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Will developing country debt forgiveness increase agricultural trade?

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ABSTRACT

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Latin American countries are important customers in international agricultural trade. However, between 1981 and 1987, U.S. agricultural exports to these countries declined by almost 50%. One explanation for the above decrease is the change in financial conditions facing many countries in this region. Outstanding debt in the Latin American countries continued to rise through the 1980's, reaching over $120 billion for Brazil and Mexico by 1987.

In this paper, we develop an import model which considers the effect of the debt crisis on the ability of developing countries to purchase agricultural commodities in world markets. We estimate the model for four countries: Mexico, Brazil, Chile, and Venezuela.

The estimated results are used in a simulation model to obtain the effects of a 50% debt forgiveness scenario. Results indicate only a modest improvement in agricultural imports of the four Latin American countries considered in this study. These four countries would expand agricultural imports by $400 million per annum given the debt reduction.

1. INTRODUCTION

The developing market economies (DMEs), particularly the Latin American countries, are important customers in international agricultural trade. DMEs imported agricultural goods worth over $96 billion in 1988 (calendar year), accounting for over 22% of the total value of world agricultural

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imports. [1] In this group, Latin American consumers imported total agricultural goods worth over $14 billion. Despite this importance, agricultural imports in developing countries in general, and Latin American countries in particular, have stagnated. For example, U.S. agricultural exports to Latin America have declined by almost 50% between 1981 and 1987. While an improvement occurred in Latin American purchases in 1988 and 1989, U.S. agricultural exports were still over 20% less than in 1981.

One explanation for the above decrease is the change in financial conditions facing many countries in this region. In the 1970s, Latin American countries borrowed significantly from foreign commercial banks obtaining large capital inflows to purchase imported goods. The Latin countries continued to borrow in the 1980s, but the magnitude was much more modest and the funds came primarily from official government lending and international organizations. By the end of the decade, the Latin countries had reduced the proportion of their long-term foreign debt held by commercial lenders, mostly banks, from 70% to 60%. The loans in the 1980s, in effect, were used to service the debt accumulated in the earlier decade. However, outstanding debt continued to increase until the late 1980s. For most of the decade, new loans exceeded the reduction in principal on debt already outstanding.

The change in financial flows is exemplified by Brazil and Mexico. These countries received long-term foreign financial inflows averaging over $5 billion per annum in the 1970s but suffered from an average annual outflow in the 1980s (World Bank). Outstanding debt, though, continued to rise to over $120 billion for both countries by end-1987. With large external debts, high inflation rates, and a volatile economic environment in Brazil and Mexico in the 1980s, as well as in other Latin American countries, the prospects for continued financial constraints are high.

While most analysts agree that the debt crisis has affected the ability of DMEs to import agricultural products, there is considerable diversity in opinion with regards to the magnitude of the impact. Koerner and Rossmiller (1989) indicate that some trade experts feel that U.S. agricultural exports could expand $3 billion per year from an end to the debt crises. On the other hand, Robert Paarlberg in a testimony before the Joint Economic Committee (May 18, 1989) stated:

"It has become something of convention, here in Washington, to attribute all of this disappointing import decline to just one cause – the Latin American debt crisis. I do not deny that the debt crisis has played a role,

[1] 1988 FAO Trade Yearbook, Food and Agriculture Organization of the United Nations, Rome, Italy.

TABLE 1

Total agricultural imports and total imports from the U.S.

	Total [a]			From U.S. [b]		
	1982	1987	Percent change	1982	1987	Percent change
Brazil	1796	1437	−20	577	418	−28
Chile	512	226	−56	248	40	−82
Mexico	1954	1609	−18	1493	1215	−19
Venezuela	1766	1055	−40	746	459	−38

[a] FAO Trade Yearbook.
[b] Foreign Agricultural Trade of the United States.

and I do not deny that U.S. farm exports would profit from an easing of that crisis. But the magnitude of the export gains to U.S. farmers that might accompany an end to the debt crisis should not be exaggerated."

The objective of this study is to estimate the effect of the debt crisis on developing countries ability to undertake foreign purchases of agricultural products. We empirically estimate an agricultural import demand equation for four Latin American countries: Brazil, Mexico, Venezuela, and Chile. These countries were chosen because of their importance in agricultural trade with the United States, importing over $3 billion in 1988, and because they are large external debtors (see Table 1). The estimated equation includes a variable which measures the effect of existing debt on the ability of these countries to import agricultural goods. Once the impact of the debt on agricultural imports for these countries has been determined, a simulation model is introduced in which the effects of 50% debt forgiveness can be assessed for the four Latin American importers as well as the exporting nations.

The paper is organized as follows. Section 2 provides a brief summary of the debt crisis and the events which led to it. Section 3 introduces the estimated import demand equation and discusses the results. The next section provides a description of the modeling framework and the simulation scenario for debt forgiveness. The effect of debt forgiveness on Latin American agricultural imports is measured and implications for U.S. agricultural exports are drawn. The last section concludes with summary and implications of the analysis for a broader range of developing countries.

2. LATIN AMERICAN DEBT CRISIS

The origin of the 1980s debt crisis can be traced back to the 1973–74 oil shock. Following the sharp increase in oil prices, developed and developing

oil importing countries faced increased trade deficits. For many of the DMEs, the deficits were financed through increased foreign borrowing from commercial banks. With high commodity prices, strong economic activity, and low interest rates, the debtor countries were able to meet their debt service obligations in the following years.

The scenario, however, changed following the second oil shock of 1979–80. Industrial market economies (IMEs), fearing inflation due to energy price increases, did not follow with an accommodative monetary policy. Instead, energy conservation programs were implemented and restrictive monetary policy led to worldwide economic stagnation, higher interest rates, and reduced credit to developing countries. Lower incomes in IMEs reduced the demand for imports from DMEs. With higher interest rates and reduced DME exports, the ability of debtor countries to service their debt became more problematic. The ratios of interest payments to total exports and debt service to total exports increased by 43.2% and 47.5%, respectively, between 1981 and 1983. [2]

The debt crisis has implications on foreign trade, in general, and the ability of DMEs to import agricultural products, in particular. In order for the debtor countries to meet their debt service obligations, they must expand exports to obtain foreign exchange, spend less on imports, or seek new foreign creditors, as well as maintain sustained economic growth. Export expansion has been made more difficult since the industrial economies turned to increased protectionism after the second oil shock and the increased oil prices. Dornbusch (1984) claims that the protectionist policies of IMEs include commodities in which the DMEs could sustain strong export growth and earn foreign exchange to service their debt and maintain imports.

The debt crisis also has had implications for U.S. agricultural policy. A main result of the crisis was the increased dependence of debtor countries on imports of agricultural products via U.S. export programs. Nearly 100% of Brazilian, Chilean and Mexican imports of corn, other coarse grain, soybean, oilseed and wheat were purchased in 1986 under GSM-102, a credit guarantee program. In later years, Venezuela has relied almost entirely on GSM-102 for importation of wheat.

Over the last few years, several proposals have been introduced aimed at alleviating the debt problem. The first notable proposal was the Baker plan of 1985. The plan emphasized the importance of economic growth to the resolution of the debt problem and the plan recognized the need for new financing to achieve this goal. The Baker plan, however, was criticized for

[2] See Orlando and Teitel (1986).

failing to provide enough incentives for policy reforms in the debtor countries as well as for new lending by commercial banks. In early 1989, the Treasury Secretary, Nicholas Brady proposed a new plan known as the Brady plan. The plan is much more specific than the Baker plan and provides specific roles to be played by the various institutions. In addition, the plan calls for a significant reduction in debt, partly by encouraging commercial lenders to forgive debt.

3. AGRICULTURAL IMPORT DEMAND EQUATION AND DEBT

Existing studies on financial constraints and import decisions by Hemphill (1974) and Moran (1989) lack the direct link between external debt and imports. In order to meet our primary objective of estimating the impact of existing debt on agricultural imports, an import demand equation has to be specified. Khan (1974) provides a framework for estimating an import demand equation for developing countries. In his specification, total imports are specified as a function of the real import price and real income. This specification has served as a cornerstone for many studies that estimated import demand equations.

The underlying specification of our import demand equation is similar to the one proposed by Khan and used by others. [3] Since it is our purpose to investigate the impact of external debt on agricultural trade flows, two additional variables were added to the estimation. [4] These are external debt and foreign exchange reserves. We hypothesize that during the 1980s increase in external debt signifies an increase in financial constraints and thus will cause a decline in imports. By the same token, an increase in foreign exchange reserves represents an ease in financial stress that leads to increase in imports. An index of domestic agricultural production was also added to the estimated equation to account for the substitution between domestic production and imports. Thus our import demand specification is:

$$\ln m_t = c_0 + c_1 \ln \text{PM}_t^* + c_2 \ln R_t + c_3 \ln Y_t + c_4 \ln Q_t + c_5 \ln \text{DB}_t + c_6 \ln m_{t-1} \qquad (1)$$

[3] Houthakker and Magee (1969), Goldstein and Khan (1978), Bahmani-Oskooee (1986) and Tegene (1989).

[4] Though this approach seems to produce an ad hoc specification, others have used similar approach in analyzing the effects of specific variables on import demand equations. For example, Bahmani-Oskooee (1986) and Tegene (1989) have added an exchange rate variable to traditional import demand equation to measure its impact.

where m is agricultural imports, PM is the import price, DB is external debt, R is foreign exchange reserves, Y is real income, Q is a domestic agricultural production index, and the subscript t denotes period t. We hypothesize $c_1 < 0$, $c_2 > 0$, $c_3 > 0$, $c_4 < 0$, and $c_5 < 0$.

Several issues relating to the empirical estimation had to be considered. First, was the time period to be used for the estimation. We chose to use data (annual) covering the 1981–1988 period in which the debt crisis has become more serious, and an increase in the debt signified an increase rather than an easing of financial stress. [5] A second issue was the method of estimation. Because of the short observation period, individual equations for each country could not be estimated. Therefore, we use cross-sectional time-series approach in estimating equation (1). Thus, the final estimated equation is:

$$\ln m_{i,t} = c_0 + c_1 \ln \text{PM}^*_{i,t} + c_2 \ln R_{i,t} + c_3 \ln Y_{i,t} + c_4 \ln Q_{i,t} + \sum_{1}^{i} c_{5,i} \Delta_i \text{DB}_{i,t} + c_6 \ln m_{i,t-1} \quad (2)$$

where Δ_i is a dummy variable for country i – Brazil, Chile, Mexico, and Venezuela. [6] Data sources are available in the Data Appendix.

Table 2 lists the estimated coefficients and the respective t-values in parentheses. Since the equation was estimated in log-linear form, the coefficients can be interpreted as elasticities. Overall, the equation performed relatively well as indicated by the R^2-statistic.

All coefficients carried the expected sign and most were significant. The price coefficient was negative and significant. The coefficient value of -1.47 indicates that agricultural imports of these countries are price elastic. The income variable had the correct positive sign but was not statistically significant. Its magnitude, though, indicates that the elasticity

[5] We recognize the potential drawbacks of using such a limited time period in the analysis. However, after experiencing with longer period data, we are convinced that the debt variable has a different effect on imports during the earlier and later period. In the 1970s, debt signified capital inflow and additional resources available to finance imports. On the other hand, in the 1980s, debt signifies increase in financial stress and less resources available to finance imports.

[6] The debt variable in equation (2) was multiplied by the individual country dummy variables. This enables us to calculate separate debt elasticity for each country. We also experimented by adding separate country dummy variables to the equation. However, the results with the current specification were superior and alleviated the degrees of freedom problem.

TABLE 2

Agricultural import demand equation

Variable	Coefficient	t-value
Intercept	26.278 *	(3.45)
Price	−1.479 *	(−4.27)
Income	0.398	(1.40)
Agricultural production	−2.352	(−1.73)
Lagged imports	0.657 *	(2.98)
Reserves	0.187 *	(2.12)
$\text{Debt}_{\text{Brazil}}$	−0.618	(−1.17)
$\text{Debt}_{\text{Chile}}$	−1.049 *	(−2.20)
$\text{Debt}_{\text{Mexico}}$	−0.983 *	(−2.59)
$\text{Debt}_{\text{Venezuela}}$	−1.309 *	(−3.26)
	$R^2 = 0.86$	

Asterisk denotes significant coefficient at the 10% level.

of agricultural imports with respect to income is inelastic. The production index variable was, as expected, negative and significant, while the lagged import variable was positive.

The financial variable of total reserves was positive, as hypothesized, and significant. This indicates that as total reserves increase and financial constraints ease, agricultural imports would increase.

The debt variable was negative for all four countries, and significant for three. The elasticity of agricultural imports with respect to the debt variable was close to unity at −1.05 and −0.98 for Chile and Mexico, respectively. It was elastic and significant at −1.31 for Venezuela. The debt coefficient for Brazil was inelastic and not significant at −0.62.

4. DEBT FORGIVENESS AND INTERNATIONAL AGRICULTURAL TRADE

In order to evaluate the potential effects of debt forgiveness on individual commodity trade, we used the Static World Policy Simulation (SWOPSIM) modeling framework developed by Roningen (1986). [7] SWOPSIM models are multi-country multi-commodity partial equilibrium static net trade models. For each country and for each commodity in the model, demand and supply functions are specified as functions of own and cross prices and shift parameters. The difference between domestic supply and

[7] The structure of SWOPSIM models is delineated in the Appendix.

total demand is net trade, implying an implicit export supply or import demand function. When an exogenous change occurs in the shift parameter, the model recalculates domestic supply and demand levels, rebalancing world trade, production, consumption, and prices in the process. The pattern of prices and quantities observed in the base period can then be compared to the pattern which emerges from the model. [8]

As in all comparative static partial equilibrium models, the simulation results should be interpreted judiciously. Output from the exercises indicate what might have happened if debt was forgiven in 1986, the base period, and all other exogenous variables pertinent to agricultural markets remained the same.

There are three economic relationships which we try to capture in the simulation model: short- and long-run demand effects, and a long-run supply effect. We postulate that consumer demand would increase if 50% of debt outstanding is forgiven; a relaxation of the foreign exchange constraint would allow consumers to purchase more imported agricultural products. Second, reduced financial stress is likely to not only increase financial inflows but, over the long-run, to stimulate economy-wide growth, thus generating higher incomes and increased purchases of domestic and foreign agricultural commodities. On the supply side, more money incoming means more money to purchase capital inputs, fertilizers, and chemicals. These farm inputs can, in turn, generate increased productivity in the domestic agricultural sector and, thereby, reduce imports of basic foods. While these two long-run effects may not be equal in magnitude, they do affect the demand for imports in an offsetting manner.

We followed a multi-step procedure in calculating the magnitude of the demand and supply shift factor for each country and commodity (DS_{ij} and SS_{ij}). Firstly, the import demand elasticity with respect to debt for each country (δ_i), estimated in equation (2) by the coefficient $c_{5,i}$, was weighted according to each commodity's import share in each country (α_{ij}) in the model. This was a necessary step because we did not estimate debt elasticities for the individual commodities specified in the SWOPSIM

[8] The use of partial equilibrium SWOPSIM model is not without its limitations. One criticism is that it is a static model which tries to address a dynamic problem and does not endogenize economic growth. This criticism is valid. However, the alternatives are limited as well. For example, computable general equilibrium models are also static and do not generate projections of economic growth. This leaves us with macroeconomic forecast models which model economic growth as an endogenous variable. However, these models do not have the commodity detail capacity that SWOPSIM offers.

model. [9] Next, the weighted import elasticity was multiplied by the percent of debt forgiveness (0.50) and by the share of imports relative to total demand (m_{ij}/D_{ij}).

To capture the long-run demand and supply effects, we assume that economy-wide growth and agricultural sector growth rates return to the levels achieved during the 1965–80 period rather than the slower growth years of the 1980s. These estimates should be interpreted as a benchmark approximation of which there could be considerable deviation in a post-debt crises environment.

The demand-side shifter is calculated by multiplying the percent increase in each country's income (ΔY_i) by the income elasticity (π_{ij}) for each country and commodity. The supply-side shifter is simply calculated by the percent increase in overall agricultural production (ΔQ_i):

$$\text{DS}_{ij} = \alpha_{ij}\delta_i(0.50)(m_{ij}/D_{ij}) + \Delta Y_i\ \pi_{ij} \tag{3}$$

$$\text{SS}_{ij} = \Delta Q_i \tag{4}$$

The magnitude of the demand-side shift factor depends mostly on the base level of imports. Milk powder, corn, soybeans, and other oilseeds are the main imports for Mexico; cheese, milk powder, and wheat are the key commodities for Brazil; grains, soymeal and oil are important imports for Chile; and wheat, sorghum (other coarse grains), and oilseeds products are the major imports for Venezuela (Table 3). [10] The supply-side shifter equals 1.8%, 1.2%, 0% and 0.4% for Mexico, Brazil, Chile and Venezuela, respectively.

Simulation results indicate that imports by the four Latin countries increase by $400 million per annum as a result of the 50% debt forgiveness (Table 4). Mexican, Brazilian, Chilean and Venezuelan imports expand by $154, $157, $5 and $83 million, respectively. The three commodities most affected by the increase in Latin countries purchasing power are wheat, milk powder, and meats. Brazil and Venezuela would increase their imports of wheat by $45 and $23 million, respectively. Mexico and Brazil would increase their imports of dairy powder by $37 and $19 million. Also,

[9] Ideally, one would have liked to estimate individual import demand equations for each of the commodities, and to include the measurement of debt to obtain a separate debt elasticity for each commodity. However, given the detailed commodity coverage of SWOPSIM and data requirements, this was not feasible. Other simulation models, such as computable general equilibrium models, often do not estimate demand relations but rather use hypothesized elasticities.

[10] Brazilian and Mexican foreign purchases of milk powder were partly due to subsidized U.S. Commodity Credit Corporation (CCC) direct sales. Since these sales may not reflect commercial demand, we reduced base level milk powder imports in calculating the α_{ij}'s.

TABLE 3

Demand shifters with 50% debt forgiveness

Commodity	Mexico	Brazil	Chile	Venezuela
Beef	2.4	2.2	*	1.3
Pork	2.4	2.6	*	1.4
Mutton and lamb	2.6	2.1	*	1.3
Poultry meat	3.2	3.3	*	1.7
Poultry eggs	3.0	3.3	*	1.5
Dairy milk	3.0	2.5	*	1.2
Dairy butter	4.3	3.6	*	1.8
Dairy cheese	3.3	3.5	*	1.2
Dairy powder	9.9	5.1	*	1.1
Wheat	2.1	5.4	*	18.6
Corn	2.6	*	3.5	*
Coarse grains	*	*	1.3	5.3
Rice	2.2	1.5	*	*
Soybeans	4.8	*	*	4.3
Soymeal	−1.2	*	8.8	14.0
Soyoil	3.1	3.8	12.7	3.4
Other oilseeds	5.1	*	*	*
Other meals	−1.2	*	*	*
Other oils	3.2	3.8	*	12.0
Cotton	1.6	2.6	*	1.9
Sugar	1.3	1.5	*	*
Tobacco	2.5	2.7	*	1.0

Asterisk denotes less than 0.5.

the results indicate that Brazil would import $70 million more of beef and pork relative to the base period. Unlike wheat and other grains, which are mainly affected by the foreign exchange constraint, the effect on the consumption of meats is mainly due to larger income growth and the relatively high income responsiveness on meats relative to other agricultural commodities.

The increased demand for agricultural products by the four Latin American countries would lead to some upward pressure on world commodity prices. Although the increases would be small (less than 1% for most commodities), they would stimulate a production response in exporting nations. In the United States the price and production effects would mean an increase in the value of farm production of $203 million, with most of the gain in meats and grains, i.e. $166 million (Table 5). [11] There

[11] Farm production is valued at market prices which include a fixed producer subsidy equivalent. When world prices increase we assume they are fully transmitted to domestic markets so that U.S. producer prices increase in line with world prices.

TABLE 4

Changes in the value of agricultural trade relative to 1986 base

Commodity	Mexico	Brazil	Chile	Venezuela	Total
Beef	7	42	0	5	54
Pork	12	28	0	3	43
Mutton and lamb	1	0	0	0	1
Poultry meat	8	27	0	4	39
Poultry eggs	25	26	0	3	54
Dairy milk	0	0	0	0	0
Dairy butter	2	5	0	0	7
Dairy cheese	12	16	0	2	30
Dairy powder	37	19	0	0	56
Wheat	3	45	2	23	73
Corn	14	9	0	0	23
Coarse grains	2	0	0	8	10
Rice	0	5	0	0	5
Soybeans	15	−52	0	1	−36
Soymeal	−2	−18	1	21	2
Soyoil	1	5	2	1	9
Other oilseeds	17	−8	0	0	9
Other meals	−1	0	0	0	−1
Other oils	4	0	0	11	15
Cotton	−1	8	0	0	7
Sugar	−3	0	0	1	−2
Tobacco	1	0	0	0	1
Total	154	157	5	83	399

Positive sign indicates an increase in net imports and a negative sign indicated an increase in net exports.

would be little change in U.S. exports of oilseeds and products because Brazil would become more competitive in these markets. The U.S. also improves its agricultural trade position by exporting $109 million more than in the base period, or a 0.8% increase.

TABLE 5

Effects on U.S. agriculture

Commodity	Farm production	Trade
	($ million)	
Ruminated and non-ruminant meats	92	57
Dairy	31	25
Grains	74	45
Oilseeds and products [a]	6	−18
Total	203	109
Percent of 1986 base period	0.1	0.8

[a] Includes cotton.

TABLE 6

Trade effects on other agricultural exporters

Commodity	Argentina	Australia	Canada	EEC	New Zealand
	($ million)				
Ruminated and non-ruminant meats	10	7	5	55	3
Dairy	3	5	4	42	11
Grains	9	14	16	14	0
Oilseeds and products [a]	0	0	4	4	0
Total	22	26	29	115	14
Percent of 1986 base period	0.6	0.5	0.7	[b]	0.5

[a] Includes cotton.
[b] EEC is a net agricultural importer.

Other exporting countries would experience improved agricultural trade as well, approximately 0.5% of base period net exports (Table 6). The European Community would expand sales by $115 million, Argentina by $22 million, Canada by $29 million, Australia by $26 million, and New Zealand by $14 million. For Argentina, Australia and Canada the increased exports would be concentrated in grains and livestock products. For the European Community and New Zealand the gains in exports would be focused mostly in meats and dairy products.

SUMMARY AND IMPLICATIONS

In this paper we developed an import model which considers the effect of the debt crisis on the ability of developing countries to purchase agricultural commodities in world markets. We estimated the model for four Latin countries: Mexico, Brazil, Chile, and Venezuela. Over the period of our analysis we found that a decline in debt reduces financial stress and allows developing countries to relax import restrictions.

We next developed a multi-country multi-commodity simulation model to estimate the trade effects of a 50% debt forgiveness. The results of the simulation exercise suggest modest improvements in agricultural imports of the four Latin American countries considered in this study. These four countries would expand agricultural imports $400 million per annum given the debt reduction. Among the exporters, the United States and the European Community would incur the largest benefits by increasing their trade by nearly $225 million. Furthermore, if we assume a 100% debt forgiveness for all DMEs and further assume that these countries have similar behavioral responses as Brazil, Mexico, Chile and Venezuela, then U.S. agricultural exports could increase $925 million.

There are two reasons why the simulation results indicate only small trade gains. Firstly, agricultural imports of developing countries tend to be basic foodstuffs: wheat, corn, oilseeds, and dairy powder. Consumption of these commodities are less likely to be squeezed in times of financial constraints. Rather, curtailment of imports are more likely to be for luxury consumer goods. Second, as foreign exchange became less available to developing countries in the early to mid-1980s, U.S. credit guarantee programs expanded and substituted for commercial borrowing guaranteed by DME governments.

Overall, we conclude that while the debt crisis had a negative effect on agricultural exports to DMEs, the magnitude of the effect was relatively modest. Though solving the debt crisis will help expand agricultural exports, expectations regarding the size of the expansion should not be overly emphasized.

APPENDIX

SWOPSIM models are multi-country multi-commodity partial equilibrium static net trade models. The world model includes 22 commodity groups and is made up of 36 linked country or regional models, 24 of which represent countries or regions in the developing world. [12] For each country/region i and commodity j (or k) in the model, a demand and supply function is specified:

$$D_{ij} = D_{ij}(\text{CP}_{ij}, \text{CP}_{ik}, S_{ik}, \text{DS}_{ij}) \tag{A1}$$

$$S_{ij} = S_{ij}(\text{PP}_{ij}, \text{PP}_{ik} \text{ or } \text{CP}_{ik}, \text{SS}_{ij}) \tag{A2}$$

where CP_{ij} and PP_{ij} are the domestic incentive prices facing consumers and producers of commodity j in country i. [13] CP_{ik} and PP_{ik} are the cross-product consumer and producer prices for commodity k (for all relevant k's). CP_{ik} in the supply function accounts for the use of commodity k as an intermediate input in the production of commodity j. S_{ik} in the demand function accounts for the derived demand for the product as an intermedi-

[12] For more details on the structure, base values, and parameter estimates of SWOPSIM models, see Roningen (1986) and Roningen and Dixit (1990).

[13] The supply and demand equations are specified in constant elasticity form in the SWOPSIM framework. In the supply equations for animal products, the consumer price of feeds is included rather than the producer price. In the demand equations for feeds, the quantity supplied of animal products are included, with the parameters equalling the average share of product fed. Other conditions and restrictions regarding the supply and demand functions can be found in Roningen (1986) and Roningen and Dixit (1989). The data set is published in Sullivan, Wainio and Roningen (1989).

ate input for the production of commodity k. S_{ik} is usually a livestock quantity that enters into demand functions for feed. DS_{ij} and SS_{ij} are shift factors for demand and supply, respectively.

Trade is the difference between domestic supply and total demand:

$$T_{ij} = S_{ij} - D_{ij} \tag{A3}$$

Implicitly, an export supply or import demand function can be calculated.

Domestic incentive prices depend on the level of consumer and producer support wedges (CSW_{ij} and PSW_{ij}) and world prices denominated in local currency:

$$CP_{ij} = CSW_{ij} + F_{ij}(E_i * WP_j) \tag{A4}$$

$$PP_{ij} = PSW_{ij} + G_{ij}(E_i * WP_j) \tag{A5}$$

where CSW_{ij} and PSW_{ij} depend on the level of government support in each country, as measured by producer and consumer subsidy equivalents (PSES/CSES). [14] E_i is the exchange rate defined as local currency (i) per U.S. dollar, and WP_j is the world reference price of commodity j. The functional relationships, $F_{ij}(\ )$ and $G_{ij}(\ )$, allow a specification of world to domestic prices to be less than or equal to 1, depending on price transmission coefficients. [15]

World markets clear when net trade of a commodity across all countries is equal to 0. For commodity j, this occurs when:

$$\sum_{i=1}^{n} T_{ij} = \sum_{i=1}^{n} S_{ij} - \sum_{i=1}^{n} D_{ij} = 0 \tag{A6}$$

Data

Agricultural import quantities and prices (M_t and P_t) were obtained from the Food and Agriculture Organization of the United Nations. GNP,

[14] The PSE/CSE is a broader measure of policy support than the nominal rate of protection. It includes direct income payments, input and credit subsidies, marketing and structural assistance as well as market price support. A positive PSE (CSE) indicates that government policy subsidizes producers (consumers), while a negative PSE (CSE) indicates that the net effect of government policy is to tax the sector.

[15] The price transmission elasticity is defined as the change in the internal producer (consumer) price given a change in the world reference price. If the developing country's government wants to protect its consumers from a 20% world price increase, for example, then policies may be implemented with the result that consumer (and producer) prices may rise by only 10%. In this case, the implied price transmission elasticity is 0.5.

CPI (as the deflator) and foreign exchange reserve data were obtained from the International Financial Statistics to construct the income variable Y_t. The debt variable D_t was constructed as the sum of the medium- and long-term outstanding debt available from the World Bank Debt Tables (1988). The production index variable, Q_t, was available from the Food and Agriculture Organization.

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