The World Feed-Grains Trade Model: Specification, Estimation, and Validation

by Michael Helmar, S. Devadoss,
and William H. Meyers

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Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa 50011

Michael Helmar is a research associate; S. Devadoss is an adjunct assistant professor; and William H. Meyers is a professor of economics and associate director of CARD.

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Introduction

The feed-grains trade model is one of the three models in the world trade modeling system developed, updated, and maintained by the Center for Agricultural and Rural Development (CARD). The other two commodity trade models are for wheat and the soybeans complex. The three world models are related through cross-price linkages in the supply and demand components of these models, yet each model can be solved independently. In general, however, all three trade models are solved iteratively to obtain a simultaneous solution. Equilibrium prices, quantities of supply and demand, and net trade are determined by equating excess demands and supplies across regions and explicitly linking prices in each region to a world reference price.

The trade models, along with the U.S. domestic crops and livestock models maintained by CARD, have been used extensively to examine the impact of domestic and foreign farm-policy changes and of exogenous shocks. Policy scenarios evaluated with this modeling system have ranged from very restrictive mandatory supply control to complete elimination of domestic and foreign farm programs. The models are also used periodically to project key agricultural variables over 10-year periods. The analyses of impacts of exogenous shocks include technology shocks, such as yield changes; changes in macroeconomic variables, such as income growth, inflation rate, or exchange rates; and external policy shocks, such as tariffs and subsidies. Requests for policy research have come from the U.S. Congress, the National Governors' Association, the U.S. Department of Agriculture, the U.S. Agency for International Development, Agriculture Canada, the Commission of the European Communities, and farm organizations including the National Corn Growers Association, the Iowa Corn Promotion Board, the Iowa Soybean Promotion Board, and the National Pork Producers' Council.

The organization of this documentation is as follows. In the next section, model structure is presented, along with national and regional details. The third section contains theoretical foundations for model specification. The fourth section presents estimation procedures and results. In the fifth section, elasticity estimates are reported, and the model is validated using simulation results. A brief discussion of the applications and limitations of the model is presented in the final section.

Modeling Approach

The purposes of this section are to describe the structure of the feed-grains model and to explain national and regional disaggregation.

The overall structure of the model is based upon the dissertation research of Bahrenian (1987). The model is a nonspatial partial equilibrium model--nonspatial because it does not identify trade flows between specific regions, and in partial equilibrium because only one commodity is modeled.

Figure 1 illustrates the structural components of the model, which includes domestic supply and demand functions for major trading and producing countries and regions. Equilibrium prices, quantities, and net trade are determined by equating excess demands and supplies across regions and explicitly linking prices in each region to a world price. Except where they are set by governments, domestic prices are linked to world prices via price-linkage equations including those concerning bilateral exchange rates and transfer-service margins. Where some degree of insulation of domestic prices from external market conditions exists, trade flows are restricted. The

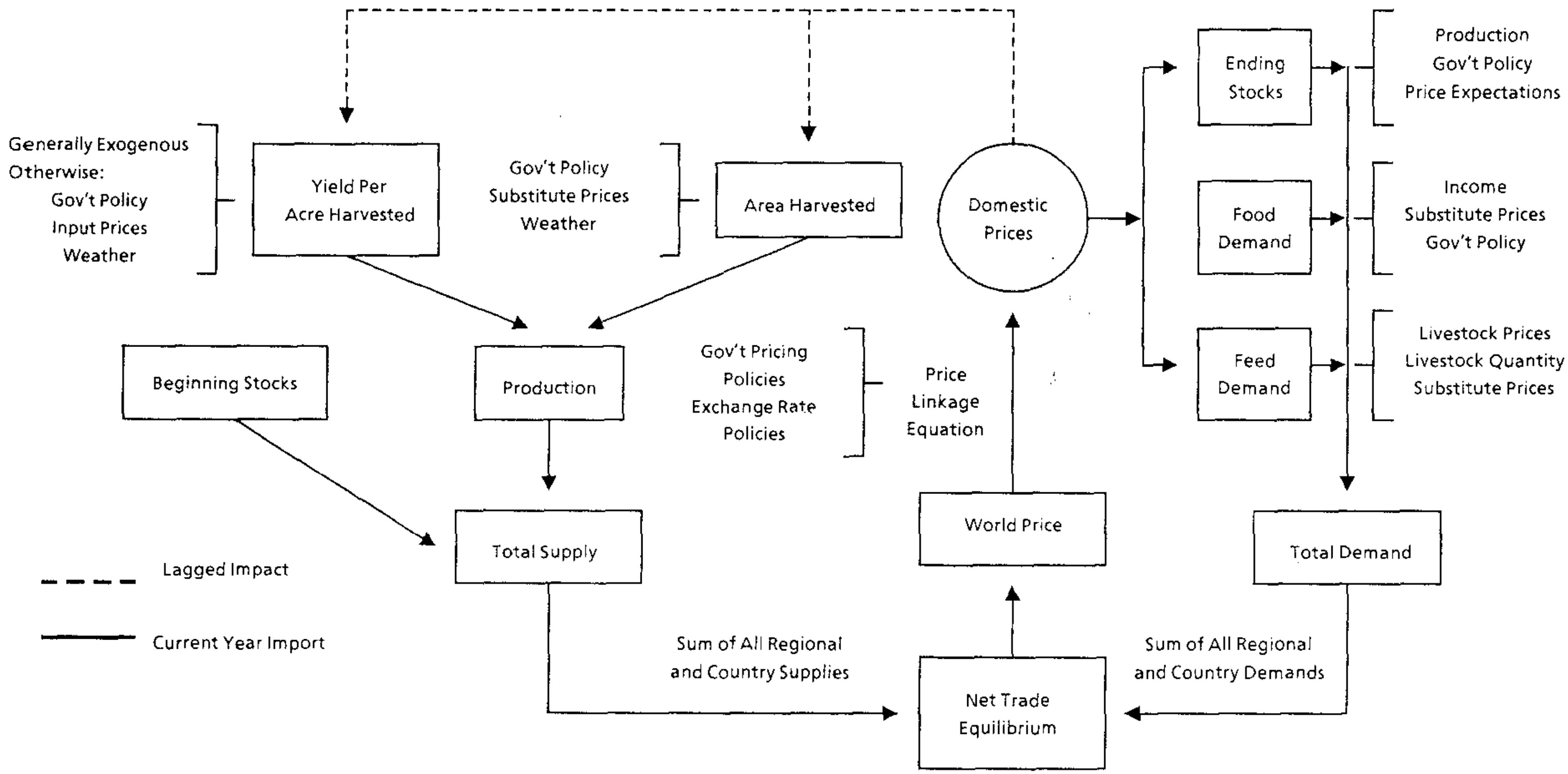

Figure 1. Representation of the structure of the world feed-grains trade model

price-linkage equation defines the degree of price transmission of external market conditions into the internal system. Trade occurs whether or not price transmission is allowed. The quantity traded adjusts only to internal conditions if there is no price transmission.

The basic elements of a nonspatial equilibrium supply and demand model are illustrated in Figure 2. The U.S. export supply curve (ESUS) is the difference between domestic supply (SUS) and demand (DUS) in the United States and represents the quantity of exports at various price levels supplied to the world market. Other exporters' supply and demand schedules are given in the lower panel. The curve ESO is the combined excess supply of all competing exporters, which is the difference between the supply and demand of all exporters. The import-demand schedule (EDT) of all importers is the difference between total demand and total supply. Other competitors' export supply and importers' import demand are represented in the middle diagram of the top panel. The export-demand schedule (EDN) facing the United States is the difference between the import demand of all importers and the export supply of all competitors. The kinked and relatively inelastic nature of the EDN is due to certain foreign countries' restrictive trade policies, which insulate domestic prices from world price variability. A trade equilibrium is achieved by the clearing of excess demands and supplies generated within each region.

The necessary components of the model are given in the following equations:

$$EDT = \sum_{i}^{m} [FOD_i(PD_i, X_{1i}) + FED_i(PD_i, X_{2i}) + SD_i(PD_i, X_{3i}) - S_i(PD_i, X_{4i})],$$

$$i = 1, \ldots, m \text{ importers;}$$

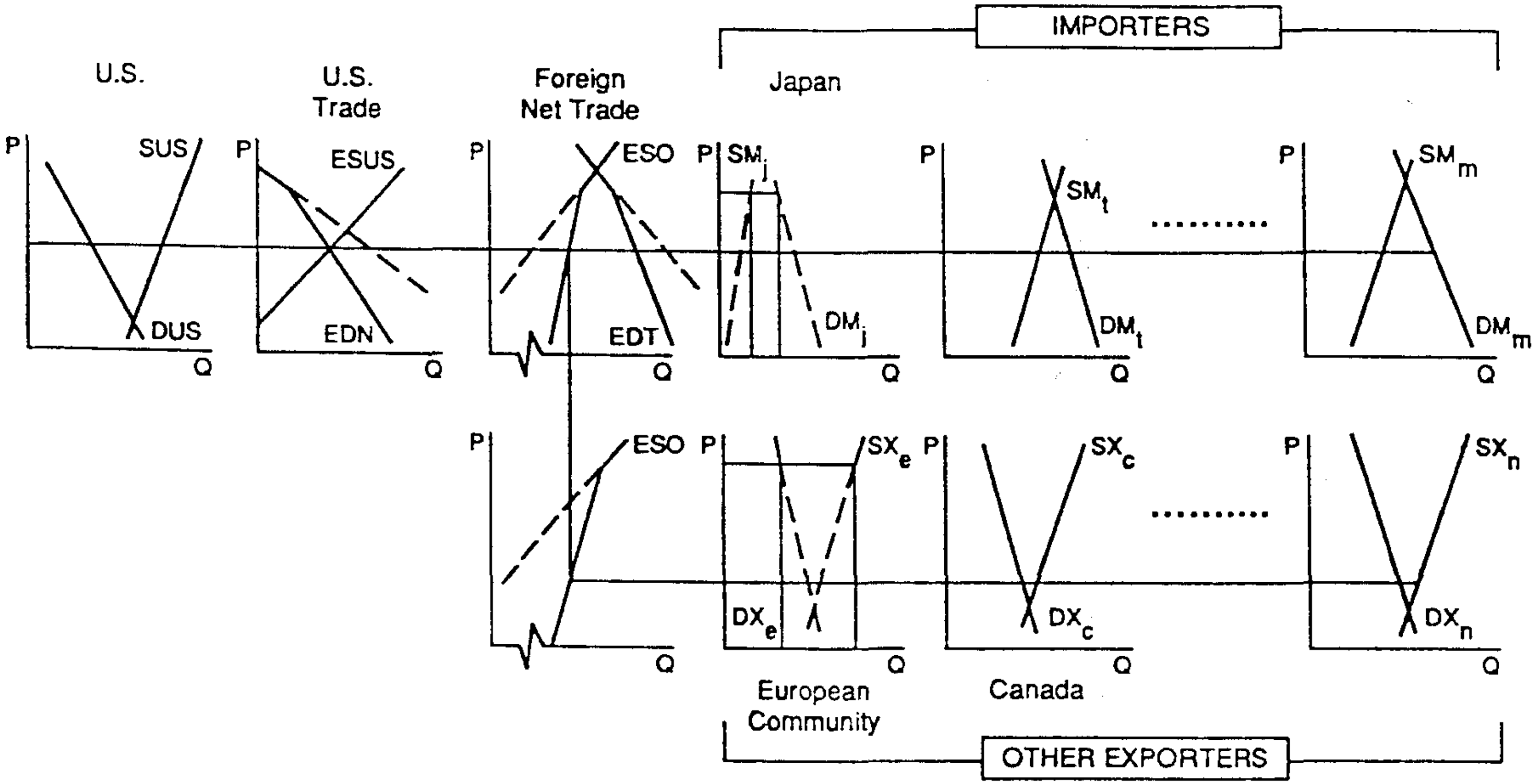

Figure 2. Determination of equilibrium prices and quantities in the CARD/FAPRI agricultural trade models

$$ESO = \sum_{j}^{n} \{S_j(PS_j, X_{4j}) - [FOD_j(PD_j, X_{1j}) + FED_j(PD_j, X_{2j}) + SD_j(PD_j, X_{3j})]\},$$

j = 1, ..., n exporters;

$$ESUS = S_u(P_u, X_{4u}) - [FOD_u(P_u, X_{1u}) + FED_u(P_u, X_{2u}) + SD_u(P_u, X_3u)],$$

U.S. excess supply;

$ESUS = EDN = EDT - ESO,$ world market-equilibrium;

$PD_i = G_i(P_u * e_i, Z_i),$ i = 1, ..., m importers; and

$PD_j = G_j(P_u * e_j, Z_j),$ j = 1, ..., n exporters;

where

FOD = domestic food demand,

FED = domestic feed demand,

SD = domestic stock demand,

S = domestic supply,

EDT = excess-demand function of all importers,

ESO = excess-supply function of all exporters, excluding the United States,

ESUS = excess-supply function of the United States,

EDN = excess-demand facing the United States,

PD = domestic market price,

PS = domestic supply price,

P_u = Gulf port price,

e = exchange rate,

Z = vector of policy variables influencing price transmission,

X_k = vector of demand shifters (k = 1, ..., 3), and

X_4 = vector of supply shifters.

The model contains 22 country or regional submodels. The feed-grain exporters modeled include the United States, Canada, the European Community (EC), Argentina, Australia, Thailand, China, and South Africa. Importers modeled include the USSR, Japan, Eastern Europe, Brazil, Mexico, Egypt, Saudi Arabia, India, Nigeria, other Latin American countries, other African and Middle Eastern countries, high-income East Asia, other Asian countries, and the rest of the world.

Specification

Theoretical Foundations

This section contains a conceptual model of domestic demand and supply, which reflects the general structure of the country submodels. Specifications for individual countries vary significantly, however, particularly for the United States, Canada, and the European Community. The feed-grain markets of these countries are modeled in detail by incorporating their respective domestic policies. The specifications for other countries are, in general, less detailed.

Domestic Supply Block. The domestic supply block of i^{th} country (exporting or importing country) is specified as

Area Harvested,

$$AH_{i,t} = AH(PS_{i,t-1}, PC_{i,t-1}, GP_{it}, Z_{i,t});$$

Production,

$$PROD_{it} = AH_{i,t} * YLD_{i,t}; \text{ and}$$

Supply,

$$S_{i,t} = PROD_{i,t} + IM_{i,t} + BS_{i,t},$$

where area harvested ($AH_{i,t}$) is expressed as a function of the lagged domestic supply price of feed-grains ($PS_{i,t-1}$), the lagged domestic price of competing crops ($PC_{i,t-1}$), the government policy variable ($GP_{i,t}$), and a vector of other variables that affect the acreage planted (Z_{it}). Feed-grains production ($PROD_{i,t}$) is equal to acreage harvested times yield ($YLD_{i,t}$). Finally, feed-grains supply is equal to production plus imports ($IM_{i,t}$) plus beginning stocks ($BS_{i,t}$).

Domestic Demand Block. The conceptual specifications for the domestic demand block are as follows:

Per Capita Food Demand,

$$PFOD_{i,t} = FOD(PD_{i,t}, PY_{i,t});$$

Total Food Demand,

$$FOD_{i,t} = POP_{i,t} * PFOD_{i,t};$$

Feed Demand,

$$FED_{i,t} = FED(PD_{i,t}, PS_{i,t}, LPI_{i,t}, LN_{it}); \text{ and}$$

Ending Stocks,

$$SD_{i,t} = SD(PD_{i,t}, PROD_{i,t}, GS_{i,t});$$

where $PFOD_{i,t}$ is per capita consumer food demand for feed grains, $PY_{i,t}$ is per capita income, $FOD_{i,t}$ is total food demand, $FED_{i,t}$ is total feed demand, $LPI_{i,t}$ is the livestock price index, $LN_{i,t}$ is the livestock number, $SD_{i,t}$ is ending stocks demand, and $GS_{i,t}$ is government stocks.

The detailed theoretical specifications for the U.S feed-grains market are discussed below.

Acreage response and supply. The estimation of how supply response will change government commodity programs has been problematic because of frequent adjustments made in the composition of such programs, as well as the changes in their underlying payment structures and acreage-reduction options.

The most common approach used to incorporate the influence of commodity programs is to include effective support payment and diversion payment variables as explanatory variables in the area planted equations (see Houck and Ryan 1972). As de Gorter and Paddock (1985) note, however, these composite variables ignore the voluntary nature of the commodity programs and impose questionable restrictions on the effects of changing policy parameters.

Estimating feed-grains supply response entails the use of endogenous participation rates. The model's participation rate ([program planted and idled]/base acreage) is expressed as a function of the difference between participant expected net returns (PARTENR) and nonparticipant expected net returns (NPARTENR):

$$PART = f(PARTENR - NPARTENR), \tag{1}$$

where PART represents the model's participation rate. Increases in participant expected net returns relative to nonparticipant expected net returns have a positive effect on program participation.

Participant expected net returns (PARTENR) per acre are derived from deficiency payments, diversion payments, cash receipts from marketing, and the variable costs of production and of maintaining idled land. It is assumed that farmers base program participation and planting decisions on a comparison of expected net returns under various alternatives. This approach makes it possible to incorporate a variety of factors that affect producer decisions but are omitted in models utilizing only market prices or aggregate measures such as Houck and Ryan's effective support rate. The arithmetic representation of PARTENR is as follows:

$$\text{PARTENR} = \max[0, \text{TP} - \max(\text{LR}, \text{LFR})] * \text{PY}(1 - \text{ARPR} - \text{PLDR})$$
$$+ \text{DPR} * \text{PY} * \text{PLDR} + \max(\text{LR}, \text{LFP}) * \text{TY}(1 - \text{ARPR} - \text{PLDR})$$
$$- \text{VC}(1 - \text{ARPR} - \text{PLDR}) - 20(\text{ARPR} + \text{PLDR}). \quad (2)$$

The first component of the right-hand side of equation (2) is the expected deficiency payments. The variables that enter into the expected deficiency payments are target price (TP), loan rate (LR), lagged farm price (LFP), program yield (PY), acreage-reduction program rate (ARPR), and paid land-diversion rate (PLDR). The model ARP rate is, in essence, the proportion of base acreage that all program participants are required to idle to qualify for deficiency payments. The model PLD rate represents the average proportion of base acreage idled by program participants to qualify for diversion payments. The second term is expected diversion payments, where DPR is the diversion payment rate. The third component is market return, where TY is the trend yield. The fourth component is the variable cost of production from planted acreage, where VC is the variable cost of feed-grain production per acre. The final component indicates that $20 per acre is expected to be spent in maintaining the land idled under the acreage reduction and the paid land diversion programs.

Nonparticipant expected net returns are defined as

$$\text{NPARTENR} = \text{LFP} * \text{TY} - \text{VC}, \quad (3)$$

where the variables are defined as in the above two equations.

Area planted under programs (APP) is defined as

$$\text{APP} = \text{PART}(1 - \text{ARPR} - \text{PLDR}) * \text{BA}, \quad (4)$$

where BA is the base average.

Total land idled (IA) under the acreage reduction and the paid land diversion programs is defined as

$$IA = PART(ARPR + PLDR) * BA, \quad (5)$$

where PLDR is equal to the announced rate times the percentage of acreage reduction program participants also participating in the paid land diversion program.

Nonprogram planted acres (APNP) is expressed as a behavioral relationship with the following variables:

$$APNP = f(NPARTNR, OCENR, APP, IA, LAPNP), \quad (6)$$

where OCENR represents the expected net returns from a competing crop and LAPNP is the lagged nonprogram planted acres. An increase in the nonparticipant expected net return, given the values of the other variables, will have a positive effect on APNP. Total planted area (AP) is defined as

$$AP = APP + APNP. \quad (7)$$

The ratio of area harvested to area planted (AH/AP) is expressed as a behavioral relationship with the following functional form:

$$(AH/AP) = f(T, LFP, X_{(AH/AP)}), \quad (8)$$

where T represents the same trend, and $X_{(AH/AP)}$ represents a vector of other variables that affect the (AH/AP) ratio.

Area harvested is defined as

$$AH = AP(AH/AP). \quad (9)$$

Yield per acre (YD) is expressed as a function of government policy parameters such as target prices (TP), idled acreage (IA), time trend (T) to represent technological progress, and other factors (X_{WY}). Target prices have a positive effect on yield because higher target prices are assumed to induce greater input usage. Idled land is assumed to be drawn from less productive land; therefore, an increase in land idling is expected to increase yields. The functional form of the yield equation is

$$YD = f(TP, IA, T, X_{WY}). \tag{10}$$

Production (PROD) is defined as the product of acres harvested and yields per acre:

$$PROD = AH * YD. \tag{11}$$

Expected net returns are affected significantly by policy parameters. Therefore, the incorporation of the program-participation decision, which depends upon expected net returns, into the determination of planted acres provides a means of analyzing the effects of policy parameter changes on participation rate, acreage planted, yield, production, and planted area and production of alternative crops.

Supply is the sum of production, beginning stocks (BI), and exogenous imports (IM). Thus, the feed-grain supply equation is

$$S = PROD + BI + IM. \tag{12}$$

Demand

Demand is disaggregated into a number of categories. Major demand components include food use, feed use, seed use, stocks, and exports.

Domestic Disappearance. The theoretical specification for food use is based upon the consumer theory of utility maximization subject to budget constraints. Solution of utility maximization yields consumer demand as a function of own price, cross prices, and income. Restrictions (homogeneity, symmetry, Cournot aggregation, and Angel aggregation) derived from demand theory are not imposed on the estimation, however. The functional form of per capita food demand (FOOD) is

$$FOOD = f(P_{own}, P_{cross}, RPCE, X_{food}), \tag{13}$$

where P_{own} represents the own price of the commodity in real terms, P_{cross} represents the real price of competing goods, RPCE represents real per capita consumer expenditure, and X_{food} represents a vector of other variables that explain food use. Total food use is determined as the product of per capita food use and population.

Because feed is an input into the livestock production equation, the theoretical specification of feed demand follows the derived demand approach. Thus, feed demand (FEED) is expressed as a function of the real price of the commodity (P_{own}), the real price of competing feed products (P_{cfeed}), livestock product prices (PL), livestock numbers (LN), and a vector of other variables X_{feed}. Thus, the functional form of feed demand is

$$FEED = f(P_{own}, P_{cfeed}, PL, LN, X_{feed}). \tag{14}$$

The demand for seed use (SEED) is specified as a function of acreage planted (AP) and a time trend (T). The behavioral relationship is written as

$$SEED = f(AP, T). \tag{15}$$

Stocks. Total inventories (EI) are further disaggregated into Commodity Credit Corporation (CCC) inventories, Farmer-Owned Reserve (FOR) stocks, nine-month-loan-program carryover, and "free" stocks unencumbered by government programs. Commodity Credit Corporation, FOR, and nine-month-loan stocks are exogenous in the model; however, in policy analyses these stocks are adjusted to reflect factors ranging from loan rates and market prices to participation rates and the availability of generic certificates.

Free (or private) stocks are endogenized in the model by using speculative and transactional motives of inventory demand theory. The speculative motive indicates that the amount of grain stored at any time depends upon the difference between current and expected prices. According to the theory of stock demand, this price difference must be equated to the marginal cost of storage to determine the optimal level of storage. It is assumed further that commercial stockholders base their expectation regarding future prices upon expected production and government stocks. The transaction motive indicates that the amount of grain stored is determined by the level of current output. Using these two motives for storage, the behavioral relationships for free stocks (STOCK) are specified as

$$STOCK = f(P_{own}, PROD, EPROD, GSTOCK, X_{STOCK}), \quad (16)$$

where PROD is current production, EPROD is expected production, GSTOCK is government stock (the sum of CCC, FOR, and nine-month-loan stocks), and X_{STOCK} is a vector of other variables that influence free stocks.

Exports. Feed-grain exports are determined as residuals:

$$EX = PROD + BI + IM - FOOD - FEED - SEED - EI.$$

The above specification of demand is based upon a price theory that may not be applicable to the centrally planned economies of the Soviet Union, China, and Eastern Europe, or indeed to most other developing countries. For these regions, demand is postulated to depend upon income and available supplies which are derived mainly from production. That is,

$$QD = f(QP_t, Y_t). \tag{17}$$

A linear specification of this demand function is

$$QD_t = \alpha_0 + \alpha_1 Y + \alpha_2 QP_t, \qquad \alpha_1 > 0, \text{ and } 0 < \alpha_2 < 1. \tag{18}$$

Import demand as a residual of demand and supply becomes

$$QM_t = QD_t - QP_t.$$

Data Sources

The data used for the analyses include feed-grain use and supply-quantity data obtained from the Foreign Agricultural Service of the USDA. Macroeconomic data such as income, exchange rates, and inflation are obtained from the International Monetary Fund (IMF). All macroeconomic data have been converted to the appropriate crop-year basis for each country or regional component. For example, a calendar-year macrovariable is converted to an October-September crop-year basis by taking a weighted average of its October to December values for the first year and of its January to September values for the second year. Weights are 0.25 for the first three months and 0.75 for the second nine months. Most feed-grain price data were derived from Food and Agricultural Organization (FAO) price statistics. Additional price information regarding the United

States, Canada, Australia, and the European Community was obtained from USDA Agricultural Statistics (various years), Canada Grain Trade Statistics (various years), Yearbook of the Commonwealth of Australia (various years), and The Agricultural Situation in the Community (various years).

Empirical Results

This section presents estimation procedures, estimated equations, and identities. Reasons for the inclusion of relevant variables in an equation, along with the sign and the significance of the estimated coefficients, are discussed. The equations reported here reflect the state of the model as of summer 1989.

Most of the equations in the model are estimated using annual data from the period 1965/66-1986/87 (or shorter intervals if data were unavailable at the time of estimation).

All equations are estimated using ordinary least squares (OLS) utilizing AREMOS, an econometric package developed by The WEFA Group. Given the simultaneity of the model and the nonlinearity of many of the modeled relationships, OLS is not the most appropriate estimation technique from a theoretical standpoint. OLS does, however, make it easy to replace unsatisfactory equations, an important strength for a model that is constantly undergoing revision. Future revisions of the model will utilize more appropriate estimation techniques.

For each estimated equation, t-statistics are presented in parentheses below the parameter estimates. Where appropriate, elasticities evaluated at the mean of all variables are reported in brackets. Also reported for each estimated equation are the estimation period, the R-squared, the adjusted

R-squared, the standard error of estimates, the Durbin-Watson statistic, and the mean of the dependent variable.

United States Submodel

The U.S. component of the feed-grains model is illustrated in Table 1. Estimated equations are reported in the following order: corn, sorghum, barley, and oats. The estimated results are satisfactory, with anticipated signs and generally high R-square values. The supply side is modeled by estimating participation rate and nonparticipant acreage. Total area planted is equal to nonparticipant planted area plus participant planted area. Participant planted area is equal to the participation rate times the base area times the percentage of base acres that participants can plant. Acreage harvested as a percentage of acreage planted is determined endogenously. Yield is also determined endogenously. Production is determined as area harvested times yield.

The expected participation rate for corn (Eq. 1.1) is estimated as a function of expected participant net returns minus a weighted average of nonparticipant expected net returns and soybean expected net returns and a series of dummy variables for years with no government land-idling programs. The positive coefficients for the variable--the difference between participant net returns and the weighted average of nonparticipant and soybean net returns--indicate that more farmers will participate in the government program if program benefits are greater.

The participant, nonparticipant, and soybean expected net returns are given by identities 1.2, 1.3, and 1.4, respectively. The nonparticipant corn acreage in the next year (1.5) is estimated as a function of area planted by participants, corn acreage idled under ARP, PLD programs plus CRP acres,

Table 1. Structural parameter estimates of the U.S. feed-grains submodel

Corn

(1.1) Corn Program Participation Rate (Next Year)

$$\text{COMPRU9F} = \underset{(14.04)}{0.561} + \underset{(2.59)}{0.770}[\text{CONRPU9F} - (0.8\ \text{CONRNU9F}$$

$$+ 0.2\ \text{SBNRNU9F})]/\text{PWSAU9} - \underset{(3.83)}{0.594}\ \text{DM173} - \underset{(3.86)}{0.6}\ \text{DM174}$$

$$- \underset{(3.89)}{0.615}\ \text{DM175} - \underset{(3.45)}{0.535}\ \text{DM176} - \underset{(3.62)}{0.559}\ \text{DM179} - \underset{(3.67)}{0.568}\ \text{DM180}$$

$R^2 = 0.85 \qquad DW = 1.65$

(1.2) Participants Corn Expected Net Return

$$\text{CONRPU9F} = [\text{Max}(\text{COPTGU9F} - \text{Max}\ (\text{COPLNU9F},\ \text{COPFMU9}),\ 0]$$

$$* \text{COYHPU9F}(1 - \text{COMARU9F} - \text{COMPLU9F}) + \text{CODPRU9F} * \text{COYHPU9F}$$

$$* \text{COMPLU9F} + \text{MAX}(\text{COPLNU9F},\ \text{COPFMU9})$$

$$* \text{COYHTU9F}(1 - \text{COMARU9F} - \text{COMPLU9F}) - \text{COVCAU9F}(1 - \text{COMARU9F}$$

$$- \text{COMPLU9F}) - 20(\text{COMARU9F} + \text{COMPLU9F})$$

(1.3) Nonparticipants Corn Expected Net Return

$$\text{CONRNU9F} = \text{COPFMU9} * \text{COYHTU9F} - \text{COVCAU9F}$$

(1.4) Soybeans Expected Net Return

$$\text{SBNRNU9F} = \text{SBPFMU9} * \text{SBYHTU9F} - \text{SBVCAU9F}$$

(1.5) Corn Nonprogram Acreage (Next Year)

$$\text{COAPNU9F} = \underset{(38.99)}{82.741} - \underset{\substack{(48.13)\\ [-0.43]}}{0.963}\ \text{COAPPU9F} - \underset{\substack{(22.31)\\ [-0.15]}}{0.743}(\text{COAIAU9F} + \text{COCRPU9F})$$

$$+ \underset{\substack{(2.04)\\ [0.05]}}{5.050}\ \text{CONRNU9F}/\text{PWSAU9} - \underset{\substack{(0.78)\\ [-0.03]}}{2.814}\ \text{SBNRNU9F}/\text{PWSAU9}$$

Table 1. Continued

$- 7.830$ DM17274
(6.23)

$R^2 = 1.00$ DW = 2.40

(1.6) Corn Program Acreage (Next Year)

COAPPU9F = COMPRU9F * COABAU9F(1 - COMARU9F - COMPLU9F)

(1.7) Total Corn Area Planted (Next Year)

COAPAU9F = COAPPU9F + COAPNU9F

(1.8) Corn Area Harvested as a Proportion of Area Planted (Next Year)

COAHPU9F = 0.800 - 0.043 DM182 + 0.020 LOG(TREND-1959)
(28.75) (3.70) (1.90)

+ 0.010 DMCOYU9F + 0.030 DM1S77
(1.80) (4.10)

+ 0.034(COAIAU9F + COCRPU9F)/COAPAU9F
(2.40)
[0.01]

$R^2 = 0.900$ DW = 2.32

(1.9) Corn Area Idled

COAIAU9F = COABAU9F * COMPRU9F(COMARU9F + COMPLU9F)

(1.10) Total Corn Area Harvested

COAHAU9F = COAPAU9F * COAHPU9F

(1.11) Corn Yield (Next Year)

COYHAU9F = 211.400 + 2134.020 COPTGU9F/PWSAU9
(5.20) (1.46)
[0.23)

Table 1. Continued

$$+ \underset{(9.46)}{83.272} \text{ LOG(TREND - 1945)} + \underset{\substack{(0.50)\\[0.01]}}{0.092} \text{ COAIAU9F} + \text{COCRPU9F}$$

$$+ \underset{(3.95)}{10.604} \text{ DMCOYU9F} - \underset{(2.63)}{20.804} \text{ DM182}$$

$R^2 = 0.92$ DW = 2.35

(1.12) Corn Production (Next Year)

COSPRU9F = COAHAU9F * COYHAU9F

(1.13) Corn Feed Use

$$\text{COUFEU9G} = \underset{(3.20)}{40.505} - \underset{\substack{(5.91)\\[-0.29]}}{1749.760} \text{ COPFMU9/PWSAU9}$$

$$+ \underset{\substack{(2.04)\\[0.29]}}{2374.48} \text{ LVPIU9/PWSAU9} - \underset{\substack{(2.22)\\[-0.14]}}{0.430}\text{(WHUFEU9 * 60/56 + SGUFEU9}$$

$$\text{+ BAUFEU9 * 48/56 + OAUFEU9 * 32/56)/GCAUU9}$$

$$+ \underset{(4.13)}{10.230} \text{ LOG(TREND - 1959)} + \underset{\substack{(1.28)\\[0.06]}}{4.941} \text{ SMPFMU9/PWSAU9}$$

$$+ \underset{(4.72)}{14.430} \text{ DM173} - \underset{(3.46)}{6.735} \text{ DM176}$$

$R^2 = 0.89$ DW = 3.08

(1.14) Total Corn Feed Use

COUFEU9 = COUFEU9G * GCAUU9

(1.15) Corn Food Use

$$\text{COUOFU9C} = \underset{(10.40)}{5.900} - \underset{\substack{(2.12)\\[-0.14]}}{0.337} \text{ COPFMU9/(WHPFMU9/2.763 + SUPRTU9/25.805)}$$

Table 1. Continued

$$+ 4.071 \text{ LOG(CESAU9/DEPOPU9)}$$
(16.82)
(1.59)

$$- 2.530 \text{ DM1S83 LOG(CESAU9/DEPOPU9)} + 0.345 \text{ DM1S80}$$
(1.85) (5.88)
[-0.99]

$$+ 5.900 \text{ DM1S83}$$
(1.89)

$R^2 = 0.99$ DW = 1.80

(1.16) Total Corn Food Use

COUOFU9 = COUOFU9 * DEPOPU9

(1.17 Corn Gasohol Use

$$\text{COUGAU9} = 0.000 - 4772.700 \text{ DM1S80} * \text{COPFMU9/PWFSAU9}$$
(0.00) (2.67)
[-0.11]

$$+ 602.730 \text{ DM1S79} * \text{LOG(TREND} - 1965)$$
(8.12)

$$- 1580.690 \text{ DM1S79} + 12.871 \text{ TRND8184}$$
(8.01) (2.20)

$R^2 = 0.99$ DW = 2.76

(1.18) Corn Seed Use

$$\text{COUSDU9} = 296.314 + 0.280 \text{ COAPAU9F} + 0.150 \text{ TREND}$$
(5.51) (13.88) (5.40)
[1.20]

$R^2 = 0.95$ DW = 1.72

(1.19) Total Corn Domestic Use

COUTOU9 = COUFEU9G + COUOFU9 + COUGAU9 + COUSDU9

Table 1. Continued

(1.20) Corn Free Stocks

$$\text{COFREU9} = 465.703 - 31056.000\ \text{COPMFU9/PWSAU9} - 0.053\ \text{COSPRU9F}$$

(1.47) (1.89) (1.74)

[-1.64] [-0.66]

$$+\ 0.147\ \text{LAG(COSPRU9F)} + 231.238\ \text{DM1S75}$$

(3.92) (2.12)

[1.83]

$$-\ 0.313(\text{CO9LNU9} + \text{COCCCU9} + \text{COFORU9})$$

(7.46)

[-0.68]

$R^2 = 0.85$ $DW = 1.94$

(1.21) Corn Total Stocks

$$\text{COCOTU9} = \text{COFREU9} + \text{CO9LNU9} + \text{COFORU9} + \text{COCCCU9}$$

(1.22) Corn Gulf-Port Price

$$\text{COPOBU9} = 1.0913\ \text{CORPF} * 39.368 + 5.8374$$

(1.23) Corn Domestic Market Equilibrium

$$\text{COSPRV9} + \text{LAG(COCOTU9)} + \text{COSMTU9} = \text{COUFEU9} + \text{COUFOU9} + \text{COUXTU9} + \text{COCOTU9} + \text{COURSU9}$$

Sorghum

(1.24) Sorghum Participation Rate

$$\text{SGMPRU9} = 26.685 + 1.153(\text{SGENRPU9} - \text{SGNRNU9})/\text{PWSAU9} - 0.013\ \text{TREND}$$

(1.68) (1.87) (1.65)

$$+\ 0.314\ \text{DM172} - 0.600\ \text{DM174} - 0.586\ \text{DM175}$$

(2.41) (4.62) (4.55)

$$-\ 0.573\ \text{DM176} - 0.635\ \text{DM177} - 0.554\ \text{DM180}$$

(4.47) (4.78) (4.31)

Table 1. Continued

$$- 0.507\ DM181$$
(3.82)

$R^2 = 0.91$ DW = 1.67

(1.25) Sorghum Participant Net Return

SGNRPU9 = max{SGPTGU9 - max[SGPLNU9, LAG(SGPFMU9)],0}

* SGYHPU9(1 - SGMARU9 - SGMPLU9) + SGDPRU9 * SGYHPU9 * SGMPLU9

+ max[SGPLNU9, LAG(SGPFMU9)] * SGYHTU9(1 - SGMARU9

- SGMPLU9) - SGVCAU9(1 - SGMARU9 - SGMPLU9)

- 20(SGMARU9 + SGMPLU9)

(1.26) Wheat Net Return

WHNRNU9 = LAG(WHPFMU9) * WHYHTU9 - WHVCAU9

(1.27) Sorghum Nonparticipant Net Returns

SGNRNU9F = SGPFMU9 * SGYHTU9F - SGVCAU9F

(1.28) Sorghum Area Planted by Participants

SGAPPU9 = SGMPRU9 * SGABAU9(1 - SGMARU9 - SGMPLU9)

(1.29) Sorghum Area Planted by Nonparticipants

SGAPNU9 = 19.783 + 8.691 SGNRNU9/PWSAU9 - 1.096 WHNRNU9/PWSAU9
(20.03) (3.42) (0.43)
[0.20] [-0.02]

- 0.868 SGAPPU9 - 0.747 SGAIAU9 + SGCRPU9
(17.89) (8.66)
[-0.47] [-0.19]

- 5.557 DM1S74 - 2.851 DM173 + 2.070 DM185
(11.07) (4.09) (3.53)

$R^2 = 0.99$ DW = 2.35

Table 1. Continued

(1.30) Sorghum Area Idled under the ARP and PLD Programs

SGAIAU9 = SGABAU9 * SGMPRU9(SGMARU9 + SGMPLU9)

(1.31) Sorghum Total Area Planted

SGAPAU9 = SGAPPU9 + SGAPNU9

(1.32) Sorghum Area Harvested as a Proportion of Area Planted

SGAHPU9 = 0.544 + 0.023 DMSGYU9 + 0.103 LOG(TREND - 1959)
(13.62) (2.34) (7.34)

R^2 = 0.76 DW = 1.56

(1.33) Sorghum Total Area Harvested

SGAHAU9 = SGAPAU9 * SGAHPU9

(1.34) Sorghum Yield

SGYHAU9 = 1369.810 + 0.171 TREND + 806.744 SGPTGU9/PWSAU9
(4.33) (4.56) (0.95)
[0.14]

+ 8.422 DMSGYU9
(4.95)

R^2 = 0.78 DW = 2.64

(1.35) Sorghum Production

SGSPRU9 = SGAHAU9 * SGYHAU9

(1.36) Sorghum Feed Use

SGUFEU9 = 568.311 - 115318.000 SGPFMU9/PWSAU9
(2.43) (2.59)
[-2.08]

Table 1. Continued

```
         + 60406.300 COPFMU9/PWSAU9 + 17993.500 WHPFMU9/PWSAU9
               (1.50)                      (1.67)
               [1.21]                      [0.47]

         + 38.731 CATNFU9 - 15.952 TRND6783
            (1.68)          (3.98)
            [0.65]
```

R^2 = 0.66   DW = 1.64

(1.37) Sorghum Food, Seed, and Industrial Use

```
SGUFOU9 = 14.803 - 1857.54 SGPFMU9/PWSAU9
           (7.84)    (1.30)
                    [-1.42]

        + 949.118 BAPFMU9/PWSAU9 + 567.415 COPFMU9/PWSAU9
           (1.48)                  (0.57)
           [0.71]                  [0.48]

        + 14.652 DM185
          (6.61)
```

R^2 = 0.81   DW = 2.04

(1.38) Sorghum Free and Nine-Month Loan Stocks

```
SGF9LU9  = 51.677 + 0.395 LAG(SGF9LU9) - 14294.5 SGPFMU9/PWSAU9
            (0.39)  (2.02)                 (1.92)
                                          [-1.51]

          + 0.230 SGSPRU9 - 0.234(SGCCCU9 + SGFORU9)
            (2.30)          (2.01)
            [1.97]         [-0.38]
```

R^2 = 0.60   DW = 1.70

(1.39) Sorghum Total Stocks

SGCOTU9 = SGCCCU9 + SGFORU9 + SGF9LU9

(1.40) Sorghum Price Linkage Equation

SGPOBU9 = 5.90457 + 44.7348 SORPF

Table 1. Continued

(1.41) Sorghum Domestic Market Equilibrium

SGSPRU9 + LAG(SGCOTU9) + SGSMTU9 = SGUFEU9 + SGUFOU9 + SGUXNU9

+ SGCOTU9

(1.42) World Market Equilibrium

SGUXNU9 = SGSMNAR + SGSMNAU + SGSMNZA + SGSMNMX + SGSMNNG

+ SGSMNIN + SGSMNROW + SGSTDIS

Barley

(1.43) Barley Participation Rate

BAMPRU9 = 1.990 + 3.455(BANRPU9 - BANRNU9)/PWJMU9
(2.45) (3.08)

- 0.825 DM171 - 0.720 DM174 - 0.689 DM175 - 0.661 DM176
(4.57) (4.68) (4.65) (4.57)

- 0.634 DM177 - 0.733 DM180 - 0.540 DM181
(4.47) (4.94) (3.80)

- 0.469 LOG(TREND - 1959)
(2.08)

R^2 = 0.91 DW = 1.75

(1.44) Barley Participant Net Returns

BANRPU9 = max{BAPTGU9 - max[BAPLNU9, LAG(BAPFMU9)], 0}

* BAYHPU9(1 - BAMARU9 - BAMPLU9) + BADPRU9 * BAYHPU9 * BAMPLU9

+ MAX[BAPLNU9, LAG(BAPFMU9) * BAYHTU9(1 - BAMARU9 - BAMPLU9]

- BAVCAU9(1 - BAMARU9 - BAMPLU9)

- 20(BAMARU9 + BAMPLU9)

(1.45) Barley Nonparticipant Net Returns

BANRNU9F = BAPFMU9 * BAYHTU9F - BAVCAU9F

Table 1. Continued

(1.46) Barley Area Planted by Participants

BAAPPU9 = BAMPRU9 * BAABAU9(1 - BAMARU9 - BAMPLU9)

(1.47) Barley Area Planted by Nonparticipants

```
BAAPNU9 = 10.303 + 12.083 BANRNU9/PWJMU9 - 0.908 BAAPPU9
         (15.20)   (1.68)                  (10.95)
                   [0.35]                  [-0.39]

        - 0.553 DM1S74(BAAIAU9 + BACRPU9)+ 2.706 DM1S84
         (2.07)                            (4.27)
        [-0.04]

        - 411.320 (WHNRNU9/49 + OANRNU9/27 * 0.5)/PWJMU9
           (1.86)
          [-0.42]
```

R^2 = 0.93   DW = 1.40

(1.48) Barley Area Idled under the ARP and PLD Programs

BAAIAU9 = BAABAU9 * BAMPRU9(BAMARU9 + BAMPLU9)

(1.49) Barley Total Area Planted

BAAPAU9 = BAAPPU9 + BAAPNU9

(1.50) Barley Area Harvested as a Proportion of Area Planted

```
BAAHPU9 = 0.917 - 0.037 DM180 + 0.035 DM18183 - 0.038 DM185
        (301.61)  (2.98)        (4.53)          (3.04)
```

R^2 = 0.72   DW = 1.67

(1.51) Barley Total Area Harvested

BAAHAU9 = BAAPAU9 * BAAHPU9

(1.52) Barley Yield

```
BAYHAU9 = -1528.970 + 0.795 TREND + 4.504 DMBAYU9
             (9.48)   (9.76)        (5.21)
```

Table 1. Continued

+ 424.511 BAPTGU9/PWJMU9 + 2.653 DM171
(1.03) (0.60)
[0.07]

R^2 = 0.90 DW = 2.15

(1.53) Barley Production

BASPRU9 = BAAHAU9 * BAYHAU9

(1.54) Barley Feed Use

BAUFEU9 = 120.627 + 0.638 LAG(BAUFEU9)

- 16246.500 BAPFMU9/PWJMU9 + 9325.640 COPFMU9/PWJMU9
(2.93) (2.31)
[-0.66] [0.43]

+ 1068.560 WHPFMU9/PWJMU9 + 31.705 DM18285
(0.39) (2.85)
[0.06]

R^2 = 0.90 DW = 2.32

(1.55) Barley Per Capita Food, Seed, and Industrial Use

BAUFOU9C = 0.243 - 1.234 BAPFMU9/PWJMU9
(2.97) (1.20)
[-0.02]

+ 0.220 LOG(CEJMU9/DEPOPU9) + 0.049 DM1S78
(5.30) (6.06)
[0.31]

- 0.017 TRND8185
(8.15)

R^2 = 0.95 DW = 2.16

(1.56) Barley Total Food, Seed, and Industrial Use

BAUFOU9 = BAUFOU9C * DEPOPU9

Table 1. Continued

(1.57) Barley Free and Nine-Month Loan Stocks

$$BAF9LU9 = \underset{(0.69)}{72.526} + \underset{(2.10)}{0.349}\, LAG(BAF9LU9) - \underset{\substack{(2.43)\\ [-0.48]}}{7600.720}\, BAPFMU9/PWJMU9$$

$$+ \underset{\substack{(1.72)\\ [0.89]}}{0.300}\, BASPRU9 - \underset{\substack{(2.94)\\ [-0.20]}}{0.632}(BACCCU9 + BAFORU9)$$

$$- \underset{(3.04)}{48.099}\, DM18183$$

$R^2 = 0.73$ DW = 2.12

(1.58) Barley Total Stocks

$$BACOTU9 = BAF9LU9 + BACCCU9 + BAFORU9$$

(1.59) Barley Exports

$$BAUXTU9 = -200\, BAPFMU9 + 100\, COPFMU9 + 40\, WHPFMU9 + BAUXEU9$$

(1.60) Barley Domestic Market Equilibrium

$$BASPRU9 + LAG(BACOTU9) + BASMTU9 = BAUFOU9 + BAUFEU9 + BAUXTU9 + BACTOU9 + BAURSU9$$

Oats

(1.61) Oats Participation Rate

$$OAMPRU9 = \underset{(0.00)}{0.000} + \underset{(4.96)}{5.215}(OANRPU9 - OANRNU9)/PWJMU9 * DM1S82$$

$$+ \underset{(9.00)}{0.202}\, DM1S82$$

$R^2 = 0.83$ DW = 2.22

Table 1. Continued

(1.62) Oats Participant Net Returns

OANRPU9 = max{OAPTGU9 - max[OAPLNU9, LAG(OAPFMU9)], 0}

* OAYHPU9(1 - OAMARU9 - OAMPLU9) + OADPRU9 * OAYHPU9 * OAMPLU9

+ max[OAPLNU9, LAG(OAPFMU9)] * OAYHTU9(1 - OAMARU9 - OAMPLU9)

- OAVCAU9(1 - OAMARU9 - OAMPLU9)

- 20(OAMARU9 + OAMPLU9)

(1.63) Oats Nonparticipant Net Returns

OANRNU9F = OAPFMU9 * OAYHTU9 - OAVCAU9

(1.64) Oats Area Planted by Participants

OAAPPU9 = OAMPRU9 * OAABAU9(1 - OAMARU9 - OAMPLU9)

(1.65) Oats Area Idled under the ARP and PLD Programs

OAAIAU9 = OAABAU9 * OAMPRU9(OAMARU9 + OAMPLU9)

(1.66) Oats Area Planted by Nonparticipants

OAAPNU9 = OAAPAU9 - OAAPPU9

(1.67) Oats Total Area Planted

OAAPAU9 = 7.783 + 0.666 OAAHAU9 + 0.164 COAIAU9 - 6.283 DM183
(10.08) (9.64) (6.58) (5.73)
[0.47] [0.10]

R^2 = 0.95 DW = 1.35

(1.68) Oats Total Area Harvested

OAAHAU9 = 13.560 + 0.195 LAG(OAAHAU9) + 18.835 OANRNU9/PWJMU9
(3.22) (0.87) (2.76)
[0.22]

Table 1. Continued

```
     - 0.480 OAAIAU9 + OACRPU9 - 0.434 TRND7186
        (0.84)                   (2.95)
       [-0.01]

     - 230.106(CONRNU9/101 + SBNRNU9/96 + BANRNU9/43)/PWJMU9
          (2.75)
         [-0.26]
```

R^2 = 0.95 DW = 1.99

(1.69) Oats Yield

```
OAYHAU9 = -938.112 + 0.501 TREND + 5.270 DMOAYU9
             (6.74)   (7.12)        (7.11)
```

R^2 = 0.81 DW = 2.91

(1.70) Oats Production

OASPRU9 = OAAHAU9 * OAYHAU9

(1.71) Oats Feed Use

```
OAUFEU9 = 868.822 - 49237.300 OAPFMU9/PWJMU9
          (37.90)      (8.91)
                      [-0.52]

        + 14173.500 COPFMU9/PWJMU9 - 21.787 TRND7186 - 65.391 DM17780
             (5.25)                   (24.15)            (6.41)
             [0.27]
```

R^2 = 0.98 DW = 2.47

(1.72) Oats Per capita Food, Seed, and Industrial Use

```
OAUFOU9C = 1.116 - 2.920 OAPFMU9/PWJMU9 + 1.224 OAAPAU9F/DEPOPU9
          (5.34)  (0.91)                 (3.27)
                 [-0.04]                 [0.24]

         - 0.376 LOG(CEJMU9/DEPOPU9)
          (4.71)
         [-0.95]
```

R^2 = 0.95 DW = 1.86

Table 1. Continued

(1.73) Oats Total Food, Seed, and Industrial Use

OAUFOU9 = OAUFOU9C * DEPOPU9

(1.74) Oats Free and Nine-Month Loan Stocks

$$OAF9LU9 = \underset{(1.10)}{-38.842} + \underset{(2.91)}{0.382}\ LAG(OAF9LU9)$$

$$- \underset{\substack{(4.38)\\ [-0.35]}}{14470.900}\ OAPFMU9/PWJMU9 + \underset{[1.16]}{0.440}\ OASPRU9$$

$$- \underset{[-0.04]}{0.203}(OACCCU9 + OAFORU9)$$

$R^2 = 0.97$ DW = 1.76

(1.75) Oats Total Stocks

OACOTU9 = OACCCU9 + OAFORU9 + OAF9LU9

(1.76) Oats Imports

$$OASMNU9 = \underset{(2.91)}{-22.854} + \underset{(1.67)}{22.840}\ OAPFMU9/COPFMU9 + \underset{(12.11)}{37.841}\ DM1S83$$

$$- \underset{(7.82)}{44.715}\ DM173$$

(1.77) Oats Domestic Market Equilibrium

OASPRU9 + LAG(OACOTU9) + OASMTU9 = OAUFOU9 + OAXTU9 + OACOTU9 + OAURSU9

(1.78) Total Feed Grain Exports (Corn, Barley, and Oats)

FGUXNU9 = COUXNU9 + 21.772 BAUXNU9 + 14.515 OAUXNU9

Table 1. Continued

(1.79) World Market Equilibrium

FGUXNU9 = FGSMNAR + FGSMNAU + FGSMNCA + FGSMNTH + FGSMNE2 + FGSMNZA + FGSMNJP + FGSMNSU + FGSMNE8 + FGSMNCN + FGSMNR4 + FGSMNBR + FGSMNMX + FGSMNEG + FGSMNSA + FGSMNNO + FGSMNFO + FGSMNSO + FGSMNROW + FGSTDIS

Endogenous Variables

BAAHAU9: Barley area harvested, mil. ac.
BAAHPU9: Barley harvested area/planted area
BAAIAU9: Barley area idled by ARP, PLD programs, mil. ac.
BAAPAU9: Barley area planted, mil. ac.
BAAPNU9: Barley area planted by nonparticipants, mil. ac.
BAAPPU9: Barley area planted by participants, mil. ac.
BACOTU9: Barley total ending stocks, mil. bu.
BAF9LU9: Barley free and 9-month loan stocks, mil. bu.
BAMPRU9: Barley model participation rate, equals (ARP + PLD + program planted area)/program base
BANRNU9: Barley expected net returns to nonparticipants, $/ac.
BANRNU9F: Barley expected nonparticipant net returns, next year, $/ac.
BANRPU9: Barley expected net returns to program participants, $/base
BAPFMU9: Barley farm market price, $/bu.
BASPRU9: Barley production, mil. bu.
BAUFEU9: Barley feed use, mil. bu.
BAUFOU9: Barley food, seed, and industrial use, mil. bu.
BAUFOU9C: Barley per-capita food, seed and industrial use, bu./capita
BAYHAU9: Barley yield per harvested acre, bu./ac.
COAHAU9F: Corn area harvested, next year, mil. ac.
COAHPU9F: Corn harvested area/planted area, next year
COAIAU9: Corn acreage idled by ARP, PLD programs, mil. ac.
COAIAU9F: Corn acreage idled by ARP, PLD programs, next year, mil. ac.
COAPAU9F: Corn area planted, next year, mil. ac.
COAPNU9F: Corn area planted by nonparticipants, next year, mil. ac.
COAPPU9F: Corn area planted by participants, next year, mil. ac.
COCOTU9: Corn total ending stocks, mil. bu.
COFREU9: Corn free stocks, mil. bu.
COMPRU9F: Corn model participation rate, equals (ARP + PLD + program planted area)/program base, next year
CONRNU9: Corn expected nonparticipant net returns, $/ac.
CONRPU9F: Corn expected net returns to participants, next year, $/base ac.
COSPRU9F: Corn production, next year, mil. bu.
COUFEU9: Corn feed use, mil. bu.
COUFEU9G: Corn feed use per GCAU, bu./GCAU

Table 1. Continued

COUFOU9:	Corn food, seed and industrial use, mil. bu.
COUGAU9:	Corn gasohol use, mil. bu.
COUOFU9:	Corn food (nonfeed, nongasohol, nonseed) use, mil. bu.
COUSDU9:	Corn seed use, mil. bu.
COYHAU9F:	Corn yield per harvested acre, next year, bu./ac.
COUTOU9:	Total corn domestic use, mil. bu.
COPOBU9:	Corn Gulf Port price $/mt.
CORPF:	Corn farm price $/bu.
OAAHAU9:	Oats area harvested, mil. ac.
OAAIAU9:	Oats area idled by ARP, PLD program, mil. ac.
OAAPAU9:	Oats area planted, mil. ac.
OAAPAU9F:	Oats area planted, next year, mil. ac.
OAAPNU9:	Oats area planted by nonparticipants, mil. ac.
OAAPPU9:	Oats area planted by participants, mil. ac.
OACOTU9:	Oats total ending stocks, mil. bu.
OAF9LU9:	Oats free and 9-month loan stocks, mil. bu.
OAMPRU9:	Oats model participation rate, equals (ARP + PLD + program planted area)/program base
OANRNU9:	Oats expected net returns to nonparticipants, $/ac.
OANRPU9:	Oats expected net returns to participants, $/base ac.
OAPFMU9:	Oats farm market price, $/bu.
OASMNU9:	Oats net imports, mil. bu.
OASPRU9:	Oats production, mil. bu.
OAUFEU9:	Oats feed use, mil. bu.
OAUFOU9:	Oats food, seed & industrial use, mil. bu.
OAUFOU9C:	Oats per-capita food, seed and industrial use, bu./capita
OAYHAU9:	Oats yield per harvested acre, bu./ac.
SBNRNU9F:	Soybean expected net returns, next year, $/ac.
SGAHAU9:	Sorghum area harvested, mil. ac. (1)
SGAHPU9:	Sorghum harvested area/sorghum planted area (8)
SGAIAU9:	Sorghum acreage idled by ARP, PLD programs, mil. ac. (1)
SGAPAU9:	Sorghum area planted, mil. ac. (1)
SGAPNU9:	Sorghum area planted by nonparticipants, mil. ac. (1)
SGAPPU9:	Sorghum area planted by participants, mil. ac. (1)
SGCOTU9:	Sorghum total ending stocks, mil. bu. (1)
SGF9LU9:	Sorghum free and 9-month loan stocks, mil. bu. (1)
SGMPRU9:	Sorghum model participation rate, equals (ARP + PLD + program planted area)/program base (8)
SGNRNU9:	Sorghum expected net returns to nonparticipants, $/ac. (8)
SGNRPU9:	Sorghum expected net returns to participants, $/base ac. (8)
SGPOBU9:	Sorghum Gulf Port price, $/mt
SGSPRU9:	Sorghum production, mil. bu. (1)
SGUFEU9:	Sorghum feed use, mil. bu. (1)
SGUFOU9:	Sorghum food, seed and industrial use, mil. bu. (1)
SGUXNU9:	Sorghum exports, mil. bu. (1)
SGYHAU9:	Sorghum yield per harvested acre, bu./ac. (1)
SORPF:	Sorghum farm price, $/bu.
WHNRNU9F:	Wheat expected net returns to nonparticipants, next year, $/ac.
FGUXNU9:	U.S., net feed-grain exports, 1000 mt.

Table 1. Continued

FGSMNAR:	Argentina, feed-grain imports, 1000 mt.
FGSMNAU:	Argentina, feed-grain imports, 1000 mt.
FGSMNTH:	Thailand, feed-grain imports, 1000 mt.
FGSMNE2:	EC, feed-grain imports, 1000 mt.
FGSMNZA:	South Africa, feed-grain imports, 1000 mt.
FGSMNJP:	Japan, feed-grain imports, 1000 mt.
FGSMNSU:	Soviet Union, feed-grain imports, 1000 mt.
FGSMNE8:	Eastern Europe, feed-grain imports, 1000 mt.
FGSMNCN:	China, feed-grain imports, 1000 mt.
FGSMNR4:	High Income East Asia, feed-grain imports, 1000 mt.
FGSMNBR:	Brazil, feed-grain imports, 1000 mt.
FGSMNMX:	Mexico, feed-grain imports, 1000 mt.
FGSMNEG:	Egypt, feed-grain imports, 1000 mt.
FGSMNSA:	Saudi Arabia, feed-grain imports, 1000 mt.
FGSMNNO:	Other Latin America, feed-grain imports, 1000 mt.
FGSNFFO:	Other Africa and Middle East, feed-grain imports, 1000 mt.
FGSMNSO:	Other Asia, feed-grain imports, 1000 mt.
FGSMNROW:	Rest of the World, feed-grain imports, 1000 mt.
SGSMNAR:	Argentina, sorghum imports, 1000 mt.
SGSMNAU:	Australia, sorghum imports, 1000 mt.
SGSMNZA:	South Africa, sorghum imports, 1000 mt.
SGSMNMX:	Mexico, sorghum imports, 1000 mt.
SGSMNNG:	Nigeria, sorghum imports, 1000 mt.
SGSMNIN:	India, sorghum imports, 1000 mt.
SGUXNU9:	U.S., sorghum exports, 1000 mt.
SGSMNROW:	ROW, sorghum imports, 1000 mt.

Exogenous Variables

BAABAU9:	Barley program acreage base, mil. ac.
BACCCU9:	Barley CCC stocks, mil. bu.
BACRPU9:	Barley program base enrolled in the CRP, mil. ac.
BADPRU9:	Barley diversion payment rate, $/bu.
BAFORU9:	Barley FOR stocks, mil. bu.
BAMARU9:	Barley model ARP rate, equals ARP area/(ARP + PLD + program planted area)
BAMPLU9:	Barley model PLD rate, equals PLD area/(ARP + PLD + program planted area)
BAPLNU9:	Barley loan rate, $/bu.
BAPTGU9:	Barley target price, $/bu.
BASMTU9:	Barley imports, mil. bu.
BAURSU9:	Barley statistical discrepancy, mil. bu.
BAUXTU9:	Barley exports, mil. bu.
BAVCAU9:	Barley variable production costs--includes family labor and interest on variable expenses, $/ac.
BAVCAU9F:	Barley variable production costs, next year, $/ac.
BAYHPU9:	Barley program yield, bu./ac.
BAYHTU9:	Barley trend yield, bu./ac.

Table 1. Continued

BAYHTU9F: Barley trend yield, next year, bu./ac.
CATNFU9: Cattle on feed, 13 states, average of 3rd quarter this year and next
CATN3U9: Cattle on feed, 13 states, 3rd quarter
CEAJU9: U.S. real personal consumption expenditures, Aug.-July year, billion 1982 dollars
CEJMU9: U.S. real personal consumption expenditures, June-May year, billion 1982 dollars
CESAU9: U.S. real personal consumption expenditures, Sept.-Aug. year, billion 1982 dollars
CEU9: U.S. real personal consumption expenditures, calendar year, billion 1982 dollars
CO9LNU9: Corn 9-month loan stocks, mil. bu.
COABAU9F: Corn program acreage base, next year, mil. ac.
COCCCU9: Corn CCC stocks, mil. bu.
COCRPU9F: Corn program base enrolled in the CRP, next year, mil. ac.
CODPRU9F: Corn diversion payment rate, next year, $/bu.
COFORU9: Corn FOR stocks, mil. bu.
COMARU9F: Corn model ARP rate, equals ARP area/(ARP + PLD + program planted area), next year
COMPLU9F: Corn model PLD rate, equals PLD area/(ARP + PLD + program planted area), next year
CONRNU9F: Corn expected net returns to nonparticipants, next year, $/ac.
COPFMU9: Corn farm market price, $/bu.
COPLNU9F: Corn loan rate, next year, $/bu.
COPTGU9F: Corn target price, next year, $/bu.
COSMTU9: Corn imports, mil. bu.
COUOFU9C: Corn food use per capita, bu./capita
COUXEU9: Corn export demand shifter, mil. bu.
COUXTU9: Corn exports, mil. bu.
COVCAU9F: Corn variable production costs--includes family labor and interest on variable expenses, next year, $/ac.
COYHPU9F: Corn program yield, next year, bu./ac.
COYHTU9F: Corn trend yield, next year, bu./ac.
DEPOPU9: U.S. population including overseas armed forces, July 1
DM17072: 1 from 1970-1972; 0 otherwise
DM171: 1 in 1971; 0 otherwise
DM172: 1 in 1972; 0 otherwise
DM17274: 1 from 1972-1974; 0 otherwise
DM173: 1 in 1973; 0 otherwise
DM174: 1 in 1974; 0 otherwise
DM175: 1 in 1975; 0 otherwise
DM17576: 1 in 1975 and 1976; 0 otherwise
DM176: 1 in 1976; 0 otherwise
DM17677: 1 in 1976 and 1977; 0 otherwise
DM177: 1 in 1976; 0 otherwise
DM17780: 1 from 1977-1980; 0 otherwise
DM179: 1 in 1979; 0 otherwise
DM180: 1 in 1980; 0 otherwise

Table 1. Continued

DM181:	1 in 1981; 0 otherwise
DM18183:	1 from 1981-1983; 0 otherwise
DM182:	1 in 1982; 0 otherwise
DM18285:	1 from 1982-1985; 0 otherwise
DM183:	1 in 1983; 0 otherwise
DM18385:	1 from 1983-1985; 0 otherwise
DM18387:	1 from 1983-1987; 0 otherwise
DM18485:	1 in 1984 and 1985; 0 otherwise
DM185:	1 in 1985; 0 otherwise
DM1NPRGF:	1 when no program in the next years 1973-1976, 1979-1980; 0 otherwise
DM1S73:	1 beginning in 1973; 0 otherwise
DM1S74:	1 beginning in 1974; 0 otherwise
DM1S75:	1 beginning in 1975; 0 otherwise
DM1S77:	1 beginning in 1977; 0 otherwise
DM1S78:	1 beginning in 1978; 0 otherwise
DM1S79:	1 beginning in 1979; 0 otherwise
DM1S80:	1 beginning in 1980; 0 otherwise
DM1S81:	1 beginning in 1981; 0 otherwise
DM1S82:	1 beginning in 1982; 0 otherwise
DM1S83:	1 beginning in 1983; 0 otherwise
DM1S84:	1 beginning in 1984; 0 otherwise
DM1S85:	1 beginning in 1985; 0 otherwise
DMBAYU9:	Barley yield dummy: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise
DMCOYU9F:	Corn yield dummy, next year: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise
DMCTYU9F:	Cotton yield dummy, next year: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise
DMOAYU9:	Oats yield dummy: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise
DMSBYU9F:	Soybean yield dummy, next year: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise
DMSGYU9:	Sorghum yield dummy: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise
DMWHYU9F:	Wheat yield dummy, next year: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise
FBPMIU9:	Fiber price index (Yanagishima)
GCAUU9:	Grain-consuming animal units, crop year basis
HAPUU9:	High-protein animal units, crop year basis
LVPIU9:	Livestock price index, crop year basis
OAABAU9:	Oats program acreage base, mil. ac.
OACCCU9:	Oats CCC stocks, mil. bu.
OACRPU9:	Oats program base enrolled in the CRP, mil. ac.
OADPRU9:	Oats diversion payment rate, $/bu.
OAFORU9:	Oats FOR stocks, mil. bu.
OAMARU9:	Oats model ARP rate, equals ARP area/(ARP + PLD + program planted area)

Table 1. Continued

OAMPLU9:	Oats model PLD rate, equals PLD area/(ARP + PLD + program planted area)
OAPLNU9:	Oats loan rate, $/bu.
OAPTGU9:	Oats target price, $/bu.
OASMTU9:	Oats total imports, mil. bu.
OAURSU9:	Oats statistical discrepancy, mil. bu.
OAUXTU9:	Oats total exports, mil. bu.
OAVCAU9:	Oats variable production costs--includes family labor and interest on variable expenses, $/ac.
OAYHPU9:	Oats program yield, bu./ac.
OAYHTU9:	Oats trend yield, bu./ac.
PW:	U.S. wholesale price index, 1967=100
PWAJU9:	U.S. wholesale price index, Aug.-July year, cal. 1967=100
PWFSAU9:	Producer price index for fuels, etc., Sept.-Aug. year, calendar 1967=100
PWJMU9:	U.S. wholesale price index, June-May year, cal. 1967=100
PWSAU9:	U.S. wholesale price index, Sept.-Aug. year, cal. 1967=100
SBPFMU9:	Soybean farm market price, $/bu.
SBVCAU9F:	Soybean variable production costs--includes family labor and interest on variable expenses, next year $/ac. (7)
SBYHTU9F:	Soybean trend yield, next year, bu./ac. (8)
SMPFMU9:	Soybean meal market price, 44% protein, Decatur, $/ton
SGABAU9:	Sorghum program acreage base, mil. ac. (1)
SGCCCU9:	Sorghum CCC stocks, mil. bu. (1)
SGCRPU9:	Sorghum program base enrolled in the CRP, mil. ac. (6)
SGDPRU9:	Sorghum diversion payment rate, $/bu. (2)
SGFORU9:	Sorghum FOR stocks, mil. bu. (1)
SGMARU9:	Sorghum model ARP rate, equals ARP area/(ARP + PLD + program planted area) (8)
SGMPLU9:	Sorghum model PLD rate, equals PLD area/(ARP + PLD + program planted area) (8)
SGPLNU9:	Sorghum loan rate, $/bu. (1)
SGPTGU9:	Sorghum target price, $/bu. (1)
SGSMTU9:	Sorghum imports, mil. bu. (1)
SGURSU9:	Sorghum statistical discrepancy, mil. bu. (8)
SGUXEU9:	Sorghum export demand shifter, mil. bu. (8)
SGVCAU9:	Sorghum variable production costs--includes family labor and interest on variable expenses, $/ac. (7)
SGVCAU9F:	Sorghum production costs, next year, $/ac. (7)
SGYHPU9:	Sorghum program yield, bu./ac. (1)
SGYHTU9:	Sorghum trend yield, bu./ac. (8)
SUPRTU9:	Granulated sugar retail price, cents/lb.
TREND:	Calendar year.
TRND6783:	Trend from 1967-1983: 1 in 1967, 2 in 1968,...17 in 1983 and after.
TRND7186:	Trend from 1971-1986: 0 until 1970, 1 in 1971, 2 in 1972,...16 in 1986 and after.
TRND8184:	Trend from 1981-1984; 0 until 1980; 1 in 1981, 2 in 1982,...4 in 1984 and after.

Table 1. Continued

TRND8185:	Trend from 1981-1985; 0 until 1980; 1 in 1981, 2 in 1982,...5 in 1985 and after.
TRND8587:	Trend from 1985-1987; 0 until 1984; 1 in 1985, 2 in 1986, 3 in 1987 and after
WHPFMU9:	Wheat farm market price, $/bu.
WHUFEU9:	Wheat feed use, mil. bu.
WHVCAU9F:	Wheat variable production costs-includes family labor and interest on variable expenses, next year, $/ac.
WHYHTU9F:	Wheat trend yield, next year, bu./ac.
FGSTDUS:	Feedgrain statistical discrepancy
SGSTDIS:	Sorghum statistical discrepancy
TRND8185:	Trend from 1981-1985; 0 until 1980; 1 in 1981, 2 in 1982,...5 in 1985 and after.
TRND8587:	Trend from 1985-1987; 0 until 1984; 1 in 1985, 2 in 1986, 3 in 1987 and after
WHNRNU9F:	Wheat expected net returns to nonparticipants, next year, $/ac.
WHPFMU9:	Wheat farm market price, $/bu.
WHUFEU9:	Wheat feed use, mil. bu.
WHVCAU9F:	Wheat variable production costs--includes family labor and interest on variable expenses, next year, $/ac.
WHYHTU9F:	Wheat trend yield, next year, bu./ac.

nonparticipant expected net returns, and soybean expected net returns. The area planted by participants has a coefficient of -0.96, which indicates that enrollment of an additional acre in the government program will reduce nonprogram acres by less than one. As expected, nonparticipant net returns have a positive effect and soybean net returns have a negative effect on the corn acreage planted by nonparticipants. The area planted by participants is specified by identity (1.6) as participation rate times base acreage times the proportion of base acres used for planting. Total area planted (1.7) is the sum of areas planted by participants and nonparticipants. Acreage harvested as a percentage of acreage planted (1.8) is estimated to reflect the impact of weather. The proportion of acreage idled under ARP, PLD, and CRP to total acreage planted is used as one of the variables explaining the effect of idled land (1.9) on area harvested. Total corn-area harvested (1.10) is determined as the area planted times the proportion of area harvested to area planted.

Corn yield (1.11) is endogenously determined as a function of real target price; time trend; acreage idled under ARP, PLD, and CRP; and two dummy variables. Elasticity of the target price is 0.23, which indicates that a 10 percent increase in the real target price will lead to a 2.3 percent increase in yield. Acreage idled by participants has a positive coefficient because farmers increase the use of other inputs on the base acreage planted to increase per acre yield. The trend variable is included to reflect technological progress. The dummy variable DMCOYU9F captures the weather effect on yield. It takes the value of one when actual yields are more than one standard deviation from trend yield and of minus one when actual yields are less than one standard deviation from trend yield. Total corn production is described by identity (1.12) as corn yield times area harvested.

On the demand side, corn feed use, food use, corn seed use, and stock demand are estimated separately. The dependent variable in the feed equation (1.13) is feed use per grain-consuming animal unit. The explanatory variables in the feed use equation include own (real corn price) and cross (real sorghum price) prices. Other feed uses--wheat, sorghum, barley, oats--are also used to capture the substitution effect in feed use. Because corn is an input in the livestock sector, a livestock product-price index is included to reflect the demand for corn in livestock production. The computed own-price elasticity of feed use is -0.14, and substitute price elasticity is 0.06. Total feed use (1.14) is equal to grain-consuming animal units times feed use per grain-consuming animal unit. Corn food use (1.15) is estimated in per capita terms. Own-price elasticity is negative in all food-demand equations, and elasticity with respect to real per capita consumer expenditures is positive. Other explanatory variables include cross prices for wheat (a substitute for corn used in baking) and sugar (a substitute for corn sweeteners). Total corn food use is given by the identity (1.16) as per capita food use times population.

Corn gasohol demand (1.17) is found to depend in part upon the ratio of corn and fuel prices, but trend and shift variables are needed to account for the expansion of the industry in the 1980s. Corn seed use is estimated as a function of acreage planted and a time trend. Total domestic use is given by identity (1.19) as the sum of feed, food, gasohol, and seed use. Corn free-stock demand (1.20) is estimated as a function of corn price, current and expected production, and government stocks. Results show that the elasticity of current farm price is -0.64 and that the free-stock level is very sensitive to changes in corn production. The coefficient of -0.31 on FOR, CCC, and nine-month-loan stocks indicates that a one-bushel increase in these stocks will reduce free stocks by about one-half bushel. Total corn stocks are given by the identity (1.21) as the sum of stocks, FOR, CCC, and nine-month-loan stocks.

The estimated equations for sorghum, barley, and oats are specified in equations 1.24 through 1.79 in Table 1. The estimated structural equations for these feed grains are similar to those of corn. Hence, these equations are not explained further.

Canadian Submodel

The Canadian component of the model is reported in Table 2. Because Canada is one of the major exporters of feed grains, the revenue of Canadian farmers depends largely on world prices. To protect farmers from low prices, the Canadian Wheat Board (CWB) sets initial prices for barley and wheat delivered to the CWB, on the basis of a quota level set by the CWB for each farmer. These initial prices are important because they determine the average allocations of wheat and barley. Farmers can also sell their products on the open market, whose prices are referred to as "off-board."

Because off-board price influences acreage allocation, it is included in the barley acreage harvested equation (2.1). Rapeseed price enters this equation as a substitute price. The dummy variable for 1971 reflects the effects of the "Lower Inventory for Tomorrow" program. Other explanatory variables used in this equation are lagged barley acreage, oats acreage harvested, barley residual yield, and a dummy variable for 1984. Own-price

Table 2. Structural parameter estimates of the Canadian feed-grains submodel

---

(2.1) Barley Area Harvested

```
BAAHHCA = 2412.850 + 0.519 LAG(BAAHHCA)
            (3.87)   (5.13)

        + 16.548 LAG(BAPOBCA/NARDDCA) - 3.811 LAG(RSPFMCA/NARDDCA)
          (4.27)                        (3.02)
          [0.47]                       [-0.03]

        - 0.592 OAAHHCA + 1286.530 D71 + 609.629 D84
         (3.71)            (4.30)         (1.85)
        [-0.03]

        + 1458.010 BARESCA
            (3.11)
```

R^2 = 0.29 DW = 1.98

(2.2) Barley Production

BASPRCA = BAAHHCA * BAYHHCA

(2.3) Barley Domestic Use

```
BAUDTCA = -48.141 - 6.734 BAPOBCA/NARDDCA
           (0.04)   (3.23)
                   [-0.12]

        + 2.759 SMPFMCA/NARDDCA + 382.406 LVCACCA
         (2.72)                   (6.77)
         [0.11]                   [1.06]

        - 1364.54(D67 + D68) - 765.259(D80 + D81 + D82 + D83 + D84)
            (6.39)               (3.69)
```

R^2 = 0.94 DW = 2.13

(2.4) Barley Off-Board Price

```
BAPOBCA = 11.180 + 38.524 BARPF * NIMEUCA + 20.803 D73
          (2.17)   (17.22)                   (2.53)
                   [0.87]
```

R^2 = 0.95 DW = 1.47

Table 2. Continued

(2.5) Rapeseed Farm Price

RSPM1CA = -55.981 + 45.9068 SOYPF * NIMEUCA

+ 14.6135 SOPMKU9/SOMPM - 54.6791 D80

(2.6) Soybean Farm Price

SBPFMCA = -4.005 + 36.877 SOYPF * NIMEUCA + 47.406 D85
(0.99) (56.74) (7.35)
[1.00]

R^2 = 0.99 DW = 2.55

(2.7) Soy Meal Price

SMPFMCA = 13.212 + 1.139 SOMPM * NIMEUCA + 49.840 D73
(1.05) (16.48) (2.66)
[0.92]

R^2 = 0.94 DW = 1.96

(2.8) Grain-consuming Animal Units

LVCACCA = 12.559 + 0.026 NANPDCA/NARDDCA - 0.005 BAPOBCA/NARDDCA
(17.97) (13.46) (1.44)
[0.36] [-0.03]

+ 0.915 D7175 - 1.818(D76 + D77 + D78)
(3.60) (7.22)

+ 1.486(D82 + D83 + D84)
(5.24)

R^2 = 0.97 DW = 2.15

(2.9) Barley Imports

BASMNCA = BAUDTCA + BACOTCA - BASPRCA - LAG(BACOTCA)

Table 2. Continued

2.10 Corn Acreage Harvested

```
COAHHCA = 604.672 + 0.683 LAG(COAHHCA)
           (3.12)   (6.88)

        + 1.106 LAG(COPFMCA/NARDDCA) - 0.469 LAG(SBPFMCA/NARDDCA)
         (2.13)                         (1.79)
         [0.19]                        [-0.17]

        - 0.162 OAAHHCA + 114.916 D81
         (3.38)            (3.15)
```

R^2 = 0.99   DW =2.58

2.11 Corn Production

COSPRCA = COAHHCA * COYHHCA

2.12 Corn Domestic Use

```
COUDTCA = -5785.060 - 19.830 COPFMCA/NARDDCA
             (5.73)    (3.10)
                      [-0.56]

        + 2.717 SMPFMCA/NARDDCA + 13.376 BAPOBCA/NARDDCA
         (2.09)                  (2.24)
         [0.17]                  [0.37]

        + 514.468 LVCACCA + 1428.720 SHIFT77
           (9.21)             (5.69)
           [2.17]

        - 1082.380 (D71 + D72)
            (3.82)
```

R^2 = 0.98   DW = 2.43

2.13 Corn Stocks

```
COCOTCA = -220.811 + 0.609 LAG(COCOTCA) - 0.849 COPFMCA/NARDDCA
            (1.18)   (4.82)                (0.82)
                                          [-0.14]

        + 0.170 COSPRCA + 278.557(D75 + D76) - 422.117 D81
         (4.69)            (3.36)               (3.54)
         [0.92]
```

Table 2. Continued

- 663.341 D83
  (5.00)

$R^2 = 0.98$ DW = 2.35

(2.14) Corn-Price Linkage

COPFMCA = 6.801 + 36.932 CORPF * NIMEUCA
(2.21) (31.61)
[0.93]

$R^2 = 0.98$ DW = 1.56

(2.15) Corn Imports

COSMNCA = COUDTCA + COCOTCA - COSPRCA - LAG(COCOTCA)

(2.16) Feed-Grain Imports

FGSMNCA = BASMNCA + COSMNCA + OASMNCA

Endogenous Variables

BAAHHCA = Canada, Barley Planted Area, 1000 ha
BAYHHCA = Canada, Barley Yield, MT/ha
BASPRCA = Canada, Barley Production, 1000 MT
BAUDTCA = Canada, Domestic Barley Consumption, 1000 MT
BAPOBCA = Canada, Barley Off-Board Price, can $/MT
RSPFMCA = Canada, Rapeseed Price Received by Farmers, can $/MT
SBPFMCA = Canada, Soybean Price, can $/MT
SMPFMCA = Canada, Soymeal Price, can $/MT
WHPOBCA = Canada, Wheat Off-Board Price, can $/MT
LVCACCA = Canada, Grain Consuming Animal Units
BARPF = Barley Price, can $/MT
COAHHCA = Canada, Corn Area Harvested, 1000 ha
COYHHCA = Canada, Corn Yield, MT/ha
COSPRCA = Canada, Expected Corn Production, 1000 MT
COUDTCA = Canada, Domestic Corn Use, 1000 MT
COCOTCA = Canada, Corn Ending Stocks, 1000 MT
COSNMCA = Canada, Corn Imports, 1000 MT
COPFMCA = Canada, Farm-Level Corn Price, $/MT

Table 2. Continued

Exogenous Variables

NARDDCA = Canada, GDP Deflater, 1980 = 1.0
OAAHHCA = Canada, Oat Area Harvested, 1000 ha
BARESCA = Canada, Barley Residual Yield, MT/ha
TREND = Calendar Year + 1
NIMEUCA = Canada, Exchange Rate Can $/ U.S. $
NANPDCA = Canada, GDA, BIL $C
SBPFMCA = Soybean Price, Can $/MT
OAAHHCA = Oats Area Harvested, 1000 ha
D67 = Dummy variable: 1 in 1967, 0 otherwise
D68 = Dummy variable: 1 in 1968, 0 otherwise
D71 = Dummy variable: 1 in 1971, 0 otherwise
D72 = Dummy variable: 1 in 1972, 0 otherwise
D73 = Dummy variable: 1 in 1973, 0 otherwise
D74 = Dummy variable: 1 in 1974, 0 otherwise
D75 = Dummy variable: 1 in 1975, 0 otherwise
D7175 = Dummy variable: 1 in 1971-1975, 0 otherwise
D76 = Dummy variable: 1 in 1976, 0 otherwise
SHIFT77 = Dummy variable
D78 = Dummy variable: 1 in 1978, 0 otherwise
D80 = Dummy variable: 1 in 1980, 0 otherwise
D81 = Dummy variable: 1 in 1981, 0 otherwise
D82 = Dummy variable: 1 in 1982, 0 otherwise
D83 = Dummy variable: 1 in 1983, 0 otherwise
D84 = Dummy variable: 1 in 1984, 0 otherwise

elasticity of barley acreage harvested is 0.47 and cross-price elasticity is -0.25. Barley production is given as acreage harvested times yield per acre.

On the demand side, only barley food use is endogenously estimated (2.3). The variables that explain barley food use are off-board price, soybean-meal price, grain-consuming animal units, and two shift variables for the late 1960s and early 1980s. Own-price elasticity of barley food use is estimated at -0.12 and substitute-price elasticity is 0.11. Barley off-board price, rapeseed farm price, soybean farm price, and soybean-meal price are endogenously estimated. Grain-consuming animal units are endogenously estimated as a function of real barley price, real income, and dummy variables. Because barley is an input in livestock production, barley price has a negative effect on the number of grain-consuming animal units. Barley imports (2.9) are defined as total use minus total supply.

The CWB does not exercise its policy over the corn market. Corn and barley are produced in different regions of Canada. The soybean is the substitute crop for corn in production. Therefore soybean price is included in corn acreage (2.10). Oats acreage harvested is also included in corn acreage. The other variables that enter the corn-acreage equation are corn price and a dummy variable. Own-price elasticity is 0.19 and substitute-price elasticity, -0.17. Corn yield is exogenous. Therefore, production is obtained by multiplying acreage and yield.

On the demand side, domestic corn use and stock demand are endogenously estimated. The variables that enter the domestic use equation are corn price, soybean-meal and barley prices (as substitute prices), grain-consuming animal units, and dummy variables. Own-price elasticity is -0.56, and cross-price elasticities are 0.17 for soybean-meal price and 0.37 for barley price. Because corn is an input in the livestock sector, the number of grain-consuming animal units is included to reflect the demand for corn in the livestock production as derived demand for corn.

Corn ending stocks are estimated as a function of corn price, production, lag inventories, and dummy variables. The price elasticity of stock demand is estimated at -0.14. Current crop production has a positive effect on stock demand. The Canadian corn price at the farm level is linked to the U.S. farm price (2.14). Corn imports (2.15) are defined as total use minus total supply. Total feed-grain imports (2.16) are equal to barley imports, corn imports, and oats imports.

Australian Submodel

The Australian component of the model is reported in Table 3. Australia traditionally has exported barley, which is the major feed-grain crop produced in this region. Wheat and barley are substitute crops both in terms of production and consumption. The barley-acreage equation (3.1) is estimated as a function of lagged barley prices and wheat prices, lagged acreage, wool price, and two dummy variables for 1967 and 1973. These dummy variables make allowances for changes in the Australian government's domestic policies regarding barley production. Wool price is included in the acreage equation because the land could be used for grazing sheep. Total production (3.2) is given as acreage harvested times yield.

On the demand side, barley domestic use and stocks are modeled. Domestic use (3.3) is estimated as a function of barley price (own price), wheat price (substitute price), income, and two dummy variables. Own-price elasticity is

Table 3. Structural parameter estimates of the Australian feed-grains submodel

(3.1) Barley Area Harvested

$$\begin{aligned} \text{BAAHHAU} = {} & \underset{(1.47)}{1181.580} + \underset{(3.94)}{0.551}\ \text{LAG(BAAHHAU)} \\ & + \underset{\substack{(2.68)\\ [0.60]}}{0.116}\ \text{LAG(BAPFMAU/NARDDAU)} \\ & - \underset{\substack{(-1.80)\\ [-0.46]}}{0.076}\ \text{LAG(WHPFMAU/NARDDAU)} \\ & - \underset{\substack{(-1.03)\\ [-0.20]}}{1.955}\ \text{LAG(GWPFMAU/NARDDAU)} - \underset{(-2.15)}{665.054}\ \text{D67} \\ & - \underset{(-0.20)}{88.180}\ \text{D73} + \underset{(3.62)}{610.208}\ \text{(D83 + D84 + D85)} \end{aligned}$$

$R^2 = 0.91$ DW(1) = 1.41   DW(2) = 2.31

(3.2) Barley Production

BASPRAU = BAAHHAU * BAYHHAU

(3.3) Domestic Barley Uses

$$\begin{aligned} \text{BAUDTAU} = {} & \underset{(4.40)}{1540.550} - \underset{\substack{(-6.19)\\ [-1.27]}}{0.128}\text{(BAPFMAU/NARDDAU)} \\ & + \underset{\substack{(3.43)\\ [0.66]}}{0.056}\text{(WHPFMAU/NARDDAU)} \\ & + \underset{\substack{(1.99)\\ [0.38]}}{3.752}\text{(NANPDAU/NARDDAU)} + \underset{(2.81)}{335.239}\ \text{D81} \\ & - \underset{(-5.74)}{602.548}\text{(D84 + D85 + D86)} - \underset{(-2.48)}{318.71}\ \text{D69} \end{aligned}$$

$R^2 = 0.87$ DW(1) = 1.57   DW(2) = 2.07

Table 3. Continued

(3.4) Barley Ending Stocks

$$BACOTAU = \underset{(7.66)}{794.707} - \underset{\substack{(-5.17)\\ [-1.85]}}{0.038}(BAPFMAU/NARDDAU)$$

$$+ \underset{\substack{(1.69)\\ [0.19]}}{0.189}\ LAG(BACOTAU) - \underset{(-7.92)}{353.629}\ SHIFT79$$

$$+ \underset{(2.08)}{119.724}(D80 + D82) - \underset{(-4.11)}{212.868}(D72 + D77)$$

$R^2 = 0.87$ $DW(1) = 2.32$ $DW(2) = 1.46$

(3.5) Barley Prices

$$BAPFMAU = \underset{(-0.51)}{-283.784} + \underset{\substack{(17.57)\\ [1.05]}}{5560.210}(BARPF * NIMEUAU)$$

$$+ \underset{(3.67)}{3200.200}\ D82 - \underset{(-4.96)}{3872.090}(D84 + D85)$$

$R^2 = 0.96$ $DW(1) = 1.41$ $DW(2) = 1.39$

(3.6) Sheep Inventory

$$SHCOTAU = \underset{(1.04)}{17.337} + \underset{(8.27)}{0.811}\ LAG(SHCOTAU)$$

$$- \underset{\substack{(-0.63)\\ [-0.06]}}{0.001}\ LAG(SGPFMAU/NARDDAU)$$

$$+ \underset{\substack{(2.16)\\ [0.10]}}{0.062}\ LAG(GWPFMAU/NARDDAU) + \underset{\substack{(2.75)\\ [0.23]}}{0.137}\ LAG[LAG(GWPFMAU/NARDDAU)]$$

$$- \underset{\substack{(-1.63)\\ [-.21]}}{0.002}\ LAG(WHFPMAU/NARDDAU) + 10.24(D84 + D85)$$

$R^2 = 0.91$ $DW(1) = 2.15$ $DW(2) = 1.48$

Table 3. Continued

(3.7) Greasy-wool Farm Price

$$GWPFMAU = \underset{(1.35)}{83.910} + \underset{\substack{(8.10)\\ [0.75]}}{318.458}(COLFAU * NIMEUAU)$$

$$+ \underset{\substack{(1.38)\\ [0.08]}}{1.020}(LTARCRUD * NIMEUAU) - \underset{(-1.14)}{0.409}\ LAG(SHCOTAU)$$

$$+ \underset{(5.62)}{91.326}\ D72 + \underset{(2.89)}{55.869}\ D86 + \underset{(2.94)}{55.256}\ D81 + 48.206\ D73$$

R = 0.98   DW(1) = 1.99   DW(2) = 2.49

(3.8) Barley Net Imports

$$BASMNAU = BAUDTAU + BACOTAU - BASPRAU - LAG(BACOTAU)$$

(3.9) Sorghum Prices

$$SGPFMAU = \underset{(-0.87)}{-301.650} + \underset{\substack{(24.54)\\ [1.07]}}{5099.850}(SORPF * NIMEUAU)$$

$$- \underset{(-6.07)}{2691.54}(D83 + D84 + D85) + \underset{(2.72)}{1342}\ D86$$

R^2 = .98   DW(1) = 2.03   DW(2) = 2.75

(3.10) Sorghum Area Harvested

$$SGAHHAU = \underset{(3.40)}{277.240} + \underset{(14.56)}{0.809}\ LAG(SGAHHAU) + \underset{\substack{(3.24)\\ [0.50]}}{0.025}\ LAG(SGPFMAU/NARDDAU)$$

$$- \underset{\substack{(1.97)\\ [-0.35]}}{0.014}\ LAG(WHPFMAU/NARDDAU) - \underset{\substack{(2.86)\\ [-0.40]}}{0.018}\ LAG(BAPFMAU/NARDDAU)$$

$$+ \underset{(3.51)}{124.448}\ D80 - \underset{(5.68)}{247.635}\ D73 - \underset{(4.42)}{188.930}\ D77$$

R^2 = 0.98   DW(1) = 1.78   DW(2) = 2.32

Table 3. Continued

(3.11) Sorghum Production

SGSPRAU = SGAHHAU * SGYHHAU

(3.12) Sorghum Stock

SGCOTAU = 6.468 + 0.288 LAG(SGCOTAU) + 0.028 SGSPRAU
(2.63) (1.68)

+ 93.584 D72 + 108.016(D76 + D77 + D79)
(3.45) (6.02)

- 51.736 D84
(1.87)

R^2 = 0.84 DW(1) = 2.48 DW (2) = 1.90

(3.13) Sorghum Imports

SGSMNAU = 977.377 - 0.047(SGPFMAU/NARDDAU)
(3.50) (2.40)

- 1.098 SGSPRAU - 176.122(D73 + D74)
(12.17) (1.63)

R^2 = 0.93 DW(1) = 1.78 DW(2) = 2.12

(3.14) Market Equilibrium

SGUDTAU = SGSPRAU + LAG(SGCOTAU) + SGSMNAU - SGCOTAU

(3.15) Wheat Farm Price

WHPFMAU = - 135.300 + 100.531 WHPEXAU - 3271.930(D72 + D73)
(0.40) (38.49) (8.24)
[1.05]

- 1604.540 D77

R^2 = 0.99 DW(1) = 2.31 DW(2) = 1.29

Table 3. Continued

(3.16) Wheat Export Price

$$WHPEXAU = \underset{(0.67)}{4.059} + \underset{(17.87)}{0.973}\ WHPGPU90 * NIMEUAU + \underset{(2.38)}{23.400}\ D82$$

$$- \underset{(3.09)}{22.92}(D84 + D85 + D86)$$

$R^2 = 0.97$ DW(1) = 1.35 DW(2) = 2.55

(3.17) Feed-Grain Imports

FGSMNAU = BASMNAU + COSMNAU + OASMNAU

Endogenous Variables

BAAHHAU = Barley Area Harvested, 1000 ha
BACOTAU = Barley Ending Stocks, 1000 MT
BAPFMAU = Barley prices at farm level, AUS $/MT
BAUDTAU = Domestic Barley Consumption, 1000 MT
SGPFMAU = Sorghum prices at farm level, AUS $/MT
SHCOTAU = Sheep inventories, mil head
GWPFMAU = Greasy-wool producer price (cents/kg)
BASMNAU = Barley net imports, 1000 MT
BASPRAU = Barley production, 1000 MT
SGAHHAU = Sorghum Area Harvested, 1000 ha
SGSPRAU = Sorghum Production, 1000 MT
SGCOTAU = Sorghum Stocks, 1000 MT
SGSMNAU = Sorghum Imports, 1000 MT
SGUDTAU = Sorghum Use, 1000 MT
WHPFMAU = Wheat Farm Price, AUS $/MT
WHPEXAU = Wheat Export Price, AUS $/MT
FGSMNAU = Feed-Grain Imports, $1000 MT

Exogenous Variables

TREND = Time Trend
NARDDAU = Gross Domestic Product Deflator, 1980=1.0
BAYHHAU = Barley Yield, MT/ha
NIMEUAU = Exchange Rate ($US/$AUS)
NANPDAU = GDP, Bil $AV
LTARCRUD = Grain-consuming Animals, 1000 heads
D67 = 1 in 67, 0 otherwise
D69 = 1 in 69, 0 otherwise
D73 = 1 in 73, 0 otherwise

Table 3. Continued

D74 = 1 in 74, 0 otherwise
D76 = 1 in 76, 0 otherwise
D79 = 1 in 79, 0 otherwise
D80 = 1 in 80, 0 otherwise
D81 = 1 in 81, 0 otherwise
D82 = 1 in 82, 0 otherwise
D83 = 1 in 83, 0 otherwise
D84 = 1 in 84, 0 otherwise
D85 = 1 in 85, 0 otherwise
COSMNAU = Corn Imports, 1000 MT
OASMNAU = Oats Imports, 1000 MT
SGYHHAU = Sorghum Yield, MT/ha

-1.27 and cross-price elasticity is 0.66. The explanatory variables in the barley stock-demand equation (3.4) are lag stocks, barley price, and dummy variables. The price-linkage relation is described by equation (3.5), in which barley farm price is linked to the U.S. barley price. Because Australia does not practice any trade restrictions in barley trade, price-transmission elasticity is close to one. Sheep inventories (3.6) and greasy-wool (3.7) farm prices are also endogenously estimated. Barley net imports are given by (3.8).

The supply side of the sorghum market is very similar to that of the barley market; on the demand side, stocks and imports are endogenously estimated. Feed-grains imports (3.17) are equal to barley, corn, and oats imports.

Argentine Submodel

Argentina is a competitor of the United States in the feed-grains export market. Argentina earns its foreign exchange through its agricultural exports and has a good potential to increase production. Agricultural exports are also a source of government revenue, through the export tax. The Argentine component of the model is reported in Table 4.

Corn planted area (4.1) is influenced by both corn and soybean prices. Other variables that enter the acreage equation are lagged acreage and two dummy variables. The elasticity of area harvested with respect to corn price is 0.36 and with respect to soybean farm price is -0.21. Corn yield is exogenous in the model. Corn production is given by the identity (4.2) as corn acreage times yield.

Table 4. Structural parameter estimates of the Argentine feed-grains submodel

(4.1) Corn Area Harvested

```
COAHHAR = 1130.980 + 4.059 LAG(COPFMARR)
            (2.51)  (3.65)
                     [.36]

        - 1.084 LAG(SBPFMARR) + 0.49 LAG(COAHHAR)
        (-2.67)                 (3.55)
        [-0.21]

        + 553.482 D72 - 473.278(D71 + D79)
           (2.32)       (-2.58)
```

R^2 = 0.83   DW(1) = 1.90

(4.2) Corn Production

COSPRAR = COAHHAR * COYHHAR

(4.3) Domestic Corn Use

```
COUDTAR = -915.573 - 3.647 COPFMARR
           (-0.51) (-1.37)
                   [-0.31]

        + 6.473 SGPFMARR + 0.184 COSPRAR
         (1.70)           (6.58)
         [0.44]           [0.45]

        + 47.910 CECOTAR + 650.868 D83
          (1.84)            (2.62)
          [0.78]

        + 753.055 D71 - 905.072 D70 - 715.797 SHIFT75
           (3.26)       (-3.63)       (-4.62)
```

R^2 = 0.89   DW(1) = 2.55

(4.4) Corn Ending Stocks

```
COCOTAR = 1137.360 - 2.973 COPFMARR + 0.017 COSPRAR
            (6.26) (-6.43)           (1.38)
                   [-2.94]           [0.50]
```

Table 4. Continued

$$- \underset{(-5.57)}{367.522}(D78 + D79 + D80) - \underset{(-2.85)}{284.210}\ D83$$

$$- \underset{(-3.30)}{243.050}(D71 + D73)$$

$R^2 = 0.85 \quad DW(1) = 2.76$

(4.5) Corn Prices

$$COPFMARR = \underset{(3.69)}{154.329} + \underset{\substack{(4.08)\\ [0.62]}}{21.800}(CORPF * NIMECARF/WPI80AR * 10{,}000)$$

$$- \underset{\substack{(-2.90)\\ [-0.07]}}{10.876}[WPI80AR - LAG(WPI80AR)]/LAG(WPI80AR)$$

$$- \underset{(-5.93)}{233.557}\ D74 - \underset{(-3.06)}{83.510}(D73 + D75)$$

$R^2 = 0.76 \quad DW(1) = 2.18$

(4.6) Livestock Ending Inventories

$$CECOTAR = \underset{(4.04)}{26.777} + \underset{\substack{(2.20)\\ [0.23]}}{0.0005}\ NARPDAR - \underset{\substack{(-2.82)\\ [-0.10]}}{0.024}\ SGPFMARR$$

$$- \underset{(-2.65)}{2.953}\ D70 + \underset{(3.22)}{2.65}(D75 + D76 + D77)$$

$R^2 = 0.96 \quad DW(1) = 1.57$

(4.7) Corn Net Imports

$$COSMNAR = COUDTAR + COCOTAR - COSPRAR - LAG(COCOTAR)$$

(4.8) Sorghum Area Harvested

$$SGAHHAR = \underset{(1.81)}{993.659} + \underset{(3.84)}{0.474}\ LAG(SGAHHAR) + \underset{\substack{(2.72)\\ [9.15]}}{5.615}\ LAG(SGPFMARR)$$

Table 4. Continued

```
     - 4.150 LAG(WHPFMARR) + 958.860 SGRESAR
      (2.76)                  (5.11)
     [-0.67]

     - 576.571 D72 + 864.013(D81 + D82)
        (2.46)        (3.77)
```

R^2 = 0.85   DW(1) = 1.82

(4.9) Sorghum Production

SGSPRAR = SGAHHAR * SGYHHAR

(4.10) Sorghum Domestic Use

```
SGUDTAR = 694.595 + 52.330 CECOTAR - 23.477 SGPFMARR
           (0.38)   (2.14)            (4.79)
                    [1.35]           [-2.56]

        + 13.306 COPFMARR + 693.536 D82
          (3.99)             (2.30)
          [1.79]

        + 900.100(D70 + D72) + 1659.790 D73
           (3.51)                (4.96)
```

R^2 = 0.83   DW(1) = 2.39

(4.11) Sorghum Stocks

```
SGCOTAR = 342.603 + 0.127 LAG(SGCOTAR) - 0.897 SGPFMARR
           (4.58)  (1.31)                 (3.11)
                                         [-1.30]

        + 107.303 D77 - 120.302(D79 + D83) + 338.460 D81
           (2.42)        (3.63)               (7.546)

        + 161.907 D84
           (3.469)
```

(4.12) Sorghum Farm Price

```
SGPFMARR = 166.593 + 13.883 SORPF * NIMECARF/WPI80AR * 10,000
            (6.38)   (3.79)
                     [0.44]
```

Table 4. Continued

```
- 12.300[WPI80AR - LAG(WPI80AR)]/LAG(WPI80AR)
  (5.22)
 [-0.09]

- 149.428 D74 - 18.063(D73 + D75)
   (6.02)        (1.09)
```

R^2 = 0.81   DW = 2.34

(4.13) Sorghum Imports

SGSMNAR = SGUDTAR + SGCOTAR - SGSPRAR - LAG(SGCOTAR)

(4.14) Soybean Farm Price

```
SBPFMARR = 194.490 + 25.374 SOYPF * NIMECARF/WPI80AR * 10,000
            (2.50)    (6.67)
                      [0.80]

         - 43.903[WPI80AR - LAG(WPI80AR)]/LAG(WPI80AR)
           (5.42)

         - 222.841 D74 + 400.807 D75 + 134.495 D82
            (3.25)         (5.84)         (2.05)
```

R^2 = 0.89   DW = 1.37

(4.15) Wheat Farm Price

```
WHPFMARR = 239.884 + 13.509(WHEPF NIMECARF/WPI80AR) * 10,000
            (5.05)    (2.78)
                      [0.43]

         - 17.143[WPI80AR - LAG(WPI80AR)]/LAG(WPI80AR)
           (4.93)

         - 130.853(D73 + D75) - 192.142 D74 + 78.999 D77
            (3.65)                (4.32)        (2.65)

         + 85.845 D80
           (2.87)
```

R^2 = 0.85   DW(1) = 2.06

Table 4. Continued

(4.16) Argentine Feed-Grain Imports

FGSMNAR = COSMNAR + BASMNAR + OASMNAR

Endogenous Variables

COAHHAR = Argentina, Corn Area Harvested, 1000 ha
COSPRAR = Argentina, Corn Production, 1000 MT
COUDTAR = Argentina, Total Domestic Corn Use, 1000 MT
COCOTAR = Argentina, Corn Ending Stocks, 1000 MT
COPFMAR = Argentina, Corn Farm Prices, 1980 Pesos/MT
CECOTAR = Argentina, Cattle Ending Inventories, mil.head
COSMNAR = Argentina, Corn Net Imports, 1000 MT
SGAHHAR = Argentina, Sorghum Area Harvested, 1000 ha
SGSPRAR = Argentina, Sorghum Production, 1000 MT
SGUDTAR = Argentina, Total Domestic Sorghum Use, 1000 MT
SGCOTAR = Argentina, Sorghum Ending Stocks, 1000 MT
SGPFMAR = Argentina, Sorghum Farm Price, 1980 Pesos/MT
SGSMNAR = Argentina, Sorghum Net Imports, 1000 MT
SBPFMAAR = Argentina, Soybean Farm Price, 1980 Pesos/MT
WHFMARR = Argentina, Wheat Farm Price, 1980 Pesos/MT
FGSMNAR = Argentina, Feed-Grain Imports, 1980 1000 MT

Exogenous Variables

COYHHAR = Argentina, Corn Yield, MT/ha
TREND = Calendar Year
WPI80AR = Wholesale Price Index in Argentina, 1980 base period
NARPDAR = Argentina, Real GDP, 1980 Australes
NIMECARF = Commercial Exchange Rate, 1980 Australes/U.S. $
D70 = 1 in 1970, 0 otherwise
D71 = 1 in 1971, 0 otherwise
D72 = 1 in 1972, 0 otherwise
D73 = 1 in 1973, 0 otherwise
D74 = 1 in 1974, 0 otherwise
D75 = 1 in 1975, 0 otherwise
D76 = 1 in 1976, 0 otherwise
D77 = 1 in 1977, 0 otherwise
D78 = 1 in 1978, 0 otherwise
D79 = 1 in 1979, 0 otherwise
D80 = 1 in 1980, 0 otherwise
D81 = 1 in 1981, 0 otherwise
D82 = 1 in 1982, 0 otherwise
D83 = 1 in 1983, 0 otherwise
D84 = 1 in 1984, 0 otherwise
SGRESAR = Deviation from trend yield, MT/ha
SGYHHAR = Argentina, Sorghum Yield Per Acre, MT/ha

On the demand side, corn domestic use and ending stocks are endogenously estimated. The explanatory variables in the corn domestic use equation (4.3) are corn price, sorghum price, production, cattle stocks, and dummy variables. Own-price elasticity of domestic corn use is -0.31. Sorghum is the major substitute for corn in feed use. The substitute-price elasticity is 0.44. Because corn is an input in the livestock sector, cattle stock is included in the equation to reflect the demand for corn in livestock production--i.e., derived demand for corn. Corn ending stocks (4.4) are modeled as a function of corn farm price, corn production, and dummy variables. In equation 4.5, corn farm prices are linked to U.S. farm prices. Total livestock ending stocks (4.6) are endogenously estimated as a function of sorghum farm price, real income, and dummy variables. Net corn imports are given by the identity (4.7).

The other major coarse grain produced in Argentina is sorghum. The structure of the sorghum market is similar to that of the corn market. Estimated equations for sorghum are given in equations 4.8 to 4.13. Soybean and wheat price-linkage equations are given in equations 4.14 and 4.15. Argentina's total feed-grain exports--the sum of corn, barley, and sorghum--are specified in equation 4.16.

The European Community Submodel

The feed grains modeled for the EC are barley and corn, which the community exports and imports, respectively. Before the estimated equations are described, a summary of the EC's grain policies is provided.

Common Agricultural Policy (CAP) price-support policies regulate markets via selected policy instruments to maintain grain prices to producers at predetermined levels generally well above those of the world market. Market supplies are controlled through government intervention, import restrictions, and aggressive export policies. The policy prices in operation are the target price, the threshold price, and the intervention price.

The target price is the price considered to be acceptable in the most grain-deficient area (Duisburg, Germany). The intervention price is equal to the target price minus transport costs from the largest grain surplus area (Ormes, France) to Duisburg, plus a "market element" to the intervention price. The intervention price is the price at which government agencies buy commodities for storage and is thus a "supported price level." The threshold price represents the lowest price at which imported grain can enter the EC without depressing prices below the target-price level. The threshold price is equal to the target price minus the transportation and marketing costs from Rotterdam to Duisburg.

The variable levy for imports is equal to the threshold price minus the world price. The variable levy paid by importers is a source of revenue for the EC budget and for the European Agricultural Guarantee and Guidance Fund (EAGGF). Export restitutions are export subsidies paid grain exporters to bridge the gap between internal market price and world-market price and thus to make EC exports competitive on the export market. These export payments are a drain on the EAGGF. Further details concerning EC grain policies can be found in Burtin (1987), Miller (1987), and OECD (1987).

The estimated equations are given in Table 5. Barley area harvested (5.1) is estimated as a function of real barley intervention price, oats area harvested, lag barley area harvested, and dummy variables. Because oats competes with barley for acreage, oats acreage enters into the barley area harvested equation. Own-price elasticity is estimated at 0.81. Barley production is described by identity (5.2) as area harvested times yield. Barley yield is exogenous in the model.

On the demand side, barley nonfeed use, feed use, and stocks are estimated. The explanatory variables in the nonfeed use equation (5.3) are real threshold price and real income. Own-price and income elasticities are -0.27 and 0.75, respectively. The barley feed equation (5.4) is estimated as a function of barley real threshold price, poultry production, and dummy variables. Pork production enters into the barley feed equation, because barley is used in hog feeding. Own-price elasticity is -0.17. Barley ending stocks (5.5) are estimated as a function of beginning stocks, deviation from production, and dummy variables. Barley net imports are described by identity (5.6) as domestic demand minus total supply.

Corn area harvested (5.7) is estimated as a function of real corn intervention price, oats area harvested, lag corn area, and dummy variables. As in the case of barley, oats is a substitute crop to corn on the supply side; thus, oats acreage enters into the corn area harvested. Own-price elasticity is estimated at 0.14. Corn production (5.8) is equal to acreage harvested times yield.

On the demand side, corn domestic use and stocks are estimated. Because soybean meal and wheat are also used for livestock feeding, soybean-meal price and wheat feed use enter into the corn domestic use equation (5.9). Other variables in the domestic use equation are corn threshold price, poultry production, and dummy variables. Own-price elasticity is -0.27. Corn stocks (5.10) are estimated as a function of real threshold price, corn production, and dummy variables. Corn threshold price is significant, with an elasticity

Table 5. Structural parameter estimates of the European Community feed-grains submodel

(5.1) Barley Acreage Harvested

```
BAAHHE2 = 5564.110 + 0.578 LAG(BAAHHE2)
            (4.88)   (7.78)

        + 4.356 BAPIEO/NARDDEO - 0.578 OSAHHE2 + 523.498 D75
         (3.16)                   (3.05)            (4.02)
         [0.08]

        + 452.063 D7781 + 492.411 DEC9
          (3.99)
```

R^2 = 0.99   DW = 2.39

(5.2) Barley Production

BASPRE2 = BAAHHE2 * BAYHHE2

(5.3) Barley Nonfeed Use

```
BAUHTE2 = 4683.180 - 9.620 BAPTHEO/NARDDEO
            (4.21)   (6.84)
                    [-0.27]

        + 3.080 NANPDE2/NARDDEO + 731.148(D74 + D75)
         (8.57)                    (3.45)
         [0.75]
```

R^2 = 0.96   DW = 1.83

(5.4) Barley Feed Use

```
BAUFEE2 = 22070.900 - 20.219 BAPTHEO/NARDDEO - 3701.070 SHIFT81
             (2.69)    (1.74)                     (6.38)
                      [-0.17]

        + 1794.350(D77 + D78) - 1785.150(D74 + D75)
            (3.06)                 (3.05)

        + 1.641 POSPRE2
         (2.80)
         [0.48]
```

R^2 = 0.97   DW = 2.80

Table 5. Continued

(5.5) Barley Stocks

$$BACOTE2 = \underset{(4.18)}{2454.460} + \underset{(1.06)}{0.196}\, LAG(BACOTE2) + \underset{(2.99)}{1369.490}\, D82$$

$$- \underset{(4.16)}{1088.480}(D69 + D71 + D72 + D73) + \underset{\substack{(3.89)\\ [0.02]}}{0.151}\, BARESE2$$

$$+ \underset{(4.45)}{2101.180}\, D84 + \underset{(2.30)}{1339.140}\, D85$$

$R^2 = 0.87$ DW = 1.62

(5.6) Barley Imports

BASMNE2 = BAUFEE2 + BAUHTE2 + BACOTE2 - BASPRE2 - LAG(BACOTE2)

(5.7) Corn Acreage Harvested

$$COAHHE2 = \underset{(3.35)}{1381.610} + \underset{(9.05)}{0.827}\, LAG(COAHHE2) - \underset{(2.89)}{0.373}\, OSAHHE2$$

$$- \underset{(8.08)}{759.870}\, D76 - \underset{(4.78)}{288.497}(D80 + D81 + D83)$$

$$+ \underset{\substack{(1.95)\\ [0.14]}}{2.440}\, COPIEO/NARDDEO$$

$R^2 = 0.94$ DW = 1.46

5.8 Corn Production

COSPRE2 = COAHHE2 * COYHHE2

5.9 Corn Domestic Use

$$COUDTE2 = \underset{(3.75)}{33770.200} - \underset{\substack{(2.03)\\ [-0.27]}}{35.153}\, COPTHEO/NARDDEO$$

Table 5. Continued

```
+ 11.1038 SMPFMEO/NARDDEO - 1.068 WHUFEE2 - 2400.280 D75
  (3.94)                    (11.76)             (1.77)
  [0.09]                    [-0.44]

- 3834.570(D80 + D81 + D82) + 5.073 PYSPRE2
    (4.54)                      (4.70)
                                [0.64]
```

R^2 = 0.96   DW = 1.36

(5.10) Corn Stocks

```
COCOTE2 = 4945.430 - 10.099 COPTHEO/NARDDEO + 0.055 COSPRE2
            (3.09)    (3.47)                     (1.14)
                     [-0.77]                     [0.30]

        + 2144.240 D74 - 1698.670(D83 + D84)
            (5.99)          (6.02)

        + 653.991(D76 + D77)
           (2.47)
```

R^2 = 0.92   DW = 1.87

(5.11) Corn Imports

COSMNE2 = COUDTE2 + COCOTE2 - COSPRE2 - LAG(COCOTE2)

(5.12) Pork Production

```
POSPRE2 = 5936.120 + 2.161 NANPDE2/NARDDEO
            (4.42)   (6.18)
                     [0.54]

        - 7.682 BAPTHEO/NARDDEO + 1168.570 SHIFT80
         (3.26)                     (5.18)
                                   [-0.21]

        - 0.465 SMPFMEO/NARDDEO
         (0.71)
        [-0.01]
```

R^2 = 0.98   DW = 1.61

Table 5. Continued

(5.13) Poultry Production

```
PYSPRE2 = 1375.180 + 1.655 NANPDE2/NARDDEO
            (2.40) (11.23)
                    [0.90]

        - 4.465 COPTHEO/NARDDEO + 654.949 SHIFT80
         (4.76)                   (6.73)
        [-0.27]
```

R^2 = 0.99   DW = 2.09

(5.14) Soy Meal Price

```
SMPFMEO = 15.910 + 1.130 SOMPM * NIMEUEO
          (2.72) (20.29)
                  [0.90]
```

R^2 = 0.98   DW = 2.59

(5.15) Feed-Grain Imports

FGSMNE2 = BASMNE2 + COSMNE2 + OASMNE2

Endogenous Variables

BAAHHE2 = EC Barley Area Harvested, 1000 ha
BACOTE2 = EC Barley Ending Stocks, 1000 MT
BAUFEE2 = EC Barley Feed Use, 1000 MT
BAUHTE2 = EC Barley Food Use, 1000 MT
BASPRE2 = EC Barley Production, 1000 MT
BASMNE2 = EC Barley Imports, 1000 MT
COAHHE2 = EC Corn Area Harvested, 1000 ha
COCOTE2 = EC Corn Ending Stocks, 1000 MT
COUDTE2 = EC Corn Domestic Use, 1000 MT
COSPRE2 = EC Corn Production, 1000 MT
COSMNE2 = EC Corn Imports, 1000 MT
POSPRE2 = EC Pork Production, 1000 MT
PYSPRE2 = EC Poultry Production, 1000 MT
SMPFME2 = EC Soymeal Price, ECU/MT
FGSMNE2 = EC Feed-Grain Imports, 1000 MT

Table 5. Continued

Exogenous Variables

BAPIEO = EC Barley Intervention Price, ECU/MT
NARDDEO = EC GDP Deflator, 1980=1.0
OSAHHE2 = EC Oats Area Harvested, 1000 ha
BARESE2 = Deviation from trend production, 1000 MT
BAPTHEO = EC Barley Threshold Price, ECU/MT
NANPDE2 = EC GNP, Bil ECU
COPIEO = EC Corn Intervention Price, ECU/MT
COPTHEO = EC Corn Threshold Price, ECU/MT
WHUFEE2 = EC Wheat Feed Use, 1000 MT
D69 = 1 in 1969 and 0 otherwise
D71 = 1 in 1971 and 0 otherwise
D72 = 1 in 1972 and 0 otherwise
D73 = 1 in 1973 and 0 otherwise
D74 = 1 in 1974 and 0 otherwise
D75 = 1 in 1975 and 0 otherwise
D76 = 1 in 1976 and 0 otherwise
D77 = 1 in 1977 and 0 otherwise
D78 = 1 in 1978 and 0 otherwise
D80 = 1 in 1980 and 0 otherwise
D81 = 1 in 1981 and 0 otherwise
D82 = 1 in 1982 and 0 otherwise
D83 = 1 in 1983 and 0 otherwise
D84 = 1 in 1984 and 0 otherwise
D85 = 1 in 1985 and 0 otherwise
D7781 = 1 from 77-81, 0 otherwise
DEC9 = 1 after 1972, 0 otherwise
SHIFT80 = 1 after 1979, 0 otherwise
SHIFT81 = 1 after 1980, 0 otherwise

estimate of -0.77. Corn imports (5.11) are equal to total domestic demand minus domestic supply.

Poultry (5.12) and pork (5.13) production are also endogenized in the model because these variables are used as explanatory variables in the feed-demand equations. Economic Community soybean-meal price (5.14) is linked to the U.S. soybean-meal price. Elasticity in the price-linkage equation is 0.90. The EC feed-grain imports are described by identity (5.15) as a sum of the imports of barley, corn, and oats.

Thai Submodel

Because corn is the major feed grain produced and used in Thailand, only this grain is modeled for the country. The Thai component of the model is reported in Table 6. Corn area harvested (6.1) is estimated as a function of real corn farm price, real sorghum farm price, time trend, and dummy variables. Sorghum is a competing crop and thus its price enters the corn area-harvested equation. Own-price elasticity is 0.16 and cross-price elasticity -0.14. Corn production (6.2) is equal to corn area harvested times yield.

On the demand side, feed use and stock use are estimated. The explanatory variables in the corn feed-use equation (6.3) are real corn farm price, corn production, poultry production, and dummy variables. Own-price elasticity is -0.12. Corn ending stocks (6.4) are estimated as a function of beginning stocks, real corn farm price, and dummy variables. Own-price elasticity in stock demand is -1.45. Corn imports are described by (6.5) as domestic demand minus domestic supply.

Poultry production (6.6) is endogenously estimated as a function of real corn farm price and real income. Input-price elasticity in this equation is

Table 6. Structural parameter estimates of the Thai feed-grains submodel

(6.1) Corn Area Harvested

$$COAHHTH = \underset{(26.27)}{-1286998} + \underset{\substack{(1.58)\\ [0.16]}}{0.094}\ LAG(COPFMTH/NARDDTH)$$

$$- \underset{\substack{(0.75)\\ [-0.14]}}{0.086}\ LAG(SGPFMTH/NARDDTH) - \underset{(3.93)}{164.472}\ D778$$

$$- \underset{(1.78)}{67.928}(D76 + D77) + \underset{(22.26)}{169762}\ LOG(TREND) + \underset{(2.84)}{141.930}\ D71$$

$$+ \underset{(1.66)}{84.120}\ D74$$

R^2 0.99 DW = 2.07

(6.2) Corn Production

$$COSPRTH = COAHHTH * COYHHTH$$

(6.3) Corn Feed Use

$$COUFETH = \underset{(1.17)}{-160.041} - \underset{\substack{(0.44)\\ [-0.12]}}{0.027}\ COPFMTH/NARDDTH + \underset{\substack{(6.38)\\ [0.92]}}{3.350}\ PLSPRTH$$

$$+ \underset{\substack{(2.20)\\ [0.61]}}{0.110}\ COSPRTH - \underset{(2.82)}{139.223}\ D7073$$

$$+ \underset{(2.85)}{222.858}\ D80 - \underset{(1.28)}{116.460}\ D81$$

$R^2 = 0.98$ DW = 2.14

(6.4) Corn Stocks

$$COCOTTH = \underset{(3.24)}{268.164} + \underset{(0.69)}{0.117}\ LAG(COCOTTH)$$

$$- \underset{\substack{(2.49)\\ [-1.45]}}{0.082}\ COPFMTH/NARDDTH + \underset{(2.44)}{123.953}\ D70$$

Table 6. Continued

$$+ \underset{}{129.343}(D75 + D82) - \underset{(2.05)}{101.245}\ D73$$

$R^2 = 0.75$ DW = 1.39

(6.5) Corn Imports

COSMNTH = COUFETH + COUHTTH + COCOTTH - COSPRTH - LAG(COCOTTH)

(6.6) Poultry Production

$$PLSPRTH = \underset{(1.40)}{45.019} - \underset{\substack{(3.00)\\[-0.61]}}{0.036}\ COPFMTH/NARDDTH$$

$$+ \underset{\substack{(16.61)\\[2.09]}}{0.483}\ NANPDTH/NARDDTH - \underset{(5.21)}{60.914}\ D7679$$

$R^2 = 0.96$ DW = 2.17

(6.7) Corn Price-Linkage Equation

$$COPFMTH = \underset{\substack{(0.18)\\[1.00]}}{24.950} + \underset{(11.97)}{34.758}\ CORPF * NIMEUTH - \underset{(2.93)}{592.534}\ D73$$

$R^2 = 0.91$ DW = 1.18

(6.8) Sorghum Price Linkage

$$SGPFMTH = \underset{(2.91)}{127.000} + \underset{\substack{(27.75)\\[0.86]}}{0.833}\ COPFMTH - \underset{(3.38)}{222.369}\ D74$$

$$+ \underset{(13.47)}{683.487}(D81 + D82)$$

$R^2 = 0.99$ DW = 1.18

Table 6. Continued

Endogenous Variables

COAHHTH = Thailand, corn area harvested, 1000 ha
COCOTTH = Thailand, corn ending stocks, 1000 MT
COUFETH = Thailand, corn feed use, 1000 MT
COSPRTH = Thailand, corn production, 1000 MT
COSMNTH = Thailand, corn imports, 1000 MT
COPFMTH = Thailand, corn farm price, baht/MT
SGPFMTH = Thailand, sorghum farm price, baht/MT
PLSPRTH = Thailand, poultry production, 1000 MT

Exogenous Variables

NARDDTH = Thailand, GDP deflator, 1980 = 1.0
Trend = Time Trend
NANPDTH = Thailand, GDP, bil. baht
NIMEUTH = Thailand exchange rate, baht/U.S. $
D74 = 1 in 1974 and 0 otherwise
D75 = 1 in 1975 and 0 otherwise
D76 = 1 in 1976 and 0 otherwise
D77 = 1 in 1977 and 0 otherwise
D80 = 1 in 1980 and 0 otherwise
D81 = 1 in 1981 and 0 otherwise
D82 = 1 in 1982 and 0 otherwise
D7073 = 1 from 70-73, 0 otherwise
D7780 = 1 from 77-80, 0 otherwise
D7679 = 1 from 76-79, 0 otherwise

-0.61. Corn price (6.7) in Thailand is linked to the U.S. corn price with a price-transmission elasticity of 1.00. Sorghum price (6.8) is linked to the Thai corn farm price.

South African Submodel

Two major feed grains produced and consumed in South Africa are corn and sorghum. The estimated equations are presented in Table 7. Corn area harvested (7.1) is estimated as a function of real corn farm price, lag area harvested, and dummy variables. Supply-price elasticity is 0.04. Corn yield is exogenous in the model. Corn use (7.2) is estimated as a function of real income and dummy variables. The income coefficient is positive and significant. Income elasticity is estimated at 0.28. Corn stocks (7.4) are endogenized in the model. The explanatory variables in the stock equation are real corn farm price, corn production (7.3), and dummy variables. Real corn farm price, with an elasticity of -0.58, has a negative effect on stocks. Corn production has a strong positive effect on stocks. Corn farm price (7.5) is linked to U.S. corn farm price. Price-transmission elasticity is 1.26. The equilibrium identity is given in equation (7.6).

Sorghum area harvested (7.7) is a function of real sorghum farm price, wheat farm price, and dummy variables. Because wheat is a competing crop, wheat price is used in the sorghum area harvested. Own-price elasticity is 0.95 and cross-price elasticity is -0.82. Sorghum production (7.8) is described as acreage times yield. Sorghum use (7.9) is estimated as a function of real sorghum price and income. Demand-price elasticity is -0.30 and income elasticity is 0.26. Sorghum stocks (7.10) are estimated as a function of real sorghum price and production. Stock-price elasticity is -0.48. Sorghum

Table 7. Structural parameter estimates of the South African feed-grains submodel

(7.1) Corn Area Harvested

COAHHZA = 2031.360 + 0.512 LAG(COAHHZA) - 988.149 D72
(3.63) (3.81) (11.53)

+ 456.140 D73 - 266.049 SHIFT78 - 193.934(D68 + D69)
(3.51) (4.98) (2.51)

+ 0.883 LAG(COPFMZA/NARDDZA) * LAG(COYHHZA)
(2.45)
[0.04]

R^2 = 0.95 DW = 1.36

(7.2) Corn Use

COUDTZA = 6046.490 + 33.690 NANPDZA/NARDDZA
(7.81) (3.59)
[0.28]

+ 942.812 SHIFT73 + 676.624(D81 + D82)
(5.72) (4.29)

- 17.979 COPFMZA/NARDDZA
(3.11)
[-0.36]

R^2 = 0.96 DW = 1.17

(7.3) Corn Production

COSPRZA = COAHHZA * COYHHZA

(7.4) Corn Stocks

COCOTZA = 12.903 + 0.265 COSPRZA - 6.495 COPFMZA/NARDDZA
(0.02) (13.89) (1.06)
[-0.58]

+ 302.226 D68 + 1382.990 D80
(1.64) (6.02)

R^2 = 0.98 DW = 1.36

Table 7. Continued

(7.5) Corn Farm Price

```
COPFMZA = -15.642 + 59.187 CORPF * NIMEUZA
           (2.79)   (20.77)
                     [1.26]

        - 33.210 D84 - 37.339(D73 + D74 + D75)
          (2.63)        (6.06)
```

R^2 = 0.98 DW = 2.15

(7.6) Corn Imports

COSMNZA = COUDTZA + COCOTZA - COSPRZA - LAG(COCOTZA)

(7.7) Sorghum Area Harvested

```
SGAHHZA = 217.154 + 0.020 LAG(SGPFMZA/NARDDZA)
           (3.75)   (9.75)
                    [0.95]

        + 95.774 D71 + 126.415 D73 - 0.011 LAG(WHPFMZA/NARDDZA)
          (4.38)        (5.50)       (3.60)
                                    [-0.82]

        - 77.117 D78 + 50.125 D69
          (3.40)       (2.15)
```

R^2 = 0.93 DW = 1.79

(7.8) Sorghum Production

SGSPRZA = SGAHHZA * SGYHHZA

(7.9) Sorghum Use

```
SGUDTZA = 16.646 - 0.008 SGPFMZA/NARDDZA
          (0.15)   (2.32)
                  [-0.30]

        + 5.400 NANPDZA/NARDDZA + 0.193 SGSPRZA
         (3.50)                  (3.04)
         [0.95]                  [0.26]
```

Table 7. Continued

$$+ \ 133.729 \ D80$$
$$(2.92)$$

$R^2 = 0.88$ DW = 1.86

(7.10) Sorghum Stocks

$$SGCOTZA = \underset{(0.49)}{16.706} + \underset{\substack{(8.06) \\ [1.51]}}{0.316} \ SGSPRZA - \underset{(4.27)}{86.100}(D70 + D71)$$

$$- \underset{(3.85)}{151.896} \ D83 - \underset{\substack{(1.50) \\ [-0.48]}}{0.004} \ SGPFMZA/NARDDZA$$

$R^2 = 0.87$ DW = 2.51

(7.11) Sorghum Farm Price

$$SGPFMZA = \underset{(2.28)}{1050.390} + \underset{\substack{(12.70) \\ [0.83]}}{0.933} \ SGPFMU9 * NIMEUZA$$

$$- \underset{(4.09)}{2471.500} \ D74 + \underset{(5.65)}{3982.420} \ D82 + \underset{(2.83)}{1782.540} \ D69$$

$$- \underset{(2.79)}{1693.660} \ D72$$

$R^2 = 0.98$ DW = 2.04

(7.12) Sorghum Imports

SGSMNZA = SGUDTZA + SGCOTZA - SGSPRZA - LAG(SGCOTZA)

(7.13) Wheat Farm Price

$$WHPFMZA = \underset{(2.74)}{1827.880} + \underset{\substack{(12.90) \\ [0.85]}}{4729.080} \ WHEPF * NIMEUZA$$

Table 7. Continued

+ 5446.900(D80 + D81 + D82) − 5752.210(D73 + D74 + D75)
(5.90) (7.60)

$R^2 = 0.98$ DW = 2.34

(7.14) Feed-Grain Imports

FGSMNZA = COSMNZA + BASMNZA + OASMNZA

Endogenous Variables

COAHHZ = South Africa, Corn Area Harvested, 1000 ha
COSPRZA = South Africa, Corn Production, 1000 MT
COCOTZA = South Africa, Corn Stocks, 1000 MT
COUDTZA = South Africa, Corn Domestic Use, 1000 MT
COPFMZA = South Africa, Corn Farm Price, Rand/MT
COSMNZA = South Africa, Corn Imports, 1000 MT
SGAHHZA = Soth Africa, Sorghum Area Harvested, 1000 ha
SGSPRZA = South Africa, Sorghum Production, 1000 MT
SGUDTZA = South Africa, Sorghum Use, 1000 MT
SGCOTZA = South Africa, Sorghum Stocks, 1000 MT
SGPFMZA = South Africa, Sorghum Farm Price, Rand/MT
SGSMNZA = South Africa, Sorghum Imports, 1000 MT
WHPFMZA = South Africa, Wheat Farm Price, Rand/MT
FGSMNZA = South Africa, Feed-Grain Imports, 1000 MT

Exogenous Variables

COYHHZA = South Africa Corn Yield, MT/ha
NARDDZA = South Africa, GDP Deflator, 1980 = 1.0
NANPDZA = South Africa, GDP Bil Rand
NIMEUZA = U.S. Exchange Rate, Rand/U.S.$
D68 = 1 in 1968 and 0 Otherwise
D69 = 1 in 1969 and 0 Otherwise
D70 = 1 in 1970 and 0 Otherwise
D71 = 1 in 1971 and 0 Otherwise
D72 = 1 in 1972 and 0 Otherwise
D73 = 1 in 1973 and 0 Otherwise
D74 = 1 in 1974 and 0 Otherwise
D75 = 1 in 1975 and 0 Otherwise
D78 = 1 in 1978 and 0 Otherwise
D80 = 1 in 1980 and 0 Otherwise
D81 = 1 in 1981 and 0 Otherwise
D82 = 1 in 1982 and 0 Otherwise
D83 = 1 in 1983 and 0 Otherwise
D84 = 1 in 1984 and 0 Otherwise
SHIFT73 = One after 1972, 0 otherwise
SHIFT78 = One after 1977, 0 otherwise

production is significant, with a positive effect on stocks. Sorghum farm price (7.11) is linked to U.S. farm price, with a price transmission elasticity of 0.83. Sorghum imports (7.12) are described as domestic demand minus domestic supply. Wheat farm price (7.13) is linked to U.S. wheat farm price. Price-transmission elasticity is 0.85. Feed-grain imports (7.14) are defined as the sum of imports of corn, barley, and sorghum imports.

Soviet Submodel

Until 1970 the Soviet Union was a significant net exporter of feed grains. Since then, because of unstable weather and the economic policies, the Soviet Union has become a major net importer of feed grains. The major feed grains grown traditionally in the Soviet Union are oats and barley; in the past two decades, however, corn has been introduced into Soviet agriculture. The grain embargo of 1980 significantly changed Soviet policies toward grain imports. Those changes included changes in the cropping pattern; i.e., deemphasizing crops abundant in the world market, such as wheat, and emphasizing less abundant crops such as corn.

The estimated equations are presented in Table 8. On the supply side, feed-grain production is endogenously estimated. The independent variables used in production (8.1) are feed-grain acreage harvested, feed-grain domestic use, and a shift variable for the period 1970 and 1971. Acreage harvested is described by identity (8.2) as production divided by yield.

Feed grains are used largely for feed, and their use is constrained by production. Feed-grain domestic use (8.3) is estimated as a function of U.S. corn price deflated by light Arabian crude-oil price, current production, and livestock inventories. The United States corn price is used because a consistent price series is unavailable. Own-price elasticity is estimated at -0.07. Both livestock inventories and production have positive effects on the domestic use of feed grains. Feed-grain ending stocks (8.4) are endogenously estimated as a function of lag inventories, production deviation from its trend, and dummy variables for 1977 and 1984. Livestock inventories (8.5) are estimated as a function of income and lag livestock inventories. Equation (8.6) equates the net import demand of feed grain to domestic demand minus supply.

Chinese Submodel

As in the Soviet submodel, in the Chinese submodel total feed grains are modeled (see Table 9). On the supply side, area is endogenously estimated. The explanatory variables used in the feed-grain area harvested equation (9.1) are feed-grain yield, lagged acreage, and dummy variables. Total production (9.2) is given by the identity acreage times yield. Feed-grain use in China is constrained by production. Thus, feed-grain domestic use (9.3) is estimated as a function of production, hog inventories, and a shift variable for the period 1978-83. Income and lag hog inventories enter the hog inventories equation (9.4) as explanatory variables. Feed-grain net imports are described by identity (9.5) as domestic use minus production.

Eastern European Submodel

Production is endogenously estimated in the Eastern European submodel, as in the Soviet submodel (see Table 10). The variables explaining feed-grain production (10.1) in Eastern Europe are yield, lagged domestic use, and two dummy variables for 1975 and 1979.

Table 8. Structural parameter estimates of the Soviet feed-grains submodel

(8.1) Feed-Grain Production

$$FGSPRSU = \underset{(-4.96)}{-43847.900} + \underset{(10.59)}{50542.900}\ FGYHHSU$$

$$+ \underset{(7.62)}{0.446}\ LAG(FGUDTSU) - \underset{(-3.16)}{11050.200}(D70 + D71)$$

$R^2 = 0.93$ DW(1) = 1.57 DW(2) = 2.04

(8.2) Feed-Grain Area Harvested

FGAHHSU = FGSPRSU/FGYHHSU

(8.3) Feed-Grain Domestic Uses

$$FGUDTSU = \underset{(-0.87)}{-26713} - \underset{\substack{(-2.27)\\ [-0.07]}}{16961.100}(CORPF/LTARCRUD)$$

$$+ \underset{(2.47)}{613.463}\ CECOTSU + \underset{(10.12)}{0.635}\ FGSPRSU$$

$$- \underset{(-3.15)}{7345.85}(D82 + D83)$$

$R^2 = 0.98$ DW(1) = 2.32 DW(2) = 1.99

(8.4) Feed-Grain Ending Stocks

$$FGCOTSU = \underset{(1.69)}{962.328} + \underset{(5.17)}{0.071}\ FGPRESSU$$

$$+ \underset{(5.71)}{0.787}\ LAG(FGOTSU) - \underset{(-5.11)}{4242.930}\ D77$$

$$+ \underset{(2.78)}{2118.360}\ D84$$

$R^2 = 0.83$ DW(1) = 1.55 DW(2) = 1.97

Table 8. Continued

(8.5) Animal Inventories

$$\underset{}{CECOTSU} = \underset{(5.42)}{34.586} + \underset{\substack{(5.52)\\ [0.26]}}{0.023}\ NANPGSU + \underset{(4.14)}{0.430}\ LAG(CECOTSU)$$

$R^2 = 0.99$ DW(1) = 1.89 DW(2) = 2.53

(8.6) Feed-Grain Net Imports

FGSMNSU = FGUDTSU + FGCOTSU - FGSPRSU - LAG(FGCOTSU)

Endogenous Variables

FGAHHSU = Soviet Union, total feed-grain area harvested, 1000 ha
FGYHHSU = Soviet Union, feed-grain average yield, MT/hg
FGSPRSU = Soviet Union, feed-grain production, 1000 MT
FDUDTSU = Soviet Union, feed-grain domestic use, 1000 MT
FGCOTSU = Soviet Union, feed-grain ending stocks, 1000 MT
CECOTSU = Soviet Union, ending cattle inventories, mil head
FGSMNSU = Soviet Union, net imports of feed grains, 1000 MT

Exogenous Variables

TREND = Time Trend
LTARCRUD = Light Arabian crude oil price (U.S. $/bbl.)
NANPGSU = Soviet Union, real GDP, 1995 SUS
FGPRESSU = Deviation of actual production from trend production
D70 = 1 in 1970 and 0 Otherwise
D71 = 1 in 1971 and 0 Otherwise
D77 = 1 in 1977 and 0 Otherwise
D82 = 1 in 1982 and 0 Otherwise
D83 = 1 in 1983 and 0 Otherwise

Table 9. Structural parameter estimates of the Chinese feed-grains submodel

(9.1) Feed-Grain Area Harvested

$$FGAHHCN = \underset{(5.03)}{13512.500} + \underset{(2.44)}{873.488}\ FGYHHCN$$

$$+ \underset{(1.67)}{0.264}\ LAG(FGAHHCN) + \underset{(4.58)}{2477.420}\ D75$$

$$+ \underset{(5.35)}{3423.170}(D76 + D77 + D78 + D79 + D80)$$

$$- \underset{(-2.14)}{1172.690}\ D85 + \underset{(2.33)}{1832.590}\ D81$$

$R^2 = 0.97$ DW(1) = 1.49   DW(2) = 1.61

(9.2) Feed-Grain Production

FGSPRCN = FGAHHCN * FGYHHCN

(9.3) Feed-Grain Domestic Uses

$$FGUDTCN = \underset{(1.56)}{1943.290} + \underset{(37.65)}{0.854}\ FGSPRCN$$

$$+ \underset{(2.34)}{16.716}\ HOCOTCN + \underset{(8.72)}{4800.920}\ D7883$$

$R^2 = 0.998$ DW(1) = 1.58   DW(2) = 2.13

(9.4) Hog Inventories

$$HOCOTCN = \underset{(4.84)}{107.554} + \underset{(3.07)}{0.086}\ NANYNCN$$

$$+ \underset{(2.64)}{0.352}\ LAG(HOCOTCN) + \underset{(4.33)}{50.817}\ SHIFT71$$

$$+ \underset{(2.21)}{25.160}\ D79$$

$R^2 = 0.96$ DW(1) = 1.76   DW(2) = 2.26

Table 9. Continued

(9.5) Feed-Grain Net Imports

FGSMNCN = FGUDTCN - FGSPRCN

Endogenous Variables

FRAHHCN = China, feed-grain area harvested, 1000 MT
FGYHHCN = China, feed-grain average yield, MT/ha
FGSPRCN = China, feed-grain production, 1000 MT
FGUDTCN = China, feed-grain domestic use, 1000 MT
HOCOTCN = China, hog ending inventories, mil head
FGSMNCN = China, net imports of feed grains, 1000 MT

Exogenous variables

NANYNCN = China, net material product produced, bil 1980 yuan
D75 = 1 in 1975 and 0 Otherwise
D76 = 1 in 1976 and 0 Otherwise
D77 = 1 in 1977 and 0 Otherwise
D78 = 1 in 1978 and 0 Otherwise
D79 = 1 in 1979 and 0 Otherwise
D80 = 1 in 1980 and 0 Otherwise
D7883 = 1 from 78-83, 0 Otherwise
SHIFT71 = 1 after 1970, 0 Otherwise

Table 10. Structural parameter estimates of the Eastern European feed-grains submodel

(10.1) Feed-Grain Production

$$FGSPRE8 = \underset{(1.72)}{2638.060} + \underset{(10.86)}{10085.100}\ FGYHHE8 + \underset{(3.67)}{0.211}\ LAG(FGUDTE8) + \underset{(2.92)}{3315.710}\ D75 + \underset{(2.30)}{2713.390}\ D79$$

$R^2 = 0.98$ DW(1) = 2.16 DW(2) = 2.47

(10.2) Feed-Grain Uses

$$FGUDTE8 = \underset{(-2.21)}{-6599.810} + \underset{(4.49)}{0.741}\ FGSPRE8 + \underset{(3.95)}{386.514}\ HOCOTE8 - \underset{(-4.73)}{5549.630}\ SHIFT81 + \underset{(1.56)}{2709.450}\ D85$$

$R^2 = 0.98$ DW(1) = 1.46 DW(2) = 1.35

(10.3) Feed-Grain Ending Stocks

$$FGCCOTE8 = \underset{(-5.84)}{-2150.610} + \underset{(9.06)}{0.092}\ FGSPRE8 + \underset{(1.15)}{0.097}\ LAG(FGCOTE8) + \underset{(3.45)}{763.352}\ D69 - \underset{(-4.94)}{687.101}(D72 + D73 + D74) + \underset{(4.11)}{717.713}(D84 + D85)$$

$R^2 = 0.97$ DW(1) = 2.02 DW(2) = 2.84

(10.4) Hog Inventories

$$HOCOTE8 = \underset{(0.52)}{1.082} + \underset{\substack{(2.25)\\ [0.24]}}{16.519}\ NARPDIE8$$

Table 10. Continued

$$+ \underset{(2.67)}{0.413}\ LAG(HOCOTE8) + \underset{(2.62)}{0.0004}\ LAG(FGUDTE8)$$

$$+ \underset{(3.55)}{5.762}\ D75 + \underset{(2.49)}{4.096}\ D77 - \underset{(-2.09)}{4.281}\ D85$$

$R^2 = 0.99$ DW(1) = 1.80 DW(2) = 2.64

(10.5) Feed-Grain Net Imports

FGSMNE8 = FGUDTE8 + FGCOTE8 - FGSPRE8 - LAG(FGCOTE8)

Endogenous Variables

FGYHHE8 = Eastern Europe, Expected Average Yields, MT/ha
FGSPRE8 = Eastern Europe, Expected Feed-Grain Production, 1000 MT
FGUDTE8 = Eastern Europe, Domestic Total Feed-Grain Uses, 1000 MT
FGCOTE8 = Eastern Europe, Ending Feed-Grain Stocks, 1000 MT
HOCOTE8 = Eastern Europe, Ending Hog Inventories, mil head
FGSMNE8 = Eastern Europe, Net Imports of Feed Grains, 1000 MT

Exogenous Variables

NARPDIE8 = Eastern Europe; Real GDP Index; 1980 = 1.0
D69 = 1 in 1969 and 0 Otherwise
D72 = 1 in 1972 and 0 Otherwise
D73 = 1 in 1973 and 0 Otherwise
D74 = 1 in 1974 and 0 Otherwise
D75 = 1 in 1975 and 0 Otherwise
D79 = 1 in 1979 and 0 Otherwise
D84 = 1 in 1984 and 0 Otherwise
D85 = 1 in 1985 and 0 Otherwise
SHIFT81 = 1 after 1980, 0 Otherwise

On the demand side, domestic use and stocks are endogenously estimated. Production and hog inventories enter into the feed-grain use equation (10.2) as explanatory variables. Because feed grains are used in hog feeding, hog inventories are included in the domestic use equation. Stocks are estimated as a function of production, lag inventories, and dummy variables. Hog inventories (10.4) are also endogenously estimated. The independent variables in the hog inventories equation are income, domestic feed-grain use, lag inventories, and dummy variables. Feed-grain net imports are described by the equilibrium identity (10.5) as domestic demand minus domestic supply.

Japanese Submodel

Japan imports corn, barley, and sorghum. These three feed grains are modeled in the Japanese submodel, illustrated in Table 11.

Corn is the most consumed grain in Japan, yet production of the crop is almost nonexistent. The low production levels of corn are exogenous in the model. Corn utilization in Japan has expanded from less than 2 million metric tons in 1960/61 to more than 17 mmt in 1988/89. This growth has paralleled growth in livestock production. Corn utilization (11.1) depends upon the real corn-import unit value, hog numbers, poultry production, sorghum use, and rice feed use. The real corn-import unit value has a negative coefficient but is not statistically significant. Estimated elasticity (-0.11) falls between the -0.07 value determined by Liu (1985) and the -0.50 value determined by Sullivan et al. (1989). Neither hog numbers nor poultry production is significant, although both have the expected positive signs. This lack of statistical significance could be due to multicollinearity between the two variables. Both hog and poultry production increased steadily over the estimation period. Sorghum is

Table 11. Structural parameter estimates of the Japanese feed-grains submodel

(11.1) Total Corn Use

$$COUDTJP = \underset{(-0.12)}{-538.000} - \underset{\substack{(-1.00)\\ [-0.11]}}{0.0265}\ COVIMJP/NARDDJP$$

$$+ \underset{\substack{(1.85)\\ [1.42]}}{1606.720}\ HOCOTJP$$

$$- \underset{\substack{(-6.21)\\ [-0.39]}}{0.9335}\ SGUDTJP - \underset{\substack{(-3.37)\\ [-0.07]}}{1.0536}\ RIUFEJP$$

$$+ \underset{\substack{(0.52)\\ [0.20]}}{2.2860}\ PYSPRJP$$

$R^2 = 0.99$ DW = 2.41

(11.2) Corn Ending Stocks

$$COCOTJP = \underset{(1.63)}{619.000} + \underset{\substack{(1.92)\\ [0.44]}}{0.4741}\ LAG(COCOTJP)$$

$$- \underset{\substack{(-1.26)\\ [-0.40]}}{0.0085}\ COVIMJP/NARDDJP$$

$$+ \underset{(1.69)}{300.130}\ SHIFT73$$

$R^2 = 0.83$ DW = 2.84

(11.3) Corn Import Value

$$COVIMJP = \underset{(2.66)}{4266.37} + \underset{\substack{(16.77)\\ [0.87]}}{1.0252}\ COPOBU9 * NIMEUJP$$

$$- \underset{(-4.91)}{8615.57}\ D73$$

$R^2 = 0.95$ DW = 1.78

Table 11. Continued

(11.4) Corn Net Import

COSMNJP = COCOTJP + COUDTJP - COSPRJP - LAG(COCOTJP)

(11.5) Barley Area Harvested

BAAHHJP = -70.2894 + 0.8950 LAG(BAAHHJP)
(-2.90) (22.29)
[0.97]

+ 0.0006 BAPGPJP/NARDDJP
(3.65)
[0.50]

R^2 = 0.98 DW = 1.17

(11.6) Barley Production

BASPRJP = BAAHHJP * BAYHHJP

(11.7) Barley Imports

BASMNJP = 781.960 + 0.0064 NANPDJP/NARDDJP
(1.30) (5.61)
[1.02]

- 0.0272 BAPRSJP/NARDDJP
(-5.59)
[-1.09]

+ 0.0140 COVIMJP/NARDDJP + 559.3300 D7677
(2.24) (6.02)
[0.43]

R^2 = 0.93 DW = 1.80

(11.8) Barley Stock

BACOTJP = -79.3835 + 0.5373 LAG(BACOTJP)
(-0.81) (2.97)
[0.50]

Table 11. Continued

```
              + 0.2412 BASMNJP
                (2.53)
                [0.67]
```

R^2 = 0.73   DW = 1.93

(11.9) Barley Feed Use

```
BAUFEJP = 355.520 - 0.0065 BAPRSJP/NARDDJP
            (1.01)  (-1.97)
                    [-0.29]

              + 0.0081 COVIMJP/NARDDJP
                (1.98)
                [0.28]

              + 0.9803 PYSPRJP
                (8.47)
                [0.71]
```

R^2 = 0.95   DW = 1.53

(11.10) Barley Equilibrium Condition

BAUHTJP = BASPRJP + BASMNJP + LAG(BACOTJP) - BAUFEJP - BACOTJP

(11.11) Sorghum Imports

```
SGSMNJP = 232.710 - 0.2161 SGPOBU9 * NIMEUJP/NARDDJP
            (0.20)  (-1.88)
                    [-1.78]

              + 0.2161 COPOBU9 * NIMEUJP/NARDDJP
                (2.17)
                [1.87]

              + 407.200 HOCOTJP
                  (5.15)
                  [0.87]

              + 869.670 D7679 - 1232.300 D8083
                  (4.24)          (-5.41)
```

R^2 = 0.94   DW = 2.20

Table 11. Continued

(11.12) Sorghum Stocks

SGCOTJP = -57.1494 + 0.5308 LAG(SGCOTJP)
(-0.61) (2.74)
[0.52]

+ 0.0561 SGSMNJP
(2.02)
[0.65]

R^2 = 0.62 DW = 2.01

(11.13) Sorghum Equilibrium Condition

SGUDTJP = SGSMNJP + LAG(SGCOTJP) - SGCOTJP

(11.14) Hog Inventories

HOCOTJP = -22.6137 + 0.5071 LAG(HOCOTJP)
(-1.52) (2.78)
[0.49]

- 0.00004 COVIMJP/NARDDJP
(-2.75)
[-0.17]

+ 2.3213 LOG(NANPDJP/NARDDJP)
(1.76)

(11.15) Poultry Production

PYSPRJP = -2520.170 + 0.7362 LAG(PYSPRJP)
(-1.23) (5.71)
[0.68]

- 0.0035 COVIMJP/NARDDJP
(-2.79)
[-0.16]

+ 240.05 LOG(NANPJP/NARDDJP)
(1.38)

Table 11. Continued

(11.16) Feed-Grain Imports

FGSMNJP = COSMNJP + BASMNJP + OASMNJP

Endogenous Variables

BAAHHJP: Japan, barley area harvested, 1000 hectares
BACOTJP: Japan, barley ending stocks, 1000 metric tons
BASMNJP: Japan, barley net imports, 1000 metric tons
BASPRJP: Japan, barley production, 1000 metric tons
BAUFEJP: Japan, barley feed use, 1000 metric tons
BAUHTJP: Japan, barley food use, 1000 metric tons
COCOTJP: Japan, corn ending stocks, 1000 metric tons
COVIMJP: Japan, corn import unit value, Yen/metric ton
COSMNJP: Japan, corn net imports, 1000 metric tons
COUDTJP: Japan, corn domestic use, 1000 metric tons
HOCOTJP: Japan, hog inventories, January 1, million head
PYSPRJP: Japan, poultry production, cal. year, 1000 metric tons
SGCOTJP: Japan, sorghum ending stocks, 1000 metric tons
SGSMNJP: Japan, sorghum net imports, 1000 metric tons
SGUDTJP: Japan, sorghum domestic use, 1000 metric tons

Exogenous Variables

BAPGPJP: Japan, barley government purchase price, Yen/metric ton
BAPRSJP: Japan, barley resale price, Yen/metric ton
BAYHHJP: Japan, barley yield per hectare, metric tons
COPOBU9: U.S., corn gulf port price, $/metric ton
COSPRJP: Japan, corn production, 1000 metric tons
D73: Dummy variable, 1 in 1973, 0 otherwise
D7677: Dummy variable, 1 in 1976 and 1977, 0 otherwise
D7679: Shift variable, 1 from 1976-79, 0 otherwise
D8083: Shift variable, 1 from 1980-83, 0 otherwise
DOPOPJP: Japan, population, million
NANPDJP: Japan, gross domestic product, billion Yen
NARDDJP: Japan, gross domestic product deflator, 1980=100
NIMEUJP: Japan, bilateral exchange rate, period average, Yen/$
RIUFEJP: Japan, rice feed use, 1000 metric tons
SGPOBU9: U.S., sorghum gulf port price, $/metric ton
SHIFT73: Shift variable, 1 beginning in 1973, 0 otherwise
SHIFT74: Shift variable, 1 beginning in 1974, 0 otherwise
SHIFT77: Shift variable, 1 beginning in 1977, 0 otherwise
SHIFT79: Shift variable, 1 beginning in 1979, 0 otherwise
SHIFT80: Shift variable, 1 beginning in 1980, 0 otherwise

used as a feed in Japan, and here it is estimated that the crop has a nearly one-for-one substitution effect with corn and is highly significant. Rice feeds also have a substitution effect with corn. Although only a small amount of rice is fed livestock each year, the coefficient is negative and significant.

Unlike rice, wheat, and barley, which in Japan are insulated from world price fluctuations, corn enters the country freely. Because of this, corn ending stocks are influenced by world price. Food security is still a determining factor in the level of stocks held, however. With corn, stocks are a combination of stocks held by formula feed processors and agricultural cooperatives, and those held by the Formula Feed Supply Stabilization Organization under a government-subsidized program.

The corn ending stocks equation (11.2) contains beginning stocks, real corn-import unit value, and a shift variable beginning in 1973/74. The real corn-import unit value has the expected negative coefficient but is not significant. The shift variable reflects a combination of occurrences which have led to increased stock levels in Japan. One of them was the reduction in rice stocks in the early 1970s due to increased rice feeding. This reduction not only resulted in increased competition for feed grains, but also left idle a large amount of stockholding capacity. These effects would normally have been fairly short lived, but they were followed by policies aimed at increasing stocks beginning in 1976.

The corn-import unit value equation (11.3) is the price linkage between the U.S. Gulf-port price for corn and the average value of corn imported into Japan. It also contains a dummy variable for 1973--the first oil embargo. The Gulf-port price in Yen is highly significant, and the elasticity indicates a high degree of price transmission. The dummy variable for 1973/74 is negative, implying that most corn purchases made by Japanese importers were made at lower than the season average price. This variable is also significant. The Japanese corn market is cleared through the net import identity (11.4).

There are four behavioral equations and two identities modeled for the barley component of the Japanese feed-grains submodel. Barley area harvested (11.5) is a function of the previous year area and of the real government purchase price of barley. Barley policies are similar to those for wheat, with the purchase price being set well above the world price to support barley producers. Barley purchase price is set by the government before planting. Because of this, current purchase price is used in the equation. The coefficient of real purchase price has a positive sign and is significant. Supply elasticity (0.50) is similar to estimates of 0.55 by Sullivan et al. (1989) and of 0.6 by Tyers (1984) for "other coarse grains." Barley production (11.6) is the product of barley area harvested and barley yield.

Barley imports are handled by the government food agency, as are imports of wheat, thereby maintaining domestic policy prices. The barley net imports equation (11.7) contains real income, real barley resale price, real corn-import unit value, and a shifter for 1976-77. Real barley resale price has the anticipated sign and is highly significant. Estimated elasticity is high compared to that determined by other studies, but it is for barley imports, not for total consumption. Tyers estimated the total coarse grain (including corn) demand elasticity to be -0.6. The corn-import unit value was used because corn enters Japan freely, and this price should be reflected in the price paid by feed producers. The coefficient is positive, indicating that corn is a competing feed. The cross-price elasticity (0.43) is higher than the value of 0.20 found in Sullivan et al., but it is still fairly low.

Most barley imported into Japan is used for livestock feed. As incomes increase in Japan, meat and livestock products consumption is also increasing, which implies a positive and fairly substantial effect on barley imports. The coefficient for real income is positive and significant at the 5-percent level. Income elasticity is similar to the estimate of 0.96 in Tyers for total coarse grains.

The shifter for 1976/77 takes into account the stock-building programs begun in 1976. For barley, there was a two-year buildup of stocks. This variable has the expected sign and is highly significant.

The Japanese government has a buffer-stocks policy for feed as well as for food grains. The specification for the barley-stocks equation (11.8) is similar to that for wheat stocks. Beginning stocks represent an adjustment toward a desired level of buffer stocks, whereas net imports represent transaction demand. Both have the expected positive signs and are significant at the 5-percent level.

Barley utilization is subdivided into feed and food uses. Feed use (11.9) is dependent upon barley resale price, corn-import unit values, and livestock numbers. The real barley resale price has a negative coefficient as expected, but it is not significant. Corn is a substitute in feed rations for barley. The corn-import unit value is used to capture these substitution effects. The coefficient has the expected positive sign but is not significant at the 5-percent level. Barley is fed to poultry in Japan; poultry production is used in this equation and is highly significant with the anticipated positive sign.

Barley food use is the market clearing identity. Food use is the residual of government managed supply and stock changes, and feed use is the residual of the livestock industry.

There is no sorghum production in Japan, so all demand for this grain must be met by imports. The sorghum component consists of two behavioral equations and of one identity.

Because Japan does not produce sorghum, imports of this grain reflect the country's internal demand conditions. Sorghum imports (11.11) are a function of both sorghum price on the world market and corn price on the world market because there are no import barriers against these two grains entering Japan. Imports are also affected by hog inventories. During the period 1976-79, sorghum imports were well above normal levels, corresponding to a period of rapid increase in livestock production. During the early 1980s, livestock production slowed as markedly as it had increased in the late 1970s, and sorghum imports declined. The real sorghum Gulf-port price in Yen, per metric ton, is used as the world price affecting Japanese imports. The real corn Gulf-port price in Yen, per metric ton, is also used as the world price of the competing imported feed grain. Both variables have the expected sign, but neither is significant at the 5-percent level. The most significant variable in the import equation is hog inventories. The estimated elasticity is only slightly less than unity, indicating that sorghum use in Japan closely follows hog production. The two shift variables are significant and represent the sharper-than-normal increases and decreases in livestock production over their respective periods.

As with other grains, there is a minimum level of buffer stocks of sorghum which the government subsidizes. Formula-feed processors and cooperatives hold these stocks, as they do corn, in addition to their private reserves. The specification for the sorghum ending stocks equation (11.12) includes beginning stocks and sorghum imports. As with other grain stocks, beginning stocks and imports represent an adjustment toward a desired level of stocks and transaction demands, respectively. Both variables have the expected positive signs and are significant.

The Japanese sorghum market is cleared through the sorghum-use identity (11.13). Sorghum use is equal to sorghum imports less the annual change in stock level.

The simple livestock equations in this submodel are not meant to capture cycles, but merely to mimic long-term growth rates in livestock production and to reflect income and certain input effects.

The hog inventory equation (11.14) consists of a one-year lag of the dependent variable, the real corn-import unit value, and the log of real income. The lagged dependent variable implies that current hog numbers depend, in part, upon the previous year's hog numbers. This variable has a positive sign and is significant at the 5-percent level. The corn-import unit value represents the effects of input prices. It is expected that, as inputs become more expensive, fewer animals will be kept. The sign on this variable is negative and significant. The estimated elasticity (-0.17) is slightly above the very low estimate of -0.07 determined by Sullivan et al. The log of real income is positive, as expected.

The poultry production equation (11.15) is specified similarly to the hog inventory equation. The lagged dependent variable is the most significant variable in the equation. The corn-import unit value is negative and significant, and estimated elasticity is the same as the -0.16 found in Sullivan et al. The log of real income is positive but not significant at the 5-percent level.

Feed-grain imports are described by identity (11.16) as the sum of imports of corn, barley, and oats.

Brazilian Submodel

The Brazilian component of the feed-grains model is reported in Table 12. For Brazil, three feed grains--corn, barley, and oats--are combined and modeled as one commodity. Feed-grain area harvested (12.1) is estimated as a function of real barley price, wheat price, soybean price, lagged acreage, and dummy variables. Because wheat and soybeans are competing crops, the prices of these two crops enter the area harvested equation. Own-price supply elasticity is 0.29, and cross-price elasticities are -0.28 (wheat) and -0.16 (soybean). Feed-grain yield is exogenous in the model. Feed-grain production (12.2) is described by the identity as acreage times yield.

On the demand side, only domestic use (12.3) is estimated. The explanatory variables in the domestic use equation are real income, real corn price, and dummy variables. Own-price elasticity is -0.13 and income elasticity is 0.49. Feed-grain imports are described by the identity as domestic use minus domestic supply. Three price-linkage equations for corn, wheat, and soybeans are estimated. Price-transmission elasticities for corn, wheat, and soybeans are 0.52, 0.1, and 0.72, respectively.

Mexican Submodel

For Mexico, supply and use equations for feed grains (corn, barley, and oats) and sorghum are estimated. The estimated equations are presented in Table

Table 12. Structural parameter estimates of the Brazilian feed-grains submodel

(12.1) Feed-Grain Area Harvested

```
FGAHHBR = 8410.300 + 0.259 LAG(FGAHHBR)
            (4.03)   (2.65)

        + 0.554 LAG(COPFMRBR) - 0.274 LAG(WHPFMRBR)
         (4.14)                  (3.68)
         [0.29]                 [-0.28]

        - 0.018 LAG(SBPFMRBR) + 1687.950 DM85
         (0.44)                     (3.84)
        [-0.16]

        + 1255.330 DM81 - 1551.800 DM72
            (3.11)           (4.09)
```

R^2 = 0.95   DW = 1.98

(12.2) Feed-Grain Production

FGSPRBR = FGAHHBR * FGYHHBR

(12.3) Feed-Grain Use

```
FGUDTBR = 9790.180 + 0.884 NANPDBR/NARDDBR
            (8.48)  (11.00)
                     [0.49]

        - 0.377 COPFMRBR + 3212.420 DM79S
         (1.81)               (6.59)
        [-0.13]

        + 3007.840 DM71
            (4.27)
```

R^2 = 0.98   DW = 2.37

(12.4) Feed-Grain Imports

FGSMNBR = FGUDTBR + FGCOTBR - FGSPRBR - LAG(FGCOTBR)

Table 12. Continued

(12.5) Corn Farm Price

```
COPFMRBR = 2304.480 + 20416.400 COPFMU9 * NIMEUBR/NARDDBR
             (5.44)       (7.97)
                          [0.52]

           + 1525.310(D77 + D78 + D79) + 2217.080 D82
             (7.02)                       (7.22)

           + 1381.720(D71 + D72)
```

R^2 = 0.91 DW = 1.44

(12.6) Wheat Farm Price

```
WHPFMRBR = 5336.550 + 0.502 LAG(WHPFMRBR)

           + 5973.040(WHEPF * NIMEUBR)/NARDDBR

           - 2355.990 LAG(WHSPRBR/WHUDTBR) + 2386.490 D84

           - 1976.840(D78 + D79)
```

(12.7) Soybean Farm Price

```
SBPFMRBR = 2286.600 + 0.544 SBPFMU * 36.744 NIMEUBR/NARDDBR
             (1.74)   (5.65)
                      [0.72]

           * 1000 + 7231.790 DM72 + 5306.360 DM75
                      (7.96)          (5.96)

           + 2970.680 DM82 - 2803.060 DM66
             (3.35)          (3.08)
```

R^2 = 0.92 DW = 1.98

Endogenous Variables

FGAHHBR = Brazil, feed-grains area harvested, 1000 ha
FGSPRBR = Brazil, feed-grains production, 1000 MT
FGUDTBR = Brazil, feed-grains domestic use, 1000 MT
FGSMMBR = Brazil, feed-grains imports, 1000 MT
COPFMRBR = Brazil, real corn price, 1980 C2/MT

Table 12. Continued

WHPFMRBR = Brazil, real wheat price, 1980 C2/MT
SBPFMRBR = Brazil, real soybean price, 1980 C2/MT

Exogenous Variables

FGCOTBR = Brazil, feed-grains stocks, 1000 MT
FGYHHBR = Brazil, feed-grains yield, MT/ha
NANPDBR = Brazil, GDP, mil C2
NARDDBR = GDP deplator, 1980 = 1.0
NIMEUBR = Brazil, exchange rate, 1980 C2/$
DM66 = 1 in 66, 0 Otherwise
DM71 = 1 in 71, 0 Otherwise
DM72 = 1 in 72, 0 Otherwise
DM75 = 1 in 75, 0 Otherwise
DM77 = 1 in 77, 0 Otherwise
DM78 = 1 in 78, 0 Otherwise
DM79 = 1 in 79, 0 Otherwise
DM81 = 1 in 81, 0 Otherwise
DM82 = 1 in 82, 0 Otherwise
DM84 = 1 in 84, 0 Otherwise
DM85 = 1 in 85, 0 Otherwise

Table 13. Structural parameter estimates of the Mexican feed-grains submodel

(13.1) Feed-Grain Production

FGSPRMX = -8433.290 + 9415.450 FGYHHMX + 0.748 LAG(FGAHHMX)
(4.60) (15.26) (4.60)

- 1921.540(D82 + D84) + 0.198 LAG(COPFMMXR)
(6.38) (1.41)
[0.08]

R^2 = 0.95 DW = 2.33

(13.2) Feed-Grain Area Harvested

FGAHHMX = FGSPRMX/FGYHHMX

(13.3) Feed-Grain Domestic Use

FGUDTMX = 8866.240 - 2536.480 COPFMMXR/WHPFMMXR
(3.96) (1.09)
[-0.28]

+ 7.042 POSPRMX + 1777.270 D77 + 1952.300(D80 + D81)
(6.55) (2.05) (3.23)

R^2 = 0.90 DW = 2.04

(13.4) Feed-Grain Stocks

FGCOTMX = -1360.420 + 0.215 LAG(FGCOTMX) + 0.197 FGSPRMX
(3.94) (2.21) (4.97)
[2.86]

+ 1233.340 D80 - 623.537 D78 - 473.300 D84
(5.81) (2.97) (2.27)

R^2 = 0.90 DW = 1.93

(13.5) Corn Farm Price

COPFMMXR = 2536.360 + 0.315 LAG(COPFMMXR) + 8.094 COPFMU9
(2.61) (1.87) (1.49)
[0.16]

Table 13. Continued

$$* \; NIMEUMX/NARDDMX - \underset{\substack{(2.51)\\ [-0.08]}}{1180.260} \; (NARDDMX)$$

$$- \; LAG(NARDDMX)/LAG(NARDDMX) - \underset{(2.40)}{601.006}(D72 + D73)$$

$$+ \underset{(2.03)}{668.376} \; D67 - \underset{(2.31)}{731.143} \; D81$$

$R^2 = 0.88 \qquad DW = 2.41$

(13.6) Wheat Farm Price

$$WHPFMMXR = \underset{(1.70)}{945.483} + \underset{(6.11)}{0.741} \; LAG(WHPFMMXR)$$

$$+ \underset{\substack{(2.61)\\ [-0.08]}}{1137.180}[NARDDMX - LAG(NARDDMX)]/LAG(NARDDMX)$$

$$+ 901.418 \; D74 + \underset{(2.58)}{594.963} \; D75 + \underset{(2.97)}{805.780} \; D83$$

$R^2 = 0.95 \qquad DW = 1.88$

(13.7) Pork Production

$$POSPRMX = \underset{(3.11)}{675.916} + \underset{\substack{(6.41)\\ [0.87]}}{0.172} \; NANPDMX/NARDDMX$$

$$+ \underset{\substack{(4.26)\\ [-0.88]}}{0.140} \; LAG(COPFMMXR) - \underset{(2.08)}{143.988} \; D71 + \underset{(2.67)}{177.264} \; D75$$

$R^2 = 0.96 \qquad DW = 2.39$

(13.8) Feed-Grain Imports

$$FGSMNMX = FGCOTMX + FGUDTMX - FGSPRMX - LAG(FGCOTMX)$$

Table 13. Continued

* NIMEUMX/NARDDMX - 1180.260 (NARDDMX)
(2.51)
[-0.08]

- LAG(NARDDMX)/LAG(NARDDMX) - 601.006(D72 + D73)
(2.40)

+ 668.376 D67 - 731.143 D81
(2.03) (2.31)

R^2 = 0.88 DW = 2.41

(13.6) Wheat Farm Price

WHPFMMXR = 945.483 + 0.741 LAG(WHPFMMXR)
(1.70) (6.11)

+ 1137.180[NARDDMX - LAG(NARDDMX)]/LAG(NARDDMX)
(2.61)
[-0.08]

+ 901.418 D74 + 594.963 D75 + 805.780 D83
(2.58) (2.97)

R^2 = 0.95 DW = 1.88

(13.7) Pork Production

POSPRMX = 675.916 + 0.172 NANPDMX/NARDDMX
(3.11) (6.41)
[0.87]

+ 0.140 LAG(COPFMMXR) - 143.988 D71 + 177.264 D75
(4.26) (2.08) (2.67)
[-0.88]

R^2 = 0.96 DW = 2.39

(13.8) Feed-Grain Imports

FGSMNMX = FGCOTMX + FGUDTMX - FGSPRMX - LAG(FGCOTMX)

Table 13. Continued

(13.13) Sorghum Farm Price

```
SGPFMMXR = 2292.740 + 0.004 SGPFMU9 * NIMEUMX/NARDDMX
             (9.97)   (5.37)
                      [0.42]

         - 2157.700[NARDDMX - LAG(NARDDMX)]/LAG(NARDDMX)
             (14.40)
             [-0.18]

         - 545.397 D73 + 468.452 D75
             (3.45)        (3.10)
```

R^2 = 0.96   DW = 1.65

(13.14) Sorghum Imports

SGSMNMX = SGUDTMX + SGCOTMX - SGSPRMX - LAG(SGCOTMX)

Endogenous Variables

FGSPRMX = Mexico, Feed-Grain Production, 1000 MT
FGAHHMX = Mexico, Feed-Grain Area Harvested, 1000 ha
FGUDTMX = Mexico, Feed-Grain Domestic Use, 1000 MT
COPFMMXR = Mexico, Corn Farm Price, 1980 pesos/MT
WHPFMMXR = Mexico, Wheat Farm Price, 1980 pesos/MT
POSPRMX = Mexico, Pork Production, 1980 pesos/MT
FGCOTMX = Mexico, Feed-Grain Stocks, 1000 MT
FGSMNMX = Mexico, Feed-Grain Imports, 1000 MT
SGAHHMX = Mexico, Sorghum Area Harvested, 1000 ha
SGSPRMX = Mexico, Sorghum Production, 1000 MT
SGUDTMX = Mexico, Sorghum Domestic Use, 1000 MT
SGCOTMX = Mexico, Sorghum Stocks, 1000 MT
SGPFMMXR = Mexico, Sorghum Farm Price

Exogenous Variables

FGYHHMX = Mexico, Feed-Grain Yield, MT/ha
NARDDMX = Mexico, GDP Deflator, 1980 = 1.0
NIMEUMX = Mexico, Exchange Rate, pesos 1$
NANPDMX = Mexico, GDP, mil pesos
D67 = 1 in 1967 and 0 Otherwise
D71 = 1 in 1971 and 0 Otherwise
D72 = 1 in 1972 and 0 Otherwise

Table 13. Continued

D73 = 1 in 1973 and 0 Otherwise
D74 = 1 in 1974 and 0 Otherwise
D75 = 1 in 1975 and 0 Otherwise
D77 = 1 in 1977 and 0 Otherwise
D78 = 1 in 1978 and 0 Otherwise
D79 = 1 in 1979 and 0 Otherwise
D80 = 1 in 1980 and 0 Otherwise
D81 = 1 in 1981 and 0 Otherwise
D82 = 1 in 1982 and 0 Otherwise
D83 = 1 in 1983 and 0 Otherwise
D84 = 1 in 1984 and 0 Otherwise

13. Feed-grain production (13.1) is endogenously estimated as a function of real corn farm price, feed-grain yield, lagged acreage, and dummy variables. Estimated supply-price elasticity is 0.08. Feed-grain area harvested (13.2) is derived by dividing production by yield. Feed-grain domestic use (13.3) is estimated as a function of the ratio of corn farm price to wheat farm price, pork production, and dummy variables. Own-price demand elasticity is estimated at -0.28, and cross-price demand elasticity is restricted at 0.28. Poultry production is significant in explaining the variation in feed-grain domestic use. The explanatory variables in the stock equation (13.4) are production, lag stocks, and dummy variables.

Corn farm price (13.5) is linked to U.S. corn farm price. Price-transmission elasticity is 0.16. Other explanatory variables in the price-linkage equation are lagged corn farm price, inflation, and dummy variables. Wheat farm price (13.6) is estimated as a function of lagged wheat farm price, inflation, and dummy variables.

Because pork production (13.7) is one of the explanatory variables in the domestic feed-grain use equation, it is endogenously estimated as a function of real corn farm price and real income. Input-price elasticity is estimated at -0.88. Feed-grain imports are described by the identity (13.8) as domestic demand minus domestic supply.

In contrast with the feed-grains component, the sorghum area component (13.9) is endogenously estimated. The explanatory variables in this equation are real sorghum farm price, real wheat farm price, lagged sorghum acreage, and dummy variables. Own-price supply elasticity is 0.66 and cross-price elasticity is 0.80. Sorghum production (13.10) is the product of area times yield.

Sorghum domestic use (13.11) is estimated as a function of real sorghum price, real income, and sorghum imports. Own-price demand elasticity is -0.60. The important explanatory variable in the sorghum stock equation (13.12) is production. Sorghum farm price (13.13) is linked to the U.S. farm price. Price-transmission elasticity is 0.42. Sorghum imports are described by identity (13.14) as domestic demand minus domestic supply.

Egyptian Submodel

Only corn is modeled for Egypt (see Table 14). On the supply side, corn production (14.1) is endogenously estimated. The explanatory variables in corn production are real corn farm price, real wheat farm price, lagged production, corn yield, and dummy variables. Because wheat is a competing crop, wheat farm price is used to capture the cross-price effect on corn production. Corn-price elasticity is 0.11 and the wheat price elasticity is -0.07. Corn yield is exogenous in the model. Corn area harvested (14.2) is described as production divided by yield.

On the demand side, corn domestic use and stocks are endogenously estimated. Because corn domestic use (14.3) is constrained by production, production is one of the explanatory variables in the domestic use equation. Other explanatory variables are real income and dummy variables. Corn stocks (14.4) are estimated as a function of corn farm price, production, and dummy variables. Price elasticity of stock demand is estimated at -0.24. Corn farm price (14.5) is linked to U.S. farm price. Price-transmission elasticity is 0.70. Corn imports (14.6) are equal to domestic demand minus domestic supply. Feed-grain imports (14.7) are determined as the sum of corn and barley imports.

Table 14. Structural parameter estimates of the Egyptian feed-grains submodel

---

(14.1) Corn Production

```
COSPREG = -634.338 + 0.760 LAG(COSPREG) + 321.735 COYHHEG
           (1.03)    (6.00)                (2.44)

        + 336.531 LAG(COPFMEG/NARDDEG)
           (1.25)
           [0.11]

        - 256.604 LAG(WHPFMEG/NARDDEG) + 323.852 DM178
           (0.65)                        (2.99)
          [-0.07]

        + 240.775 DM180
           (2.18)
```

R^2 = 0.97   DW = 2.07

(14.2) Corn Area Harvested

COAHHEG = COSPREG/COYHHEG

(14.3) Corn Domestic Use

```
COUDTEG = -468.468 + 12.065 NANPDEG/NARDDEG
           (0.62)    (2.57)
                     [0.46]

        + 1271.100 DM184 + 0.805 COSPREG - 257.171 D79
           (6.23)          (1.66)          (1.24)
                           [0.65]

        + 565.047 D85
           (2.85)
```

R^2 = 0.99   DW = 1.59

(14.4) Corn Stocks

```
COCOTEG = 1298.830 - 598.080(COPFMEG/NARDDEG) * SHIFT73
          (52.09)    (4.43)
                    [-0.24]

        + 0.347 COSPREG * SHIFT73 - 370.817 DM179
         (7.62)                     (5.47)
```

Table 14. Continued

$$- 190.284(DM177 + DM176)$$

$R^2 = 0.95 \quad DW = 1.99$

(14.5) Corn Farm Price

$$COPFMEG = -133.801 + 40.817 \; COPFMU9 * NIMEUEG$$
$$\quad\quad (2.98) \quad (4.92)$$
$$\quad\quad\quad\quad [0.70]$$

$$+ 134.098 \; LAG(COUDTEG/COSPREG) - 23.663 \; DM178$$
$$(2.98) \quad\quad\quad\quad (1.82)$$
$$[2.42]$$

$R^2 = 0.92 \quad DW = 1.35$

(14.6) Corn Imports

COSMNEG = COUDTEG + COCOTEG - COSPREG - LAG(COCOTEG)

(14.7) Feed-Grain Imports

FGSMNEG = COSMNEG + BASMNEG

Endogenous Variables

COSPREG = Egypt, Corn Production, 1000 MT
COAHHEG = Egypt, Corn Area Harvested, 1000 ha
COUDTEG = Egypt, Corn Domestic Use, 1000 MT
COCOTEG = Egypt, Corn Stocks, 1000 MT
COPFMEG = Egypt, Corn Farm Price, pounds/MT
COSMNEG = Egypt, Corn Imports, 1000 MT
FGSMNEG = Egypt, Feed-Grain Imports, 1000 MT

Exogenous Variables

COYHHEG = Egypt, Corn Yield, MT/ha
NARDDEG = Egypt, GDP Deflator, 1980=100
WHPFMEG = Egypt, Wheat Farm Price, pounds/MT
NANPDEG = Egypt, GDP, mil.pounds
NIMEUEG = Egypt, Exchange Rates
D79 = 1 in 1979 and 0 Otherwise

Table 14. Continued

D85 = 1 in 1985 and 0 Otherwise
D176 = 1 in 1976, 0 Otherwise
D177 = 1 in 1977, 0 Otherwise
D178 = 1 in 1978, 0 Otherwise
D179 = 1 in 1979, 0 Otherwise
D184 = 1 in 1984, 0 Otherwise
SHIFT73 = 1 after 1972, 0 Otherwise

Indian Submodel

Only sorghum is modeled in the submodel for India (see Table 17). Sorghum area harvested (15.1) is specified as a function of real per acre returns from the sorghum crop, real per acre returns from the wheat crop, lagged acreage, and dummy variables. Wheat is the competing crop for sorghum. Own-price elasticity is 0.11 and cross-price elasticity is -0.18. Sorghum production (15.2) is defined as acreage times yield.

On the demand side, sorghum domestic use and stocks are endogenously estimated. Sorghum production is an important variable in explaining the variation in sorghum use (15.3). Explanatory variables in the sorghum stocks equation (15.4) are production, lag stocks, and dummy variables. Variation in real sorghum price (15.5) is explained by the ratios of sorghum production to use, lagged price, and dummy variables. Sorghum imports (15.6) are described as domestic demand minus domestic supply.

Nigerian Submodel

Only sorghum is modeled in the Nigerian submodel (see Table 16). Sorghum area harvested (16.1) is estimated as a function of sorghum farm price, corn farm price, lagged acreage, and dummy variables. Own-price supply elasticity is estimated at 0.57, and cross-price elasticity is restricted at -0.57. Sorghum production (16.2) is described as acreage times yield.

On the demand side, only sorghum use is estimated. The explanatory variables in the sorghum-use equation (16.3) are real sorghum price and production. Own-price demand elasticity is -0.003. Variation in the sorghum price (16.4) is captured by the ratio of production to use, GDP deflator, and

Table 15. Structural parameter estimates of the Indian feed-grains submodel

(15.1) Sorghum Area Harvested

$$\text{SGAHHIN} = \underset{(8.05)}{14200.100} + \underset{(2.06)}{0.218}\ \text{LAG(SGAHHIN)}$$

$$+ \underset{\substack{(4.31)\\ [0.11]}}{2.895}\ \text{LAG[(SGPFMIN/NARDDIN) * SGYHHIN]}$$

$$+ \underset{(4.31)}{1162.740}\text{(D68 + D69)} - \underset{\substack{(4.62)\\ [-0.18]}}{1.433}\ \text{LAG[(WHPFMIN/NARDDIN) * WHYHHIN]}$$

$$- 1652.700\ \text{D74} + \underset{(2.51)}{700.813}\ \text{D79} - \underset{(4.13)}{1147.010}\ \text{D72}$$

$R^2 = 0.95$ DW = 1.98

(15.2) Sorghum Production

$$\text{SGSPRIN} = \text{SGAHHIN} * \text{SGYHHIN}$$

(15.3) Sorghum Domestic Use

$$\text{SGUDTIN} = \underset{(2.72)}{1277.310} + \underset{\substack{(19.68)\\ [0.87]}}{0.892}\ \text{SGSPRIN} + \underset{(3.63)}{643.314}\text{(D67 + D68 + D69)}$$

$R^2 = 0.96$ DW = 1.92

(15.4) Sorghum Stocks

$$\text{SGCOTIN} = \underset{(0.39)}{59.918} + \underset{(5.02)}{0.293}\ \text{LAG(SGCOTIN)} + \underset{\substack{(2.10)\\ [0.42]}}{0.032}\ \text{SGSPRIN}$$

$$+ \underset{(8.15)}{763.250}\ \text{D77} + \underset{(6.60)}{325.024}\text{(D73 + D74 + D75 + D76)}$$

$$+ \underset{(3.44)}{336.723}\ \text{D78}$$

$R^2 = 0.94$ DW = 2.10

Table 15. Continued

(15.5) Sorghum Real Price

SGPFMIN = 1953.370 + 0.861 LAG(SGPFMIN)
(2.65) (12.39)

- 1894.350 SGSPRIN/SGUDTIN + 179.487 D71 - 448.156 D74
(2.68) (1.80) (4.28)
[-1.76]

R^2 = 0.96 DW = 2.49

(15.6) Sorghum Imports

SGSMNIN = SGUDTIN + SGCOTIN - SGSPRIN - LAG(SGCOTIN)

Endogenous Variables

SGAHHIN = India, Sorghum Area Harvested, 1000 ha
SGSPRIN = India, Sorghum Production, 1000 MT
SGPFMIN = India, Sorghum Farm Price, rupees/MT
SGUDTIN = India, Sorghum Domestic Use, 1000 MT
SGCOTIN = India, Sorghum Stocks, 1000 MT
SGSMNIN = India, Sorghum Imports, 1000 MT

Exogenous Variables

SGYHHIN = India, Sorghum Yield, MT/ha
NARDDIN = India, GDP Deflator, 1980=1.0
WHPFMIN = India, Wheat Farm Price, rupees/MT
WHYHHIN = India, Wheat Yield, MT/ha
D67 = 1 in 1967 and 0 Otherwise
D68 = 1 in 1968 and 0 Otherwise
D69 = 1 in 1969 and 0 Otherwise
D71 = 1 in 1971 and 0 Otherwise
D72 = 1 in 1972 and 0 Otherwise
D73 = 1 in 1973 and 0 Otherwise
D74 = 1 in 1974 and 0 Otherwise
D75 = 1 in 1975 and 0 Otherwise
D76 = 1 in 1976 and 0 Otherwise
D77 = 1 in 1977 and 0 Otherwise
D79 = 1 in 1979 and 0 Otherwise

Table 16. Structural parameter estimates of the Nigerian feed-grains submodel

(16.1) Sorghum Area Harvested

$$SGAHHNG = \underset{(1.25)}{1772.790} + \underset{(1.67)}{0.191}\ LAG(SGAHHNG) - \underset{(8.45)}{1807.930}\ D72$$

$$- \underset{(1.45)}{752.201}\ SHIFT80 + \underset{\substack{(1.66)\\ [0.57]}}{3646.560}\ LAG(SGPFMNG/COPFMNG)$$

$$- \underset{(3.60)}{756.556}\ D67 - \underset{(4.30)}{908.218}\ D74$$

$R^2 = 0.94$ DW = 2.44

(16.2) Sorghum Production

$$SGSPRNG = SGAHHNG * SGYHHNG$$

(16.3) Sorghum Use

$$SGUDTNG = \underset{(1.85)}{129.776} + \underset{\substack{(58.04)\\ [0.97]}}{0.968}\ SGSPRNG - \underset{\substack{(0.38)\\ [-0.003]}}{0.056}\ SGPFMNG/NARDDNG$$

$R^2 = 1.00$ DW = 2.70

(16.4) Sorghum Price

$$SGPFMNG = \underset{(0.64)}{195.819} + \underset{(10.16)}{85.252}\ SHIFT79$$

$$- \underset{\substack{(0.53)\\ [-1.41]}}{164.038}\ LAG(SGSPRNG/SGUDTNG) + \underset{(4.09)}{25.062}\ SHIFT71$$

$$+ \underset{\substack{(5.69)\\ [0.35]}}{65.202}\ NARDDNG$$

$R^2 = 0.99$ DW = 1.30

Table 16. Continued

(16.5) Corn Price

COPFMNG = 14.423 + 0.966 SGPFMNG + 9.964 SHIFT71
(8.49) (28.28) (5.11)
[0.89]

- 27.198 SHIFT79
(6.17)

R^2 = 1.00 DW = 1.67

(16.6) Corn Imports

SGSMNNG = SGUDTNG + SGCOTNG - SGSPRNG - LAG(SGCOTNG)

Endogenous Variables

SGAHHNG = Nigeria, Sorghum Area Harvested, 1000 ha
SGSPRNG = Nigeria, Sorghum Production, 1000 MT
SGPFMNG = Nigeria, Sorghum Farm Price, Naira/MT
COPFMNG = Nigeria, Corn Farm Price, Naira/MT
SGUDTNG = Nigeria, Sorghum Domestic Use, 1000 MT
SGSMNNG = Nigeria, Sorghum Imports, 1000 MT

Exogenous Variables

SGYHHNG = Nigeria, Sorghum Yield, MT/ha
NARDDNG = Nigeria, GDP Deflator, 1980=1.0
D67 = 1 in 1967 and 0 Otherwise
D72 = 1 in 1972 and 0 Otherwise
D74 = 1 in 1974 and 0 Otherwise
SHIFT71 = 1 after 1970, 0 Otherwise
SHIFT79 = 1 after 1978, 0 Otherwise
SHIFT80 = 1 after 1979, 0 Otherwise

and dummy variables. Corn farm-price (16.5) is endogenously estimated as a function of sorghum farm-price and dummy variables. Corn imports (16.6) are described as domestic demand minus domestic supply.

Saudi Arabian Submodel

In Table 17, which describes the Saudi feed-grains submodel, barley domestic use (17.1) is endogenously estimated as a function of egg production and a dummy variable. Because barley is a major feed used in egg production, egg production is used as an explanatory variable in the barley domestic use equation. Egg production (17.2) is also endogenously estimated as a function of real income, crude-oil price, lagged egg production, and dummy variables. Barley imports (17.3) are described as domestic use minus domestic supply. Feed-grain imports (17.4) are defined as barley imports plus corn imports.

High-Income East Asian Submodel

Three behavioral equations--area harvested, domestic use, and stocks--are endogenously estimated in the high-income East Asia submodel, which is illustrated in Table 18. The explanatory variables in the area harvested equation (18.1) are real U.S. corn price expressed in local currencies, lagged acreage, and dummy variables. Supply-price elasticity is 0.27. Production (18.2) is described as acreage times yield.

Feed-grain domestic use (18.3) is estimated as a function of corn price and income. Demand is inelastic at -0.09, and income elasticity is close to unity. Stocks (18.4) are estimated as a function of corn price, production, and lag stocks. Feed-grain imports (18.5) are described as domestic demand minus domestic supply.

Table 17. Structural parameter estimates of the Saudi Arabian feed-grains submodel

(17.1) Barley Domestic Use

```
BAUDTSA = -866.522 + 3.453 EGSPRSA + 921.522 SHIFT74
           (6.44)   (27.61)          (5.75)
```

$R^2 = 0.99$ DW = 1.47

(17.2) Egg Production

```
EGSPRSA = -118.971 + 0.685 LAG(EGSPRSA)
           (1.15)   (7.76)

        + 4.699 SHIFT82 * LTARCRUD * NIMEUSA/NARDDSA
          (5.44)

        + 201.016 D81 - 260.198 D82 - 162.801 D79
           (4.89)        (5.78)        (4.71)

        + 0.001 SHIFT75 * NANPDSA/NARDDSA + 118.971 * SHIFT74
          (2.92)
```

$R^2 = 1.00$ DW = 2.35

(17.3) Barley Imports

BASMNSA = BAUDTSA + BACOTSA - BASPRSA - LAG(BACOTSA)

(17.4) Feed-Grain Imports

FGSMNSA = BASMNSA + COSMNSA

Endogenous Variables

BAUDTSA = Saudi Arabia, Barley Domestic Use, 1000 MT
EGSPRSA = Saudi Arabia, Egg Production, mil pieces
BASMNSA = Saudi Arabia, Barley Imports, 1000 MT
FGSMNSA = Saudi Arabia, Feed-Grain Imports, 1000 MT

Exogenous Variables

LTARCRUD = Saudi Arabia, Crude Oil Price, $/bbl
NIMEUSA = Saudi Arabia, Exchange Rate, Riyals/$

Table 17. Continued

NARDDSA = Saudi Arabia, GDP Deflator, 1980=1.0
NANPDSA = Saudi Arabia, GDP, mil Riyals
BACOTSA = Saudi Arabia, Barley Imports, 1000 MT
COSMNSA = Saudi Arabia, Corn Imports, 1000 MT
D81 = 1 in 1981 and 0 Otherwise
SHIFT74 = 1 after 1973, 0 Otherwise
SHIFT75 = 1 after 1974, 0 Otherwise
SHIFT82 = 1 after 1981, 0 Otherwise

Table 18. Structural parameter estimates of the high-income East Asian feed-grains submodel

(18.1) Feed-Grain Area Harvested

```
FGAHHR4 = -85.308 + 0.848 LAG(FGAHHR4)
           (2.07)  (13.50)

          + 48.692 LAG(CORPF/NARDDU9 * NIMERUUS) - 196.049 D76
            (3.31)                                 (5.26)
            [0.27]

          - 96.520 D85
            (2.54)
```

R^2 = 0.97   DW = 1.93

(18.2) Feed-Grain Production

FGSPRR4 = FGAHHR4 * FGYHHR4

(18.3) Feed-Grain Domestic Use

```
FGUDTR4 = 494.539 - 159.844 CORPF/NARDDU9 * NIMERUUS
           (0.96)    (1.40)
                    [-0.09]

          + 46.511 NARPDR4$ + 1111.520(D78 + D82) - 818.368 D85
           (26.56)                (4.68)              (2.42)
            [0.99]
```

R^2 = 0.99   DW = 1.64

(18.4) Feed-Grain Stocks

```
FGCOTR4 = -448.384 + 0.782 LAG(FGCOTR4)
            (1.67)   (7.70)

          - 13.654 CORPF/NARDDU9 NIMERUUS + 0.544 FGSPRR4
            (0.18)                          (3.33)
           [-0.03]                          [0.60]
```

R^2 = 0.84   DW = 1.71

Table 18. Continued

(18.5) Feed-Grain Imports

FGSMNR4 = FGUDTR4 + FGCOTR4 - FGSPRR4 - LAG(FGCOTR4)

Endogenous Variables

FGAHHR4 = High-Income East Asia, Feed-Grains Area Harvested, 1000 ha
FGSPRR4 = High-Income East Asia, Feed-Grains Production, 1000 MT
FGUDTR4 = High-Income East Asia, Feed-Grains Domestic Use, 1000 MT
FGCOTR4 = High-Income East Asia, Feed-Grains Stocks, 1000 MT
FGSMNR4 = High-Income East Asia, Feed-Grains Imports, 1000 MT

Exogenous Variables

FGYHHR4 = High-Income East Asia, Feed-Grains Yield, MT/ha
NARDDU9 = High-Income East Asia, GNP Deflator, 1980=1
NIMERUUS = U.S. Exchange Rate Index, trade weighted, 1980=100
D76 = 1 in 1976 and 0 Otherwise
D78 = 1 in 1978 and 0 Otherwise
D82 = 1 in 1982 and 0 Otherwise
D85 = 1 in 1985 and 0 Otherwise

"Other Asia" Submodel

In the submodel for other regions of Asia (see Table 19), feed-grain production (19.1) is estimated as a function of yield and U.S. corn farm price. Supply-price elasticity is 0.80. Area harvested (19.2) is derived as production divided by yield. Explanatory variables in the domestic use equation (19.3) are production, income, and corn price. Feed-grain imports (19.4) are described as domestic demand minus domestic supply.

"Other Africa and Middle East" Submodel

In the submodel for other regions of Africa and the Middle East (see Table 20), feed-grain production (20.1) is estimated as a function of U.S. corn farm price, corn yield, and lag production. Supply is very inelastic at 0.03. Feed-grain area harvested (20.2) is derived from production divided by yield. Feed-grain domestic use (20.3) is estimated as a function of income, production, crude-oil prices, and dummy variables. Feed-grain stocks (20.4) are endogenously estimated as a function of U.S. corn price, production, and lagged stocks. Feed-grain imports (20.5) are defined as domestic demand minus domestic supply.

"Other Latin America" Submodel

In the submodel for other regions of Latin America (see Table 21), feed-grain production (21.1) is estimated as a function of U.S. corn farm price, U.S. wheat farm price, lagged production, and dummy variables. Own-price elasticity of supply is estimated at 0.37 and cross-price elasticity is estimated at -0.22.

On the demand side, feed-grain stocks and imports are endogenously estimated. The explanatory variables in the stocks equation (21.2) are feed-

Table 19. Structural parameter estimates of the "other Asia" feed-grains submodel

(19.1) Feed-Grain Production

$$FGSPRSO = \underset{(1.47)}{2174.060} + \underset{(8.77)}{14013.200}\ FGYHHSO + \underset{\substack{(2.12)\\ [0.80]}}{642.332}\ LAG(CORPF)$$

$R^2 = 0.94$ DW = 2.85

(19.2) Feed-Grain Area Harvested

$$FGAHHSO = FGSPRSO/FGYHHSO$$

(19.3) Feed-Grain Domestic Use

$$FGUDTSO = \underset{(0.94)}{763.642} + \underset{(12.67)}{0.834}\ FGSPRSO + \underset{\substack{(5.11)\\ [0.17]}}{13.174}\ NARPDSO$$

$$- \underset{\substack{(0.90)\\ [-0.01]}}{130.900}\ CORPF - \underset{(4.71)}{1517.620}\ D75$$

$R^2 = 0.99$ DW = 2.26

(19.4) Feed-Grain Imports

$$FGSMNSO = FGUDTSO + FGCOTSO - FGSPRSO - LAG(FGCOTSO)$$

Endogenous Variables

FGSPRSO = Other Asia, Feed-Grains Production, 1000 MT
FGAHHSO = Other Asia, Feed-Grains Area Harvested, 1000 ha
FGUDTSO = Other Asia, Feed-Grains Domestic Use, 1000 MT
FGSMNSO = Other Asia, Feed-Grains Imports, 1000 MT

Exogenous Variables

FGYHHSO = Other Asia, Feed Grains Yield, MT/ha
NARPDSO = Other Asia, GDP
D75 = 1 in 1975 and 0 Otherwise

Table 20. Structural parameter estimates of the "other Africa and Middle East" feed-grains submodel

(20.1) Feed-Grain Production

FGSPRFO = -17989.700 + 0.621 LAG(FGSPRFO)
(4.36) (6.88)

+ 425.437 LAG(CORPF) + 25849.700 FGYHHFO
(0.79) (6.07)
[0.03] [1.05]

R^2 = 0.95 DW = 1.32

(20.2) Feed-Grain Area Harvested

FGAHHFO = FGSPRFO/FGYHHFO

(20.3) Feed-Grain Domestic Use

FGUDTFO = -2952.890 + 10.710 NARPDFOF + 0.916 FGSPRFO
(0.99) (2.96) (5.69)
[0.22] [0.84]

+ 131.100 SHIFT79 * LTARCRUD + 2326.950 D83
(3.63) (1.71)

- 2507.450 D80
(1.80)

R^2 = 0.97 DW = 1.77

(20.4) Feed-Grain Stocks

FGCOTFO = -4740.590 + 0.143 LAG(FGCOTFO) - 65.499 CORPF
(4.87) (0.93) (0.31)
[-0.05]

+ 0.266 FGSPRFO
(5.28)
[2.93]

R^2 = 0.87 DW = 2.08

Table 20. Continued

(20.5) Feed-Grain Imports

FGSMNFO = FGUDTFO + FGCOTFO - FGSPRFO = LAG(FGCPTFO)

Endogenous Variables

FGSPRFO = Other Africa and Middle East, Feed-Grains Production, 1000 MT
FGAHHFO = Other Africa and Middle East, Feed-Grains Area Harvested, 1000 AC
FGUDTFO = Other Africa and Middle East, Feed-Grains Domestic Use, 1000 MT
FGCOTFO = Other Africa and Middle East, Feed-Grains Stocks, 1000 MT
FGSMNFO = Other Africa and Middle East, Feed-Grains Imports, 1000 MT

Exogenous Variables

FGYHHFO = Other Asia and Middle East, Feed Grains Yield, MT/ha
NARPDFOF = Other Asia and Middle East, GDP, 1980 $US
LTARCRUD = Light Arabian crude oil price (U.S. $/bbl)
SHIFT79 = 1 after 1978, 0 Otherwise
D80 = 1 in 1980 and 0 Otherwise
D83 = 1 in 1983 and 0 Otherwise

Table 21. Structural parameter estimates of the "other Latin America" feed-grains submodel

(21.1) Feed-Grain Production

```
FGSPRNO = 1756.370 + 0.589 LAG(FGSPRNO)
           (3.36)    (5.98)

        + 1179.560 LAG(CORPF) - 548.130 LAG(WHEPF)
           (4.95)                (3.45)
           [0.37]               [-0.22]

        - 820.788 D76 + 436.605 D79
          (3.66)         (1.95)
```

R^2 = 0.94 DW = 1.47

(21.2) Feed-Grain Stocks

```
FGCOTNO = 717.277 + 0.184 LAG(FGCOTNO) + 0.181 FGSPRNO
          (3.86)   (2.15)                 (5.37)
                                          [1.95]

        + 537.875 D80 - 191.124 D85 + 322.949 (D77 + D81)
          (6.99)         (2.27)        (5.62)
```

R^2 = 0.94 DW = 2.02

(21.3) Feed-Grain Imports

```
FGSMNNO = -1463.100 + 24.455 NARPDNO - 6728.830(CORPF/SOMPM)
            (4.70)    (8.08)              (0.51)
                      [2.02]             [-0.07]

        + 821.078(D80 + D81 + D82 + D83) - 554.892 LAG(CORPF)
          (6.09)                            (2.24)
                                           [-0.80]

        + 379.717 LAG(WHEPF)
          (2.58)
          [0.72]
```

R^2 = 0.97 DW = 1.87

(21.4) Feed-Grain Domestic Use

```
FGUDTNO = FGSPRNO + LAG(FGCOTNO) + FGSMNNO - FGCOTNO
```

Table 21. Continued

Endogenous Variables

FGSPRNO = Other Latin America, Feed-Grains Production, 1000 MT
FGCOTNO = Other Latin America, Feed-Grains Stocks, 1000 MT
FGSMNNO = Other Latin America, Feed-Grains Imports, 1000 MT
FGUDTNO = Other Latin America, Feed-Grains Domestic Use, 1000 MT

Exogenous Variables

NARPDNO = Latin America, GDP, 1980 $US
D76 = 1 in 1976 and 0 Otherwise
D77 = 1 in 1977 and 0 Otherwise
D79 = 1 in 1979 and 0 Otherwise
D80 = 1 in 1980 and 0 Otherwise
D81 = 1 in 1981 and 0 Otherwise
D82 = 1 in 1982 and 0 Otherwise
D83 = 1 in 1983 and 0 Otherwise
D85 = 1 in 1985 and 0 Otherwise

grain production, lagged stocks, and dummy variables. Feed-grain imports (21.3) are estimated as a function of income, U.S. corn price, U.S. wheat price, and U.S. soybean meal price. Feed-grain domestic use is derived as a residual in equation (21.4).

Rest-of-the-World Submodel

For the rest of the world (ROW), feed grains (corn, barley, and oats) and sorghum are modeled separately in the feed-grains submodel, illustrated in Table 22. Feed-grain area harvested (22.1) is estimated as a function of corn price, wheat price, lagged acreage, and dummy variables. Own-price supply elasticity is 0.16 and cross-price elasticity is -0.16. Feed-grain production (22.2) is described as area times yield. Explanatory variables in the domestic use equation (22.3) are barley price, wheat price, income, and dummy variables. Feed-grain stocks (22.4) are estimated as a function of production, barley price, lagged stocks, and dummy variables. Feed-grain imports (22.5) are defined as domestic demand minus domestic supply.

The structure of the sorghum model is similar to that of the feed-grains model. Sorghum area harvested (22.6) is estimated as a function of sorghum price, lagged acreage, and a set of dummy variables. Estimated own-price supply elasticity is 0.15. Sorghum production (22.7) is defined as area times yield. Explanatory variables in the domestic use equation (22.8) are sorghum price, corn price, soybean meal price, production, income, and dummy variables. Own-price demand elasticity is -0.27, and cross-price elasticities are 0.37 (corn price) and 0.02 (soybean-meal price). Sorghum stocks (22.9) are estimated as a function of production, lagged stocks, and dummy variables. Sorghum imports (22.10) are described as domestic demand minus domestic supply.

Table 22. Structural parameter estimates of the ROW feed-grains submodel

(22.1) Feed-Grain Area Harvested

```
FGAHHROW = 361.005 + 0.873 LAG(FGAHHROW)
            (2.18)   (9.73)

         + 1.514 LAG(CORPF * NIMERUUS) - 1.238 LAG(WHEPF * NIMERUUS)
          (2.39)                          (2.57)
          [0.16]                         [-0.16]

         + 127.641(D79 + D81)
```

R^2 = 0.94   DW = 1.91

(22.2) Feed-Grain Production

FGSPRROW = FGAHHROW * FGYHHROW

(22.3) Feed-Grain Domestic Use

```
FGUDTROW = 4514.460 - 21.985 BARPF * NIMERUUS + 17.422 RERGDPFG
             (2.88)    (2.84)                     (3.15)
                      [-0.48]                     [0.68]

         + 6.847 WHEPF * NIMERUUS + 3693.470 DAT6977
          (1.50)                   (10.64)
          [0.22]

         - 1963.060(D71 + D72)
             (3.47)
```

R^2 = 0.90   DW = 2.95

(22.4) Feed-Grain Stocks

```
FGCOTROW = 1614.650 + 0.400 LAG(FGCOTROW) + 0.333 FGSPRROW
             (2.02)   (4.97)                (3.60)
                                            [0.98]

         - 3.361 BARPF * NIMERUUS - 3415.710 SHIFT74
          (1.29)                     (6.60)
         [-0.23]
```

R^2 = 0.98   DW = 2.39

Table 22. Continued

(22.5) Feed-Grain Imports

FGSMNROW = FGUDTROW + FGCOTROW - FGSPRROW - LAG(FGCOTROW)

(22.6) Sorghum Area Harvested

```
SGAHHROW = 2696.380 + 0.652 LAG(SGAHHROW)
            (1.96)   (7.18)

         + 100323.000 LAG(SORPF/NARDDU9) + 2851.820 D85
             (3.63)                          (4.68)
             [0.15]

         - 2987.720 D76 + 1651.370 D73
             (4.73)         (2.80)

         + 1950.950(D67 + D69 + D70 + D71)
            (4.88)
```

R^2 = 0.94   DW = 2.32

(22.7) Sorghum Production

SGSPRROW = SGAHHROW * SGYHHROW

(22.8) Sorghum Domestic Use

```
SGUDTROW = 2341.870 + 0.787 SGRGDPRE + 0.733 SGSPRROW
            (0.57)   (2.33)           (6.31)

         - 275076.000 SORPF/NARDDU9 + 308263.000 CORPF/NARDDU9
             (1.90)                      (2.39)
            [-0.27]                      [0.34]

         + 227.612 SOMPM/NARDDU9 - 1502.510(D77 + D78 + D79)
           (0.91)                   (3.55)
           [0.02]

         + 2859.320 D81 - 3131.590 D85
            (4.30)         (3.22)
```

R^2 = 0.97   DW = 2.48

Table 22. Continued

(22.9) Sorghum Stocks

```
SGCOTROW = -2054.910 + 0.219 LAG(SGCOTROW) + 0.122 SGSPRROW
             (2.39)   (2.26)                   (3.52)
                                               [1.84]

         + 1167.640 SHIFT76 + 917.285 D81
             (6.31)             (6.40)

         - 546.914(D83 + D84)
            (4.96)
```

$R^2 = 0.94$ DW = 1.55

(22.10) Sorghum Imports

SGSMNROW = SGUDTROW + SGCOTROW - SGSPRROW - LAG(SGCOTROW)

Endogenous Variables

FGAHHROW = ROW, Feed-Grains Area Harvested, 1000 ha
FGSPRROW = ROW, Feed-Grains Production, 1000 MT
FGUDTROW = ROW, Feed-Grains Domestic Use, 1000 MT
FGCOTROW = ROW, Feed-Grains Stock, 1000 MT
FGSMNROW = ROW, Feed-Grains Imports, 1000 MT
SGAHHROW = ROW, Sorghum Area Harvested, 1000 ha
SGSPRROW = ROW, Sorghum Production, 1000 MT
SGUDTROW = ROW, Sorghum Domestic Use, 1000 MT
SGCOTROW = ROW, Sorghum Stocks, 1000 MT
SGSMNROW = ROW, Sorghum Imports, 1000 MT

Exogenous Variables

SGRGDPRE = Real GDP, ROW for Sorghum model, 1980 $US
RERGDPFG = Real GDP, ROW for feedgrains model, 1980 $US
NIMERUUS = U.S. Exchange Rate Index, trade weighted, 1980=100
NARDDU9 = U.S., GDP Deflator, 1980=100
D67 = 1 in 1967 and 0 Otherwise
D69 = 1 in 1969 and 0 Otherwise
D70 = 1 in 1970 and 0 Otherwise
D71 = 1 in 1971 and 0 Otherwise
D72 = 1 in 1972 and 0 Otherwise
D73 = 1 in 1973 and 0 Otherwise
D76 = 1 in 1976 and 0 Otherwise

Table 22. Continued

D77 = 1 in 1977 and 0 Otherwise
D78 = 1 in 1978 and 0 Otherwise
D79 = 1 in 1979 and 0 Otherwise
D81 = 1 in 1981 and 0 Otherwise
D83 = 1 in 1983 and 0 Otherwise
D84 = 1 in 1984 and 0 Otherwise
D85 = 1 in 1985 and 0 Otherwise
DAT6977 = 1 from 69-77, 0 Otherwise
SHIFT74 = 1 after 1973, 0 Otherwise
SHIFT76 = 1 after 1975, 0 Otherwise

Evaluation

The estimated model presented in the previous section seems to reflect adequately the structure of the world feed-grains market. The explanatory power of the model has not been fully investigated, however. This section reviews several measures of the model's explanatory power. Performance of the model can be measured in terms of the validity of its estimates, its ability to reproduce actual data in a dynamic simulation, and its stability.

To measure this model's forecasting ability, a simulation of the model is run over the sample period (1972-1982). Simulation results are then compared with actual data. Statistics measuring the model's fitting performance include mean error (ME), mean percentage error (MPE), mean absolute error (MAE), root mean square error (RMSE), and root mean square percentage error (RMSPE).

Mean error measures the average error of simulated values from actual values. The size of the ME depends upon the variable size. To eliminate this problem, MPE is often used. In computing ME and MPE, positive and negative deviations offset each other, which might result in small values of error measurement. To avoid this problem, MAE is used in computing the simulation statistics.

The RMSE is the square root of the average error of simulated values from actual values. The size of RMSE depends upon the variable size. To eliminate this problem, RMSPE is used instead.

The Appendix presents several key simulation statistics for important endogenous variables. Simulation statistics must always be interpreted with care. For example, small absolute simulation errors in a variable that takes a value near zero in some year results in a large RMSPE. Moreover, the simulation statistics for a particular variable may be unsatisfactory, not because of a particular problem with the equation determining that variable but because of a problem elsewhere in the model.

In general, the simulation statistics indicate that the model behaves satisfactorily. Considering the inelasticity of most of the markets represented in the model, it is not surprising that the poorest results were obtained for prices and variables very sensitive to absolute and relative prices. For example, expected nonparticipant net returns are very sensitive to prices, and participation rates are very sensitive to the relationship between participant and nonparticipant net returns. The participation rate determines program area planted and idled, and both nonparticipant returns and program acreage have an important effect on nonprogram acreage. Because the RMSPE's for market prices are generally high, so are those for expected nonparticipant net returns, the participation rate, program planted and idled area, and nonparticipant area planted.

The free-stocks equations behave less satisfactorily than most of the other equations in the model. Stocks are more price-sensitive than most other supply and demand categories, and thus errors in simulated prices account for part of the problem. Free stocks are also more variable than most of the other inputs.

On the other hand, most of the statistics are encouraging for the major components of supply and demand. The RMSPE is less than 10 percent for most total area planted and production variables.

The simulation results represent one common approach to model validation. If a model is to be used for projections and forward-looking policy analysis, it is not sufficient to evaluate the ability of the model to replicate historical data. It is also necessary to assess the ability of the model to provide defensible answers to the questions it is intended to address. An examination of model elasticities is one way of assessing the plausibility of the model's behavior. The third section reported single-equation elasticities evaluated at the means of all variables. Because of the model's many interactions, how the model behaves when all equations are operating simultaneously should be considered. Tables 23-25 provide model-elasticity estimates obtained by shocking a particular variable and allowing the effects to feed through all equations in the model. These elasticities are evaluated in the 1982/83 crop year.

The U.S. production elasticities reported in Table 23 represent the net effect of all model equations directly or indirectly affecting planted area. In general, the results are consistent with expectations. Own-price elasticities are positive and cross-price elasticities are negative for all crops. The production elasticities reported in Table 23 for both the United States and other countries are inelastic with respect to own prices.

Domestic demand elasticities are reported in Table 24. All own-price elasticities are negative, which is consistent with expectations. Substitute crop prices have a positive effect on domestic demand components. Price-transmission elasticities are given in Table 25. The price-transmission elasticities for Canada, Australia, Thailand, South Africa, and Japan are close to one because of their free-trade policies in feed grains. The price-transmission elasticities for Argentina, Brazil, and Mexico are well below one because of their restrictive trade policies in feed grains.

Uses of the Model

This section discusses the broader applicability of the model and briefly identifies some of the reports and publications prepared by utilizing the model. Included also is a general description of the experience in running the model.

Table 23. Summary of estimated production elasticities from the feed-grains trade model

Country/ Region	Elasticity with Respect to							
	Corn Price	Sorghum Price	Barley Price	Oats Price	Wheat Price	Soybean Price	Rapeseed Price	Wool Price
U.S.[a]								
Corn	0.08					-0.02		
Sorghum		0.27			-0.04			
Barley			0.53	-0.32	-0.33			
Oats	-0.25		-0.31	1.05		-0.21		
Canada								
Barley			0.47				-0.03	
Corn	0.08					-0.09		
Australia								
Barley			0.35		-0.27			-0.14
Sorghum		0.16	-0.14		-0.12			
Argentina								
Corn	0.39					-0.22		
Sorghum					-1.19			
EC-12								
Barley								
Corn	0.07							
Thailand								
Corn	0.02	-0.11						
S. Africa								
Corn	0.04							
Sorghum		0.42			-0.21			
Japan								
Barley								
Brazil								
Feed grains	0.19				-0.22	-0.01		
Mexico								
Feed grains	0.05							
Sorghum		0.16			-0.25			
Egypt								
Corn	0.07				-0.04			
India								
Sorghum	0.07				-0.17			

Table 23. Continued

Country/ Region	Corn Price	Sorghum Price	Barley Price	Oats Price	Wheat Price	Soybean Price	Rapeseed Price	Wool Price
	Elasticity with Respect to							
Nigeria								
Sorghum	-0.59	0.64						
High-income East Asia								
Feed grains	0.21							
Other Asia								
Feed grains	0.05							
Other Africa and Middle East								
Feed grains	0.02							
Other Latin America								
Feed grains	0.32							
ROW								
Feed grains	0.11							
Sorghum		0.08						

[a]1989/90 elasticities.

Table 24. Summary of estimated domestic demand elasticities from the feed-grains trade model

Country/ Region	Corn Price	Sorghum Price	Barley Price	Oats Price	Soy Meal Price	Wheat Price	Income
	Elasticity with Respect to						
U.S.							
Corn food	-0.14					0.09	1.59
Corn feed	-0.29				0.06		
Corn stocks	-1.64						
Sorghum non-feed	0.48	-1.42	0.71				
Sorghum feed	1.21	-2.08				0.47	
Sorghum stocks		-1.51					
Barley nonfeed			-0.02				0.31
Barley feed	0.43		-0.66			0.06	
Barley stocks			0.48				
Oats nonfeed				-0.04			-0.95
Oats feed use	0.27			-0.52			
Oats stocks				-0.35			
Canada							
Barley use			-0.09		0.08		
Corn use	-0.24		0.14		0.10		0.82
Australia							
Barley use			-0.81			0.37	0.40
Barley stocks			-5.21				
Argentina							
Corn use	-0.25	0.28					
Corn stocks	-1.00						
Sorghum use	2.58	-3.62					
Sorghum stocks		-1.71					
EC-12							
Corn use	-0.58				0.06	0.41	0.19
Corn stocks	-0.35						
Barley feed			-0.15				0.30
Barley food			-0.13				0.78
Thailand							
Corn feed use	-0.11						0.88
Corn stocks	-0.35						
South Africa							
Corn use	-0.34						0.37
Corn stocks	-0.53						
Sorghum use		-0.13					0.85
Sorghum stocks		-0.35					
USSR							
Total feed-grain use	-0.03						
China							
Total feed-grain use							0.01

Table 24. Continued

Country/ Region	Corn Price	Sorghum Price	Barley Price	Oats Price	Soy Meal Price	Wheat Price	Income
	Elasticity with Respect to						
E. Europe							
Total feed grains							0.16
Japan							
Corn use	-0.04						0.30
Corn stocks	-0.14						
Sorghum use	0.52	-0.51					0.51
Barley use							0.42
Brazil							
Feed-grain use	-0.08						0.61
Mexico							
Sorghum use		-0.43					0.94
Feed-grain use	-0.31					0.28	0.41
Egypt							
Corn use							0.48
Corn stocks	-0.45						
Saudi Arabia							
Barley use							0.30
Nigeria							
Sorghum use		-0.002					
HIEA[a]							
Feed-grain use	-0.02						1.05
Feed-grain stock	-0.03						
Other Asia							
Feed-grain use	-0.01						0.22
Other Africa and Middle East							
Feed-grain stocks	-0.03						0.17
Other Latin America							
Feed-grain imports	-0.02				0.02		1.32
ROW[b]							
Feed-grain use			-0.58			0.23	0.84
Feed-grain stocks			-0.52				
ROW[b]							
Sorghum use	0.22	-0.18			0.02		0.29

[a]High-income East Asia.
[b]ROW category includes different countries for feed-grains and sorghum demand, respectively.

Table 25. Key price-transmission elasticities of feed-grains prices with respect to U.S. feed-grains prices

Country/ Region	U.S. Corn Price	U.S. Barley Price	U.S. Sorghum Price
Canada			
Barley		1.04	
Corn	0.94		
Australia			
Barley		1.01	
Sorghum			1.02
Argentina			
Corn	0.64		
Sorghum			0.49
Thailand			
Corn	0.99		
South Africa			
Corn	1.05		
Sorghum			0.95
Japan			
Corn	0.83		
Brazil			
Corn	0.53		
Mexico			
Corn	0.16		
Sorghum			0.39
Egypt			
Corn	0.86		

As indicated in previous sections, FAPRI models are highly flexible: they function in a highly interactive environment but are also capable of being operated independently. SAS and AREMOS, an econometric package developed by The WEFA Group, are generally used for estimation. The policy analyses, however, are conducted on microcomputers using LOTUS 1-2-3. One of the major advantages of using LOTUS 1-2-3 for policy analyses is that this program provides an opportunity for the analyst to examine changes occurring in endogenous variables during iteration.

The feed-grains trade model, along with other trade models and domestic crops and livestock models, is used on a regular basis to generate 10-year projections of demand, supply, trade, prices, and other key agricultural variables in the United States and other countries. These projections serve as a baseline scenario for policy-impact analyses. The models were used to analyze farm bill options during debate in 1985 and 1990, as well as some cost-cutting alternatives that were proposed later in response to budget pressure. Scenarios were also evaluated on specific trade and policy issues. A selected list of publications from these studies follows:

- "Impacts of EEC Policies on U.S. Export Performance in the 1980s." W. H. Meyers, R. Thamadoran, and M. Helmar. Chapter 6 in <u>Confrontation or Negotiation: United States Policy and European Agriculture</u>. New York: Associated Faculty Press, 1985.

- "Macroeconomic Impacts on the U.S. Agricultural Sector: A Quantitative Analysis for 1980-84." W. H. Meyers, M. Helmar, S. Devadoss, and D. Blanford. Chapter 24 in <u>Embargoes, Surplus Disposal, and U.S. Agriculture</u> AER Number 564, ERS/USDA, December 1986.

- "An Export Disposal Policy for Wheat and Corn Stocks by the United States: A Quantitative Analysis for 1977-1984." W. H. Meyers, S. Devadoss, and M. Helmar. Chapter 19 in <u>Embargoes, Surplus disposal, and U.S. Agriculture</u>, AER Number 564, ERS/USDA, December 1986.

- "The Iowa State University FAPRI Trade Model." W. H. Meyers, S. Devadoss, and M. Helmar. Proceedings of the International Agricultural Trade Research Consortium on Agricultural Trade Modeling: The State of Practice and Research Issues, Staff Report No. AGES861215, IED/ERS/USDA, June 1987, pp. 44-56.

- "Agricultural Trade Liberalizations: Cross-Commodity and Cross-Country Impact Products." W. H. Meyers, S. Devadoss, and M. Helmar. Journal of Policy Modeling, Vol. 9, No. 3 (November 1987), pp. 455-482.

- "FAPRI Ten-Year International Agricultural Outlook, July 1987." Food and Agricultural Policy Research Institute. Staff Report #4-87. University of Missouri-Columbia and Iowa State University, Ames.

- "FAPRI Ten-Year International Agricultural Outlook, March 1988." Food and Agricultural Policy Research Institute. Staff Report #1-88, University of Missouri-Columbia and Iowa State University.

- "Commodity Market Outlook and Trade Implications Indicated by the FAPRI Analysis." W. H. Meyers, S. Devadoss, and B. Angel. Food Aid Projections for the Decade of the 1990s. Report of an ad hoc panel meeting, National Research Council, October 6-7, 1988, pp. 98-121.

- "Agricultural Market Outlook and Sensitivity to Macroeconomic, Productivity, and Policy Changes." S. R. Johnson, W. H. Meyers, P. Westhoff, and A. Womack. CARD Working Paper #87-WP36 (November 1988). Center for Agricultural and Rural Development, Iowa State University, Ames.

- "Policy Scenarios with the FAPRI Commodity Models." CARD Working Paper #88-WP41 (December 1988). Center for Agricultural and Rural Development, Iowa State University, Ames.

- "FAPRI U.S. and World Agricultural Outlook, May 1989." Food and Agricultural Policy Research Institute. Staff Report #2-89. University of Missouri-Columbia and Iowa State University.

- "The Impact of the U.S. Export Enhancement Program on the World Wheat Market." H. G. Brooks, S. Devadoss, and W. H. Meyers. CARD Working Paper #89-WP46 (December 1989). Center for Agricultural and Rural Development, Iowa State University, Ames.

The feed-grains trade model should be evaluated as a model under construction. The model is continually being revised to deal with perceived problems, so this documentation must be seen as a snapshot of a work in progress, rather than as a portrait of a completed effort. Some of the shortcomings of the model have been pointed out, and efforts will be made to correct these shortcomings in the months and years to come.

Any revisions to the model should be made recognizing the strengths of the model. In its present form, the model makes it possible to examine a variety of issues important in policy analysis and market outlook. For the most part, the model behaves in an internally consistent and intuitively appealing way. Although it may be desirable to impose more structure upon the model and to use more appropriate estimation techniques, the current strengths of the model should not be sacrificed unnecessarily in the process.

APPENDIX

Simulation Statistics from the Dynamic Simulation of the World Feed-Grains Trade Model

VARIABLE	MEAN ERROR	MEAN % ERROR	MEAN ABS ERROR	RMS ERROR	RMS % ERROR
COMPRU9F	0.06867	954160995	0.07143	0.12399	82540.05
COAPNU9F	-5.31338	-8.52318	5.41716	9.38806	14.87173
COYHAU9F	0.07222	0.07229	0.07222	0.13417	0.13422
CONRNU9F	-1.87805	-1.53586	22.69363	29.44899	25.75262
CONRPU9F	2.90509	1.89494	11.69931	16.62321	12.81442
SBNRNU9F	-1.63E-05	-1.21E-05	3.24E-05	3.82E-05	3.22E-05
COAIAU9F	0.78394	22.00762	0.78394	1.45723	48.62771
COAPPU9F	4.88681	7.60E+10	5.05407	9.06168	6667948
COAPAU9F	-0.42656	-0.58747	1.10758	1.22377	1.60567
COAHAU9F	-0.18417	-0.33225	0.81937	1.05152	1.58462
COSPRU9F	-11.45748	-0.26088	74.50196	93.54089	1.53303
COUFEU9G	-0.29380	-0.46299	1.23264	1.74515	2.67723
COUOFU9C	-.0024717	-0.08931	0.03556	0.04264	1.69042
COUSDU9	-0.30026	-1.74447	0.67661	0.81939	4.58497
COUGAU9	-0.65433	-1.76745	1.13566	2.42727	6.23833
COFREU9	-22.35752	-0.06168	75.06295	98.26025	14.88671
COUOFU9	-0.56272	-0.08930	7.86926	9.44385	1.69042
COUFOU9	-1.51731	-0.20728	7.30551	8.86246	1.53225
COUFEU9	-16.76152	-0.46299	74.84488	105.51	2.67723
COCOTU9	-22.35752	-0.77982	75.06295	98.26025	8.66177
FGUXNU9	219.27	0.86071	2605.89	3185.52	7.17457
COUXNU9	115.97	0.70534	2720.41	3354.49	7.61831
COUXTU9	4.56533	0.70236	107.10	132.06	7.60844
SGMPRU9	-.0070639	1.43E+09	0.05451	0.09093	92664.38
SGAPNU9	0.31083	8.33908	0.96927	1.32914	22.33890
SGYHAU9	3.58E-05	6.59E-05	3.58E-05	3.58E-05	6.64E-05
SGAHPU9	.00934446	1.20743	0.01807	0.02281	2.86235
SGNRNU9	3.74875	8.72634	9.87446	13.49439	25.62470
SGNRPU9	2.47369	3.56787	4.38849	6.96467	9.04932
WHNRNU9	-8.98E-06	-1.63E-05	9.71E-06	1.12E-05	1.94E-05
SGAIAU9	-0.05239	-1.36906	0.09480	0.17088	11.42441
SGAPAU9	0.28710	1.78141	0.38312	0.53117	3.28135
SGAPPU9	-0.02373	2.03E+10	0.74629	1.14988	1229451
SGAHAU9	0.39571	3.02233	0.50080	0.68873	5.17008
SGSPRU9	23.67641	3.02240	29.07012	41.47677	5.17012
SGUFEU9	4.35103	1.66063	27.05872	31.00093	6.54194
SGUFOU9	0.35613	3.68982	0.78870	0.99707	9.47213
SGF9LU9	19.45855	-4.06468	48.53070	58.72155	103.93
SGCOTU9	19.45855	11.05919	48.53070	58.72155	51.20989
SGUXNU9	203.09	3.64602	953.10	1089.70	18.03922
SGUXTU9	7.99515	3.64602	37.52148	42.89921	18.03922
BAMPRU9	0.03326	1.50E+09	0.08463	0.12934	157258
BAAPNU9	0.09624	4.85722	0.75973	0.90652	27.42340
BAAHPU9	.00379184	0.42234	.00950811	0.01143	1.24591
BAYHAU9	.00015633	.00033759	.00015633	.00015637	.00033976
BANRNU9	-0.75320	-2.26921	4.70115	5.93577	13.69429
BANRPU9	0.55400	0.92642	1.83324	2.99033	4.34015
OANRNU9	-1.76658	-8.42785	6.18771	7.26652	26.04502
BAAIAU9	-0.04400	5.86364	0.17140	0.35491	21.87889

VARIABLE	MEAN ERROR	MEAN % ERROR	MEAN ABS ERROR	RMS ERROR	RMS % ERROR
BAAPAU9	0.34562	3.98160	0.44560	0.61027	6.91151
BAAPPU9	0.24937	1.30E+10	0.72619	1.04515	1368144
BAAHAU9	0.35370	4.40200	0.41305	0.57008	7.01706
BASPRU9	17.67088	4.40235	20.24538	28.89350	7.01728
BAUFEU9	12.08818	5.96489	14.27238	18.78033	9.57326
BAUFOU9C	.00053626	0.09433	.00777799	.00889251	1.24202
BAF9LU9	11.34467	9.00888	16.09727	22.04687	17.57032
BACOTU9	11.34467	7.52149	16.09727	22.04687	15.32927
BAUFOU9	0.10110	0.09433	1.71159	1.95750	1.24202
BAUXTU9	4.72558	17.17393	14.71380	19.18843	45.31030
OAMPRU9	-.0015233	-1.44025	.00152334	.00505235	4.77677
OAAHAU9	0.13463	1.34766	0.85564	1.01717	8.91682
OAAPAU9	0.14222	1.17258	0.95383	1.14155	7.03588
OAYHAU9	-3.25E-05	-6.38E-05	3.25E-05	3.36E-05	6.66E-05
CONRNU9	1.77927	1.37236	19.03631	26.83481	23.87806
OANRPU9	-1.82299	-8.02309	6.04353	7.04618	25.68062
SBNRNU9	-2.01E-05	-1.59E-05	2.86E-05	3.60E-05	2.97E-05
OAAIAU9	-.0014403	-1.44025	.00144025	.00477678	4.77678
OAAPNU9	0.15663	1.34653	0.96823	1.15838	7.27867
OAAPPU9	-0.01440	-1.44025	0.01440	0.04777	4.77678
OASPRU9	6.24534	1.34759	43.81247	51.84205	8.91680
OAUFEU9	8.68326	1.59375	20.00501	26.49280	5.31576
OAUFOU9C	.00022575	0.35206	0.01312	0.01538	4.42132
OAF9LU9	4.94010	1.96257	25.21033	28.41485	12.68252
OASMNU9	-0.03043	-43.18576	2.80223	3.82063	203.30
OACOTU9	4.94010	0.90833	25.21033	28.41485	10.87849
OAUFOU9	0.08280	0.35206	2.94411	3.49482	4.42132
OASMTU9	-0.03043	6.71E+10	2.80223	3.82063	7245168
COPFMARR	2.60463	1.33967	26.89206	33.88797	12.67511
SGPFMARR	1.58486	0.86221	17.85582	20.99320	9.15835
SBPFMARR	8.62716	2.13411	29.16210	42.70288	6.94543
WHPFMARR	-3.60777	-0.64704	13.28491	20.95538	5.73200
CECOTAR	-0.36764	-0.62070	0.79019	1.01107	1.71587
COAHHAR	6.78389	0.66000	158.32	227.60	7.19844
COCOTAR	-5.23322	11.11052	104.54	128.45	49.86941
COSMNAR	23.01655	1.17513	356.01	637.69	7.84916
COSPRAR	-6.40698	0.66176	517.70	800.80	7.19646
COUDTAR	-5.99364	0.04051	125.95	151.52	4.22386
SGAHHAR	115.21	5.68759	179.96	219.10	10.29441
SGCOTAR	-0.08290	18.77862	24.74097	32.50462	54.34872
SGSMNAR	-349.30	7.87368	556.52	686.11	17.19490
SGSPRAR	322.87	5.68670	517.81	642.48	10.29027
SGUDTAR	-27.51077	1.06413	334.45	392.92	17.32652
FGSMNAR	23.01655	1.07951	356.01	637.69	7.66783
BAPFMAU	-424.49	-2.71539	729.55	1012.96	8.47224
SGPFMAU	-49.94925	-0.03448	879.28	1193.12	10.54409
SHCOTAU	9.94786	7.08375	10.26327	11.40448	8.03038
GWPFMAU	-3.45547	-1.41075	6.34242	10.02437	4.16832
WHPEXAU	-3.70343	-3.27889	7.42658	9.31788	8.29839
WHPFMAU	-246.62	-2.93823	721.25	895.32	9.48168
BAAHHAU	-25.82487	0.44170	317.41	347.84	15.35284

VARIABLE	MEAN ERROR	MEAN % ERROR	MEAN ABS ERROR	RMS ERROR	RMS % ERROR
BACOTAU	24.44326	35.06320	49.84557	61.42801	71.96216
BASMNAU	20.14492	1.59662	444.22	519.42	43.07005
BASPRAU	-18.28322	0.43864	379.33	424.00	15.35142
BAUDTAU	-6.43738	-0.33170	148.59	175.84	14.50796
SGAHHAU	53.14331	9.47890	54.19797	62.88104	10.88122
SGCOTAU	3.70495	24.39559	18.52019	23.07295	57.61360
SGSMNAU	-148.35	29.91202	148.35	167.51	40.43437
SGSPRAU	99.38588	9.47890	100.93	117.48	10.88121
SGUDTAU	-51.60305	-11.31733	70.45686	87.66370	33.39873
FGSMNAU	139.42	-3.05921	563.50	668.73	42.66939
BAPOBCA	0.13919	0.54735	6.26217	7.92956	8.77397
COPFMCA	-2.81771	-2.15721	11.87021	14.75276	13.10470
RSPM1CA	0.04871	-0.35294	11.57364	13.42926	4.62647
SBPFMCA	0.35549	0.36192	6.08269	7.16184	3.51171
SMPFMCA	1.27795	0.84454	11.50196	17.21827	7.44672
LVCACCA	-0.02066	-0.08370	0.25011	0.32865	1.69367
BAAHHCA	-366.41	-7.43133	435.71	535.21	10.99792
BASMNCA	891.60	-25.30289	1068.63	1210.00	35.59047
BASPRCA	-822.25	-7.43129	990.12	1210.85	11.00054
BAUDTCA	69.34676	1.06186	257.90	285.38	4.08436
COAHHCA	3.55234	1.12617	22.72131	26.88015	4.07096
COCOTCA	-9.56355	3.57175	59.29414	80.13329	13.73385
COSMNCA	29.37212	92.36064	260.95	334.11	212.07
COSPRCA	10.32121	1.12483	123.84	143.91	4.07227
COUDTCA	46.94623	1.40351	352.33	403.78	7.53465
FGSMNCA	920.97	-37.39976	1130.90	1227.26	56.43200
COPFMTH	-71.73199	-2.04701	201.01	264.60	16.42253
SGPFMTH	-58.59605	-2.00697	171.04	232.48	13.77628
PLSPRTH	6.58826	8.02403	13.84751	16.44615	18.25611
COAHHTH	0.96853	0.10968	23.78098	29.50723	2.13320
COCOTTH	12.48812	41.24080	35.69294	46.73291	113.96
COSMNTH	-3.06458	0.30431	74.43764	84.23098	4.73026
COSPRTH	7.67071	0.11386	48.14346	61.40497	2.13132
COUFETH	9.83195	0.26685	48.63586	58.84256	27.61262
FGSMNTH	-3.06458	0.30431	74.43764	84.23098	4.73026
SMPFME0	-1.69140	-0.60390	7.23421	9.37054	5.33908
POSPRE2	84.65281	0.97707	185.17	257.55	2.75616
PYSPRE2	7.02067	0.24773	95.43399	113.98	2.51521
BAAHHE2	-45.78286	-0.37000	62.19146	75.26013	0.60754
BACOTE2	-59.42174	-0.28830	294.37	432.96	13.22900
BASMNE2	129.66	-10.03809	554.13	759.40	138.67
BASPRE2	-154.23	-0.37000	210.78	253.43	0.60754
BAUFEE2	60.05552	0.20640	458.53	559.87	1.70568
BAUHTE2	-54.76520	-0.57528	196.47	224.00	2.27752
COAHHE2	42.15126	1.12887	66.27192	83.54807	2.21188
COCOTE2	9.23924	0.31244	199.19	253.61	6.89861
COSMNE2	-247.37	-1.64972	742.35	917.93	4.76636
COSPRE2	184.02	1.12887	311.41	382.73	2.21188
COUDTE2	-86.47077	-0.19969	871.39	1013.55	2.71480
FGSMNE2	-117.72	-1.59481	1113.03	1464.77	7.58780

VARIABLE	MEAN ERROR	MEAN % ERROR	MEAN ABS ERROR	RMS ERROR	RMS % ERROR
COPFMZA	0.05098	3.58590	16.11529	19.49860	19.24701
SGPFMZA	-55.18451	0.12009	724.64	926.53	10.27966
WHPFMZA	190.24	3.27492	836.45	955.12	10.34514
COAHHZA	45.16524	1.02598	89.77749	109.78	2.51424
COCOTZA	29.17369	90.81157	193.05	234.34	318.59
COSMNZA	-141.18	72.94877	624.87	723.71	209.51
COSPRZA	59.33890	1.02597	199.97	267.85	2.51423
COUDTZA	-122.07	-2.05976	376.72	422.68	6.62516
SGAHHZA	-1.47730	0.56699	28.45731	34.27667	13.57640
SGSPRZA	-8.24531	0.56698	45.28777	52.99357	13.57639
SGUDTZA	1.41498	0.80535	23.65482	30.33212	10.78082
COVIMJP	-1178.74	-3.76374	2888.91	3697.18	10.74420
HOCOTJP	0.03356	0.31994	0.13286	0.15521	1.83212
PYSPRJP	5.77171	0.26998	17.55612	25.20639	2.46884
BAAHHJP	-14.10511	-13.93462	19.89812	22.03704	22.77607
BACOTJP	0.33259	3.74783	77.16546	100.75	21.79072
BASMNJP	-22.47168	-1.43244	66.30237	82.69094	6.01666
BASPRJP	-44.68392	-13.93462	60.39135	68.31218	22.77608
BAUFEJP	-21.92299	-1.50804	50.47059	59.00623	4.70508
BAUHTJP	-54.62503	-12.47661	103.49	114.21	23.89764
COCOTJP	0.24677	0.62391	108.67	147.72	12.88077
COSMNJP	168.98	0.93260	512.41	556.62	5.72228
COUDTJP	172.58	0.88589	473.96	515.43	5.45140
SGCOTJP	-65.99527	-12.87387	80.68662	103.84	21.71774
SGSMNJP	-81.79503	-0.95404	285.76	357.88	9.18196
SGUDTJP	-82.03387	-1.04283	277.88	325.09	8.48398
FGSMNJP	146.51	0.66294	492.03	539.47	4.71434
CECOTSU	0.06775	0.05239	0.53056	0.62991	0.56746
FGAHHSU	-1192.64	-2.56960	1692.19	2205.09	4.79826
FGCOTSU	600.69	29.70951	671.03	853.68	57.70396
FGSMNSU	869.61	37.80022	1990.87	2555.17	85.52086
FGSPRSU	-1966.77	-2.56960	2837.04	3889.23	4.79826
FGUDTSU	-1258.51	-1.51838	3269.60	3531.58	4.21887
HOCOTE8	-0.54917	-0.83040	1.15896	1.39307	2.22625
FGSPRE8	-516.22	-0.98467	761.80	975.20	1.85660
FGCOTE8	-56.65738	-1.19541	213.90	261.19	10.66911
FGUDTE8	-707.17	-1.20286	1459.72	1646.37	2.94752
FGSMNE8	-232.64	1.41096	1295.86	1497.74	29.43054
FGAHHE8	-142.42	-0.98467	214.93	264.95	1.85660
HOCOTCN	-0.99679	-0.20086	8.12983	9.54447	3.41679
FGAHHCN	-169.20	-0.76442	336.81	459.65	2.08013
FGUDTCN	-521.51	-1.03281	1037.19	1209.82	2.53285
FGSPRCN	-275.44	-0.76442	714.58	903.88	2.08013
FGSMNCN	-244.43	1050.81	809.98	924.53	3118.08
FGAHHR4	8.13678	3.15196	34.93972	41.85965	8.67651
FGCOTR4	-111.67	-1.37005	279.65	319.60	22.41220
FGUDTR4	-96.42578	-1.70712	220.87	276.67	4.93346

VARIABLE	MEAN ERROR	MEAN % ERROR	MEAN ABS ERROR	RMS ERROR	RMS % ERROR
FGSPRR4	26.27451	3.15197	85.49704	104.71	8.67652
FGSMNR4	-102.74	-2.50359	224.86	259.53	6.75907
COPFMRBR	292.29	4.15136	813.37	1054.05	16.28529
WHPFMRBR	301.65	2.68680	517.73	671.55	6.05587
SBPFMRBR	851.19	5.94966	1734.37	2604.20	19.41611
FGAHHBR	184.43	1.80155	638.12	763.54	6.76288
FGUDTBR	219.08	1.06443	486.42	592.42	3.40010
FGSPRBR	296.25	1.80155	981.96	1152.43	6.76288
FGSMNBR	-77.17444	22.43592	1065.61	1434.82	249.46
COPFMMXR	40.90076	1.35796	137.57	163.37	4.24797
SGPFMMXR	-1135.12	-37.71501	1135.12	1201.15	38.69064
WHPFMMXR	171.35	4.72296	217.85	279.58	8.48418
POSPRMX	-176.87	-22.32433	176.87	191.12	23.36837
FGAHHMX	-60.35520	-0.64541	186.39	205.33	2.58348
FGCOTMX	-58.97374	-1.89149	114.12	126.96	31.42600
FGUDTMX	-1276.96	-10.07792	1314.68	1761.95	13.85476
FGSPRMX	-74.53489	-0.64541	219.54	241.02	2.58347
FGSMNMX	-1190.01	-76.30048	1298.07	1764.24	124.40
SGAHHMX	-366.15	-32.71025	380.09	418.13	37.70080
SGCOTMX	-140.84	-106.26	159.42	198.38	285.72
SGUDTMX	19.61030	4.46831	432.25	524.32	20.65143
SGSPRMX	-1010.00	-32.71025	1037.90	1154.96	37.70080
SGSMNMX	1032.18	226.37	1032.18	1116.38	323.20
COPFMEG	5.07662	8.03033	10.27258	13.41314	17.50329
COSPREG	-6.69008	-0.48215	82.52108	97.09313	3.32049
COCOTEG	75.33648	1.18E+13	213.63	409.64	1.24E+09
COUDTEG	136.40	7.95968	225.47	389.36	25.10591
COAHHEG	-2.68619	-0.48274	21.63005	25.46592	3.31804
COSMNEG	151.54	94.31192	260.70	437.25	311.50
FGSMNEG	151.54	94.31191	260.70	437.25	311.50
EGSPRSA	2.01817	-0.37836	15.52853	22.62711	8.43879
BAUDTSA	-3.86641	-14.09296	234.14	328.24	312.30
BASMNSA	-3.86641	-90.06810	234.14	328.24	636.70
FGSMNSA	-3.86641	11.59490	234.14	328.24	138.82
SGPFMNG	0.41599	1.67139	5.41618	7.01691	8.56454
COPFMNG	0.51871	1.16258	4.85304	6.65848	6.52481
SGAHHNG	-28.16769	-0.39456	72.70190	92.79794	1.69217
SGUDTNG	-2.85629	-0.04921	56.55966	63.70818	1.74207
SGSPRNG	-13.03162	-0.39455	50.19004	66.49798	1.69218
SGAHHIN	-215.25	-1.31587	263.40	313.52	1.92876
SGCOTIN	-23.06123	-3.14143	35.93889	43.53019	6.55774
SGUDTIN	-208.12	-2.02908	254.94	286.24	2.78533
SGSPRIN	-145.01	-1.31587	176.73	212.59	1.92876
FGSPRNO	71.43142	1.46564	328.34	396.58	6.22965
FGCOTNO	36.04320	16.23362	97.17264	110.91	31.90571
FGSMNNO	-116.92	-7.94362	256.09	296.75	17.50903
FGUDTNO	-55.83711	-0.58254	201.45	248.46	3.13378
FGSPRFO	396.55	1.72737	1176.69	1487.44	5.49464
FGCOTFO	0.02511	6.54349	442.86	585.90	23.21762
FGUDTFO	399.61	1.66028	1207.67	1561.68	5.34979

VARIABLE	MEAN ERROR	MEAN % ERROR	MEAN ABS ERROR	RMS ERROR	RMS % ERROR
FGSMNF0	11.52385	13.99406	866.92	1000.44	60.27547
FGAHHF0	377.93	1.72738	1080.67	1374.42	5.49465
FGSPRS0	73.24111	0.41848	525.77	643.72	3.20084
FGUDTS0	-70.81785	-0.32963	584.13	668.81	3.21444
FGSMNS0	-144.06	-11.05999	214.30	259.18	71.09976
FGAHHS0	53.94412	0.41847	440.84	535.62	3.20084
FGAHHROW	-45.87889	-1.74856	67.80092	77.29219	2.96423
FGCOTROW	-115.89	-5.54915	211.60	255.68	15.24383
FGUDTROW	167.89	2.29260	710.09	826.81	7.90393
FGSPRROW	-181.82	-1.76893	272.42	310.43	2.98389
FGSMNROW	330.48	-18.42145	721.14	951.29	46.55936
SGAHHROW	52.09708	0.56373	383.08	455.45	3.08652
SGCOTROW	38.00612	2.19138	114.76	140.28	9.41128
SGUDTROW	-133.31	-0.52061	428.77	613.24	2.65435
SGSPRROW	63.73288	0.56371	488.17	576.47	3.08652
SGSMNROW	-207.86	-4.67129	492.28	615.37	14.61896
CORPF	-0.03741	-1.46265	0.24210	0.31271	12.26411
SORPF	.00094152	0.27313	0.18472	0.23280	9.55658
BARPF	-0.03279	-1.41571	0.11502	0.13712	6.30999
COPOBU9	-2.64774	-2.43111	9.58241	12.61072	11.05964
SGPOBU9	-0.68248	-0.66109	7.48562	10.00379	8.76890
OAPFMU9	-0.01929	-2.09989	0.13018	0.14497	10.07583
BAPFMU9	-0.03279	-1.41571	0.11502	0.13712	6.30999
SGPFMU9	0.02186	1.23003	0.19654	0.25456	10.82247

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