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External Shocks and Policy Alternatives in Small Open Economies

The Case of El Salvador

Samuel Morley

Valeria Piñeiro

Sherman Robinson

Markets, Trade and Institutions Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Samuel Morley, International Food Policy Research Institute
Visiting Senior Research Fellow, Markets, Trade and Institutions Division
s.morley@cgiar.org

Valeria Piñeiro, International Food Policy Research Institute
Collaborator, Markets, Trade and Institutions Division
v.pineiro@cgiar.org

Sherman Robinson, International Food Policy Research Institute
Senior Research Fellow, Environment and Production Technology Division
s.robinson@cgiar.org

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ABSTRACT

In this paper we used a dynamic, regionalized computable general equilibrium (CGE) model to analyze the effect of various negative balance of payments shocks on output and employment and the effect of different alternative investment strategies on growth. The model shows clearly how sensitive El Salvador is to remittance or terms of trade shocks. Each 10 percent reduction in remittances lowers gross domestic product (GDP) by 0.2 percent and household consumption by 1.4 percent, with the cost rising as the shock intensifies. Any negative balance of payments shock forces a reduction in absorption, production, and employment and a real devaluation. Because El Salvador's economy is dollarized, that real devaluation can only come about through a fall in domestic prices brought about by recession. We show that the impact of the shock on output depends on how flexible wages are—the impact is smaller when real wages are flexible and greatest when they are fixed in dollars.

We used the CGE model to analyze alternative investment strategies for increasing the growth rate. The investment share of GDP is low, and the model makes it clear that without some strategy for increasing investment, the economy's overall growth rate is likely to remain low. We hypothesized two alternative growth rates for investment, both associated with an increase in exogenous technical change. Both strategies require a marginal increase in the share of output devoted to investment. We also showed that if El Salvador can increase the investment share from 15.5 percent to just 16 percent over five years by producing a growth rate in investment of 8 percent per year, and if that increase produces a 1 percent increase in the rate of technical change in all sectors, then the growth rate of the economy will practically double, rising from 2.85 percent to 4.95 percent per year. There are equally favorable effects on employment for unskilled labor and on wages for skilled labor.

Keywords: general equilibrium models, El Salvador, development strategies, regional development

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1. INTRODUCTION

El Salvador is a small open economy that is increasingly subject to external shocks over which it has little control, at least in the short run. It imports most of its fuel, is highly dependent on remittances, and runs very large trade deficits. Policymakers are forced to operate in an increasingly turbulent and difficult external environment, made more difficult by the concentration of exports in very few sectors and by the large fraction of necessary intermediate inputs that are imported. In a recent project, we updated the El Salvador social accounting matrix (SAM) and built a dynamic regionalized computable general equilibrium (CGE) model to help in the analysis of external shocks and to explore some policy alternatives. This paper briefly describes the updated SAM and the CGE model and presents simulation results that show the severe impact of either the reduction of remittance inflows or the deterioration in terms of trade through increased oil prices or a fall in the price of coffee, one of El Salvador's main exports. Section 2 describes the updated SAM, and Section 3, the regionalized CGE model. In Section 4, we display the comparative static results for three different negative external shocks—a fall in remittances, a rise in the price of oil, and a fall in the price of coffee. In Section 5, we use the dynamic version of the model to show the positive effect of increasing investment and productivity on the growth rate. Section 6 concludes.

2. THE UPDATED SOCIAL ACCOUNTING MATRIX (SAM)

Prior to this project, El Salvador had a national SAM based on data from 2002. We updated the national SAM to 2005 and extended it in three directions. First, we regionalized the SAM, using information from recent household surveys and the recent agricultural census.[1] Second, we put land into the matrix, which permits us to tie production in agriculture to each of the four regions in the SAM. Third, we regionalized household income so that we could show the regional impact of each external shock or the increases in productivity that we simulated.

The SAM is disaggregated into the 46 sectors shown in Table A.1 (in the Appendix) and into the four regions defined in footnote 1. We separately report four factors of production, skilled and unskilled labor, land, and capital. Table 2.1 displays the macro SAM that results from aggregating all the columns and rows of the full regionalized SAM.[2] Several important characteristics of the economy can be seen in Table 2.1. In the first place, there is a very large imbalance between imports and exports, thanks to remittances. Imports in 2005 can be seen in the Commodities column and in the Rest of the World row. There were 7,660 imports, comprising 20 percent of the value of total supply (and 44 percent of gross domestic product [GDP]). Exports were only 4,574. Most of the resulting commercial deficit of 3,086 was financed by remittances, which were estimated at 2,437 in 2005 and have grown rapidly since.[3] Another important characteristic of the Salvadorian economy is the high share of capital in GDP. Total GDP at factor cost is the sum of payments in the Activity column to labor capital (including land), or 16,035. Of that amount, the labor share is only 37 percent, which is one of the lowest in the region.

Table 2.1—2005 Macro SAM for El Salvador (Millions of U$S dollars)

	Commodities	Margin Costs	Activities	Labor	Capital	Land	Household
Commodities		3466.44	9060.93				15933.84
Margin Costs	3466.44						
Activities	25111.21						
Labor			5762.2				
Capital			9864.88				
Land			423.19				
Household				5762.2	9864.88	423.19	
Government							
Indirect Tax	1310.33						
Direct Tax							757.28
Saving-Investment							2025.95
Change of Stocks							
Rest of the World	7660.21						
Total	37548.19	3466.44	25111.2	5762.2	9864.88	423.19	18717.07

[1] We aggregated the data by departamentos into four regions, as follows: region occidental (departamentos Ahuachapan, Santa Ana, and Sonsonante), Central 1 (Chalatenango, La Libertad, San Salvador, and Cuscatlan), Central 2 (La Paz, Cabanas, and San Vicente), and Oriental (Usulatan, San Miguel, Morazan, and La Union).

[2] The full SAM can be found on the IFPRI website.

[3] Total remittances are found in the Rest of World column and Household row.

Table 2.1—Continued

	Government	Indirect Tax	Direct Tax	Saving-Investment	Change of Stocks	Rest of the World	Total
Commodities	1756.56			2683.19	73.14	4574.09	37548.18
Margin Costs							3466.44
Activities							25111.21
Labor							5762.2
Capital							9864.88
Land							423.19
Household	229.99					2436.8	18717.07
Government		1310.33	757.28				2067.6
Indirect Tax							1310.33
Direct Tax							757.28
Saving-Investment	-226.01					956.38	2756.32
Change of Stocks				73.14			73.14
Rest of the World	307.06						7967.26
Total	2067.6	1310.33	757.28	2756.33	73.14	7967.27	

Source: 2005 social accounting matrix.

The disaggregated SAM shows why and how El Salvador is so vulnerable to external shocks. On the one hand, the import share of total commodity demand is very high in many key sectors. Table 2.2 shows imports and total supply in nonagricultural sectors—42 percent of petroleum is imported, as is 49 percent of metals, machinery, and transportation equipment. Perhaps most important of all is *maquila*, treated here as an industrial service of assembly (*csind*, in the last row of Table 2.2). *Maquila* is one of El Salvador's most important exports, as discussed below. However, we see here that of the total supply of *maquila* (1,793), 1,360 (or 76 percent) is imported. All of these data imply that any growth strategy, particularly one relying on export promotion, is going to require a great deal of imports. For the same reason, any negative external shock is likely to have a big impact on domestic production.

Table 2.2—Imports and total supply

	Imports	Total Supply
Chemicals	891.79	1939.94
Oil	651.98	1543.36
Rubber	175.51	520.47
Non metal	84.51	444.19
Metals	433.75	1025.29
Machinery	859.54	1437.36
Transport equipment	543.95	1312.72
Electricity	23.32	538.6
Commerce	18.96	3464.95
Restaurants	282.81	1471.86
Transportation	282.55	2079.2
Communications	25.22	844.27
Financial Services	30.26	666.11
Real State	62.86	975.56
Social Services	71.54	1208.87
Maquila	1360.13	1792.74

Source: 2005 social accounting matrix.

The SAM not only indicates the large share of total supply in many key sectors that is imported, but also the high concentration of exports in a small number of sectors, all of which also increase the economy's potential vulnerability to balance of payments shocks. Table 2.3 shows the share of exports in total production by major sector. Forty-one percent of exports come from *maquila* (*csind*); 17 percent from the two tourism sectors, restaurants and hotels, and travel; and an additional 5 percent from coffee. In other words, almost two-thirds of total export revenue comes from just four sectors. Other than coffee, agriculture makes only a limited contribution to exports. Other than maquila, all the sectors of manufacturing make up no more than 22 percent of export receipts, and as we have seen, *maquila* itself uses a great deal of imports. At present, what all of this is likely to mean is that both the potential to expand exports seems to be quite limited, and the import share in key sectors is high, which implies a limited capacity to respond to balance of payments shocks either by expanding exports or by significant import substitution.

Table 2.3—Share of exports and imports by sector

	%Total Exports	% Total Imports
Coffee	5.05	0.02
Grains	0.11	1.77
Other agricultural products	0.12	1.58
Fishery	1.75	0.59
Minnery	0.05	3.91
Milling	2.40	0.73
Sugar	1.76	0.05
Other agroindustry	1.80	4.41
Beverages	1.49	1.28
Textiles	2.36	2.57
Paper	2.38	2.45
Chemicals	3.82	11.65
Oil	0.96	8.52
Plastic and rubber	1.32	2.43
Metals	3.54	5.77
Machinery	1.41	10.93
Transportation equipment	0.59	7.30
Restaurants and hotels	8.14	3.55
Transportation and storage	9.38	3.52
Communication	2.92	0.33
Real state	1.18	0.79
Social services	2.60	0.92
Maquila	41.00	16.64

Source: 2005 social accounting matrix.

3. THE COMPUTABLE GENERAL EQUILIBRIUM (CGE) MODEL

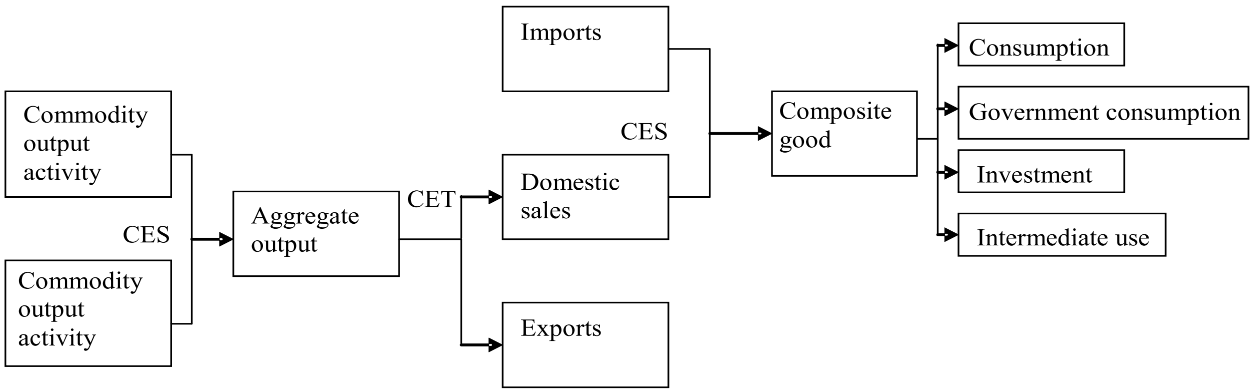
The regional CGE model used in this part of the research was based on the standard model used by IFPRI (see Lofgren, Harris, and Robinson 2001), which follows the neoclassical structuralist tradition originally presented in Dervis, de Melo, and Robinson (1982), but with some necessary modifications to capture the multimarket aspect of the agricultural sector included in this work. The advantage of the regionalized model is that it links decisions made at the national level with outcomes on poverty, employment, and production across regions. This, in turn, permits us to examine policies intended to improve the regional distribution of activities and income in a consistent general equilibrium fashion, which incorporates national macrofiscal and monetary constraints. This advance was made possible by the availability of regional information from the recent agricultural census.

The CGE model has three components. The first shows the payments that are registered in the SAM, following the same disaggregation of factors, activities, commodities, and institutions shown in the matrix. The second includes equations that represent the behavior of the different institutions present. The third describes the system of constraints that must be satisfied by the whole system covering the factor and goods markets, the balances for savings, investments, the government, and the current account of the rest of the world.

Each producer maximizes profits under constant returns to scale and perfect competition. There are three factors of production: labor (differentiated by skill and region), land (differentiated by region), and capital. Production is related to factor inputs in a constant elasticity of substitution (CES) production function, which allows the producers to substitute these three inputs until they reach the point at which the marginal revenue of each factor equals the factor price (wage or rent). The second choice that the producers make is the amount of intermediate inputs they will use. This specification is made assuming fixed shares that specify the appropriate amount of intermediate inputs per unit of output and labor/capital (value added). Finally, output prices depend on the value added (cost of labor and capital, intermediate inputs, and any relevant taxes and subsidies.

Figure 3.1 shows the flow of a single commodity from producers to final demand. First, there is the combination of goods from all producers into an aggregate commodity output. This is achieved using a CES product demand system, with the intention of leaving it up to the buyers to determine how much to buy of each product (maximizing their consumption). The aggregate output is sold domestically or internationally. The producers' allocation between domestic sales and exports is specified via a constant elasticity of transformation (CET) function, assuming imperfect transformability between exports and domestic sales. The producers will sell their products to the market with the highest profitability. The domestic price is the international price times the exchange rate, plus any possible export taxes or export subsidies. The domestic good is combined with imports to produce the composite commodity. For this, the Armington (1969) specification is used, which means that the domestically produced and imported goods are imperfect substitutes.

Figure 3.1—Flow of goods from producers to the national composite commodity



Source: Authors' creation.
Note: CES: constant elasticity of substitution; CET: constant elasticity of termination.

This model has three institutions—households, government, and the rest of the world—which do three things—(1) produce, (2) consume, and (3) accumulate capital. Households save a constant fraction of their disposable income and buy consumption goods with the remainder. Household income is the sum of salaries, profits, and government and rest of the world transfers. Household consumption of goods and services is determined by a linear expenditure system (LES). The government receives taxes, consumes goods and services, and makes transfers to households. The capital account collects the savings from the households, government, and rest of the world and buys capital goods (investment).

Our CGE model contains detailed information on the demand and supply of 46 economic sectors/commodities, with their 67 corresponding activities (7 agricultural activities, further disaggregated by 4 regions). Labor is disaggregated by qualification (skilled and nonskilled) and by region. Workers within each region can migrate between sectors and across regions according to labor demand; however, for skilled labor, total labor supply stays constant. Land is disaggregated by region and is region specific, which is one element that drives the regional production results. The other feature of our treatment of labor is the supply curve for unskilled labor. We assume that there is an excess supply of unskilled labor, at least over the range of solutions that we analyze. In essence, this means that the supply curve of labor is flat, or that the wage is fixed and employment is endogenous. However, because the entire model is a real model—or is expressed in terms of the numeraire—the wage of unskilled labor is fixed either in real terms or, in the case of El Salvador, in dollars.

Household income and expenditure patterns vary across regions. This is important because the incomes earned by workers in different sectors will benefit different households, depending on their location and factor endowments. These representative households receive factor incomes and per capita transfers from the national government. Households save some of their incomes and use their remaining income to consume goods under an LES of demand. All commodity markets are national, so that prices in all commodity markets differ only in transportation costs.

The Dynamic Version of the Model

For the total factor productivity (TFP) simulations, we used a recursive dynamic CGE model, which is solved in two stages. The first stage aims to find a solution for a one-year equilibrium using a static CGE model. In the second stage, a model between periods is used to handle the dynamic linkages that update the variables that drive growth. The intertemporal equations provide values for all exogenous variables that are needed by the static CGE model for the next period, which is then solved for a new equilibrium. The model is solved forward in a dynamically recursive fashion, with each static solution depending only on current and past variables. The model does not incorporate future expectations; instead, the behavior of its agents is based on adaptive expectations, because the model is solved one period at a time. The variables and parameters used as linkages between periods are the aggregate capital stock (which is updated endogenously, given previous investment and depreciation), the population, the domestic labor force, factor productivity, export and import prices, export demand, tariff rates, and transfers to and from the rest of the world (all of which are modified exogenously).[4]

The allocation of new capital across sectors is done by adjusting the proportion of each sector's share in aggregate investment as a function of the relative profit rate of each sector compared with the average profit rate of the economy as a whole. Sectors with higher (or lower) average profit rates will get higher (or lower) shares of the available investment. Over time, sector profit rates should converge.

For the dynamic version of the model, we assume the same closures used in the comparative static version; we also assume that the labor force grows by 0.5 percent per year. We add those additional workers to the supply of skilled labor or to the surplus of unskilled labor.[5] The growth of capital is determined by the amount of investment, net of depreciation. We also update the rate of unembodied technical change by 1 percent per year or by a different amount when we do simulated technical change experiments. We can then vary over time the exogenous rates of saving, taxes, and each of the other policy parameters in the model to determine the effect of these changes on the economy's growth rate.

As mentioned earlier, growth in the labor force by skill class is exogenous and related to population growth, which, in turn, is based on calculated growth projections taken from national data. For unskilled labor, the total size of the available labor force does not affect the solution in any period, because in the simulations, we assume an excess or backlog of unemployed labor that is not absorbed before the end of our simulations.

With this recursive CGE model, we are able to use these scenarios for the economy, project the growth paths of the endogenous variables, and compare the *base year* path (in which there are no changes in policy variables) with the paths obtained with the proposed policy changes. The simulations run with the Salvadorian model give us the growth path for the Salvadorian economy for 2005–2010 under a number of different policy alternatives. These paths are compared with the one obtained from the base simulation (in which no exogenous policy changes were included) to see the impacts of implementing various TFP scenarios combined with new investment.

To summarize, the dynamic accumulation process is updated by the following:

- Exogenous trends, such as labor force growth, productivity changes, capital stock growth, and population growth
- Economic behavior, such as distribution of investment by sector, distribution of labor force by sector, and category)
- Implemented policies, such as changes in remittances, international prices, and changes in TFP accompanied with investment)

[4] The dynamic model used in this research follows the models developed by the IFPRI (see Lofgren, Harris, and Robinson 2001; Thurlow 2003).

[5] There has been a steady decline in the population growth rate, from more than 1 percent per year in the 1990s to less than 0.5 percent per year since 2000.

4. BALANCE OF PAYMENTS SHOCKS

In recent years, El Salvador has been affected by at least three separate balance of payments shocks. After a period of very rapid growth prior to 2008, remittances either leveled off or declined in 2009. During 2008, the price of coffee, an important export, fell by 15 percent, while the price of oil rose by 85 percent between 2007 and 2008. In our first set of experiments, we simulate the impact of a 50 percent reduction in remittances (Remitt3), a 20 percent reduction in coffee prices (PWEcoff), and a 20 percent increase in the international price of oil (PWMfuel). Table 4.1 displays the results of these three shocks.

Before examining the results, however, we want to point out several characteristics of the model that bear on the results. As mentioned previously, El Salvador is dollarized. In our model, we have two alternative closures: We could fix either the real exchange rate or the level of foreign saving. We have fixed the level of foreign saving, which means that the *real* exchange rate is endogenous. However, because the nominal exchange rate is fixed (at one dollar), then the internal cost of living index has to change to get the change in the real exchange rate determined by the model. This is a critical feature of the Salvadorian economy.

Table 4.1—Macro results for three negative balance of payments shocks

	Base	Remitt3	PWE coff	PWMfuel
Absorption	20447.00	-7.02	-0.42	-0.67
Consumption	15932.54	-6.96	-0.38	-0.71
Investment	2682.92	-7.94	-0.53	-0.44
Stocks	73.14			
Government	1754.73	-6.94	-0.65	-0.69
Exports	4559.63	14.34	-0.8	0.48
Imports	-7646.62	-7.38	-0.79	-1.07
GDP at market prices	17356.35	-1.25	-0.36	-0.19
Real Exchange Rate	100.00	8.90	0.70	-0.20
CPI	100.00	-6.70	-0.60	0.30

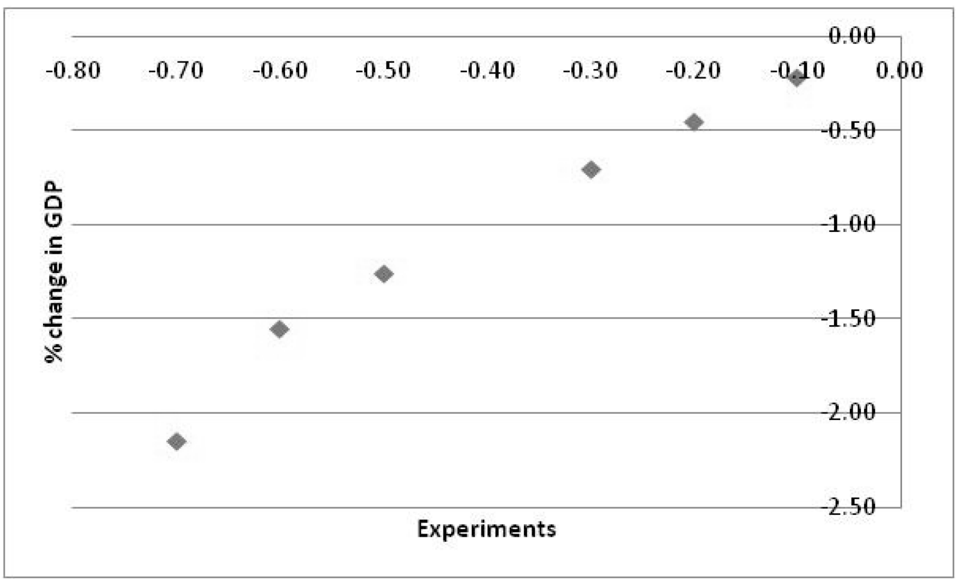
Source: Author worksheets.
Note: We assume that real wages are constant in all three simulations.

The second closure issue is how the economy adjusts to changes in domestic saving. A negative balance of payments shock requires some combination of an increase in domestic saving or a reduction in investment, given that foreign saving is fixed. We assume what is called a balanced closure, in which the investment share of total absorption is fixed and in which all households and the government have the same percentage decrease in their nominal spending. Recall that we are assuming a flat supply curve for unskilled labor. We can fix the minimum wage either in dollars or relative to the cost of living. In this simulation, we have chosen the latter, which will turn out to be a significant distinction, as explained later. A final point to bear in mind is that for these balance of payments shocks, we are using the comparative statics model, which does not tell us how long it takes for these full impacts to be felt. Instead, the solution gives us a good indication of the size and direction of the change in the economy in reaction to a negative change in external conditions.

Because we do not permit the country to increase borrowing when it suffers a negative balance of payments shock, there must be some combination of reduced imports or increased exports to counterbalance the shock. In the language of trade theory, there has to be an increase in the production of tradable goods and a reduction in nontradables. In each case, total absorption must decline. A flat unskilled labor supply curve ends up producing a reduction in total production, even though there is an increase in exports (except in the case of falling coffee prices). The change that causes this to happen is the real devaluation. With the 50 percent decline in remittances, the real exchange rate depreciates by 8.9 percent. However, because the nominal exchange rate is constant, it is brought about by a reduction of 6.7 percent in the consumer price index (CPI). In other words, the economy contracts, which in itself tends to drive down the demand for imports. More to the point, the contraction reduces the demand for nontradables and drives down their prices. Because prices of tradables are constant, production of tradables becomes relatively more profitable, which causes production to shift from nontradables to tradables.

Because El Salvador is a small, open economy, it is likely to be particularly sensitive to adverse balance of payments shocks. To see just how sensitive it is, we reran the comparative statics experiments, but using the fixed real wage closure for unskilled labor and varying the reduction in remittances from –10 percent to –70 percent. The results for GDP are displayed in Figure 4.1. Losing 20 percent of remittances costs 0.5 percent of GDP, whereas a reduction of 50 percent costs 1.2 percent. Unfortunately, the relationship appears to be nonlinear; more severe shocks have a relatively larger effect on the growth rate than do smaller ones.

Figure 4.1—Percent change in GDP in response to remittance shocks



Source: Authors' worksheets.

The Impact of Balance of Payments Shocks on Sectoral Output

In Table 4.2, we have aggregated the change in value added by major sectors to show more clearly the shift toward the production of tradables. The change in value added for *maquila* is shown separately because of its central importance to exports and the economy. The remittance experiment shows the process most clearly. All the traded goods sectors, agriculture, processed food, industry, and *maquila* have positive growth rates, whereas services (which here include construction) have a negative growth rate. The results for the two price experiments are more ambiguous. In the coffee case, not surprisingly, agriculture contracts because of the impact of the price shock on the coffee sector itself. Other than agriculture, the relative growth rates favor the rest of the traded goods sector relative to services. A rise in the price of oil is almost universally contractionary, except for a small increase in industrial production. Oil and fertilizer are key inputs for almost every sector, so the rise in oil prices raises input costs across the board. Because there is not much internal production of import substitutes in this key sector, costs rise, inflation increases, and output goes down in virtually every sector.

Table 4.2—Sectoral growth rates of value added

	Base	Remitt3	PWEcoff	PMWfuel
Agriculture	1508.28	0.549	-3.250	-0.236
Processed food	1279.97	0.779	0.218	-0.176
Other industry	2534.15	1.505	0.177	0.612
Services	10448.83	-1.766	0.035	-0.373
Maquila	278.8	4.861	0.453	-0.075
Total	16050.02			

Source: Authors' worksheets.

Unemployment and Real Wages

Our simulations assume that the real wage for unskilled labor is constant, which implies that any variation in demand will be reflected in a change in unemployment. For skilled labor, capital, and land, the impact of any exogenous change will be on the real wage. In Table 4.3, we show how the three negative balance of payments shocks affect wages and unemployment. In the base, construction unemployment rates are zero or constant. Note that in the unemployment part of the table, the numbers shown are the equilibrium unemployment rate after the shock. In the real wage portion of the table, the numbers shown are the percentage change in the real wage from its base level.

Table 4.3—Unemployment and the real wage

Unemployment Rate (UNEMPRX)				
	Base	Remitt3	PWEcoff	PWMfuel
flab-nk-or	0	2.428	1.710	0.771
flab-nk-c1	0	2.942	0.170	0.644
flab-nk-c2	0	2.944	2.518	0.831
flab-nk-oc	0	2.223	2.017	0.983
Average	0	1.781	0.516	0.465
Real Wage (WREALXP) (%change)				
	Base	Remitt3	PWEcoff	PWMfuel
flnd-or	0.821	-4.311	-4.008	-1.606
flnd-c1	0.821	-2.063	-9.968	1.808
flnd-c2	0.821	-4.087	-5.902	-1.929
flnd-oc	0.821	-4.806	-3.010	-1.959
flab-sk-or	0.821	-4.398	-1.034	0.898
flab-sk-c1	0.821	-3.623	-0.225	-0.740
flab-sk-c2	0.821	-2.731	2.332	-0.713
flab-sk-oc	0.821	-2.718	-2.021	-0.763
unskilled labor	0.821	0.000	0.000	0.000
fcap	0.274	-1.286	-0.105	-1.005

Source: Authors' worksheets.

Several important conclusions can be drawn from the table. The first is that each negative shock causes a rise in unemployment—about 1.8 percent on average in the remittance shock and a good deal less for the two price shocks. For the other factors of production, each shock leads to a reduction in real wages, or rates of return, which means that these shocks lead to a narrowing of wage differentials. Those unskilled workers who keep their jobs gain relative to skilled workers or profits; however, offsetting that, fewer of them have jobs.

It may seem obvious that these negative shocks would lead to rising unemployment, but, in fact, it is not so obvious. All we know is that the adjustment requires a fall in absorption and a shift of production in favor of traded goods. Why should that adjustment cause an increase in unemployment? The reason is that there is a difference in capital or labor intensity between the traded and the nontraded goods sectors. The traded goods sectors that expand must use or require more capital and less unskilled labor than the contracting nontraded goods sectors. Because the total supply of capital is fixed in these comparative statics experiments, the additional amount of unskilled labor needed in the expanding sectors is less than what is released in the nontraded contracting sectors. The result is a rise in unemployment. Had we assumed full employment, the real wage of unskilled labor would have contracted by enough to make it profitable to substitute unskilled labor for the other factors and hire the otherwise unemployed.

The Effect of Real Wages Demands on the Economy's Reaction to Negative Balance of Payments Shocks

In the simulations analyzed so far, we have assumed a constant nominal wage—or a flat supply curve—for unskilled labor. Because this is a real model, however, the constant nominal wage translates into two different *real* supply curves. In the simulation used so far, that nominal wage is expressed relative to the cost of living index. But in El Salvador, where wage demands (and prices) are expressed in dollars, an alternative closure fixes the wage in dollars, which makes a fairly big difference in how the economy reacts to shocks. The reason for this difference is that if workers demand a fixed wage in dollars, then the fall in domestic prices during the adjustment will not reduce the cost of labor in the export sector. In other words, real devaluation will not lower the cost of unskilled labor. Instead, it will dampen the expansion of the exports, which, as Section 3 showed, are an important part of the adjustment to a remittance shock. Of course, the wages of skilled labor, capital, and land will fall, but the overall change in the structure of production toward tradables will be smaller. As a result, more of the total adjustment to the shock will come through domestic recession and less through adjustment in the production structure.

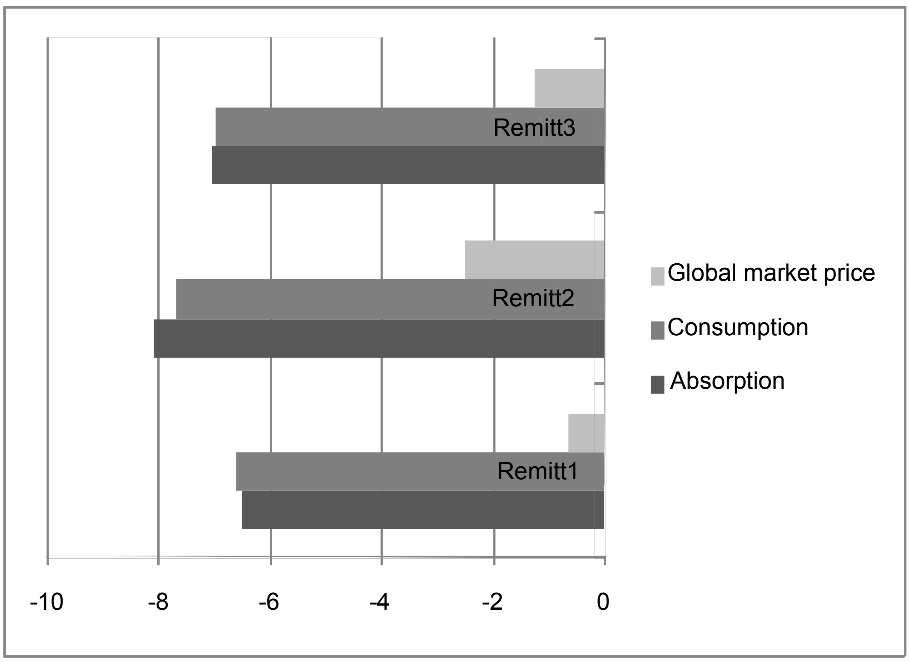
To see how important the treatment of real wages is for El Salvador, we reran the remittance simulation using three different closures for unskilled labor. Remitt1 makes the unskilled labor market neoclassical—that is, the supply of unskilled labor is fixed, and the real wage is endogenous. In Remitt2, the wage is fixed in dollars. Remitt3 fixes the real wage relative to the CPI, which is the closure used in Section 3. Table 4.4 and Figure 4.2 show the macro results of these three alternatives. The main point of the table and figure is the sensitivity of the real economy to how wages are determined. If workers insist on wages fixed in dollars (Remitt2), then GDP falls by 2.5 percent, compared with only 0.6 percent with full wage flexibility or 1.2 percent with fixed real wages. The same difference is seen in consumption, investment, and total absorption. We know that absorption has to fall with this negative balance of payments shock, but the point is that it falls further the more inflexible the wages are in dollars.

Table 4.4—Macro impact under three alternative labor market closures

	Base	Remitt1	Remitt2	Remitt3
Absorption	20447	-6.49	-8.09	-7.02
Consumption	15934	-6.61	-7.67	-6.96
Investment	2683	-7.02	-8.88	-7.64
Stocks	73	0.00	0.00	0.00
Government	1757	-4.85	-11.01	-6.94
Exports	4560	15.43	12.14	14.34
Imports	-7646	-6.73	-8.70	-7.38
GDP at market price	17360	-0.63	-2.51	-1.25
CPI	100	-6.70	-6.60	-6.70
Real xrt	1	9.10	8.40	8.90

Source: Authors' worksheets.

Figure 4.2—The effect of alternative labor market closures on gross domestic product (GDP), consumption, and absorption



Source: Authors' worksheets.

Consider now the effect of these alternative closures on real wages and unemployment. Unemployment of unskilled labor is defined to be zero in both the base run and the vertical supply curve simulation (Remitt1). However, dollar wage inflexibility pushes the unskilled unemployment rate up to 5.2 percent, which is significantly higher than if workers demand a fixed real wage in purchasing power. The reason is that because the overall price index falls (see Table 4.4), nominal wage demands in Remitt3 also fall, which is particularly important in a very open economy such as El Salvador, where many consumer goods are imported. Because the CPI comprises both domestically produced and imported goods, it does not fall as far as domestic prices do. Thus, if the nominal wage is fixed in terms of the CPI, its change must lie between the fall in domestic prices and the constant price of imports, and it must be relatively close to the latter. The implication of this fact on relative wages is quite striking: If unskilled labor fixes its wage in dollars, as it does in Remitt2, then there is a large increase in the real wage because of the fall in the CPI. As can be seen, the real wage for unskilled labor in each of the four regions rises by about 7 percent, whereas the real wages or rates of return of all the other factors of production fall sharply. For unskilled labor, when wages are fixed in either dollars or the cost of living, the impact of a negative balance of payments shock comes through unemployment. Unfortunately, that rise in unemployment is one reason GDP has to contract. With wage inflexibility, the adjustment to shocks is less in prices and wages and more in output and unemployment.

Table 4.5—Unemployment and real wages under alternative closures

Unemployment Rate (UNEMPPRX)				
	Base	Remitt1	Remitt2	Remitt3
flab-nk-or	0	0	7.96	2.43
flab-nk-c1	0	0	8.17	2.94
flab-nk-c2	0	0	8.41	2.94
flab-nk-oc	0	0	7.91	2.22
average	0	0	5.23	1.78
Real Wage (WREALXP)				
	Base	Remitt1	Remitt2	Remitt3
flnd-or	0.82	-3.79	-5.33	-4.31
flnd-c1	0.82	-1.15	-3.74	-2.06
flnd-c2	0.82	-3.29	-5.54	-4.09
flnd-oc	0.82	-4.13	-6.31	-4.81
flab-sk-or	0.82	-3.94	-5.36	-4.40
flab-nk-or	0.82	-2.80	7.09	
flab-sk-c1	0.82	-3.15	-4.60	-3.62
flab-nk-c1	0.82	-3.68	7.09	
flab-sk-c2	0.82	-2.14	-3.93	-2.73
flab-nk-c2	0.82	-3.50	7.09	
flab-sk-oc	0.82	-2.10	-4.07	-2.72
flab-nk-oc	0.82	-2.45	7.09	
fcap	0.27	-0.55	-2.77	-1.29

Source: Authors' worksheets.
Note: Unemployment is for unskilled labor only.

5. DYNAMICS: SIMULATING THE EFFECT OF INCREASING PRODUCTIVITY

From a policy perspective, it is useful to know the effects of exogenous changes in conditions, which is what we derived in Section 4. However, it is also important to know how the economy reacts over time to policy changes. Suppose the government, in response to a negative balance of payments shock, increases expenditure on productivity-enhancing investments. Can that, over time, offset the negative comparative statics effect of the shock itself? More generally, what is the likely effect on the economic growth rate of increasing the growth rate of productivity through additional investment? To address questions like these, we have built a dynamic version of the CGE model (see Section 2). In this section, the model is run over a five-year time horizon, with various increases in sectoral or national productivity with and without a simultaneous balance of payments shock. The tables that follow report only the annual growth rates over the five-year time horizon of each economic variable of interest.

We performed two simple productivity experiments. In one, we increased the annual growth rate of investment by 4 percent per year, which made the investment share of GDP slightly higher than the base in year five. We assumed that this was sufficient to raise the growth rate of productivity in all agricultural sectors by 1 percent per year. In the second experiment, we raised the annual growth rate of investment by 8 percent per year, which raised the investment share of GDP from 15.5 percent to 16.0 percent by year five. We assumed that this amount of additional investment was sufficient to raise the productivity in all sectors by 1 percent per year. (Note: We have no empirical evidence that this amount of increased investment will in fact bring so large an increase in productivity.) The third experiment combined the national increase in productivity and associated investment with the negative balance of payments shock. To make the experiment roughly consistent with the comparative statics experiment on remittances, we assumed a 10 percent annual decline in remittances such that over the five years, the total decline was around 50 percent. In all these experiments, we assumed that the nominal wage was fixed in dollars (closure#2)

The first thing was to establish the economy's baseline growth rate, where we get the growth path of the economy in the scenario where nothing happens (no exogenous changes are introduced). As noted earlier, El Salvador has a relatively low investment rate, equal to 15.5 percent in 2005. We assumed that the growth rate of the labor force was equal to that of the population, or 0.5 percent per year. Exogenous technical change was fixed at 1 percent per year in all sectors. Given these three assumptions, the economic growth rate was 2.8 percent per year (see Table 5.1).

Table 5.1—Growth rate of macro variables with increased productivity and investment

Demand-side GDP table						
				Growth rate per year		
		INITIAL	Base	TFPag	TFP-natl	TFP-natl-remit
Absorption	REAL	20446.59	2.44	2.98	4.26	2.95
Consumption	REAL	15933.71	2.60	3.13	4.03	2.32
Investment	REAL	2683.18	2.32	4.00	8.00	8.00
Stocks	REAL	73.14				
Government	REAL	1756.56	1.22			
Exports	REAL	4559.72	3.95	5.12	7.40	9.31
Imports	REAL	-7646.00	2.43	3.18	4.66	3.28
GDP at market prices	REAL	17360.31	2.85	3.47	4.95	4.64

Source: Authors' worksheets.

In the first experiment, we assumed that the country succeeds in increasing investment by 4 percent per year, so that the investment share of GDP in the final year grew slightly from 15.5 percent. We then assumed that all of the additional investment is devoted to agriculture. In that case, not only does the capital stock grow more rapidly, but also, it is assumed, the rate of technical change in agriculture jumps by 1 percent per year. These changes increase the agricultural growth rate by 1.5 percent, the export growth rate by just more than 1 percent, and the entire economy's growth rate by 0.6 percent.

In the second experiment, we upped the growth rate of investment to 8 percent per year and extended the increase in technical change to the entire economy. Not surprisingly, this has a very large impact on the growth rate in every sector. GDP now grows by 5 percent per year, which is more than 2 percentage points higher than the baseline growth rate. In effect, this is an export- and investment-led growth strategy, but even so, private consumption rises by more than 4 percent per year, compared with 2.65 percent in the base run. The important point is that more investment increases the growth rate of consumption, even though it crowds out consumption in the short run. In the third experiment, we posited the same rapid growth of investment and technical change as in the second experiment, but with remittances falling by about 10 percent per year. As the reader can see, this decrease reduces the overall growth rate of the economy, but the big impact is on consumption. In this last experiment, consumption is crowded out by investment and exports, and although its growth rate still exceeds the base, it is almost 2 percentage points lower than the total factor productivity (TFP) national experiment.

Table 5.2 shows the annual growth rates of sectoral value added into our three simulations. Focusing investment on agriculture not only raises the growth rate of the economy, it also makes agriculture a leading sector, which has positive distributional implications as well. If we raise the investment rate to 8 percent per year and assume that this raises productivity in every sector, we get big increases in the growth rate of all sectors. Although agricultural growth is surpassed by all the other sectors, its growth rate rises by half a percentage point relative to previous experiments.

Table 5.2—Sectoral growth rates

	Growth rate (% per year)			
	Base	TFP-ag	TFPNatl	TFPNatl-r
Agriculture	2.598	4.125	4.624	4.365
Proc agric	3.245	3.880	5.371	5.305
Industry	3.247	3.850	5.610	5.703
Services	2.768	3.241	4.779	4.509
Maquila	3.120	4.641	6.879	7.210
Total	2.872	3.497	4.982	4.799

Source: Authors' worksheets.

Some additional characteristics of the growth path in these three experiments can be seen in Table 5.3. First, we see that in each experiment, the consumer price index (CPI) falls and the real exchange rate depreciates—especially in the third experiment, where rising productivity is accompanied by falling remittances. This real depreciation is the mechanism by which the economy frees enough resources to generate the 9.3 percent growth rate in exports necessary to satisfy the foreign saving constraint. We also see that since investment is growing by 8 percent in both the second and third experiments, the investment share rises from 15.5 percent to around 16 percent. (In the base run, the investment share falls to 15.2 percent by the end of the simulation.) The growth of the share is a bit higher in the experiment with remittances, but only because the GDP's growth rate is somewhat lower. Both the trade deficit and the foreign savings share fall in every one of these experiments. By construction, we are forcing the economy to grow with a constant amount of foreign savings in dollars. In effect, we are forcing the country to grow its way out of so great a dependence on either remittances or external borrowing. Increasingly, it finances its imports through export earnings, which is especially true when we take away half of its remittance revenue. The experiment shows that although it is possible to do this, household consumption suffers. Note however that even with this constraint, the growth rate of consumption is higher than it is in the base run, in which there is no change in policy.

Table 5.3—Additional macro results

Price, real exchange rate and shares					
	Initial value or share	Change from initial value (% change)			
	Initial	Base	TFPag	TFP-natl	TFP-natl-remitt
Real exchange rate	91.00	2.50	3.60	5.20	12.20
Domestic price index	109.90	-2.50	-3.50	-4.90	-10.80
Consumer price index	100.00	-2.30	-2.90	-4.20	-9.50
Terms-of-trade	100.00				
Investment/GDP	15.50	-0.20	0.80	3.30	4.00
Private savings/GDP	11.70		-0.50	1.40	2.70
Foreign savings/GDP	5.50	-0.60	-0.70	-1.00	-0.70
Trade deficit/GDP	28.60	-2.30	2.40	-3.40	-8.90

Source: Author's worksheets.

The Labor Market

The key to understanding the impact of these various growth experiments on the economy is the labor market (see Table 5.4). Recall that for skilled labor, we assume that supply is exogenous and growing by 0.5 percent per year. For unskilled labor, we assume that the wage is fixed in dollars. In other words, if there is any sort of exogenous shock, the adjustment for skilled labor will be in the wage, whereas for unskilled labor, it will be in the level of employment. Table 5.4 shows employment levels by region and skill for the base year and the final year of the simulation. Note that for skilled labor, there is no difference between the final employment levels in any of the experiments, because the labor supply is exogenous. In the base run for unskilled labor, we assume that unemployment is zero or constant, so the level of employment in the final year is simply 2.5 percent higher than the base. The table demonstrates the impact of investment on the demand for unskilled labor. If we invest only in agriculture, the rate of increase in employment for unskilled labor jumps from 0.5 percent per year to 0.8 percent. With the higher investment rate in the second experiment, employment growth rises to 0.9 percent per year. In other words, if one thinks there is excess unskilled labor—or what amounts to the same thing as underemployed labor—any investment-led growth strategy will have a big impact on employment growth for the unskilled.

Table 5.4—Regional employment indexes by region and skill

	Unskilled labor					Skilled labor	
Region	Base year	Year five				Base year	Year five
		Base	TFPag	TFP-natl	TFP-natl-remit		
East	535.7	549.2	557.7	560.2	553.4	470.0	419.0
Central-1	2416.2	2477.2	2512.3	2521.3	2491.7	997.1	1024.3
Central-2	238.9	244.9	248.4	249.4	246.2	193.2	198.1
West	517.0	530.0	538.8	541.4	534.3	391.3	401.8
Total	3707.8	3801.3	3857.2	3872.3	3825.6	2051.6	2043.2

Source: Authors' worksheets.

6. CONCLUSIONS

In this paper, we described the dynamic CGE model that we recently built for El Salvador and then conducted a number of simulations with the model, in part to show what the model can do and in part to give some guidance to policymakers on important current policy issues. We considered two policy concerns. The first was the sensitivity of the economy to external shocks, and the second is the need to increase the growth rate. The sensitivity of the economy is in part due to economic structure and to the fact that the economy is dollarized and wage demand are made in dollars. We analyzed three negative balance of payments shocks. First we analyzed a 50 percent reduction in remittances, and then we analyzed two price shocks—one a 20 percent rise in the price of petroleum and the other a 20 percent reduction in the price of coffee, an important Salvadorian export. The model made clear that each shock forces a reduction in absorption, production, and employment and a real devaluation. Because the economy is dollarized, that real devaluation can only come about through a fall in domestic prices brought about by recession. We showed that the impacts of the shock are much smaller when real wages are flexible and greatest when they are fixed in dollars, because the economy has to shift the structure of production and employment toward the tradable goods sector. However, this shift is difficult to accomplish when wages are fixed in dollars, because in that case, even a domestic recession does not drive down the cost of unskilled labor.

The adjustment to shocks is complicated by two structural characteristics of the Salvadoran economy. The first characteristic is the big proportion of imports in many key sectors, especially petroleum, *maquila*, and machinery. The second is the high concentration of exports in a very small number of sectors, some of which are unlikely to be able to expand significantly in response to a change in relative prices. This implies that any long-run growth strategy or any short-run shock adjustment strategy is likely to increase import demand more than export supply. This increase, in turn, makes it more likely that in response to a balance of payments shock, the economy will be forced to reduce the demand for imports through recession rather than through a structural shift in production toward traded goods.

The dynamic CGE model is a good tool for analyzing alternative investment strategies to increase the overall growth rate. The investment share of GDP is low, and the model makes it clear that without some strategy for increasing investment, the overall growth rate of the economy is likely to remain low. We hypothesized two alternative growth rates for investment, both associated with an increase in exogenous technical change. Both strategies require a marginal increase in the share of output devoted to investment. We showed that if El Salvador can increase the investment share from 15.5 percent to just 16 percent over five years by producing a growth rate in investment of 8 percent per year, and if that produces in turn a 1 percent increase in the rate of technical change in all sectors, then the economic growth rate will practically double, rising from 2.85 percent to 4.95 percent per year. There are equally favorable effects on employment for unskilled labor and on wages for skilled labor.

The development lessons are clear, and the stakes are high. If investment becomes more profitable so that investment increases, and if a way can be found to devote more of that investment to raising productivity—particularly in the tradable goods sectors—the impact on growth and employment will be positive and large.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1—Sector disaggregation

acafé	coffee
agran	grains
aazuc	sugar cane
afrut	fruits
avege	vegetables
aotag	other agricultural products
agana	livestock
aavic	poultry
asilv	forestry
apesc	fishery
amine	minnery
acarn	meat
alact	dairy
amoli	mining
aazum	sugar cane
aotal	other agroindustry
abebi	beverages
ataba	tobacco
atext	textiles
avest	clothing
acuer	leather
amade	wood
apape	paper
aimpr	printing
aquim	chemicals
apetr	oil
acauc	plastic and rubber
anome	mineral products
ameta	metals
amaqu	machinery
amtra	transportation equipment
aelec	electricity
aagua	water
acons	construction
acome	commerce
arest	restaurants and hotels
atran	transportation equipment
acomu	communication
abanc	banks and financial institutions
ainmu	real state
aalqu	property rentals
asoci	social services
adome	domestic services
asgob	government
asind	industrial services
aoser	other services

Source: Survey data.

Table A.2—Household disaggregation

Households	
hhd-or	region oriental
hhd-c1	region central 1
hhd-c2	region central 1
hhd-oc	region occidental

Source: Survey data.

Table A.3—A formal statement of the dynamic computable general equilibrium model

Symbol	Explanation	Symbol	Explanation
$a \in A$	Activities	$c \in CMN(\subset C)$	Commodities not in *CM*
$a \in ACES(\subset A)$	Activities with a constant elasticity of substitution (CES) function at the top of the technology nest	$c \in CT(\subset C)$	Transaction service commodities
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$f \in F$	Factors
$c \in CX(\subset C)$	Commodities with domestic production	$fsub \in F$	Factors used in composite factors
$c \in C$	Commodities	$f2s \in F$	Composite factors
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$i \in INS$	Institutions (domestic and rest of world)
$c \in CDN(\subset C)$	Commodities not in *CD*	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CE(\subset C)$	Exported commodities	$i \in INSDNG(\subset INSD)$	Domestic nongovernmental institutions
$c \in CEN(\subset C)$	Commodities not in *CE*	$h \in H(\subset INSDNG)$	Households
$c \in CM(\subset C)$	Imported commodities	$fls \in F$	Factors with supply curve
PARAMETERS			
$cwts_c$	Weight of commodity ***c*** in the consumer price index (CPI)	$\overline{qg}_c$	Base-year quantity of government demand
$dwts_c$	Weight of commodity ***c*** in the producer price index	$\overline{qinv}_c$	Base-year quantity of private investment demand
ica_{ca}	Quantity of ***c*** as intermediate input per unit of activity ***a***	$shif_{if}$	Share for domestic institution ***I*** in income of factor ***f***
$icd_{cc'}$	Quantity of commodity ***c*** as trade input per unit of ***c'*** produced and sold domestically	$shii_{ii'}$	Share of net income of *i'* to ***I*** (*i'* ∈ INSDNG'; ***I*** ∈ INSDNG)
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	ta_a	Tax rate for activity a
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	te_c	Export tax rate
$inta_a$	Quantity of aggregate intermediate input per activity unit	tf_f	Direct tax rate for factor f
iva_a	Quantity of aggregate intermediate input per activity unit	$\overline{tins}_i$	Exogenous direct tax rate for domestic institution i

Table A.3—Continued

Symbol	Explanation	Symbol	Explanation
PARAMETERS			
$\overline{mps}_i$	Base savings rate for domestic institution *i*	$tins01_i$	0–1 parameter, with 1 for institutions with potentially flexed direct tax rates
$mps01_i$	0–1 parameter, with 1 for institutions with potentially flexed direct tax rates	tm_c	Import tariff rate
pwe_c	Export price (foreign currency)	tq_c	Rate of sales tax
pwm_c	Import price (foreign currency)	$trnsfr_{i\,f}$	Transfer from factor *f* to institution *i*
$qdst_c$	Quantity of stock change	tva_a	Rate of value-added tax for activity *a*
$etals_f$	Parameter in labor supply equation		
$INVSHR1_a$	Capital shares	PK_r	Price of capital
$DKAPS_{fa}$	Gross fixed capital formation	QF_{fa}	Next-period sectoral capital stock
$WFXAV$	Average capital rental rate	$deprate^k$	Capital stock depreciation rate
GREEK LETTERS			
α_a^a	Efficiency parameter in the CES activity function	δ_c^t	constant elasticity of transformation (CET) function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
		$\rho_{f2s,a}^{fs}$	CES exponent for factor (that goes into composite factor) *f2s* aggregate
$\alpha_{f2s,a}^{fs}$	Shift parameter for factor (that goes into composite factor) for *f2s* CES aggregates	$\delta_{fsub,f2s,a}^{fs}$	Share parameter for factor (that goes into composite factor) for *f2s* CES aggregates
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity *c* for household *h*
α_c^q	Armington function shift parameter	γ_{ach}^h	Subsistence consumption of home commodity *c* from activity *a* for household *h*
α_c^t	CET function shift parameter	θ_{ac}	Yield of output *c* per unit of activity *a*

Table A.3—Continued

Symbol	Explanation	Symbol	Explanation
GREEK LETTERS			
β^{h}_{ach}	Marginal share of consumption spending on home commodity *c* from activity *a* for household *h*	ρ^{a}_{a}	CES production function exponent
β^{m}_{ch}	Marginal share of consumption spending on marketed commodity *c* for household *h*	ρ^{va}_{a}	CES value-added function exponent
δ^{a}_{a}	CES activity function share parameter	ρ^{ac}_{c}	Domestic commodity aggregation function exponent
δ^{ac}_{ac}	Share parameter for domestic commodity aggregation function	ρ^{q}_{c}	Armington function exponent
δ^{q}_{c}	Armington function share parameter	ρ^{t}_{c}	CET function exponent
VARIABLES			
$\overline{CPI}$	Consumer price index	$\overline{MPSADJ}$	Savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	Change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_{f}$	Quantity supplied of factor
$\overline{FSAV}$	Foreign savings (Foreign Currency Units)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	Government consumption adjustment factor	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor f in activity a
$\overline{IADJ}$	Investment adjustment factor		
$WFSUB_{fsub}$	Average wage of factor *fsub* (used in composite factor)		
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QF_{fa}	Quantity demanded of factor f from activity a
DPI	Producer price index for domestically marketed output	QG_{c}	Government consumption demand for commodity
EG	Government expenditures	QH_{ch}	Quantity consumed of commodity c by household h
EH_{h}	Consumption spending for household	QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h
EXR	Exchange rate (Local Currency Units per unit of FCU)	$QINTA_{a,rg}$	Quantity of aggregate intermediate input
$GOVSHR$	Government consumption share in nominal absorption	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
$GSAV$	Government savings	$QINV_{c}$	Quantity of investment demand for commodity
$INVSHR$	Investment share in nominal absorption	QM_{c}	Quantity of imports of commodity

Table A.3—Continued

Symbol	Explanation	Symbol	Explanation
VARIABLES			
MPS_i	Marginal propensity to save for domestic nongovernmental institution (exogenous variable)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PA_a	Activity price (unit gross revenue)	QT_c	Quantity of commodity demanded as trade input
PDD_c	Demand price for commodity produced and sold domestically	$QVA_{a,rg}$	Quantity of (aggregate) value added
PDS_c	Supply price for commodity produced and sold domestically	QX_c	Aggregated quantity of domestic output of commodity
PE_c	Export price (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity *c* from activity *a*
$PINTA_{a,rg}$	Aggregate intermediate input price for activity *a*	$TABS$	Total nominal absorption
PM_c	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution *i* (*i* ∈ INSDNG)
PQ_c	Composite commodity price	$TRII_{ii'}$	Transfers from institution *i'* to *i* (both in the set INSDNG)
$PVA_{a,rg}$	Value-added price (factor income per unit of activity)	$WFREAL_f$	Average real price of factor
PX_c	Aggregate producer price for commodity	WF_f	Average price of factor
$PXAC_{ac}$	Producer price of commodity *c* for activity *a*	YF_f	Income of factor *f*
QA_a	Quantity (level) of activity	YG	Government revenue
QD_c	Quantity sold domestically of domestic output	YI_i	Income of domestic nongovernmental institution
QE_c	Quantity of exports	YIF_{if}	Income to domestic institution *i* from factor *f*

Table A.3—Continued

#	Equation	Domain	Description
Price block			
1	$PM_c = pwm_c \cdot (1 + tm_c) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c}$ $\begin{bmatrix} import \\ price \\ (LCU) \end{bmatrix} = \begin{bmatrix} import \\ price \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} tariff \\ adjust- \\ ment \end{bmatrix} \cdot \begin{bmatrix} exchange\ rate \\ (LCU\ per \\ FCU) \end{bmatrix} + \begin{bmatrix} cost\ of\ trade \\ inputs\ per \\ import\ unit \end{bmatrix}$	$c \in CM$	Import price
2	$PE_c = pwe_c \cdot (1 - te_c) \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$ $\begin{bmatrix} export \\ price \\ (LCU) \end{bmatrix} = \begin{bmatrix} export \\ price \\ (FCU) \end{bmatrix} \cdot \begin{bmatrix} tariff \\ adjust- \\ ment \end{bmatrix} \cdot \begin{bmatrix} exchange\ rate \\ (LCU\ per \\ FCU) \end{bmatrix} - \begin{bmatrix} cost\ of\ trade \\ inputs\ per \\ export\ unit \end{bmatrix}$	$c \in CE$	Export price
3	$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c}$ $\begin{bmatrix} domestic \\ demand \\ price \end{bmatrix} = \begin{bmatrix} domestic \\ supply \\ price \end{bmatrix} + \begin{bmatrix} cost\ of\ trade \\ inputs\ per \\ unit\ of \\ domestic\ sales \end{bmatrix}$	$c \in CD$	Demand price of domestic nontraded goods
4	$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c$ $\begin{bmatrix} absorption \\ (at\ demand \\ prices\ net\ of \\ sales\ tax) \end{bmatrix} = \begin{bmatrix} domestic\ demand\ price \\ times \\ domestic\ sales\ quantity \end{bmatrix} + \begin{bmatrix} import\ price \\ times \\ import\ quantity \end{bmatrix}$	$c \in (CD \cup CM)$	Absorption
5	$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c$ $\begin{bmatrix} producer\ price \\ times\ marketed \\ output\ quantity \end{bmatrix} = \begin{bmatrix} domestic\ supply\ price \\ times \\ domestic\ sales\ quantity \end{bmatrix} + \begin{bmatrix} export\ price \\ times \\ export\ quantity \end{bmatrix}$	$c \in CX$	Marketed output value
6	$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$ $\begin{bmatrix} activity \\ price \end{bmatrix} = \begin{bmatrix} producer\ prices \\ times\ yields \end{bmatrix}$	$a \in A$	Activity price
7	$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$ $\begin{bmatrix} aggregate \\ intermediate \\ input\ price \end{bmatrix} = \begin{bmatrix} intermediate\ input\ cost \\ per\ unit\ of\ aggregate \\ intermediate\ input \end{bmatrix}$	$a \in A$	Aggregate intermediate input price

Table A.3—Continued

EQUATIONS			
#	Equation	Domain	Description
Price block			
8	$$PA_a \cdot (1-ta_a)\cdot QA_a \;=\; PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$$ $$\begin{bmatrix} activity\ price \\ (net\ of\ taxes) \\ times\ activity\ level \end{bmatrix} = \begin{bmatrix} value\text{-}added \\ price\ times \\ quantity \end{bmatrix} + \begin{bmatrix} aggregate \\ intermediate \\ input\ price\ times \\ quantity \end{bmatrix}$$	$a \in A$	Activity revenue and costs
9	$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c$$ $$\begin{bmatrix} CPI \end{bmatrix} = \begin{bmatrix} prices\ times \\ weights \end{bmatrix}$$		Consumer price index
10	$$DPI = \sum_{c \in C} PDS_c \cdot dwts_c$$ $$\begin{bmatrix} Producer\ price\ index \\ for\ non\text{-}traded\ outputs \end{bmatrix} = \begin{bmatrix} prices\ times \\ weights \end{bmatrix}$$		Producer price index for nontraded market output
Production and commodity block			
11	$$QA_a = \alpha_a^a \cdot \left(\delta_a^a \cdot QVA_a^{-\rho_a^a} + (1-\delta_a^a)\cdot QINTA_a^{-\rho_a^a}\right)^{-\frac{1}{\rho_a^a}}$$ $$\begin{bmatrix} activity \\ level \end{bmatrix} = CES\begin{bmatrix} quantity\ of\ aggregate\ value\text{-}added, \\ quantity\ aggregate\ intermediate\ input \end{bmatrix}$$	$a \in ACES$	CES technology: activity production function
12	$$\frac{QVA_a}{QINTA_a} = \left(\frac{PINTA_a}{PVA_a} \cdot \frac{\delta_a^a}{1 - \delta_a^a}\right)^{\frac{1}{1+\rho_a^a}}$$ $$\begin{bmatrix} value\text{-}added - \\ intermediate\text{-} \\ input\ quantity \\ ratio \end{bmatrix} = f\begin{bmatrix} intermediate\text{-}input \\ - value\text{-}added \\ price\ ratio \end{bmatrix}$$	$a \in ACES$	CES technology: value-added intermediate input ratio
13	$$QVA_a = iva_a \cdot QA_a$$ $$\begin{bmatrix} demand\ for \\ value\text{-}added \end{bmatrix} = f\begin{bmatrix} activity \\ level \end{bmatrix}$$	$a \in ALEO$	Leontief technology: demand for aggregate value-added
14	$$QINTA_a = inta_a \cdot QA_a$$ $$\begin{bmatrix} demand\ for\ aggregate \\ intermediate\ input \end{bmatrix} = f\begin{bmatrix} activity \\ level \end{bmatrix}$$	$a \in ALEO$	Leontief technology: demand for aggregate intermediate input

Table A.3—Continued

EQUATIONS			
#	Equation	Domain	Description
Production and commodity block			
15	$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot QF_{f\,a}{}^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$ $\begin{bmatrix} \text{quantity of aggregate} \\ \text{value-added} \end{bmatrix} = CES \begin{bmatrix} \text{factor} \\ \text{inputs} \end{bmatrix}$	$a \in A$	Value added and factor demands
16	$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot QF_{f\,a}{}^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot QF_{f\,a}{}^{-\rho_a^{va}-1}$ $\begin{bmatrix} \text{marginal cost of} \\ \text{factor } f \text{ in activity } a \end{bmatrix} = \begin{bmatrix} \text{marginal revenue product} \\ \text{of factor } f \text{ in activity } a \end{bmatrix}$	$a \in A$ $f \in F$	Factor demand
17	$QFS_f = UNEMP_f + \sum_{f,a} QF_{f,,a}$	$a \in A$ $f \in F$	Factor equilibrium for factors
18	$WFREAL_f = \frac{YF}{CPI \cdot \sum_a QF_{f,a}} \cdot CPI0$ $\begin{bmatrix} \text{average real wage} \\ \text{per factor unit} \end{bmatrix} = \begin{bmatrix} \text{average wage corrected} \\ \text{by consumer index price} \end{bmatrix}$	$f \in F$	Real wages
19	$QFS_f = QFS0 * \left[\frac{\frac{WF_f * WFDIST_f * QF_f}{QFS_f}}{\frac{CPI}{\frac{WF0_f}{CPI0}}} \right]^{etals_f}$	$f \in F$	Labor supply
20	$QINT_{c\,a} = ica_{c\,a} \cdot QINTA_a$ $\begin{bmatrix} \text{intermediate demand} \\ \text{for commodity } c \\ \text{from activity } a \end{bmatrix} = f \begin{bmatrix} \text{aggregate intermediate} \\ \text{input quantity} \\ \text{for activity } a \end{bmatrix}$	$a \in A$ $c \in C$	Disaggregate d intermediate input demand
21	$QXAC_{a\,c} + \sum_{h \in H} QHA_{ach} = \theta_{a\,c} \cdot QA_a$ $\begin{bmatrix} \text{marketed quantity} \\ \text{of commodity } c \\ \text{from activity } a \end{bmatrix} + \begin{bmatrix} \text{household home} \\ \text{consumption} \\ \text{of commodity } c \\ \text{from activity } a \end{bmatrix} = \begin{bmatrix} \text{production} \\ \text{of commodity } c \\ \text{from activity } a \end{bmatrix}$	$a \in A$ $c \in CX$	Commodity production and allocation
22	$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}{}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$ $\begin{bmatrix} \text{aggregate} \\ \text{marketed} \\ \text{production of} \\ \text{commodity } c \end{bmatrix} = CES \begin{bmatrix} \text{activity-specific} \\ \text{marketed} \\ \text{production of} \\ \text{commodity } c \end{bmatrix}$	$c \in CX$	Output aggregation function

Table A.3—Continued

EQUATIONS			
#	Equation	Domain	Description
Production and commodity block			
23	$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}-1}$ $\begin{bmatrix} \text{marginal cost of com-} \\ \text{modity } c \text{ from activity } a \end{bmatrix} = \begin{bmatrix} \text{marginal revenue product of} \\ \text{commodity } c \text{ from activity } a \end{bmatrix}$	$a \in A$ $c \in CX$	First-order condition for output aggregation function
24	$QX_c = \alpha_c^t \cdot \left(\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}}$ $\begin{bmatrix} \text{aggregate marketed} \\ \text{domestic output} \end{bmatrix} = CET \begin{bmatrix} \text{export quantity, domestic} \\ \text{sales of domestic output} \end{bmatrix}$	$c \in (CE \cap CD)$	Output transformation (CET) function
25	$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}}$ $\begin{bmatrix} \text{export-domestic} \\ \text{supply ratio} \end{bmatrix} = f \begin{bmatrix} \text{export-domestic} \\ \text{price ratio} \end{bmatrix}$	$c \in (CE \cap CD)$	Export-domestic supply ratio
26	$QX_c = QD_c + QE_c$ $\begin{bmatrix} \text{aggregate} \\ \text{marketed} \\ \text{domestic output} \end{bmatrix} = \begin{bmatrix} \text{domestic market} \\ \text{sales of domestic} \\ \text{output [for} \\ c \in (CD \cap CEN)] \end{bmatrix} + \begin{bmatrix} \text{exports [for} \\ c \in (CE \cap CDN)] \end{bmatrix}$	$c \in$ $(CD \cap CEN)$ $\cup$ $(CE \cup CDN)$	Output transformation for nonexported commodites
27	$QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + (1 - \delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}}$ $\begin{bmatrix} \text{composite} \\ \text{supply} \end{bmatrix} = f \begin{bmatrix} \text{import quantity, domestic} \\ \text{use of domestic output} \end{bmatrix}$	$c \in (CM \cap CD)$	Composite supply (Armington) function
28	$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q} \right)^{\frac{1}{1+\rho_c^q}}$ $\begin{bmatrix} \text{import-domestic} \\ \text{demand ratio} \end{bmatrix} = f \begin{bmatrix} \text{domestic-import} \\ \text{price ratio} \end{bmatrix}$	$c \in (CM \cap CD)$	Import-domestic demand ratio
29	$QQ_c = QD_c + QM_c$ $\begin{bmatrix} \text{composite} \\ \text{supply} \end{bmatrix} = \begin{bmatrix} \text{domestic use of} \\ \text{marketed domestic} \\ \text{output [for} \\ c \in (CD \cap CMN)] \end{bmatrix} + \begin{bmatrix} \text{imports [for} \\ c \in (CM \cap CDN)] \end{bmatrix}$	$c \in$ $(CD \cap CMN)$ $\cup$ $(CM \cap CDN)$	Composite supply for nonimported outputs and nonproduced imports

Table A.3—Continued

EQUATIONS			
#	Equation	Domain	Description
Production and commodity block			
30	$QT_c = \sum_{c' \in C'} \left(icm_{c\,c'} \cdot QM_{c'} + ice_{c\,c'} \cdot QE_{c'} + icd_{c\,c'} \cdot QD_{c'} \right)$ $\begin{bmatrix} \text{demand for} \\ \text{transactions} \\ \text{services} \end{bmatrix} = \begin{bmatrix} \text{sum of demands} \\ \text{for imports, exports,} \\ \text{and domestic sales} \end{bmatrix}$	$c \in CT$	Demand for transactions services
Institution block			
31	$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{f\,a} \cdot QF_{f\,a}$ $\begin{bmatrix} \text{income of} \\ \text{factor } f \end{bmatrix} = \begin{bmatrix} \text{sum of activity payments} \\ \text{(activity-specific wages} \\ \text{times employment levels)} \end{bmatrix}$	$f \in F$	Factor income
32	$YIF_{i\,f} = shif_{i\,f} \cdot \left[\left(1 - tf_f\right) \cdot YF_f - trnsfr_{row\,f} \cdot EXR \right]$ $\begin{bmatrix} \text{income of} \\ \text{institution } i \\ \text{from factor } f \end{bmatrix} = \begin{bmatrix} \text{share of income} \\ \text{of factor } f \text{ to} \\ \text{institution } i \end{bmatrix} \cdot \begin{bmatrix} \text{income of factor } f \\ \text{(net of tax and} \\ \text{transfer to RoW)} \end{bmatrix}$	$i \in INSD$ $f \in F$	Institutional factor incomes
33	$YI_i = \sum_{f \in F} YIF_{i\,f} + \sum_{i' \in INSDNG'} TRII_{i\,i'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR$ $\begin{bmatrix} \text{income of} \\ \text{institution } i \end{bmatrix} = \begin{bmatrix} \text{factor} \\ \text{income} \end{bmatrix} + \begin{bmatrix} \text{transfers} \\ \text{from other domestic} \\ \text{non-government} \\ \text{institutions} \end{bmatrix} + \begin{bmatrix} \text{transfers} \\ \text{from} \\ \text{government} \end{bmatrix} + \begin{bmatrix} \text{transfers} \\ \text{from} \\ \text{RoW} \end{bmatrix}$	$i \in INSDNG$	Income of domestic, non-governmental institutions
34	$TRII_{i\,i'} = shii_{i\,i'} \cdot (1 - MPS_{i'}) \cdot (1 - TINS_{i'}) \cdot YI_{i'}$ $\begin{bmatrix} \text{transfer from} \\ \text{institution } i' \text{ to } i \end{bmatrix} = \begin{bmatrix} \text{share of net income} \\ \text{of institution } i' \\ \text{transfered to } i \end{bmatrix} \cdot \begin{bmatrix} \text{income of institution} \\ i'\text{, net of savings and} \\ \text{direct taxes} \end{bmatrix}$	$i \in INSDNG$ $i' \in INSDNG'$	Intra-institutional transfers
35	$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{i\,h} \right) \cdot \left(1 - MPS_h\right) \cdot (1 - TINS_h) \cdot YI_h$ $\begin{bmatrix} \text{household income} \\ \text{disposable for} \\ \text{consumption} \end{bmatrix} = \begin{bmatrix} \text{household income, net of direct} \\ \text{taxes, savings, and transfers to} \\ \text{other non-government institutions} \end{bmatrix}$	$h \in H$	Household consumption expenditure

Table A.3—Continued

EQUATIONS			
#	Equation	Domain	Description
Institution block			
36	$QH_{ch} = \gamma_{ch} + \dfrac{\beta^{m}_{ch} \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma^{m}_{c'h} - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma^{h}_{ac'h} \right)}{PQ_c}$ $\begin{bmatrix} \textit{quantity of} \\ \textit{household demand} \\ \textit{for commodity } c \end{bmatrix} = f \begin{bmatrix} \textit{household} \\ \textit{consumption} \\ \textit{spending,} \\ \textit{market price} \end{bmatrix}$	$c \in C$ $h \in H$	Household consumption demand for marketed commodities
37	$QHA_{ach} = \gamma^{h}_{ach} + \dfrac{\beta^{h}_{ach} \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma^{m}_{c'h} - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma^{h}_{ac'h} \right)}{PXAC_{ac}}$ $\begin{bmatrix} \textit{quantity of} \\ \textit{household demand} \\ \textit{for home commodity } c \\ \textit{from activity } a \end{bmatrix} = f \begin{bmatrix} \textit{household} \\ \textit{disposable} \\ \textit{income,} \\ \textit{producer price} \end{bmatrix}$	$a \in A$ $c \in C$ $h \in H$	Household consumption demand for home commodities
38	$QINV_c = \overline{IADJ} \cdot \overline{qinv}_c$ $\begin{bmatrix} \textit{fixed investment} \\ \textit{demand for} \\ \textit{commodity } c \end{bmatrix} = \begin{bmatrix} \textit{adjustment factor} \\ \textit{times} \\ \textit{base-year fixed} \\ \textit{investment} \end{bmatrix}$	$c \in CINV$	Investment demand
39	$QG_c = \overline{GADJ} \cdot \overline{qg}_c$ $\begin{bmatrix} \textit{government} \\ \textit{consumption} \\ \textit{demand for} \\ \textit{commodity } c \end{bmatrix} = \begin{bmatrix} \textit{adjustment factor} \\ \textit{times} \\ \textit{base-year government} \\ \textit{consumption} \end{bmatrix}$	$c \in C$	Government consumption demand
40	$YG = \sum_{i \in INSDNG} TINS_i \cdot YI_i + \sum_{f \in F} tf_f \cdot YF_f + \sum_{a \in A} tva_a \cdot PVA_a \cdot QVA_a$ $+ \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CM} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in CE} te_c \cdot pwe_c \cdot QE_c \cdot EXR$ $+ \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR$ $\begin{bmatrix} \textit{government} \\ \textit{revenue} \end{bmatrix} = \begin{bmatrix} \textit{direct taxes} \\ \textit{from} \\ \textit{institutions} \end{bmatrix} + \begin{bmatrix} \textit{direct taxes} \\ \textit{from} \\ \textit{factors} \end{bmatrix} + \begin{bmatrix} \textit{value-} \\ \textit{added} \\ \textit{tax} \end{bmatrix}$ $+ \begin{bmatrix} \textit{activity} \\ \textit{tax} \end{bmatrix} + \begin{bmatrix} \textit{import} \\ \textit{tariffs} \end{bmatrix} + \begin{bmatrix} \textit{export} \\ \textit{taxes} \end{bmatrix}$ $+ \begin{bmatrix} \textit{sales} \\ \textit{tax} \end{bmatrix} + \begin{bmatrix} \textit{factor} \\ \textit{income} \end{bmatrix} + \begin{bmatrix} \textit{transfers} \\ \textit{from} \\ \textit{RoW} \end{bmatrix}$		Government revenue

Table A.3—Continued

#	Equation	Domain	Description
Institution block			
41	$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI}$ $\begin{bmatrix} government \\ spending \end{bmatrix} = \begin{bmatrix} government \\ consumption \end{bmatrix} + \begin{bmatrix} transfers\ to\ domestic \\ non\text{-}government \\ institutions \end{bmatrix}$		Government expenditures
System Constraint Block			
42	$\sum_{a \in A} QF_{f\,a} = \overline{QFS}_f$ $\begin{bmatrix} demand\ for \\ factor\ f \end{bmatrix} = \begin{bmatrix} supply\ of \\ factor\ f \end{bmatrix}$	$f \in F$	Factor market
43	$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c$ $+ QINV_c + qdst_c + QT_c$ $\begin{bmatrix} composite \\ supply \end{bmatrix} = \begin{bmatrix} intermediate \\ use \end{bmatrix} + \begin{bmatrix} household \\ consumption \end{bmatrix} + \begin{bmatrix} government \\ consumption \end{bmatrix}$ $+ \begin{bmatrix} fixed \\ investment \end{bmatrix} + \begin{bmatrix} stock \\ change \end{bmatrix} + \begin{bmatrix} trade \\ input\ use \end{bmatrix}$	$c \in C$	Composite commodity markets
44	$\sum_{c \in CM} pwm_c \cdot QM_c + \sum_{f \in F} trnsfr_{row\,f} = \sum_{c \in CE} pwe_c \cdot QE_c + \sum_{i \in INSD} trnsfr_{i\,row} + \overline{FSAV}$ $\begin{bmatrix} import \\ spending \end{bmatrix} + \begin{bmatrix} factor \\ transfers \\ to\ RoW \end{bmatrix} = \begin{bmatrix} export \\ revenue \end{bmatrix} + \begin{bmatrix} institutional \\ transfers \\ from\ RoW \end{bmatrix} + \begin{bmatrix} foreign \\ savings \end{bmatrix}$		Current account balance for rest world (in foreign currency)
45	$YG = EG + GSAV$ $\begin{bmatrix} government \\ revenue \end{bmatrix} = \begin{bmatrix} government \\ expenditures \end{bmatrix} + \begin{bmatrix} government \\ savings \end{bmatrix}$		Government balance
46	$TINS_i = \overline{tins}_i \cdot \left(1 + \overline{TINSADJ} \cdot tins01_i\right) + \overline{DTINS} \cdot tins01_i$ $\begin{bmatrix} direct\ tax \\ rate\ for \\ institution\ i \end{bmatrix} = \begin{bmatrix} base\ rate\ adjusted \\ for\ scaling\ for \\ selected\ institutions \end{bmatrix} + \begin{bmatrix} point\ change \\ for\ selected \\ institutions \end{bmatrix}$	$i \in INSDNG$	Direct institutional tax rates
47	$MPS_i = \overline{mps}_i \cdot \left(1 + \overline{MPSADJ} \cdot mps01_i\right) + DMPS \cdot mps01_i$ $\begin{bmatrix} savings \\ rate\ for \\ institution\ i \end{bmatrix} = \begin{bmatrix} base\ rate\ adjusted \\ for\ scaling\ for \\ selected\ institutions \end{bmatrix} + \begin{bmatrix} point\ change \\ for\ selected \\ institutions \end{bmatrix}$	$i \in INSDNG$	Institutional savings rate

Table A.3—Continued

EQUATIONS			
#	Equation	Domain	Description
System Constraint block			
48	$$\sum_{i\in INSDNG} MPS_i \cdot \left(1-TINS_i\right)\cdot YI_i + GSAV + EXR\cdot \overline{FSAV} =$$ $$\sum_{c\in C} PQ_c \cdot QINV_c + \sum_{c\in C} PQ_c \cdot qdst_c$$ $$\begin{bmatrix} \text{non-govern-} \\ \text{ment savings} \end{bmatrix} + \begin{bmatrix} \text{government} \\ \text{savings} \end{bmatrix} + \begin{bmatrix} \text{foreign} \\ \text{savings} \end{bmatrix} =$$ $$\begin{bmatrix} \text{fixed} \\ \text{investment} \end{bmatrix} + \begin{bmatrix} \text{stock} \\ \text{change} \end{bmatrix}$$		Savings-investment balance
49	$$TABS = \sum_{h\in H}\sum_{c\in C} PQ_c \cdot QH_{c\,h} + \sum_{a\in A}\sum_{c\in C}\sum_{h\in H} PXAC_{ac} \cdot QHA_{ach}$$ $$+\sum_{c\in C} PQ_c \cdot QG_c + \sum_{c\in C} PQ_c \cdot QINV_c + \sum_{c\in C} PQ_c \cdot qdst_c$$ $$\begin{bmatrix} \text{total} \\ \text{absorption} \end{bmatrix} = \begin{bmatrix} \text{household} \\ \text{market} \\ \text{consumption} \end{bmatrix} + \begin{bmatrix} \text{household} \\ \text{home} \\ \text{consumption} \end{bmatrix}$$ $$+\begin{bmatrix} \text{government} \\ \text{consumption} \end{bmatrix} + \begin{bmatrix} \text{fixed} \\ \text{investment} \end{bmatrix} + \begin{bmatrix} \text{stock} \\ \text{change} \end{bmatrix}$$		Total absorption
50	$$INVSHR \cdot TABS = \sum_{c\in C} PQ_c \cdot QINV_c + \sum_{c\in C} PQ_c \cdot qdst_c$$ $$\begin{bmatrix} \text{investment-} \\ \text{absorption} \\ \text{ratio} \end{bmatrix} \cdot \begin{bmatrix} \text{total} \\ \text{absorption} \end{bmatrix} = \begin{bmatrix} \text{fixed} \\ \text{investment} \end{bmatrix} + \begin{bmatrix} \text{stock} \\ \text{change} \end{bmatrix}$$		Ration of investment to absorption
51	$$GOVSHR \cdot TABS = \sum_{c\in C} PQ_c \cdot QG_c$$ $$\begin{bmatrix} \text{government} \\ \text{consumption-} \\ \text{absorption} \\ \text{ratio} \end{bmatrix} \cdot \begin{bmatrix} \text{total} \\ \text{absorption} \end{bmatrix} = \begin{bmatrix} \text{government} \\ \text{consumption} \end{bmatrix}$$		Ration of government consumption to absorption
52	$$WFKAV^a_{f\,t} = \sum_a \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right]$$ $$\begin{bmatrix} \text{average capital} \\ \text{rental rate} \end{bmatrix} = \begin{bmatrix} \text{weighted sum of sectors'} \\ \text{capital rental rates} \end{bmatrix}$$		Average economywide rental rate of capital
53	$$INVSHR1^a_{f\,a\,t} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{WFKAV^a_{f\,t}} - 1 \right) + 1 \right)$$ $$\begin{bmatrix} \text{share of} \\ \text{new capital} \end{bmatrix} = \begin{bmatrix} \text{share of} \\ \text{existing capital} \end{bmatrix} \cdot \begin{bmatrix} \text{capital rental} \\ \text{rate ratio} \end{bmatrix}$$		Sector's share of the new capital investment

Table A.3—Continued

EQUATIONS			
#	Equation	Domain	Description
System Constraint block			
54	$DKAPS_{f,a,t}^{a} = INVSHR1_{f,a,t}^{a} * \left(\frac{\sum_c PQ_{c,t} * QINV_{c,t}}{PK_{f,t}}\right)$ $\begin{bmatrix} quantity\ of\ new \\ capital\ by\ sector \end{bmatrix} = \begin{bmatrix} share\ of \\ new\ capital \end{bmatrix} \cdot \begin{bmatrix} total\ quantity\ of \\ new\ capital \end{bmatrix}$		Allocate gross fixed capital formation
55	$PK_{f\,t} = \sum_{c} PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}}$ $\begin{bmatrix} unit\ price \\ of\ capital \end{bmatrix} = \begin{bmatrix} weighted\ market\ price \\ of\ investment\ commodities \end{bmatrix}$		Price of capital
56	$QF_{f,a,t+1} = QF_{f,a,t+1} \cdot \left(1 + \frac{DKAPS_{f,a,t}^{a}}{QF_{f,a,t}} - deprate_{f}\right)$ $\begin{bmatrix} average\ capital \\ rental\ rate \end{bmatrix} = \begin{bmatrix} weighted\ sum\ of\ sectors' \\ capital\ rental\ rates \end{bmatrix}$		Updating quantity of capital

Source: Authors adaptation from Lofgren et al (2001).

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2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org