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Modeling World Peanut Product Markets: A Tool for Agricultural Trade Policy Analysis

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Abstract

This paper presents a new partial-equilibrium, multi-market international model developed to analyze policies affecting peanut products markets. The model covers four goods (food-quality peanuts, crush-quality peanuts, peanut oil, and groundnut cake) in 13 countries/regions (Argentina, Canada, China, the EU-15, the Gambia, India, Malawi, Mexico, Nigeria, Senegal, South Africa, the United States, and Rest of World). Welfare is evaluated by looking at consumers' equivalent variation, quasi-profits in farming (peanut farming, livestock), quasi-profits in crushing, and taxpayers' revenues and outlays implied by distortions. We calibrate the model for three recent years (1999/2000, 2000/01, and 2001/02) on historical data. We illustrate the model's applicability with a peanut trade liberalization scenario. The impact of the reform scenario is measured in deviation from the historical baseline and by averaging the three estimates of annual impacts.

Keywords: agricultural trade policy analysis, crush, Doha, groundnut, model, oil, peanuts.

MODELING WORLD PEANUT PRODUCT MARKETS: A TOOL FOR AGRICULTURAL TRADE POLICY ANALYSIS

Introduction

This paper presents a model developed for formal analysis of international peanut (groundnut) product markets.[1] This paper is part of a research program on agricultural trade policy analysis undertaken by the World Bank for a series of agricultural commodity case studies covering cotton, dairy, grains, peanuts, rice, and sugar in the context of the Doha Round of the World Trade Organization (WTO) negotiations. The peanut model presented here is used for analysis of multilateral agricultural and trade policy reform scenarios.

The model has important features that set new standards in peanut market modeling in the context of severe data limitations on the production, utilization, and trade of value-added peanut products. Most previous investigations of peanut/groundnut policy have assumed exogenous world prices and have focused on unilateral reforms (Hathie and Lopez 2002; Kherallah and Govindan 1999; Rucker and Thurman 1990; among others). Our model provides an explicit determination of world peanut product prices via world market clearing. The Doha Round of WTO negotiations and its focus on development make our modeling effort particularly relevant given the importance of peanuts in many developing economies, including several African economies. Many analyses of peanut policy reforms have reached pessimistic conclusions, which may be reassessed in the context of the expectation that multilateral trade liberalization leads to much higher world prices.

Another important feature is the product disaggregation. The model distinguishes crush- and food-quality peanuts in each country. Crush-quality peanut product is essentially a nontraded commodity, selling at a discount in most countries, and it is treated as such in the model. The model includes an endogenous quality premium for food-quality peanuts, which are traded internationally. So are peanut oil and cake since significant trade flows are observed. World prices transmit to domestic markets via price transmission equations incorporating the exchange rate, transportation margins, policy instruments, and an implicit discount for quality and transaction costs.

Consumer choices are approached in a consistent fashion and reflect consumption decisions on oil and food peanuts, leading to an exact consumer welfare measure. The policy coverage is extensive and includes tariffs and taxes for most countries and the 2002 U.S. peanut program. Finally, the country coverage is unique and includes a large set of developing economies, including five African countries for which peanuts are an important crop and source of rural income.

The model starts with the agricultural sector producing crush-quality and food-quality groundnuts and explains crushing and eventually the final consumption of food groundnuts and peanut oil. Agriculture provides groundnuts, which are used as seeds, crushed for oil and byproducts, made into cake for livestock feed, and used as food (such as groundnuts and peanut butter), which is aggregated into a single food use category. Policy instruments are present in all three markets (peanuts, oil, and cake), and these interact to distort agents' decisions in these markets and hence distort trade flows and world market prices.

In the following section, we present the model structure. Next, we explain how the model is calibrated and give the implied elasticity values for each country. We also explain the policy coverage in the model and how policy instruments are parameterized. Finally, we illustrate the model's applicability with a simple but telling trade policy reform scenario.

The Groundnut Model

Since groundnut quality varies widely within and across countries, we model two qualities of groundnuts (food quality and crush quality) and their respective prices in each country. Food-quality groundnuts are traded internationally, and the world price for these groundnuts is determined by the world market equilibrium. In each country, the domestic price of food groundnuts is linked to the world price via a price-transmission equation reflecting the exchange rate, policy distortions, and the implicit presence of transaction costs from the border to the domestic market and farmgate. The imperfect transmission of world price effects to domestic markets for food-quality peanuts is consistent with the quality differential across countries, since the world price (the so-called Rotterdam Price) is a price for the best available quality worldwide.

In each country, the crush-quality groundnut market is treated as a nontraded good market, which it is in most countries. Domestic supply satisfies the crush-groundnut demand. In each country, food-quality groundnuts receive a quality premium relative to crush-quality groundnuts. This premium is endogenous and driven by cost to reflect the relative marginal cost of food-quality peanuts. As more food peanuts are produced relative to crush peanuts (as in a movement along a food-crush peanut transformation frontier), the premium for food peanuts increases to reflect the higher relative marginal cost of food-quality peanuts.

Given serious data constraints on land allocation decisions and yields for the two qualities of groundnuts, land allocation is modeled as an aggregate, which responds positively to an average groundnut producer price. The average producer price reflects the prices received for the two groundnut qualities at marketing time, weighed by their respective shares in total groundnut production in the country. The weights are endogenous. This approach mimics two separate production decisions for which individual data are not available and which are "revealed" at harvest time. It is clear that if the price of food-quality peanuts rises relative to the price of crush-quality peanuts, then farmers will exert more effort to increase the average quality of their crop, resulting in a larger share of food-quality peanuts in their aggregate peanut crop.

In each country, crushing is driven by crush margins (the net value of oil and cake produced in fixed proportions per unit of crushed groundnut). The demand for oil comes from consumers (domestic and/or foreign). The demand for cake comes from feed demand of the livestock sector (domestic and/or foreign). Excess demand/supply for these two commodities links the domestic and world markets. At equilibrium, the world oil and cake markets clear to determine the world price of these two traded commodities.

In each country, a representative consumer derives utility from consuming an aggregate food-peanut product and peanut oil. Welfare is evaluated by looking at the consumer's equivalent variation, quasi-profits in farming (peanut farming, livestock), quasi-profit in crushing, and taxpayer revenues and outlays implied by distortions.

Country coverage includes Argentina, Canada, China, the EU-15, the Gambia, India, Malawi, Mexico, Nigeria, Senegal, South Africa, the United States, and an aggregate Rest of World. Commodity coverage includes four commodities: food-quality groundnuts, crush-quality groundnuts, groundnut oil, and groundnut cake. The policy coverage reflects the current (2002) level of trade and domestic policies presented in the policy section of the paper. The policy coverage allows an ambitious research program to analyze the separate impact of border measures on groundnuts, oil, and cake in all countries, their combined effects, and domestic policy such as the new U.S. peanut policy. We calibrate the model for three years (1999/2000, 2000/01, and 2001/02) on historical data using Microsoft Excel. Then, the impact of policy scenarios is measured in deviation from the historical baseline expressed in 1995 constant U.S. dollars.

Agricultural Markets (Groundnuts)

Groundnut Supply

For the sake of exposition, we abstract from a country subscript when we present the structure of the country models. When required, we make it clear when aggregation over countries is necessary. In each producing country, the aggregate supply of peanuts, PS, is a function of the current domestic price, P_{pavrg}, which is the average of domestic farmgate prices for food-peanut production, FPS, and crush-peanut production, CPS, or $P_{pavrg}=(CPS/PS)P_{cp}+(1-(CPS/PS))P_{fp}$. A linear specification is chosen for the supply:

$$PS = b_{po} + b_{p1}\, P_{pavw} = b_{po} + b_{p1}[(CPS/PS)P_{cp} + (FPS/PS)P_{fp}]. \qquad (1)$$

Share coefficients (CPS/PS) and (1 – (CPS/PS)) are endogenous and reflect the composition of aggregate output. Estimates of parameters **b** come from the econometric or consensus estimates of supply elasticities depending on availability. This convoluted approach to modeling the aggregate supply decision is motivated by the lack of data on individual land allocation and yield for the two types of peanuts in most countries. Aggregate data are available for land, yield, and supply-price responses; separate data is available for crush-quality peanut and food-quality peanut outputs.

We explain next how domestic price P_{fp} is determined. The farmgate price of food peanuts is a function of the world price of food peanuts expressed in local currency, P_{pw}, inclusive of trade distortions τ_p or $(P_{pw} + \tau_p - tc_p)$, brought back to the farmgate level and scaled down by scalar ψ to reflect the imperfect transmission between world and domestic markets. We include transaction costs affecting the farmgate price from the border, t_{cp}, and domestic policy t_d that may affect the price received by farmers. The domestic producer price for food peanuts is $P_{fp} = \psi(P_{pw} + \tau_p - tc_p) + t_d$. If $\psi = 1$, then full transmission is assumed. We use values between 0.3 and 1 for this scalar parameter.

The crush-quality groundnut price is determined by the domestic equilibrium for crush-quality peanuts, since the latter are treated as a nontraded goods market. Domestic supply satisfies the crush-quality groundnut demand. Relative to crush-quality, food-quality groundnuts receive a quality premium. This price premium is endogenous and driven by cost to reflect the relative marginal cost of food-quality peanuts. The typical premium is such that P_{cp} is between 40 and 50 percent of P_{fp}. As more food peanuts are produced relative to crush peanuts (as in a movement along a food-crush peanut transformation frontier), the premium for food peanuts increases to reflect the higher relative marginal cost of food-quality peanuts. We calibrate the two prices as follows: $P_{cp} = P_{fp}\,(0.42 + 0.05$ CPS/PS)), which reflects the stylized facts of the two prices' relationship.

Price P_{pw} is determined by the equilibrium of the world market for food peanuts. Price P_{cp} is determined by the domestic market equilibrium for crush peanuts (demand=supply), as it is considered a nontraded good. The demand for crush peanuts is explained in what follows.

The change in welfare of peanut producers is measured by the change in realized quasi-profit, from the initial situation reflecting the current distorted prices to a set of new prices. This welfare measure is

$$\Delta\boldsymbol{\Pi}_p = \int_{P^0_{pavrg}}^{P^1_{pavrg}} PS(P_{pavrg})\,dP_{pavrg} \qquad (2)$$

where superscripts 0 and 1 indicate old and new situations.

Groundnut Demand

The total demand for crush-quality peanuts, TPD_c, is a sum of demands coming from seed use, PD_{seed}, and crushing industry use, PD_{crush}:

$$TPD_c = PD_{seed} + PD_{crush}. \quad (3)$$

Seed demand. The seed-derived demand, PD_{seed}, is assumed to be driven by the price of peanuts and the expected production requirement for the year, which for simplicity is assumed to be equal to the actual output for the year. Hence, we assume instantaneous adjustment of seed demand to concurrent production changes. We also assume that the seed demand reflects an economic decision under an agronomic constraint, and we assume that other inputs prices are constant in peanut production:

$$PD_{seed} = \alpha_{s0} + \alpha_{s1}PS + \alpha_{s2}P_{cp}, \quad (4)$$

with α_{s0} denoting the intercept summarizing the effects of other input prices in the cost of peanut production, α_{s1} denoting the seed requirement per unit of output, and α_{s1} denoting the price response of seed demand.

Crush demand. The crush demand, PD_{crush}, is driven by peanut oil demand and/or by cake demand. Given the joint product of oil and cake and the positive economic value attached to cake, the derived demand from crushing reflects both peanut oil and its by-product cake. Groundnut cake is a valuable source of protein feed, especially in developing economies. The derived demand for crush peanuts is driven by the crush margin, b_{crush}:

$$PD_{crush} = PD_{crush}(b_{crush}) \text{ with } b_{crush} = \gamma_{oil} P_o + \gamma_{cake} P_{cake} - P_{cp}. \quad (5)$$

Parameters γ_{oil} and γ_{cake} reflect the jointness of cake and oil in crushing (the oil and cake produced per unit of crushed peanut).

Crush-peanut domestic market equilibrium. The supply and demand for crush peanuts are set equal ($TPD_{crush} = CPS$).

Food-groundnut demand. Food-quality groundnut demand, PD_{food}, represents a single aggregate food use representing several food items in peanut equivalent (such as prepared peanuts, peanut butter, and candies). The final demand for food peanuts is part of an incomplete final demand system for food peanuts and peanut oil, and an aggregate all other goods, based on the Linquad demand system (Lafrance 1998).[2] The system explains final consumption decisions for the two peanut goods as determined by corresponding prices described in a vector $\mathbf{P_{pg}}$, $\mathbf{P_{pg}} = (P_{pp}, P_o)$, and income, M. The demand is

$$PD_{food} = PD_{food}(P_{pp}, P_o, P_{og}, M). \quad (6)$$

Price P_{og} describes the price of an aggregate all other goods. The parameterization of PD_{food} with the Linquad demand system is explained in the section dedicated to the final consumer. The consumer price P_{pp} is the world price of food peanuts inclusive of distortions d_{pp} affecting consumers and a price wedge dictated by transaction cost tc_p. A net importer status would imply an additional transportation margin a_{tp} and $P_{pp} = P_{pw} + d_{pp} + tc_p + a_{tp}$ in the latter case.

Food-peanut domestic market equilibrium. The equilibrium equation is given as

$$DP_f - PS_f = PFPnetrade. \quad (7)$$

Net trade could be either imports or exports. At the world level, the sum over all countries of net trade flows is equal to zero.

Food-peanut world market equilibrium. The sum of excess demands over all countries is equal to zero ($\sum_{all\,i} PFPnetrade_i = 0$) and determines the world price for food-quality peanuts.

The Crushing Industry

Oil and Meal Production

This section describes the modeling of the peanut oil and cake[3] supplies. We make the usual assumption of fixed proportion in the jointness of cake and oil production and price-taking assumptions in oilseed crushing to describe the crushing cost. As the margin increases, the demand for crush peanuts increases. Market equilibrium between the horizontal supply of oil and cake and their respective market demands are such that equation (8) is satisfied. If the marginal cost were higher (lower) than the marginal price, a decrease (increase) in quantity of peanuts crushed would induce a joint movement along the demands for oil and cake to match the new production levels of oil and cake and an increase (decrease) in the industry price of oil and cake, re-establishing equilibrium.

The oil supply, POS, and the cake supply, CakeS, are $POS = \gamma_{oil} PD_{crush}$, and $CakeS = \gamma_{cake} PD_{crush}$. The welfare of the crusher is just the quasi-profit from crushing.

The change in welfare between two policy regimes is just the difference in profits between the two states of the world:

$$\Delta\mathbf{\Pi}_{crush} = PD^{1}_{crush}(b^{1}_{crush}) - PD^{0}_{crush}(b^{0}_{crush}), \tag{8}$$

where margin b^{i}_{crush} is evaluated at prices prevailing in period i.

Peanut Oil and Cake Demand

Peanut oil demand is a final demand coming from the consumer. Peanut oil is one of two peanut goods the final consumer purchases, as earlier explained in the section on food-peanut demand. The oil demand structure is similar to that for prepared-peanut demand:

$$POD = POD(P_{pp}, P_{o}, P_{og}, M). \tag{9}$$

The calibration of POD is explained in the section on the final consumer.

Cake demand is a derived demand from livestock production. Cake or meal demand is an output-constant demand, which is a function of livestock numbers (aggregate livestock animal units, LAU), the price of cake, and the price of other feed products, P_{feed}. We assume that the animal unit numbers and prices of competing feed products are unaffected by the policy reform and we abstract away from them in the policy scenario. The cake demand is

$$CakeD = CakeD(P_{cake}, P_{feed}, LAU). \tag{10}$$

Oil and Cake Domestic Market Equilibria

We assume trade in peanut oil and cake is an excess demand/supply and provides closure in these markets:

$$POD - POS = POnetrade, \tag{11}$$

and

$$CakeD - CakeS = Cakenetrade, \tag{12}$$

with POnetrade and Cakenetrade representing the country import from or export to the world market for the two products.

We link the world price in domestic currency and the domestic price for these two products via a price transmission equation similar to that for the food-peanut price with scalars ψ_{cake} and ψ_{oil}. The equations are

$$P_{cake} = \psi_{cake} (P_{cakew} + \tau_{cake} - tc_{cake}) + t_{pc}, \tag{13}$$

and

$$P_o = \psi_{oil} (P_{ow} + \tau_o - tc_o) + t_{po}, \tag{14}$$

with parameters τ, tc, and t representing price wedge for trade distortions, transaction costs, and domestic policy distortion in these two markets.

Oil and Cake World Market Equilibria

For each product, the sum of excess demand over all countries is equal to zero and determines the world price for the product ($\sum_{all\,i} POnetrade_i = 0$; $\sum_{all\,i} Cakenetrade_i = 0$).

Treatment and Calibration of Final Consumption

We follow the demand calibration approach described in Beghin, Bureau, and Drogué 2003. We have a representative consumer with expenditure function e(**P**, U), with **P** being the vector of relevant consumer prices, and with U denoting utility. We are interested in a vector of two peanut-containing goods, **PGD** = (PPD, POD), that is, prepared peanuts and peanut oil, with prices $\mathbf{P_{pg}}$, $\mathbf{P_{pg}} = (P_{pp}, P_o)$. For completeness, we have an aggregate other goods, OG, with price P_{og}. The approach allows us to derive an exact welfare measure from an incomplete demand system. The price vector **P** is decomposed into $P = (\mathbf{P_{pg}}, P_{og})$, and income is denoted by M, with subscripts indicating the respective commodities. The Linquad expression of the vector of Marshallian demands for agricultural and food goods is

$$\mathbf{PGD}^M = \boldsymbol{\varepsilon} + \mathbf{V}\mathbf{p_{pg}} + \boldsymbol{\chi}(M - \boldsymbol{\varepsilon}'\mathbf{p_{pg}} - \tfrac{1}{2}\mathbf{p_{pg}}'\mathbf{V}\mathbf{p_{pg}} - \delta(p_{og})) \tag{15}$$

corresponding to the expenditure function

$$e(\mathbf{p_{pg}}, p_{og}, u) = \boldsymbol{\varepsilon}'\mathbf{p_{pg}} - \tfrac{1}{2}\mathbf{p_{pg}}'\mathbf{V}\mathbf{p_{pg}} - \delta(p_{og}) + \theta(p_{og}, u)\ \exp(\boldsymbol{\chi}'\mathbf{p_{pg}}). \tag{16}$$

The elements of vectors **ε** and **χ** in equations (15) and (16), together with the elements of matrix **V,** are calibrated using the following procedure. The calibration imposes homogeneity of degree one in prices for e(.) by normalizing $\mathbf{P_{pg}}$ by the Consumer Price Index (CPI). Calibration imposes symmetry of the Hessian of e(.) by imposing symmetry of **V**. Concavity is also imposed by calibration of parameter $\delta(q_{og})$ in (15). Parameters **ε, χ,** and **V** are identified by solving the system of equations:

$$\begin{cases} \dfrac{\partial \mathbf{PGD}}{\partial M} = \boldsymbol{\chi} \\ \dfrac{PGD_i^M - \chi_i M}{\chi_i} = \left((\dfrac{1}{\chi_i} - p_i) \right) \varepsilon_i + \left((\dfrac{p_i}{\chi_i} - \tfrac{1}{2} p_i^2) \right) v_{ii} - \sum_{j \neq i} \varepsilon_j p_j - \sum_{j \neq i} \left((v_{ij} \dfrac{p_j}{\chi_i} - \tfrac{1}{2} p_i p_j) \right) - \tfrac{1}{2} \sum_{j \neq i} \sum_{k \neq i} v_{jk} p_j p_k \\ \dfrac{\partial PGD_i^M}{\partial p_j} = v_{ij} - \chi_i \varepsilon_j - \chi_i \sum_{allk} v_{jk} P_k \\ \dfrac{\partial PGD_i^M}{\partial p_i} = v_{ii}(1 - \chi_i p_i) - \chi_i \varepsilon_i - \chi_i \sum_{i \neq j} v_{ij} p_j, \end{cases} \tag{17}$$

where the derivatives $\partial PGDi/\partial p_j$ are estimated thanks to prior information on local elasticities at the reference point, denoted by a bar above the variables. Parameter δ is set to zero if curvature conditions are satisfied (see Beghin, Bureau, and Drogué 2003 for details), or M – δ = M. The calibration is sequential. First, the elements of χ, i.e., the slope of income response of consumption of peanut goods, are calibrated using estimates of the income demand elasticities. Then, the estimated χ is used in the next three equations in (17), which are then linear in unknown parameters ε and **V**. Elements ν_{ik} are set equal to zero for cross-price responses $\partial PGD_i/\partial p_k$ for which no prior information is known. This procedure allows accommodation of various stages of knowledge on cross-price effects in an integrable system of demands. Each additional known cross-price response corresponds to a new equation for a new $\nu_{ik.}$ The system of equations (17) is exactly identified if curvature is met. Calibration makes it possible to express the functional form of the Marshallian demand system (15), and to retrieve the right-hand side of the derivatives shown. The expression

$$\frac{\partial \mathbf{PGD}^H}{\partial \mathbf{P_{pg}}} = \mathbf{V} + \boldsymbol{\chi}(M - \boldsymbol{\varepsilon}'\mathbf{P_{pg}} - \tfrac{1}{2}\mathbf{P_{pg}}'\mathbf{V}\mathbf{P_{pg}})\boldsymbol{\chi}'$$

for the Linquad Hicksian price response is derived from the Slutsky identity, with the calibrated values of the elements of **V** and **ε**.

Welfare Analysis

Equations (15) and (16) lead to an equivalent variation, EV, equal to

$$\text{EV} = [\text{M} - \boldsymbol{\varepsilon}'\mathbf{P^1_{pg}} - 0.5\ \mathbf{P^1_{pg}}'\mathbf{V}\ \mathbf{P^1_{pg}}]\ \exp[(\boldsymbol{\chi}\mathbf{P^0_{pg}} - \boldsymbol{\chi}\mathbf{P^1_{pg}}] \qquad (18)$$

$$- [\text{M} - \boldsymbol{\varepsilon}_{\mathbf{pg}}'\mathbf{P^0_{pg}} - 0.5\ \mathbf{P^0_{pg}}'\mathbf{V}\ \mathbf{P^0_{pg}}].$$

We compute the change in expenditure, which would keep utility at the free-trade utility level under the distorted program prices. Superscripts 0 and 1 denote initial distorted and final free-trade prices.

Taxpayers

With policy reforms, there is a potential change in tax revenues associated with the trade of food peanuts, oil, and cake. These changes are captured by the accounting identity (new flow × new tax rates × new prices – old flows × old tax rates × old prices).

Net Welfare Gains from Policy Reform

Net welfare is defined as the EV of the consumer net of losses/gains to peanut producers, changes in livestock producers' surplus, changes in profits in crushing, and gains (losses) for taxpayers.

Calibration

Production, Utilization, and Trade Data

We use the Production, Supply, and Distribution (PS&D) data of the U.S. Department of Agriculture, Foreign Agricultural Service (USDA-FAS 2003a) to calibrate production, utilization, and trade of peanuts and products for three years (1999/2000–2001/02). The latter dataset is completed by Food and Agriculture Organization data whenever USDA-FAS PS&D is not available.

The macro data consist of gross domestic product (GDP) (as a proxy for income), a GDP deflator (a proxy for the CPI), and the exchange rate. They come from the International Monetary Fund's *International Financial Statistics* (IMF 2001) and the World Bank's *World Development Indicators* database (World Bank 2003). The baseline and simulations were run for the three years and averaged.

Policy Instruments

Table 1 presents the parameterized policy instruments by country. The description of these policies is presented in detail in Diop, Beghin, and Sewadeh 2003. The coverage of border measures is extensive. The coverage of domestic distortions (farm support, other taxes/subsidies) is spotty despite a long search through World Bank sources and Attaché Reports of the USDA-FAS (2003b). Domestic distortions in OECD (Organization for Economic Cooperation and Development) countries are documented but are harder to collect for developing economies. We cover the major features of the new U.S. farm legislation on peanuts (loan rate and countercyclical payments based on target price). Trade protection in the United States is not effective since preferential imports of peanuts could enter at zero tariffs and the current tariff rate quota (TRQ) is underfilled. Hence, the high tariffs for out-of-quota peanut imports do not apply in this case.

Domestic price wedges such as value-added taxes are available for a few countries (e.g., China) but are not covered systematically. India and China have the highest protection levels, including a strong protection of value-added activities. Given the strong governmental presence in peanut markets in these two countries, it is hard to know exactly what protection levels are provided to farmers. Some African countries have some border protection on oil and prepared-peanut products to protect their domestic value-added activities.

TABLE 1. Current trade and domestic policy parameters used in the model

Country	Commodity	Description	Unit	99/00	00/01	01/02
Argentina	Peanuts	Export tax	% of border price	3.5	3.5	3.5
Argentina	Peanut meal	Export rebate	%	3.2	3.2	3.2
Argentina	Peanut oil	Export rebate	%	2.3	2.3	2.3
EU-15	Peanut oil	Import tariff	%	6.4	6.4	6.4
EU-15	Peanut oil	Import subsidy for oil from Senegal	%	10.0	10.0	10.0
China	Peanuts	Import tariff	%	30.0	30.0	30.0
China	Peanuts	Value-added tax	%	17.0	17.0	17.0
China	Peanut meal	Tariff	%	5.0	5.0	5.0
China	Peanut oil	Tariff	%	9.7	9.7	9.7
China	Peanut oil	Value-added tax	%	17.0	17.0	17.0
India	Peanuts	Tariff	%	44.0	44.0	44.0
India	Peanut meal	Tariff	%	45.0	45.0	45.0
India	Peanut oil	Tariff refined oil	%	35.0	35.0	35.0
Rest of world	Peanuts	Tariff	%	5.4	5.4	5.4
Rest of world	Peanut meal	Tariff	%	0.0	0.0	0.0
Rest of world	Peanut oil	Tariff	%	0.0	0.0	0.0
Canada	Peanuts	Tariff	%	0.0	0.0	0.0
Mexico	Peanuts	Tariff	%	0.0	0.0	0.0
Senegal	Peanuts	Tariff	%	5.0	5.0	5.0
Senegal	Peanuts	Tariff on processed	%	20.0	20.0	20.0
Senegal	Peanut meal	Tariff	%	0.0	0.0	0.0
Senegal	Peanut oil	Tariff refined oil	%	20.0	20.0	20.0
Nigeria	Peanuts	Tariff	%	0.0	0.0	0.0

TABLE 1. Continued

Country	Commodity	Description	Unit	99/00	00/01	01/02
Nigeria	Peanut meal	Tariff	%	0.0	0.0	0.0
Nigeria	Peanut oil	Tariff refined oil	%	0.0	0.0	0.0
Republic of South Africa	Peanuts	Tariff	%	0.0	0.0	0.0
Republic of South Africa	Peanuts	Tariff processed peanut food	%	6.0	6.0	6.0
Republic of South Africa	Peanut meal	Tariff	%	0.0	0.0	0.0
Republic of South Africa	Peanut oil	Tariff refined oil	%	0.0	0.0	0.0
Malawi	Peanuts	Tariff	%	5.0	5.0	5.0
Malawi	Peanuts	Tariff processed for consumption	%	25.0	25.0	25.0
Malawi	Peanut meal	Tariff	%	0.0	0.0	0.0
Malawi	Peanut oil	Tariff refined oil	%	20.0	20.0	20.0
Gambia	Peanuts	Tariff	%	0.0	0.0	0.0
Gambia	Peanut meal	Tariff	%	0.0	0.0	0.0
Gambia	Peanut oil	Tariff refined oil	%	0.0	0.0	0.0
U.S.	Peanuts	*Out-of-quota tariffs*				
U.S.	Peanuts	Shelled, out-of-quota tariffs	%	140	136	132
U.S.	Peanuts	In-shell out-of-quota tariffs	%	173	169	164
U.S.	Peanuts	Duty-free imports from Mexico	1,000 mt	3.9	4.0	4.2

TABLE 1. Continued

Country	Commodity	Description	Unit	99/00	00/01	01/02
U.S.	Peanuts	*Mexico above-quota tariffs*				
U.S.	Peanuts	Shelled peanuts (port price<$652/mt)	$/mt	685.1	665.6	591.6
U.S.	Peanuts	Shelled peanuts (port price>$652/mt)	%	105	102	99
U.S.	Peanuts	In-shell peanuts (port price<$284/mt)	$/mt	452.4	439.5	390.6
U.S.	Peanuts	In-shell peanuts (port price>$284/mt)	%	159	154	150
U.S.	Peanuts	*GATT schedule of U.S. peanut imports (shelled basis)*				
U.S.	Peanuts	Argentina	1,000 mt	43.9	43.9	43.9
U.S.	Peanuts	Mexico	1,000 mt	3.9	4.0	4.2
U.S.	Peanuts	Others	1,000 mt	9.0	9.0	9.0
U.S.	Peanuts	Total TRQ	1,000 mt	56.8	56.9	57.1
U.S.	Peanuts	Domestic target price	$/lb	0.2475	0.2475	0.2475
U.S.	Peanuts	Domestic producer price at qualibration	$/lb	0.254	0.274	0.234
U.S.	Peanuts	Domestic fixed payment (fully coupled)	$/lb	0.018	0.018	0.018
U.S.	Peanuts	Domestic loan rate scaled up 1.1 for annual average	$/lb	0.1775	0.1775	0.1775
U.S.	Peanut meal	Tariff	%	0	0	0
U.S.	Peanut oil	Tariff	%	0	0	0

Supply and Demand Elasticities

Table 2 shows the various elasticities used in the model. Most of the elasticities come from the elasticity database of the Food and Agricultural Policy Research Intitute (FAPRI) models and are a combination of econometric and consensus estimates. Both demand and supply are price inelastic. Income elasticities are positive but smaller than one. These values are consistent with common wisdom on the price responsiveness of agricultural markets.

Illustrative Policy Reform Scenario

We illustrate the model capability with a simple but telling scenario.[4] We consider multilateral peanut trade liberalization for peanuts, holding meal and oil tariffs at their baseline values. Many debates of the Doha Round of the WTO evolve around narrow agricultural negotiations. Hence, it is useful to assess what a narrow agricultural liberalization would achieve relative to a full trade liberalization encompassing value-added products (oil and cake). We call this scenario PMTL (peanut multilateral trade liberalization). We report results in Tables 3 and 4. All results from changes in price and physical flows are reported in percentage changes from the baseline. Changes in welfare are reported in 1995 purchasing power parity (PPP) in U.S. dollars. The baseline and simulations were run for three years (1999–2001) and averaged. Much is achieved by peanut trade liberalization alone but with a large second-best component since distortions are present in the value-added markets. In this peanut liberalization scenario, the price of peanuts goes up by 18 percent. However, world prices for cake and oil are little affected, increasing by 0.5 percent and 2 percent respectively. Crush margins are primarily affected by changes in peanut prices. Margins improve in India and China but deteriorate in countries with no or small oil and cake distortions. Consumer welfare implications are as follows. In highly protected peanut markets, food-peanut prices are lower with the PMTL scenario and consumers benefit. In countries with no peanut distortions, peanut prices increase and hurt consumers. Oil prices increase by a small amount, and the welfare effects of the latter are negative but moderate. African economies benefit marginally from this scenario because they still are handicapped by the protection of value-added markets prevailing in several large countries, namely China and India. The potential welfare gains for the Africa-5 total about $56 million.[5]

TABLE 2. Elasticities used in the model

Country	Commodity	Activity	Elasticity	Value
Argentina	Peanuts	Supply	Own-price	0.3
Argentina	Peanuts	Food demand	Own-price	-0.2
Argentina	Peanuts	Food demand	Income	0.4
Argentina	Peanuts	Crush demand	Crush-margin elasticity	0.2
Argentina	Peanuts	Seed demand	Own-price	-0.3
Argentina	Peanuts	Seed demand	Output	0.8
Argentina	Peanuts	Inventory demand	Own-price	-0.9
Argentina	Peanut meal	Feed-derived demand	Own-price	-0.3
Argentina	Peanut meal	Inventory demand	Own-price	-0.6
Argentina	Peanut oil	Final demand	Own-price	-0.5
Argentina	Peanut oil	Final demand	Income	0.4
Argentina	Peanut oil	Inventory demand	Own-price	0.5
EU-15	Peanuts	Supply	Own-price	na
EU-15	Peanuts	Food demand	Own-price	-0.36
EU-15	Peanuts	Food demand	Income	0.3
EU-15	Peanuts	Crush demand	Crush-margin elasticity	0.15
EU-15	Peanuts	Seed demand	Own-price	na
EU-15	Peanuts	Seed demand	Output	na
EU-15	Peanuts	Inventory demand	Own-price	-0.95
EU-15	Peanut meal	Feed-derived demand	Own-price	-0.41
EU-15	Peanut meal	Inventory demand	Own-price	-0.9
EU-15	Peanut oil	Final demand	Own-price	-0.375
EU-15	Peanut oil	Final demand	Income	0.2
EU-15	Peanut oil	Inventory demand	Own-price	-0.9
China	Peanuts	Supply	Own-price	0.38
China	Peanuts	Food demand	Own-price	-0.15
China	Peanuts	Food demand	Income	0.3
China	Peanuts	Crush demand	Crush-margin elasticity	0.13
China	Peanuts	Seed demand	Own-price	-0.1
China	Peanuts	Seed demand	Output	0.85
China	Peanuts	Inventory demand	Own-price	na
China	Peanut meal	Feed-derived demand	Own-price	-0.35
China	Peanut meal	Inventory demand	Own-price	na
China	Peanut oil	Final demand	Own-price	-0.25
China	Peanut oil	Final demand	Income	0.175
China	Peanut oil	Inventory demand	Own-price	na

TABLE 2. Continued

Country	Commodity	Activity	Elasticity	Value
India	Peanuts	Supply	Own-price	0.35
India	Peanuts	Food demand	Own-price	-0.38
India	Peanuts	Food demand	Income	0.9
India	Peanuts	Crush demand	Crush-margin elasticity	0.26
India	Peanuts	Seed demand	Own-price	0.2
India	Peanuts	Seed demand	Output	0.9
India	Peanuts	Inventory demand	Own-price	na
India	Peanut meal	Feed-derived demand	Own-price	-0.35
India	Peanut meal	Inventory demand	Own-price	na
India	Peanut oil	Final demand	Own-price	-0.35
India	Peanut oil	Final demand	Income	0.3
India	Peanut oil	Inventory demand	Own-price	na
Rest of World	Peanuts	Supply	Own-price	0.35
Rest of World	Peanuts	Food demand	Own-price	-0.25
Rest of World	Peanuts	Food demand	Income	0.2
Rest of World	Peanuts	Crush demand	Crush-margin elasticity	0.15
Rest of World	Peanuts	Seed demand	Own-price	-0.35
Rest of World	Peanuts	Seed demand	Output	0.7
Rest of World	Peanuts	Inventory demand	Own-price	-0.12
Rest of World	Peanut meal	Feed-derived demand	Own-price	-0.4
Rest of World	Peanut meal	Inventory demand	Own-price	-0.75
Rest of World	Peanut oil	Final demand	Own-price	-0.375
Rest of World	Peanut oil	Final demand	Income	0.9
Rest of World	Peanut oil	Inventory demand	Own-price	-0.775
Canada	Peanuts	Supply	Own-price	na
Canada	Peanuts	Food demand	Own-price	-0.4
Canada	Peanuts	Food demand	Income	0.4
Canada	Peanuts	Crush demand	Crush-margin elasticity	na
Canada	Peanuts	Seed demand	Own-price	na
Canada	Peanuts	Seed demand	Output	na
Canada	Peanuts	Inventory demand	Own-price	-0.83
Canada	Peanut meal	Feed-derived demand	Own-price	na
Canada	Peanut meal	Inventory demand	Own-price	na
Canada	Peanut oil	Final demand	Own-price	na
Canada	Peanut oil	Final demand	Income	na

TABLE 2. Continued

Country	Commodity	Activity	Elasticity	Value
Canada	Peanut oil	Inventory demand	Own-price	na
Mexico	Peanuts	Supply	Own-price	0.23
Mexico	Peanuts	Food demand	Own-price	-0.3
Mexico	Peanuts	Food demand	Income	0.4
Mexico	Peanuts	Crush demand	Crush-margin elasticity	na
Mexico	Peanuts	Seed demand	Own-price	na
Mexico	Peanuts	Seed demand	Output	na
Mexico	Peanuts	Inventory demand	Own-price	na
Mexico	Peanut meal	Feed-derived demand	Own-price	na
Mexico	Peanut meal	Inventory demand	Own-price	na
Mexico	Peanut oil	Final demand	Own-price	na
Mexico	Peanut oil	Final demand	Income	na
Mexico	Peanut oil	Inventory demand	Own-price	na
Senegal	Peanuts	Supply	Own-price	0.35
Senegal	Peanuts	Food demand	Own-price	-0.2
Senegal	Peanuts	Food demand	Income	0.6
Senegal	Peanuts	Crush demand	Crush-margin elasticity	0.35
Senegal	Peanuts	Seed demand	Own-price	-0.2
Senegal	Peanuts	Seed demand	Output	0.9
Senegal	Peanuts	Inventory demand	Own-price	-0.55
Senegal	Peanut meal	Feed-derived demand	Own-price	-0.35
Senegal	Peanut meal	Inventory demand	Own-price	-0.85
Senegal	Peanut oil	Final demand	Own-price	-0.5
Senegal	Peanut oil	Final demand	Income	0.3
Senegal	Peanut oil	Inventory demand	Own-price	na
Nigeria	Peanuts	Supply	Own-price	0.35
Nigeria	Peanuts	Food demand	Own-price	-0.2
Nigeria	Peanuts	Food demand	Income	0.3
Nigeria	Peanuts	Crush demand	Crush-margin elasticity	0.2
Nigeria	Peanuts	Seed demand	Own-price	-0.2
Nigeria	Peanuts	Seed demand	Output	0.9
Nigeria	Peanuts	Inventory demand	Own-price	-0.85
Nigeria	Peanut meal	Feed-derived demand	Own-price	-0.35
Nigeria	Peanut meal	Inventory demand	Own-price	na
Nigeria	Peanut oil	Final demand	Own-price	-0.38

TABLE 2. Continued

Country	Commodity	Activity	Elasticity	Value
Nigeria	Peanut oil	Final demand	Income	0.6
Nigeria	Peanut oil	Inventory demand	Own-price	na
South Africa	Peanuts	Supply	Own-price	0.35
South Africa	Peanuts	Food demand	Own-price	-0.2
South Africa	Peanuts	Food demand	Income	0.6
South Africa	Peanuts	Crush demand	Crush-margin elasticity	0.2
South Africa	Peanuts	Seed demand	Own-price	-0.2
South Africa	Peanuts	Seed demand	Output	0.9
South Africa	Peanuts	Inventory demand	Own-price	-0.85
South Africa	Peanut meal	Feed-derived demand	Own-price	-0.35
South Africa	Peanut meal	Inventory demand	Own-price	na
South Africa	Peanut oil	Final demand	Own-price	-0.38
South Africa	Peanut oil	Final demand	Income	0.3
South Africa	Peanut oil	Inventory demand	Own-price	na
Malawi	Peanuts	Supply	Own-price	0.35
Malawi	Peanuts	Food demand	Own-price	-0.2
Malawi	Peanuts	Food demand	Income	0.6
Malawi	Peanuts	Crush demand	Crush-margin elasticity	0.2
Malawi	Peanuts	Seed demand	Own-price	-0.2
Malawi	Peanuts	Seed demand	Output	0.9
Malawi	Peanuts	Inventory demand	Own-price	-0.85
Malawi	Peanut meal	Feed-derived demand	Own-price	-0.35
Malawi	Peanut meal	Inventory demand	Own-price	-0.85
Malawi	Peanut oil	Final demand	Own-price	-0.38
Malawi	Peanut oil	Final demand	Income	0.3
Malawi	Peanut oil	Inventory demand	Own-price	na
Gambia	Peanuts	Supply	Own-price	0.35
Gambia	Peanuts	Food demand	Own-price	-0.2
Gambia	Peanuts	Food demand	Income	0.6
Gambia	Peanuts	Crush demand	Crush-margin elasticity	0.2
Gambia	Peanuts	Seed demand	Own-price	-0.2
Gambia	Peanuts	Seed demand	Output	0.9
Gambia	Peanuts	Inventory demand	Own-price	-0.85
Gambia	Peanut meal	Feed-derived demand	Own-price	-0.35
Gambia	Peanut meal	Inventory demand	Own-price	-0.85

TABLE 2. Continued

Country	Commodity	Activity	Elasticity	Value
Gambia	Peanut oil	Final demand	Own-price	-0.38
Gambia	Peanut oil	Final demand	Income	0.3
Gambia	Peanut oil	Inventory demand	Own-price	-0.375
U.S.	Peanuts	Supply	Own-net return	0.35
U.S.	Peanuts	Food demand	Own-price	-0.2
U.S.	Peanuts	Food demand	Income	0.3
U.S.	Peanuts	Crush demand	Crush-margin elasticity	0.25
U.S.	Peanuts	Seed demand	Own-price	-0.2
U.S.	Peanuts	Seed demand	Output	0.9
U.S.	Peanuts	Inventory demand	Own-price	-0.55
U.S.	Peanut meal	Feed-derived demand	Own-price	-0.35
U.S.	Peanut meal	Inventory demand	Own-price	-0.85
U.S.	Peanut oil	Final demand	Own-price	-0.25
U.S.	Peanut oil	Final demand	Income	0.15
U.S.	Peanut oil	Inventory demand	Own-price	-0.85

TABLE 3. Impact of peanut trade liberalization (PMTL scenario)

	New Levels After Reform			Baseline Levels			Average Change
	99/00	**00/01**	**01/02**	**99/00**	**00/01**	**01/02**	**for 3 years**
Peanut trade							
Net exporters							
Argentina	292	239	299	226	177	185	42%
China	-224	-348	-143	540	450	525	-149%
Gambia	15	20	21	8	11	1	68%
India	-421	-474	-342	100	100	125	-490%
Malawi	4.0	5.2	4.3	2	3	3	71%
Nigeria	150	167	168	0	0	0	16,191%
Senegal	44	42	27	2	4	5	1,163%
South Africa	33	26	41	20	16	35	49%
U.S.	512	390	431	255	141	231	1121%
Total net exports	405	67	507	1,153	902	1,124	-71%
Net importers							
Canada	107	97	102	116	107	110	-8%
European Union	419	408	435	457	441	463	-7%
Mexico	88	58	65	101	72	75	-15%
Rest of World	-398	-505	-157	290	272	415	-220%
Residual	189	10	61	189	10	61	0%
Total Net Imports	405	67	507	1,153	902	1,124	-71%
Peanut price:							
U.S. runners 40/50%							
CIF Rotterdam	963	1,051	822	820	888	700	18%

TABLE 3. Continued

	New Levels After Reform			Baseline Levels			Average Change
	99/00	**00/01**	**01/02**	**99/00**	**00/01**	**01/02**	**for 3 years**
Peanut meal trade							
Net exporters							
Argentina	62.48	44.74	43.45	67.00	50.00	52.00	-11%
China	48.92	56.35	62.30	9.00	15.00	25.00	290%
Gambia	4.78	9.71	9.85	5.00	10.00	10.00	-3%
India	95.46	123.48	170.79	10.00	20.00	100.00	481%
Malawi	-0.08	-0.08	-0.04	0.00	0.00	0.00	-7%
Nigeria	-3.09	-3.43	-3.04	0.00	0.00	0.00	-318%
Senegal	126.68	139.86	137.69	130.00	144.00	140.00	-2%
South Africa	-5.12	-0.24	-0.09	-5.00	0.00	0.00	-10%
U.S.	-36.80	-43.78	-31.42	6.00	5.00	5.00	-806%
Rest of World	-61.78	-66.96	-68.71	8.00	14.00	-12.00	-326%
Total net exports	231.45	259.66	320.79	230.00	258.00	320.000	0.5%
Net importers							
European Union	187	196	179	186	194	178	1%
Residual	44	64	142	44	64	142	0%
Total net imports	231	260	321	230	258	320	1%
Peanut meal price: 48/50%							
CIF Rotterdam	123	135	126	122	134	125	0.5%

TABLE 3. Continued

	New Levels After Reform			Baseline Levels			Average Change
	99/00	**00/01**	**01/02**	**99/00**	**00/01**	**01/02**	**for 3 years**
Peanut oil trade							
Net exporters							
Argentina	43	37	36	46	41	42	-10%
China	35	41	33	0	5	2	1,933%
Gambia	0.02	0.00	0.11	0	0	0	4%
India	63	76	53	0	0	0	6,402%
Malawi	-0.014	-0.010	0.007	0.000	0.000	0.000	-1%
Nigeria	32	31	26	35	35	30	-10%
Senegal	95	99	107	98	102	109	-2%
South Africa	0	0	0	0	0	0	-3%
U.S.	-31	-68	-39	2	-30	-10	-420%
Rest of World	-37	-51	-37	18	11	8	-477%
Total net exports	200	165	182	199	164	181	0%
Net importers							
European Union	151	111	121	150	110	120	1%
Residual	49	54	61	49	54	61	0%
Total net imports	200	165	182	199	164	181	0%
Peanut oil price:							
CIF Rotterdam	756	697	669	744	685	659	1.7%
Welfare	0.0008	632	759	561			651

TABLE 4. Welfare effects of the PMTL policy scenario (in million $ at 1995 prices)

Country	**PMTL (Average 1999-2001)**
Argentina	21
EU-15	-75
China	349
India	167
Rest of world	107
Canada	-10
Mexico	-13
Senegal	26
Nigeria	19
South Africa	3
Malawi	7
Gambia	1
U.S.	48
Africa-5 total[a]	56
Total	651

[a] Denotes the aggregate of Senegal, Nigeria, South Africa, Malai, and the Gambia.

For the large protectionist countries (e.g., China and India), the net effect of the peanut price increase and removal of protection is beneficial to final users of peanuts, other things being equal. Peanut imports expand in these countries. For countries with moderate or no protection before the reforms, the net impact (tariff removal and terms of trade) is an increase in domestic prices of peanuts, handicapping peanut users (final consumers and crushers). These substantial terms-of-trade effects have a large impact on trade and complicate the welfare impact of the reforms since allocative efficiency gains can be offset by large price increases originating in post-reform world markets.

Crush margins deteriorate in the European Union, India, Malawi, Senegal, and the United States. However, margins improve in China, the Gambia, Nigeria, and South Africa. Countries facing deteriorating margins but that have a competitive peanut production expand their production and exports of peanuts (e.g., Senegal and the United States) but reduce their exports of processed products.

Trade patterns change dramatically. Table 4 shows the welfare impact of the reforms by country. China and India experience trade reversal, becoming large importers of peanuts. The aggregate net welfare effects amount to about $650 million at 1995 prices. Not surprisingly, China and India experience the largest welfare gains, because they have the two most distorted peanut product markets. The "moderate" world welfare effect first comes from offsets (some countries gain in aggregate whereas others, chiefly the EU-15, lose).

Conclusions

This paper presented a new international peanut product model with important and novel features that set new standards in peanut market modeling in the context of severe data limitations on the production, utilization, and trade of value-added peanut products. The model provides an explicit world price determination via world market clearing. The model distinguishes crush- and food-quality peanuts by treating crush peanuts as a nontraded commodity and by incorporating an endogenous quality premium for food-quality peanuts in each country. Food-quality peanuts are traded internationally.

World prices transmit to domestic market via a price transmission equation incorporating the exchange rate, transportation margins, policy instruments, and an implicit discount for quality and transaction costs. In addition, consumer choices are approached in a consistent fashion and reflect consumption decisions on oil and food peanuts, leading to an exact consumer welfare measure.

The policy coverage is also extensive, including tariffs and taxes for most countries and the new (2002) U.S. peanut program. Finally, the country coverage is unique and includes five African countries.

We illustrate the model's capability with a peanut trade liberalization scenario, which shows the intricate linkages between the four markets and the welfare effects for individual countries.

Endnotes

1. We use the terms *peanut* and *groundnut* interchangeably.

2. Some other oils could be easily added to the demand system, if ever an expanded investigation covered other oils (e.g., soy, sunflower, and rapeseed oils).

3. We use the terms *cake* and *meal* interchangeably.

4. An extensive analysis of further policy reforms is provided in Diop, Beghin, and Sewadeh 2003.

5. Africa-5 denotes our aggregate of the Gambia, Malawi, Nigeria, Senegal, and South Africa.

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