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AGRICULTURAL POLICIES AND MIGRATION IN A U.S.-MEXICO FREE TRADE AREA: A COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

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Abstract

A U.S.–Mexico agreement to form a free trade area (FTA) is analyzed using an 11-sector, three-country, computable general equilibrium (CGE) model that explicitly models farm programs and labor migration. The model also uses a flexible functional form for specifying sectoral import demand functions, which is an empirical improvement over earlier specifications using a constant elasticity of substitution (CES) function. The model identifies the trade-offs among bilateral trade growth, labor migration, and agricultural program expenditures under alternative FTA scenarios. Trade liberalization in agriculture greatly increases rural-urban migration within Mexico and migration from Mexico to the U.S. Migration is reduced if Mexico grows relative to the U.S. and also if Mexico retains farm support programs. However, the more support that is provided to the Mexican agricultural sector, the smaller is bilateral trade growth.

1. Introduction

In June 1990, Mexican President Salinas de Gortari and President Bush agreed to negotiate the establishment of a free trade area (FTA) between their two countries. An agreement between the U.S. and Mexico will complement the U.S.–Canada free trade agreement, which went into effect in January 1988, creating a North American free trade area (or NAFTA). The trade block will not, in fact, be a "free trade" area, in which all trade barriers among member countries are removed. Assuming that U.S.–Mexico negotiations follow the precedent set in the U.S.–Canada agreement, tariffs will fall to zero over intervals negotiated sector by sector, but liberalization of nontariff barriers will be selective. U.S.–Canadian agricultural trade, although substantially liberalized by the gradual elimination of tariffs, was liberalized less than other sectors. Domestic agricultural programs in both countries, and the nontariff barriers used to support them, remained essentially intact [Goodloe and Link (1991)].

Drawing on experience with the U.S.–Canada FTA, realistic analysis of a U.S.–Mexico FTA should consider alternative treatments of agricultural trade, including partial liberalization scenarios and scenarios for retention or restructuring of domestic agricultural programs. This article provides an analysis of the U.S.–Mexico free trade agreement using a three-country, 11-sector, computable general equilibrium (CGE) model. Our "FTA–CGE" model focuses on three modeling issues which are especially important in analyzing a U.S.–Mexico FTA. First is the explicit modeling of agricultural policies in the two countries in order to capture the linkages, particularly in Mexico, between bilateral agricultural trade barriers and social policy objectives. Mexican agricultural policies that are modeled include tariffs; import quotas for beans, corn,and other grains; input subsidies to producers and processors; and low income tortilla subsidies to consumers. The tariff equivalents of quotas are determined endogenously and are not treated as fixed *ad valorem* wedges. U.S. policies included in the model are deficiency payments and the Export Enhancement Program (EEP). Since government agricultural program expenditures on subsidies for farmers and processors are included in the model, one can analyze the fiscal impacts of changes in agricultural output and trade.

A second issue is labor migration, and the effect that liberalization of trade in agriculture in particular is likely to have in stimulating rural-urban migration in Mexico and migration from Mexico to the U.S. rural and urban labor markets. Migration issues are not explicitly part of the FTA negotiations. However, labor migration is sensitive to relative economic conditions in the two countries, and to the mix of trade and domestic policies in Mexican agriculture. The FTA–CGE model includes migration equations and the results indicate the importance of migration in different FTA scenarios.

The third modeling issue concerns the specification of import demand. The standard approach in trade-focused CGE models has been to adopt the Armington assumption of product differentiation coupled with use of a constant elasticity of substitution (CES) import aggregation function. The CES specification has been criticized because it constrains import demand equations to have an expenditure elasticity of one, and also implies that every country has market power in its export markets.[1] Brown (1987) shows that these assumptions have led earlier multi-country trade models to generate unrealistically large terms-of-trade effects under trade-liberalization scenarios. The FTA–CGE model employs the Almost Ideal Demand System (AIDS) to describe import demand, a flexible functional form

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[1]The CES formulation has also been criticized on econometric grounds [Alston *et al.* (1990)].

which allows non-unitary expenditure elasticities and yields more realistic empirical results, while retaining the essential property of imperfect substitutability.

In sections 2 to 5, we present the core CGE model and describe how we model import demand, migration, and agricultural programs. In section 6, we present model simulations. Our analysis with the FTA–CGE model focuses on the trade-offs between bilateral export growth, migration, and farm program expenditures. Trade liberalization, in which both tariffs and quotas are removed, results in significant bilateral export growth but also large Mexican migration flows. We estimate how much Mexican growth is required to absorb the increased rural migration without increased migration to the U.S. We show that migration can be reduced by simultaneously lowering trade barriers and increasing agricultural program expenditures in Mexico to support rural employment. Our results indicate that it is feasible to design transition policies so that Mexico can adjust gradually to the structural changes induced by trade liberalization, and so reap the benefits over time from the creation of an FTA without a precipitous shock to the labor markets in both countries from a dramatic increase in migration.

2. Core Three–Country CGE Model

The FTA–CGE model is an 11-sector, three-country, computable general equilibrium model composed of two single-country CGE models linked through trade and migration flows, plus a set of export-demand and import-supply equations to represent the rest of the world. The model is an extension of earlier CGE modeling undertaken at the USDA, which began with the single-country, USDA/ERS CGE model, designed to provide a framework for analyzing the effects of changes in agricultural policies and exogenous shocks on U.S.

agriculture [Robinson, Kilkenny, and Hanson (1990)]. The USDA/CGE model was extended by Kilkenny and Robinson (1988, 1990), and Kilkenny (1991) to model U.S. agricultural programs explicitly. The specification of import demand with the AIDS function was incorporated into the USDA/ERS CGE model by Hanson, Robinson, and Tokarick (1989). The multi-country application of the USDA/CGE was initially developed by Hinojosa and Robinson (1991), who also used the AIDS import-demand function. The FTA–CGE model extends the Hinojosa and Robinson model with an explicit modeling of domestic farm programs in both the U.S. and Mexico.

Table 1 and Figure 1 present aggregate data on the two economies and their trade, which are used to generate the benchmark or base solution of the FTA–CGE model. Mexico is a much smaller and poorer economy than the U.S. The gap between Mexico and the U.S. is wider than that between Spain and Portugal and the European Community.[2] Mexico has a higher trade share than the U.S. and is very dependent on the U.S. market, which accounts for 75 percent of Mexican exports. Most U.S. trade, on the other hand, is with the rest of the world. While Mexico is a significant market for the U.S., it takes only about 3 percent of total U.S. exports. Mexico, typical of a developing country, has a much larger share of its labor force in agriculture: 13.1 percent compared to 1.4 percent.

Table 2 shows the sectoral structure of GDP, employment, and trade for the two countries, as well as existing trade barriers. The model's 11 sectors include four farm and one food processing sector. The corn sector refers to corn used for human consumption. In Mexico, this includes white corn, the small proportion of yellow corn used for food, and No.

[2]The gap remains large, even using purchasing power parity comparisons such as those provided by the United Nations/World Bank International Comparisons Project (ICP). See Kravis and Summers (1982) for the latest comparative figures that include Mexico and Summers and Heston (1991) for the latest update on the ICP methodology.

Table 1 — Comparative Aggregate Data, U.S. and Mexico

	Mexico	U.S.
GDP ($US billions, 1988)	176.7	4,847.4
Per Capita GNP ($US, 1988)	1,760	19,990
Trade flows (percent of GDP)		
Total exports	13.6	7.1
Exports to partner	10.1	0.2
Total imports	12.0	10.1
Imports from partner	6.3	0.4
Employment structure (percent)		
Rural labor	13.1	1.4
Urban unskilled labor	13.6	17.3
Urban skilled labor	38.8	48.6
White collar workers	34.6	32.7
Total	100.0	100.0
Population, ages 15-64 (millions)	49	162
Total population (millions)	84	246

Sources:
GDP, per capita GNP, and population data refer to 1988 and come from World Bank, World Development Report 1990. All other data come from U.S. and Mexican social accounting matrices developed by the Economic Research Service, U.S. Department of Agriculture (USDA/ERS).

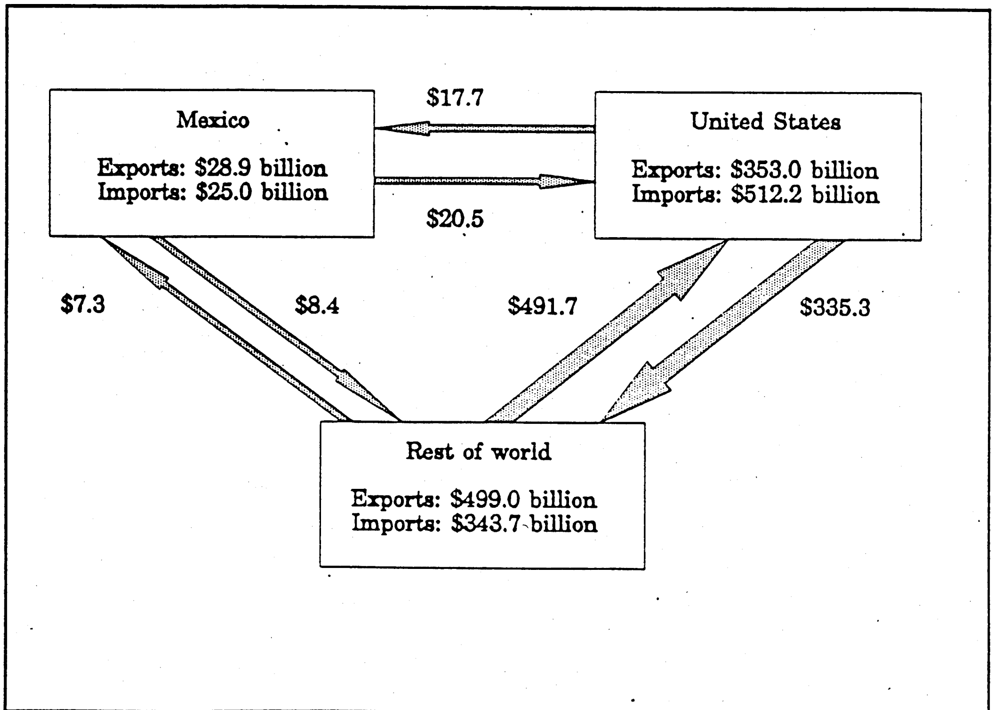

Figure 1: U.S.-Mexico Trade, Base Run

Table 2 — Sectoral Structure of U.S. and Mexican Economies, Base Solution

	Sectoral shares (percent) in:									
	GDP		Employment		Imports		Exports		Bilateral import barriers	
Commodity	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico
Food corn	0.0%	0.6%	0.0%	6.3%	0.0%	1.2%	0.3%	0.0%	0.0%	55.0%
Program crops	0.5%	1.0%	0.4%	5.5%	0.0%	3.3%	3.3%	0.1%	0.0%	23.1%
Fruits/vegetables	0.2%	0.9%	0.4%	3.1%	0.4%	0.1%	0.4%	3.0%	13.2%	12.5%
Other agriculture	0.8%	4.6%	1.4%	8.9%	1.5%	1.3%	0.4%	3.8%	0.6%	8.9%
Food processing	1.7%	7.6%	1.5%	2.5%	2.3%	5.2%	2.9%	3.7%	7.0%	8.2%
Other light mfg.	4.5%	5.3%	5.1%	2.7%	16.2%	4.3%	7.0%	6.0%	4.7%	8.1%
Oil and refining	2.2%	2.5%	0.5%	0.5%	11.6%	5.0%	2.6%	10.2%	1.5%	8.8%
Intermediates	5.6%	7.9%	4.5%	3.2%	12.7%	16.7%	13.9%	12.3%	2.2%	8.0%
Consumer durables	1.8%	2.6%	1.7%	0.8%	28.4%	14.8%	10.0%	18.6%	1.8%	12.0%
Capital Goods	5.2%	3.5%	4.9%	2.2%	25.0%	26.4%	31.7%	12.0%	3.6%	12.7%
Services	77.4%	63.6%	79.6%	64.4%	1.8%	21.6%	27.5%	30.3%	0.1%	0.0%

Notes:
Bilateral import barriers are the combined rate of trade-weighted tariffs and tariff equivalents of quotas on trade between Mexico and the U.S. Percent composition columns sum to 100%, except for rounding error.
Sources:
U.S. and Mexican social accounting matrices, USDA/ERS. 1987 for U.S. and 1988 for Mexico.

2 yellow corn imports from the U.S., which are assumed to enter food use. In the U.S., the corn sector refers to No. 2 yellow corn, which exports to Mexico. The composition of the program crops sector corresponds to the other crops eligible for U.S. deficiency payments — feed corn, food grains, soybeans, and cotton. Other agriculture includes livestock, poultry, forestry and fishery, and other miscellaneous agriculture. The fruits and vegetables sector in Mexico includes beans, a major food crop.

There are six primary factors, including four labor types, capital, and agricultural land. The four labor types are rural, urban unskilled, urban skilled, and professional. The base year for Mexico is mostly 1988.[3] The U.S. uses a 1987 base year because of the severe contraction of agricultural output following the 1988 drought. Bilateral trade flows are from 1988. Because of the volatility in U.S. 1987-88 agricultural output, the model follows Adams and Higgs (1986) and Hertel (1990) in the use of a "synthetic" base year for the U.S., imposing 1988 U.S.–Mexican bilateral trade flows on a 1987 base U.S. economy. This approach has the advantage of achieving a more representative U.S. base year, with minimal adjustment to the data.[4] Tariffs and tariff equivalents of quotas are 1988 trade-weighted rates.

The core model follows the standard theoretical specification of trade-focused CGE models.[5] Each sector produces a composite commodity that can be transformed according

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[3]The data base is documented in Burfisher, Hinojosa, Thierfelder, and Hanson (1991). Some of the Mexican agricultural support data refer to 1989. The Mexican agricultural programs have changed dramatically over the past few years, and it is important to use the latest data available.

[4]A comparison of 1987 and 1988 U.S.-Mexico trade shows that Mexican farm imports increased in 1988 as U.S. agricultural output fell. Use of a 1987/88 split year for the U.S. moderates the importance of Mexico in U.S. agricultural trade relative to 1988.

[5]See the appendix for a complete equation listing. Robinson (1989) and de Melo (1988) survey single-country, trade-focused, CGE models. The FTA-CGE model is implemented using the GAMS software, which is described in Brooke, Kendrick, and Meeraus (1988).

to a constant elasticity of transformation (CET) function into a commodity sold on the domestic market or into an export. Output is produced according to a CES production function in primary factors, and fixed input-output coefficients for intermediate inputs. The model simulates a market economy, with prices and quantities assumed to adjust to clear markets. All transactions in the circular flow of income are captured. Each country model traces the flow of income (starting with factor payments) from producers to households, government, and investors, and finally back to demand for goods in product markets.

Consumption, intermediate demand, government, and investment are the four components of domestic demand. Consumer demand is based on Cobb-Douglas utility functions, generating fixed expenditure shares. Households pay income taxes to the government and save a fixed proportion of their income. Intermediate demand is given by fixed input-output coefficients. Real government demand and real investment are fixed exogenously.

In factor markets, full employment for all labor categories is assumed. Aggregate supplies are set exogenously. The model can incorporate different assumptions about factor mobility. In the experiments reported here, we assume that agricultural land is immobile among crops, but that all other factors are mobile, including capital.[6] The results should be seen as reflecting adjustment in the long-run, with capital able to leave the agricultural sectors.

There are three key macro balances in each country model: the government deficit, aggregate investment and savings, and the balance of trade. Government savings is the difference between revenue and spending, with real spending fixed exogenously but revenue

[6]Note, however, that labor markets are segmented. Rural labor does not work in the industrial sectors, and urban labor does not work in agriculture. These labor markets are linked through separate migration equations.

depending on a variety of tax instruments. The government deficit is therefore determined endogenously. Real investment is set exogenously, and aggregate private savings is determined residually to achieve the nominal savings-investment balance.[7] The balance of trade for each country (and hence foreign savings) is set exogenously, valued in world prices.

Each country model solves for relative domestic prices and factor returns which clear the factor and product markets, and for an equilibrium real exchange rate given the exogenous aggregate balance of trade in each country. The GDP deflator defines the numeraire in each country model, and the currency of the rest of the world defines the international numeraire. The model determines two equilibrium real exchange rates, one each for the U.S. and Mexico, which are measured with respect to the rest of the world. The cross rate (U.S. to Mexico) is implicitly determined by an arbitrage condition.

The model specifies sectoral export supply and import demand functions for each country, and solves for a set of world prices that achieve equilibrium in world commodity markets. At the sectoral level, in each country, demanders differentiate goods by country of origin and exporters differentiate goods by country of destination.

3. Import Demand Equations

The standard approach in "Armington" trade models is to specify a constant elasticity of substitution (CES) import aggregation function.[8] In the case of a multi-country model, the

[7]Enterprise savings rates are assumed to adjust to achieve the necessary level of aggregate savings in each country.

[8]The properties of CGE models incorporating CES import aggregation functions have been extensively studied. See, for example, de Melo and Robinson (1989) and Devarajan, Lewis, and Robinson (1990).

function aggregates imports from all countries of origin. In the simplest case, the CES function is extended to include goods from many countries, with the substitution elasticity assumed to be the same for all pairwise comparisons of goods by country of origin.[9] The first-order conditions define import demand as a function of relative prices and the elasticity parameter. In our model, with three countries of origin, there are fifteen prices associated with each sector in each country of destination, including the prices of the CES and CET aggregates.

As noted earlier, the use of CES functions in multi-country Armington trade models has led to empirical problems due to the restrictive nature of the CES functions. Instead of the CES import aggregation function, we use import demand equations based on the Almost Ideal Demand System (or AIDS).[10] The AIDS function is a flexible functional form in that it can generate arbitrary values of substitution elasticities at a given set of prices, and also allows expenditure elasticities different from one.

In the AIDS approach, the expenditure shares are given by:

$$S_{i,k,c1} = \alpha_{i,k,c1} + \sum_{c2} \gamma_{i,k,c1,c2} \log(PM_{i,k,c2}) + \beta_{i,k,c1} \log\left[\frac{\bar{C}_{i,k}}{P_{i,k}}\right] \tag{1}$$

where subscript i refers to sectors; subscript k refers to the U.S. and Mexico; and subscript c1 refers to the U.S., Mexico, and the rest of the world. $S_{i,k,c1}$ is the expenditure share on

[9]Other generalizations of the CES function could allow different, but fixed, elasticities of substitution between goods from different countries. See, for example, the CRESH function described in Dixon *et al.* (1982). It is also common to use nested CES functions, with a two-good CES function specifying substitution between domestically produced goods and a composite of imports, which is itself a CES function of goods from various countries of origin.

[10]The AIDS specification in this model draws heavily on work by Robinson, Soule, and Weyerbrock (1991). The discussion below is based on their paper.

imports of good i into country k from country c1. $\bar{C}_{i,k}$ is nominal expenditure on composite good i in country k, $PM_{i,k,c2}$ is the domestic price of imports, and $P_{i,k}$ is the aggregate price of the composite good. The Greek letters are parameters.

We adopt the notation convention that when k = c1,

$$M_{i,k,k} = D_{i,k},\ PM_{i,k,k} = PD_{i,k} \text{ and } S_{i,k,k} = PD_{i,k} \cdot D_{i,k} / \bar{C}_{i,k}$$

where $M_{i,k,c1}$ is the import of good i into country k from country c1, $D_{i,k}$ is the domestically produced good sold on the domestic market, and $PD_{i,k}$ is the price of $D_{i,k}$. Deaton and Muellbauer (1980) define the aggregate price index, $P_{i,k}$, by a translog price index. In econometric work, the translog price index is often approximated by a geometric price index — a procedure we have followed in the results presented below.[11]

Various restrictions on the parameters are required to have the system satisfy standard properties of expenditure functions such as symmetry, homogeneity, adding up, and local concavity. We calibrated the parameters for the FTA–CGE model by starting from a set of expenditure elasticities and substitution elasticities for each sector in each country. We assumed that substitution elasticities are the same for goods from any pair of countries, so our AIDS functions are effectively simple extensions of the multi-country CES functions to include expenditure elasticities different from one.[12]

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[11]The geometric price index is usually called a Stone index. Robinson, Soule, and Weyerbrock (1991) analyze the empirical properties of different import aggregation functions in a three-country model of the U.S., European Community, and rest of world, which is a close cousin of the FTA–CGE model. Green and Alston (1990) discuss the computation of various elasticities in the AIDS system when using the Stone or translog price indices.

[12]We drew on work at the International Trade Commission for estimates of the various elasticities. See Reinert and Shiells (1991) who present estimates of substitution elasticities. They are currently working on estimating AIDS functions.

4. Migration

The FTA–CGE model specifies three migration flows: rural Mexico to rural U.S. labor markets, urban unskilled Mexico to urban unskilled U.S. labor markets, and internal migration within Mexico from rural to unskilled urban labor markets. Migration is assumed to be a function of wage differentials between the two countries. In equilibrium, migration levels are determined which maintain a specified ratio of real wages, $wgdf_{mig}$, for each labor category in the two countries, measured in a common currency, and a specified ratio of real wages between the rural and unskilled urban markets in Mexico:

$$WF_{mig,mx} = wgdf_{mig} \cdot WF_{mig,us} \cdot \frac{EXR_{mx}}{EXR_{us}} . \qquad (2)$$

where the index *mig* refers to the three migration flows, WF is the wage, and EXR is the exchange rate. The domestic labor supply in each skill category in each country is then adjusted by the migrant labor flow.

An implication of this specification of migration flows is that real wages measured in a common currency are equated, but they can grow at different rates measured in the domestic currency. It is therefore possible to observe migrants moving from a labor market where real wages are rising to one in which they are falling in domestic currency terms. The issue is in the specification of what motivates migrants. For example, if they are motivated by the desire to accumulate savings which they intend to repatriate, then migration will be sensitive to the exchange rate. On the other hand, if they are motivated by observations on relative changes within the two economies then migration could be expected to be insensitive to the exchange rate. The model probably overstates the sensitivity of migration to the exchange rate, generating a backward flow of migrants into Mexico when the Mexican peso appreciates.

Migration flows generated by the FTA–CGE model refer to changes in migration from a base of zero. They should be seen as additional migration flows due to the policy change, adding to current flows. Current migration flows are substantial, both within Mexico and between Mexico and the U.S.[13] In addition, the net migration flows generated by the model represent workers, or heads of households. In recent years, a substantial share of migrants have been family members. The model thus probably understates total increased migration due to a policy change, since family members will tend to migrate with workers.

5. Agricultural Programs

In both the U.S. and Mexico, the agricultural sector is characterized by a complex set of trade policies and domestic agricultural programs. These policies distort production, consumption and trade, and require significant fiscal expenditures in both countries. Tables 3 and 4 present data on their agricultural program expenditures in the base year. Mexican agricultural program expenditure in 1988, totaling $1.6 billion, represented over one-half of total national subsidy expenditure, and equaled almost one percent of GDP.[14] In the U.S., deficiency payments and expenditures on the export enhancement program (EEP) in 1987 totalled $11.5 billion, or one percent of government spending and 10 percent of the fiscal deficit.

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[13]Various researchers have placed the net increase of undocumented Mexican immigrants in the U.S. to be around 100,000 a year during the 1980s. See Bean, Edmonston, and Passel (1990).

[14]This total represents agricultural expenditures for 1989 and subsidies to food processing for 1988.

Table 3 — Mexican Agricultural Program Expenditures

Subsidy	Food corn	Other program crops	Fruits & vege-tables	Other agri-culture	Food proces-sing	Total
			- - - Billion Pesos - - -			
Credit (CSUB)	169.4	183.8	78.1	44.2	0.0	475.4
Fertilizer (FSUB)	77.4	217.8	18.0	0.0	0.0	313.2
Insurance (INSUB)	138.4	293.7	16.9	0.0	0.0	448.9
Irrigation (IRSUB)	189.4	533.2	44.1	0.0	0.0	766.6
Feed (FDSUB)	0.0	0.0	0.0	31.7	0.0	31.7
Direct payment (DSUB)	0.0	0.0	0.0	0.0	325.1	325.1
Price (PSUB)	0.0	0.0	0.0	0.0	1,085.1	1,085.1
Tortilla (LOSUB)	0.0	0.0	0.0	0.0	223.8	223.8
Total (billion pesos)	574.6	1,228.4	157.0	75.9	1,633.9	3,669.9
Total ($US millions)	$253.1	$541.1	$69.2	$33.4	$719.8	$1,616.7
Producer incentive equivalent (PIE), %	16.4%	20.8%	3.1%	0.2%	0.4%	

Notes:
"Food Corn" refers to corn used for human consumption (85% of total corn output). "Fruits & vegetables" includes beans (frijoles). CSUB, FSUB, INSUB, IRSUB, and FDSUB refer to 1989. DSUB, PSUB, and LOSUB refer to 1988. The PIE rates are given *ad valorem*, although they are modelled as specific subsidies (per unit output).
Source:
Burfisher, *et al.* (1991).

Table 4 — U.S. Agricultural Program Expenditures

	Food corn	Other program crops	Total
		- - - $ billion - - -	
Deficiency payments	0.76	9.85	10.62
Export Enhancement Program (EEP)	0.00	0.88	0.88
EEP for exports to Mexico	0.00	0.03	0.03
Total	0.76	10.74	11.50
Producer incentive equivalent (PIE), %	18.7%	18.8%	

Notes:
Programs include deficiency payments and the Export Enhancement Program (EEP) for wheat in 1987.
EEP payments for exports to Mexico refer to 1988.
"Food corn" refers to No. 2 yellow corn. Deficiency payments for food corn are computed as a share of total deficiency payments. The share of No. 2 corn exported to Mexico as a share of total corn output (11%).
PIE rates are given *ad valorem*, although they are modelled as specific rates (per unit ouput).
Sources:
Agricultural Outlook, April 1991 and unpublished USDA data.

Table 5 — How Agricultural Programs are Modeled

	Program instruments:		Program:	
	Fixed	Endogenous	United States	Mexico
Price Wedges				
PX, output price		PIE	Deficiency payment program	CSUB: credit FSUB: fertilizer INSUB: insurance IRSUB: irrigation FDSUB: feed DSUB: direct
PD, domestic sales price	itax psub		itax: indirect tax	 psub: price subsidy
PM, import price	tm	TM2	Tariffs and quotas on imports	Tariffs and quotas on imports
PE, export price	tee		EEP: Export enhancement program	
PVA, value added price	vatr			Value added tax
Income Transfers				
Households	losub			losub: low income tortilla subsidy

Notes:
PIE refers to "producer incentive equivalent." In the model, the PIE variable equals the sum of all price-wedge instruments that affect the output price (PX). Tariff rates, tm, are fixed parameters. The tariff equivalent of a quota, TM2, is a variable determined endogenously, given the fixed import quota.

In the FTA–CGE model, agricultural policies are modeled either as price wedges, which affect output decisions, or lump-sum income transfers. The wedges and transfers are either specified exogenously or determined endogenously, based on the institutional characteristics of the program being modelled. The various programs and how they are treated in the model are summarized in Table 5.

Border policies (tariffs, quotas, and export subsidies) affect producers through their effect on the output price, $PX_{i,k}$, which is effectively a weighted average of the prices of output sold in the domestic market, $PD_{i,k}$, and in each export market, $PE_{i,k,c1}$. Similarly, they affect consumers through the price of the composite good, $P_{i,k}$, which is effectively a weighted average of the domestic currency price of the imported good, $PM_{i,k}$, and the domestic good price, $PD_{i,k}$.[15] Given the CET and AIDS functions, the link between trade policy and domestic prices is weaker than in a model where all goods are perfect substitutes.

5.1 Mexican Agricultural Programs

Six Mexican policies are modeled.[16] In the four agricultural sectors, these are input subsidies, tariffs, and quotas. In the food processing sector, we model direct subsidies and price subsidies, in addition to tariffs and quotas. The sixth Mexican policy is the low income, or tortilla, subsidy.

Mexico provides its farmers with input subsidies on credit, fertilizer, insurance, irrigation, and feed. Input subsidies are represented in the model as a per-unit mark-up on

[15]PX is a CET aggregation of PD and PE, while P is a translog or Stone aggregation of PD and PM.

[16]Mexican agricultural policies are described in Krissoff and Neff (1992); Burfisher (1992); Mielke (1989, 1990); O'Mara and Ingco (1990); and Roberts and Mielke (1986).

output price measured as a fixed number of pesos per unit of output.[17] Reflecting their effect on the producer's output decision, input subsidies are summed into a Producer Incentive Equivalent ($PIE_{i,k}$), in pesos per unit of output. For the U.S. and Mexico, the producer incentive equivalents in *ad valorem* terms range from 16 to 21 percent (Tables 3 and 4). Given the assumption of fixed input-output coefficients, the profit maximization problem uses the value added-price ($PVA_{i,k}$) in computing the marginal revenue product as an argument to determine demand for primary factors. PVA is the price received by producers (PX, defined net of indirect taxes), minus the cost of intermediate inputs (given by input-output coefficient, $IO_{j,i,k}$), and plus all subsidies (PIE):

$$PVA_{i,k} = PX_{i,k} - \sum_{j} (IO_{j,i,k} \cdot P_{j,k}) + PIE_{i,k} \qquad (3)$$

Increasing the producer's value-added price with a positive PIE increases factor returns and induces a resource pull of factors toward the subsidized sector, causing output in the sector to expand.

Import quotas in agriculture are used by the Mexican government as a supply management tool to maintain targeted domestic farm prices. Import licenses are generally issued after the domestic crop has been harvested and purchased. To acquire a license, private importers or Mexico's food parastatal, the Compania Nacional de Subsistencias Populares (CONASUPO), must show that domestic supplies are being purchased for not less than the government target price. Mexico is assumed to be a small country in the world market for its agricultural imports, so that their quotas do not affect the world price. The

[17]Input subsidies can be tied directly to output because intermediate demand is modeled with fixed input-output coefficients. With more complex production functions, input subsidies should be directly tied to input usage. A "u" as the final letter in the name of a subsidy signifies that it is provided per unit of output.

tariff equivalent of the quota, $TM2_{i,k,c1}$, can be calculated as the "price-gap" between the world price and the domestic price. Following Dervis, de Melo, and Robinson (1982) and Kilkenny (1991), $TM2_{i,k,c1}$ is determined endogenously, so that the quota's *ad valorem* equivalent (and hence the value to license holders of the import premia) changes with the price gap.

Premium income from each sector is distributed to the holders of import licenses. Since only Mexicans are awarded licenses, the rent is retained domestically. In the FTA–CGE model, the rent is allocated between government revenue and enterprise income according to the share of the government and private sector in imports.[18] Tariffs are modelled with fixed *ad valorem* rates, $TM_{i,k,c1}$, and tariff revenues are paid by consumers to the government.

Since December 1987, Mexico has placed price controls on almost all basic foods, including corn products, wheat products, dairy, eggs, poultry, and pork. To enable food processors to sell their output at low consumer prices fixed by price controls, the government offsets processors' high input prices with two types of subsidies. One is a direct subsidy, $DSUB_{i,k}$. This is a modeled as a fixed budgetary transfer from the government to the processing sector, with a unit value ($DSUBU_{i,k}$) that varies with a change in output:

$$DSUBU_{i,k} = \frac{DSUB_{i,k}}{XD_{i,k}} \tag{4}$$

$DSUBU_{i,k}$ is included in the $PIE_{i,k}$ price wedge on producer's value-added price, and the direct subsidy expenditure is treated as a fixed component of Mexican farm program expenditures.

[18]Tariffs and quotas are modelled identically for the U.S. and Mexico, except that in the U.S., quota premia accrue to capital income.

The Mexican government also provides processors with an input price subsidy, $PSUB_{i,k}$, to compensate them for the high purchase price of domestic agricultural inputs, and to enable them to sell their output on the domestic market at the controlled retail price $\bar{P}_{i,k}$. $PSUBU_{i,k}$ is the input price subsidy in pesos per unit of output. Its initial value is calculated from data on sectoral government expenditures on price subsidies, $PSUB_{i,k}$, and domestic sales, $D_{i,k}$ as:

$$PSUBU_{i,k} = \frac{PSUB_{i,k}}{D_{i,k}} \tag{5}$$

Price subsidies increase a processor's domestic sales price to $PDA_{i,k}$, the "actual" domestic sales price received by each producer:

$$PDA_{i,k} = PD_{i,k} + PSUBU_{i,k} \tag{6}$$

In a model with more sectoral disaggregation, the unit price subsidy should be modeled endogenously as the price wedge on a processor's domestic sales price that is required to maintain the fixed retail price of the composite good, $\bar{P}_{i,k}$. Because the 11-sector model aggregates all food processing into a single sector, $PSUBU_{i,k}$ is represented as a fixed price wedge and consumer food prices are permitted to vary. Quota removal under an FTA is simulated by simply removing the wedge, rather than allowing the model to determine the change in $PSUBU_{i,k}$. $PSUBU_{i,k}$ enters into $PIE_{i,k}$ where it affects each producer's value-added price. The cost of the price subsidy to the government increases with an increase in domestic sales, and is included in agricultural program expenditures.

Mexico provides low income consumers with subsidized corn tortillas. Under one program, low prices are offered in CONASUPO-owned retail outlets located in low-income neighborhoods. More recently, the government has provided low-income households with one kg. per day of tortillas, approximately one-half the daily average household consumption

[Levy and van Wijnbergen, (1991)]. Since the FTA–CGE model has only a single aggregate household, with no differentiation by income, the tortilla subsidy is represented as a lump-sum income transfer to the single household. Similar to direct subsidies to processors, expenditure by the government on low income corn subsidies, $LOSUB_{i,k}$, is fixed and enters into Mexican agricultural program expenditures.

5.2 U.S. Agricultural Programs

Two U.S. farm programs could be affected by an FTA — deficiency payments and the EEP.[19] The U.S. deficiency payments program provides payments to farmers who participate in feed grain, wheat, rice, or cotton programs. The payment rate is calculated as the difference between a fixed target price ($TP_{i,k}$) and the market price ($PX_{i,k}$) or loan rate, whichever difference is less. The total payment a farm receives ($DEFPAY_{i,k}$) is the payment rate multiplied by eligible base production ($XP_{i,k}$):[20]

$$DEFPAY_{i,k} = \left(TP_{i,k} - PX_{i,k}\right) \cdot XP_{i,k} \tag{7}$$

The U.S. EEP program is intended to counter competitors' subsidies and other "unfair" trade practices in targeted U.S. agricultural export markets, and to develop, expand, or maintain foreign markets. Under the EEP program, the USDA approves an initiative to permit an importing country to tender for a specified quantity of a designated commodity.

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[19] Our modeling of these programs in the FTA–CGE model follows Kilkenny and Robinson (1988, 1990) and Kilkenny (1991).

[20] The initial value of the target price is calculated from base-year data on the aggregate cost of deficiency payment (DEFPAY) which is then used to estimate the mark-up on the market price. The model also implicitly fixes participation rates at the base year rate, implying that any increase in U.S. program crop output comes from outside the deficiency payments program. In recent years, the market price has been above the loan rate, so we have not had to model the non-recourse loan program.

Exporting firms bid for the sale, which are contingent on receiving an EEP bonus from the Commodity Credit Corporation (CCC). EEP bonuses are fungible, in-kind certificates backed by commodities owned by the CCC. The firms estimate the per unit subsidy they will need to complete the sale and then compete against each other for the EEP bonus. The CCC then accepts one of the bids, based on the price and bonus ranges. In effect, the EEP program works as an *ad valorem* export subsidy, which is how it is treated in the FTA–CGE model. The subsidy rate, $TEE_{i,k,c1}$, is applied as a mark-up on the world export price:

$$PE_{i,k,c1} = PWE_{i,k,c1} \cdot EXR_k \cdot (1 + TEE_{i,k,c1}) \tag{8}$$

which allows U.S. producers to lower the world price of their goods relative to other suppliers, while maintaining their received price (PE). Total EEP expenditures are included in farm program expenditures.

For each country, the policy-ridden, value-added producer price becomes:

$$PVA_{i,k} = \frac{\left[(1 - ITAX_{i,k}) \cdot PD_{i,k} + PSUBU_{i,k}\right] \cdot D_{i,k} + \sum_{c1} PE_{i,k,c1} \cdot E_{i,k,c1}}{XD_{i,k}} - \sum_{j} (IO_{j,i,k} \cdot P_{j,k}) + PIE_{i,k} \tag{9}$$

where: ITAX is the indirect tax rate, PSUBU is the subsidy rate on domestic sales (by food processors in Mexico), and PIE is a bundle of subsidies in domestic currency per unit of total output (Table 5). The other variables are defined above.

Four types of elasticity parameters are used in the model. The production specification requires sectoral elasticities of substitution among primary factors. The CET export supply functions require elasticities of transformation between goods sold on the home and export markets. The AIDS import demand functions require sectoral income elasticities and substitution elasticities for home goods and for goods from each import source. We have drawn on estimates and "quesstimates" from various studies, including Hinojosa and Robinson (1991); Hanson, Robinson, and Tokarick (1989); and Reinert and Shiells (1991). In lieu of econometric estimation, sensitivity analysis was carried out to check for the robustness of the model results using alternative elasticity parameters.

6. Model Results

6.1 Scenarios

We analyze the effects of a U.S.–Mexico FTA under six scenarios, which are summarized in Table 6. All the scenarios involve changes in policies between the U.S. and Mexico, leaving unchanged their policies with respect to the rest of the world. The first scenario is the removal of all non-agricultural protection between the U.S. and Mexico, leaving all agricultural protection and programs intact. The second scenario is removal of tariffs and quotas in all industrial and agricultural sectors, but again leaving all agricultural programs, except for the removal of the U.S. EEP program with respect to Mexico.[21] A third scenario considers trade and agricultural liberalization, removing all Mexican subsidies to farmers and food processors, in addition to full trade liberalization. We also ran a variant of Scenario 3, 3a, in which input subsidies to the food corn sector were eliminated, but all

[21]U.S. quotas on sugar imports (in the processed food sector) were also left intact. As a net sugar importer, Mexico is unlikely to become a sugar exporter to the U.S. under an FTA, except insofar as it attempts to increase its quota rents from arbitrage sales to the U.S. market. In any event, trade in sugar and items of high sugar content was not liberalized under the U.S.—Canada FTA, and is likely to be excluded from the U.S.—Mexico FTA.

Table 6 — Description of Scenarios

No.	Scenario	Description
1.	Industrial trade liberalization	Remove all non-agricultural tariffs and quotas.
2.	Trade liberalization	Remove all tariffs and quotas. Remove U.S. EEP program subsidizing exports to Mexico.
3.	Trade and Mexican agricultural liberalization	Scenario 2 plus eliminate all agricultural support programs in Mexico.
3a.	Trade and Mexican corn liberalization	Scenario 2 plus eliminate input subsidies for corn sector in Mexico.
4.	Trade liberalization plus common agricultural policies	Scenario 2 plus add a deficiency payment program for corn and other program crops in Mexico.
5.	Partial trade liberalization	Tariffication of Mexican agricultural import quotas at 50% of tariff equivalent. Add deficiency payment program to Mexico in corn. Leave all existing agricultural programs intact.
6.	Partial liberalization plus capital growth in Mexico	Tariffication of Mexican agricultural import quotas at 50% of tariff equivalent. Mexican capital stock 10% higher. Mexican agricultural subsidies (PIE) cut in half for corn and other program crops. No deficiency payment program in Mexico.

other Mexican agricultural programs remained intact.[22] The fourth and fifth scenarios explore the effects of restructuring Mexican domestic agricultural policies in conjunction with an FTA. In the fourth scenario, in addition to full U.S.–Mexico trade liberalization, Mexico adopts a deficiency payments program for corn and program crops similar to the U.S. program and continues its farm and food processing subsidies. This mix of policies has the effect of protecting Mexican producers through domestic programs rather than trade barriers. In the fifth scenario, a deficiency payments program is combined with the tariffication of Mexican quota protection in the corn and program crops sectors at one-half the level of the tariff equivalents of base year quotas. This partial trade liberalization scenario reduces the fiscal burden of protecting Mexican producers because some tariff barriers are maintained. In the sixth scenario, the Mexican aggregate capital stock is assumed to be augmented by 10 percent, simulating the effects of the anticipated increased capital inflows under an FTA, which should lead to Mexican growth relative to the U.S.

6.2 Aggregate results

Table 7 presents the macro results from the six scenarios. All scenarios result in slight increases in GDP in both countries. In all but the first scenario, there is a very small real appreciation of the U.S exchange rate. In Mexico, there is a small real depreciation, except in the case of Mexican growth (scenario 6).

Bilateral trade increases in all the scenarios. Mexico increases its exports both to the U.S. and to the rest of the world. The FTA results in some trade diversion for Mexico, whose imports from the rest of the world decline by 2–3 percent. An FTA with Mexican growth

[22] The scenarios of full trade and program liberalization of Mexican agriculture are designed to replicate the scenarios described by Levy and van Wijnbergen (1991) in their single-country CGE model of Mexico.

Table 7 – Aggregate Results of an FTA Under Alternative Scenarios

Scenario	1 Industry trade lib	2 All trade lib	3 Trade + all ag	3a Trade + corn	4 Common ag policy	5 Partial trade lib	6 Growth + partial lib
	- - - Percent change from base model solution - - -						
Real GDP							
U.S.	0.01	0.23	0.28	0.34	0.11	0.04	0.00
Mexico	0.07	0.27	0.24	0.31	0.23	0.15	7.43
Real exchange rate							
U.S.	0.0	-0.8	-0.3	-0.9	-0.7	-0.3	-0.6
Mexico	0.4	2.6	2.2	1.6	3.5	1.5	-0.5
Exports (world prices)							
U.S. to Mexico	6.1	9.1	10.6	9.5	8.6	7.3	16.6
U.S. to rest	0.0	0.3	0.9	0.5	0.1	0.0	-0.3
Mexico to U.S.	4.1	5.2	5.7	5.4	5.1	4.8	6.3
Mexico to rest	1.6	3.8	5.4	4.2	3.4	2.2	17.2
Rest to U.S.	0.0	0.4	0.9	0.6	0.2	0.1	0.2
Rest to Mexico	-2.0	-2.8	-2.4	-2.7	-2.9	-2.3	6.5
Real wages: U.S.							
Rural	0.0	-1.3	-3.4	-2.1	-0.6	-0.2	0.2
Urban unskilled	0.0	-1.7	-4.2	-2.5	-0.8	-0.3	0.0
Urban skilled	0.0	0.1	0.3	0.2	0.1	0.0	0.0
Professional	0.0	0.1	0.3	0.2	0.1	0.0	0.0
Land rental	0.0	1.3	2.3	1.6	1.0	0.3	0.8
Capital rental	0.0	0.1	0.3	0.2	0.1	0.0	0.0
Real wages: Mexico							
Rural	0.6	1.8	-0.1	2.6	1.4	1.2	4.5
Urban unskilled	0.6	-0.2	-3.0	-1.1	0.7	0.7	3.2
Urban skilled	0.6	1.1	0.3	1.1	1.2	0.8	3.5
Professional	0.5	1.0	0.2	0.9	1.0	0.7	3.4
Land rental	0.6	-8.8	-24.2	-14.1	-3.2	-0.5	0.1
Capital rental	0.6	1.1	0.0	1.1	1.2	0.8	-1.4
Net farm program expenditure							
U.S.	0.3	0.3	0.2	0.3	0.4	0.5	0.3
Mexico	5.2	15.9	-96.9	-0.7	35.4	17.6	-24.3
Migration	- - - 1000's persons - - -						
Mexican rural-US rural	1	26	66	39	12	4	0
Mexican urban-US urban	7	212	544	324	100	39	-2
Mexican rural-Mex urban	1	290	773	464	119	40	21

Notes:
The "real exchange rate" is the price-level deflated exchange rate, using the GDP deflator. A positive change represents a depreciation. Exports are value at world prices (in dollars). "Net farm program expenditure" equals farm program expenditures minus tariff revenue and import quota premium revenue accruing to the government from agriculture and food processing.

(scenario 6), however, does result in an increase of imports from the rest of the world. An FTA is trade creating for the U.S., with U.S. imports increasing from both Mexico and the rest of the world in all scenarios. The Mexican growth scenario results in a slight diversion of U.S. exports away from the rest of the world as part of a large increase in U.S. exports to Mexico. This result emphasizes the importance of investment growth in Mexico in determining the overall benefits of an FTA for the U.S.

Sectoral results are given in Tables 8a and 8b. U.S. export growth to Mexico is highest in the agricultural sectors where Mexican protection has remained relatively high. U.S. export growth corresponds to the decline in Mexican food corn and program crop output under all five agricultural trade and liberalization scenarios. Full liberalization of the Mexican food corn sector (scenarios 3 and 3a) result in a nearly 20 percent fall in output while U.S. food corn output rises about 5 percent and exports to Mexico soar by almost 200 percent.

Mexico's fruit and vegetable sector undergoes less spectacular yet significant export growth (ranging from 18 percent to 21 percent) under an FTA which includes agriculture, reflecting the high initial U.S. tariff rates in this sector. Trade liberalization leads to a significant increase in two-way trade in fruits and vegetables, with exports expanding in both countries. Mexican fruit and vegetable output expands, while U.S. output hardly changes. A policy mix in Mexico that maintains some trade barriers for agriculture (scenario 5) results in much lower, although still significant, growth in U.S. exports of corn and program crops to Mexico.

Table 8a — Sectoral Results, Scenarios 1 - 3a

Scenario	1 Industry trade lib		2 All trade lib		3 Trade + all ag		3a Trade + corn	
	Output	Exports	Output	Exports	Output	Exports	Output	Exports
United States	--- Percent change from base model solution ---							
Food corn	0.0	-1.0	4.1	156.0	5.1	185.4	5.3	196.3
Program crops	0.0	-0.4	0.8	40.5	1.7	88.2	1.0	39.2
Fruits/vegetables	0.0	-0.7	0.1	14.2	0.7	13.6	0.2	14.0
Other agriculture	0.0	-0.4	0.2	8.3	0.6	6.8	0.4	8.2
Food processing	0.0	6.6	0.3	6.3	0.7	5.7	0.4	6.4
Other light mfg.	0.0	6.4	0.2	6.0	0.5	6.0	0.3	6.2
Oil & refining	0.0	13.8	0.0	13.9	0.0	13.9	0.0	14.0
Intermediates	0.0	4.8	0.2	4.7	0.5	4.7	0.3	4.9
Consumer durables	0.2	11.2	0.3	10.8	0.7	10.8	0.4	10.9
Capital goods	0.0	4.7	0.2	4.7	0.5	4.6	0.3	4.7
Services	0.0	-0.4	0.2	-0.8	0.6	-1.0	0.4	-0.7
Mexico								
Food corn	-0.1	0.0	-10.2	0.0	-19.4	0.0	-19.1	0.0
Program crops	0.2	0.0	-7.1	0.0	-21.1	0.0	-6.7	0.0
Fruits/vegetables	0.0	0.3	5.3	19.1	3.1	17.6	6.1	20.8
Other agriculture	0.0	0.3	0.9	3.0	-1.3	1.8	1.0	3.4
Food processing	0.0	13.4	0.9	11.0	-2.0	7.1	0.9	10.9
Other light mfg.	0.7	9.2	0.9	10.5	1.2	11.8	1.0	10.8
Oil & refining	0.0	3.7	0.0	3.7	0.0	3.7	0.0	3.6
Intermediates	0.2	2.9	0.4	3.7	0.7	4.8	0.5	4.0
Consumer durables	1.0	3.9	2.4	5.4	4.5	7.5	2.7	5.7
Capital goods	0.1	5.2	0.6	6.1	1.2	7.4	0.7	6.3
Services	-0.1	0.7	0.0	1.0	0.4	1.9	0.2	1.2

Notes:
Real output and exports. Exports are to the partner country (U.S. or Mexico).

Table 8b — Sectoral Results, Scenarios 4 - 6

Scenario	4		5		6	
	Common ag policy		Partial trade lib		Growth + partial lib	
	Output	Exports	Output	Exports	Output	Exports
United States	--- Percent change from base model solution ---					
Food corn	3.3	128.0	1.2	49.0	2.6	100.6
Program crops	0.6	36.3	0.2	13.7	0.5	54.3
Fruits/vegetables	-0.1	14.4	-0.2	14.8	-0.3	26.4
Other agriculture	0.1	8.3	0.1	8.6	0.0	17.8
Food processing	0.1	6.2	0.1	6.4	0.0	16.1
Other light mfg.	0.1	5.9	0.0	6.2	-0.1	14.2
Oil & refining	0.0	13.8	0.0	13.8	0.0	23.0
Intermediates	0.1	4.6	0.0	4.7	0.0	14.8
Consumer durables	0.2	10.8	0.2	11.0	0.1	14.0
Capital goods	0.1	4.6	0.1	4.6	0.0	10.5
Services	0.1	-0.8	0.0	-0.6	0.0	1.2
Mexico						
Food corn	-3.1	0.0	-1.5	0.0	-4.5	0.0
Program crops	-6.0	0.0	-2.6	0.0	-3.6	0.0
Fruits/vegetables	4.6	18.0	4.2	17.4	8.1	17.4
Other agriculture	0.9	2.7	0.2	1.5	8.8	5.5
Food processing	0.9	11.0	0.3	8.7	9.5	17.4
Other light mfg.	0.8	10.2	0.7	9.6	10.0	20.2
Oil & refining	0.0	3.7	0.0	3.7	0.0	-1.5
Intermediates	0.3	3.5	0.2	3.1	7.0	7.7
Consumer durables	2.1	5.1	1.4	4.3	12.2	12.8
Capital goods	0.5	5.9	0.2	5.4	6.0	11.5
Services	-0.1	0.8	-0.1	0.6	7.4	5.9

Notes:
Real output and exports. Exports are to the partner country (U.S. or Mexico).

6.3 Migration and Farm Program Expenditure

Complete trade liberalization and the accompanying removal of subsidies to Mexican agriculture and food industries (scenario 3) has a major effect on migration. About 12 percent of Mexico's rural labor force (839,000 workers) migrate either to the U.S. or to Mexican urban areas (Table 7). These workers come from the corn, program crop, and other agricultural sectors, which contract sharply with quota and program removal. Expansion of fruit and vegetable output, spurred by export growth to the U.S., is insufficient to absorb the displaced agricultural workers. A total of 610,000 Mexican workers migrate to the U.S., 66,000 directly from the Mexican rural sector to the U.S. rural sector and another 544,000 urban unskilled migrants moving to the U.S. from Mexican cities. There is a domino effect at work, with rural-urban migration in Mexico leading, in turn, to migration from Mexico to U.S. urban areas. Isolating the impact of Mexican food corn liberalization (scenario 3a) indicates that about 60 percent of the total outmigration associated with complete agricultural trade and program liberalization is due to liberalization of the corn sector.

In addition to large migration flows, scenarios 3 and 3a also generate the worst distributional outcomes. Real wages of both rural and urban unskilled workers fall sharply in the U.S., due to increased migration, and fall in Mexico for the same reason, although to a lesser degree. Full trade liberalization and removal of agricultural programs in Mexico yields a pattern of integration with lower wages for the poorest members of both societies.[23]

Scenarios 4 and 5 were designed to ameliorate the impact of trade liberalization on Mexican migration. They are successful in reducing the migration flows, but they also

[23]In scenario 3a, the FTA–CGE model shows Mexican rural wages rising. This result is explained by the large exodus of rural workers out of the food corn sector, while the rest of the higher paying program crops continue to be supported. The Mexican government, however, has already begun to cut support for other program crops, leaving food corn relatively protected at this time.

increase Mexican agricultural program expenditures. Scenario 4, which adds a deficiency payments program in Mexico similar to that in the U.S., supports the corn and program crop output that had previously been supported by a quota. Mexican agricultural output falls only slightly in these sectors, but Mexican agricultural imports from the U.S. still increase sharply because removal of trade barriers lowers the relative price of imports. The deficiency payments program leads to a much smaller increase in migration, but incurs a 35.4 percent increase in Mexican net farm program expenditures (which take account of change in import tariff and premium revenue, as well as budgetary outlays).

Scenario 5, which replaces agricultural quotas with tariffs set at half of the tariff equivalents of base year quotas, supports the Mexican corn and program crop producer prices and results in only a small contraction in output. Only 44,000 workers leave Mexican agriculture. While scenarios 4 and 5 both reduce Mexican migration flows, the increase in Mexican agricultural program expenditures is much lower when partial trade barriers are maintained (scenario 5), increasing only 17.6 percent.

Scenario 6 results in very low Mexican migration flows and only a slight contraction in output in the corn and program crops sectors (3–5 percent). Expansion of other sectors absorbs Mexican rural labor and eliminates any new net increases in the migration flow to the U.S. (indeed, reversing it by 2,000). Net agricultural program expenditures fall 24.3 percent, due both to decreased input subsidies and to increased tariff revenue. Scenario 6 is the only agricultural liberalization FTA scenario where real wages rise for all labor groups in both countries. This scenario indicates the importance to the success of the FTA for both countries of Mexico achieving more rapid growth.

Figures 2 and 3 show the trade-offs between migration and Mexican agricultural program spending and growth. Both figures start from the full trade and Mexican agricultural

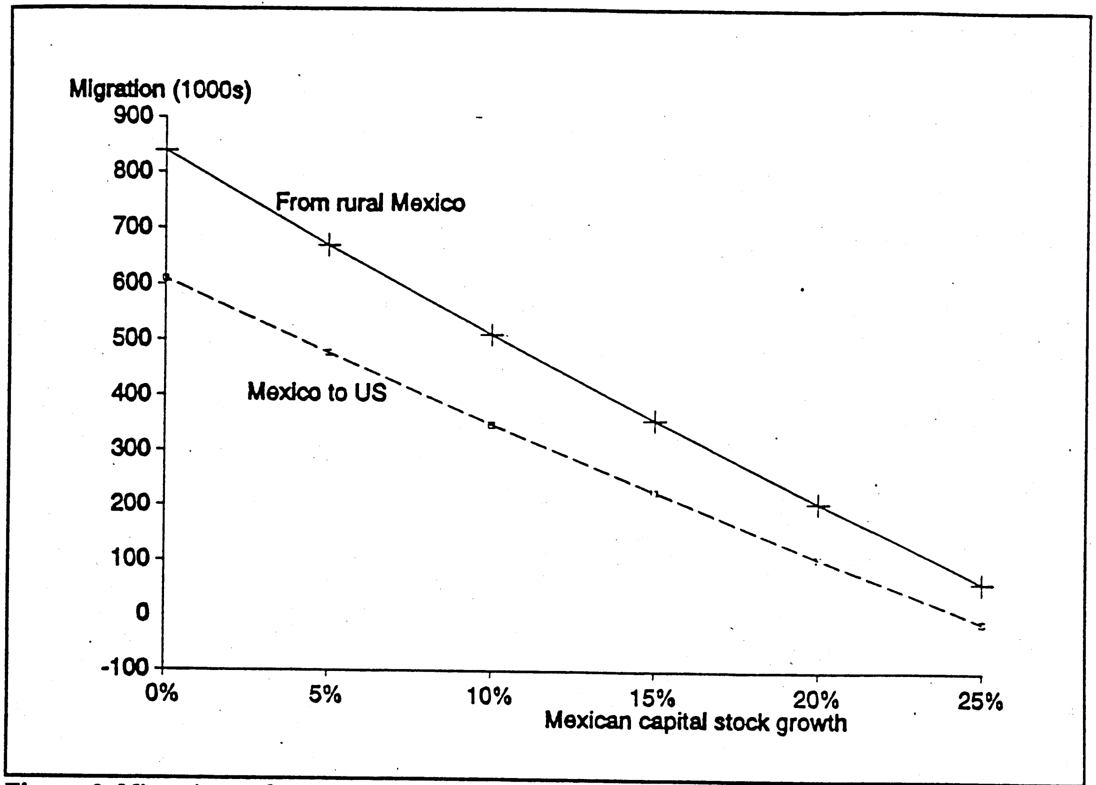

Figure 2: Migration and Capital Stock Growth in Mexico

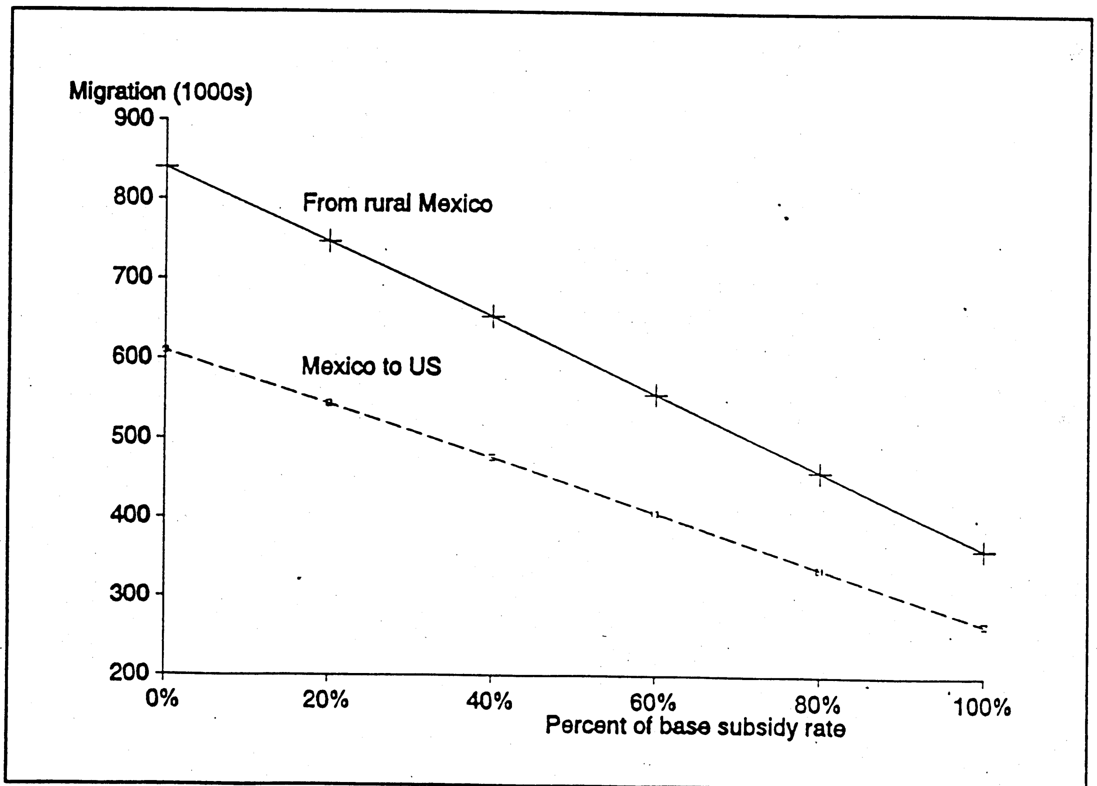

Figure 3: Migration and Agricultural Input Subsidies in Mexico

program liberalization (scenario 3) as their base. Figure 2 shows the sensitivity of different types of migration to increased growth. In order to counteract completely the increases in migration resulting from scenario 3, the Mexican capital stock would have to grow 25 percent relative to the U.S. Figure 3 demonstrates the sensitivity of migration to spending on agricultural input subsidies. With a 100 percent reinstatement of input subsidies, the level of migration is close to that of scenario 2, which is still significant. It is interesting to note that both for increased capital growth and agricultural support policies, the migration relationship is almost linear. Each percentage point increase in the Mexican capital stock reduces migration to the U.S. by roughly 25,000 workers and each percentage point increase in agricultural input subsidies reduces migration by 3,500 workers.

7. Conclusion

This article analyzes the effects of a U.S.–Mexico free trade agreement using a multi-country CGE model in which labor migration and domestic agricultural programs are modeled explicitly, and a flexible functional form is used for import demand equations. The model is used to analyze six scenarios. These represent complete bilateral trade liberalization and Mexican agricultural program elimination; two combinations of Mexican agricultural programs that would reduce the labor migration caused by an FTA; and trade liberalization with a capital inflow into Mexico.

Our results show that both countries achieve welfare gains under an FTA, even in scenarios in which some production and trade distorting policies are maintained. Bilateral trade increases significantly with removal of trade barriers. An FTA is trade creating for both countries in all scenarios, but some scenarios lead to trade diversion for Mexico, with slightly reduced imports from the rest of the world. As Mexico grows, however, its trade with both the U.S. and the rest of the world grows.

We show that alternative structures of FTA's generate trade-offs between the growth in exports that is stimulated by lower trade barriers, versus the cost such liberalization generates in agricultural program expenditures and new net increases in labor migration flows. Free trade increases bilateral trade, but induces large rural outmigration from Mexico. Mexico can reduce labor migration through the adoption of a deficiency payments program that maintains agricultural income, but the fiscal effects are prohibitive. Retaining some trade barriers in agriculture reduces bilateral trade growth, but also reduces migration and growth in agricultural program expenditures. Increased capital inflows into Mexico result in expanded bilateral trade, much lower migration flows, and a large reduction in Mexican agricultural program expenditures. Dynamic effects are clearly very important in achieving the full benefit of an FTA.

These findings suggest that Mexico will need a lengthy transition period and must allocate resources to agriculture during the transition. Trade liberalization leads to an immediate increase in rural outmigration, while the increased growth needed to absorb the displaced labor takes longer. The rapid introduction of free trade in agriculture and the elimination of agricultural support programs may not be desirable for either country when the social and economic costs associated with increased migration are weighed against the benefits of increased trade growth.

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Appendix: The US-Mexico FTA–CGE Model

Introduction

This appendix presents the equations of the US-Mexico, FTA–CGE model in the format of the software in which the program was written, GAMS. GAMS stands for "General Algebraic Modeling System" and the software is described in Brooke, Kendrick, and Meeraus (1988). For ease of exposition, the model equations are somewhat simplified. The agricultural support programs are represented by *ad valorem* equivalents, while the full model specifies the programs explicitly. All sectors are shown with CET transformation functions between goods supplied to the domestic and export markets. The full model assumes that two agricultural sectors (corn and other program crops) have an infinite elasticity of transformation between domestic and export goods. In the full model, the output of the oil sector in both countries is fixed exogenously.

GAMS statements are case insensitive. However, we use a number of notation conventions to improve readability:

Variables are all in upper case.
Variable names with a suffix 0 represent base-year values and are specified as parameters (or constants) in the model.
Parameters are all in lower case.
Sets are all in lower case.

In the GAMS language:

Parameters are treated as constants in the model and are defined in separate "PARAMETER" statements.
"SUM" represents the summation operator, sigma.
"PROD" represents the product operator, pi.
"LOG" is the natural logarithm operator.
"$" introduces a conditional "if" statement.
The suffix .FX indicates a fixed variable.
The suffix .L indicates the level or solution value of a variable.
The suffix .LO indicates the lower bound of a variable.
The suffix .UP indicates the upper bound of a variables.
An asterisk (*) in column one indicates a comment. Some alternative treatments are shown commented out.
A Subsets is denoted by the subset name followed by the name of the larger set in parentheses. In statements, the subset name is then used by itself.
A semicolon (;) terminates a GAMS statement.
Items betweeen slashes ("/") are data.

The US-Mexico FTA-CGE Model in GAMS

```
*#################### Definition of sets #####################

 SETS

 cty1    universe             / US          USA
                                MX          Mexico
                                RT          Rest of world /

 k(cty1) countries            / US          USA
                                MX          Mexico /

 i  sectors of production     / corn        corn+feedgrains
                                agprog      other program crops
                                frtveg      fruits and vegetables
                                othag       other agriculture
                                food        food processing
                                lmfg        other light mfg
                                oil         oil
                                int         intermediates
                                cdur        consumer durables
                                kgood       capital goods
                                svc         services            /

 iag(i)   ag sectors            / corn, agprog, frtveg, othag /
 iagn(i)  non ag sectors

 iqr(i,k,cty1)    import rationed sectors
 iqrn(i,k,cty1)   non rationed sectors

 ied(i,k)   sectors with export demand function for rt
                                / corn.us, agprog.us /
 iedn(i,k)  not ied

 iff   factors of production / capital     capital
                               rulab       rural labor
                               urbunlab    urban unskilled labor
                               skillab     skilled labor
                               proflab     professional labor
                               land        ag land    /

 nmig(iff)   non-migrating factors
                               / capital, skillab, proflab, land /

 mig   migrant types           / usag    migrants to us rulab
                                 usurb   migrants to us urbunlab
                                 mxurb   migrants to mx urbunlab /

 hh    households              / hhall /

 ins   institutions            / labr     labor
                                 ent      enterprises
                                 prop     property income /
 ;
 iagn(i)          = not iag(i) ;
 iqr(i,k,cty1)    = NO ;
 iqrn(i,k,cty1)   = not iqr(i,k,cty1) ;
 iedn(i,k)        = not ied(i,k) ;

 ALIAS(i,j) ;
```

```
ALIAS(k,l) ;
ALIAS(cty1,cty2) ;
ALIAS(la,lb) ;
ALIAS(iff,f) ;

SET pt(k,cty1)  three trading partners     /   us. (mx,rt)
                                               mx. (us,rt)
                                           / ;

SET pt3(cty1,cty2) two trading partners    /   us. (mx)
                                               mx. (us)
                                           / ;
*################## Definition of variables #################

VARIABLES

*## PRICE BLOCK

   EXR(k)              exchange rate
   P(i,k)              price of composite good
   PD(i,k)             domestic price
   PE(i,k,cty1)        domestic price of exports
   PINDEX(k)           numeraire price index
   PM(i,k,cty1)        domestic price of imports
   PWE(i,cty1,cty2)    world price of exports from cty1 to cty2
   PWM(i,cty1,cty2)    world price of imports into cty1 from cty2
   PX(i,k)             average output price
   PVA(i,k)            value added price
   TM2(i,k,cty1)       import premium rate

*## PRODUCTION AND TRADE BLOCK

   E(i,cty1,cty2)      exports from cty1 to cty2
   M(i,cty1,cty2)      imports into cty1 from cty2
   X(i,k)              composite goods supply
   XD(i,k)             domestic output
   XXD(i,k)            domestic sales
   SMQ(i,k,cty1)       import value share (AIDS function)
   INT(i,k)            intermediate demand

*## FACTOR BLOCK

   WFDIST(i,iff,k)    factor price distortion constants
   YFCTR(iff,k)       factor income
   FS(iff,k)          factor supply
   FDSC(i,iff,k)      factor demand by sector
   WF(iff,k)          average factor price

*## INCOME AND EXPENDITURE BLOCK

   CDD(i,k)           final demand for private consumption
   FSAV(k,cty1)       net foreign savings
   FBAL(k)            current account balance
   INDTAX(k)          indirect tax revenue
   SSTAX(k)           factor taxes
   TARIFF(k,cty1)     tariff revenue
   PREM(i,k)          premium income from import rationing
   YH(hh,k)           household income
   YINST(ins,k)       institutional income
   WALRAS             Walras law for system
   WALRAS2(k)         Walras law for each country
```

```
GDTOT(k)            government real consumption
GD(i,k)             governmend demand by sector
GOVSAV(k)           government saving
GOVREV(k)           government revenue
HHT(k)              govt transfers to households
ENTT(k)             govt transfers to enterprises
ID(i,k)             investment demand by sector of origin
DST(i,k)            inventory investment demand
ZTOT(k)             aggregate nominal investment
ZFIX(k)             aggregate real fixed investment
HSAV(k)             aggregate household savings
REMIT(k)            remittance income to households
FKAP(k)             foreign capital flow to enterprises
FBOR(k)             foreign borrowing by government
FSAVE(k)            foreign savings
ENTSAV(k)           enterprise savings
ESR(k)              enterprise savings rate
VATAX(k)            value added taxes
ENTAX(k)            enterprise taxes
HTAX(k)             household taxes

EEP(i,k,cty1)       US bilateral export subsidy expenditures
PIE(i,k)            producer incentive equivalent per unit of output
PDS(i,k)            domestic price subsidies per unit domestic supply

*## MIGRATION BLOCK

USMIGAG             Mexican rural migrants to US rural sector
USMIGURB            Mexican urban migrants to US urban sector
MXMIG               Mexican internal rural to urban migrants


*#################### Definition of Parameters ################

PARAMETERS

mrat(i,k,cty1)      rationed import level
tm(i,k,cty1)        tariff rates on imports
tee(i,k,cty1)       export subsidy (EEP) rates
pwts(i,k)           price index weights
sprem(i,k)          allocation share of premium income

io(i,j,k)           input output coefficients by country

rhoc(i,k)           CES import aggregation parameter
rhot(i,k)           CET export transformation parameter
etae(i,k)           export demand elasticity for rest of world
ac(i,k)             CES import function shift parameter
ad(i,k)             production function shift parameter
alpha(i,iff,k)      Cobb-Douglas factor share parameter
alpha2(i,iff,k)     CES factor share parameter
at(i,k)             CET export function shift parameter
delta(i,k,cty1)     CES import function share parameter
gamma(i,k,cty1)     CET export function share parameter

aq(i,k)             constant in translog price index
aqs(i,k)            constant in Stone price index
smq0(i,k,cty2)      share parameter in Stone price index

amq(i,k,cty1)       constant in aids function
betaq(i,k,cty1)     income coefficients in aids function
gammaq(i,k,cty2)    price coefficients in aids function
```

```
  cles(i,hh,k)          household consumption shares
  gles(i,k)             government expenditure shares
  zshr(i,k)             investment demand shares
  mps(hh,k)             savings propensities by households
  sintyh(hh,ins,k)      institution to household income mapping shares
  rhsh(hh,k)            remittances to household income mapping shares
  thsh(hh,k)            household transfer income shares
  sstr(iff,k)           factor income tax rate
  hhtr(hh,k)            household income tax rate
  entr(k)               enterprise income tax rate
  vatr(i,k)             value added tax rate
  itax(i,k)             indirect tax rate

*## Parameters for migration

  cost(mig)             fixed cost of migration
  wgdf(mig)             wage differential
 ;

*################### EQUATION DECLARATION #####################

  EQUATIONS

*## PRICE BLOCK

   PMDEF(i,k,cty1)          definition of domestic import prices
   PEDEF(i,k,cty1)          definition of domestic export prices
   ABSORPTION(i,k)          value of domestic sales
   SALES(i,k)               value of domestic output
   PINDEXDEF(k)             definition of general price level
   ACTP(i,k)                value added price inclusive of subsidies

*## PRODUCTION BLOCK

   ACTIVITY(i,k)            production function
   PROFITMAX(i,iff,k)       first order conditions for profit maximum
   INTEQ(i,k)               intermediate demand
   CET(i,k)                 CET function
   ESUPPLY(i,k,cty1)        export supply
   EDEMAND(i,k)             Export demand from rest of world (rt)
*  ARMINGTON(i,k)           composite good aggregation function
*  COSTMIN(i,k,cty1)        FOC for cost minimization of composite good
   PDAIDS(i,k)              price transformation for AIDS
*  TRLOGP(i,k)              translog price index
   STONEP(i,k)              stone price index
   AIDS(i,k,cty1)           aids import share equation
   AIDS2(i,k,cty1)          definition of import expenditure shares
   AIDS3(i,k)               demand for domestic good

*## INCOME BLOCK

   YFCTREQ(iff,k)           factor income
   TARIFFDEF(k,cty1)        tariff revenue
   PREMIUM(i,k)             import premia
   INDTAXDEF(k)             indirect taxes on domestic production
   YINST1(k)                labor institution income
   YINST2(k)                enterprise institution income
   YINST3(k)                property institution income
   HHY(hh,k)                household income
   ENTAXEQ(k)               enterprise taxes
   SSTAXEQ(k)               social security tax
   HTAXEQ(k)                household taxes
```

```
   VATAXEQ(k)               value added tax
   GOVREVEQ(k)              government revenue
   GOVSAVEQ(k)              government savings
   HSAVEQ(k)                household savings
   ENTSAVEQ(k)              enterprise savings
   TOTSAVE(k)               total savings
   FORSAVE(k)               foreign savings

*## EXPENDITURE BLOCK

   CDDEQ(i,k)               consumer demand
   GDEQ(i,k)                government expenditure
   INVEST(i,k)              fixed investment demand by sector
   INVEST2(k)               total investment demand
   EEPDEF(i,k,cty1)         US EEP subsidies expenditure

*## MIGRATION BLOCK

   WGEQ1                    Mex-US rural wage equalization
   WGEQ2                    Mex-US urban wage equalization
   WGEQ3                    Mexican rural-urban wage equalization
   FS1                      US rural labor migration equilibrium
   FS2                      US urban labor migration equilibrium
   FS3                      Mexican rural labor migration equilibrium
   FS4                      MX urban labor migration equilibrium

*## MARKET CLEARING

   EQUIL(i,k)               goods market equilibrium
   FMEQUIL(iff,k)           factor market equilibrium

*## BALANCE OF TRADE EQUILIBRIUM

   CAEQ(k,cty1)             trade balance by trade partner
   FBALEQ(k)                aggregate trade balance by country

*## TRADE CONSISTENCIES

   TRCON(i,cty1,cty2)       export import symmetry conditions
   TRCON7                   fsav consistency
   TRCON10(i,cty1,cty2)     PWM to PWE consistency
 ;


*################### EQUATION ASSIGNMENT #################

*## PRICE BLOCK

 PMDEF(i,k,cty1)$pt(k,cty1)..  PM(i,k,cty1) =E= PWM(i,k,cty1)*EXR(k)
                                *(1 + tm(i,k,cty1) + TM2(i,k,cty1) ) ;

 PEDEF(i,k,cty1)..    PE(i,k,cty1) =E= PWE(i,k,cty1)
                                *(1 + tee(i,k,cty1))*EXR(k) ;

 ABSORPTION(i,k)..    P(i,k)*X(i,k) =E= PD(i,k)*XXD(i,k) +
                        SUM(cty1, (PM(i,k,cty1)*M(i,k,cty1))) ;

 SALES(i,k)..       PX(i,k)*XD(i,k) =E= PDA(i,k)*XXD(i,k) +
                        SUM(cty1, (PE(i,k,cty1)*E(i,k,cty1))) ;

 PINDEXDEF(k)..     PINDEX(k) =E= SUM(i, pwts(i,k)*PX(i,k)) ;
```

```
 PDADEF(i,k)..      PDA(i,k) =E= PD(i,k)*(1 - itax(i,k)) + PDS(i,k) ;

 ACTP(i,k)..        PVA(i,k) =E= PX(i,k) - SUM(j, io(j,i,k)*P(j,k))
                                 + PIE(i,k);

 ## PRODUCTION AND TRADE BLOCK

*Cobb-Douglas Production Function Equations

* ACTIVITY(i,k)..       XD(i,k) =E= AD(i,k)*PROD(iff$alpha(i,iff,k),
*                                FDSC(i,iff,k)**alpha(i,iff,k));

* PROFITMAX(i,iff,k)$wfdist0(i,iff,k)..
*                       WF(iff,k)*WFDIST(i,iff,k)*FDSC(i,iff,k) =E=
*                       XD(i,k)*(1 - vatr(i,k))
*                       *PVA(i,k)*alpha(i,iff,k) ;

*CES Production Function (alternative to Cobb-Douglas)

 ACTIVITY(i,k)..     XD(i,k) =E= ad(i,k)*( SUM(iff$fdsc0(i,iff,k),
                              alpha2(i,iff,k)*FDSC(i,iff,k)
                              **(-rhop(i,k))))**(-1/rhop(i,k)) ;

 PROFITMAX(i,iff,k)$wfdist0(i,iff,k)..  WF(iff,k)*WFDIST(i,iff,k) =E=
                     (1 - vatr(i,k))*PVA(i,k)*ad(i,k)
                     *( SUM(f$fdsc0(i,f,k), alpha2(i,f,k)*FDSC(i,f,k)
                     **(-rhop(i,k)))  )**((-1/rhop(i,k)) - 1)
                     *alpha2(i,iff,k)*FDSC(i,iff,k)**(-rhop(i,k)-1);

 INTEQ(i,k)..          INT(i,k)  =E= SUM(j, io(i,j,k)*XD(j,k));

 CET(i,k)..  XD(i,k) =E= at(i,k)*(SUM(cty1$E0(i,k,cty1),
                    gamma(i,k,cty1)*E(i,k,cty1)**(-rhot(i,k)))
                  + (1 - SUM(cty1, gamma(i,k,cty1)))*XXD(i,k)
                  **(-rhot(i,k)))**(-1/rhot(i,k)) ;

 ESUPPLY(i,k,cty1)$E0(i,k,cty1)..
                       E(i,k,cty1)/XXD(i,k) =E= (PDA(i,k)/PE(i,k,cty1)
                       *gamma(i,k,cty1)/(1 - SUM(cty2$PT(k,cty2),
                       gamma(i,k,cty2))))**(1/(1 + rhot(i,k))) ;

 EDEMAND(i,k)$ied(i,k)..    E(i,k,"rt") =E= E0(i,k,"rt")
                        *(PWE(i,k,"rt")/PWE0(i,k,"rt"))**(-etae(i,k)) ;

*## CES import demand equations

* ARMINGTON(i,k)..  X(i,k) =E= ac(i,k)*(SUM(cty1$M0(i,k,cty1),
*                            delta(i,k,cty1)*M(i,k,cty1)
*                            **(-rhoc(i,k))) + (1- SUM(cty1$pt(k,cty1),
*                            delta(i,k,cty1)))*XXD(i,k)
*                            **(-rhoc(i,k)))**(-1/rhoc(i,k)) ;

* COSTMIN(i,k,cty1)$M0(i,k,cty1)..
*                       M(i,k,cty1)/XXD(i,k) =E=
*                       (PD(i,k)/PM(i,k,cty1)*delta(i,k,cty1)/
*                       (1 - SUM(cty2$pt(k,cty2), delta(i,k,cty2))))
*                        **(1/(1 + rhoc(i,k))) ;
```

```
*## AIDS import demand equations.  Alternative to CES version.  In AIDS
*## version, can use Stone or translog price index.  Notation
*## is that domestically produced goods sold on the domestic
*## market are indicated as imports from a country to itself.

 PDAIDS(i,k)..        PM(i,k,k) =E= PD(i,k) ;

*## Translog price index
* TRLOGP(i,k)..        LOG(P(i,k)) =E= aq(i,k) + SUM(cty2, amq(i,k,cty2)
*                          *LOG(PM(i,k,cty2))) + (1/2)*SUM((cty1,cty2),
*                          gammaq(i,k,cty1,cty2)*LOG(PM(i,k,cty1))
*                          *LOG(PM(i,k,cty2))) ;

*## Stone price index
 STONEP(i,k)..         LOG(P(i,k)) =E=  LOG(aqs(i,k)) + SUM(cty2,
                          SMQ0(i,k,cty2)*LOG(PM(i,k,cty2))) ;

 AIDS(i,k,cty1)..      SMQ(i,k,cty1) =E= amq(i,k,cty1) + betaq(i,k,cty1)
                          *LOG(X(i,k)) + SUM(cty2, gammaq(i,k,cty1,cty2)
                          *LOG(PM(i,k,cty2))) ;

 AIDS2(i,k,cty1)$pt(k,cty1)..
                       PM(i,k,cty1)*M(i,k,cty1) =E=
                          SMQ(i,k,cty1)*P(i,k)*X(i,k) ;

 AIDS3(i,k)..          PD(i,k)*XXD(i,k) =E= SMQ(i,k,k)*X(i,k)*P(i,k) ;

*## INCOME BLOCK

 YFCTREQ(iff,k)..  YFCTR(iff,k) =E= SUM(i, WF(iff,k)*WFDIST(i,iff,k)
                                    *FDSC(i,iff,k));

 TARIFFDEF(k,cty1)..   TARIFF(k,cty1) =E= SUM(i, tm(i,k,cty1)
                          *M(i,k,cty1)*PWM(i,k,cty1))*EXR(k) ;

 PREMIUM(i,k)..    PREM(i,k) =E= SUM(cty1, TM2(i,k,cty1)*M(i,k,cty1)
                                    *PWM(i,k,cty1))*EXR(k) ;

 INDTAXDEF(k).. INDTAX(k) =E= SUM(i, itax(i,k)*PD(i,k)*XXD(i,k)) ;

 YINST1(k)..     YINST("labr",k) =E= SUM(la, (1.0 - sstr(la,k))
                                    *YFCTR(la,k));

 YINST2(k)..     YINST("ent",k)  =E= YFCTR("capital",k)
                          *(1.0-sstr("capital",k))
                          + EXR(k)*FKAP(k) - ENTSAV(k)
                          - ENTAX(k) + ENTT(k)
                          + SUM(i, (1-sprem(i,k))*PREM(i,k)) ;

 YINST3(k)..     YINST("prop",k) =E= YFCTR("land",k)
                                    *(1.0 - sstr("land",k)) ;

 HHY(hh,k)..     YH(hh,k)  =E= SUM(ins, sintyh(hh,ins,k)*YINST(ins,k))
                          + rhsh(hh,k)*EXR(k)*REMIT(k)
                          + HHT(k)*thsh(hh,k) ;

 ENTAXEQ(k)..    ENTAX(k)  =E= ENTR(k)*(YFCTR("capital",k) + ENTT(k)) ;

 SSTAXEQ(k)..    SSTAX(k)  =E= SUM(iff, sstr(iff,k)*YFCTR(iff,k));

 HTAXEQ(k)..     HTAX(k)   =E= SUM(hh, hhtr(hh,k)*YH(hh,k)) ;
```

```
VATAXEQ(k)..    VATAX(k)  =E= SUM(i, vatr(i,k)*PVA(i,k)*XD(i,k)) ;

GOVREVEQ(k)..   GOVREV(k) =E= SUM(cty1, TARIFF(k,cty1)) + INDTAX(k)
                            + SUM(i, sprem(i,k)*PREM(i,k))
                            + SSTAX(k) + HTAX(k)
                            + ENTAX(k) + VATAX(k) + FBOR(k)*EXR(k);

GOVSAVEQ(k)..   GOVSAV(k) =E= GOVREV(k)
                            - SUM(i, GD(i,k)*P(i,k)) - HHT(k)
                            - ENTT(k) - FPE(k)
                            - SUM((j,cty1) EEP(j,k,cty1)) ;

HSAVEQ(k)..     HSAV(k)   =E= SUM(hh, mps(hh,k)*
                               ((1.0-hhtr(hh,k))*YH(hh,k)));

ENTSAVEQ(k)..   ENTSAV(k) =E= ESR(k)*YFCTR("capital",k) ;

TOTSAVE(k)..    ZTOT(k)   =E= GOVSAV(k) + HSAV(k)
                            + ENTSAV(k) + EXR(k)*FSAVE(k);

FORSAVE(k)..    FSAVE(k)  =E= FBAL(k)-FKAP(k)-FBOR(k)-REMIT(k);

*## EXPENDITURE BLOCK

CDDEQ(i,k)..    P(i,k)*CDD(i,k) =E= SUM(hh, cles(i,hh,k)*YH(hh,k)
                              *(1 - hhtr(hh,k))*(1 - mps(hh,k)));

GDEQ(i,k)..     GD(i,k) =E= gles(i,k)*GDTOT(k) ;

INVEST(i,k)..   ID(i,k) =E= zshr(i,k)*ZFIX(k) ;

INVEST2(k)..    ZTOT(k) =E= SUM(i, P(i,k)*(ID(i,k) + DST(i,k)))
                          + WALRAS2(k) ;

EEPDEF(i,k,cty1)..  EEP(i,k,cty1) =E= tee(i,k,cty1)*PWE(i,k,cty1)
                                     *E(i,k,cty1)*EXR(k) ;

*## MARKET CLEARING
*## PRODUCT MARKETS

EQUIL(i,k)..    X(i,k) =E= INT(i,k)+CDD(i,k)+GD(i,k)+ID(i,k)+DST(i,k);

*## FACTOR MARKETS

FMEQUIL(iff,k)..    SUM(i, FDSC(i,iff,k)) =E= FS(iff,k) ;

WGEQ1..     WF("rulab","mx")=E=(wgdf("usag")*WF("rulab","us")
                 - COST("usag"))*(EXR("mx")/EXR("us")) ;

WGEQ2..     WF("urbunlab","mx")=E=(wgdf("usurb")*WF("urbunlab","us")
                 - COST("usurb"))*(EXR("mx")/EXR("us")) ;

WGEQ3..     WF("rulab","mx")=E=(wgdf("mxurb")*WF("urbunlab","mx")
                 - COST("mxurb")) ;

FS1..    FS("rulab","us")     =E= FS0("rulab","us") + USMIGAG ;

FS2..    FS("urbunlab","us")  =E= FS0("urbunlab","us") + USMIGURB ;

FS3..    FS("rulab","mx")     =E= FS0("rulab","mx") - MXMIG - USMIGAG ;

FS4..    FS("urbunlab","mx")  =E= FS0("urbunlab","mx") + MXMIG
```

```
                              - USMIGURB;

*## BALANCE OF TRADE

 CAEQ(k,cty1)..    SUM(i, PWM(i,k,cty1)*M(i,k,cty1)) =E=
                         SUM(i, PWE(i,k,cty1)*E(i,k,cty1))
                         + FSAV(k,cty1) ;

 FBALEQ(k)..    FBAL(k) =E= SUM(cty1, FSAV(k,cty1)) ;

*## TRADE CONSISTENCIES AND FIXED WORLD PRICES

 TRCON7..       WALRAS  =E= SUM((i,k), PWM(i,k,"rt")*M(i,k,"rt")
                          - PWE(i,k,"rt")*E(i,k,"rt"))
                          - SUM(k, FBAL(k)) ;

 TRCON10(i,cty1,cty2)$PT3(cty1,cty2)..
                         PWE(i,cty1,cty2) =E= PWM(i,cty2,cty1) ;

 TRCON(i,cty1,cty2)..   M(i,cty1,cty2)   =E= E(i,cty2,cty1) ;

 PWM.FX(i,k,"rt")                = PWM0(i,k,"rt") ;
 PWE.FX(i,k,"rt")$iedn(i,k)      = PWE0(i,k,"rt") ;

*#################### MODEL CLOSURE ###################

*## FACTOR MARKET CLOSURE

*## In this version, factors are fully mobile, factor returns adjust,
*## with base year factor return distortions (WFDIST) fixed.

  FS.FX(nmig,k)                 = FS0(nmig,k) ;
  WFDIST.FX(i,iff,k)            = WFDIST0(i,iff,k) ;

  FDSC.FX(i,iff,k)$(wfdist0(i,iff,k) EQ 0)    = 0 ;
  WFDIST.FX(i,iff,k)$(wfdist0(i,iff,k) EQ 0) = 0 ;

*### Following statements fix land in agricultural sectors

  FDSC.FX(i,"land",k)           = FDSC0(i,"land",k) ;
  WFDIST.LO(i,"land",k)         = -inf ;
  WFDIST.UP(i,"land",k)         = +inf ;
  WF.FX("land",k)               = 1 ;
  FS.LO("land",k)               = -inf ;
  FS.UP("land",k)               = +inf ;

*## FOREIGN MARKET CLOSURE
* In this version, the exchange rate is the equilibrating variable,
* and the foreign balance (current account balance) is fixed
* exogenously.  Note that there is one exchange rate variable for each
* country and one balance of trade constraint, FBAL(k).  Note that FBAL is
* defined for each country with respect to the aggregate of trade balances
* with all its trading partners.  Cross rates are implicitly set by arbitrage
* conditions.  There is no attempt to fix the balance of trade bilaterally.
* The model also has below-the-line variables to finance the balance of trade
* (FBOR, REMIT, FKAP, and FSAVE).  In this version, FSAVE is determined
* residually.

   FBAL.FX(k)          = FBAL0(k) ;
*  EXR.FX(k)           = EXR0(k) ;
   FBOR.FX(k)          = FBOR0(k) ;
   REMIT.FX(k)         = REMIT0(k) ;
```

```
   FKAP.FX(k)           = FKAP0(k) ;

*# IMPORT RATIONING

  TM2.FX(i,k,cty1)$iqrn(i,k,cty1)  = TM20(i,k,cty1) ;
  M.FX(i,k,cty1)$iqr(i,k,cty1)     = mrat(i,k,cty1) ;

*## GOVERNMENT CLOSURE
* Real government spending (GDTOT) is fixed exogeneously.
* The government deficit (GOVSAV) is determined residually.

  GDTOT.FX(k)           = GDTOT0(k) ;
  GD.FX(i,k)            = GD0(i,k) ;
  HHT.FX(k)             = HHT0(k) ;
  ENTT.FX(k)            = ENTT0(k) ;

*## INVESTMENT CLOSURE
* In this version, total real investment is fixed exogenously
* and savings adjusts.  The inventory component of investment
* is fixed exogenously.

*  ZTOT.FX(k)           = ZTOT0(k) ;
*  ESR.FX(k)            = ESR0(k) ;
   DST.FX(i,k)          = DST0(i,k) ;
*  ID.FX(i,k)           = ID0(i,k) ;
   ZFIX.FX(k)           = ZFIX0(k) ;

*## FARM PROGRAM CLOSURE
*## In this version, programs are given by ad valorem equuivalents.
*## Value added subsidies are included in vatr and import rationing
*## is treated above.

   PIE.FX(i,k)          = PIE0(i,k) ;
   PDS.FX(i,k)          = PDS0(i,k) ;

*## NUMERAIRE PRICE INDEX

   PINDEX.FX(k)         = PINDEX0(k) ;

*## ADDITIONAL RESTRICTIONS

  FDSC.FX(i,iff,k)$(wfdist0(i,iff,k) EQ 0)  = 0 ;
  PWE.FX(i,cty1,cty1)                       = 0 ;
  PWM.FX(i,cty1,cty1)                       = 0 ;
  E.FX(i,cty2,cty1)$(E0(i,cty2,cty1) eq 0)  = 0 ;
  M.FX(i,cty2,cty1)$(M0(i,cty2,cty1) eq 0)  = 0 ;
```