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Small Countries and the Case for Regionalism vs. Multilateralism

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Abstract

Much of the debate over whether or not developing countries gain from regional trade agreements (RTA's) has focused on two characteristics that are common to developing countries: their relatively high tariffs and their high trade dependencies on one or a few developed trade partners. In this paper, we address a third common characteristic: their use of distorting domestic policies that are closely linked to trade restrictions. We argue that participation in an RTA can create pressures for domestic policy reforms. We analyze the case of a small country, Mexico, forming an RTA with two larger countries, the U.S. and Canada, in the North American Free Trade Agreement (NAFTA). Mexico exhibits all three characteristics of a developing country: relatively high tariffs, a high trade dependency on the U.S., and an extensive and pervasive system of farm support that was linked to the restriction of trade. For the analysis, we use a 26-sector, multi-country, computable general equilibrium (CGE) model in which the three single-country models are linked through trade flows, and farm programs are modeled in detail. We find that there are welfare gains from trade liberalization in all three countries only when domestic reforms are in place. Mexico gains from NAFTA only when it also removes domestic distortions in agriculture. Then, agriculture can generate allocative efficiency gains that are large enough to offset the terms of trade losses which arise because Mexico has higher initial tariffs than other RTA members.

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I. Introduction

Much of the debate over whether or not developing countries gain from regional trade agreements (RTA's) has focused on two characteristics that are common to developing countries: their relatively high tariffs, and their high trade dependencies on one or a few developed trade partners. In this paper, we address a third common characteristic: their use of distorting domestic policies that are closely linked to trade restrictions. We argue that participation in an RTA can create pressures for domestic policy reforms. Because many domestic policies, particularly in agriculture, insulate producers from changing market prices, these domestic reforms can be crucial for the efficiency gains from trade liberalization to be realized. Furthermore, the pressure for domestic reform is stronger the higher the developing country's trade dependence on its RTA partner. Since an RTA can force domestic adjustments that will be necessary for global trade liberalization, it can be a building bloc towards multilateralism.

In this paper, we analyze the case of a small country, Mexico, forming an RTA with two larger countries, the U.S. and Canada, in the North American Free Trade Agreement (NAFTA). Mexico exhibits all three characteristics of a developing country: relatively high tariffs, a high trade dependency on the U.S., and an extensive and pervasive system of farm support that was linked to the restriction of trade. For the analysis, we use a 26-sector, multi-country, computable general equilibrium (CGE) model in which the three single-country models are linked through trade flows, and farm programs are modeled in detail.[1] We simulate NAFTA under two regimes: First, we assume the farm programs which restricted supply responses in the three countries remained in place when NAFTA was implemented. Next, we assume NAFTA occurs in an environment with reformed, largely nondistorting farm programs evident in all three countries in 1997. While domestic budgetary and political pressures were important motivations for the domestic farm program reforms in all three countries over the past decade, we show that trade policy reforms also created pressure for domestic policy changes. We calculate the budget costs of maintaining distortionary programs in the presence of open regional trade and show that the RTA would have dramatically increased the cost of distortionary domestic programs in Mexico. The comparison of the two scenarios illustrates the effects domestic policy distortions have on welfare changes following an RTA.

We find that trade creation exceeds trade diversion under NAFTA, whether or not domestic reforms have occurred. However, there are greater gains when domestic farm program

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[1]Our model is an extension of the CGE modeling undertaken at the USDA, which began with a single-country model of the United States to analyze the effects of changes in agricultural policies and exogenous shocks on U.S. agriculture (Robinson, Kilkenny, and Hanson, 1990). See Kilkenny and Robinson (1990) and Kilkenny (1991) for an extension of that model to include detailed U.S. farm programs. See Hinojosa and Robinson (1991) and Burfisher, Robinson, and Thierfelder (1992) for earlier versions of the U.S.-Mexico model used in this paper.

reforms have been adopted. Furthermore, there are welfare gains from trade liberalization in all three countries only when domestic reforms are in place. For Mexico, domestic farm program reforms linked to NAFTA are critical: agriculture can now generate allocative efficiency gains that are large enough to offset the terms of trade losses which arise because Mexico has higher initial tariffs than other RTA members. Mexico gains from NAFTA only when it also removes domestic distortions in agriculture.

The next section reviews recent literature on the effects of RTAs versus multilateralism on developing economies. Section three describes trade policies, domestic farm programs and trade dependencies in NAFTA countries. Section four presents the main features of our NAFTA-CGE model, emphasizing our specification of agricultural policies. Section five presents the empirical results, and the final section presents conclusions.

II. Recent Literature

Much of the debate over the benefits of regional trade agreements (RTA's) versus multilateral free trade addresses trade creation and trade diversion effects of an RTA. Bhagwati and Panagariya (1996) and Panagariya (1998, 1996) make the case for multilateralism by arguing that small countries lose unambiguously from an RTA and gain unambiguously from multilateralism. Because RTAs give preferential treatment to member countries, they divert trade from non-member, least-cost suppliers. To illustrate the trade diversion effects of an RTA, they present Viner's model of a customs union in which two countries remove bilateral tariffs. When the rest of the world is the least cost supplier and faces constant costs, an RTA with the supplier who faces increasing costs can only divert trade.[2] The liberalizing country loses because it foregoes tariff revenue from the new union member but does not face a lower internal price for the imported good, since the rest of the world determines its market price. In this framework, the larger the trade partner's share of total imports, the bigger the tariff revenue loss when an RTA is formed. Similarly, the trade partner who initially has higher tariffs loses from an RTA because more tariff revenue is redistributed away from it. Since developing countries often have high trade dependencies and high tariffs, Bhagwati and Panagariya argue that they will lose from an RTA. They make the case for multilateralism, arguing that the small country must gain when domestic producers compete at the world price, and any tariff revenue transferred to the RTA

[2] In contrast, when the union partner is the supplier facing constant costs, an RTA improves welfare in the liberalizing country. It benefits from the price reduction and still collects tariff revenue from the countries excluded from the union. There is only trade creation from the RTA. As Panagariya (1996) notes, this case is even better than multilateral tariff elimination due to the tariff revenue collected. However, he argues it is usually the case that the rest of the world, not the union partner, faces constant costs while union members face increasing costs. While there will be trade creation for some commodities, the majority of goods will come from a partner with increasing costs — trade diversion will dominate in most RTAs.

partner will be returned to domestic consumers.[3]

As an example of the damage an RTA does to a developing country, Panagariya (1997) calculates welfare losses as high as $3.26 billion for Mexico from NAFTA. When making this calculation, he assumes that the rest of the world is the least cost supplier with a horizontal export supply curve and that the U.S. has increasing costs so its supply curve is upward sloping. Since Mexico had higher initial tariffs than the U.S., its loss of tariff revenue exceeds its gains from preferential access to the U.S. market (foregone tariff revenue in the U.S.).[4]

De Melo et al. (1993) note that the case of pure trade diversion, while unambiguously welfare-worsening, is too extreme a model to characterize actual RTAs.[5] They present a more balanced view of the welfare effects of an RTA in an analytical model in which integration both creates and diverts trade. In this case, the country which lowers its barriers against a trade partner faces a new domestic price which is lower than the tariff-inclusive mark-up over the constant cost supplier (the rest of the world), but higher than the free trade price. The welfare effects on the tariff-reducing country are ambiguous: it loses because it has diverted all imports from the lowest cost supplier, but it benefits because total imports have increased. De Melo and others note that, in this environment: (1) the higher the initial tariff on a given sector, the larger the benefits and the smaller the costs of an RTA; (2) the lower the post-RTA tariff on non-union countries, the less likely that the lower-priced goods of the latter will be displaced; and (3) the greater the complementarity in import demands between the union partner, the greater the gains from an RTA. The latter point suggests that there are large gains from an RTA between developed and developing countries — such as the U.S. and Mexico — which have different factor endowments. Determining the net welfare impact of an RTA in this model is an empirical issue.

Robinson and Thierfelder (1999) survey the empirical literature in which multi-country CGE models have been used to analyze the impact of regional trade agreements. The multi-country CGE models differ widely in terms of country and commodity coverage, assumed market structure, policy detail, and specification of macroeconomic closure. In spite of these differences, surveys of these models support two general conclusions about the empirical effects

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[3]Schiff (1996) also discusses country size and the welfare impacts of an FTA. Like Panagariya, he argues that the smaller a country's imports from its partner, the smaller the welfare losses of foregone tariff revenue.

[4]This calculation uses aggregate trade and tariff numbers — the changes in total U.S. exports to Mexico and the average wage.

[5]See also Winters (1996) for a discussion of the theory with models that allow both trade creation and trade diversion. De Rosa (1998) provides a balanced survey of theoretical models that allow for both trade creation and diversion when an RTA is formed with a partner facing either constant or increasing cost.

of regional trade agreements: (1) in aggregate, trade creation is always much larger than trade diversion; and (2) welfare — measured in terms of real GDP or equivalent variation — increases for member countries.

In addition to issues relating to trade diversion and tariff revenue losses, developing countries also have domestic distortions which affect the welfare gains from an RTA. Clarete and Whalley (1988) discuss the links between domestic distortions and trade reform in a small open economy. [6] They find significant interactions between trade and domestic policies and that the social cost of trade distortions are approximately doubled when distortions are included. As they conclude, "The lesson would seem to be that these interactions need to be considered more fully in numerical economic policy analysis for developing countries." (p. 358).

Moving in that direction, Anderson (1997) evaluates the interaction between trade reform under the Uruguay Round and domestic distortions in agriculture in developing countries. He introduces the anticipated agricultural price increases in a general equilibrium model with domestic distortions in agriculture. [7]

Like Anderson, we consider the effects of trade liberalization with and without domestic intervention in agriculture. However, we model agricultural policies in more detail, not just as exogenous price wedges. This lets us discuss domestic agricultural policies that are directly linked to trade restrictions. In this framework, trade liberalization, as under an RTA, increases the cost of domestic support, creating pressure for reform.

III. Characteristics of NAFTA Countries

A. Country size and trade dependence

GDP data indicate that Mexico is much smaller than the U.S., its primary trade partner. Mexico accounts for 5.1 percent of NAFTA GDP, while the U.S. accounts for 87.5%. Like Mexico, Canada is relatively small in the region, accounting for only 7.4% of NAFTA GDP.

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[6] They incorporate two domestic distortions — rent-seeking activities associated with import quotas and sector-specific minimum wages which induce rural-urban migration — in a general equilibrium model of the Philippines.

[7] Anderson uses a CGE model with nine developing countries and 15 agricultural sectors. He simulates world price changes due to the Uruguay round, from Goldin and van der Mensbrugghe (1995), in two versions of the base model — one with and the other without distortions. Anderson and Tyers (1993) perform similar simulations — world price shocks in a model with and without domestic distortions in agriculture — in a partial equilibrium framework. They also find that domestic distortions are at least as important to domestic welfare as are trade prices.

Data on bilateral trade flows reveal a lopsided dependency between the U.S. and Mexico. Mexico is heavily dependent on the U.S. for trade (table 1). In 1993, 81.2% of its total exports went to the U.S. The U.S. was an even bigger market for Mexico's agriculture as 94.2% of its agricultural exports went to the U.S. In contrast, the U.S. sent 7.4% of its total exports and 7.1% of its agricultural exports to Mexico. Similarly on the import side, Mexico is heavily dependent on the U.S., which accounts for 80.0% of Mexico's imports. In agriculture Mexico's dependence is not as strong, with 61.0% of its imports coming from the U.S. The U.S. relies on Mexico for only 5.1% of its imports, however the dependence is stronger in agriculture for which Mexico supplies 32.7% of the U.S. total.

B. Trade restrictions

In general, pre-NAFTA tariff rates among the U.S. and Canada are low, while those of Mexico are relatively high. In table 2, we show the combined tariff rate equivalent of applied tariffs and import quotas that were in place in 1993, the model base year. Mexico has the highest tariffs and tariff equivalent of quotas among NAFTA countries, with a trade weighted average of 7.9%. In contrast, the trade weighted averages for the U.S. and Canada are 2.9% and 1.9% respectively. There is considerable intersectoral variation in tariff rates in all three countries. Mexico has high trade restrictions in wheat (67%) and corn (90.4%), two crops which the U.S. supports through endogenous input subsidies to maintain a fixed output price. One implication is that under NAFTA increased Mexican demand for U.S. wheat and corn will reduce the cost of such price supports. U.S. protection rates are high for sugar manufacturing (70%), reflecting the U.S. sugar quota.[8]

C. Domestic distortions in agriculture

Domestic agricultural programs in all three NAFTA countries have undergone fundamental change since the CUSTA and NAFTA agreements were first initiated (table 3). In general, these reforms have both lowered support levels and "decoupled" support by making payments independent from farmers' production decisions or market conditions.[9]

In the U.S., farm program reforms began in the mid-1980's with the introduction of increased planting flexibility and fixed base program acreage (USDA, 1996). In 1996, the U.S. adopted the Federal Agriculture Improvement and Reform (FAIR) Act, whose main effect was to replace the crop-linked, deficiency payments/supply management program with a program of temporary "contract" payments based on land acreage enrolled in the former deficiency

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[8]In our NAFTA simulations, we maintain U.S. sugar import restrictions for Canada; we eliminate the U.S. sugar quota against Mexico.

[9]See Burfisher, Robinson, and Thierfelder (1998) for a more detailed discussion of the changes in domestic farm programs in each NAFTA country.

payments program. The payments were capped at about $36 billion over 1996-2002, and scheduled to decline over the 7-year program.

Canada introduced its new generation of farm programs in 1991 under the Farm Income Protection Act (FIPA). Among the reforms was the elimination of grain freight subsidies by August, 1995. Subsidies were replaced with voluntary revenue insurance programs to which producers and the federal and provincial governments contribute. The Gross Revenue Insurance Program (GRIP) has already been discontinued due to its high costs. The Net Income Stabilization Account (NISA) extends farm income risk management support to all grains, oilseeds, and some horticulture. The government provides matching grants to farmers' contributions to savings accounts. Savings earn relatively high, subsidized rates of return and farmers may withdraw funds during years of lower than average income. Canada continues to support poultry, dairy, and eggs through supply management programs. These programs rely on production and import quotas to maintain farm prices for these commodities at levels that are based on the costs of production. Because the effectiveness of these programs requires trade restrictions, Canada has exempted these three sectors from free trade under NAFTA. Butter and skim milk prices are additionally supported through marketing board purchases, and export subsidies financed through levies on producers. Direct payments to dairy producers were phased out in 1996.

Mexican agricultural policy reforms began in the late 1980's. In 1988, tariffs were sharply lowered following Mexico's accession to the GATT, and most import quotas were converted to tariffs. However, import licensing remained an important instrument for price support -- particularly for corn, a staple crop produced by Mexico's large subsistence farm sector. Beginning in 1991, Mexico began to lower agricultural input subsidies, and the reduce the pervasive role of the government in purchasing, storing and distributing agricultural commodities. Subsidies to corn and wheat millers were reduced, and most retail food price controls were eliminated. Guaranteed producer prices and government purchases were continued only for corn and beans. In 1993, in anticipation of NAFTA, Mexico adopted the PROCAMPO program. PROCAMPO is a 15-year, direct payments program that compensates producers for the loss of input subsidies, price support, and import protection. It was designed to provide transitional, decoupled income support to farmers, while allowing Mexico's agriculture to undergo structural change in response to market conditions. In 1996, Mexico announced the Alliance for the Countryside (Alianza para al Campo), a major initiative to improve agricultural productivity. Alianza is an umbrella grouping that includes PROCAMPO and other programs.

IV. The Model

A. Overview

The NAFTA-CGE model is a 26-sector, multi-country, CGE model of the U.S., Canada, and Mexico in which the three single-country models are linked through trade flows.[10] For the purpose of describing the model, it is useful to distinguish between the individual "country" models and the multi-region model system as whole, which determines how the individual country models interact. When the model is actually used, the *within* country and *between* country relationships are solved for simultaneously.

Each country CGE model follows closely what has become a standard theoretical specification for trade-focused CGE models.[11] In addition to 26 sectors – including eight farm and nine food processing – each country model has seven factors of production – four labor types, two land types, and capital. Land is disaggregated into irrigated and dryland in Mexico. Each crop uses both land types in production and it is assumed that the land types are poor substitutes.[12] Both irrigated and dryland are perfectly mobile across crops. In the United States, each crop is grown using one of two possible land types. One land type is used to produce either fruits/vegetables, cotton, or other agricultural production. The second land type is assumed to be perfectly mobile among wheat, corn, other feed grains, and oilseeds production. Capital is mobile across sectors. Labor is mobile across sectors, but it is segmented into four labor categories. There is some labor mobility between labor categories due to labor migration. We assume full employment and constant factor supplies.

Mexican rural workers can migrate to urban unskilled labor markets in Mexico. The domestic factor supplies incorporate the migrant labor flows. Migration is assumed to depend on wage differentials. In equilibrium, migration maintains a fixed wage differential between rural and urban unskilled labor markets in Mexico. The average wage, upon which labor bases its migration decision, includes labor income plus a share of the dryland income for rural workers.[13] Migration flows generated by the CGE model refer to changes from a base flow of zero. They should be viewed as additional migration flows due to the policy change, adding to (or reducing)

[10] The countries can also be linked through international migration flows. To focus on the welfare effects of an RTA in a second-best environment, we chose not to include migration flows. See Burfisher, Robinson, and Thierfelder (1992) for a discussion of US-Mexico trade when migration can occur.

[11] Robinson (1989) surveys CGE models applied to developing countries. Shoven and Whalley (1984) survey models of developed countries. The theoretical properties of this family of trade-focused CGE models are discussed in Devarajan, Lewis, and Robinson (1990).

[12] We assume an elasticity of substitution between land types in Mexico of 0.8 in all sectors.

[13] This treatment, whereby Mexican rural income in the migration equation includes both wages and a share of land income, differs from that in Robinson, et al. (1993). This specification is closer to that of Levy and van Wijnbergen (1994), who describe migration as a function of income or utility differentials.

current flows.

For each sector, the model specifies production, consumption and trade equations. Output supply is given by constant elasticity of substitution (CES) value added production functions, while intermediate inputs are demanded in fixed proportions. Producers are assumed to maximize profits, implying that each factor is demanded so that marginal revenue product equals marginal cost. However, factors do not receive a uniform wage or "rental" (in the case of capital) across sectors; instead, we include sectoral factor market distortions that fix the ratio of the sectoral return to a factor relative to the economy-wide average return for that factor. These factor market distortions can be interpreted as productivity differences based on sectoral differences in value added shares to each input.

The single aggregate household in each economy has a Cobb-Douglas expenditure function, consistent with optimization of a Cobb-Douglas utility function. Sectoral household consumption is a fixed share of household income. Real investment and government consumption by sector are constant in the model simulations. Consumers demand a composite of the imported and domestic variety of each good.

Sectoral export-supply and import-demand functions are specified for each country. In common with other CGE models (both single and multi-country), the NAFTA-CGE model specifies that goods produced in different countries are imperfect substitutes. At the sectoral level, in each country, demanders differentiate goods by country of origin and exporters differentiate goods by destination market. When modeling import demands, the Almost Ideal Demand System (AIDS) specification is adopted. This specification allows import expenditure elasticities to be different from one and also allows cross-country substitution elasticities to vary for different pairs of countries. Exports are supplied according to a CET function between domestic sales and total exports, and allocation between export and domestic markets occurs in order to maximize revenue from total sales. The rest of the world is modeled simply as a supplier of imports to and demander of exports from the three NAFTA countries. Production activities in the rest of the world are not explicitly modeled; instead, this region is assumed to have flat export-supply curves and downward-sloping aggregate import-demand curves. With this structure, we can incorporate the key assumption of Bhagwati and Panagariya that supply from RTA partner countries is less elastic than that from the rest of world.

In common with other CGE models, the model only determines relative prices and the absolute price level must be set exogenously. In our model, the aggregate consumer price index in each sub-region is set exogenously, defining the *numeraire*. The advantage of this choice is that solution wages and incomes are in real terms. The solution exchange rates in the sub-regions are also in real terms, and can be seen as equilibrium price-level-deflated (PLD) exchange rates, using the country consumer price indices as deflators.[14] World prices are converted into domestic currency using the exchange rate, including any tax or tariff components. Cross-trade price consistency is imposed, so that the world price of Mexico's exports to the U.S. are the same as the world price of the U.S.'s imports from Mexico.

At the macro economic level, all income from production goes to the single household which pays taxes and consumes based on fixed expenditure shares. The government collects taxes, administers transfer payments and has a fixed real expenditure on goods and services. The government budget deficit is endogenous. Total savings of households, the government and foreign capital must equal investment, which is fixed. The household savings rate is endogenous to insure that savings equals investment. The current account is constant and the exchange rate varies.

Each country model traces the circular flow of income from producers, through factor payments, to households, government, and investors, and finally back to demand for goods in product markets. The country models incorporate tariffs which flow to the government, and non-tariff revenues which go to the private sector. Each economy is also modeled as having a number of domestic market distortions. There are sectorally differentiated indirect taxes, as well as household and corporate income taxes. Production distortions in agriculture are modeled in detail, as described below. When we simulate NAFTA, we maintain domestic distortions in sectors other than agriculture.

B. Modeling Farm Programs

We model agricultural trade and domestic farm programs explicitly as either price wedges, which affect output and labor migration decisions; lump-sum income transfers; or as switching regimes which respond to price or output targets. The wedges and transfers are either specified exogenously or determined endogenously, depending on the institutional characteristics of the program being modeled. See table 4 for a summary of the various programs, the variables they affect and the countries in which they apply.

Many of the 1993 policies are "coupled" in that they influence producers' decisions. These policies affect the producer's value added price, the payment to primary factors. It is calculated as the unit value of production net of indirect taxes and payments to intermediate goods. Government subsidies are calculated per unit of output and are added to the value added price as the producer incentive equivalent (PIE) (equation 1, table 5a). A positive PIE increases the payment to factors, pulling resources into the subsidized sector and increasing output.

[14] De Melo and Robinson (1989) and Devarajan, Lewis, and Robinson (1993) discuss the role of the real exchange rate in this class of model. We fix the exchange rate for the rest of world, thereby defining the international *numeraire.*

The components of the producer incentive equivalent vary by sector and by country. In Canada and Mexico, it consists of exogenous input subsidies whose rate varies by sector (see table 3). The PIE for Mexican corn millers also includes endogenous payments under the Guaranteed Price Program. The Mexican government fixes the price of corn and compensates the corn millers for the artificially high price of inputs. In the United States, the PIE consists of the deficiency payments which are determined endogenously, and are not treated as fixed *ad valorem* wedges. Following Kilkenny (1991), and Kilkenny and Robinson (1990), we model the U.S. deficiency payment as per unit of output as the difference between a fixed target price and the market price. We calculate the initial unit value of the deficiency payment from data on total government expenditure on deficiency payments (including direct deficiency payments and marketing loan deficiency payments), base output, and participation rates. The unit value of the deficiency payment is a component of the producer incentive equivalent (equation 2, table 5a). We fix the eligible production at the base year levels.[15] The total payment a farm receives is the payment rate multiplied by eligible base production. Planting flexibility introduced under the 1990 Farm Bill is captured by treating 50% of deficiency payments as direct payments, or income transfers.

In all three countries, direct payments are modeled as income transfers to the household, and are decoupled from producers' decision-making. In Mexico, the direct payment also supplements the rural wage, thereby influencing the rural migration decision. In the U.S., the direct payment is assumed to be capitalized in returns to land. In Canada, NISA payments are assumed to be nondistorting household income transfers.

Canada restricts the supply of livestock and poultry. Producers minimize cost subject to a constraint on the level of output (equation 6, table 5a).[16] Similarly, Canada also maintains a fixed price for dairy manufacturing (equation 7, table 5a). We impose a lower bound on the output price. When there is pressure for the price to fall below the target price, the government subsidizes exports to bolster the price to farmers.[17]

All countries impose tariffs and quotas on farm and food processing sectors (equations 4 and 5, table 5a). These border policies indirectly affect the producer value added price through

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[15] Alternatively, the participation rate can be made endogenous, and changes in deficiency payment expenditures would result from both changes in the deficiency payment and from changes in base acreage.

[16] To model this, we maintain an upper bound on the output level in these sectors. When there is pressure for output to expand beyond the constraint, the marginal factor productivity declines; resources become more expensive, eliminating the incentive to expand output.

[17] Both the supply and price management policies are modeled as switching regimes using the PATH solver in GAMS.

their effect on the price of domestic output. Since we treat imports as imperfect substitutes for domestic goods, we insulate the domestic price from the full effect of border price shocks. Tariffs and quotas raise the price of imports, increasing demand for the domestically produced variety, and raising its price. Since the producer price is a weighted average of the prices of output sold on the domestic market and in each export market, it, too, will increase. Tariffs are measured as an *ad valorem* rate. They increase the domestic price of the imported good relative to its world price.

In the model, we assume endogenous ad valorem tariff equivalents of quotas. The initial rates are calculated as the wedge between the world price and the domestic price, adjusted for transport costs and any tariffs that are used in combination with the quota. In the model, these tariff equivalent rates adjust to maintain a specified level of imports.

Under NAFTA, import quotas are converted to tariff rate quotas (TRQ). Under this system, a specified volume of a commodity may enter at low or zero duty, and quantities above that level are taxed at a higher rate. In the model, TRQ rates are invoked endogenously when imports exceed a specified quantity threshold (equation 8, table 5a).

For each country, net farm program expenditure is computed by summing government expenditure and revenues arising from the various programs. In the model, it is included in total government fiscal expenditure and any increase in the net farm program expenditure will increase the government budget deficit.

V. Results

We simulate NAFTA under two regimes: First, we assume the farm programs which restricted supply responses in the three countries remained in place when NAFTA was implemented, at 1993 levels of program expenditure. Next, we assume NAFTA occurs in an environment with the reformed, largely nondistorting farm programs evident in all three countries in 1997, at 1997 levels of program expenditure.[18] In both scenarios, we model NAFTA as the removal of bilateral trade barriers among all three countries, with the exceptions of some sectors as specified by the Agreement.[19]

In all three countries, NAFTA has a greater effect on agriculture under the new farm programs than under pre-NAFTA farm programs. Production changes by a bigger absolute

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[18]Since we start from different base models, we must compare absolute, not percent, changes across scenarios.

[19]The U.S. maintains its import quota on processed sugar from Canada and dairy manufactured goods from Canada; Mexico and Canada retain bilateral restrictions on each others' imports of dairy manufactured goods and poultry.

amount in each country, with the biggest changes occurring in the U.S. and Mexico, countries which insulated agriculture from price shocks with pre-NAFTA farm programs. Under both old and new programs, NAFTA has a greater impact on Mexican agriculture than on U.S. and Canadian farm sectors, reflecting Mexico's greater trade dependence on its North American partners and higher pre-NAFTA trade barriers.

Another indication of NAFTA's impact is the change in factor employment defined as the number of workers, acres of land, and value of capital stock initially employed in agriculture that must find new employment, in agriculture or elsewhere, after changes in agricultural policies (table 6). In Mexico, employment effects of NAFTA are substantially greater under the new farm programs than the old – 1.2 percent of the agricultural labor force must find new employment under old programs while 4.5% must change sectors under new programs. The same pattern holds for the U.S., but the changes are less extreme with a 0.1 percent change in labor employment under the old programs and a 0.2 percent change under the new programs. In Canada, labor adjustment to NAFTA is marginally greater under its new program than under its pre-NAFTA farm support program (0.379 percent vs. 0.385 percent).

Under both old and new farm programs, Mexico's terms of trade decline because of NAFTA. Mexico's import barriers were higher than those of its North American partners, causing Mexico's imports to increase more than its exports as those barriers were lifted. Some analysts have cited the deterioration in Mexico's terms of trade due to NAFTA as an argument against regional trade agreements (Bhagwati and Panagariya, 1996). We find that Mexico experiences a welfare loss only when there are distorting domestic policies in place that prevent an efficient reallocation of resources in response to trade reforms. Similarly, in the U.S., the flexibility introduced by farm program reform leads to larger welfare gains under NAFTA (tables 7 and 8). Under decoupled farm programs, resources can move more easily into sectors that become more profitable under free trade and out of sectors that face import competition. For Mexico, the problem is exacerbated by the dramatic increase in farm program expenses under free trade and distorting policies. There is an increase in lump sum taxes on the consumer, reducing welfare as real disposable income declined.

Under both old and new programs, trade creation dominates trade diversion. Trade expansion (defined as the increase in total exports) is the highest for the U.S. and the lowest for Mexico. Furthermore, farm program reforms within NAFTA also benefit members' trade with nonmembers. There is less absolute trade diversion for the U.S. and Canada and Mexico's trade with non-member countries increases more under new farm programs.

At the sectoral level, output changes following NAFTA illustrate the interaction between domestic and trade policies. Under Mexico's former, guaranteed price program, producers and consumers faced fixed prices for corn. Input subsidies to corn millers compensated them for purchasing corn at the artificially high, guaranteed price. To reduce the costs of its corn price support program, Mexico restricted corn imports; the tariff equivalent of the quota was 90.4 percent in 1993. With this program in place, corn milling production would have increased substantially under NAFTA to maintain the domestic price of corn which also faced downward pressure from cheaper imported corn. Mexican corn output would have risen slightly, despite elimination of high trade barriers to corn. To maintain its guaranteed price for corn under NAFTA, Mexico's farm program expenditures would have increased by 140 percent. Such a dramatic increase in program costs demonstrates why Mexico needed to restructure its farm program support in a free trade environment.[20]

In contrast, without price supports for corn, Mexico's corn production declines following NAFTA as consumers substitute cheaper imported corn for the domestic variety. Corn milling output increases by a smaller amount as producers are responding only to cheaper imported corn, not an increased subsidy to maintain demand for domestic corn. Other agricultural sectors benefit in Mexico. Fruit and vegetables expands more as resources are released from corn production. Likewise wheat does not contract as much. This affects the U.S., whose wheat exports to Mexico do not expand as much under NAFTA with the new programs compared to under NAFTA with the old programs.

In the U.S., the interaction between domestic and trade policies is less dramatic than in Mexico, because U.S. price support programs did not rely on tariffs to help support the domestic price. The U.S. had endogenous deficiency payments to maintain fixed output prices for wheat, corn, feedgrains, and oilseeds. As in Mexico, these programs insulated producers from increased competition due to NAFTA. However, for the U.S., NAFTA increased demand for crops formerly supported with deficiency payments, particularly corn and wheat. In the scenario with NAFTA under the old farm programs, U.S. farm program expenditures actually declined slightly by 0.5%.
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VI. Conclusion

Mexico, when it considered joining NAFTA, had characteristics typical of a small developing country: (1) relatively high tariffs; (2) a high trade dependency on its RTA partner; and (3) extensive domestic distortions in agriculture. According to some theoretical models, its relatively high tariffs and trade dependence meant welfare losses under NAFTA. We find that domestic distortions contribute to net welfare losses because they insulate agriculture and prevent the efficient reallocation of domestic resources in response to changing market signals. They also require a lump sum tax increase on consumers in order to maintain high farm prices when borders are opened. However, when domestic reforms accompany NAFTA, Mexico experiences

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[20]Indeed, Mexico initiated its reform program, PROCAMPO, in October 1993, before NAFTA went into effect.

a welfare gain from the RTA.[21] While Mexico still experiences terms of trade losses, its larger efficiency gains now lead to a net welfare gain under NAFTA. Furthermore, we find that trade creation dominates trade diversion with and without domestic policy reforms. There is greater trade expansion when domestic distortions are removed.

Similar to Mexico, many developing countries maintain distorting domestic farm programs whose effectiveness depends on trade restrictions. We find that high trade dependencies and high tariffs — other characteristics of developing countries — create pressure for domestic reform following the formation of an RTA. Given the current emphasis on reducing distortions in agriculture in the Uruguay round and future multilateral negotiations, our results suggest that an RTA can be a building bloc, not a stumbling bloc, to multilateralism.

[21]This is in contrast to Panagariya (1997), who does not consider domestic distortions when he calculates the welfare losses of NAFTA for Mexico. Instead, he bases his analysis on the tariff revenue lost and trade diversion with no trade creation.

References

Anderson, James E. (1997). "The Uruguay Round and Welfare in Some Distorted Agricultural Economies," NBER Working Paper No. 5932.

Anderson, Kym and Rod Tyers (1993). "More on Welfare Gains to Developing Countries from Liberalizing World Food Trade," *Journal of Agricultural Economics,* Vol 44, no. 2, pp. 189-204.

Bhagwati, Jagdish (1993). "Regionalism and Multilateralism: an Overview," in De Melo, Jaime and Arvind Panagariya (eds.), *New Dimensions in Regional Integration.* Cambridge: Cambridge University Press.

Bhagwati, Jagdish and Anne Krueger (1995). *The Dangerous Drift to Preferential Trade Agreements*. Washington, D.C.: AEI Press.

Bhagwati J. and Arvind Panagariya (1996). "Preferential Trading Areas and Multilateralism -- Strangers, Friends, or Foes?" in, *The Economics of Preferential Trade Agreements,* edited by Jagdish Bhagwati and Arvind Panagariya. Washington, D.C.: AEI Press.

Brooke, Anthony, David Kendrick, and Alexander Meeraus (1988). *GAMS: A User's Guide*. Redwood City, CA: The Scientific Press.

Burfisher, Mary E., Sherman Robinson and Karen Thierfelder (1998). "Farm Policy Reforms and Harmonization in the NAFTA," in *Regional Trade Agreements and U.S. Agriculture* edited by Mary E. Burfisher and Elizabeth A. Jones. Washington, D.C.: U.S. Department of Agriculture, Agriculture Economic Report Number 771.

Burfisher Mary E., Sherman Robinson and Karen Thierfelder (1992). "Agricultural and Food Policies in a United States-Mexico Free Trade Area," *North American Journal of Economics and Finance,* Vol 3, no. 2, pp. 117-139.

Clarete, Ramon L. and John Whalley (1988). "Interactions between Trade Policies and Domestic Distortions in a Small Open Developing Economy," Journal of International Economics, Vol. 24, pp. 345-358.

DeRosa, Dean A. (1998). "Regional Integration Arrangements: Static Economic Theory, Quantitative Findings, and Policy Guidelines," Policy Research Working Paper 2007. Washington, D.C.: The World Bank.

Devarajan, Shantayanan, Jeffrey D. Lewis and Sherman Robinson (1990). "Policy Lessons from Trade-Focused, Two-Sector Models." Journal of Policy Modeling. Vol. 12, pp. 625-657.

Devarajan, Shantayanan, Jeffrey D. Lewis, and Sherman Robinson (1993). "External Shocks, Purchasing Power Parity, and the Equilibrium Real Exchange Rate." *World Bank Economic Review,* Vol. 7., No. 1 (January), pp. 45-63.

Goldin, Ian and Dominique van der Mensbrugghe (1996). "Assessing Agricultural Tariffication under the Uruguay Round," in *The Uruguay Round and the Developing Countries*, edited by Will Martin and L. Alan Winters. Cambridge: Cambridge University Press.

Green, Richard and Julian M. Alston (1990). "Elasticities in AIDS Models." *American Journal of Agricultural Economics.* Vol. 72, no. 2 (May), pp. 442-445.

Hinojosa-Ojeda, Raul and Sherman Robinson (1991). "Alternative Scenarios of U.S.-Mexico Integration: A Computable General Equilibrium Approach," Giannini Foundation Working Paper No. 609, University of California, Berkeley.

Kilkenny, Maureen (1991). "Computable General Equilibrium Modeling of Agricultural Policies: Documentation of the 30-Sector FPGE GAMS Model of the United Sates," Report No. AGES 9125, Economic Research Service. Washington, DC: U.S. Department of Agriculture.

Kilkenny, Maureen and Sherman Robinson (1990). "Computable General Equilibrium Analysis of Agricultural Liberalization: Factor Mobility and Macro Closure," *Journal of Policy Modeling*, Vol 12., pp. 527-556.

Levy Santiago and Sveder van Wijnbergen (1994). "Agriculture in the Mexico-U.S. Free Trade Agreement: A General Equilibrium Analysis," in *Modeling Trade Policy: Applied General Equilibrium Assessments of North American Free Trade,* edited by Joseph F. Francois and Clinton R. Shiells. Cambridge: Cambridge University Press.

de Melo, Jaime and Sherman Robinson (1989). "Product Differentiation and the Treatment of Foreign Trade in Computable General Equilibrium Models of Small Economies." *Journal of International Economics.* Vol. 27, no. 1-2 (August), pp. 47-67.

Panagariya, Arvind (1998). "The Regionalism Debate: An Overview," Center for International Economics, Department of Economics, University of Maryland at College Park, Working paper No. 40.

Panagariya, Arvind (1997). "An Empirical Estimate of Static Welfare Losses to Mexico from NAFTA", unpublished mimeo, Center for International Economics, University of Maryland, College Park.

Panagariya, Arvind (1996). "The Free Trade Area of the Americas: Good for Latin America?" *The World Economy*, Vol. 19, no 5. pp. 485 - 516.

Robinson, Sherman (1989). “Multisectoral Models,” in Handbook of Development Economics, edited by Hollis Chenery and T.N. Srinivasan. Amsterdam: New Holland.

Robinson, Sherman, Mary E. Burfisher, Raul Hinojosa-Ojeda, and Karen Thierfelder (1993). “Agricultural Policies and Migration in a U.S.-Mexico Free Trade Area: A Computable General Equilibrium Analysis,” *Journal of Policy Modeling*, Vol 15 nos. 5&6, pp. 673-701.

Robinson, Sherman, Maureen Kilkenny and Kenneth Hanson (1990). “The USDA/ERS Computable General Equilibrium Model of the United States. Report No. AGES 9040. Economic Research Service. Washington, DC: U.S. Department of Agriculture.

Robinson, Sherman, Mary Soule, and Silvia Weyerbrock (1991). “Import Demand Functions, Trade Volume, and Terms-of-Trade Effects in Multi-Country Trade Models.” Unpublished manuscript, Department of Agricultural and Resource Economics, University of California at Berkeley.

Robinson, Sherman and Karen Thierfelder (1999). “Trade Liberalization and Regional Integration: The Search for Large Numbers,” International Food Policy Research Institute, Trade and Macroeconomics Division, Working Paper No. 34.

Schiff, Maurice (1996). “Small Is Beautiful: Preferential Trade Agreements and the Impact of Country Size, Market Share, Efficiency and Trade Policy,” Policy Research Working Paper 1668. Washington, D.C.: The World Bank.

Shoven, John B. and John Whalley (1984). “Applied General-Equilibrium Models of Taxation and International Trade.” *Journal of Economic Literature*. Vol. 22, no. 3 (September), pp. 1007-1051

U.S. Department of Agriculture, Economic Research Service (1996). *Provisions of the Federal Agriculture Improvement and Reform Act of 1996.* Agriculture Information Bulletin No. 729.

Winters, L. Alan (1996). “Regionalism versus Multilateralism,” Policy Research Working Paper 1687. Washington, D.C.: The World Bank.

Table 1 Trade dependencies among NAFTA countries, 1993

	Imports from partner (as a percent of total)				Exports to partner (as a percent of total)			
	U.S.	Canada	Mexico	Rest of World	U.S.	Canada	Mexico	Rest of World
United States								
Total		17.40	5.11	77.48		17.61	7.44	74.95
Agriculture		44.87	32.70	22.43		16.52	7.11	76.37
Canada								
Total	70.93		0.91	28.16	78.58		0.53	20.89
Agriculture	75.54		1.16	23.30	39.52		2.13	58.35
Mexico								
Total	79.88	1.38		18.74	81.23	3.25		15.52
Agriculture	61.02	5.70		33.29	94.21	2.65		3.14

Table 2 Tariff and tariff equivalent of quota rates, 1993

	U.S.	Canada	Mexico
Poultry	0.49	0.30	10.58
Livestock	0.82	0.56	15.00
Wheat	2.47	0.00	67.00
Corn	0.15	0.23	90.38
Feed grain	0.15	0.00	9.07
Fruits & vegetables	4.55	0.95	16.30
Oilseeds	0.00	0.00	7.30
Other agriculture	1.60	0.64	8.79
Forestry & fisheries	0.26	0.47	11.78
Meat	9.60	3.04	19.70
Dairy manufacturing	6.78	12.30	89.60
Sugar manufacturing	70.40	4.93	15.00
Prepared fruits & vegetables	5.26	7.00	20.00
Wheat milling	1.06	2.84	17.41
Feed milling	0.10	1.43	8.64
Corn milling	0.50	2.84	11.07
Oil milling	1.08	7.10	20.10
Miscellaneous food processing	5.50	9.30	30.10
Light manufacturing	8.96	3.44	9.76
Oil	0.55	0.08	5.79
Intermediates	4.06	0.60	6.04
Fertilizer	3.51	1.84	8.02
Consumer durables	2.42	1.78	9.12
Capital goods	2.56	1.46	7.81
Services	0.00	0.00	0.00
Trade weighted average	2.92	1.91	7.91

Source: World Trade Organization, tariff data base; various Attache Reports, Foreign Agricultural Service, USDA; tariff equivalent of quotas are calculated by authors from PSE data, and International Trade Commission (1990). Import quotas converted to tariff rate quotas in 1995.

Table 3	**Producer incentive equivalent of agricultural distortions, 1993**					
	U.S		Canada		Mexico	
	1993	1997	1993	1997	1993	1997
	subsidy rate per unit of output					
Poultry	0.21	0.00	0.32	0.10	7.30	1.37
Livestock	0.45	0.00	0.25	0.56	3.59	0.64
Wheat	14.09	3.55	0.43	0.52	2.68	1.29
Corn	6.11	0.65	0.18	0.09	2.56	1.05
Feedgrain	17.96	2.08	0.11	0.24	2.15	1.94
Oilseeds	2.18	0.96	0.17	0.16	2.67	0.37
Other agriculture	7.54	0.11	0.10	0.10	0.09	0.05
Meat manufacturing	0.00	0.33	0.00	0.00	0.00	0.00
Dairy manufacturing	0.01	0.30	2.65	0.06	5.84	5.12
Sugar manufacturing	0.67	0.34	0.00	0.00	1.14	0.35
Wheat milling	0.00	0.00	0.00	0.00	1.78	0.00
Feed milling	0.00	0.00	0.00	0.00	4.21	0.00
Corn milling	0.00	0.00	0.00	0.00	14.56	12.15

Note: Producer incentive equivalent refers to subsidy expenditure relative to producer price.
Source: OECD, “Producer and Consumer Subsidy Equivalents,” electronic data base, 1998.

Table 4 How policies are modeled

	Countries and sectors	Impact	Instrument	
			Endogenous	Exogenous
Deficiency Payments	U.S. : wheat, corn, feed grain & other agriculture	PVA, value added price	DEFPAY	
Input subsidies	Mexico: livestock, wheat, corn, feed grain, oil seeds, other agriculture & dairy manufacturing Canada: poultry, livestock, wheat, corn, feed grain, oil seeds, & dairy manufacturing	PVA, value added price		insub
Guaranteed price	Mexico: corn prices are fixed, subsidy to corn millers	PX, output price for the sector in which prices are guaranteed & PVA, value added price in the sector which uses the fixed price commodity as an input	PSUBU, per unit subsidy to the processor	
Tariff rate quotas	U.S.: sugar and dairy manufacturing against Canada and Rest of World Mexico: dairy manufacturing and poultry against Canada	PWM, world import price	TRQ	
Tariffs	U.S.: all sectors Mexico: all sectors Canada: all sectors	PWM, world import price		tm

	Countries and sectors	Impact	Instrument	
			Endogenous	Exogenous
Quotas	U.S.: sugar manufacturing, dairy manufacturing, & meat (treated as exogenous in base model and eliminated for partner countries in NAFTA) Mexico: wheat, corn, & dairy manufacturing (treated as exogenous in base model and eliminated for partner countries in NAFTA)	PWM, world import price	TM2	
Indirect taxes	U.S.: all sectors Canada: all sectors except prepared fruits and vegetables	PD, domestic sales price		itax
Value added tax	Mexico: all sectors	PVA, value added price		vatr,
Export subsidies	Canada: wheat, feed grain and oilseeds	PE, domestic export price		te0
Supply management	Canada: livestock & poultry	X, output level is constant	SCALE, payment to value added	
Price management	Canada: dairy manufacturing	PX, output price is constant	TE, export subsidy	
Crop and revenue insurance	Canada: grains and oilseeds U.S.: grains and oilseeds	PVA, value added price		ins
Direct payments	U.S., Mexico, and Canada	YH, household income		dirpay

Table 5a Policy equations

#	Equation	Complementarity constraint	Description
1	$PVA_{i,k} = PX_{i,k} - \text{Ó}_{j}\ IO_{j,i,k} + PIE_{i,k}$		Value added price
2	$PIE_{i,k} = \dfrac{DEFPAY_{i,k}}{X_{i,k}} + insub_{i,k} + PSUBU_{i,k}$		Producer incentive equavalent (PIE)
3	$DEFPAY_{i,k} = \overline{XP}_{i,k} \cdot (\overline{TP}_{i,k} - PX_{i,k})$		Deficiency payment
4	$PM_{i,k,cty1} = PWM_{i,k,cty1} \cdot EXR_{k} \cdot$ $(1 + tm_{i,k,cty1} + TM2_{i,k,cty1} + TRQ_{i,k,cty1})$		Import price
5	$TARIFF_{k,cty1} = \sum_{i} tm_{i,k,cty1} \cdot M_{i,k,cty1} \cdot PWM_{i,k,cty1} \cdot EXR_{k} +$ $\sum_{i} TRQ_{i,k,cty1} \cdot (M_{i,k,cty1} - M0_{i,k,cty1}) \cdot PWM_{i,k,cty1} \cdot EXR_{k}$		Tariff revenue with snapback provision
6	$X_{i,k} \leq \overline{X}_{i,k}$	$SCALE_{I,K} \leq 1$	Supply management
7	$PX_{i,k} \geq \overline{PX}_{i,k}$	$TE_{i,k} \geq 0$	Price management
8	$M_{i,k,cty1} \leq \overline{M}_{i,k,cty1}$	$TRQ_{i,k,cty1} \geq 0$	Tariff rate quota
9	$EXPSUB_{k} = \sum_{i,cty1} (te0_{i,k,cty1} + TE_{i,k,cty1}) \cdot$ $PWE_{i,k,cty1} \cdot E_{i,k,cty1} \cdot EXR_{k}$		Export subsidy

Note: the subscripts i refers to sectors; k refers to NAFTA countries; and cty1 refers to NAFTA countries and the rest of the world; a bar over a variable indicates a fixed level of that variable.

Table 5b Model variables	
$DEFPAY_{i,k}$	Deficiency payment by sector
$E_{i,k,cty1}$	Exports of good i from country k to country cty1
$EXPSUB_k$	Export subsidy paid by country k
EXR_k	Exchange rate by country
$IO_{i,j,k}$	Input output table: amount of good i used to make one unit of good j, by country
$M_{i,k,cty1}$	Imports of good i in country k, from country cty1
$PIE_{i,k}$	Producer incentive equivalent of price support programs for good i, in country k; measured per unit of output
$PREM_{i,k}$	Quota rents for good i in country k
$PVA_{i,k}$	Value added price of good i in country k
$PWE_{i,k,cty1}$	World price of exports from country cty1 in country k for good i
$PWM_{i,k,cty1}$	World price of imports from country cty1 in country k for good i
$PX_{i,k}$	Output price of good i in country k
$SCALE_{i,k}$	Constraint on marginal factor productivity in production of good i in country k
$TE_{i,k,cty1}$	Export subsidy on good i from country k to country cty1, to maintain price of commodity i in country k (price management policy)
$TM2_{i,k,cty1}$	Tariff equivalent of the quota on imports of good i from country cty1, in country k
$TP_{i,k}$	Target output price of good i in country k
$TRQ_{i,k,cty1}$	Tariff rate quotas on country k's imports of good i from country cty1,
$X_{i,k}$	Output of good i in country k
Parameters	
$insub_{i,k}$	Input subsidy per unit of output of good i in country k
$te0_{i,k,cty1}$	Export subsidy per unit of export on good i from country k to country cty1
$tm_{i,k,ct}$	Tariff rate per unit of import on country k's import of good i from country cty1

Table 6 Factor market adjustment following NAFTA (percent change)		
	NAFTA and 1993 Policies	NAFTA and 1997 Policies
U.S.		
Labor	0.124	0.156
Capital	0.033	0.045
Land	0.070	0.046
Canada		
Labor	0.379	0.385
Capital	2.203	2.208
Land	0.039	0.040
Mexico		
Labor	1.151	4.520
Capital	2.600	3.540
Land	4.845	4.174

Note: Percent change in factor employment refers to number of workers, land, or capital that leave any farm sector due to NAFTA, relative to base level of agricultural employment. They may be reemployed in other farm or nonfarm sectors.

Table 7 Aggregate results, NAFTA and 1993 policies

	Real GDP	Real Absorption	Farm Program Expenditure	Terms of Trade
		percent change from base		
U.S.	0.01	0.01	-0.49	0.56
Canada	0.01	0.11	-0.07	0.37
Mexico	0.03	-0.11	140.21	-0.92

	Trade Expansion [b]	Trade Creation	Trade Diversion	Welfare
		billion U.S. dollars		
U.S.	5.80	6.27	-0.47	0.34
Canada	2.29	5.67	-3.37	0.57
Mexico	0.81	0.41	0.40	-1.02

[a] Welfare is calculated as equivalent variation; in the format reported here, a positive number is a welfare gain.
[b] Trade expansion is defined as the increase in exports from the base for each country; trade creation is the increase in exports to countries in NAFTA; trade diversion is the change in exports to countries outside NAFTA (the rest of world).

Table 8 Aggregate results, NAFTA and 1997 policies

	Real GDP	Real Absorption	Farm Program Expenditure	Terms of Trade
		percent change from base		
U.S.	0.01	0.01	0.03	0.58
Canada	0.01	0.11	-0.25	0.37
Mexico	0.26	0.10	-0.42	-1.03

	Trade Expansion [b]	Trade Creation	Trade Diversion	Welfare
		billion U.S. dollars		
U.S.	5.84	6.47	-0.63	0.43
Canada	2.30	5.67	-3.37	0.57
Mexico	0.90	0.42	0.48	0.34

[a] Welfare is calculated as equivalent variation; in the format reported here, a positive number is a welfare gain.
[b] Trade expansion is defined as the increase in exports from the base for each country; trade creation is the increase in exports to countries in NAFTA; trade diversion is the change in exports to countries outside NAFTA (the rest of world).

Appendix: Structure of the NAFTA-CGE Model

Solving the CGE Model

The CGE model presented here has been developed and solved using a package called the General Algebraic Modeling System (or GAMS).[22] GAMS is designed to make complex mathematical models easier to construct and understand. We use it to solve a large, fully determined, non-linear CGE model in which the number of equations equals the number of variables. GAMS has become a powerful tool for modelers because of two related developments of the last several years. First, the increasing power and availability of personal computers allows every modeler to have desktop access to computational resources that were once available only on mainframe computers. Second, the development of packaged software such as GAMS, to solve complex mathematical or statistical problems has permitted modelers to return their attention to economics.

To a great extent, the GAMS representation of model equations is easily read as standard algebraic notation. Subscripts indicating countries, sectors, or factors appear in parentheses [**Xij** becomes **X(i,j)**], and a few special symbols are used to indicate algebraic operations [**Ó** becomes **SUM**, **Ð** becomes **PROD**]. For example, the Cobb-Douglas consumer price index equation:

$$PINDCON = \prod_i PQ_i^{pwtc_i}$$

is represented in GAMS as:

PINDCON = PROD(i, PQ(i)pwtc(i,k))**

where **PROD** stands for the product operator **Ð**, the **i** at the left of the parenthetic expression is the sectoral index over which summation occurs, and the two asterisks (**) indicate exponentiation.

The "$" introduces a conditional "if" statement in an algebraic statement. For example, PM(i,k,cty1)$imi(i,k,cty1) = xxx will carry out the expression shown for all PM(i,k,cty1) that belong to the set imi(i,k,cty1); in other words, calculate an import price for all sectors in which there are imports.

Tables 1 and 2 list the regional, sectoral, and factor classifications used in the model, as well as identifying the sectoral subsets that are needed in the equations of the model. Table 3 contains the parameter definitions used in the CGE model equations. Table 4 contains the variables that appear in the model.

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[22]GAMS is suiitable for solving linear, non-linear, or mixed integer programming problems as well. For a thorough introduction to model-building in GAMS, see Brooke, Kendrick, and Meeraus (1988).

Table 1: Regional and Sectoral in the NAFTA-CGE Model

COUNTRIES AND REGIONS			
CTY1,CTY2	Universe	US	United States
		CA	Canada
		MX	Mexico
		RT	Rest of World
K(cty1), L(cty1)	Countries	US	United States
		CA	Canada
		MX	Mexico
SECTORS AND GROUPINGS			
I,J,	Sectors of production	POULTRY	Poultry
		LVSTK	Livestock
		WHEAT	Wheat
		CORN	Corn
		FEEDGRN	Feed Grains
		FRTVEG	Fruits & Vegetables
		OILSEED	Oilseeds
		OTHAG	Other Agriculture
		FOR-FISH	Forestry & Fishery
		FOOD	Processed Food
		MEAT	Processed Meats
		DAIRYMFG	Dairy Manufacturing
		SUGARMFG	Sugar Manufacturing
		FVPREPS	Prepared Fruits & Vegetables
		WHTMILL	Wheat Milling
		FEEDMILL	Feed Milling
		CORNMILL	Corn Milling
		OILMILL	Oil Milling
		MISCFOOD	Miscellaneous Foods
		LMFG	Light Manufacturing
		OL	Oil
		INT	Intermediate Goods
		FERT	Fertilizer
		CD	Consumer Durables
		KG	Capital Goods
		SE	Services
ik(i)	Capital and intermediates (OL, INT, KG)		
oil(i)	Oil sector (OL)		
noil(i)	Non-oil sectors		
iag(i)	Agricultural sectors (POULTRY, LVSTK, WHEAT, CORN, FEEDGRN, FRTVEG, OILSEED, OTHAG)		
iagn(i)	Non-agricultural sectors		
ipr(i)	Processing sectors (MEAT, DAIRYMFG, SUGARMFG, FVPREPS, WHTMILL, FEEDMILL, CORNMILL, OILMILL, MISCFOOD)		
iprn(i)	Non-processing sectors		
im(i,k)	Import sectors		
imn(i,k)	Non-import sectors		
ie(i,k)	Export sectors		
ien(i,k)	Non-export sectors		
imi(i,k,cty1)	Bilateral imports in base data		
iei(i,k,cty1)	Bilateral exports in base data		
ie1(i,k)	Aggregate CET export sectors		
ie2(i,k)	Competitive export sectors (WHEAT.CA, WHEAT.US)		
iec(i,k)	Sectors with second-level export CET (All sectors in this version of the model)		
iecn(i,k)	Sectors with second-level competitive sectors		
ied(i,k)	Sectors with export demand from RT		
iedn(i,k)	Not ied (All sectors in this version of the model)		
iedw(i,k)	Setors with export RT-demand belonging to an aggregate curve		
isnap(i,k,cty1)	Sectors with snap-back provisions (SUGARMFG.US.CA, SUGARMFG.US.RT, DAIRYMFG.US.CA, DAIRMFG.US.RT, DIARYMFG.MX.CA, POULTRY.MX.CA)		
SMGMT(i,k)	Sectors with supply management (LVSTK.CA, POULTRY.CA)		
NSMGMT(i,k)	Non-supply management sectors		
PMGMT(i,k)	Price management sectors (DAIRYMFG.CA)		
NPMGMT(i,k)	Non-price management sectors		
DPAY(i,k)	Endogenous deficiency payment sectors (WHEAT.US, CORN.US, FEEDGRN.US, OTHAG.US)		
NDPAY(i,k)	Non-deficiency payment sectors		
FXP(i,k)	Fixed price sectors (CORN.MX)		
PS(i,k)	Producer Subsidy Sectors (CORNMILL.MX)		
NPS(i,k)	Non-Producer Subsidy sectors		

Table 2: Factor and Income Classifications in the NAFTA-CGE Model

FACTORS AND GROUPINGS

iff,f	Factors of production	RULAB	Rural labor
		URBUNLAB	Urban unskilled labor
		UNIONLAB	Urban skilled labor
		YUPS	Professional labor
		CAPITAL	Capital
		LAND	Agricultural land
LA(iff), LB(iff)	Labor categories	RULAB	Rural labor
		URBUNLAB	Urban unskilled labor
		UNIONLAB	Urban skilled labor
		YUPS	Professional labor
LC	Land categories	LAND1	Irrigated land (MX) or land for grains & oilseeds (US&CA)
		LAND2	Non-irrigated land (MX) or land for non-grains and non-oilseeds (US&CA)
IFF2(iff)	Non-nested inputs	RULAB	Rural labor
		URBUNLAB	Urban unskilled labor
		UNIONLAB	Urban skilled labor
		YUPS	Professional labor
		CAPITAL	Capital
FACT	Aggregate factors	LAND	
		LABOR	
		CAPITAL	

MIGRATION MAPPINGS

imigrl(la, k,l)	Labor mobility map (within category)
imigru(k,la,lb)	Labor mobility map (across category) (MX.URBUNLAB.RULAB)
imigk(k,l)	Capital mobility map
lmig(la,k)	Mobile labor factors (within category)
rmig(la,k)	Mobil labor factors (across category)
kmig(k)	Countries with mobile capital

HOUSEHOLDS AND INSTITUTIONS

hh	Households	HHALL	Single household category
ins	Institutions	LABR	Labor
		ENT	Enterprises
		PROP	Property income

Table 3: Parameters in the NAFTA-CGE Model

Model Parameters	
CLES(i,hh,k)	Household consumption shares
ENTR(k)	Enterprise income tax rate
GLES(i,k)	Government expenditure shares
HHTR(hh,k)	Household income tax rate
IO(i,j,k)	Input-output coefficients
ITAX(i,k)	Indirect tax rates
MPS(hh,k)	Savings propensities by households
PVAB0(i,k)	Base-year value added price
PWTC(i,k)	Consumer price index weights (PQ)
PWTS(i,k)	Consumer price index weights (PD)
PWTX(i,k)	Consumer price index weights (PX)
SPREM(i,k)	Share of premium revenue to the government
SSTR(iff,k)	Factor payment tax rates
TC(i,k)	Consumption tax rates
TE0(i,k)	Tax rates on exports
THSH(hh,k)	Household transfer income shares
TM(i,k,cty1)	Tariff rates on imports
TMREAL(i,k,cty1)	Real tariff rates on imports for real GDP calculations
VATR(i,k)	Value added tax rate
XP0(i,k)	Initial quantity of output under deficiency payments program
ZSHR(i,k)	Investment demand shares
Production and trade function parameters	
AC(i,k)	Armington function shift parameter
AD(i,k)	Cobb-Douglas production function shift parameter
AD2(i,k)	CES production function shift parameter
AE(i,k)	CET export composition function shift parameter
ALPHA(i,iff,k)	Cobb-Douglas factor share parameter
ALPHA2(i,iff,k)	CES factor share parameter
AT(i,k)	CET function shift parameter
DELTA(i,k,cty1)	Armington function share parameter
GAMMA(i,k,cty1)	CET export composition function share parameters
GAMMAK(i,k)	CET function share parameter
RHOE(i,k)	CET export composition function exponent
RHOP(i,k)	CES production function exponent
RHOT(i,k)	CET function exponent
Nested land function parameters	
ALC(i,k)	CES land composite function shift parameter
ALPHALC(i,lc,k)	CES land share parameter
RHOL(I,K)	CES land aggregate exponent
SIGMALC(i,k)	Elasticity of substitution in land composite
Parameters for farm programs	
DIRPAY(k)	Direct payments
INSUB(i,k)	Input subsidy rate per unit of output
Parameters for AIDS import demand functions	
AMQ(i,k,cty1)	Share parameter in AIDS function
AQ(i,k)	Constant in translog price index
AQS(i,k)	Constant in Stone price index
BETAQ(i,k,cty1)	Coefficient in AIDS function
ELASTPQ(i,k,cty1)	Translog own price elasticity of dmeand
ELASTPQ2(i,k,cty1)	Stone own price elasticity of demand
ELASTSQ(i,k,cty1,cty2)	Translog elasticity of substitution
ELASTSQ2(i,k,cty1,cty2)	Stone elasticity of substutition
GAMMAQ(i,k,cty1,cty2)	Price parameter in AIDS function
SMQ0(i,k,cty1)	Base year import value share
SUMYQ(i,k)	Weighted sum of income elasticities

Table 4: Variables in the NAFTA CGE model

Price block

EXR(k)	Exchange rate
GDPDEF(k)	GDP deflator
PD(i,k)	Domestic prices
PDA(i,k)	Domestic prices net of indirect taxes
PE(i,k,cty1)	Domestic price of exports
PEK(i,k)	Average domestic price of exports
PINDCON(k)	Consumer price index
PINDEX(k)	Output price index
PINDOM(k)	Domestic price index
PM(i,k,CTY1)	Domestic price of imported goods
PQ(i,k)	Price of composite goods
PREM(i,k)	Premium income from import rationing
PVA(i,k)	Value added price including subsidies
PVAB(i,k)	Value added price net of subsidies
PWE(i,cty1,cty2)	World price of exports
PWERAT(i,k)	Ratio of world export prices
PWEFX(i)	Benchmark world export price
PWM(i,cty1,cty2)	World price of imports
PX(i,k)	Average output price
TE(i,k)	Export subsidies
TM2(i,k,cty1)	Import premium rates
TM3(i,k,cty1)	Snapback tariffs

Production block

D(i,k)	Domestic sales of domestic output
E(i,cty1,cty2)	Bilateral exports
EK(i,k)	Aggregate sectoral exportss
INT(i,k)	Intermediate demand
M(i,cty1,cty2)	Bilateral imports
Q(i,k)	Composite goods supply
SCALE(i,k)	Output multiplier
SMQ(i,k,cty1)	Import value share in total sectoral demand
X(i,k)	Domestic output

Factor block

AGDIST(k)	Adjustment to restrict agricultural capital
AVWF(iff,k)	Average wage with current weights
FDSC(i,iff,k)	Factor demand by sector
FS(iff,k)	Factor supply
FSAG(k)	Agricultural capital stock
FT(k)	Factor tax rate
WF(iff,k)	Average factor price
WFDIST(i,iff,k)	Factor differential
YFCTR(iff,k)	Factor income

Land block

LFDSC(i.lc,k)	Land demand by sector
FSL(lc,k)	Land supply
WLC(lc,k)	Average land type price
WLDIST(i.lc,k)	Land differential

Farm programs

DEFPAY(i,k)	Deficiency payments
FPE(k)	Total farm program expenditures
PIE(i,k)	Producer incentive equivalent
PSUBU(i,k)	Producer subsidy rate
TP(i,k)	Target price

Migration block

MIGK(K)	Capital migration flows
MIGL(la,k)	Labor migration flows (within category)
MIGRU(la,k)	Labor migration flows (across category)
WGDFL(la,k,lb,l)	Wage differentials
WGDFK(k,l)	Rental differentials

Income and expenditure block

CDD(i,k)	Private consumption demand
DST(i,k)	Inventory investment demand
ENTSAV(k)	Enterprise savings
ENTAX(k)	Enterprise taxes
ENTT(k)	Government transfers to enterprises
ESR(k)	Enterprise savings rate
EXPSUB(k)	Export subsidy payment
FBAL(K)	Current account balance
FBOR(k)	Foreign borrowing by government
FKAP(k)	Foreign capital flow to enterprises
FSAV(k,cty1)	Bilateral net foreign savings
FSAVE(k)	Foreign savings
FTAX(k)	Factor taxes
GD(i,k)	Government demand by sector
GDPVA(k)	Nominal expenditure GDP
GDTOT(k)	Government real consumption
GOVSAV(k)	Government savings
GOVREV(k)	Government revenue
HHT(k)	Government transfer to households
HSAV(k)	Aggregate household savings
HTAX(k)	Household taxes
ID(i,k)	Investment demand (by sector of origin)
INDTAX(k)	Indirect tax revenue
REMIT(k)	Remittance income to households
RGDP(k)	Real GDP
SSTAX(k)	Factor taxes
TARIFF(k,cty1)	Tariff revenue
VATAX(k)	Value added taxes
YH(hh,k)	Household income
YINST(ins,k)	Institutional income
ZFIX(k)	Fixed aggregate real investment
ZTOT(k)	Aggregate nominal investment

Welfare

CDH(i,hh,k)	Consumption by household and commodity
UTIL(hh,k)	Utility by household
EV(hh,k)	Equivalent variation
YN(hh,k)	New spending on consumer goods for EV calculation

Table 5: Quantity Equations in the NAFTA-CGE Model

```
(1)     X(i,k) =AD2(i,k)* ( SUM(iff$FDSC0(i,iff,k),
                 ALPHA2(i,iff,k)*FDSC(i,iff,k)**(-RHOP(i,k))) )**(-1/RHOP(i,k)) ;

(2)     (1-ft(i,iff2,k))*WF(iff,k)*WFDIST(i,iff,k) =
        SCALE(i,k)*(1 - vatr(i,k))*pva(i,k)*AD2(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);

(3)     FDSC(i,"land",k) =E= ALC(i,k)*( SUM(lc$LFDSC0(i,lc,k),
            ALPHALC(i,lc,k)*LFDSC(i,lc,k)**(-RHOL(i,k))) )**(-1/RHOL(i,k)) ;

(4)     WLC(lc,k)*WLDIST(i,lc,k) =
        SCALE(i,k)*(1 - vatr(i,k))*PVA(i,k)*SAD(i,k)*SAD2(i,k)*AD2(i,k)*
        (SUM(f$FDSC0(i,f,k), ALPHA2(i,f,k)*FDSC(i,f,k)**
         (-RHOP(i,k))) )**((-1/RHOP(i,k)) - 1)*
        ALPHA2(i,"land",k)*FDSC(i,"land",k)**(-RHOP(i,k) -1)*
        ALC(i,k)*(SUM(sct$LFDSC0(i,sct,k), ALPHALC(i,sct,k)*LFDSC(i,sct,k)
        **(-RHOL(i,k)) ) )**((-1/RHOL(i,k)) -1)*ALPHALC(i,lc,k)
         *LFDSC(i,lc,k)**(-RHOL(i,k) -1) ;

(5)      WFDIST(iag,"capital",k) = AGDIST(k)*WFDIST0(iag,"capital",k) ;

(6)     INT(i,k)  = SUM(j, IO(i,j,k)*X(j,k));
```

Model Specification

There are 26 sectors for each country in the model; to focus on agricultural policies and trade, there are 9 farm sectors and 10 food processing sectors in the model. There are eight factors of production – rural labor, urban unskilled labor, urban skilled labor, professional labor, irrigated and non-irrigated land, agricultural capital and capital used in other sectors. The output-supply and input-demand equations are shown in Table 5. Output is produced according to a constant elasticity of substitution, CES, production function of the primary factors (equation 1), with intermediate inputs demanded in fixed proportions (equation6). There is a CES aggregation of irrigated and non-irrigated land (equation 3).[23] Producers are assumed to maximize profits, implying that each factor is demanded such that marginal product equals marginal cost (equation 2 for all factors except land and equation 4 for land types). In each economy, factors are not assumed to receive a uniform wage or "rental" (in the case of capital) across sectors. "Factor market distortion" parameters (the WFDIST (WLDIST) that appears in equation 2 (equation 4)) are imposted that fix the ratio of the sectoral return to a factor relative to the economy-wide average return for that factor. Agricultural capital is restricted to farm sectors. Rather than create two types of capital inputs, we introduce the variable, AGDIST(k) which allows the payment to agricultural capital to adjust to meet the constraint that the supply of agricultural capital is

[23]For Mexico, each farm product can be produced using irrigated and non-irrigated land. For the U.S. and Canada, land is restricted to two subsets of farm sectors: grains and oilseeds use one type of land while all other agricultural sectors use another type of land.

constant. Adjustment to agricultural capital payments appear in equation 5 in which payment to agricultural capital by sector (defined for the agricultural sectors, iag), is adjusted by the endogenous AGDIST(k).

Table 6: Price Equations in the NAFTA-CGE Model

(7)	PM(i,k,cty1) = PWM(i,k,cty1)*EXR(k) *(1 + TM(i,k,cty1) + TM2(i,k,cty1) + TM3(i,k,cty1)) ;
(8)	PE(iei,k,cty1) = PWE(iei,k,cty1)* (1 + te0(iei,k) + TE(iei,k))*EXR(k) ;
(9)	PE(ie2,k,cty1) = PD(i,k);
(10)	PWE(i,cty1,cty2) =E= PWM(i,cty2,cty1) ;
(11)	PEK(i,k) * EK(i,k) =E= SUM(cty1$pt(k,cty1), PE(i,k,cty1) * E(i,k,cty1)) ;
(12)	PDA(i,k) =E= (1-itax(i,k))*PD(i,k) ;
(13)	PQ(i,k)*Q(i,k) =E= PD(i,k)*D(i,k) +SUM(cty1$imi(i,k,cty1), (PM(i,k,cty1)*M(i,k,cty1))) ;
(14)	PX(i,k)*X(i,k) =E= PDA(i,k)*D(i,k) +SUM(cty1$iei(i,k,cty1), (PE(i,k,cty1)*E(i,k,cty1))) ;
(15)	PINDCON(k) =E= PROD(i$pwtc(i,k), PQ(i,k)**pwtc(i,k)) ;
(16)	PVA(i,k) =E= PX(i,k) - SUM(j,IO(j,i,k)*PQ(j,k)) + PIE(i,k);
(17)	PVAB(i,k) =E= (1.0-ITAX(i,k))*PD(i,k)*D(i,k)/X(i,k)+ (SUM(cty1, PE(i,k,cty1)*E(i,k,cty1)))/X(i,k)- SUM(j,IO(j,i,k)*PQ(j,k)) ;

The price equations are shown in Table 6. In equations 7 and 8, world prices are converted into domestic currency, including any tax or tariff components. Equation 9 describes the export price when domestic and export goods are perfect substitutes. Equation 10 guarantees cross-trade price consistency, so that the world price of country A's exports to country B are the same as the world price of country B's imports from country A. Equation 11 defines the aggregate export price as the weighted sum of the export price to each destination. Equation 12 calculates the domestic price, net of indirect tax. Equations 13 and 14 describe the prices for the composite commodities Q and X. Q represents the aggregation of sectoral imports (M) and domestic goods supplied to the domestic market (D). X is total sectoral output, which is a CET aggregation of total supply to export markets (E) and goods sold on the domestic market (D). The consumer price index, a Cobb-Douglas aggregate of consumer prices, appears in equation 15. Equation 16 defines the sectoral price of value added, or "net" price (PVA) as the output price (PX) minus the unit cost of intermediate inputs (from the input-output coefficients), plus production incentives from exogenous agricultural producer subsidy schemes (PIE). Equation 17 describes the value added price net of indirect taxes which are taken out of domestic sales (PD*D).

TABLE 7: Income and Expenditure Equations in the NAFTA-CGE Model

```
(18)  YFCTR(iff2,k) =SUM(i, (1-ft(k))*WF(iff2,k)*WFDIST(i,iff2,k)*FDSC(i,iff2,k));

(19)  YFCTR("land",k) =E= SUM((i,lc), WLC(lc,k)*WLDIST(i,lc,k)*LFDSC(i,lc,k) );

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

(21)  YINST("ent",k)  = 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))  - SUM(i, (SCALE(i,k)-1)*X(i,k)*(1 - vatr(i,k))*PVA(i,k)) ;

(22)  YINST("prop",k) = YFCTR("land",k)*(1.0 - sstr("land",k)) ;

(23)  YH(hh,k)  = SUM(ins, sintyh(hh,ins,k)*YINST(ins,k))+ rhsh(hh,k)*EXR(k)*REMIT(k)+ HHT(k)*thsh(hh,k) +DIRPAY(k);

(24)  TARIFF(k,cty1) = SUM(i$imi(i,k,cty1), TM(i,k,cty1)*M(i,k,cty1)*PWM(i,k,cty1))*EXR(k)
      +SUM(i, TM3(i,k,cty1)*(M(i,k,cty1) - M0(i,k,cty1))*PWM(i,k,cty1))*EXR(k);

(25)  PREM(i,k) = SUM(cty1$imi(i,k,cty1), TM2(i,k,cty1)*M(i,k,cty1)*PWM(i,k,cty1))*EXR(k) ;

(26)  EXPSUB(k) = SUM((i,cty1), (te0(i,k) + TE(i,k))*PWE(i,k,cty1)*E(i,k,cty1)*EXR(k)) ;

(27)  INDTAX(k) =SUM(i, itax(i,k)*PD(i,k)*D(i,k)) ;

(28)  VATAX(k)  = SUM(i, vatr(i,k)*PVA(i,k)*X(i,k)) ;

(29)  ENTAX(k)  = ENTR(k)*(YFCTR("capital",k) + ENTT(k)) ;

(30)  SSTAX(k)  = SUM(iff, sstr(iff,k)*YFCTR(iff,k));

(31)  HTAX(k)   = SUM(hh, hhtr(hh,k)*YH(hh,k)) ;

(32)  FTAX(k)   = SUM((iff2,i), ft(k)*WF(iff2,k)*WFDIST(i,iff2,k)*FDSC(i,iff2,k)) ;

(33)  GOVREV(k) = SUM(cty1, TARIFF(k,cty1)) + INDTAX(k) - EXPSUB(k)+ SUM(i, sprem(i,k)*PREM(i,k))
      + FTAX(k) + SSTAX(k) + HTAX(k) + ENTAX(k) + VATAX(k) + FBOR(k)*EXR(k);

(34)  GOVSAV(k) = GOVREV(k) - SUM(i, GD(i,k)*PQ(i,k)) - HHT(k )- ENTT(k) - FPE(k) ;

(35)  HSAV(k)   = SUM(hh, mps(hh,k)*((1.0-hhtr(hh,k))*YH(hh,k)));

(36)  ENTSAV(k) = esr(k)*YFCTR("capital",k) ;

(37)  FSAVE(k) = FBAL(k)-FKAP(k)-FBOR(k)-REMIT(k) ;

(38)  ZTOT(k) = GOVSAV(k) + HSAV(k) + ENTSAV(k) + EXR(k) * FSAVE(k);

(39)  ZTOT(k) = SUM(i, PQ(i,k)*(ID(i,k)+DST(i,k))) + WALRAS2(k) ;

(40)  PQ(i,k)*CDD(i,k) = SUM(hh, CLES(i,hh,k)*YH(hh,k)*(1.0-hhtr(hh,k))*(1.0-mps(hh,k)));

(41)  GD(i,k) = gles(i,k)*GDTOT(k) ;

(42)  ID(i,k) = zshr(i,k)*ZFIX(k) ;

(43)  GDPY(k)..    GDPVA(k) =E= SUM(i, PVAB(i,k)*X(i,k) + PREM(i,k)) + INDTAX(k) + SUM(cty1, TARIFF(k,cty1)) ;

(44)  GDPR(k)..    RGDP(k) =E= SUM(i, var0(i,k)*X(i,k)) ;
```

In the NAFTA CGE model, the aggregate consumer price index in each region is set exogenously (PINDCON in equation 15), defining the *numeraire.* The advantage of this choice is that solution wages and incomes are in real terms. The solution exchange rates in the sub-regions are also in real terms, and can be seen as equilibrium price-level-deflated (PLD) exchange rates, using the country consumer price indices as deflators. The exchange rate for the Rest of the World (rt) is fixed, thereby defining the international *numeraire.*

The circular flow of income from producers, through factor payments, to households, government, and investors, and finally back to demand for goods in product markets is shown in the equations in Table 7. Equations 18 - 23 describe the payment to factors, institutions, and households in the model.

The country models incorporate official tariff revenue (TARIFF in equation 24) which flows to the government, and the tariff equivalent of non-tariff barriers (PREM in equation 25) which is allocated as rents to the private sector and income to the government (the share parameter SPREM defines the share of premium income which accrues to the government). The country models also allow for export subsidies by commodity (the same rate applies to each trade partner, in contrast to the tariff rates which can vary by partner). There are two types of export subsidies, one which is exogenous in the base data, te0(i,k) and one which is endogenous and is used as part of the price management policy – when there is pressure for the price of a good to fall below the price floor, the export subsidy turns on to support the price.

Each economy is modeled as having a number of domestic market distortions, including sectorally differentiated indirect and value-added taxes (equations 27 and 28) as well as factor, household, and corporate income taxes (equations 29-32). Taxes accrue to the government as revenue (equation 33). The government spends its revenue on goods and services, transfer payments and production subsidies (equation 34). The remainder is government savings. Other forms of savings are described in equations 35 - 38. Total savings equals expenditure on investment goods, equation 39. The single household category in each economy has a Cobb-Douglas expenditure function (equation 40). Real investment and government consumption are set in equations 41 and 42. GDP from value added is described in equation 43 and real GDP is described in equation 44.

TABLE 8: Export Equations in the NAFTA-CGE Model

```
(45)   X(i,k) = AT(i,k)*( GAMMAK(i,k) *EK(i,k)**(-RHOT(i,k))+ (1 - GAMMAK(i,k)) *D(i,k) **(-RHOT(i,k)))**(-1/RHOT(i,k)) ;

(46)   X(ie2,k) = D(ie2,k) + EK(ie2,k) ;

(47)   X(ien,k) =D(ien,k) ;

(48)   EK(i,k) = D(i,k)*(PDA(i,k)/PEK(i,k)*GAMMAK(i,k)/(1 - GAMMAK(i,k)))**(1/(1+RHOT(i,k))) ;

(49)   E(iec,k,cty1) = EK(iec,k) * (((GAMMA(iec,k,cty1)*PEK(iec,k)) /(AE(iec,k)**RHOE(iec,k) * PE(iec,k,cty1)))
       **(1/(1+RHOE(iec,k))))  ;

(50)   PE(iecn,k,cty1) = PEK(iecn,k) ;

(51)   E(ied,k,"rt") = EB(ied,k)*(PWE(ied,k,"rt")/PWEB(ied,k))**(-etae(ied,k)) ;

(52)   M(i,cty1,cty2)  = E(i,cty2,cty1) ;
```

Export-related functions are shown in Table 8. Exports are supplied according to a CET function between domestic sales and exports (equation 45).[24] Allocation between export and domestic markets occurs in order to maximize revenue from total sales (equation 48). There is a nested CET function to allocate exports by region (equation 49). When export regions are perfect substitutes (as defined in the subset iecn), the price to each region is the aggregate export price (equation 50). The rest of the world (“rt”) can be treated as a large supplier of imports to each model region at fixed world prices (defined for commodities in the subset iedn). Or, the price can be endogenous with the supply curve defined in equation 51 (over the subset ied). Equation 52 ensures trade consistency: the quantity of goods country A exports to country B equals the quantity of goods country B imports from country A.

TABLE 9: Armington Import Demand Equations in the NAFTA-CGE Model

```
(53)   Q(i,k) =  AC(i,k)*(SUM(cty1$imi(i,k,cty1),  DELTA(i,k,cty1)*M(i,k,cty1) **(-RHOC(i,k))) + (1- SUM(cty1$PT(k,cty1),
        DELTA(i,k,cty1)))*D(i,k) **(-RHOC(i,k)))**(-1/RHOC(i,k) ;

(54)   Q(imn,k) =  D(imn,k) ;

(55)   M(i,k,cty1)/D(i,k) = (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))) ;
```

Imports are treated as imperfect substitutes for domestic goods. We consider two functional forms for imports – constant elasticity of substitution (CES) or Almost Ideal Demand System (AIDS). Both specifications are presented here. Table 9 summarizes the equations

[24]When exports and domestic goods are perfect substitutes (as defined over commodities in the set ie2), equation 46 describes the allocation of production between domestic and exported goods. When exports are zero (as defined over the commodities ien) all production goes to domestic sales, equation 47.

needed for a CES import specification. The consumer purchases a composite commodity (Q) made up of imports by region and the domestic variety (equation 53). For sectors with no imports (defined by the subset imn), the composite commodity consists only of the domestic good (equation 54). Consumers maximize utility by choosing the optimal ratio of imports to the domestic variety as a function of relative prices (equation 55).

TABLE 10: AIDS Import Demand Equations in the NAFTA-CGE Model

(56)	PM(i,k,k) = PD(i,k) ;
(57)	LOG(PQ(i,k)) = LOG(AQS(i,k)) + SUM(cty2,SMQ0(i,k,cty2)*LOG(PM(i,k,cty2))) ;
(58)	SMQ(i,k,cty1) = AMQ(i,k,cty1) + BETAQ(i,k,cty1)*LOG(Q(i,k)) + SUM(cty2, GAMMAQ(i,k,cty1,cty2)*LOG(PM(i,k,cty2))) ;
(59)	SMQ(i,k,k) = 1 - SUM(cty1$pt(k,cty1), SMQ(i,k,cty1)) ;
(60)	PM(i,k,cty1)*M(i,k,cty1) =E=smq(i,k,cty1)*PQ(i,k)*Q(i,k) ;
(61)	PD(i,k) * D(i,k) = SMQ(i,k,k) * Q(i,k)*PQ(i,k) ;

Alternatively, import demand follow the AIDS specification, as shown in Table 10. The expenditure shares, SMQ, are given by equations 58 and 59. We adopt the convention that when k = cty1, we are describing the domestic component of composite demand (D). Hence in equation 56, the "own" price of imports is simply the domestic price, and in equation 61, D is determined by the $SMQ_{i,k,k}$ share, while the import demands are determined in equation 60. The composite price index, PQ, is defined in equation 52 as a Stone price index [Deaton and Muellbauer (1980)].[25]

[25]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 that is bradly similar to our Southern Africa CGE model. Green and Alston (1990) discuss the computation of various elasticities in the AIDS system when using the Stone or translog price indices.

TABLE 11: Migration Relations in the NAFTA-CGE Model

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(62)  AVWF(iff2,k) =E= SUM(i, (1-ft(i,iff2,k))*wfdist(i,iff2,k)*wf(iff2,k)*fdsc(i,iff2,k))/SUM(j, fdsc(j,iff2,k))
        + dirsh(iff2,k)*DIRPAY(k)/SUM(j, FDSC(j,"rulab","mx")) +LSH(iff2,k)*SUM(i, LFDSC(i,"land2","mx")*
        WLC("land2","mx")*WLDIST(i,"land2","mx") )/SUM(j, FDSC(j,"rulab","mx"))  ;

(63)  (AVWF(la,k)/EXR(k)) =wgdfl(la,k,la,l)*(AVWF(la,l)/EXR(l)) ;

(64)  (AVWF("capital",k)/EXR(k)) =wgdfk(k,l)*(AVWF("capital",l)/EXR(l)) ;

(65)  AVWF(la,k) =wgdfl(la,k,lb,k)*AVWF(lb,k) ;

(66)  FS(la,k) =E= FS0(la,k) + MIGL(la,k) + MIGRU(la,k) ;

(67)  FS("capital",k) =E= FS0("capital",k) + MIGK(k) ;

(68)  SUM(k, MIGL(la,k)) =E= 0 ;

(69)  SUM(la, MIGRU(la,k)) =E=  0 ;

(70)  SUM(k, MIGK(k)) =E=  0 ;
```

Table 11 outlines the labor migration relations in the model. Equilibrium international migration levels are determined which maintain a specified ratio of real wages in the two labor categories in the countries, measured in a common currency. We assume that Mexican rural workers include direct payments and a share of their land income as part of their wage income upon which they make their migration decision. According to equation 63, the international labor migration equilibrium requires that real average wages (AVWF, described in equation 62) remain in a fixed ratio (WGDFL) for each migrating labor category in the two countries, measured in a common currency. Equation 64 describes the same relationship for capital migration. Similarly, internal migration in each country maintains a specified ratio of average real wages between skilled and unskilled labor markets (the EXR terms become irrelevant), equation 65. Domestic labor supply in each skill category in each country is then adjusted by the migrant labor or capital flows (equations 66 and 67). Equations 68-70 insure that workers do not "disappear" or get "created" in migration process.

Table 12: Welfare Measure in the NAFTA-CGE Model

(71)	CDH(i,hh,k) = CLES(i,hh,k)*(1.0 - MPS(hh,k))*YH(hh,k)*(1.0 - hhtr(hh,k))/PQ(i,k) ;	
(72)	UTILEQ(hh,k)..	UTIL(hh,k) = PROD(i, CDH(i,hh,k)**CLES(i,hh,k)) ;
(73)	EVEQ(hh,k)..	EV(hh,k) = (1.0 - MPS(hh,k))*YH0(hh,k)*(1.0 - hhtr(hh,k)) - YN(hh,k) ;
(74)	YNEQ(hh,k)..	UTIL(hh,k) = PROD(i,(CLES(i,hh,k)*YN(hh,k)/PQ0(i,k))**CLES(i,hh,k)) ;

We use equivalent variation to measure welfare. It is the amount the consumer would be willing to pay to avoid the policy change. First, we describe the consumer's utility following a policy shock. Equation 71 describes household consumption by commodity; utility is a Cobb-Douglas aggregate of consumption (equation 72). We determine the income (YN) necessary to attain this utility level at the prices the consume faced before the policy shock (PQ0) (equation 74). Equivalent variation is the base level income minus this hypothetical income (equation 73). A negative number indicates a welfare gain because at the original prices the consumer needs more income to attain the level of utility observed after the price shock.[26]

Farm program equations appear in Table 13. Equation 75 indicates the cost of deficiency payments. It is the difference between the fixed target price (TP) and the endogenous market price (PX) for a eligible crops (XP0). To represent Mexico's guaranteed price program for corn, we fix the marked price for corn and allow an endogenous subsidy to corn millers (PSUBU) to offset the high input cost. The exogenous subsidies per unit of output are part of insub. We convert all farm programs into a rate per unit, or "producer subsidy equivalent," PIE, in equation (76). This enters the value added price described in equation 16, Table 6. Total farm program expenditures are summarized in equation 77.

In addition to explicit payments to producers, we model policies that maintain prices, quantities and import levels. We set an upper bound for imports and outputs in certain sectors (equations 78 and 79) and a lower bound for producer price in other sectors (equation 80). There are complementarity constraints – variables which become endogenous when the constraints described in equations 78- 80 bind. For the supply management program, when the output constraint binds, the variable SCALE becomes less than one; when the constraint does not bind, SCALE equals one. To maintain the producer price, PX, above a lower bound, TE becomes positive; otherwise it is zero. Finally, to maintain an upper bound on imports, TM3, the tariff rate quotas are invoked endogenously; when the import constraint does not bind, TM3 equals zero.

[26]One can approximate equivalent variation with the appropriately defined price index as the numeriare in each region. When the aggregate consumer price index, PINDCON, is held constant as the numeraire, our Cobb-Douglas price index is consistent with the underlying Cobb-Douglas utility function. The changes in consumption levels generated by the model are approximately equivalent variation.

Table 14: Market-Clearing Equations in the NAFTA-CGE Model

(81)	Q(i,k) = INT(i,k)+CDD(i,k)+GD(i,k)+ID(i,k)+DST(i,k);
(82)	FS(iff2,k) = SUM(i, FDSC(i,iff2,k)) ;
(83)	FSAG(k) = SUM(iag, FDSC(iag,“capital”,k)) ;
(84)	FSL(l,k) = SUM(i, LFDSC(i,l,k)) ;
(85)	FSAV(k,cty1) = SUM(i, PWM(i,k,cty1)*M(i,k,cty1)) = SUM(i, PWE(i,k,cty1)*E(i,k,cty1)) ;
(86)	FBAL(k) = SUM(cty1, FSAV(k,cty1)) ;

To complete the model, there are a number of additional, “market-clearing” or equilibrium conditions that must be satisfied, as shown in Table 14. Equation 81 is the material balance equation for each sector, requiring that total composite supply (Q) equal the sum of composite demands. Equations 82 - 84 provides equilibrium in each factor market. Equation 85 is the balance condition in the foreign exchange market, requiring that import expenditures equal the sum of export earnings and net foreign capital inflows; equation 86 is the overall trade balance equation, summing up the bilateral trade balances.

Model Closure

The NAFTA-CGE model permits a number of different “closure”choices that affect the macroeconomic relationships in the model. In all simulations reported in this paper, we have assumed that the aggregate trade balance (FBAL) is constant for each country, and that the exchange rate (EXR) varies to achieve external balance. Total government spending (GDTOT) and fixed investment (ZFIX) are fixed exogenously.[27] In the government budget constraint, equation 34, savings (GOVSAV) and farm program expenditures (FPE) are endogenous, while household transfers (HHT) and enterprise transfers are exogenous. Since investment is fixed, some component of aggregate savings must be free to move; we require that the enterprise savings rate (ESR) adjust to achieve savings-investment balance. We allow rural-urban migration in Mexico, with the factor supply adjusting to maintain average wage differentials. These average wage differentials include payment a share of land return and a share of income from direct payments (see equation 62). All other factors are held in fixed supply and the wage to adjusts.

[27]Alternatively, one could fix investment and government consumption shares in GDP exogenously.