FAPRI Trade Model for the Soybean Sector: Specification, Estimation, and Validation

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Introduction

The international components and the overall structure of this model are based on recent work by Huyser (1983). The U.S. structure and components of the model are based on recent work by Ash (1984) and earlier work by Baumes and Meyers (1980) and Meyers and Hacklander (1979). The roots of all these models trace back to the seminal work on the soybean industry by Houck, Ryan, and Subotnik (1972). A review of related modeling work in the soybean sector can be found in Huyser and Ash.

The purpose of this paper is to briefly outline the structure and components of the model and present the specifications, parameter estimates, and validation statistics for the current operation model. The first section provides the conceptual framework for the model and a generalized specification. The second section discusses the specific submodel specifications and parameter estimates. The last section presents the validation statistics.

Structure and Components of the Model

The soybean trade model endogenizes the demand and supply of soybeans, soymeal, and soyoil in the United States; the demand and supply of soybeans and soymeal in Brazil and Argentina; and the demand of soybeans and soymeal in the EC-10, Spain, Japan, Eastern Europe, and an aggregate of the rest of the world market economies. The net trade of the USSR and Peoples Republic of China (PRC) are explicit but exogenous. Price of soybeans, soymeal, and soyoil are endogenously determined by the market clear conditions. Those countries for which parameters have not been directly estimated with econometric techniques have been assigned price and income response elasticities based on the best judgement of trade modeling specialists. These elasticities are converted to net import elasticities and reported in Appendix Table A.1.

The soybean sector trade model can be characterized as a dynamic nonspatial equilibrium model. The basic elements of a nonspatial equilibrium supply and demand model are illustrated in Figure 1. Net imports and exports are determined in the model but not trade flows between specific regions. The summation of net demands of importers (EDT) less the net supplies of other exporters (ESO) is the net excess demand facing the U.S. market (EDN). The necessary components of this model are detailed in the equations below:

(1) $EDT = \Sigma\ DM_i - \Sigma\ SM_i = \Sigma\ f_i(P_i,\ X_i) - \Sigma\ h_i(P_i,\ Z_i)$ $i = 1,..,n$ Importers

(2) $ESO = \Sigma\ SX_j - \Sigma\ DX_j = \Sigma\ h_j(P_j,\ Z_j) - \Sigma\ f_j(P_j,\ X_j)$ $j = 1,..,m$ Exporters

(3) $ESUS = h_u(P_u,\ Z_u) - f_u(P_u,\ X_u)$ United States Exports

(4) $ESUS = EDT - ESO$ World Market Equilibrium

(5) $P_i = P_u e_i + M_i$ $i = 1,..,n$

(6) $P_j = P_u e_j + M_j$ $j = 1,..,m$

where

DM = importer demand
DX = exporter demand
e = exchange rate
M = trade margin (transport cost, tariff, subsidy, etc.)
P = domestic price
SM = importer supply
SX = exporter supply
X = vector of demand shifters
Z = vector of supply shifters

The soybean sector is more complex than depicted here because it includes three distinct but closely related markets for the soybean and its two products, soymeal and soyoil.

Country or Regional Submodels

Among all the submodels, the U.S. model is the most complete. It is designed to incorporate three important characteristics of soybeans and soybean products:[1]

[1] Houck, Ryan, and Subotnik, pp. 69-70

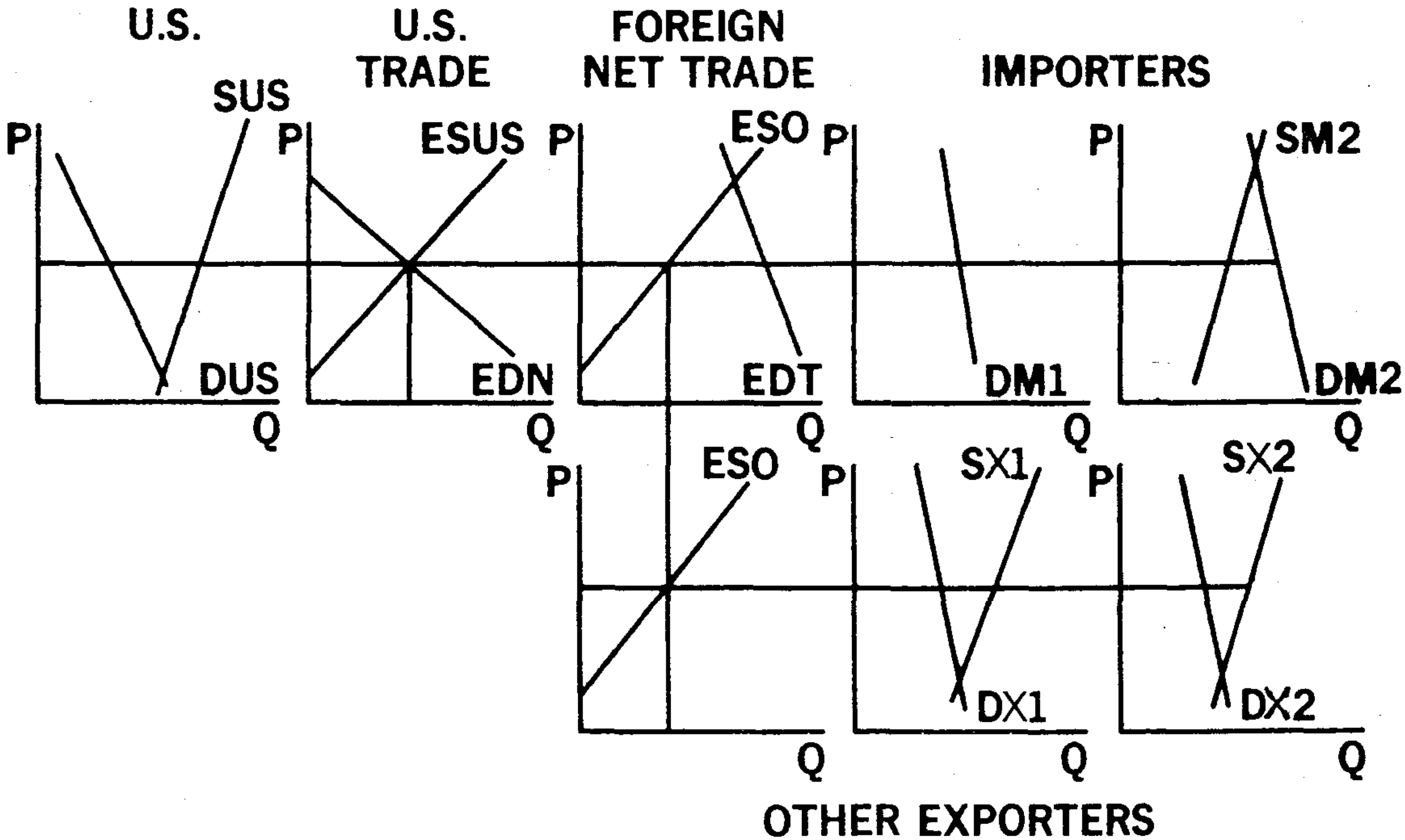

FIGURE 1. Illustration of Regional Supply and Demand Model

a. Soybean meal and oil are joint products of the soybean crushing industry and there is very little year-to-year change in the quantity of meal and oil produced from a bushel of beans.

b. Soybeans, as well as the meal and oil products have domestic use, export, and inventory demand components. Except for small quantities used for seed and feed, the domestic soybean use is for crushing.

c. The prices of soybeans, meal, and oil and the allocation of available supplies among market alternatives are simultaneously determined due to the joint product relationship.

The model structure of the U.S. components is shown in Figure 2. All quantities in Figure 2 are expressed in soybean equivalents to simplify the linkage between bean, meal, and oil sectors. The equilibrium prices and quantities are shown in broken lines. The price of soybeans is determined at (4) by the intersection of total bean demand[2] with bean supply. The interaction with meal and oil prices occurs in the crush (1) and export (2) markets, where higher product prices shift the demand for beans upward. (Hence the crush demand, export demand, and total demand schedules are represented as broken lines.) Higher meal and oil prices simultaneously reduce market demand for these products. These interacting forces are all reflected in the equilibrium levels. The equilibrium level of crush (1) determines the supplies of meal (5) and oil (9). The intersections of these supply levels with meal and oil demand determine meal and oil prices.

The basic structure of this model is similar to that of Houck, Ryan, and Subotnik (1972) except for two notable differences. First, the crushing margin was exogenous in the earlier model and is endogenous here. Second, this model incorporates a simultaneous interaction between expected production for the next crop year and carryover stocks at the end of the current crop year.

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[2]The horizontal portion of the bean stocks demand (3) represents a perfectly elastic government demand for stocks at the support price level.

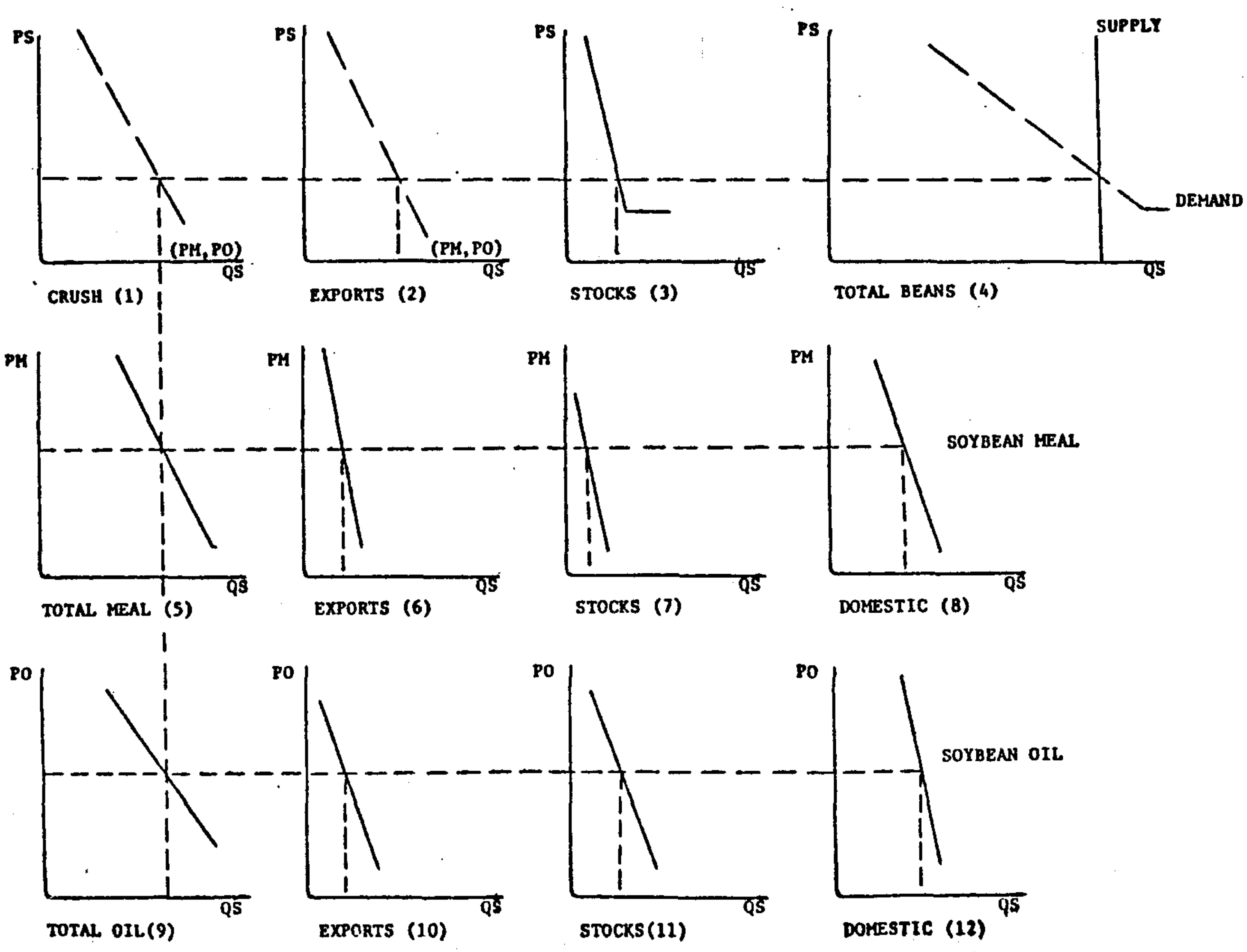


FIGURE 2. Graphical representation of the soybean demand model (all quantities in bean equivalents)

The process by which the model adjusts to an exogenous shock is shown in Figure 3, which illustrates the model response to a lower soybean crop yield. The old equilibrium is drawn in solid lines and the new equilibrium in broken lines. The supply reduction raises the bean price, which reduces demand in all bean markets. One result is a lower crush, which reduces meal and oil supplies and increases their prices. The higher meal and oil prices make crushing more profitable in the United States and abroad, so crush and export demands shift upward. The latter is a secondary effect and the equilibrium levels of crush and export demand still show a net decline. So a soybean supply reduction increases all prices and reduces quantities in all markets. This comparative static exercise indicates only the directions of change in variables, but the model impact multipliers presented in the last section assign magnitudes to these changes.

The soybean supply component consists of an aggregate acreage response function for the United States and exogenous levels of yield per acre. The supply component interacts with demand in two ways:

a. Prices in the current marketing year influence acreage planted during the year, which in turn affects supply and prices the succeeding year.

b. Acreage planted during the marketing year indicates to inventory holders the probable supply and price levels for the following year and thereby affects ending stock levels for soybeans and oil.[3] As a consequence of the acreage effect on ending stocks, planted acreage (for next year's harvest) is simultaneously determined with current price and utilization levels.

A brief reference to Figure 3 will illustrate this interaction. The increase in the equilibrium bean price shown in Figure 3 induces increased planting. The expected increase in the next year's supply causes inventory

[3] Meal does not have a long storage life and is generally only held to cover transaction needs.

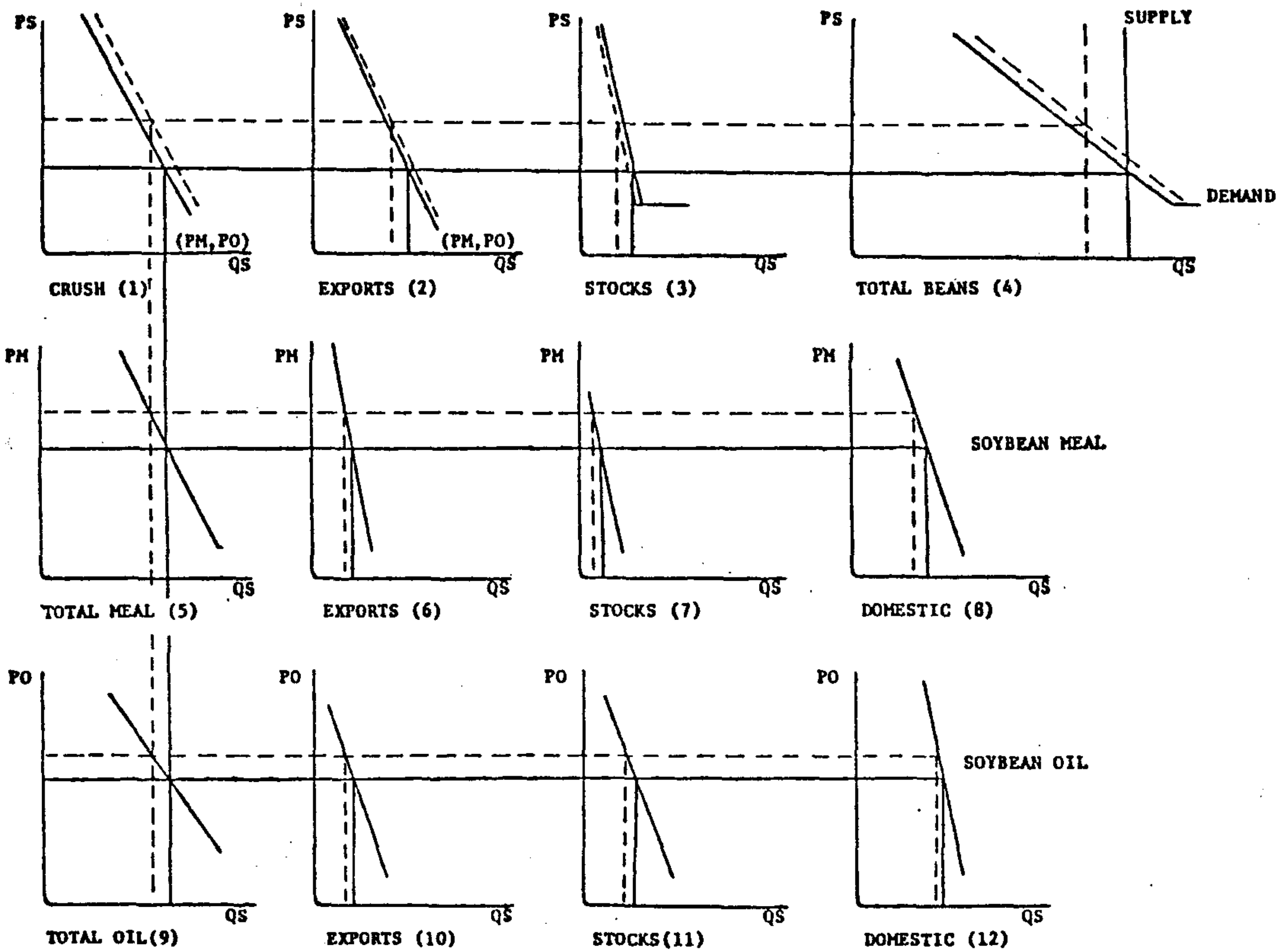


FIGURE 3. Illustration of soybean model response to supply shift

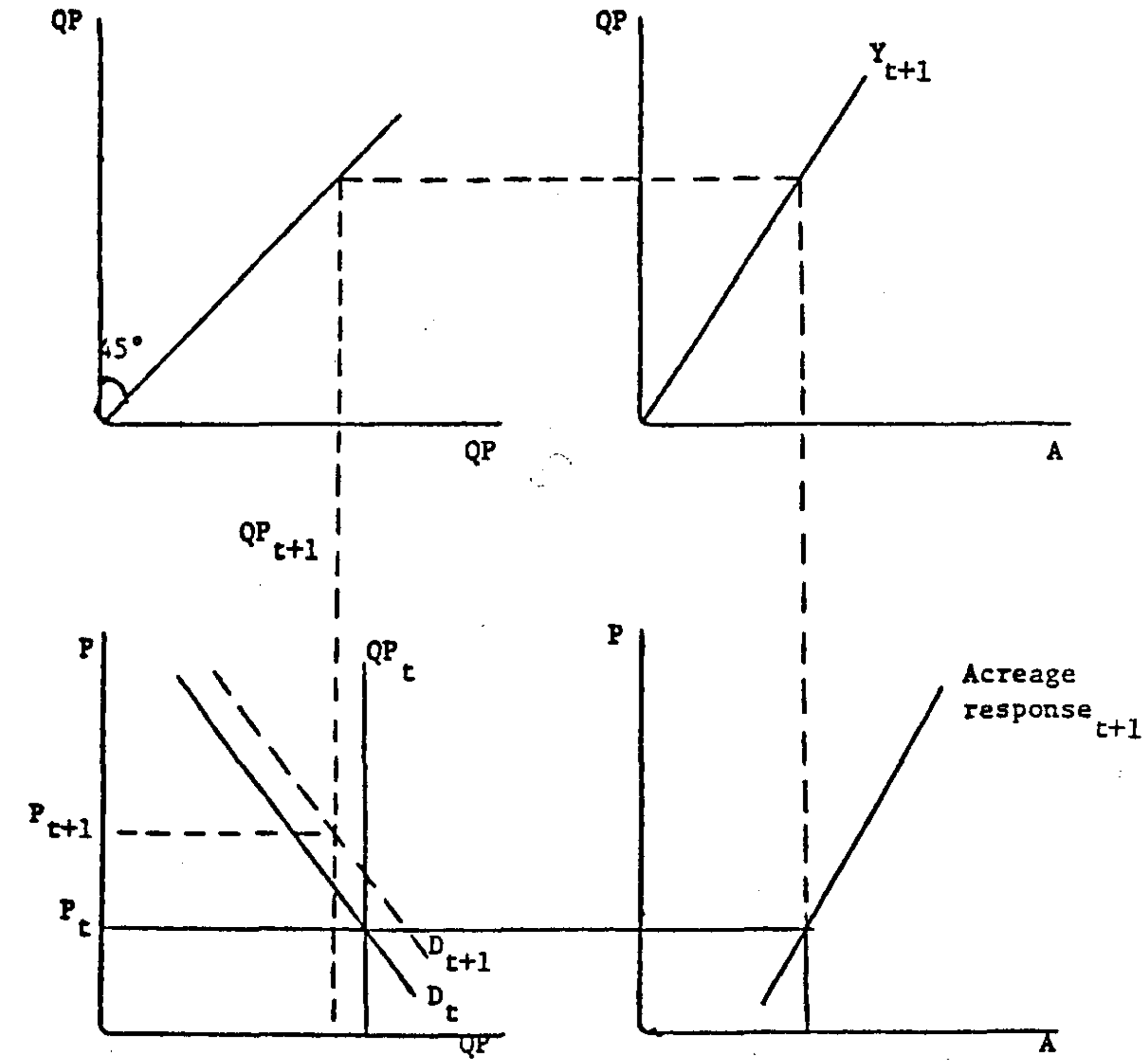
holders to reduce carryover stock levels and current prices weaken. The magnitudes associated with this interaction are relatively small.

The dynamic interactions of supply and demand across time are illustrated in Figure 4. The initial year t represents ample supply (QP_t) and low prices (P_t), so acreage planted for the next crop (A_{t+1}) is relatively low. Demand (D) increases in year t+1 and supply is below that of the previous year, so the equilibrium price rises from P_t to P_{t+1}.

The equation specification corresponding to Figure 2 is summarized in Table 1. The market demand for soybeans consists of equations for crushing (1) and inventories (2). Exports (3) are set equal to the rest of the world net import demand to impose the world market clearing condition. There is a simple linkage (4) between wholesale and farm prices since the wholesale price is used in the demand relations and the farm price is the supply inducing price for the succeeding year. The crushing margin is the value of oil and meal less the price of beans (5). Acreage planted during the marketing year is determined by equation (6). Soybean production for the next crop year is derived in (7) by using acreage planted, a conversion from planted to harvested acreage (.98), and the new crop yield per harvested acre. The domestic market clearing identity (8) equates production and beginning stocks to the demand and ending stock quantities.

In the meal sector production is determined by soybean crush and the appropriate meal crushing yield (9). The demand component consists of the estimated equation for domestic use (10) and the rest of the world net import demand (11). The identity (12) includes ending stocks as exogenous.

FIGURE 4. Illustration of dynamic interaction of soybean supply and demand



A = Soybean planted acres.
D = Soybean demand.
P = Soybean price.
QP = Soybean production.
Y = Yield per planted acre.

Table 1. Specification of the U.S. soybean model

<u>Soybean Sector</u>

(1) Crush = f(wholesale price, value of oil and meal, crushing capacity)

(2) Ending Stocks = f(wholesale price, transaction volume, expected new crop production, government stocks, beginning stocks)

(3) Exports = world net imports - competitors' net exports

(4) Farm Price = f(wholesale price)

(5) Crushing margin = value of oil and meal - wholesale price

(6) Acreage Planted for Next Crop = f(soybean net returns, corn net returns, cotton net returns, corn loan/soybean loan, corn diversion payment/corn price, lagged acres planted)

(7) Expected New Crop Production = acreage planted for next crop * new crop yield * .98

(8) Production + Beginning Stocks = crush + exports + seed + ending stock

(9) Meal Production = crush * meal crushing yield

(10) Domestic Demand = f(meal price, corn price, livestock price, high protein consuming annual units, other high protein feeds)

(11) Exports = world net imports - competitors' net exports

(12) Meal Production + Beginning Stocks = domestic + exports + ending stock

(13) Oil Production = crush * oil crushing yield

(14) Domestic Demand = f(oil price, income, quantity of competing oil and butter)

(15) Ending Stock = f(oil price, oil production, government stocks + PL480 exports, expected new crop soybean production, beginning stocks)

(16) Commercial Exports = f(oil production + beginning stocks, PL480 exports, competing oil exports, international reserves of developing countries, oil equivalent of lagged soybean exports)

(17) Oil Production + Beginning Stock = domestic + commercial exports + PL480 exports + ending stock

Oil production is also determined by the soybean crush and the appropriate oil crushing yield (13). The demand component consists of estimated equations for domestic use (14), inventories (15), and commercial exports (16). The identity (7) includes PL480 exports and government stocks as exogenous.

The other country or region submodels are less detailed than the U.S. model, but similar components have similar specifications. Other exporting countries have behavioral relationships only for soybean and meal production, soybean crush, and meal demand. Importing countries have no significant soybean production, so that is exogenous.

Multicommodity Trade Linkages

This trade model for soybeans and their products is composed of the supply and demand curves for exporters and importers and the appropriate international market linkages. Soymeal and soyoil sectors are linked together within each country through the crushing industry and linked between countries through international trade. Figure 5 illustrates this relationship. To demonstrate the domestic and trade relationships of soybeans, soymeal, and soyoil as clearly and simply as possible, the analysis assumes all quantities are in soybean equivalents and all transactions are in terms of a common currency with no transportation costs, tariffs, or trade restrictions.

The supply of soybeans in any given year is independent of the current price, therefore its supply is perfectly inelastic. The supply decision is made via the acreage planted in the previous period, which is influenced by the expected price as well as other economic factors and policy variables. The expected price is formed from information available prior to harvest,

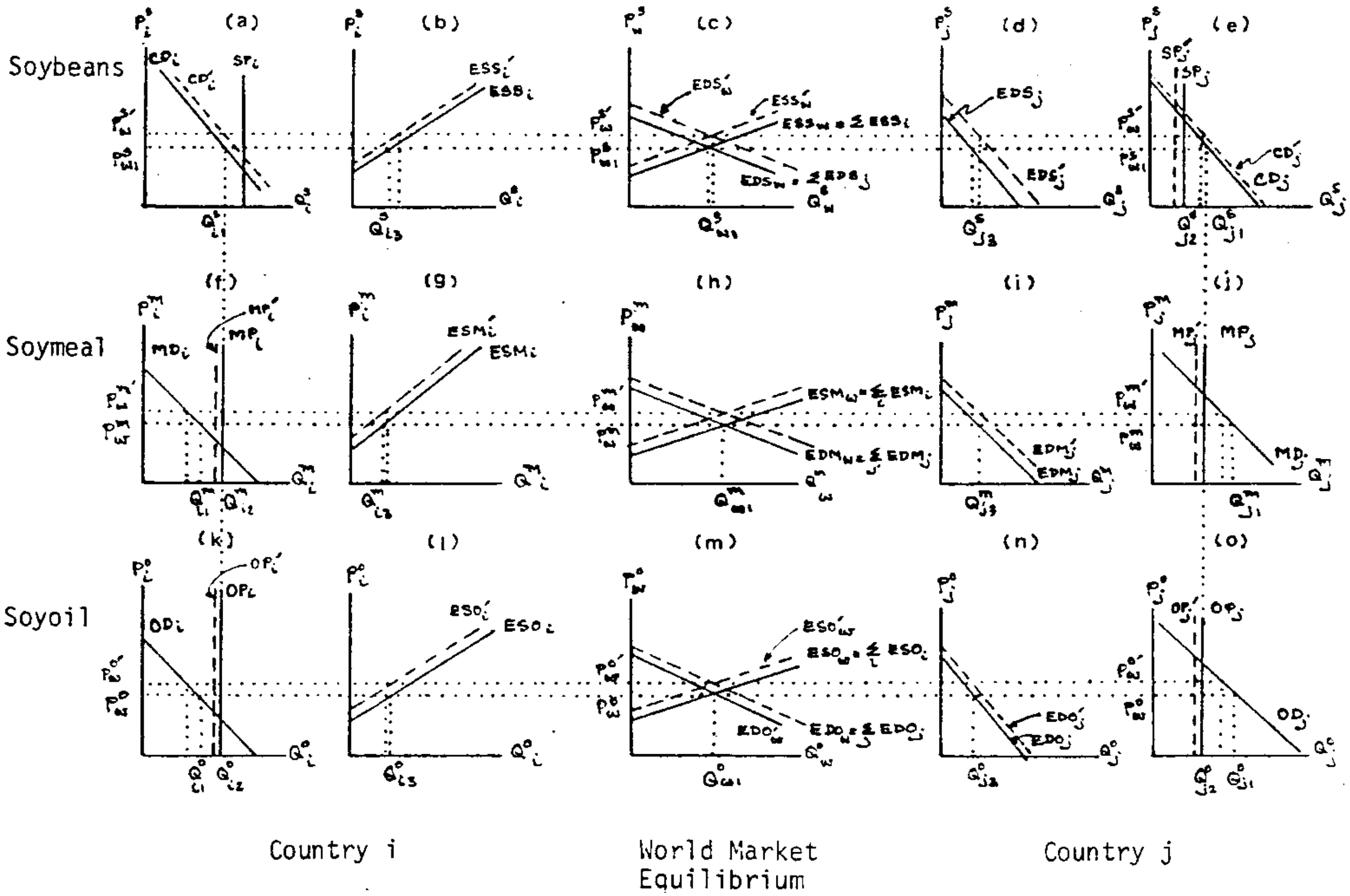


FIGURE 5. Graphical presentation of soybean and soybean products model

SOURCE: Huyser, Wipada. 1983. A Regional Analysis of Trade Policies Affecting the Soybean and Soymeal Market. Ph.D. dissertation, Iowa State University.

that is, prior to the start of the current crop year. Therefore, for the current period, soybean planted acreage and consequently production, as well as beginning stocks, are predetermined. Panels (a) and (e) illustrate a domestic soybean market with a perfectly inelastic supply of soybeans, SP_i and SP_j, for countries i and j, respectively.

Domestic use of soybeans is mainly to produce soymeal and soyoil with only small quantities used for direct consumption as food, feed, and seed. To simplify this graphical analysis, the food, feed, and seed demand, as well as soybean stock demand, are disregarded and all soybean production is assumed to be crushed.

The economic incentive for soybean crushing is the crushing margin, i.e., the difference between soymeal and soyoil product values and soybean input cost. For, given world soymeal and soyoil prices, the world soybean price determines the crush demand in each country. Domestic soybean crush demand curves are CD_i and CD_j for exporting country i and importing country j, respectively. With such demand and supply schedules, the excess supply (ESS_i) and the excess demand (EDS_j) of soybeans are derived in diagrams (b) and (d) for exporting country i and importing country j.

Diagram (c) presents the world market equilibrium where the world equilibrium price and quantity traded are established through the point of intersection of world excess supply (ESS_w) and world excess demand (EDS_w) schedules. The world excess supply (ESS_w) is derived from the horizontal summation of exporters' excess supply schedules ($\sum_i ESM_i$). The model excess demand (EDS_w) is the summation of all importers' excess demand schedules ($\sum_j EDS_j$).

The soybean world price, p^s_{w1}, clears the soybean market. It feeds back into each domestic market in such a way that crushed quantities, exports, and imports are simultaneously determined. For exporting country i, Q^s_{i1} of soybeans is crushed domestically and Q^s_{i3} is exported. Q^s_{j1} is soybeans crushed in the importing country j, of which Q^s_{j3} is from imports and Q^s_{j2} from its own soybean production. The total soyoil traded internationally is O^s_{w1}.

Soymeal and soyoil are derived products of soybeans. The volume produced from each unit of soybeans crushed depends upon the meal and oil content as well as the crushing technology. The crushing coefficients may vary some from country to country, depending upon crushing techniques, or from year to year, depending on the quality of the beans. Once the quantity of crush demand in each country is determined, the domestic supplies of soymeal and soyoil are fixed as shown by MP_i and MP_j for soymeal and OP_i and OP_j for soyoil for exporting country i and importing country j. (Here meal and oil are represented in soybean equivalents.)

Soymeal is used as a protein supplement in livestock rations. Soymeal demand schedules are derived for different levels of soymeal prices holding other factors constant. MD_i and MD_j are domestic demands of soymeal for a representative exporting country i and an importing country j.

Soymeal excess supply (ESM_i) and excess demand (EDM_j) are derived from the quantity differences of domestic supplies and domestic demands at different soymeal prices as shown in diagrams (g) and (i). The world excess supply schedule (ESM_w) of soymeal is the horizontal summation of all excess soymeal supplies for different given prices. The world excess demand schedule (EDM_w) is also analogously derived using each country's excess soymeal demand.

The world price and quantity traded of soymeal that clear the soymeal market are determined in the world soymeal trade sector at the intersection of the world excess supply (ESM_w) and the world excess demand (EDM_w). This world price, P_w^m, feeds back into the domestic sectors of countries i and j to determine domestic comsumption for i and j, i's exports and j's imports, represented by Q_{i1}^m, Q_{j1}^m, Q_{i3}^m, and Q_{j3}^m, respectively. The meal price also feeds back into crush demand by its effect on crushing margins.

The same derivation is also applied to the soyoil sector. The domestic supplies of soyoil, which are determined by the quantities of crushed soybeans, are OP_i and OP_j for exporting country i and importing country j, respectively. Soyoil, after refining and processing, is used in a number of consumer products including margarine, salad oil, cooking oil, shortening, paints, varnishes, and soap. The domestic demands of soyoil are derived with respect to different price levels, assuming other factors are constant. These are illustrated by OD_i and OD_j in the diagrams ((k) and (o), respectively). Individual country excess supply and demand for soyoil are derived in the same manner as in the soybean and soymeal sectors. World excess supply (ESO_w) and excess demand (EDO_w) for soyoil are also determined. The world soyoil price and trade volume are determined by the equilibrium of world excess demand and world excess supply. This world price, p_w^o, determines the level of domestic consumption, exports, and imports for each country and, like meal price, influences soybean crush through the crushing margin.

This analysis attempts to illustrate the linkages of soybeans, soymeal, and soyoil, as well as the linkages among trading countries. The crushing industries, through their demand for soybeans, act as the link between soybeans as an input and soymeal and soyoil as products. The world trade sectors of each of the three products link together the trading countries so that the markets are cleared. These internal and trade linkages result in all prices and quantities being simultaneously determined. Any exogenous changes which occur in any one sector will affect each sector of all other products. The new price and quantity solutions for soybeans, soymeal, and soyoil are then derived simultaneously.

To demonstrate the effects of an exogenous change, assume that domestic production of soybeans falls in importing country j, i.e., supply falls to SP_j. This shifts domestic excess demand of soybeans to the right, as well as world excess demand, which results in an increase in the world soybean clearing price. The higher world soybean price reduces the domestic soybean crush demand in importing and exporting countries, which results in reductions of soymeal and soyoil production. The excess supplies of soymeal and soyoil for exporting countries then shift to the left and the excess demand of imports shifts to the right. The rightward shift of excess demand in country j and the leftward shift of excess supply of both soymeal and soyoil introduce higher world prices of soymeal and soyoil. These higher new world prices feed back into each country's domestic sector to determine consumption levels as well as exports and imports for each country. The change in prices of soymeal and soyoil will further affect the soybean sector. A higher crush margin serves as an incentive for crush demand to shift upward. The higher world soybean price also gives an incentive for soybean production the following year to shift to the right. All these effects produce further shifts of different demand and supply schedules. The final results are simultaneously solved by the interaction of all prices of the three products. In this example the reduction of country j's domestic soybean supply to SP_j' results in a higher soybean price by $P_w^{s'}$ and lower soybean crush level in all countries. The consumption of soymeal and soyoil is also reduced because of higher soymeal and soyoil prices. The shortfall in soybean production in country j is partially offset by increased import of soybeans. Whether soymeal and soyoil imports increase or decrease depends on relative demand elasticities in importing and exporting countries. The graphical case shows no change in soymeal and soyoil imports. This graphical illustration provides important economic interrelationships among soybeans, soymeal, and soyoil, demonstrating characteristics of derived demand (soybeans) and joint products (soymeal and soyoil) for both the domestic and international trade sectors. In this analysis the prices of only three products are considered to simplify the presentation. One should be aware, however, of the influences of other economic variables enumerated in the previous section, like competing product prices, government policy, income, and livestock numbers, that affect the profit margin of the crushing industry, soymeal demand, soyoil demand, soybean production, and trade levels.

Soybean Model Specification and Estimated Parameters

Annual data of 1966 to 1982 are used for the estimation of model parameters. The model is mostly linear in nature but includes some nonlinearities. It is estimated using a nonlinear two stage least square estimation method. The principal component technique is used to allow the first stage estimation since the number of exogenous variables in the model exceeds the number of data periods. Fifteen principal component estimators are calculated from all exogenous variables and are then used as instrumental variables in the first stage. The estimation results are reported in Tables 2-9 including R-square, Durbin Watson (DW), t, and elasticity values. (Tables are presented following each country's discussion.) The following discussion describes the results of each country's domestic sector. The performance and validation of the whole model will then be considered. The variable definitions are given below the table containing estimated results.

The United States Submodel

The U.S. model component for soybeans and soybean products is reported in equations (2.1) to (2.22) of Table 2. The estimated results are satisfactory with correct signs, high R-square values, and no significant serial correlation problems.

Soybean acreage for the next crop year (2.1) is significantly influenced by the net cash return per acre of soybeans, corn, and cotton; current acreage; the ratio of corn effective support price and soybean loan rate; and the ratio of the corn diversion rate to corn farm price. Soybean crush demand (2.2) is determined by soybean price, the crushing value, and crushing capacity. Soybean inventory demand (2.3) is influenced by transactions demand and speculative demand. The former is related to crush and export levels and the latter is explained by current price and price expectations. Proxy variables for expected future price are production for next year and government carryover stocks. Dummy variables (i.e., D72, D7274) are needed to capture structural change in demand and differing seasonal price patterns. Soymeal consumption demand (SOMDDT) is a function of its price, livestock product price, high protein animal units, corn price, and other high protein meal consumption. All coefficients have correct signs and reasonable magnitudes. Soyoil domestic demand (2.6) and stocks (2.7) are endogenous in this market.

TABLE 2. Soybean and soymeal model equations, United States

			R^2	D.W.
(2.1)		SOYSAE = 7.38 +0.29*DSNRE1 - 0.16*DCORNRE	.98	2.89
	t	(2.67)(8.05) (-7.82)		
	e	[.35] [-.20]		
		-0.08*DCTNRE - 4.16*(CORPE/SOYPE)		
	t	(-4.38) (-0.72)		
	e	[-.07] [-.03]		
		-11.92*(CORPD/CORPF) + 0.87*LAG(SOYSAE)		
	t	(-2.92) (21.63)		
	e	[-.02] [0.85]		
(2.2)		SOYSC = 69.97 - 331.91*SOYPM + 294.46*((SOMPM/20)*SOMSC	.99	1.35
	t	(1.05) (-3.94) (3.76)		
	e	[-2.06] [1.95]		
		+ (SOOSC*SOOPM) + 0.79*CVSOY		
	t	(7.78)		
	e	[1.03]		
(2.3)		SOYHC = 241.17 - 29.89*(SOYPM/GNPD) + 0.16*(SOYSC + SOYMX)	.88	1.26
	t	(0.79) (-0.78) (1.46)		
	e	[-0.71] [1.35]		
		-0.12*SOYSYE*0.98*SOYSAE - 0.24*SOYHG		
	t	(-1.94) (-1.14)		
	e	[1.10]		
		+ 0.30*LAG(SOYHC) - 98.94*D72 - 41.47*D7274		
		(1.34) (-0.98) (-1.09)		
(2.4)		SOYPF = -0.05 + 0.96*SOYPM - 1.53*DUM72 + 0.63*D74	.99	1.54
	t	(-0.49)(52.38) (-10.93) (4.45)		
	e	[1.02]		
(2.5)		SOMDDT = -4452.41 - 41.25*SOMPM + 1418.028*CORPF	.93	1.97
	t	(-0.78) (-3.71) (2.45)		
	e	[-0.41] [0.19]		
		+ 6124.06*LIVI + 120.16*HPAUTST + 991.36*D80		
	t	(13.59) (2.41) (1.11)		
	e	[0.71] [1.17]		
		-3726.82*D74 - 0.81*FEEDHPS		
	t	(-2.63) (-1.52)		

Table 2. (Continued)

		R^2	D.W.
(2.6)	SOODDT = 16597.89 - 154.47*(SOOPM/GNPD) + 786.76*LOG(CEN/GNPD)	.58	1.39
	t (0.31) (-0.96) (0.12)		
	e [-0.30] [0.69]		
	- 1.82*(COODD + FAODD + PAODD) - 3.21*BUTTLD		
	t (-1.32) (-1.33)		
	e (-0.35] [-1.25]		
(2.7)	SOOHC = -73.99 - 7.46*(SOOPM/GNPD) + 0.17*SOOSP	.72	2.02
	t (-0.07)(-0.31) (3.77)		
	e [-0.13] [1.82]		
	-0.10*(SOOHCC + SOOPL) - 0.50*SOYSPE + 0.40*LAG(SOOHC)		
	t (-0.16) (-1.71) (1.48)		
	e [-0.07] [-0.91] [0.38]		
(2.8)	SOOXES = -1394.00 + 0.24*(SOOSP + LAG(SOOHC + SOOHCC))	.92	1.42
	t (-2.55) (2.99)		
	e [2.31]		
	-0.56*SOOXF - 0.28*SOOPL + 0.04*IRESDEV		
	t (-3.94) (-0.97) (3.04)		
	e [-1.09] [-0.15] [1.53]		
	- 0.06*LAG(OESOYX)		
	t (-0.72)		
	e [-0.36]		
(2.9)	DSNRE = ((SOYPF*(LAG(SOYSYE) + LAG2(SOYSYE) + LAG3(SOYSYE))/3) - SYVC)/GNPD		
(2.10)	DCORNRE = ((CORPF*(LAG(CORSYGRE) + LAG2(CORSYGRE) + LAG3 (CORSYGRE))/3) - CORVC)/GNPD		
(2.11)	DCTNRE = ((COLFAU*(LAG(COLSYE) + LAG2(COLSYE) + LAG3(COLSYE))/3) - CTVC)/GNPD		
(2.12)	SOYHT = SOYHC + SOYHG		
(2.13)	SOYMX = (SOYNMROW + SBSMNAR + SBSMNBR + SBSMNSU + SBSMNCN + SBSMNE9 + SBSMNE8 + SBSMNES + SBSMNJP)*0.0367437		
(2.14)	SOMMXES = (SOMNMROW + SMSMAR1 + SMSMNBR + SMSMNSU + SMSMNCN + SMSMNE9 + SMSMNE8 + SMSMNES + SMSMNJP)/.907185		
(2.15)	SOYSPE = SOYSYE*0.98*SOYSAE		
(2.16)	SOYSC = LAG(SOYSPE) + LAG(SOYHT) - SOYMX - SOYDV - SOYHT		

Table 2. (Continued)

	R^2	D.W.
(1.17) SOMSP = SOYSC*SOMSC*50.0		
(1.18) SOMDDT = SOMSP + LAG(SOMHT) - SOMMXES - SOMHT		
(1.19) SOOSP = SOYSC*SOOSC*100.0		
(1.20) SOODDT = SOOSP + LAG(SOOHC) + LAG(SOOHCC) - SOOXES - SOOHCC SOOHC - SOOPL		
(1.21) OESOYX = (SOYMX - SBSMNAR -SBSMNBR - SBSMNSU - SBSMNCN) *.0367436 *SOOSC*100.0		
(2.22) SOYCM = (SOMSC*SOMPM/20) + (SOOSC*SOOPM) - SOYPM		

U.S., Variable Definitions and Sources

Endogenous variables

DCORNRE: Deflated net returns from corn, \$/acre (computed [CORPF * ($CORSYGRE_{-1}$ + $CORSYGRE_{-2}$ + $CORSYGRE_{-3}$)/3 - CORVC]/GNPD)

DCTNRE: Deflated net returns from cotton, \$/acre (computed [COLFAU * ($COLSYE_{-1}$ + $COLSYE_{-2}$ + $COLSYE_{-3}$)/3] - CTVC]/GNPD)

DSNRE1: Deflated net returns from soybeans, \$/acre (computed [SOYPF * ($SOYSYE_{-1}$ + $SOYSYE_{-2}$ + $SOYSYE_{-3}$)/3 - SYVC]/GNPD)

OESOYX: Oil equivalent of total world soybean exports, million lbs. (computed SOYXTOT * SOOSC * 100)

SOMDDT: Soybean meal domestic disappearance, thousand tons: Fats & Oils Situation

SOMMXES: Soymeal exports, excluding shipments to U.S. territories, crop year, thousand tons: Fats & Oils Situation

SOMPM: Soybean meal price, 44 percent protein, Decatur, crop year average, \$/ton: Fats & Oils Situation

SOMSP: Soybean meal, U.S. production, crop year, thousand tons: Fats & Oils Situation

SOODDT: Soybean oil domestic disappearance, million lbs.: Fats & Oils Situation

SOOHC: Soybean oil, ending commercial stocks, million lbs.: Fats & Oils Situation

SOOPM: Soybean oil season average price, Decatur, ¢/lb.: Fats & Oils Situation

SOOSP: Soybean oil total U.S. production, October year, million lbs.: Fats & Oils Situation

SOOXES: Soybean oil, U.S. exports excluding shipments to U.S. territories and P.L. 480, million lbs. (computed SOOXPL - SOOPL)

SOOXT: Soybean oil, U.S. exports, commercial plus P.L. 480, million lbs.: Fats & Oils Situation

SOYHT: Soybeans, ending total stocks, August 31, million bu.: Fats & Oils Situation

SOYHC: Soybeans, ending commercial stocks, million bu.: Fats & Oils Situation

SOYCM: Soybean crushing margin, $/bu. (computed SOMSC * SOMPM/20) + (SOOSC * SOOPM) - SOYPM)

SOYMX: Soybeans, U.S. exports, crop year, million bu.: Fats & Oils Situation

SOYPF: Soybeans season average price received by farmers, $/bu.: Fats & Oils Situation

SOYPM: Soybeans, season average wholesale price, #1 yellow, $/bu.: Fats & Oils Situation

SOYSAE: Soybean acreage planted, million acres: Crop Production

SOYSC: Soybeans, total crushed, September year, million bu.: Fats & Oils Situation

SOYSPE: Soybeans, total production, million bu.: Fats & Oils Situation

SOYXTOT: Soybeans, total world exports, million bu. (computed SOYMX - SOYXSC + 0.0367 * (SOYMXBR1 - SOYXBRS1))

VALUSBX: Value of U.S. soybean exports, million dollars (computed SOYPM x SOYMX)

VALUSMX: Value of U.S. soymeal exports, million dollars (computed SOMPM x SOMMXES/1000)

Exogenous variables

BUTTLD: Butter and lard, U.S. domestic disappearance, October year, million lbs.: Fats and Oils Situation

CEN: Personal consumption expenditures on nondurable goods and services, billion $: Economic Indicators

COLFAU: Cotton, American upland, price received by farmers, August year, ¢/lb.: Agricultural Prices

COLSYE: Expected cotton yield, lb./acre: Crop Production

COODD: Cottonseed oil, domestic disappearance, October year, million lbs.: Fats & Oils Situation

CORPA: EC threshold price for corn, weighted average of countries: Marches Agricoles

CORPD: Expected effective diversion payment, corn (including support payment), $/bushel (computed)

CORPE: Corn, expected effective price support, $/bu. (computed)

CORPF: Corn, season average price received by farmers, $/bu.: Agricultural Prices

CORSYGRE: Corn yield, expected bu./acre, October year: Crop Production

CORVC: Corn, variable costs of production, $/acre: USDA-ESS Costs of Producing Selected Crops in the United States

CTVC: Cotton, variable costs of production, $/acre: USDA-ESS Costs of Producing Selected Crops in the United States

D74: Dummy variable, D74 = 1 in 1974, Ø elsewhere

D76: Dummy variable, D76 = 1 in 1976, Ø elsewhere

D80: Dummy variable, D80 = 1 in 1980, Ø elsewhere

DUM72: Dummy variable, DUM72 = 1 in 1972, Ø elsewhere

FAODD: Fats and oils disappearance less soy, cotton, palm, butter, and lard, October year, million lbs.: Fats & Oils Situation

FEEDHPS: U.S. feed, high protein consumption less fish and soy meal, October year, thousand tons: Fats & Oils Situation

CVSOY: Soybean crushing capacity, million bu.: Fats & Oils Situation

GNPD: GNP deflator, October year, 1972 = 100: Economic Indicators

HPAUTST: High protein animal units, calendar year (computed from Feed Situation)

LIVI: Livestock price index, calendar year, 1966 = 100 (computed)

IRESDEV: International reserves of nonoil exporting developing countries, millions SDR: OSS data files

PAODD: Palm oil domestic disappearance, October year, million lbs.: Fats & Oils Situation

SOMHT: Soymeal, end of year stocks, billion lbs.: Fats & Oils Statistics

SOMSC: Soybean meal computed crushing yield cwt./bu. (computed SOMSP/SOYSC * 50)

SOOHCC: Soybean oil ending stocks, CCC owned, million lbs., ASCS data

SOOPL: Soybean oil, PL-480, October year, million lbs. exported: Fats & Oils Situation

SOOSC: Soybean oil crushing yield, cwt./bu. (computed SOOSP/SOYSC * 100)

SOOXF: Soybean oil, exports by foreign nations, million lbs.: Foreign Agricultural Circular

SOYCC: Soybeans, ending stocks, CCC owned, under loan and reseal, million bu.: Fats & Oils Situation

SOYDV: Soybeans, domestic feed, seed, and residual use, million bu.: Fats & Oils Situation

SOYHF: Soybeans, ending stocks under loan, million bu.: Fats & Oils Situation

SOYHG: Soybeans, ending stocks, CCC owned, million bu. (computed, SOYCC - SOYHF)

SOYSYE: Expected soybean yield per harvested acre, September year, bu./acre: Crop Production

SYVC: Soybeans, variable cost per acre, $/acre: USDA-ESS Costs of Producing Selected Crops in the U.S.

The soyoil demand coefficients are all of correct sign but are not significant and the explanatory power is weak. The oil stock demand is influenced by transactions demand (soyoil production) and speculative demand. The former is related to soyoil production and the latter is influenced by current soyoil price and price expectations. The coming year soybean production as well as government oil stocks are important factors in forming future oil price expectations. Equation (2.8) relates soyoil exports to supply of soyoil, commercial and PL480 exports, as well as oil equivalent of the previous year's exports, and international revenues of developing countries. Equations (2.13) and (2.14) are identities clearing the world market by equating all excess demand from the rest of the world to the excess supplies of U.S. soybean and soymeal.

The Brazilian Submodel

The Brazilian market is composed of 12 equations, of which three are behavioral equations. The estimates of these behavioral equations are satisfactory with R-square ranging from 0.96 to 0.98. The approximated DW test indicates no serial correlation problems at a 5 percent significance level in this market. All prices are real price, i.e., have been deflated by the wholesale price index (with 1970 wholesale price index = 1.0).

The Brazilian soybean supply sector. Table 3 presents the Brazilian market. The soybean harvested acreage (3.1) is specified according to the Nerlovian distributed lag model where farmers partially adjusted acreage toward their long-run desired level. Soybean harvest acreage for the next crop is a function of this year soybean acreage, expected soybean real price (approximated by the moving average of current and past two year prices), and current wheat price. The lagged dependent variable is the major factor explaining expected soybean acreage harvested.

TABLE 3. Soybean and soymeal model equations, Brazil

		R^2	D.W.
(3.1)	SBAHBRE = 8948.38 + 1.127*(RPBWBR1 + LAG(RPBWBR1)	.98	2.57
t	(2.82) (0.56)		
e	[0.08]		
	+ LAG2(RPBWBR1))/3 - 22.45*RPWHBR1 + 0.53*SBAHHBR		
t	(-2.97) (3.82)		
e	[-1.16] [.48]		
(3.2)	SBUFEBR = -237399.00 + 7.91*MARBR2 + 0.39*LAG(SBUFEBR)	.97	2.71
t	(-3.86) (2.11) (2.40)		
e	[.54] [.34]		
	+ 55205.05*LOGYR81		
t	(3.89)		
(3.3)	SMUDTBR = -3943.33 - 1.66*RPMWBZ - 0.86*RPCW1BR	.96	1.78
t	(-4.01) (-0.73)		
e	[-0.2] [-0.23]		
	+ 55.27*YBR - 55.97*(YBR*D72BR) + 4174.65*D72BR		
t	(8.14) (-5.05) (5.07)		
e	[5.12]		
(3.4)	SBAHHBR = LAG(SBAHBRE)		
(3.5)	SBSPRBR = LAG(SBSPBRE)		
(3.6)	SBSPBRE = SBAHBRE*SBYDBRE		
(3.7)	RPMBR2 = SOMPM*RXCHBR/.907185		
(3.8)	MARBR2 = 0.792*RPMBR2 + 0.178*RPORBZ - RPBWBR1		
(3.9)	SBSMNBR = SBUFEBR + SBUSOBR + SBCOTBR - SBSPRBR - LAG (SBCOTBR)		
(3.10)	SMSMNBR = SMUDTBR + SMCOTBR - (SBUFEBR*SMYLDBR) - LAG(SMCOTBR)		
(3.11)	RPBWBR1 = (36.7437*SOYPM*RXCHBR) + RDBBR		
(3.12)	RPMWBZ = RPMBR2 + RDMBR		

Brazil, Variable Names and Definitions

Endogenous

MARBR2:	Soybean crushing margin, Cruzeiro/MT (calculated)
RPBWBR1:	Real soybean price, Cruzeiro/MT
RPMWBZ:	Real soymeal wholesale price, Cruzeiro/MT
RPMBR2:	Real U.S. soymeal wholesale price, Cruzeiro/MT
SBAHBRE:	Expected soybean area harvested, 1000 hectare
SBAHHBR:	Soybean area harvested, 1000 hectare
SBSMNBR:	Net exports of soybeans, 1000 MT
SBSPBRE:	Expected soybean production, 1000 MT
SBSPRBR:	Soybean production, 1000 MT
SBUFEBR:	Soybean crush, 1000 MT
SMSMNBR:	Net exports of soymeal, 1000 MT
SMUDTBR:	Soymeal domestic consumption, 1000 MT

Exogenous

D72BR:	1 prior to 1972, 0 otherwise
LOGYR81:	Log of year
RDBBR:	Real soybean price differential, Brazil-U.S., Cruzeiro/MT (calculated)
RDMBR:	Real soymeal price differential, Brazil-U.S., Cruzeiro/MT (calculated)
RPCW1BR:	Real wholesale corn price, Cruzeiro/MT
RPORBZ:	Real wholesale soyoil price, Cruzeiro/MT
RPWHBR1:	Real wheat producer price, Cruzeiro/MT
RXCHBR:	Deflated exchange rate, Cruzeiro/$US (calculated)
SBCOTBR:	Soybean ending stocks, 1000 MT
SBUSOBR:	Feed, seed, and residual soybean use, 1000 MT
SBYDBRE:	Expected soybean yield, MT/HA
SMCOTBR:	Soymeal ending stocks, 1000 MT
SMYLDBR:	Soymeal crushing yield coefficient
YBR:	Real income, million Cruzeiro

The real expected price of soybeans has a correct positive sign, but the coefficient is not significant at the 5 percent level. Soybean area harvested elasticity with respect to soybean expected price is very low, indicating that soybean acreage is not responsive to soybean price. This estimated elasticity (3.3) is lower than Williams' estimate of 0.533. However, in both studies the soybean price coefficient has a large variance and is not significant.

The real wheat price coefficient is a significant variable and has a negative sign. The substitution effect of wheat dominates its complementary effect as the double crop with soybeans in Brazil. During the 1950s and early 1960s wheat was more complementary with soybean acreage because wheat had a high minimum price. Soybeans were double cropped with wheat and required no additional machinery or fertilizer after the wheat season. From the mid 1960s, however, the world price of soybeans has increased so much that profit from selling soybeans in itself is the motivation of soybean acreage increase. Delays in the wheat harvest lower soybean yield and wheat competes with soybeans for storage facilities. Wheat, then, becomes a competitor with soybeans, and wheat price demonstrates a stronger substitution effect than complementary effect to soybean acreage. In recent years more new land has been opened up for soybean acreage and in these new areas the soybean-wheat double cropping is not a strong pattern. The estimated soybean acreage elasticity with respect to wheat price is low, indicating weak response of soybean acreage toward any change of wheat price.

Production for the next crop year is acreage harvested times yield where yield is exogenous (3.6). Current year harvested acreage and production are the lagged values of these endogenous variables (3.4) and (3.5).

Brazilian soybean crush demand. The soybean crush demand is given in (3.2). Soymeal and soyoil export markets and the soyoil domestic market are the three most important markets for the crushing industry. The soymeal domestic market was only a small portion of the soymeal market until 1979. Therefore the real crushing margin (3.8) is calculated from the soymeal export price, which is linked to the U.S. price rather than domestic price of soymeal.

The soybean crush demand is a function of the crushing margin, a one period lag of soybean crush demand and soybean production. Soybean crush demand has grown continuously since the 1960s. The lagged soybean crush demand, therefore, which is the maximum amount of soybeans crushed in the past, serves as a proxy for soybean crushing capacity for the current year. Crushing capacity had been a major constraint of soybean crush demand until the late 1970s. Since then the crushing capacity has expanded more rapidly than soybean output. Thus soybean availability can be a constraint to crush demand. These two variables are the most important factors determining soybean crush demand in Brazil.

The soybean crushing margin coefficient has a correct positive sign, as expected. The nature of the soybean crushing industry involves large capital investment (large fixed costs), therefore it will continue the operation as long as its variable profit (crushing margin) is positive. The soybean crush demand elasticity with respect to the crushing margin is very low. This finding is consistent with Williams' study, although his estimate of soybean crush demand elasticity with respect to crushing margin is only 0.01. This extremely low elasticity is the result of using domestic soymeal price, which is subject to government control, rather than the world soymeal price, which is more appropriate for the crush demand in Brazil.

Brazilian soymeal sector. The domestic demand of soymeal (3.3) is a function of real domestic soymeal and corn prices, real per capita income, and a dummy shift variable. The domestic consumption of soymeal had been minimal until 1973, when modernization in the poultry industry was encouraged. Rapid increase in per capita income creates an increase of poultry consumption demand. This in turn affects the number of poultry on farms, which adjusts quickly to the change in demand. The existing data on livestock, poultry, and hogs in Brazil are highly questionable, therefore the per capita income is used to capture the influence of rapidly growing poultry and hog industries in Brazil on the demand of soymeal.

The estimated result shows that the income variable is the most important explanatory variable of soymeal demand. This is only true after 1972, however, when domestic soymeal demand became substantial. The income elasticity of soymeal demand in this period is high. The income effect before 1972 is near zero, as indicated by the magnitude of the slope shift that cancels the income coefficient.

The soymeal price in Brazil was subject to government control most of the time during this period and varied very little year to year. Therefore, in order to allow for economic analysis of policies that allow domestic price to vary, a coefficient was imposed based upon information about other countries' soymeal price elasticities. The price coefficient was imposed at the value which gives demand price elasticity of -0.2. This price elasticity appears to be a normal price elasticity in Brazil if the soymeal price had not been restricted.

The real corn price does not show significant influence upon domestic soymeal consumption. The negative coefficient, however, indicates a substitution effect of corn on soymeal demand.

Equations (3.9) and (3.10) are the excess supplies of soybean and soymeal, respectively, which are available for exports. The price linkage equations (3.11) and (3.12) link domestic prices to U.S. prices and explicitly include exchange rates. The domestic soymeal price linkage (3.12) is only activated for analysis of policy options where this price is not fixed by the government.

The Argentine Submodel

The structure of the Argentine market is similar to the Brazilian market as represented by (4.1) to (4.12). Modeling the Argentine market is hampered by the fact that the country is a new entrant to soybean production, processing, and trade, so appropriate data series are scarce. The three behavioral equations have high R-square values and there is no indication of serial correlation problems. All prices are real prices with 1970 wholesale price index = 1.0.

Argentine soybean supply sector. Equation (4.1) is a behavioral equation of soybean area harvested based on the Nerlovian distributed lag model. Soybean area harvested is a function of expected soybean price (calculated from a three year moving average price), its one year lag (the current soybean area harvested-SBAHHAR), log of time trend (LOGYR), and shift variables.

The domestic soybean price in Argentina is not available for the period studied, so a proxy price in real Argentine pesos is calculated from the Rotterdam price. Therefore it is the world price which is associated with soybean acreage in Argentina. The soybean acreage elasticity with respect to soybean world price (in real peso) is less elastic than the U.S. soybean acreage response to soybean price but higher than the Brazilian value.

TABLE 4. Soybean and soymeal model equations, Argentina

			R^2	D.W.
(4.1)		SBAHARE = -10597.70 + 0.45*(RPBAR1 + LAG(RPBAR1)	.98	2.41
	t	(-1.81) (1.92)		
	e	[0.27]		
		+ LAG2(RPBAR1))/3 + 0.71*SBAHHAR -283.52*D76AR		
	t	(4.72) (-1.46)		
	e	[0.59]		
		+ 2523.39*LOGYR		
	t	(1.82)		
(4.2)		SBUFEAR = -14.40 + 2.43*VALAR1 - 2.28*RPBAR1	.98	2.95
	t	(-0.15) (1.18) (-1.10)		
	e	[2.63] [-2.38]		
		+ 0.89*LAG(SBUFEAR) - 108.43*D72AR + 547.06*DUM80		
	t	(8.35) (-1.44) (4.84)		
	e	[0.67]		
(4.3)		SMUDTAR = -4406.72 + 1113.72*LOGYR - 0.05*RPMAR1	.95	2.61
	t	(-4.41) (4.77) (-1.37)		
	e	[-0.17]		
		- 0.05*COUDTAR + 99.197*D72AR - 189.548D83		
	t	(-3.12) (-3.34) (-4.38)		
	e	[-1.21]		
(4.4)		SBAHHAR = LAG(SBAHARE)		
(4.5)		SBSPRBR = LAG (SBSPARE)		
(4.6)		SBSPARE = SBAHARE*SBYDARE		
(4.7)		VALAR1 = 0.792*RPMAR1 + 0.178*RPOAR1		
(4.8)		SMSPRAR = SBUFEAR*SMYLDAR		
(4.9)		SBSMNAR = SBUFEAR + SBUSOAR + SBCOTAR - SBSPRAR - LAG(SBCOTAR)		
(4.10)		SMSMAR1 = SMUDTAR + SMCOTAR - SMSPRAR - LAG(SMCOTAR)		
(4.11)		RPBAR1 = (36.7437*SOYPM*RXCHAR) + RDBAR		
(4.12)		RPMAR1 = (SOMPM*RXCHAR/.907185) + RDMAR		

Argentina, Variable Names and Definitions

Endogenous

RPBAR1:	Real soybean price, pesos/MT (calculated from EC price)
RPMAR1:	Real soymeal price, pesos/MT (calculated from EC price)
SBAHARE:	Expected soybean area harvested, 1000 hectares
SBAHHAR:	Soybean area harvested, 1000 hectares
SBSPARE:	Expected soybean production, 1000 MT
SBSPRAR:	Soybean production, 1000 MT
SBSMNAR:	Soybean net exports, 1000 MT
SBUFEAR:	Soybean crush, 1000 MT
SMSMAR1:	Soymeal net exports, 1000 MT
SMSPRAR:	Soymeal production, 1000 MT
SMUDTAR:	Soymeal domestic consumption, 1000 MT
VALAR1:	Soybean crushing value, pesos/MT of bean crushed

Exogenous

COUDTAR:	Corn domestic demand, 1000 MT
D72AR:	1 prior to 1972, 0 otherwise
D76AR:	1 prior to 1976, 0 otherwise
DUM80:	0 prior to 1980, 1 otherwise
LOGYR:	Log of year
RDBAR:	Real soybean price differential, Argentina-U.S., pesos/MT (calculated)
RDMAR:	Real soymeal price differential, Argentina-U.S., pesos/MT (calculated)
RPOAR1:	Real soyoil price, pesos/MT
RXCHAR:	Deflated exchange rate, pesos/$US, calculated
SBCOTAR:	Soybean ending stocks, 1000 MT
SBUSOAR:	Feed, seed, and residual use of soybeans, 1000 MT
SBYDARE:	Expected soybean yield, MT/HA
SMCOTAR:	Soymeal ending stocks, 1000 MT
SMYLDAR:	Soymeal crushing yield coefficient

The soybean area harvested is strongly influenced by the lagged dependent variable. The log year variable also influences soybean acreage. The log year captures the rapid but declining expansion rate of soybean acreage. Soybean production in Argentina was not significant until after 1972 and the production became substantial after 1976. The shift variables (D72AR and D76AR) explain these shifts in soybean acreage during these two periods.

Argentine soybean crush demand. Equation (4.2) represents the soybean crush demand sector. The estimated soybean crush demand is mostly explained by the crushing capacity, which is approximated by the maximum past quantity of soybeans crushed. The previous year amount of soybeans crushed has always been the maximum soybean crushed, therefore the lag of soybeans crushed is used to indicate crush capacity. The 1972 shift variable captures the change of soybean crush demand structure prior to 1973 and is highly significant. Argentina first exported soybeans and soymeal in 1973. This new trade opportunity had a strong effect on the expansion of the crushing industry.

The coefficients of product value (VALAR) and soybean price together represent the effects of a crushing margin on crush. They imply that increasing crushing margin, or product value over bean price, will increase crush.

Argentine soymeal domestic demand. Argentina did not consume any considerable quantity of soymeal until after 1972. This upward shift in the soymeal consumption pattern is very prominent. The two behavioral functions for these two periods are as follows:

(a) 1965–1972: $SMUDTAR = -2198.801 + 571.171\ LOGYR - 0.042\ RPMAR - 0.054\ COUDTAR$

(b) 1973–1980: $SMUDTAR = -5033.14 + 1259.477\ LOGYR - 0.042\ RPMAR$

These two functions, (a) and (b), clearly demonstrate the upward shift of demand after 1972.

The coefficient of the soymeal price variable has the expected sign but is very inelastic and not significant. The Argentine soymeal price is calculated from the Rotterdam price. Time trend is an important explanatory variable. The log form of time is used to explain the declining growth rate of soymeal demand. The consumption of corn demonstrates a stronger substitution than complementary effect on soymeal consumption. This finding is the same as in the Brazilian case.

The excess supplies of soybeans and soymeal, respectively, are computed by (4.9) and (4.10). The linkages between U.S. prices and real Argentine prices are (4.11) and (4.12).

The European Community Submodel

This market is composed of equations (5.1) to (5.9), with three behavioral equations. The EC produces insignificant levels of soybeans and its production is exogenous to the model. The availability of other oilseeds and other high protein meals in the EC is also exogenous to the model. They are computed in terms of high protein equivalents of soymeal. Behavioral equations, soybean crush demand (5.1), soymeal consumption demand (5.2), and high protein animal units (5.3) have good fit and show no serial correlation problems.

EC soybean crush demand. Soybeans are the major oilseed crushed in the EC and most soybeans are imports. Crushing margin and soybean price have the expected sign. Demand is very responsive to the crush capacity variable. The lagged quantity of soybeans crushed is used as a proxy for the crush capacity because actual capacity data could not be found.

TABLE 5. Soybean and soymeal model equations, European Community

		R^2	D.W.
(5.1)	SBUFEE9 = 6833.29 + 81.40*MAREC1 + 0.75*LAG(SBUFEE9)	.97	2.32
	t (3.22) (3.21) (9.64)		
	e [0.08] [0.71]		
	-5.47*OSDCRE9		
	t (-3.30)		
	e [-0.64]		
(5.2)	SMUDTE9 = -15238.4 - 17.27*PSMME9 + 21.26*CORPA	.98	2.31
	t (-8.76)(-3.17) (1.33)		
	e [-0.29] [0.25]		
	+ 8.85*HPAHCE9 -1115*WHUFEEC		
	t (6.66) (.94)		
	e [2.58] [-.12]		
(5.3)	HPAHCE9 = 274.71 + 33.99*LAG(NARDGE9)	.97	1.27
	t (2.20) (22.62)		
	e [0.91]		
(5.4)	MAREC1 = 0.792*PSMME9 + 0.178*PSOME9 - PSBME9		
(5.5)	SMSPRE9 = SBUFEE9*SMYLDE9		
(5.6)	SBSMNE9 = SBUFEE9 + SBUSOE9 + SBCOTE9 - SBSPRE9 - LAG(SBCOTE9)		
(5.7)	SMSMNE9 = SMUDTE9 - SMSPRE9 + SMCOTE9 - LAG(SMCOTE9)		
(5.8)	PSBME9 = (36.7437*SOYPM*EE9) + RDBE9		
(5.9)	PSMME9 = (SOMPM*EE9/.907185) + RDME9		

EC, Variable Names and Definitions

Endogenous

HPAHCE9: High protein consuming animal units, hog and poultry (calculated)
MAREC1: Soybean crushing margin, UA/MT
PSBME9: Soybean price, Rotterdam, UA/MT
PSMME9: Soymeal price, Rotterdam, UA/MT
SBSMNE9: Soybean imports, 1000 MT
SBUFEE9: Soybean crush demand, 1000 MT
SMSMNE9: Soymeal net imports, 1000 MT
SMSPRE9: Soymeal production, 1000 MT
SMUDTE9: Soymeal domestic consumption, 1000 MT

Exogenous

CORPA:	Corn threshold price, $/MT
EE9:	Exchange rate, UA/$
NARDGE9:	Real income, million UA
OSDCRE9:	Other oilseed crush in soybean equivalent, 1000 MT
PSOME9:	Soyoil price, Rotterdam, UA/MT
RDBE9:	Soybean price differential, Rotterdam-U.S. (calculated)
RDME9:	Soymeal price differential, Rotterdam-U.S. (calculated)
SBCOTE9:	Soybean ending stocks, 1000 MT
SBSPRE9:	Soybean production, 1000 MT
SBUSOE9:	Feed, seed, and residual uses of soybeans, 1000 MT
SMCOTE9:	Soymeal ending stocks, 1000 MT
SMYLDE9:	Soymeal crushing yield coefficient
WHUFEEC:	Wheat used for feed, 1000 MT

The other oilseed crushed variable (OSDCRE9) is another important explanatory variable. Other oilseeds crushed in the EC include rapeseed, cottonseed, peanuts, and copra seed. OSDCRE9 exhibits the expected substitution effect with soybean crush demand. The elasticity of substitution is rather low, however. This is due to the technological constraint in the crushing industry, which is becoming highly specialized.

Soybean crush demand is mostly determined by crushing capacity and crushing level of other oilseeds. This finding is consistent with previous studies of Williams (34). Soybean crush demand in this study, however, is more sensitive to its crushing value and soybean price than in Williams' study (34). Compare the estimated soybean crush demand elasticity with respect to crushing margin to Williams' estimate of 0.01.

<u>EC soymeal consumption demand</u>. The estimated soymeal demand (SMUDTE9) equation (5.2) has a high R-square and shows no indication of serial correlation problems. The import price of soymeal is a very significant variable. The EC imposes no trade barrier on soymeal imports, therefore the Rotterdam import price should be a good proxy for soymeal price in the EC as a whole. The soymeal demand is very price inelastic and of similar magnitude as elasticities found in other studies. Williams reported the soymeal price elasticity of -0.28 and Hill, Knipscheer, and Dixons reported the estimate of -0.27.

The high protein animal unit calculated from the number of poultry and hogs (HPAHCE9) is the most important explanatory variable. This is because soymeal is used mainly in the poultry and hog industry in the EC. The corn threshold price coefficient indicates a strong substitution effect of soymeal-corn demand in the EC. By contrast, Williams (34) reported strong complementary effect between corn and soymeal in the EC during 1960 to 1978. A dummy variable is also included in this equation to capture a structural shift in soymeal consumption beginning in 1967.

The Spanish Submodel

The Spanish market has recently become an important market for soybeans. Equations (6.1) to (6.8) model the Spanish market. There is no equation for soybean production in Spain. Behavioral equations of soybean crush demand and soymeal consumption demand have high predictability power and present no serial correlation problem.

Spanish soybean crush demand. Spanish soybean crush demand (SBUFEES) is a function of crushing margin and crushing capacity (6.1). These variables have significant coefficients and carry the expected signs. The soybean crush demand elasticity with respect to its crushing value is low.

Spain has increased its soybean crush level every year, except in 1973. The one year lag of soybean crush demand is used to approximate Spanish crushing capacity. In 1973 the soybean crush level dropped drastically as the result of the U.S. embargo of soybean exports. The dummy variable (DES) for this year is very significant.

Spanish soymeal demand. Soymeal is a major high protein meal used in the fast growing poultry industry. Soymeal consumption demand (SMUDTES) has a high R-square value and no significant serial correlation (6.2). A real income index is used to capture the effect of the poultry market on the soymeal demand because poultry price data are not available and poultry numbers data are questionable. The income variable is the most important variable influencing the soymeal demand and its coefficient is positive as

TABLE 6. Soybean and soymeal model equations, Spain

		R^2	D.W.
(6.1)	SBUFEES = 59.83 + 0.52*MARES1 + 0.90*LAG(SBUFEES)	.94	2.01
	t (0.38) (3.41) (13.04)		
	e [0.18] [0.83]		
	-1273.85*DES		
	t (-4.74)		
(6.2)	SMUDTES = -975.60 - 0.035*PSMMES + 0.067*CORPA*EES/EE9	.96	2.17
	t (-2.85)(-2.79) (3.74)		
	e [-0.32] [0.44]		
	+ 31.34*NARDGES - 0.85*OMUDTES		
	t (9.07) (-1.39)		
	e [1.62] [-0.16]		
(6.3)	MARES1 = 0.792*PSMMES + 0.178* PSOMES - PSBMES		
(6.4)	SMSPRES = SBUFEES *SMYLDES		
(6.5)	SBSMNES = SBUFEES + SBUSOES + SBCOTES - LAG(SBCOTES)		
(6.6)	SMSMNES = SMUDTES - SMSPRES + SMCOTES - LAG(SMCOTES)		
(6.7)	PSBMES = (36.7437*SOYPM*EES) + RDBES		
(6.8)	PSMMES = (SOMPM*EES/.907185) + RDMES		

Spain, Variable Names and Definitions

Endogenous

MARES1: Soybean crushing margin, peseta/MT
PSBMES: Soybean price, peseta/MT (calculated)
PSMMES: Soymeal price, peseta/MT (calculated)
SBSMNES: Soybean imports, 1000 MT
SBUFEES: Soybean crush demand, 1000 MT
SMSMNES: Soymeal imports, 1000 MT
SMSPRES: Soymeal production, 1000 MT
SMUDTES: Soymeal domestic consumption, 1000 MT

Exogenous

DES: 1 in 1972, 0 otherwise
EES: Exchange rate, peseta/$
NARDGES: Real per capita income, 1970 peseta
OMUDTES: Other meal consumption in soymeal equivalent, 1000 MT
PSOMES: Soyoil price, peseta/MT (calculated)
RDBES: Soybean price differential, Spain-U.S., peseta/MT (calculated)
RDMES: Soymeal price differential, Spain-U.S., peseta/MT (calculated)
SBCOTES: Soybean ending stocks, 1000 MT
SBUSOES: Feed, seed, and residual use of soybeans, 1000 MT
SMCOTES: Soymeal ending stocks, 1000 MT
SMYLDES: Soymeal crushing yield coefficient

expected. The income elasticity of soymeal demand implies a rather sensitive response of soymeal consumption demand to any change in per capita income.

The soymeal price coefficient is statistically significant and has a correct sign. The estimated demand elasticity is low. The corn threshold price calculated in Spanish currency is used for the corn price effect because Spain intends to join the EC in the near future and has worked with the EC toward common policies. There are some corn price policies in Spain. The domestic corn price in Spain is not available for this analysis, therefore the EC corn threshold price is used as a proxy. As in the case of the EC, corn price shows a substitution relationship with soymeal demand.

The consumption of other high protein meals shows its substitution effect on soymeal demand but it is not of significance. These other meals include fish meal, cottonseed meal, and sunflower meal. Their total consumption is small compared to soymeal consumption.

The Japanese Submodel

Equations (7.1) to (7.9) describe the Japanese market. Three behavioral equations, explaining soybean crush demand, soymeal consumption demand, and high protein animal consuming units, perform well with high R-square values.

Japanese soybean crush demand. The Japanese soybean crush demand (7.1) is a function of crushing value, soybean price, crushing capacity, quantity crushed of other oilseeds, and time trend. The lag soybean crush demand and log of time variables are used to reflect the soybean crushing capacity because actual crushing capacity could not be found. The log form of time trend is used to capture the fast but declining rate of growth in crushing capacity. These two variables are the most significant explanatory variables for Japanese soybean crush demand.

TABLE 7. Soybean and soymeal model equations, Japan

			R^2	D.W.
(7.1)	SBUFEJP	= -20285.40 + 5.13*VALJPTY - 12.66*UVTYSBJP	.98	2.10
	t	(-3.35) (1.65) (-3.62)		
	e	[0.16] [-0.26]		
		+ 0.78*LAG(SBUFEJP) - 2.59*OSDCRJP + 5143.29*LOGYR		
	t	(3.92) (-1.60) (3.42)		
	e	[0.74] [-0.32]		
(7.2)	SMUDTJP	= -22.96 - 2.03*PSMJPTY + 0.03*COUDTJP + 7.02*HPAHCJP	.97	1.67
	t	(-0.15)(-0.87) (1.37) (6.60)		
	e	[-0.07] [0.12] [0.96]		
(7.3)	HPAHCJP	= 69.94 + 3.47*LAG(NARDGJP)	.94	1.39
	t	(4.35)(16.04)		
	e	[0.78]		
(7.4)	VALJPTY	= 0.792*PSMJPTY + 0.178*PSOJP/1000		
(7.5)	SMSPRJP	= SBUFEJP*SMYLDJP		
(7.6)	SBSMNJP	= SBUFEJP + SBUHTJP + SBUSOJP + SBCOTJP - SBSPRJP - LAG(SBCOTJP)		
(7.7)	SMSMNJP	= SMUDTJP - SMSPRJP + SMCOTJP - LAG(SMCOTJP)		
(7.8)	UVTYSBJP	= (36.7437*SOYPM*EJP/1000) + RDBJP		
(7.9)	PSMJPTY	= (SOMPM*EJP/.907185*1000) + RDMJP		

Japan, Variable Names and Definitions

<u>Endogenous</u>

HPAHCJP: High protein animal units, hog and poultry (calculated)
PSMJPTY: Soymeal price, 1000 yen/MT
SBSMNJP: Soybean imports, 1000 MT
SBUFEJP: Soybean crush demand, 1000 MT
SMSMNJP: Soymeal imports, 1000 MT
SMSPRJP: Soymeal production, 1000 MT
SMUDTJP: Soymeal domestic consumption, 1000 MT
UVTYSBJP: Soybean import unit value, 1000 yen/MT
VALJPTY: Soybean crushing value, 1000 yen/MT

Exogenous

COUDTJP: Corn domestic consumption, 1000 MT
EJP: Exchange rate, yen/$
LOGYR: Log of year
NARDGJP: Real income index, 1980 = 100
OSDCRJP: Other oilseed crush in soybean equivalent, 1000 MT
PSOJP: Soyoil price, 1000 yen/MT
RDBJP: Soybean price differential, Japan-U.S. (calculated)
RDMJP: Soymeal price differential, Japan-U.S. (calculated)
SBCOTJP: Soybean ending stocks, 1000 MT
SBSPRJP: Soybean production, 1000 MT
SBUHTJP: Soybean food demand, 1000 MT
SBUSOJP: Feed, seed, and residual soybean use, 1000 MT
SMCOTJP: Soymeal ending stocks, 1000 MT
SMYLDJP: Soymeal crushing yield coefficient

The soybean price coefficient is statistically significant and has the correct sign. The import unit value of soybeans into Japan is used to estimate the soybean price paid by crushers because there is no import barrier for soybeans imported into Japan. Also, soybean crush demand is price inelastic. The coefficient of the crushing value variable is not significant but has a correct sign. The estimated crush demand elasticity with respect to the crushing value is low.

The other oilseed crush demand variable shows some substitution effect with soybean crush demand, but its coefficient is not statistically significant. The crush level of other oilseeds (including rapeseed and cottonseed calculated in terms of soymeal high protein equivalent) has no significant influence on the soybean crush demand in Japan. This is because the crushing industry has become highly specialized and soybean crushing level far exceeds other oilseed crushing levels.

Japanese soymeal demand. Soymeal consumption demand (7.2) in Japan is a function of soymeal price, level of corn consumption, and the number of high protein animal units, which includes only poultry and hogs. The number of high protein animal units variable (HPAHCJP) is the most important explanatory variable. The level of corn consumption also influences the Japanese soymeal demand and it exhibits a complementary effect with soymeal consumption, in contrast to the cases of the United States, EC, and Spain. The soymeal price coefficient has the correct sign but is not very significant. Also, soymeal demand is very price inelastic. This finding about Japanese soymeal demand is consistent with the result in Williams' study (34). High protein animal units is a function of real income only. The real income index is highly significant and income elasticity is less than one.

The Eastern European Submodel

For the Eastern European market, soybean crush demand is the only behavioral equation (8.1). The soybean crush demand is a function of previous year soymeal domestic demands, crushing value, and soybean import price. The lag of soymeal consumption demand is the most important explanatory variable for soybean crush demand. This is reasonable for a planned economy such as EE. The level of soybeans crushed is very responsive to the government's planned growth in soymeal consumption. This was not the case prior to 1970, however, as seen in the slope shift of -0.23 for the 1965- 1969 period.

The crush demand also has some economic response to soybean price and crushing value. Rotterdam prices are used because of absence of domestic price data for this region. The crush demand, in fact, is sensitive to soybean price and the crushing value. Equations (8.6) and (8.7) are price linkage equations for EE, using Rotterdam prices (in dollars per metric ton) as proxies.

Rest of the World Submodel

The regions of the world not explicitly modeled are aggregated into a "rest of world" net import component (9.5) to (9.7). In order to allow this residual component to adjust to price changes under alternative policies, a soymeal price elasticity of -0.3 was imposed on this meal demand (9.5). This elasticity is slightly higher in absolute value than those estimated for other regions since this includes many lower-income countries. A control variable (EUS) was included to allow for the analyses of U.S. exchange rate impacts. The change in meal demand for the rest of the world is assumed to be allocated between meal and bean imports according to the actual historical proportions (9.6) and (9.7).

TABLE 8. Soybean and soymeal model equations, Eastern Europe

```
                                                                  R2    D.W.
(8.1)  SBUFEE8 = -10.88 + 0.32*LAG(SMUDTE8) + 5.33*VALEC8        .83   1.85
       t         (-0.04) (3.39)              (0.46)
       e                 [1.36]              [1.88]

                 - 6.62*PSMEC + 206.20*D69E8
       t         (-0.52)        (0.28)
       e         [-2.24]

                 - 0.23*(LAG(SMUDTE8)*D69E8) - 215.67*D75E8
                 (-0.20)                      (-0.87)

(8.2)  VALEC8 = 0.792*PMMEC + 0.178 + POMEC

(8.3)  SMSPRE8 = SBUFEE8*SMYLDE8

(8.4)  SBSMNE8 = SBUFEE8 + SBUSOE8 - SBSPRE8

(8.5)  SMSMNE8 = SMUDTE8 - SMSPRE8 + SMCOTE8 - LAG(SMCOTE8)

(8.6)  PSMEC = (36.7437*SOYPM) + RDBE8

(8.7)  PMMEC = (SOMPM/.907185) + RDME8
```

Eastern Europe, Variable Names and Definitions

Endogenous

PMMEC: Soymeal import price, Rotterdam, $/MT
PSMEC: Soybean import price, Rotterdam, $/MT
SBSMNE8: Soybean imports, 1000 MT
SBUFEE8: Soybean crush demand, 1000 MT
SMSMNE8: Soymeal imports, 1000 MT
SMSPRE8: Soymeal production, 1000 MT
VALEC8: Soybean crushing value in EC, $/MT

Exogenous

D69E8: 1 prior to 1969, 0 otherwise
D76E8: 1 in 1974, 0 otherwise
POMEC: Soyoil import price, Rotterdam, $/MT
RDBE8: Soybean price differential, EC-U.S., $/MT (calculated)
RDME8: Soymeal price differential, EC-U.S., $/MT (calculated)
SBSPRE8: Soybean production, 1000 MT
SBUSOE8: Feed, seed, and residual use of soybeans, 1000 MT
SMCOTE8: Soymeal ending stocks, 1000 MT
SMUDTE8: Soymeal consumption, 1000 MT
SMYLDE8: Soymeal crushing yield coefficient

TABLE 9. Soybean and soymeal model equations, Rest of the World

(9.1) TOTWBX = SOYMX/0.0367437 + SBSNXBR + SBSNXAR

(9.2) TOTWBM = SOYNMROW + SBSMNSU + SBSMNCN + SBSMNE9 + SBSMNES + SBSMNE8 + SBSMNJP

(9.3) TOTWMX = SOMMXES*0.907185 + SMSNXBR + SMSNXAR

(9.4) TOTWMM = SOMNMROW + SMSMNSU + SMSMNCN + SMSMNE9 + SMSMNES + SMSMNE8 + SMSMNJP

(9.5) MENMROW = MENMROWA*(SOMPM*EUS/SOMPMA)**(-0.3)

(9.6) SOMNMROW = MENMROW*MPERROW

(9.7) SOYNMROW = (MENMROW - SOMNMROW)/0.792

ROW, Variable Names and Definitions

Endogenous

SOMNMROW: Soymeal net imports, 1000 MT
SOYNMROW: Soybean net imports, 1000 MT
TOTWBM: Total world soybean imports
TOTWBX: Total world soybean exports
TOTWMM: Total world soymeal imports
TOTWMX: Total world soymeal exports

Exogenous

MPERROW: Import ratio of soymeal to soymeal equivalent imports
SBSMNCN: Soybean net imports, PRC, 1000 MT
SBSMNSU: Soybean net imports, USSR, 1000 MT
SMSMNCN: Soymeal net imports, PRC, 1000 MT
SMSMNSO: Soymeal net imports, USSR, 1000 MT
MENMROW: Soybean and soymeal net imports, meal equivalent, 1000 MT

Validation and Performance of the Model

Performance of the model can be measured by the validity of its estimates, its ability to reproduce the actual data in a dynamic simulation, and its stability. In general, this model performs quite well. The estimates are reasonable values judging by economic theory, as well as comparison to other studies' results. All behavioral equations have high predictability and show no significant serial correlation problems, as discussed earlier. Given the size of the model (100 equations), the validity of these estimates is satisfactory. A summary of derived structural elasticities from the model can be found in Table 10 and the price transmission elasticities as shown in Table 11.

This section is concerned mainly with model performance and stability. There are no definite rules for measuring these two attributes. The judgment on the performance of any model is subjective. However, some statistics are used to assist such judgement. In order to measure this model's ability to fit, simulation of the model is run over the period of study (1966-1982). The simulation result is then compared with the actual data. Statistics measuring the model's fitting performance include residual mean square RMS error, RMS percent error, and Theil's forecast statistics. This model validation was conducted with the econometric model before the synthetic elasticities of Appendix Table A.1 was added.

The RMS error measures an average error of the simulated values from the actual values. The size of RMS error is dependent upon the variable size. To eliminate this problem, RMS percent error is often used instead. Theil's statistics are also often used to measure simulation performance of a model. There are three different components: UM (bias error), UR (regression error), and UD (disturbance error). The bias proportion UM is an indication of systematic error since it measures the extent to which the average values of the

Table 10. Price elasticities of supply and demand for soybean trade model

	Soybean Price	Soymeal Price	Soyoil Price	Value of Meal and Oil	Corn Price
U.S.					
Production	0.71				
Soybean crush	-2.08			1.96	
Soybean stocks	-0.69				
Soymeal demand		-0.41			0.19
Soyoil demand			-0.45		
Soyoil stocks			-0.13		
Brazil					
Production	0.08				
Soybean crush	-0.50			1.00	
Soymeal demand		-0.34			-0.21
Argentina					
Production	0.27				
Soybean crush	-2.26			2.50	
Soymeal demand		-0.18			
EC					
Soybean crush	-1.91			1.99	
Soymeal demand		-0.27			0.25
Spain					
Soybean crush	-4.87			5.05	
Soymeal demand		-0.32			0.44
Japan					
Soybean crush	-0.26			0.16	
Soymeal demand		-0.07			
Eastern Europe					
Soybean crush	-2.20			1.84	
Rest of World					
Soymeal demand		-0.30			

Table 11. Price transmission elasticities of soybean and soymeal prices of other regions with respect to U.S. soybean and soymeal prices

Regions	Soybean Price	Soymeal Price
Brazil	1.80	1, 0[a]
Argentina	0.97	0.96
European Community	0.90	0.88
Spain	0.86	0.84
Japan	0.91	0.53
Eastern Europe	0.88	0.88
Rest of World	--	1.00

[a]The domestic soymeal price is subject to government control and hence does not respond to U.S. soymeal price. The U.S. soymeal price is used for the Brazil soymeal export price and thus price transmission elasticity is 1.

simulated and actual series deviate from each other. The regression proportion UR indicates the ability of the model to replicate the degree of variability in the variable of interest. The disturbance proportion UD measures the error remaining after deviations from average values and average variabilities have been accounted for.

Table 12 presents RMS errors and RMS percent error and Table 13 presents Theil's forecast statistics. Most endogenous variables have very low RMS percent errors. Out of 79 endogenous variables 49 variables--including most price variables--have RMS percent errors less than 0.16 and 60 variables--including all prices--have RMS percent errors less than 0.3. Variables with high RMS percent errors are SBSPRAR, SBAHHAR, SBUFEAR, SMSPRAR, SMUDTAR, SMSNXAR, SBSNXAR, SOYCH, SMSMNES, SMSMNJP, SMSNXBR, SBSNXBR, and SOYCM. All Argentine variables have high RMS percent errors because the soybean-soymeal market did not exist at a substantial level in Argentina until the late 1970s. The contrast in the magnitude of variables during the beginning and the end of the studied periods contributes to high simulation errors. All these variables are of very small magnitude, thus any small error of prediction creates a high proportional error when such error is compared to the small actual values. The export and import variables carry high RMS error also because they are excess supplies and excess demands. Simulation errors from other domestic variables accumulate and are transferred to the export and import variables. On the whole, however, the model simulation variables have reasonably low RMS percent errors.

Theil's forecast errors of most simulation variables are from disturbance terms rather than from intercept or regression terms. This shows that the model performs satisfactorily. Table 13 presents these Theil's forecast errors, which have been weighted so that all the three components of MSE sum to 1.0. Some variables which have high UR (generally the same variables which

Table 12. STATISTICS OF FIT

VARIABLE	N	RMS ERROR	RMS % ERROR
SBSPRAR	17	204.393	0.870535
SBAHHAR	17	105.989	0.870537
HPAHCJP	17	17.0009	0.0570513
HPAHCE9	17	75.6809	0.0254919
SBSPRBR	17	456.122	0.30546
SBAHHBR	17	343.296	0.305538
DCTNRE	17	0.354542	0.0310198
DCORNRE	17	0.709581	0.0100178
SOYSA	17	2.59637	0.0471188
SOMDDT	17	749.176	0.051969
SOOHC	17	241.063	0.250174
SOMMXES	17	1416.68	0.241237
SOODDT	17	355.55	0.049585
SOYPF	17	0.482898	0.0982443
SOYSAE	17	2.59702	0.0471286
SOYSC	17	62.6502	0.0719417
SOYSPE	17	72.5865	0.0481443
SOOPM	17	3.41496	0.186953
SOMPM	17	23.4354	0.148489
SOMSP	17	1444.83	0.070162
SOYHT	17	45.9413	0.327551
SMSMAR1	17	171.419	3713474
SMUDTES	17	145.904	0.079879
DSNRE1	17	10.5524	0.154193
SOOSP	17	670.17	0.0714742
SBUFEAR	17	142.058	1.59664
SOOXES	17	206.497	0.647402
SOYMX	17	53.2447	0.0972095
SBUFEJP	17	66.29	0.0277789
UVTYSBJP	17	5.00079	0.0845655
MARBR2	17	43.4797	0.12031
RPMBR2	17	85.1403	0.146291
SBUFEBR	17	661.897	0.517883
SMUDTBR	17	164.21	0.279256
SBSMNBR	17	837.982	4.45502
SMSMNBR	17	567.375	0.995008
RPBWBR1	17	71.8298	0.165044
RPMWBZ	17	0.337035	0.00138476
PSMEC	17	21.2242	0.0898811
SMSPRE8	17	103.135	0.231805
MAREC1	17	8.9452	3.12265
PSMME9	17	22.7495	0.130789
PSBME9	17	19.3306	0.0898847
SBUFEE9	17	733.869	0.0923318
SMUDTE9	17	752.689	0.0697137
SMSPRE9	17	589.723	0.0924065
SMSMNE9	17	660.061	0.186571
SBSMNE9	17	763.768	0.0926136
SMSPRAR	17	110.898	1.59697
MARES1	17	762.277	2.80183
PSMMES	17	2090.18	0.129785
PSBMES	17	1983.16	0.0885219

Table 12. (Continued)

VARIABLE	N	RMS ERROR	RMS % ERROR
SBUFEES	17	438.647	0.200813
SBUFEE8	17	129.214	0.231051
SMSPRES	17	346.109	0.200486
SBSMNES	17	447.611	0.203815
SMSMNES	17	372.148	15.6224
VALJPTY	17	5.5935	0.0559617
PSMJPTY	17	7.0625	0.0771677
SOYHC	17	45.5928	0.489135
SOMNMROW	17	87.51	0.042764
SMSPRJP	17	50.9763	0.0277898
SMUDTJP	17	141.848	0.0691462
SBSMNJP	17	85.643	0.0247872
SMSMNJP	17	136.104	9.16188
SOYPM	17	0.535192	0.0969925
VALEC8	17	20.5269	0.0792775
PMMEC	17	25.9178	0.13096
SBSMNAR	17	164.258	7120949
SOYNMROW	17	552.027	0.123783
RPBAR1	17	49.303	0.0849189
SBSMNE8	17	120.998	0.441121
SMSMNE8	17	219.318	0.0754454
RPMAR1	17	71.1189	0.130722
MENMROW	17	502.344	0.0740195
SMUDTAR	17	24.9021	0.968973
VALAR1	17	56.3262	0.0790564
TOTWMM	17	949.693	0.113097
TOTWBM	17	1246.66	0.0642281
SMSNXAR	17	171.419	3713474
SBSNXAR	17	164.258	7120949
SMSNXBR	17	567.375	0.995008
SBSNXBR	17	837.982	4.45502
VALUSMX	17	247.335	0.259651
VALUSBX	17	473.165	0.127881
SOYCM	17	0.196747	2.06656
SHMMJP	17	2.06629	10.7726
SHMME8	17	3.64227	0.121781
SHMMES	17	3.26639	13.718
SHMME9	17	4.28895	0.0914388
SHMBJP	17	1.39023	0.0667239
SHMBE8	17	0.736068	0.459961
SHMBES	17	1.57777	0.166566
SHMBE9	17	2.39451	0.052465
SBAHARE	17	108.928	0.870587
SBAHBRE	17	343.4	0.305518
SBSPARE	17	204.512	0.870536
TOTWMX	17	933.777	0.112491
TOTWBX	17	1252.64	0.0640934
SBSPBRE	17	456.379	0.305462
SHXMAR	17	1.69838	100356
SHXMBR	17	9.9217	1.13015
SHXMUS	17	9.64444	0.165396
SHXBAR	17	1.02075	56297.1
SHXBBR	17	6.8762	4.4459

Table 12. (Continued)

VARIABLE	N	RMS ERROR	RMS % ERROR
SHXBUS	17	6.39709	0.0712458
SOYXTOT	17	46.0459	0.0646135
OESOYX	17	492.772	0.0646135

Table 13. THEIL'S FORECAST ERROR MEASURES

VARIABLE	N	RELATIVE CHANGE MSE	DECOMPOSITION BIAS (UM)	REGRESS (UR)	DISTURB (UD)	ACCURACY (U1)
SBSPRAR	17	1.25079	0.04	0.76	0.20	0.0005
SBAHHAR	17	1.28202	0.06	0.84	0.11	0.0010
HPAHCJP	17	0.00394678	0.00	0.03	0.97	0.0002
HPAHCE9	17	.000648328	0.00	0.31	0.69	0.0000
SBSPRBR	17	0.111583	0.06	0.50	0.44	0.0000
SBAHHBR	17	0.134489	0.06	0.72	0.21	0.0001
DCTNRE	17	.000069141	0.10	0.49	0.41	0.0001
DCORNRE	17	.000112595	0.00	0.00	1.00	0.0001
SOYSA	17	0.00243739	0.00	0.04	0.95	0.0009
SOMDDT	17	0.00280638	0.00	0.34	0.65	0.0000
SOOHC	17	0.0854111	0.00	0.10	0.90	0.0003
SOMMXES	17	0.0656862	0.05	0.64	0.32	0.0000
SOODDT	17	0.00273361	0.00	0.49	0.51	0.0000
SOYPF	17	0.0126869	0.00	0.12	0.88	0.0218
SOYSAE	17	0.00243804	0.00	0.03	0.96	0.0009
SOYSC	17	0.00576321	0.03	0.46	0.52	0.0001
SOYSPE	17	0.00255541	0.01	0.03	0.96	0.0000
SOOPM	17	0.0413946	0.05	0.06	0.89	0.0100
SOMPM	17	0.0306104	0.01	0.16	0.82	0.0011
SOMSP	17	0.00552775	0.02	0.38	0.61	0.0000
SOYHT	17	0.119569	0.00	0.01	0.99	0.0016
SMSMAR1	17	16.3413	0.01	0.85	0.14	0.0069
SMUDTES	17	0.00728207	0.00	0.08	0.92	0.0000
DSNRE1	17	0.0299122	0.01	0.04	0.95	0.0025
SOOSP	17	0.00579015	0.02	0.33	0.65	0.0000
SBUFEAR	17	5.21338	0.14	0.75	0.11	0.0026
SOOXES	17	0.455079	0.08	0.44	0.48	0.0006
SOYMX	17	0.00957102	0.05	0.02	0.93	0.0002
SBUFEJP	17	.000897875	0.02	0.13	0.85	0.0000
UVTYSBJP	17	0.00847208	0.00	0.18	0.82	0.0015
MARBR2	17	0.0127175	0.12	0.23	0.65	0.0003
RPMBR2	17	0.0244501	0.00	0.01	0.99	0.0003
SBUFEBR	17	0.320524	0.08	0.80	0.11	0.0001
SMUDTBR	17	1.2105	0.06	0.83	0.11	0.0008
SBSMNBR	17	12.6518	0.08	0.82	0.11	0.0022
SMSMNBR	17	0.922022	0.09	0.80	0.12	0.0002
RPBWBR1	17	0.0307803	0.03	0.15	0.82	0.0004
RPMWBZ	17	1.972E-06	0.06	0.00	0.94	0.0000
PSMEC	17	0.0097597	0.00	0.04	0.96	0.0004
SMSPRE8	17	0.152459	0.00	0.20	0.80	0.0006
MAREC1	17	13.6153	0.04	0.64	0.33	0.3928
PSMME9	17	0.019751	0.01	0.03	0.97	0.0008
PSBME9	17	0.010368	0.00	0.01	0.98	0.0005
SBUFEE9	17	0.0100195	0.04	0.04	0.92	0.0000
SMUDTE9	17	0.00573054	0.01	0.03	0.95	0.0000
SMSPRE9	17	0.0100597	0.04	0.04	0.92	0.0000
SMSMNE9	17	0.0379715	0.06	0.48	0.46	0.0000
SBSMNE9	17	0.0100348	0.04	0.04	0.92	0.0000
SMSPRAR	17	5.08138	0.13	0.75	0.11	0.0033
MARES1	17	21.8202	0.03	0.65	0.32	0.0062

Table 13. (Continued)

VARIABLE	N	MSE	(UM)	(UR)	(UD)	(U1)
PSMMES	17	0.0203184	0.01	0.04	0.95	0.0000
PSBMES	17	0.0104418	0.00	0.00	1.00	0.0000
SBUFEES	17	0.0447579	0.00	0.38	0.62	0.0001
SBUFEE8	17	0.1506	0.00	0.21	0.79	0.0005
SMSPRES	17	0.0446837	0.00	0.37	0.62	0.0001
SBSMNES	17	0.0464831	0.00	0.39	0.61	0.0001
SMSMNES	17	83.1984	0.04	0.83	0.13	0.0352
VALJPTY	17	0.00458141	0.00	0.02	0.97	0.0007
PSMJPTY	17	0.00762685	0.00	0.02	0.97	0.0010
SOYHC	17	0.205594	0.01	0.28	0.71	0.0023
SOMNMROW	17	0.0171931	0.13	0.05	0.82	0.0001
SMSPRJP	17	.000918108	0.01	0.16	0.82	0.0000
SMUDTJP	17	0.00527688	0.00	0.31	0.68	0.0000
SBSMNJP	17	.000717875	0.07	0.02	0.91	0.0000
SMSMNJP	17	55.4014	0.00	0.91	0.09	0.0378
SOYPM	17	0.0119629	0.00	0.02	0.98	0.0200
VALEC8	17	0.00946228	0.02	0.33	0.66	0.0004
PMMEC	17	0.0204378	0.01	0.16	0.83	0.0007
SBSMNAR	17	0.961791	0.09	0.60	0.31	0.0005
SOYNMROW	17	0.0139615	0.09	0.19	0.72	0.0000
RPBAR1	17	0.0108325	0.03	0.25	0.72	0.0002
SBSMNE8	17	0.50663	0.00	0.08	0.92	0.0017
SMSMNE8	17	0.00545794	0.05	0.03	0.93	0.0000
RPMAR1	17	0.0696118	0.03	0.76	0.21	0.0005
MENMROW	17	0.0112649	0.08	0.35	0.57	0.0000
SMUDTAR	17	1.33992	0.00	0.73	0.27	0.0064
VALAR1	17	0.0207047	0.03	0.64	0.34	0.0002
TOTWMM	17	0.0149348	0.08	0.46	0.46	0.0000
TOTWBM	17	0.00480045	0.08	0.00	0.92	0.0000
SMSNXAR	17	16.3413	0.01	0.85	0.14	0.0069
SBSNXAR	17	0.961791	0.09	0.60	0.31	0.0005
SMSNXBR	17	0.922022	0.09	0.80	0.12	0.0002
SBSNXBR	17	12.6518	0.08	0.82	0.11	0.0022
VALUSMX	17	0.0926655	0.01	0.02	0.98	0.0003
VALUSBX	17	0.0231243	0.04	0.04	0.92	0.0000
SOYCM	17	13.9215	0.08	0.72	0.20	8.8463
SHMMJP	17	68.7289	0.01	0.93	0.06	4.0466
SHMME8	17	0.0191221	0.00	0.39	0.61	0.0046
SHMMES	17	63.0075	0.03	0.84	0.14	2.5274
SHMME9	17	0.00786039	0.02	0.23	0.76	0.0017
SHMBJP	17	0.00466146	0.02	0.15	0.82	0.0029
SHMBE8	17	0.415952	0.01	0.12	0.87	0.3292
SHMBES	17	0.0239513	0.00	0.35	0.65	0.0145
SHMBE9	17	0.00253385	0.00	0.30	0.70	0.0010
SBAHARE	17	1.28214	0.06	0.84	0.10	0.0009
SBAHBRE	17	0.131505	0.06	0.72	0.22	0.0001
SBSPARE	17	1.25079	0.04	0.77	0.19	0.0004
TOTWMX	17	0.0148655	0.08	0.47	0.45	0.0000
TOTWBX	17	0.00499903	0.05	0.00	0.95	0.0000
SBSPBRE	17	0.111584	0.06	0.49	0.44	0.0000
SHXMAR	17	11.5006	0.01	0.82	0.17	0.8581
SHXMBR	17	0.936862	0.11	0.82	0.07	0.0252
SHXMUS	17	0.0261931	0.01	0.66	0.33	0.0024

Table 13. (Continued)

VARIABLE	N	MSE	(UM)	(UR)	(UD)	(U1)
SHXBAR	17	1.00572	0.09	0.57	0.34	0.1329
SHXBBR	17	14.3376	0.02	0.90	0.07	0.3878
SHXBUS	17	0.00485678	0.01	0.51	0.49	0.0008
SOYXTOT	17	0.00504268	0.05	0.01	0.94	0.0001
OESOYX	17	0.00484899	0.05	0.01	0.94	0.0000

have high RMS percent errors mentioned earlier) are not crucial variables in this study. Their magnitudes are small. The same explanation is applied here as when they have high RMS percent error.

The comparison of simulated values and the actual data is very satisfactory. The model has good ability for tracing upward and downward movements in the data. The estimates, in general, are close to the actual values. In cases where data show extreme fluctuations over time, the simulation results tend to be more accurate in the later years than in the beginning of the period. The actual and simulated values of a few selected variables are plotted in Figures 6-13.

Overall, this model's performance is satisfactory. All behavioral equations have high predictability and indicate no serial correlation problems. The relationship among all variables agrees with prior economic expectations. The dynamic simulation results track their actual data well with reasonably low RMS errors. The Theil's statistics indicate that the model contains relevant explanatory variables and simulation errors are mainly due to disturbances.

FIGURE 6. U.S. SOYBEAN FARM PRICE
(ACTUAL VS. PREDICTED)

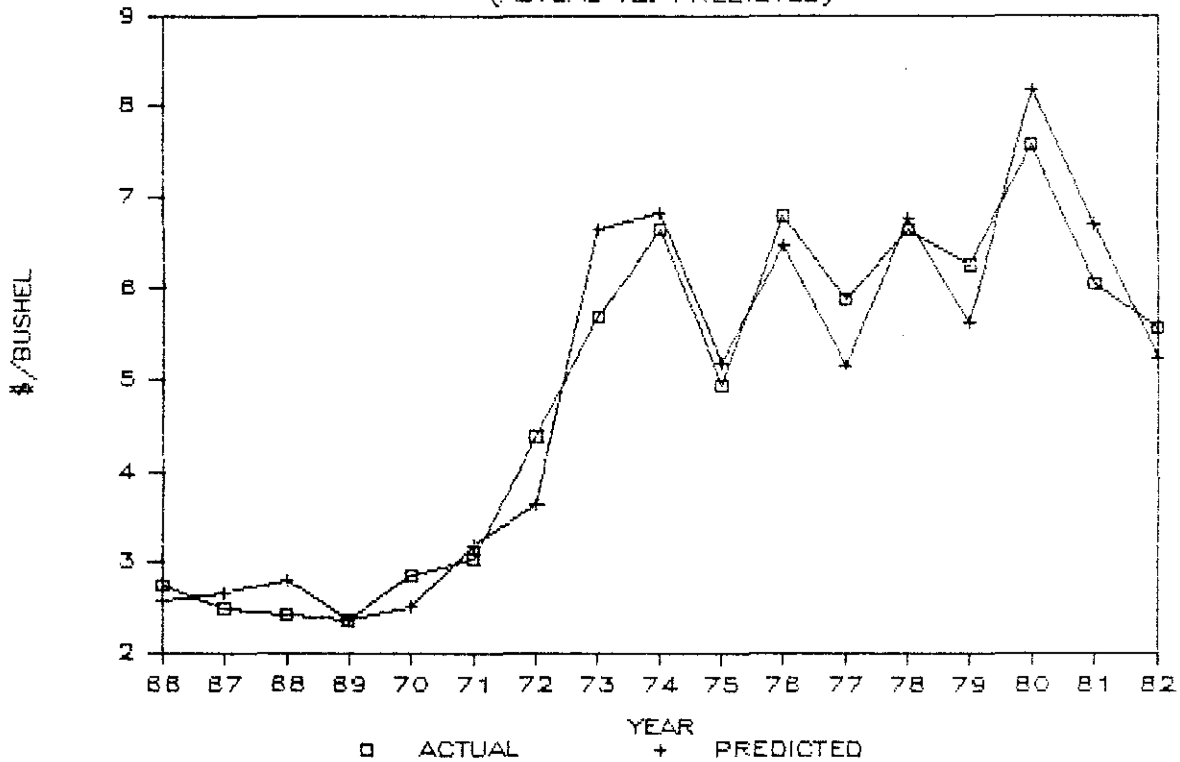


FIGURE 7. U.S. SOYMEAL PRICE, DECATUR
(ACTUAL VS. PREDICTED)

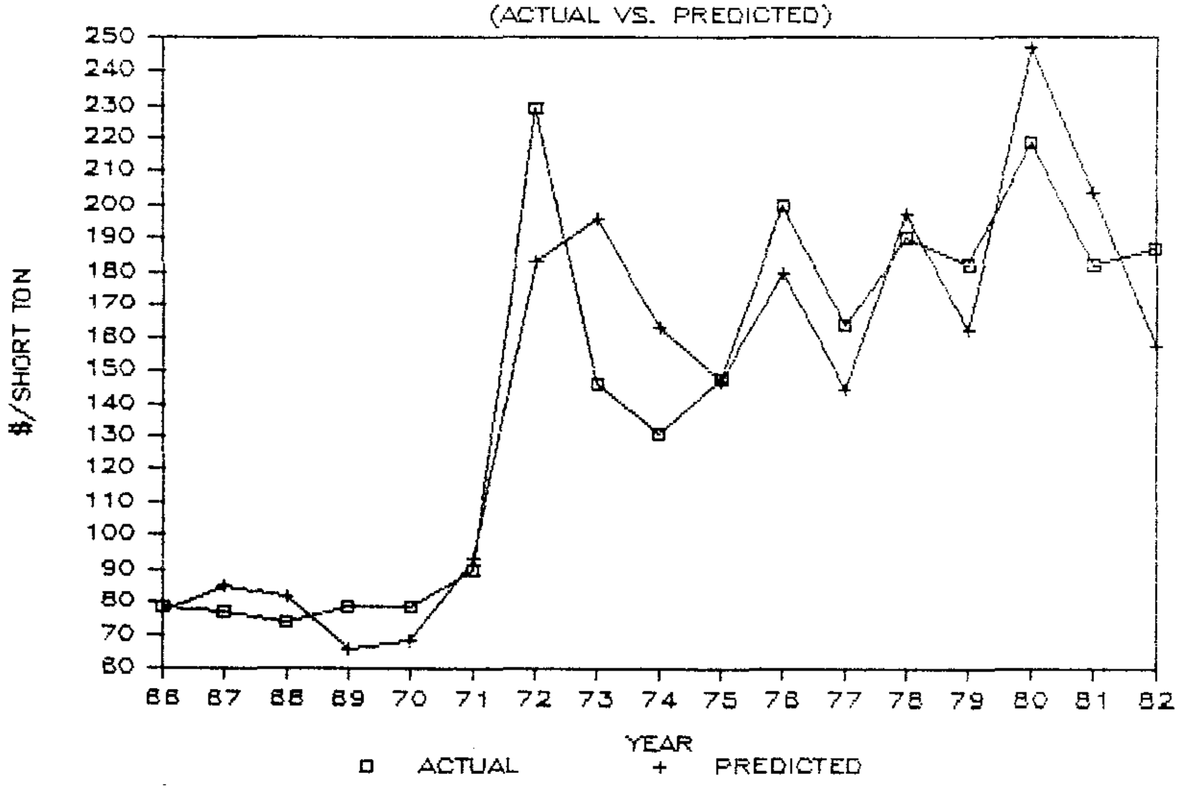


FIGURE 8. U.S. SOYOIL PRICE, DECATUR

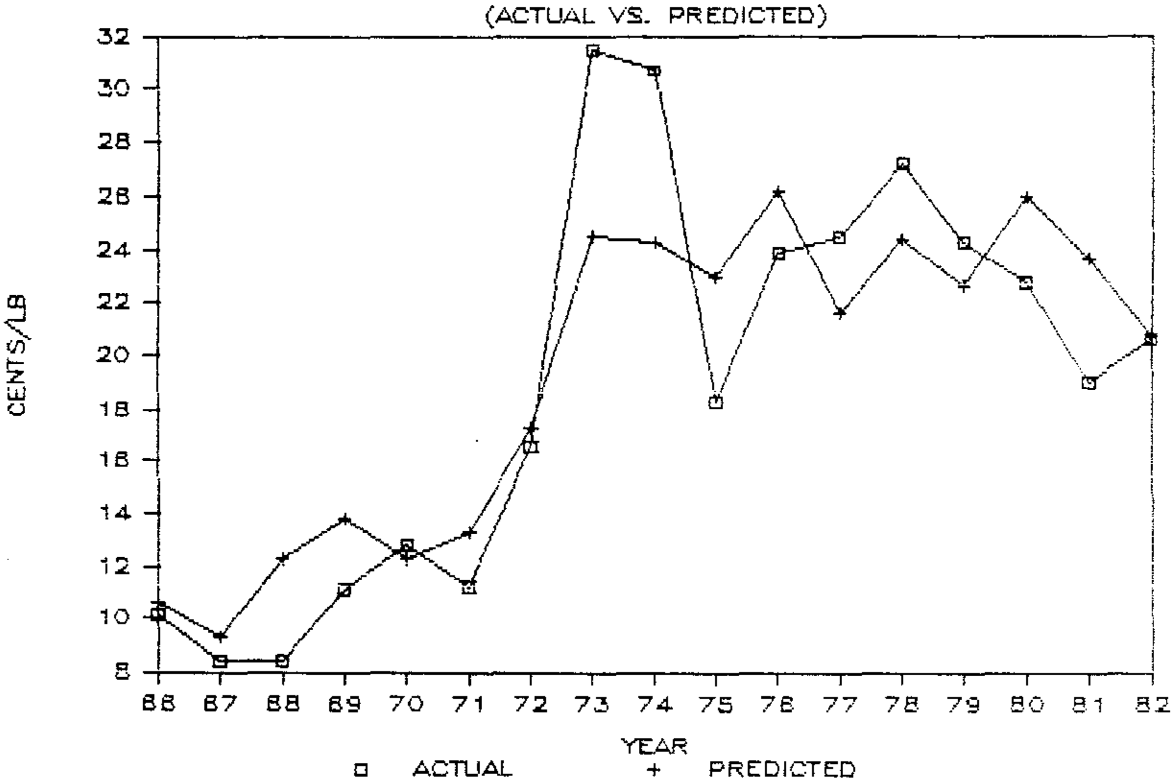


FIGURE 9. U.S. SOYBEAN EXPORTS
(ACTUAL VS. PREDICTED)

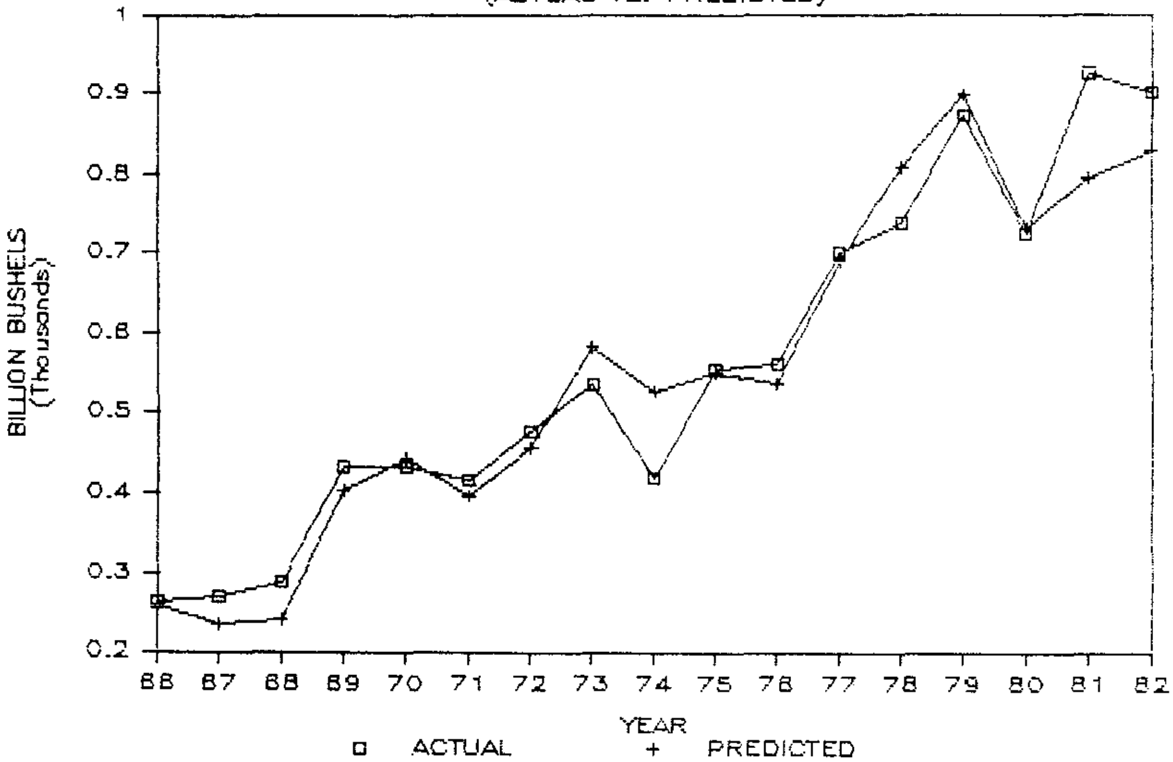


FIGURE 10. U.S. SOYMEAL EXPORTS
(ACTUAL VS. PREDICTED)

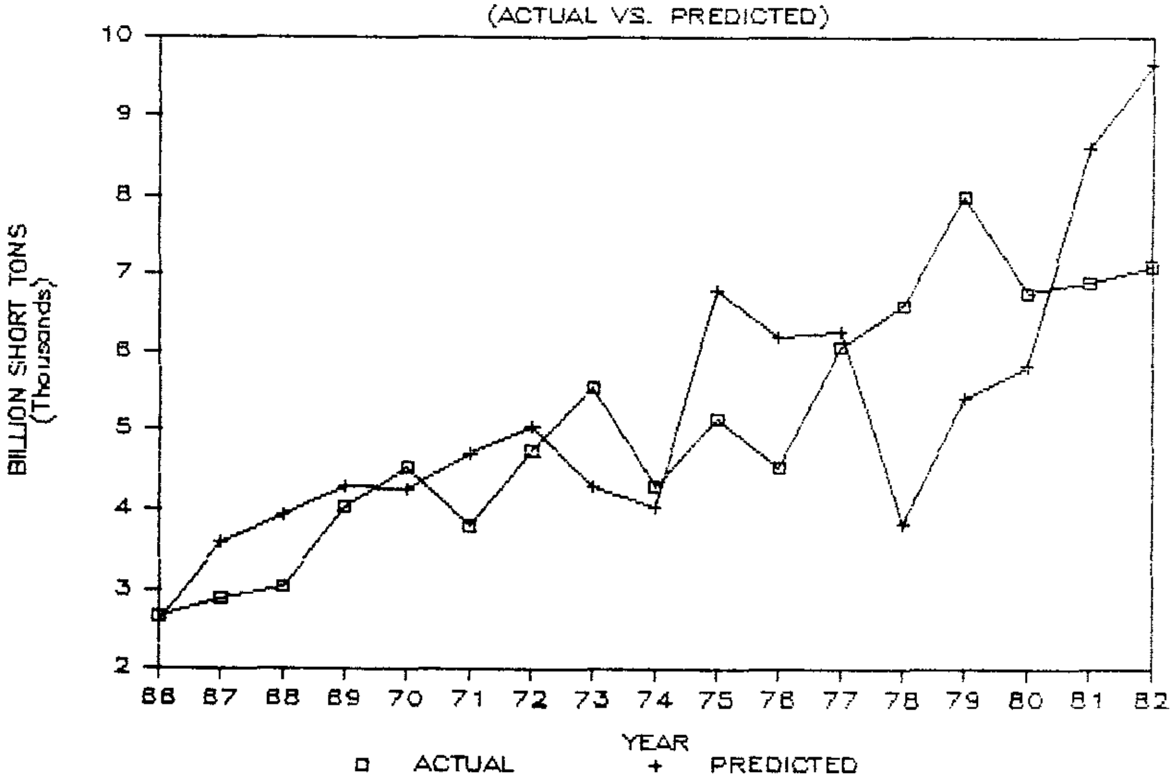


FIGURE 11. BRAZIL SOYBEAN EXPORTS
(ACTUAL VS. PREDICTED)

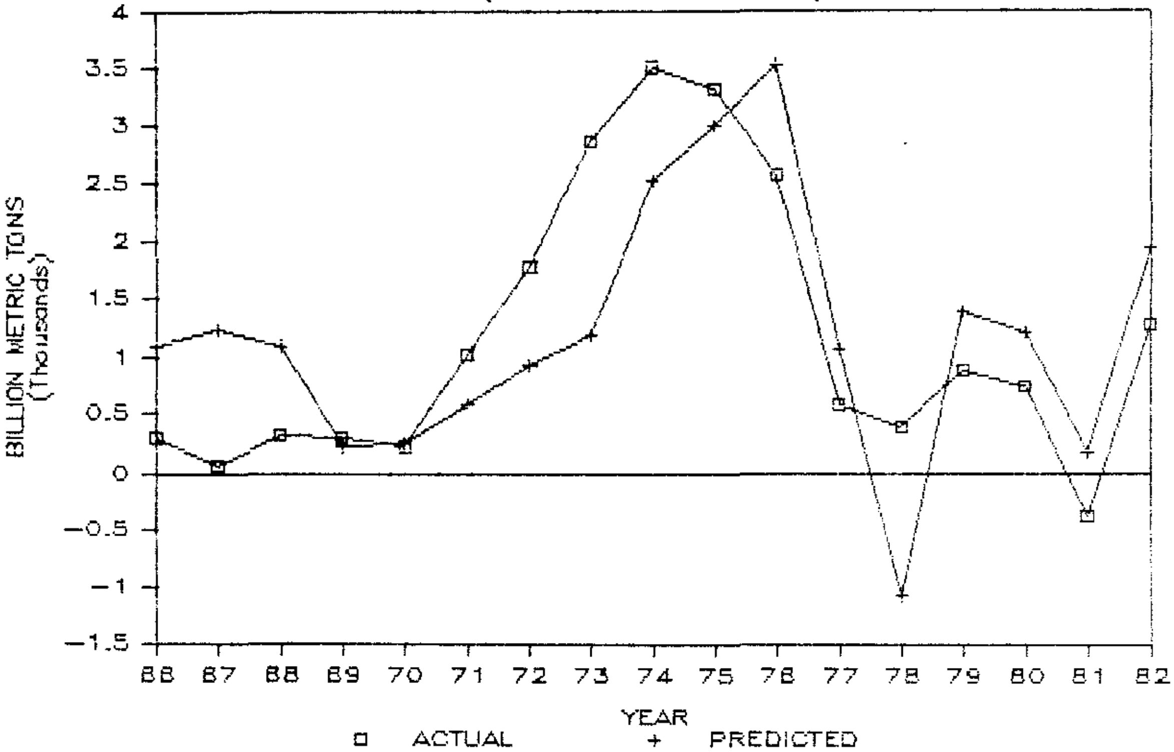


FIGURE 12. BRAZIL SOYMEAL EXPORTS
(ACTUAL VS. PREDICTED)

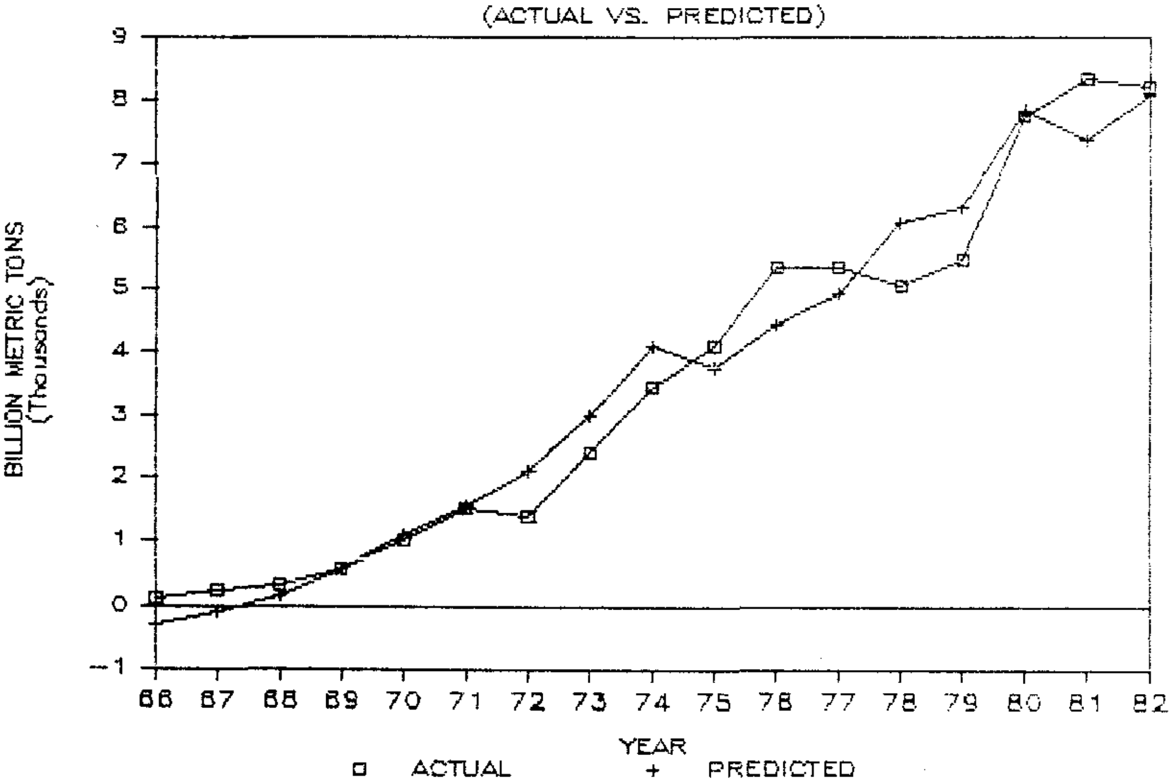


FIGURE 13. ARGENTINA SOYBEAN EXPORTS

(ACTUAL VS. PREDICTED)

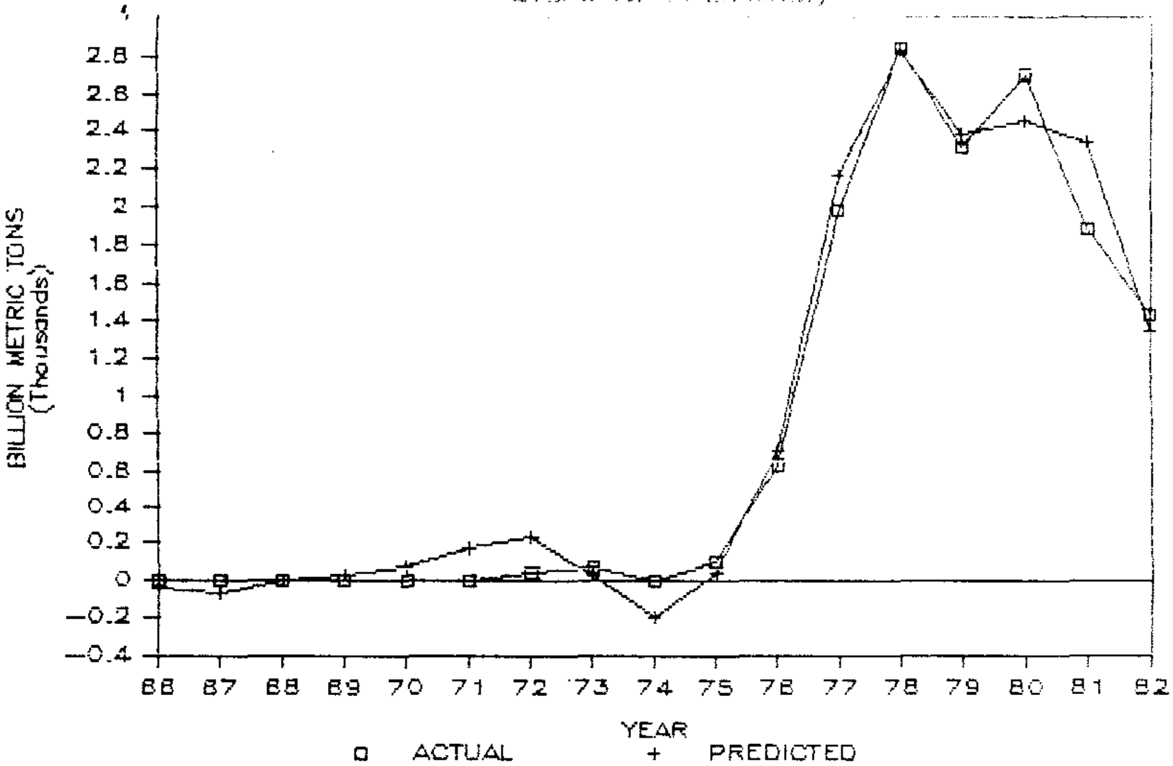
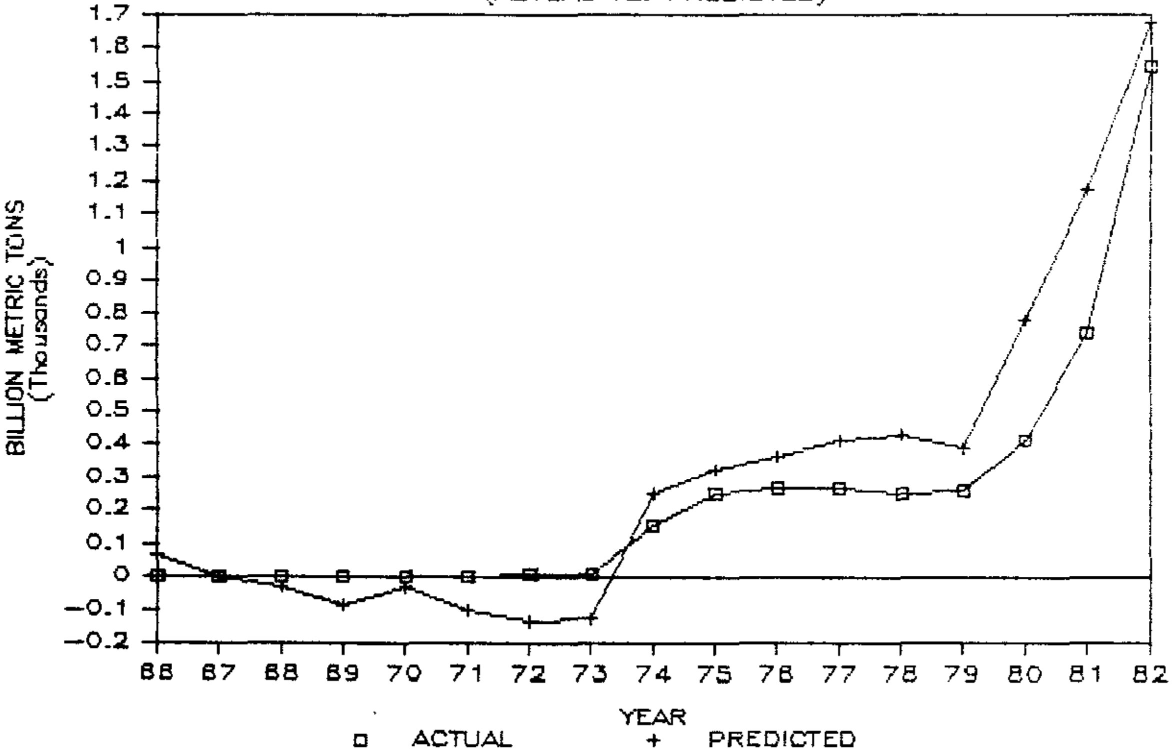


FIGURE 14. ARGENTINA SOYMEAL EXPORTS

(ACTUAL VS. PREDICTED)



Appendix A

Table A.1. Computation of Price and Income Elasticities for Net Import Demand in Selected Regions Not Included in the Model

Region	Net Imports (1)	Domestic Consumption (2)	(2)/(1)	$\frac{(2)-(1)}{(1)}$	n Income Elast.	$\left(n \times \frac{(2)}{(1)}\right)$ Adj. Income Elast.	e_d Demand Elast.	e_s Supply Elast.	e_I Price Trans.	Adj. Net Import Elasticity
	1000 MT									
SOYMEAL										
China	475.0	1019.0	2.145		0.40	0.86				
USSR	1211.0	2358.0	2.00		0.30	0.58				
ROW**	8200.0	14920.0	1.820	0.820	0.40	0.73	-0.3	0.2	0.5	-0.355
SOYBEAN										
China	568.6	8775.0	15.433		0.2	3.09				
USSR	1269.0	1785.0	1.41		0.3	0.42				

*computed as $e_d e_I \left(\frac{(2)}{(1)}\right) - e_s e_I \left(\frac{(2)-(1)}{(1)}\right)$

**rest of world (includes all countries and regions not listed in Tables 10 and A.1)

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