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Agricultural Trade Liberalization in a Multi-sector World Model

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Abstract

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Impacts of agricultural and nonagricultural trade liberalization on agriculture are assessed in a multi-commodity, multi-country framework. By modeling simultaneously all goods sectors of the economy, we evaluate the importance of: (a) relative price changes between sectors, and (b) income and exchange-rate adjustments that follow trade liberalization in a world of floating rates.
Specifically, we compare two cases using a static world policy simulation (SWOPSIM) model: agricultural multilateral liberalization and complete multilateral liberalization with floating exchange rates for all countries/regions. In both cases agricultural commodity prices tend to increase, an effect which is more pronounced when currency values adjust. The developing countries, in particular Argentina, Brazil and Mexico, have the most significant advances in agricultural and total production when exchange rates vary. Moreover, the gains from international trade are extended to all countries/regions explicitly specified in the model.

Introduction

The United States and other members of the General Agreement on Tariffs and Trade (GATT) are participating in an eighth round of Multilateral Trade Negotiations (MTN) in which resolving agricultural issues is a top priority. The importance of agriculture in these negotiations is related to current problems in the international agricultural trade environment. Although many factors account for adverse agricultural market conditions, the agricultural policies of trading countries are thought to be important contributors to mounting surpluses, falling commodity prices, and declining levels of world trade values in the eighties. This is because trade barriers, price and income support pro-

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grams, and other domestic agricultural policies buffer agricultural producers in many countries from world price movements thereby discouraging supply adjustments.

Most analyses of agricultural protectionism have been conducted in a partial equilibrium framework. For example, the OECD (1987) and World Bank (Tyers and Anderson, 1986; World Bank, 1986) studies examine liberalization in a multi-agricultural commodity model but do not consider nonagricultural sectors. Yet a reduction in protection for the nonagricultural sector can cause changes in nonagricultural and agricultural prices, changes in income, and changes in relative prices across countries via exchange rate movements. This would influence resource allocations across sectors and countries and thereby affect agricultural production, consumption, and trade. The nonagricultural component of the economy may have even more influence than sector-specific policies.

In view of the potential importance of a broad-based framework, we develop a multi-commodity, multi-country static model and attempt to assess the effects of complete (agricultural and nonagricultural) trade liberalization on the agricultural sector. By modeling all goods sectors of the economy, we are able to compare a total trade liberalization scenario in which exchange rates are endogenous with a scenario in which only agricultural trade is liberalized and there are assumed to be no exchange rate changes.

To undertake the scenarios, we use a static world policy simulation model (SWOPSIM) (Dixit and Roningen, 1986; Roningen, 1986) which includes eight countries/regions–United States (US), European Community (EC), Japan (JA), Canada (CA), Argentina (AR), Brazil (BZ), Mexico (MX), and rest-of-world (RW) — and a breakdown of commodities for each country into agricultural goods (wheat, corn, soybeans, rice, sugar, dairy, beef and poultry), a composite 'other' agricultural good, a composite nonagricultural traded good, and a nontraded good. A base level (1984) is established for levels of demand and supply, consumer prices, producer prices, and world prices. For each country producer and consumer prices (or the implicit per unit values) deviate from the world price (expressed in local currency) by an ad valorem rate of protection. Producer and consumer subsidy equivalents are used to derive these protection rates for agriculture (USDA, 1987, 1988). For nonagricultural goods, ad valorem tariff and nontariff barrier tariff-equivalent rates are used for protection measures (Anjaria et al., 1985; Whalley, 1985, 1986; Deardorff and Stern, 1986).

Analytical framework

The framework for this analysis has its origins in studies by Valdes (1985) and Deardorff and Stern (1986). We set up a 'more complete' partial equilibrium model with all produced and consumed goods specified in demand and supply functions. The model falls short of a general equilibrium characterization since factor markets are not explicitly described.

Our approach has the advantage over agricultural sector models of accounting for feedback from one sector to another as relative prices alter. Additionally, because all goods in the economy are accounted for (and hence, the total balance of trade), income and exchange rates can be modeled endogenously and the effect of floating rates (or exchange rate liberalization) can be evaluated.

The model is developed for m countries/regions, $i=1$ to m, producing and trading n goods, $j=1$ to n, and producing additionally a nontraded good, k. The traded goods include a breakdown of agricultural goods $(1, ..., n-2)$, a composite 'other agricultural' good $(j=n-1)$, and a composite nonagricultural good $(j=n)$.

The demand and supply functions, assumed to be derived from consumer and producer maximizing behavior, depend on all prices and income as delineated below:

$$\mathrm{DA}_{ij} = \mathrm{DA}_{ij}(\mathrm{PA}_{ij}, \mathrm{PT}_{in}, \mathrm{PH}_{ik}, Y_i) \tag{1}$$

$$\mathrm{DT}_{in} = \mathrm{DT}_{in}(\mathrm{PA}_{ij}, \mathrm{PT}_{in}, \mathrm{PH}_{ik}, Y_i) \tag{2}$$

$$\mathrm{DH}_{ik} = \mathrm{DH}_{ik}(\mathrm{PA}_{ij}, \mathrm{PT}_{in}, \mathrm{PH}_{ik}, Y_i) \tag{3}$$

$$\mathrm{SA}_{ij} = \mathrm{SA}_{ij}(\mathrm{PA}_{ij}, \mathrm{PT}_{in}, \mathrm{PH}_{ik}) \tag{4}$$

$$\mathrm{ST}_{in} = \mathrm{ST}_{in}(\mathrm{PA}_{ij}, \mathrm{PT}_{in}, \mathrm{PH}_{ik}) \tag{5}$$

$$\mathrm{SH}_{ik} = \mathrm{SH}_{ik}(\mathrm{PA}_{ij}, \mathrm{PT}_{in}, \mathrm{PH}_{ik}) \tag{6}$$

where D and S stand for demand and supply equations, respectively, P are prices, Y is income, A denotes agricultural goods, T represents the nonagricultural traded products either exported or imported, and H the nontraded good. Farm input prices are included implicitly in the price of nonagricultural goods faced by agricultural producers; likewise, agricultural prices represent both prices of inputs and prices of alternative outputs to nonagricultural producers.

Expenditure is defined as:

$$Y_i = \sum_{j=1}^{n} \mathrm{P}_{ij}\mathrm{D}_{ij} + \mathrm{P}_{ik}\mathrm{D}_{ik} \tag{7}$$

Alternatively, expenditure equals the value of production plus (minus) the change in foreign borrowing.

The domestic economy reaches an equilibrium when home goods have an excess supply equal to 0 and when the value of net traded goods (including agricultural goods) equals 'net capital flows', F; F is defined as including capital and service accounts and accommodating changes in international reserves. For country i:

$$\mathrm{ESH}_{ik} = \mathrm{SH}_{ik} - \mathrm{DH}_{ik} = 0 \tag{8}$$

and

$$\sum_{j=1}^{n} \mathrm{ES}_{ij}\mathrm{P}_{ij} = \sum_{j=1}^{n} \mathrm{S}_{ij}\mathrm{P}_{ij} - \sum_{j=1}^{n} \mathrm{D}_{ij}\mathrm{P}_{ij} = F_i \tag{9}$$

World markets clear when excess supply of a good across all countries is equal to 0. For agricultural commodities, this occurs when:

$$\sum_{i=1}^{m} \mathrm{ESA}_{ij} = \sum_{i=1}^{m} \mathrm{SA}_{ij} - \sum_{i=1}^{m} \mathrm{DA}_{ij} = 0 \tag{10}$$

for each j, $j=1$ to $n-1$. For the nonagricultural good that is traded, n, equilibrium occurs when:

$$\sum_{i=1}^{m} \mathrm{EST}_{in} = \sum_{i=1}^{m} \mathrm{ST}_{in} - \sum_{i=1}^{m} \mathrm{DT}_{in} = 0 \tag{11}$$

The price at which commodities are traded, expressed in each country's home currency is:

$$\mathrm{P}_{ij} = E_i \ \mathrm{PW}_j \tag{12}$$

where E_i equals home currency per U.S. dollar, PW_j is the world dollar price of good j for all traded j's.

Various government policies can place a wedge between the world price of a traded good and the domestic price or implied per unit value of that good. [1] (In the model, we assume no transportation costs or margin markups.) Consider the possibility that the home country affects domestic prices (prices faced by producers and consumers) by either imposing an ad valorem subsidy or tax on exports or imports. This has the effect of modifying equation (12) to:

$$\mathrm{P}_{ij} = E_i \ \mathrm{PW}_j \ (1 + t_{ij}) \tag{13}$$

where t_{ij} can be interpreted as an export subsidy or import tariff ($t_{ij} > 0$), or export tax or import subsidy ($t_{ij} < 0$) and is assumed to be exogenous. If the home country wants to encourage (discourage) exports, it can subsidize (tax) exports implying $t > 0 (t < 0)$. If the home country wants to discourage (encourage) imports, it can tax (subsidize) imports implying $t > 0 (t < 0)$.

A shock to the system — in terms of a change in protection in either sector of the economy, in any country or commodity market — leads to changes from base values in quantities produced, consumed, and traded and world and do-

[1] For simplication, we assume that producer and consumer prices are equal in the analytical framework. However, in the simulation exercises we allow domestic producer and consumer prices to differ. In the empirical model PSE's are used to determine producer prices and CSE's are used to determine consumer prices. PSE's and CSE's for a particular commodity often differ because the basket of policies directly affecting producers is not always the same as that directly affecting consumers (USDA, 1987, 1988). Thus, our implied producer and consumer prices can differ.

mestic prices. The system also determines either: (a) changes in each country's balance of trade under the assumption of fixed exchange rates and the availability of external financing, or (b) changes in each country's exchange rate under the assumption of floating rates which return all countries' trade balances to their initial equilibria. Thus, in the second case, we are assuming that changes in trade protection can change currency values depending on the elasticities of demand and supply for traded and nontraded goods. Since the elasticities approach does not consider a world with capital flows, we are implicitly assuming that the shock affects only the trade balance and does not induce changes in capital flows. Corden (1987) argues that the capital account depends on savings and investment decisions and it is ambiguous whether there would be a capital flows effect with implementation or removal of protection measures. While we could have arbitrarily selected to limit the *change* in the trade balance so that it did not always equal zero, there is no rigorous criteria to do so.

Through a series of differentiations and substitutions (see Appendix), we can obtain an expression for the change in the balance of trade (which equals the change in net capital outflow) in terms of changes in protection and exchange rate policies, and changes in world prices of both agricultural and nonagricultural traded goods:

$$(\Pi_1 + \Pi_2)E_i{}^* + \Pi_1\,[\mathrm{PWA}^* + (1+t\mathrm{A_i})^*] + \Pi_2\,[\mathrm{PWT}^* + (1+t\mathrm{T_i})^*] = F_i{}^* \qquad (14)$$

where the *'s indicate percentage changes in the variables and the Π's are parameters consisting of supply and demand elasticities, sector expenditure shares, and the shares of agriculture and nonagriculture in trade.

Under a fixed exchange rate system, $E_i^* = 0$, the balance of trade changes in response to changes in protection in the agriculture and nonagriculture sectors and changes in the world prices of traded goods. External financing is assumed to be forthcoming to balance the change in the value of net trade. Trade policy changes do not directly influence capital flows, but do so indirectly in order to balance the trade account. In the small country case agricultural markets would be affected (a) directly by changes in the country's agricultural protection, (b) indirectly by changes in prices of nonagricultural and nontraded goods resulting from changes in the country's nonagricultural protection, and (c) by gains in income resulting from liberalization. In the large country case, the additional effects of changes in world prices feed back to domestic prices and affect domestic production and consumption, and consequently, trade.

Under a floating exchange rate system, the country's currency would depreciate or appreciate following liberalization until the changes in the external imbalance are eliminated, that is, until $F_i^* = 0$. Hence, the exchange rate change causes a further feedback from world prices to domestic prices and subsequent adjustments to quantities.

If the parameters of equation (14), Π_1 and Π_2, are positive, then a reduction in positive protection leads to a depreciation of the exchange rate which offsets, to some extent, the negative impacts on domestic producer prices of a reduction in protection levels. If the agricultural protection levels are initially negative and nonagricultural protection is initially positive (for example, the Argentine case), then total liberalization could lead to a currency depreciation. The depreciation would reinforce the positive effects on agricultural producer prices of eliminating agricultural taxes.

The appendix differentiates the entire system of equations and derives reduced form equations for prices and exchange rates in terms of the exogenous variables, protection in the agricultural and nonagricultural sectors.

Simulation results

Although there are many alternative scenarios which we could have simulated, we chose two cases: (a) a 100% multilateral liberalization of agriculture for all countries under the assumption of fixed exchange rates for all countries/regions in the model, and (b) a 100% multilateral liberalization of all sectors for all countries under the assumption of endogenous exchange rates for all countries/regions in the model.[2]

These scenarios were designed not to predict actual outcomes of trade negotiations, but to explore the bias in agricultural trade liberalization analyses which do not account for cross-sector linkages, income, or exchange rate effects due to changes in protection.

In Tables 1 and 2, we report selected results focusing on the effects of liberalization on world agricultural prices, exchange rates, and trade. In Table 3, we present changes in values of agricultural, nonagricultural, and total domestic production resulting from liberalization. The value of production is computed by multiplying world prices (in local currency terms) times quantities supplied.

In both scenarios, world prices of all agricultural goods except soybeans rise. Sugar prices increase the most (29% in scenario 1, 33% in scenario 2), followed by dairy prices (20% in scenario 1, 26% in scenario 2), reflecting the relatively high levels of protection in these commodity markets. (Note, though, that the

[2]The model developed in the analytical section and described further in the appendix is more appropriately suited for changes of small magnitudes. However, we chose to consider full liberalization. Full liberalization most closely reflects the U.S. GATT proposal calling for elimination of all production and trade distorting subsidies and trade barriers. Modeling partial liberalization also presents several difficulties. Consider, for instance, a 10% reduction of a subsidy equivalent. Suppose, the removal of the subsidy has a positive impact on world prices. Is the new higher world price transmitted to domestic markets? Under a government policy of a specific subsidy the answer is 'yes'; but under a variable levy, the levy would adjust to maintain a fixed internal price and the answer would be 'no'. Since we do not have complete information on policy responses for all commodities and countries, we are unable to adjust the price transmission accordingly. By employing a 100% liberalization scenario, we avoid this complication.

TABLE 1

Changes in world agricultural prices and trade volumes (percent change)

	Prices		Volume	
	Case 1	Case 2	Case 1	Case 2
Wheat	1.6	5.0	3.5	7.7
Corn	0.2	2.7	6.6	10.3
Soybean	−5.4	−4.9	6.6	8.1
Rice	6.6	13.2	427.4	383.0
Sugar	29.1	33.4	140.7	130.1
Dairy	20.0	25.5	495.6	411.4
Beef	12.9	14.7	308.9	266.6
Poulstry	4.9	7.2	13.6	22.7

TABLE 2

Changes in the values of trade and exchange rates (percent change)

	Agriculture		Non-agriculture		Total		Exchange rate
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 2
US	−4	0	0	0	0	−1	—
EC	−66	−56	0	390	−89	0	−3.6
JA	−35	−37	0	13	−19	0	−2.0
CA	−16	−12	0	44	−14	0	−1.3
AR	70	74	0	−186	121	0	−1.5
BZ	28	66	0	−136	21	0	−8.6
MX	−828	−189	0	4	−19	0	−11.0
RW	219	109	0	−15	29	0	4.9

A minus sign represents depreciation relative to the dollar.

new domestic prices of the goods may be lower than initial domestic prices which include the subsidy equivalents.) Soybean prices decline because of the increased Argentine and Brazilian exports following the removal of producer taxes and consumer subsidies in these two countries (Krissoff and Ballenger, 1987). The price increases and trade volume expansion combine to produce an unambiguous rise in the value of world agricultural trade.

The effects on world prices are similar in the two scenarios, but total liberalization, and the resulting exchange rate movements, tend to reinforce the price effects of liberalization confined to the agricultural sector. The largest difference in price changes is in the rice market. This is driven by an appreciation in RW's currency which reduces RW's willingness to export rice at the

TABLE 3

Changes in value of production (percent change)

	Agriculture		Non-agriculture		Total	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
US	4	6	0	2	0	2
EC	−3	5	1	7	0	7
JA	−6	−2	0	5	0	5
CA	1	4	0	6	0	5
AR	20	25	−1	5	3	9
BZ	5	20	0	10	1	12
MX	0	18	1	15	1	16
RW	10	7	0	0	1	0

lower domestic price (in comparison to the fixed exchange rate case). The exchange rate effect, coupled with the elimination of the very high level of protection of Japanese rice, places additional upward pressure on world rice price.

In both scenarios there are substantial changes in foreign exchange earnings or costs from agricultural trade following liberalization (Table 2). In the total liberalization scenario, Argentina and Brazil post gains of 74 and 66%, respectively, as the volumes of soybeans, sugar, dairy and beef exports each expand by a minimum of 40%. For Brazil particularly, this gain in agricultural export revenues is significantly larger than in the agricultural trade liberalization case. In these two countries, protection of the nonagricultural sector has generally represented a strong bias against agricultural exports.

Table 2 also indicates that Japan and Mexico purchase considerably more foreign agricultural goods following the removal of agricultural protection. When currency values vary, the Mexican peso depreciates 11% and net expenditures on agricultural imports are much smaller than in the fixed exchange rate case. Moreover, in case 2, Mexico registers a 140% rise in foreign exchange earnings from the 'other agricultural' good (such as tomatoes and fresh vegetables) over the base period and becomes a net exporter of sugar.

Case 1 results in a 66% increase in EC expenditures on agricultural imports, with sugar, dairy, beef and poultry becoming imported goods while wheat remains an export commodity. Imports of the 'other agricultural' good, however, continue to account for more than half of foreign expenditures. Case 2 results in depreciation of the EC currency (4%) which mitigates somewhat the negative effects of agricultural liberalization on the Community's agricultural trade balance.

For the United States and Canada, the model generates decreases in net agricultural exports of 4 and 16%, respectively, in case 1, and a marginal increase and a 12% decrease, respectively, in case 2. In addition to removing the producer and consumer subsidy (tax) equivalents for specific U.S. agricultural commodities, we exogenously shifted wheat, corn and rice supply to account for removal of acreage reduction programs. (The Canadian figures, however, were not adjusted to account for domestic supply management systems that control production of dairy; the decline in Canadian agricultural exports may be substantially overstated. If we exclude dairy and its export deterioration, Canadian agricultural exports rise by approximately 3%.) In both scenarios, U.S. net export values of wheat, beef and poultry increase, soybean export value falls, and sugar and dairy net import values increase.

RW improves its net export position in all agricultural goods except soybeans and 'other agriculture'. This is not surprising since we assumed that RW, on net, has no trade barriers. With agricultural prices generally rising and perfect price transmission assumed, RW increases its agricultural production and decreases its consumption. The improved net trade position of RW, which is biased because of the lack of protection measures, enhances any decline or diminishes any improvement in other countries' commodity trade balances. In the total liberalization case, appreciation of RW's currency causes its exports to be higher priced in dollar terms and, therefore, mitigates some of the bias.

In countries which originally had low or negative protection rates, agricultural liberalization (case 1) produces increases in the values of agricultural and total production (Table 3). This is the case in Argentina and Brazil, in particular: the values of their agricultural output (including 'other agriculture') increases 20 and 5%, respectively, leading to 3 and 1% increases in total production.

Much larger increases in the value of total production occur in the flexible exchange rate case. The appreciation of the U.S. dollar and RW's currency relative to other countries' currencies and the general income increases due to complete trade liberalization lead to an expansion of total excess demand for both agriculture and nonagriculture. We observe production value increases, especially for Brazil (12%) and Mexico (16%). In the EC, agricultural and nonagricultural production both rise (5 and 7%, respectively). Japan's total production increases by 5% despite a decline in value of agricultural production.

Conclusion

This paper compares the effects of liberalizing the agricultural sector with liberalizing agricultural and nonagricultural sectors under flexible exchange rates. In the second case, there are two additional factors that can influence agricultural markets, namely any cross price effects from price changes in the nonagricultural markets and changes in exchanges rates (which occur due to changes in trade balances). In this model the cross price elasticities between agricultural and nonagricultural sectors are very small and therefore there are only small effects resulting from this linkage. Since we were only able to provide very rough estimates for these elasticities, this becomes a fruitful area for further research. The second channel of influence — exchange rate movements — does have significant effects on the agricultural sector as well as the general economies. Moreover, the income effects of complete liberalization are greater than those associated with agricultural liberalization. Some of our main findings are:

(1) The simultaneous reduction of agricultural and nonagricultural protection, allowing exchange rates to vary, tends to reinforce the upward pressure on agricultural prices that follows from agricultural liberalization alone. In most commodity markets, the reinforcing price effect occurs because the United States and rest-of-world currencies appreciate relative to the other countries'. These two regions account for 70% of world GDP. The appreciation of their currencies and the resulting contraction of their net export volumes put upward pressure on world prices.

(2) For several countries — those that experience the largest exchange rate movements following trade liberalization, such as Brazil and Mexico — the two simulations produce significantly different effects on agricultural trade values. The net agricultural export position of Brazil is favored by currency depreciation; while the negative effects on the Mexican agricultural trade balance of reducing agricultural protection is mitigated by this country's currency depreciation.

(3) Total value of production increases more for all countries (except RW) in the total liberalization case than in the agricultural liberalization case. Total and agricultural production benefit from the currency depreciations experienced by most countries because production is valued in domestic currency at higher prices than before liberalization. Higher world (dollar) prices and higher levels of income also translates into higher levels of production.

This paper illustrates the value of a broader approach to analyzing agricultural trade liberalization issues. Substantial differences for individual countries arise when results of the total liberalization scenario are compared with the results of the agricultural liberalization scenario. This model indicates, however, that these differences are smaller for the United States than those that could arise for other countries, particularly developing countries where the protection of the nonagricultural sector remains relatively high. Our analysis is limited by its high level of sector aggregation and simplistic treatment of national economies, the lack of disaggregation and information on protection for RW, and its consideration of a narrow set of macroeconomic factors. Additional studies may want to consider changes in other macroeconomic policies concomitant with trade liberalization.

Appendix

Derivation of reduced form equations

To determine the impact of small changes in the system for a single country, e.g. unilateral changes in protection, text equations (1) through (11) and (13 are differentiated. One agricultural good is assumed for purposes of exposition. Also, the country demarcation i is initially dropped for notational ease. The superscript * indicates percentage changes.

$$\mathrm{DA}^* = m_{\mathrm{A}}\,\mathrm{PA}^* + m_{\mathrm{T}}\,\mathrm{PT}^* + m_{\mathrm{H}}\,\mathrm{PH}^* + m_Y\,Y^* \tag{A1}$$

$$\mathrm{DT}^* = n_{\mathrm{A}}\,\mathrm{PA}^* + n_{\mathrm{T}}\,\mathrm{PT}^* + n_{\mathrm{H}}\,\mathrm{PH}^* + n_Y\,Y^* \tag{A2}$$

$$\mathrm{DH}^* = r_{\mathrm{A}}\,\mathrm{PA}^* + r_{\mathrm{T}}\,\mathrm{PT}^* + r_{\mathrm{H}}\,\mathrm{PH}^* + r_Y\,Y^* \tag{A3}$$

$$\mathrm{SA}^* = e_{\mathrm{A}}\,\mathrm{PA}^* + e_{\mathrm{T}}\,\mathrm{PT}^* + e_{\mathrm{H}}\,\mathrm{PH}^* \tag{A4}$$

$$\mathrm{ST}^* = f_{\mathrm{A}}\,\mathrm{PA}^* + f_{\mathrm{T}}\,\mathrm{PT}^* + f_{\mathrm{H}}\,\mathrm{PH}^* \tag{A5}$$

$$\mathrm{SH}^* = g_{\mathrm{A}}\,\mathrm{PA}^* + g_{\mathrm{T}}\,\mathrm{PT}^* + g_{\mathrm{H}}\,\mathrm{PH}^* \tag{A6}$$

where the m's, n's and r's represent demand elasticities, and e's, f 's and g's represent supply elasticities with respect to domestic prices and income. Differentiation of equations (7) and (12), yield

$$Y^* = V_{\mathrm{A}}\,(\mathrm{DA}^* + \mathrm{PA}^*) + V_{\mathrm{T}}\,(\mathrm{DH}^* + \mathrm{PH}^*) + V_{\mathrm{H}}\,(\mathrm{DH}^* + \mathrm{PH}^*) \tag{A7}$$

$$\mathrm{PT}^* = E^* + \mathrm{PWT}^* + (1 + t\mathrm{T})^* \tag{A8}$$

and

$$\mathrm{PA}^* = E^* + \mathrm{PWA}^* + (1 + t\mathrm{A})^* \tag{A9}$$

where the V's are expenditure shares:

$$V_{\mathrm{A}} = \frac{\mathrm{PADA}}{Y}$$

$$V_{\mathrm{T}} = \frac{\mathrm{PTDT}}{Y}$$

and

$$V_{\mathrm{H}} = \frac{\mathrm{PHDH}}{Y}$$

and where we distinquish the nonagricultural good ($t\mathrm{T}$) and the agricultural good ($t\mathrm{A}$) policy wedges.

By substituting for Y^* from equation (A7) into the demand equations, we can eliminate income from (A1), (A2) and (A3):

$$\text{DA}^* = a_{\text{A}}\,\text{PA}^* + a_{\text{T}}\,\text{PT}^* + a_{\text{H}}\,\text{PH}^* \tag{A10}$$

$$\text{DT}^* = b_{\text{A}}\,\text{PA}^* + b_{\text{T}}\,\text{PT}^* + b_{\text{H}}\,\text{PH}^* \tag{A11}$$

$$\text{DH}^* = c_{\text{A}}\,\text{PA}^* + c_{\text{T}}\,\text{PT}^* + c_{\text{H}}\,\text{PH}^* \tag{A12}$$

where *a, b,* and *c* are parameters comprised of price and income elasticities and expenditure shares.

To determine changes in price of the home good, we substitute equations (A6), (A8), (A9), and (A12) into the differentiated equation (7), $\text{SH}^* - \text{DH}^* = 0$:

$$\begin{aligned}\text{PH}^* = &- [(c_{\text{A}} - g_{\text{A}})/(c_{\text{H}} - g_{\text{H}})]\,[E^* + \text{PWA}^* + (1 + t\text{A})^*] \\ &- [(c_{\text{T}} - g_{\text{T}})/(c_{\text{H}} - g_{\text{H}})]\,[E^* + \text{PWT}^* + (1 + t\text{T})^*]\end{aligned} \tag{A13}$$

The home good price, therefore, is influenced by changes in the exchange rate, trade policy, and world prices of agricultural and nonagricultural goods. More specifically, if $(c_{\text{A}} - g_{\text{A}})$ and $(c_{\text{T}} - g_{\text{T}})$ are positive, then a depreciation of the home currency, an increase in world prices, or an increase in protection would place upward pressure on the price of the home good. The next step is to differentiate the net trade equation (9):

$$\theta_1(\text{SA}^* + \text{PA}^*) - \theta_2(\text{DA}^* + \text{PA}^*) + \theta_3(\text{ST}^* + \text{PT}^*) - \theta_4(\text{DT}^* + \text{PT}^*) = F^* \tag{A14}$$

where θ_1 (θ_2) is the share of the value of supply (demand) for agriculture and θ_3 (θ_4) is the share of supply (demand) for nonagriculture relative to the value of net trade. By substituting from equations (A4), (A5), (A8)-(A11) and (A13) into (A14), we obtain an expression for changes in balance of trade in terms of changes in trade and exchange rate policies, and changes in world prices of both agricultural and nonagricultural traded goods (equation 14 in text):

$$(\Pi_1 + \Pi_2)E^* + \Pi_1[\text{PWA}^* + (1 + t\text{A})^*] + \Pi_2[\text{PWT}^* + (1 + t\text{T})^*] = F^* \tag{A15}$$

where

$$\begin{aligned}\Pi_1 = {} & \theta_1(1 + e_{\text{A}}) - \theta_2(1 + a_{\text{A}}) + \theta_3 f_{\text{A}} - \theta_4 b_{\text{A}} \\ &- [(c_{\text{A}} - g_{\text{A}})/(c_{\text{H}} - g_{\text{H}})]\,[\theta_1 e_{\text{H}} - \theta_2 a_{\text{H}} + \theta_3 f_{\text{H}} - \theta_4 b_{\text{H}}]\end{aligned}$$

and

$$\begin{aligned}\Pi_2 = {} & \theta_1 e_{\text{T}} - \theta_2 a_{\text{T}} + \theta_3(1 + f_{\text{T}}) - \theta_4(1 + b_{\text{T}}) \\ &- [(c_{\text{T}} - g_{\text{T}})/(c_{\text{H}} - g_{\text{H}})]\,[\theta_1 e_{\text{H}} - \theta_2 a_{\text{H}} + \theta_3 f_{\text{H}} - \theta_4 b_{\text{H}}]\end{aligned}$$

Next, we relax the assumption of a representative country and, instead, we assume there are two countries and three goods (an agricultural good, a nonagricultural good, and a nontraded good). The following equations illustrate the implications of bilateral changes of protection in this framework.

For countries 1 and 2:

$$(\Pi_{11}+\Pi_{12})E_1{}^*+\Pi_{11}[\text{PWA}^*+(1+t\text{A}_1{}^*)] \\ +\Pi_{12}[\text{PWT}^*+(1+t\text{T}_1)^*]=F_1{}^* \quad (\text{A16})$$

$$(\Pi_{21}+\Pi_{22})E_2{}^*+\Pi_{21}[\text{PWA}^*+(1+t\text{A}_2)^*] \\ +\Pi_{22}[\text{PWT}^*+(1+t\text{T}_2)^*]=F_2{}^* \quad (\text{A17})$$

Again, we can examine the two extreme possibilities: allowing capital flows to change or allowing the exchange rate to float. In the fixed exchange rate case, with $F_1{}^*+F_2{}^*=0$ by definition, equations (A16 and A17) reduce to:

$$\tfrac{1}{2}[(\Pi_{11}-\Pi_{12})\text{PWA}^*+(\Pi_{21}-\Pi_{22})\text{PWT}^*+\Pi_{11}(1+t\text{A}_1)^* \\ -\Pi_{12}(1+t\text{A}_2)^*+\Pi_{21}(1+t\text{T}_1)^*-\Pi_{22}(1+t\text{T}_2)^*]=F_1{}^* \quad (\text{A18})$$

If country 1 liberalizes relatively more than country 2, assuming no changes in world price, then country 1 experiences a deterioration of the trade balance and, consequently, requires larger capital inflows. In the floating exchange rate case, with $E_2{}^*=-E_1{}^*$ by definition, equations (A16 and A17) reduce to:

$$-1/\Gamma[(\Pi_{11}-\Pi_{12})\text{PWA}^*+(\Pi_{21}-\Pi_{22})\text{PWT}^*+\Pi_{11}(1+t\text{A}_1)^* \\ -\Pi_{12}(1+t\text{A}_2)^*+\Pi_{21}(1+t\text{T}_1)^*-\Pi_{22}(1-t\text{T}_1)^*]=E_1{}^* \quad (\text{A19})$$

where $\Gamma_1=\Pi_{11}+\Pi_{12}+\Pi_{21}+\Pi_{22}$. Again, if country 1 liberalizes relatively more than country 2, assuming no changes in world prices, then country 1 experiences a depreciation of its currency relative to country 2's.

In equations (A18) and (A19) there are three unknown variables: changes in world prices of agricultural goods, changes in world prices of nonagricultural goods, and changes in the trade balance or exchange rate. To complete the system, the market clearing conditions (equations 10 and 11) need to be differentiated:

$$\text{SA}_1\text{SA}_1{}^*+\text{SA}_2\text{SA}_2{}^*-\text{DA}_1\text{DA}_1{}^*-\text{DA}_2\text{DA}_2{}^*=0 \quad (\text{A20})$$

and

$$\text{ST}_1\text{ST}_1{}^*+\text{ST}_2\text{ST}_2{}^*-\text{DT}_1\text{DT}_1{}^*-\text{DT}_2\text{DT}_2{}^*=0 \quad (\text{A21})$$

Substituting equations (A4), (A8)–(10) and (A13), into equation (A20) and equations (A5), (A8), (A9), (A11) and (A13) into equation (A21) yield:

$$\Gamma_2E_1{}^*+(\phi_{11}+\phi_{12})\text{PWA}^*+(\phi_{21}+\phi_{22})\text{PWT}^*+\phi_{11}(1+t\text{A}_1)^* \\ +\phi_{21}(1+t\text{A}_1)^*+\phi_{12}(1+t\text{T}_1)^*+\phi_{22}(1+t\text{T}_2)^*=0 \quad (\text{A22})$$

and

$$\Gamma_3 E_1{}^* + (\Phi_{11} + \Phi_{12})\text{PWA}^* + (\Phi_{21} + \Phi_{22})\text{PWT}^* + \Phi_{11}(1+t\text{A}_1)^* + \Phi_{21}(1+t\text{A}_1)^* + \Phi_{12}(1+t\text{T}_1)^* + \Phi_{22}(1+t\text{T}_2)^* = 0 \quad \text{(A23)}$$

where

$$\Gamma_2 = \phi_{11} + \phi_{12} - (1/E_1E_2)(\phi_{21} + \phi_{22})$$

$$\Gamma_3 = \Phi_{11} + \Phi_{12} - (1/E_1E_2)(\Phi_{21} + \Phi_{22})$$

$$\phi_{11} = \text{SA}_1[e_{\text{A}1} - e_{\text{H}1}(c_{\text{A}1} - g_{\text{A}1})/(c_{\text{H}1} - g_{\text{H}1})] - \text{DA}_1[a_{\text{A}1} - a_{\text{H}1}(c_{\text{A}1} - g_{\text{A}1})/(c_{\text{H}1} - g_{\text{H}1})]$$

$$\phi_{12} = \text{SA}_1[e_{\text{T}1} - e_{\text{H}1}(c_{\text{T}1} - g_{\text{T}1})/(c_{\text{H}1} - g_{\text{H}1})] - \text{DA}_1[a_{\text{T}1} - a_{\text{H}1}(c_{\text{T}1} - g_{\text{T}1})/(c_{\text{H}1} - g_{\text{H}1})]$$

$$\phi_{21} = \text{SA}_2[e_{\text{A}2} - e_{\text{H}2}(c_{\text{A}2} - g_{\text{A}2})/(c_{\text{H}2} - g_{\text{H}2})] - \text{DA}_2[a_{\text{A}2} - a_{\text{H}2}(c_{\text{A}2} - g_{\text{A}2})/(c_{\text{H}2} - g_{\text{H}2})]$$

$$\phi_{22} = \text{SA}_2[e_{\text{T}2} - e_{\text{H}2}(c_{\text{T}2} - g_{\text{T}2})/(c_{\text{H}2} - g_{\text{H}2})] - \text{DA}_2[a_{\text{T}2} - a_{\text{H}2}(c_{\text{T}2} - g_{\text{T}2})/(c_{\text{H}2} - g_{\text{H}2})]$$

$$\Phi_{11} = \text{ST}_1[f_{\text{A}1} - f_{\text{H}1}(c_{\text{A}1} - g_{\text{A}1})/(c_{\text{H}1} - g_{\text{H}1})] - \text{DT}_1[b_{\text{A}1} - b_{\text{H}1}(c_{\text{A}1} - g_{\text{A}1})/(c_{\text{H}1} - g_{\text{H}1})]$$

$$\Phi_{12} = \text{ST}_1[f_{\text{T}1} - f_{\text{H}1}(c_{\text{T}1} - g_{\text{T}1})/(c_{\text{H}1} - g_{\text{H}1})] - \text{DT}_1[b_{\text{T}1} - b_{\text{H}1}(c_{\text{T}1} - g_{\text{T}1})/(c_{\text{H}1} - g_{\text{H}1})]$$

$$\Phi_{21} = \text{ST}_2[f_{\text{A}2} - f_{\text{H}2}(c_{\text{A}2} - g_{\text{A}2})/(c_{\text{H}2} - g_{\text{H}2})] - \text{DT}_2[b_{\text{A}2} - b_{\text{H}2}(c_{\text{A}2} - g_{\text{A}2})/(c_{\text{H}2} - g_{\text{H}2})]$$

$$\Phi_{22} = \text{ST}_2[f_{\text{T}2} - f_{\text{H}2}(c_{\text{T}2} - g_{\text{T}2})/(c_{\text{H}2} - g_{\text{H}2})] - \text{DT}_2[b_{\text{T}2} - b_{\text{H}2}(c_{\text{T}2} - g_{\text{T}2})/(c_{\text{H}2} - g_{\text{H}2})]$$

Under the assumption of floating exchange rates, reduced form equations can be calculated from equations (A19), (A22), and (A23):

$$E_1{}^* = \omega_1(1+t\text{A}_1)^* + \omega_2(1+t\text{A}_2)^* + \omega_3(1+t\text{T}_1)^* + \omega_4(1+t\text{T}_2)^* \quad \text{(A24)}$$

$$\text{PWA}^* = \omega_5(1+t\text{A}_1)^* + \omega_6(1+t\text{A}_2)^* + \omega_7(1+t\text{T}_1)^* + \omega_8(1+t\text{T}_2)^* \quad \text{(A25)}$$

$$\text{PWT}^* = \omega_9(1+t\text{A}_1)^* + \omega_{10}(1+t\text{A}_2)^* + \omega_{11}(1+t\text{T}_1)^* + \omega_{12}(1+t\text{T}_2)^* \quad \text{(A26)}$$

where ω's are the reduced form parameters. Changes in the exchange rate, the world prices of agricultural goods, and the world prices of nonagricultural goods depend on the exogenous changes in protection. ω_1, ω_3, ω_5, ω_6, ω_{11}, and ω_{12} are expected to be negative, while ω_2, ω_4, ω_7, ω_8, ω_9, and ω_{10} are expected to be positive. Reducing protection relatively more in country 1 than in country 2 should cause a decline in the value of country 1's currency relative to country 2's and should have a positive effect on world prices.

Data sources

Three types of data are needed to develop the empirical model: (a) base year data, including quantities supplied, demanded, and traded, prices, and exchange rates for 1984; (b) elasticities, including own- and cross-price elasticities of supply and demand for agricultural and nonagricultural composite goods; and (c) measures of protection for agricultural and nonagricultural goods.

Base year data for agricultural supply and demand were obtained from the USDA Foreign Agricultural Service supply and utilization data base. Country GDP data, used to calculate other agricultural supplies and nonagricultural supplies (traded and nontraded), were obtained from *United Nations Monthly Statistics* (Special Table I, Gross domestic product and net material product by kind of economic activity), *Eurostat Review* (National accounts, gross value added at current market prices), and *International Financial Statistics*, International Monetary Fund. Trade flow figures were obtained from *International Trade 1985-86*, published by the GATT, Geneva, the Food and Agricultural Organization's *Trade Yearbook*, and, for Latin American countries, from country statistical trade yearbooks. Net trade for each good was subtracted from supply in order to obtain demand. In cases where 1984 data were unavailable, estimates were made based on the latest information available. The data set for quantities and prices for each country/region is contained in Krissoff and Ballenger (1987).

Elasticities were obtained from several sources.[3] Price elasticities for agricultural commodities were complied, based on estimates from a number of existing studies, by Gardiner, Roningen and Liu (1989). Elasticities for nonagricultural goods were obtained from Deardorff and Stern (1986) or were estimated by applying the homogeneity conditions to the equations. All the elasticities should be considered medium term estimates, that is, approximately 5 years.

Ad valorem equivalent rates of protection for nonagricultural traded goods were obtained from Whalley for developed countries and from Anjaria for the Latin American countries. Agricultural protection rates, producer and consumer subsidy equivalents (PSE's and CSE's), were developed by USDA (1988). These measures include estimates of the subsidy equivalents of domestic ag-

[3]The supply and demand equations are specified in constant elasticity form in the SWOPSIM modeling framework.

ricultural policies, such as direct payments and input subsidies, as well as the effects of trade barriers. Where agricultural PSE's and CSE's were unavailable, estimates of agricultural commodity protection were obtained from Tyers and Anderson (1986).

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