>
</tr>
<tr>
<td>commodities</td>
</tr>
<tr>
<td>Factors</td>
</tr>
<tr>
<td>Households</td>
</tr>
<tr>
<td>Government</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Capital</td>
</tr>
<tr>
<td>Account</td>
</tr>
<tr>
<td>Rest of the</td>
</tr>
<tr>
<td>World</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
The aggregate SAM consists of accounts for Activities, Commodities, Factors, Households, Government, Capital Account, and Rest of the World. The definitions of the different accounts are straightforward, except for the distinction between Activities and Commodities. Generally, Activities represents domestic production by producers and its disposition between the export and domestic markets. Commodities consists of the disposition of domestic and imported goods to final consumers. There are two reasons for maintaining this distinction. First, the distinction ensures that only domestically produced goods are exported. Second, the distinction allows more than one activity sector to produce a given commodity. This can be useful if there are two different technologies for producing the same good.

The rows in the SAM represent the sources of income. In the Commodities account, this would be purchases of intermediate goods, public and private consumption goods, and investment goods. Similarly, the Households row represents income sources from factors and remittances. The columns represent the disposition of income by each account. Thus, the Household column includes purchases of consumption goods, payments of taxes, private savings, and payments of external transfers. Since income must always equal expenditure, the row and column totals in each account must be the same.

Developing a CGE model from a SAM essentially consists of adding the behavioral equations to the structure of income and expenditure identities provided in the SAM. For instance, while the SAM provides data on payments made to factors in the production process, it says nothing about the production function that underlies those payments. This and the rest of the behavioral structure must be added as part of the model. Generally, the behavioral equations include production, consumption, import demand, export supply, savings, and investment functions. The selection of these functions allows the modeler to account for the particular structural features of the modeled economy.

In preparing the model for this paper, a SAM for Nepal for fiscal year 1990/1991 was produced. Table 2 below sets forth the aggregate SAM for 1990/1991. With respect to Table 1, Table 2 has an extra column and an extra row for tourists. This account was added because of the particular importance of tourism to the Nepalese economy and to account for the particular consumption pattern of foreign tourists. Appendix A discusses the data sources for the SAM.

Some of the basic structural problems of the Nepalese economy can be seen in Table 2. Imports are nearly three times exports with the difference being made up primarily by foreign grants and loans. Looking at the government, recurrent expenditures are partly financed by development assistance.

Once the aggregate SAM was prepared and balanced, it was disaggregated using the appropriate set of sectors, factors, households, and other agents. For the model of Nepal, 12 activity and commodity sectors, three factor types, two household types, two capital account types, and two rest of the world accounts were selected. These are set out in Table 3. Households and laborers are differentiated as either urban or rural to account for their different consumption pattern and wage levels. The two foreign exchange accounts are used to distinguish between exchange with India, using its non-convertible currency, and trade with convertible currency countries; this is a notable feature of the model which allows us to account for the differential trade policies directed at different points of origin.

1Note that this does not mean that re-exported goods are not incorporated in the model. Intermediate products, which include imported goods, are included as inputs to all sectors, accommodating re-export.
Table 2: Aggregate Social Accounting Matrix for Nepal, 1990/1991
(NRs million)

<table>
<thead>
<tr>
<th>Receipts</th>
<th>Activities</th>
<th>Commodities</th>
<th>Factors</th>
<th>Households</th>
<th>Tourists</th>
<th>Government</th>
<th>Capital Account</th>
<th>ROW</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities</td>
<td>156,556.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>78.5</td>
<td>9,366.9</td>
<td>165,824.4</td>
<td></td>
</tr>
<tr>
<td>Commodities</td>
<td>64,904.0</td>
<td>87,950.0</td>
<td>3,298.5</td>
<td>10,486.0</td>
<td>20,375.0</td>
<td></td>
<td></td>
<td>187,013.5</td>
<td></td>
</tr>
<tr>
<td>Factors</td>
<td>98,296.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>98,296.0</td>
<td></td>
</tr>
<tr>
<td>Households</td>
<td></td>
<td>94,397.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>97,381.6</td>
<td></td>
</tr>
<tr>
<td>Tourists</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,587.6</td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td>2,624.3</td>
<td>4,394.2</td>
<td>1,194.5</td>
<td>1,977.7</td>
<td>289.1</td>
<td>4,398.5</td>
<td>8,633.0</td>
<td>23,471.3</td>
<td></td>
</tr>
<tr>
<td>Capital Account</td>
<td>2,704.7</td>
<td>8,192.8</td>
<td>11,977.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,875.6</td>
<td></td>
</tr>
<tr>
<td>ROW</td>
<td></td>
<td></td>
<td></td>
<td>1,965.8</td>
<td></td>
<td>1,086.5</td>
<td>1,272.3</td>
<td>30,448.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>165,824.4</td>
<td>187,013.5</td>
<td>98,296.2</td>
<td>97,381.6</td>
<td>3,587.6</td>
<td>23,471.3</td>
<td>26,045.7</td>
<td>30,448.0</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Accounts for the Disaggregated Nepal SAM 1990/1991

<table>
<thead>
<tr>
<th>Activity Sectors</th>
<th>Commodity Sectors</th>
<th>Factors</th>
<th>Households</th>
<th>Capital Account</th>
<th>Rest of World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Crops</td>
<td>Food Crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash Crops</td>
<td>Cash Crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Processing</td>
<td>Food Processing</td>
<td>Urban Labor</td>
<td>Rural Labor Capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Textiles</td>
<td>Textiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Manufacturing</td>
<td>Chemical Manufacturing</td>
<td>Capital Goods</td>
<td>Capital Goods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital Goods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport Services</td>
<td>Transport Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity, Water, Gas</td>
<td>Electricity, Water, Gas</td>
<td>Construction Services</td>
<td>Construction Services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tourism</td>
<td>Tourism</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Private Services</td>
<td>Other Private Services</td>
<td>Public Services</td>
<td>Public Services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

India ROW
IV. The Structure of the Model

The basic structure of the model of Nepal is similar to that used in many other CGE models of developing countries. Nepal is assumed to be a small country in both exports and imports to all markets. Domestic output is created from a combination of capital, labor, and intermediate goods by profit-maximizing firms that simultaneously determine whether to export at fixed world prices or sell their output domestically. Consumers are assumed to purchase a mix of domestic and imported goods in proportions that minimize cost, given that the two goods are imperfect substitutes in consumption. This combination of domestic and imported goods is consumed on the domestic market as intermediate goods, goods for household, tourist or government consumption or goods for investment in physical capital or inventories. Income from factors is either paid as taxes to the government or as income to households. Remittances accrue to households. Households either consume or save that portion of their income that is not sent abroad or paid in household taxes. A fixed level of loans or grants from the rest of the world are used to meet any shortfalls in government spending or public and private investment while at the same time balancing foreign trade.

A. Production and Allocation of Output between Domestic and Foreign Markets

Examining the producer side of the model more specifically, Figure 1 graphically sets forth the structure of the profit maximization problem facing firms. (This is the production and disposition of the Activities account.) Firms have a fixed stock of capital in each period. If the sector is tradable, there are three potential markets (domestic, Indian, and Rest of the World) into which producers can sell their output with fixed prices for output in the two foreign markets. Profit maximization thus requires that they select the appropriate level of output, the portions of output to be sold to each market if the sector is tradable and the amount of labor required to produce the output. The solution to this producer problem is set out in the model in equations 12-15.

For purposes of explanation, assume for the moment that the output price is known. Labor and capital are combined in a Cobb-Douglas production function to generate value added (equation 12). With fixed capital, there are decreasing returns to labor. Since value added is combined in fixed proportions with intermediate inputs to form final output, the price of value added can be determined from the price of final output (equation 10). The profit maximizing firm employs labor until the marginal value product of labor equals the wage (equation 13). In the overall market, the wage varies until all available labor is utilized.

5See, for example, Shantayan Devarajan, Jeffrey D. Lewis, and Sherman Robinson, "From Stylized to Applied Models: Building Multisector CGE Models for Policy Analysis" (University of California at Berkeley, Department of Agricultural and Resource Economics, September 1991).

While it is certainly true that Nepal is a small country in imports, given the concentration of its exports in garments and carpets, a question arises as to whether it is a small country in the export market. This is particularly true for textile exports in which developed countries generally have stringent import controls. At present, Nepal can be treated as a small country, even in textiles, since it is not yet covered by quotas in several major markets.

4The equations for the model are set forth in Appendix B.
The previous discussion assumed that the price of final output is fixed. In the model, this price is endogenously determined by the price of output in the domestic market and, if output from the sector can be traded, the firm's decision to allocate output between the domestic and export markets (equations 14-15). In the tradable markets, export goods and goods for domestic use are assumed to be different products generated from domestic output with a constant elasticity of transformation (see equations 14a and 15a). The relative prices in the two markets thus determine the level of output that is sold in each market. Since in the Nepal model there are two export accounts, one for India and one for countries with a convertible currency, we have chosen to model this with two transformation functions for each tradable sector. It is assumed that domestic output is first transformed into exports to markets with convertible currencies and an intermediate domestic use product (equations 14a and 14b), which is then transformed into either exports to India or domestic output sold domestically (equations 15a and 15b). The balance between domestic demand and domestic supply will then establish the equilibrium price of domestic sales of domestic output. For sectors without exports, domestic production just equals domestic sales (equations 14' and 15').
B. Determination of Demand for Consumption, Investment and Intermediate Use and Its Allocation between Domestic and Imported Goods

Figure 2 illustrates the process by which domestic sales of domestic output are combined with imports to produce goods for domestic sale to households, tourists, and the government among others. These are the sources and uses of the Commodity account. For sectors without imports, domestic sales equal domestic output sold domestically (equations 16' and 17'). For sectors with imports, this model assumes that domestic output and imported goods are imperfect substitutes in consumption. Consumers are assumed to purchase domestic output and foreign imports in proportions that minimize the cost of meeting a composite level of demand. In the model, this is represented by equations 16-17, which assume a constant elasticity of substitution. Thus, given the fixed world price of imports, buyers will purchase a differing mix of imports and domestic output as the price of domestic output rises and falls. As in the case of export markets, the existence of two foreign accounts for imports to each sector is accounted for by a two-tiered approach. It is assumed that buyers first decide between domestic and Indian goods and then choose between using the resulting intermediate sale of goods and imports from the Rest of the World. Once the allocation of demand between imported and domestic goods is made, domestic consumption demand is determined by the price of domestic output and the domestic output sold to each sector.

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5 These functions are often referred to as Armington functions. See P.S. Armington, "A Theory of Demand for Products Distinguished by Place of Production," *IMF Staff Papers*, vol. 16, no. 1 (1969), pp. 159-178.
domestic output and imports in tradable sectors is determined, the price of domestic sales is determined (equations 6-7). Given this price, the demands of the various actors in the economy for final output can be determined. Households are assumed to spend fixed value shares of their disposable income to purchase goods. These shares are derived from a Cobb-Douglas utility function. Disposable income is total household income less taxes, fees, payments abroad, and an assumed fixed savings rate (equation 20). Similarly, tourists are assumed to spend their disposable income on goods according to fixed value shares (equation 21).

Government demand is derived from an exogenously fixed level of real demand coming entirely from the public services sector (equation 22). This does not mean that the government only consumes goods from that sector. Instead, it is an accounting device that allows the actual use of other goods, labor, and capital by the government to be set forth as the inputs to the public services sector rather than being reflected directly in government demand.

Investment demand by sector of destination of investment is a fixed fraction of total investment, after inventories, each year (equation 39). This is transformed into demand by source sector through a matrix of fixed coefficients (equation 23). The last two components of final demand are increases in inventories and intermediate demand. Both of these demands are proportional to the level of output (equations 18 and 19).

C. The Balance of Income and Expenditure

The description of the demand systems used above has ignored the origin of income for each agent. Households are assumed to receive all of the income from factors not paid to the government either as taxes or as repayment of loans (equations 25 and 26). Households also receive income from remittances and payments for factor services. Income from urban and rural workers flows to the appropriate households while capital income, after taxes, is split based on fixed shares. Remittances and payments for factor services are divided among households in fixed shares according to base year patterns. Tourists are assumed to have an income level fixed exogenously in foreign currency. Thus, a change in exchange rates will affect tourist income directly. Since government consumption is fixed, government savings is assumed to be the difference between government income and consumption (equation 35). The balance of income and expenditure in investment and changes in stocks is discussed in the section on closure below.

D. Model Closure

Several issues with respect to the macroeconomic closure of various markets in this model have already been discussed. For instance, in the labor market wages are assumed to be fully flexible with workers being paid their marginal value product while firms employ all available labor. The capital stock in the model in each period is assumed to be fixed. Thus, returns to capital are assumed to be the residual after paying for labor and intermediate goods. This implies two results: first, the rate of return to capital will vary between sectors and, second, capital will generally not be paid its marginal value product. Implicit in the discussion is that domestic prices adjust so that all goods markets clear.

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6Alternative closure rules for the labor market would fix one or more of the wages in nominal terms and allow there to be unemployment in one or more labor categories. This is often referred to as a part of Keynesian closure. See Robinson (1989).
The savings and investment market is closed by assuming that investment always equals savings. Savings is determined as a fixed share of household income, an exogenously fixed level of foreign savings (fixed in foreign currency) and government savings which is the difference between the fixed real level of government expenditure and government revenues from all taxes.\footnote{Alternative closure rules for savings and investment are possible. One such rule is to specify an investment function and require that savings adjust to equal investment. This is often referred to as Johansen closure. See Robinson (1991), p. 27.}

In the foreign exchange market, exchange rates are assumed to be fixed in any given year. All foreign transfers are assumed to be fixed in foreign currency each year as well. The foreign exchange markets clear by domestic price changes in relation to the fixed level of foreign prices and transfers which changes the real exchange rate.

E. Dynamic Updating

So far, this description has focused on the within-year operation of the model. However, this model is designed to examine changes in the level and pattern of output over a 15-year period. The dynamic portion of the model assumes that each period solves independently. The variables which are assumed to be exogenous within each year are then updated between periods. For instance, the capital stock in each sector is adjusted for both new investment and depreciation. The investment allocation matrix is adjusted for differences in rates of return between sectors in the previous year to recognize the fact that capital will flow toward sectors with a higher rate of return. Similarly, the labor stock is adjusted for the presence of new workers. Other exogenous variables such as tariff rates, tax rates, exchange rates, or world prices can also be adjusted as needed for purposes of policy simulation.

F. Calibration of Parameters of the Model

Calibration of a CGE model involves using the SAM data along with a limited amount of additional information to determine the values of all parameters in the model. For some of the equations, calibration can be done directly from the SAM. For instance, the value shares of household consumption in the SAM can be used to calibrate the household consumption function.\footnote{One additional piece of information is required for any calibration and that is the level of prices for the base period. Since this model is Walrasian, the absolute level of prices does not matter. Moreover, since the units of measure of the various commodities in the model are arbitrary, it is common to implicitly select the price level for all domestic prices to be 1 and thus adjust the units of quantity accordingly.} Similarly, the value share for tourist demand in the SAM can be used to calibrate the consumption function of tourists.

Calibrating other parameters requires information not contained in the SAM. To calibrate the parameters in the production functions, for instance, additional information is needed on the level of employment and the stock of capital in each sector. The parameters of the production function for each sector are calibrated against the data in the SAM on payments to labor and capital and estimates of employees and capital stock by sector. The parameters of the two output transformation functions are calibrated based on the data in the SAM and on estimates of the elasticity of transformation between domestic and export goods for each
market. These elasticities were selected to be consistent with the fact that most Nepalese exports are of goods with limited domestic use. Thus, most goods are assumed to have relatively inelastic transformation elasticities.

The constant elasticity functions specifying the degree of substitutability between domestic goods and imports are calibrated based on the data in the SAM and a set of assumed elasticities of substitution. These elasticities were selected to be consistent with the low elasticity of substitution expected in agriculture and higher degrees of elasticity in manufactured goods.

V. Simulation Results

A. The Baseline

Although, generally, CGE models are not built as forecasting tools (i.e., their reliability should not be judged in terms of the accuracy of predictions at constant policies), the "well behaved" baseline of Table 4 shows that the CGE model for Nepal converges and yields in general macroeconomic predictions generally in line with most credited forecasts by ADB\footnote{See, for instance, Butiong and di Mauro (1993).} and other multilateral institutions. As mentioned above, the model is calibrated on Nepal's SAM for 1990/91; data for that year are therefore historical. As for 1991/92, the baseline

<table>
<thead>
<tr>
<th>Table 4: Baseline Simulation Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(NRs million unless otherwise specified)</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Real GDP</td>
</tr>
<tr>
<td>Annual Growth of</td>
</tr>
<tr>
<td>Real GDP in per cent</td>
</tr>
<tr>
<td>Nominal GDP</td>
</tr>
<tr>
<td>GDP Price Index (1991=1.00)</td>
</tr>
<tr>
<td>Urban Household Income</td>
</tr>
<tr>
<td>Rural Household Income</td>
</tr>
<tr>
<td>Urban Household Savings</td>
</tr>
<tr>
<td>Rural Household Savings</td>
</tr>
<tr>
<td>Total Investment</td>
</tr>
<tr>
<td>Government Revenues</td>
</tr>
<tr>
<td>Government Investment</td>
</tr>
<tr>
<td>Value of Exports</td>
</tr>
<tr>
<td>Value of Imports</td>
</tr>
</tbody>
</table>

\footnote{The estimates of elasticities of both transformation and substitution used in this model were drawn from Asian Development Bank (1992).}
projection is generated by making two changes from the conditions found in the base period: (i) nominal devaluation of 40.3 per cent and (ii) changes in foreign savings and foreign aid in accordance with new available data. As the result of these adjustments, the simulated values for 1991/92 of endogenous variables are very close to published preliminary estimates. Thereafter, the baseline is entirely generated by the model.

At constant policies, real GDP is expected to grow by 3.3 per cent on average, between 1992/93 and the end of the decade. Exports are projected to grow by 6.5 per cent in the long term while imports are projected to expand by a slower 3.5 per cent, leading to some improvement in the external current account. Prices over the same period are expected to be stable.\(^1\)

B. The Impact of Trade Reform

In 1991, following similar moves by India, Nepal began an effort to liberalize its trade regime. These efforts, accompanied also by a substantial devaluation, included, among others, the elimination of most of the import license auctions and a substantial reduction in nominal tariff protection.\(^2\)

The purpose of our exercise is to analyze the impact of such tariff rates reduction on the Nepalese economy, concentrating on the removal of distortions as distinct from the other advantages often assumed to accrue to countries that liberalize their trade regimes, such as improvement in productivity arising from increase in competition. To run the simulation, all tariffs are reduced by 50 per cent (which is approximately the average nominal reduction in tariff rates introduced with the trade reform), and it is assumed that the auction system is abolished.\(^3\) In addition, we shall assume that Nepal makes up the revenue shortfall by imposing a less distorting tax on household income.

Making up the revenue is important in this simulation. A reduction in tariff revenues, without an offsetting increase in some other tax, results in a larger government deficit on recurrent expenditures which is financed in this model by reducing the level of government savings. Given the closure rule in this model that sets investments equal to savings, reduced tariff revenues result in a lower overall level of investment and thus of absorption in the economy. This reduces real GDP. Offsetting the lower tariff levels with revenues from a nondistorting tax isolates the impact of removing the distortions from the economy.

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\(^1\)It is worth mentioning here that our CGE model (as any standard CGE model) does not contain any mechanism to forecast inflation as prices are mainly a "numeraire". Values for prices have therefore to be considered only as a benchmark against which to evaluate the impact of the simulated policy change.

\(^2\)As the values used to calculate the base for the imposition of the tariffs were simultaneously adjusted upwards (the customs administration used imputed values for imports that were substantially below the true market values), the reduction of the tariff rate on true values was much less than the nominal tariff reduction.

\(^3\)There are eight different taxes or government revenue sources built into this model, including three different taxes that apply to imports. For the base year, the border price adjustments on imports include tariffs, sales taxes, and import license fees collected by what is in effect a quota auction.
Table 5 shows the results of the simulation with reduced tariffs offset by higher household taxes in such a way to keep government savings constant as a percentage of GDP. As expected, due to the fall in the prices of imports (between five and 15 per cent), demand for imports increases and so does the value of the imports. However, since the elasticities of substitution between imports and domestic output in consumption are low, the change in imports is relatively small.

The simulation impact on exports is also positive and about double the size of the change in imports. Both results, i.e., the sign and the size of the change in exports, are in line with expectations. As for the sign, the effect of reducing tariffs is to lower the costs of foreign goods to consumers. This puts pressure on domestic sellers to lower prices to maintain sales. If export prices remain unchanged, there is a shift by producers to selling into world markets. At the same time, since the world price of imports has not changed, the increase in demand for imports increases the need for foreign exchange. To cover this demand, more exports need to be sold. As for the larger size of the change in exports with respect to import, the following explanation can be provided. The domestic value of imports in the base run includes tariffs. When the tariffs are repealed, the domestic currency value of imports fall immediately by the amount of the eliminated tariffs. Increasing the level of imports then raises the value. In our case, the rise in quantity more than offsets the drop in price. Exports do not have the countervailing change in prices.

Table 5 also shows that real GDP rises, as it is expected, after the price distortions caused by the tariffs have been eliminated. The increase in real GDP, however, is relatively small, a result which is well understood by the literature and derives from the nature of the model. The model assumes constant returns to scale in the output of all sectors and assumes that all factors of production are fully used (full employment condition). Since all labor and capital are fully used in the base run and the simulation, there will only be small changes in real output. Looking at the same issue from a less

<table>
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<td>Annual Growth of Real GDP*</td>
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<td>in per cent*</td>
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<tr>
<td>Nominal GDP</td>
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<tr>
<td>GDP Price Index (1991-1.00)</td>
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<td>Rural Household Income</td>
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<td>Total Investment</td>
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<td>Government Revenues</td>
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<tr>
<td>Government Investment</td>
</tr>
<tr>
<td>Value of Exports</td>
</tr>
<tr>
<td>Value of Imports</td>
</tr>
</tbody>
</table>

*Difference in percentage points.
mathematical standpoint, this model captures the fact that pure efficiency gains from the elimination of tariffs are generally small.

In a traditional supply and demand view, the efficiency gain is the "Harberger triangle" in the trade theory, a small area compared with the size of the revenue of the tariffs. Moreover, it is well understood in public finance that placing taxes on goods with inelastic demand generally lead to smaller efficiency losses than taxes on goods with highly elastic demands. Since all sectors have relatively inelastic demand for imports, the size of the efficiency gains should be small.

Table 5 also shows that total investment rises while all savings fall. This happens because the total investment measure is in real terms while the savings measures are in nominal terms. Thus, the real decline of savings is not as large as it seems. Additionally, the foreign savings component of total savings, which accounts for about one third of all savings, is fixed in terms of foreign currency. Combining this with the decline in prices, one can see that the foreign savings now purchase more investment goods. It turns out that the small increase in total investment is composed primarily of the increased real value of the foreign savings. Finally, looking at the impact on household income and savings, the decline in nominal household income derives directly from the decline in the overall price level. Significantly, this decline is only in nominal income. Real income actually rises in all periods. Saving falls in this model by more than income because as mentioned earlier, to run the simulation, the tariff revenues are replaced by increasing taxes on households. This results in a lower level of after-tax income, and since savings are expressed as a percentage of after-tax income, they must fall by more than the decline in nominal income.

As for the simulated reduction in government revenue, this derives from the decline in prices, as tariff revenues are by construction offset by an increase in income taxes. In turn, the decline in government investment comes about directly from the decline in government revenues since government expenditures are fixed.

VI. Conclusions

This paper has demonstrated that it is possible to construct a usable CGE model of Nepal from limited available data sources. Moreover, it is suggested that the elimination of price distortions through trade liberalization has a positive impact on the economy as is shown by increase in real GDP, exports, and total investments. The results of the trade reform simulation suggest, however, that the pure efficiency benefits of trade liberalization due to the elimination of price distortions in the economy in Nepal, although it is in the expected direction, are relatively small. If there are large effects, they must come from improvements in productivity due to increased openness to trade and the lower nonprice barriers to trade that often accompany trade reform. Productivity gains, however, cannot be captured endogenously by this version of the model.

In the future, this model could be improved in a number of ways. First, the overall quality of data in the present SAM could certainly be improved. Second, through the use of existing survey data, the demand system could incorporate differentiated income elasticities among consumers. Moreover, productivity changes could be made endogenous.
Appendix A
Data Sources for the 1990/1991 Nepal SAM

There are three basic sources of data for the aggregate SAM, all of which are reported by the Nepal Ministry of Finance in its Economic Survey: the national accounts, the balance of payments, and the reporting of government income and expenditure. Unfortunately, not all these data are consistent and thus some adjustments for the purpose of balancing were necessary in developing the SAM. Generally speaking, the data in the SAM for value added and consumption and investment are from the national accounts. Data on imports, exports and foreign transfers, and capital transactions are from the balance of payments. Data on taxes and fees paid to the government are from the government income and expenditure reports.

Disaggregating the SAM for Nepal presented many data difficulties. As in most developing countries, the data sources for Nepal are somewhat limited. While data exists for aggregate items such as GDP, private and public consumption, foreign trade, and government revenues on an annual basis, very little of this data is maintained on an industry or sector basis. Therefore, the disaggregation process utilized a number of different, and sometimes conflicting, data sources. The Economic Survey and Statistical Year Book provided some useful data for preparing the disaggregated accounts. Additionally, heavy reliance was made on the structure of the disaggregated SAM for 1986/87 and 1987/88 presented in Asian Development Bank (1991) and Asian Development Bank (1992). Ultimately, some balancing items were required to reconcile the various data sources.
Appendix B
Equations of the Model

Price Definitions

For sectors with imports from or exports to markets with convertible currencies:

\[ PM_i = PWM_i \times (1 + TM_i + R_i + ST_i) \times ER \]  \hspace{1cm} (1)

\[ PE_i = PWE_i \times (1 + SUB_i + ETAX_i) \times ER \]  \hspace{1cm} (2)

For sectors with import from or exports to India:

\[ PIM_i = BPIM_i \times (1 + TIM_i + STI_i) \times IER \]  \hspace{1cm} (3)

\[ BPIE_i = \frac{IPE_i}{1 + ITN_i} \]  \hspace{1cm} (4)

\[ PIE_i = BPIE_i \times (1 - ETAX_i) \times ier \]  \hspace{1cm} (5)

For all sectors:

\[ P_i + X_i = PM_i + M_i + PXM_i + XM_i \]  \hspace{1cm} (6)

\[ PXM_i + XM_i = PIM_i + MI_i + PD_i + XXD_i \]  \hspace{1cm} (7)

\[ PX_i + XD_i = PE_i + E_i + PXE_i + XE_i \]  \hspace{1cm} (8)

\[ PXE_i + XE_i = PD_i + XXD_i + PIE_i + IE_i \]  \hspace{1cm} (9)

\[ PX_i + (1 - ITAX_i) - PVA_i + \sum_j (IO_{ij} \times P_j) \]  \hspace{1cm} (10)

\[ PK_i = \sum_j P_j \times IMAT_{ij} \]  \hspace{1cm} (11)
Production of Output and Its Disposition between Domestic and Export Markets

\[ XD_i - AD_i + L^n_{x_i} - L^n_{w_i} K_i^{\alpha-x_i} \]  \hfill (12)

\[ WA_i + WDIST_{x_i} + L^n_{x_i} = XD_i + PVA_i + ALPHL_{x_i} \]  \hfill (13)

For Sectors with exports to markets with convertible currencies:

\[ XD_i = AT \times (GAMMA_i \times E_i^{RHOST} \times (1 - GAMMA_i) \times XE_i^{RHOST})^{\frac{1}{RHOST}} \]  \hfill (14a)

\[ \frac{E_i}{XE_i} = \left( \frac{PE_i}{PF_x} \times \frac{(1 - GAMMA_i)}{GAMMA_i} \right)^{\frac{1}{RHOST - 1}} \]  \hfill (14b)

For Sectors with no exports to markets with convertible currencies:

\[ XE_i =XD_i \]  \hfill (14')

For sectors with exports to India:

\[ XE_i = AED \times (GAMMA_i \times IE_i^{RHOST} \times (1 - GAMMA_i) \times XXD_i^{RHOST})^{\frac{1}{RHOST}} \]  \hfill (15a)

\[ \frac{IE_i}{XXD_i} = \left( \frac{PE_i}{PD_i} \times \frac{(1 - GAMMA_i)}{GAMMA_i} \right)^{\frac{1}{RHOST - 1}} \]  \hfill (15b)

For Sectors with no exports to India:

\[ XXD_i = XE_i \]  \hfill (15')

Optimal Purchases of Domestic and Imported Goods

For sectors with imports from India:

\[ XM_i = ACD \times (DELTAD_i \times MI_i^{RHOST} \times (1 - DELTAD_i) \times XXD_i^{RHOST})^{\frac{1}{RHOST}} \]  \hfill (16a)
\[
\frac{MI_i}{XXD_i} = \left( \frac{PD_i}{PIM_i} + \frac{DELTAD_i}{(1 - DELTAD_i)} \right)^{-\frac{1}{m_{IO\text{MC}}}} 
\]

(16b)

For Sectors with no imports from India:

\[
XM_i = XXD_i 
\]

(16a)

For Sectors with imports from markets with convertible currencies:

\[
X_i = AC \ast (DELTAC_i \ast M_i + (1 - DELTAC_i) \ast XM_i) \ast \frac{1}{m_{IO\text{MC}}} 
\]

(17a)

\[
\frac{M_i}{XM_i} = \left( \frac{PM_i}{PIM_i} \ast \frac{DELTAC_i}{(1 - DELTAC_i)} \right)^{-\frac{1}{m_{IO\text{MC}}}} 
\]

(17b)

For Sectors with no imports from markets with convertible currencies:

\[
X_i = XM_i 
\]

(17a)

**Domestic Demand**

\[
INT_i = \sum_j (IO_{ij} \ast XD_j) 
\]

(18)

\[
DST_i = DSTR_i \ast XD_i 
\]

(19)

\[
P_i \ast CD_{i,k} = CLES_{i,k} \ast (1 - MPS_{i,k}) \ast HHY_{i,k} 
\]

(20)

\[
P_i \ast TD_i = TCLE_{i} \ast (1 - TTAX) \ast (TY \ast ER - TY) \ast IR 
\]

(21)

\[
GD_i = GLES_i \ast GDTOT 
\]

(22)

\[
ID_i = \sum_j (IMAT_{ij} \ast DK_j) 
\]

(23)
Definition of Income

\[
GY = \sum_{i,k} HHY_{ik} + DEPRECIA - REMIT*ER - IREMITS*IER
+ \sum_i (LTAX_i * WA_i * WDIST_{ik} + L_{ik})
+ CAPTAX \sum_i (PVA_i * XD_i - \sum_{k} (WA_{ik} + WDIST_{ik} + L_{ik})
- DEPRECIA)
\]

\[HHY_{urban} = (1 - LTAX_{urban}) \sum_i (WA_{urban} + WDIST_{urban} + L_{urban})
- (1 - CAPTAX) \sum_i (PVA_i * XD_i - \sum_{k} (WA_{ik} + WDIST_{ik} + L_{ik})
- DEPRECIA) + REMITS_{urban} + REMIT + ER
+ IREMITS_{urban} + IREMIT + IER
\]

\[HHY_{rural} = (1 - LTAX_{rural}) \sum_i (WA_{rural} + WDIST_{rural} + L_{rural})
- (1 - CAPTAX) \sum_i (PVA_i * XD_i - \sum_{k} (WA_{ik} + WDIST_{ik} + L_{ik})
- DEPRECIA) + REMITS_{rural} + REMIT + ER
+ IREMITS_{rural} + IREMIT + IER
\]

Definition of Government Revenue

\[
GR = TARIFF + TARIFFI + INDTAX + INCOME + RENT + EXTAX
+ (TITAX + TY + AID) + (ITAX + TYI + ITAXREF) + IER
+ PLGOVO + ER
\]

\[RENT = \sum_i M_i * R_i * PWM_i + ER \]

\[TARIFF = \sum_i M_i * (TM_i + ST_i) * PWM_i + ER \]
\[ TARIFF = \sum_i \left( M_i \times (TIM_i + STI_i) \times BPIM_i \times IER \right) \] (30)

\[ INDTAX = \sum_i (ITAX_i \times PX_i \times XD_i) \] (31)

\[ EXTAX = \sum_i \left( E_{iTAX} \times E_i \times PWE_i + ER + EITAX \times IE_i \times BPIE_i + IER \right) \] (32)

\[ SUBSIDY = \sum_i \left( SUB_i \times E_i \times PWE_i \times ER \right) \] (33)

\[ INCOME = \sum_{k_i} \left( LTAX_{k_i} \times WA_{k_i} \times WDIST_{k_i} \times L_{i,k_i} \right) \]

\[ + \sum_i \left( PVA_i \times XD_i - \sum_{k_i} \left( WA_{k_i} \times WDIST_{k_i} \times L_{i,k_i} \right) \right) \]

\[ - \text{DEPRECIATION} \] (34)

\[ = \sum_{k_i} \left( HHTAX_{k_i} \times HHY_{k_i} \right) \]

**Definition of Savings**

\[ GR = \sum_i \left( P_i + GD_i \right) + SUBSIDY + GOVSAV + GOVLOAN + ER \] (35)

\[ HHSAV_{k_i} = MSP_{k_i} \times (1 - HHTAX_{k_i}) - HHEXPAT_{k_i} \times ER \] (36)

\[ SAVINGS = \sum_{k_i} \text{HHSAV}_{k_i} + GOVSAV + \text{DEPRECIATION} + FSAVTOT + ER \] (37)

\[ \text{DEPRECIATION} = \sum_i (DEPR_i \times PK_i \times k_i) \] (38)

\[ PK_i + DK_i = KIO_i \times (SAVINGS - \sum_i (DST_i \times P_i) \]

\[ - (PLGOVO + PRIVLOAN \times ER) \] (39)

\[ DKTOT = \sum_i DK_i \] (40)
Definition of Foreign Exchange Equilibrium

\[ IRSV = \sum_i (M_i + BPIM_i - IE_i - BPIE_i) - \text{REMIT} - TYI - ITAXREF \]  \hspace{1cm} (41)

\[ FSIV = \sum_i (M_i + PWM_i - E_i + PWE_i) - \text{REMIT} - TY - AID \]

\[ + \text{GOVLOAN} + \text{PRIVLOAN} \]  \hspace{1cm} (42)

\[ FSAVTOT + ER = FSIV + ER + IRSV + IER \]  \hspace{1cm} (43)

Market Equilibrium Conditions

\[ \sum_{i} I_{i, c} = LS_{c} \]  \hspace{1cm} (44)

\[ X_{i} = INT_{i} + \sum_{h} CD_{i,h} + GD_{i} + ID_{i} + DST_{i} + TD_{i} \]  \hspace{1cm} (45)

Objective Function for the Model Solution Algorithm

\[ OMEGA = \sum_{h} \prod_{i} CD_{i,h}^{CLES} \]  \hspace{1cm} (46)
Variables and Parameters Used in the CGE Model

### Parameters

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### Variables

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<td>PD</td>
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BPEI
PWEI
IPEI

Taxes:

TMi
TIMi
ITNi
Ri
ST
STI
ETAX
EIAX
TTAX

Goods:

X
XE
XDj
XXDj
XMj
Ej
IE
MI

Factors:

Ki
WA(LC)
LS(LC)
L(L,LC)

Demand:

INTj
CDj
CDj20
TDj
IDj
DISTj
Gj
HHPj
TYj
TY
RENT

Government:

GR
INCOME
TARIFF
TARIFFI
INDTAX
EXTAX
SUBSIDY
GDTOT

Savings and Investment:

MPSi
HHSAVi

BORDER PRICE OF EXPORTS TO INDIA
WORLD MARKET PRICE OF EXPORTS
INDIAN MARKET PRICE FOR EXPORTS

TARIFF RATES ON ROW IMPORTS
TARIFF RATES ON INDIAN IMPORTS
INDIAN TARIFF RATES
TARIFF EQUIVALENT OF QUOTA AUCTION ON ROW IMPORTS
SALES TAX ON ROW IMPORTS
SALES TAX ON INDIAN IMPORTS
TAXES ON EXPORTS TO ROW
TAXES ON EXPORTS TO INDIA
TOURIST TAX RATE

COMPOSITE GOODS SUPPLY
COMPOSITE OF DOMESTIC OUTPUT AND EXPORTS - INDIA
DOMESTIC OUTPUT BY SECTOR
DOMESTIC SALES
COMPOSITE OF DOMESTIC OUTPUT AND IMPORTS - INDIA
EXPORTS TO THE ROW
EXPORTS TO INDIA
IMPORTS FROM THE ROW
IMPORTS FROM INDIA

CAPITAL STOCK
AVERAGE WAGE RATE BY LABOR CATEGORY
LABOR SUPPLY BY LABOR CATEGORY
EMPLOYMENT BY SECTOR AND LABOR CATEGORY

INTERMEDIATES USES
FINAL DEMAND FOR PRIVATE CONSUMPTION
FINAL DEMAND FOR GOVERNMENT CONSUMPTION
FINAL DEMAND FOR TOURIST CONSUMPTION
FINAL DEMAND FOR PRODUCTIVE INVESTMENT
INVENTORY INVESTMENT BY SECTOR
GROSS PRIVATE GDP
PRIVATE GDP BY HOUSEHOLD
TOURIST INCOME
TOURIST INCOME
QUANTITATIVE RESTRICTION AUCTION RENTS

GOVERNMENT REVENUE
INCOME TAX REVENUE
TARIFF REVENUE FROM ROW IMPORTS
TARIFF REVENUE FROM INDIAN IMPORTS
INDIRECT TAX REVENUE
EXPORT TAX REVENUE
EXPORT SUBSIDY PAYMENTS
TOTAL VOLUME OF GOVERNMENT CONSUMPTION

MARGINAL PROPENSITY TO SAVE
TOTAL HOUSEHOLD SAVINGS
GOVS AV
DEPRECI
SAVINGS

GOVERNMENT SAVINGS
TOTAL DEPRECIATION EXPENDITURE
TOTAL SAVINGS

Foreign Exchange:

FSAV
FSAVTOT
AID
REMIT
IREMIT
IRSAV
DR,
DKTOT

FOREIGN SAVINGS FROM CONVERTIBLE CURRENCY
TOTAL FOREIGN SAVINGS
FOREIGN AID RECEIPTS FROM OVERSEAS
GHORKA UNREQUITED REMITTANCES FROM OVERSEAS
GHORKA UNREQUITED REMITTANCES FROM INDIA
FOREIGN SAVINGS FROM INDIAN RUPEE TRANSACTIONS
VOLUME OF INVESTMENT BY SECTOR OF DESTINATION
TOTAL INVESTMENT

Variable for Objective Function:

OMEGA
Real Private Consumption


