3-1991

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

Michael D. Helmar
_Iowa State University_

S. Devadoss
_Iowa State University_

William H. Meyers
_Iowa State University_

Follow this and additional works at: http://lib.dr.iastate.edu/card_technicalreports

Part of the Agricultural and Resource Economics Commons, Agricultural Economics Commons, and the Econometrics Commons

Recommended Citation

http://lib.dr.iastate.edu/card_technicalreports/28

This Article is brought to you for free and open access by the CARD Reports and Working Papers at Iowa State University Digital Repository. It has been accepted for inclusion in CARD Technical Reports by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
The World Feed-Grains Trade Model: Specification, Estimation, and Validation

Abstract
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.

Disciplines
Agricultural and Resource Economics | Agricultural Economics | Econometrics
The World Feed-Grains Trade Model: Specification, Estimation, and Validation

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

Technical Report 91-TR 18
March 1991

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.

Support for this research was provided in part by the Food and Agricultural Policy Research Institute (FAPRI). FAPRI is a joint policy-analysis program at Iowa State University and the University of Missouri-Columbia.
## CONTENTS

Figures ........................................... v
Tables ........................................... v

Introduction ........................................ 1
Modeling Approach .................................... 2

Specification ......................................... 7
  Theoretical Foundations ............................. 7
  Demand ........................................... 12
  Data Sources ..................................... 15

Empirical Results ................................... 16
  United States Submodel ............................ 17
  Canadian Submodel ................................ 42
  Australian Submodel ............................... 49
  Argentine Submodel ............................... 56
  The European Community Submodel ................. 62
  Thai Submodel ................................... 70
  South African Submodel ............................ 74
  Soviet Submodel ................................... 79
  Chinese Submodel ................................ 80
  Eastern European Submodel ......................... 80
  Japanese Submodel ................................ 87
  Brazilian Submodel ................................ 98
  Mexican Submodel ................................ 98
  Egyptian Submodel ................................ 108
  Indian Submodel ................................... 112
  Nigerian Submodel ................................ 112
  Saudi Arabian Submodel ............................ 117
  High-Income East Asian Submodel .................. 117
  "Other Asia" Submodel .............................. 122
  "Other Africa and Middle East" Submodel ........... 122
  "Other Latin America" Submodel ..................... 122
  Rest-of-the-World Submodel ......................... 128

Evaluation .......................................... 133

Uses of the Model ................................... 135

Appendix: Simulation Statistics from the Dynamic Simulation of the World Feed-Grains Trade Model ........................................ 145

References .......................................... 151
FIGURES

1. Representation of the structure of the world feed-grains trade model .................................... 3
2. Determination of equilibrium prices and quantities in the CARD/FAPRI agricultural trade models ............ 5

TABLES

1. Structural parameter estimates of the U.S. feed-grains submodel ............................................. 18
2. Structural parameter estimates of the Canadian feed-grains submodel ........................................ 43
3. Structural parameter estimates of the Australian feed-grains submodel ...................................... 50
4. Structural parameter estimates of the Argentine feed-grains submodel ....................................... 57
5. Structural parameter estimates of the European Community feed-grains submodel ....................... 65
6. Structural parameter estimates of the Thai feed-grains submodel ............................................ 71
7. Structural parameter estimates of the South African feed-grains submodel .................................. 75
8. Structural parameter estimates of the Soviet feed-grains submodel ........................................... 81
9. Structural parameter estimates of the Chinese feed-grains submodel ........................................ 83
10. Structural parameter estimates of the Eastern European feed-grains submodel ............................... 85
11. Structural parameter estimates of the Japanese feed-grains submodel ....................................... 88
12. Structural parameter estimates of the Brazilian feed-grains submodel ...................................... 99
13. Structural parameter estimates of the Mexican feed-grains submodel ...................................... 102
14. Structural parameter estimates of the Egyptian feed-grains submodel ...................................... 109
15. Structural parameter estimates of the Indian feed-grains submodel ........................................ 113
16. Structural parameter estimates of the Nigerian feed-grains submodel .................................... 115
17. Structural parameter estimates of the Saudi Arabian feed-grains submodel ................................ 118
18. Structural parameter estimates of the high-income East Asian feed-grains submodel ............................................. 120
19. Structural parameter estimates of the "Other Asia" feed-grains submodel ......................................................... 123
20. Structural parameter estimates of the "Other Asia and Middle East" feed-grains submodel ..................................... 124
21. Structural parameter estimates of the "Other Latin America" feed-grains submodel ........................................... 126
22. Structural parameter estimates of the ROW feed-grains submodel ................................................................. 129
23. Summary of estimated production elasticities from the feed-grains trade model .................................................. 136
24. Summary of estimated domestic demand elasticities from the feed-grains trade model ..................................... 138
25. Key price-transmission elasticities of feed-grains prices with respect to U.S. feed-grains prices ............................ 140
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.
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:

\[ \text{EDT} = \sum_{i=1}^{m} \left[ \text{FOD}_i(PD_1, X_{1i}) + \text{FED}_i(PD_1, X_{2i}) + \text{SD}_i(PD_1, X_{3i}) - S_i(PD_1, X_{4i}) \right], \]

where \( m \) importers;
Figure 2. Determination of equilibrium prices and quantities in the CARD/FAPRI agricultural trade models.
\[ ESO = \sum_{j=1}^{n} \{ S_j(P_{ij}, X_{ij}) - [FOD_j(PD_j, X_{ij}) + FED_j(PD_j, X_{2j}) + SD_j(PD_j, X_{3j})] \} \]

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 \((k = 1, \ldots, 3)\), 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\textsuperscript{th} country (exporting or importing country) is specified as

Area Harvested,

\[ A_{i,t} = A(H_{i,t-1}, P_{i,t-1},GP_{i,t},Z_{i,t}); \]

Production,

\[ PROD_{i,t} = A_{i,t} \times YLD_{i,t}; \]

Supply,

\[ S_{i,t} = PROD_{i,t} + IM_{i,t} + BS_{i,t}, \]

where area harvested \((A_{i,t})\) is expressed as a function of the lagged domestic supply price of feed-grains \((P_{i,t-1})\), the lagged domestic price of competing grain products \((GP_{i,t})\), and other factors \((Z_{i,t})\).
crops \((P_{C_{i,t-1}})\), 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,

\[ FOD_{i,t} = POP_{i,t} \times PFOD_{i,t} \]

Feed Demand,

\[ FED_{i,t} = FED(PD_{i,t}, PS_{i,t}, LPI_{i,t}, LN_{i,t}) \]

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 \([\text{[program planted and idled]/base acreage]}\) is expressed as a function of the difference between participant expected net returns \((\text{PARTENR})\) and nonparticipant expected net returns \((\text{NPARTENR})\):

\[
\text{PART} = f(\text{PARTENR} - \text{NPARTENR}),
\]

where \(\text{PART}\) 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 \((\text{PARTENR})\) 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 \(\text{PARTENR}\) is as follows:
PARTENR = max\(0, TP - \max(LR, LFR)\) * PY(1 - ARPR - PLDR) \\
+ DPR * PY * PLDR + \max(LR, LFP) * TY(1 - ARPR - PLDR) \\
- VC(1 - ARPR - PLDR) - 20(ARPR + PLDR). \hspace{1cm} (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

\[ \text{NPARTENR} = \text{LFP} \times \text{TY} - \text{VC}, \hspace{1cm} (3) \]

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

Area planted under programs (APP) is defined as

\[ \text{APP} = \text{PART}(1 - \text{ARPR} - \text{PLDR}) \times \text{BA}, \hspace{1cm} (4) \]

where BA is the base average.
Total land idled (IA) under the acreage reduction and the paid land diversion programs is defined as

\[ IA = \text{PART}(\text{ARPR} + \text{PLDR}) \times \text{BA}, \]  

(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:

\[ \text{APNP} = f(\text{NPARTNR}, \text{OCENR}, \text{APP}, \text{IA}, \text{LAPNP}), \]  

(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

\[ \text{AP} = \text{APP} + \text{APNP}. \]  

(7)

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

\[ \left(\frac{\text{AH}}{\text{AP}}\right) = f(T, \text{LFP}, X_{\text{(AH/AP)}}), \]  

(8)

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

Area harvested is defined as

\[ \text{AH} = \text{AP(AH/AP)}. \]  

(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

\[ YD = f(TP, IA, T, X_{wy}). \]  \hspace{1cm} (10)

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

\[ PROD = AH \times YD. \]  \hspace{1cm} (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

\[ S = PROD + BI + IM. \]  \hspace{1cm} (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 \( (\text{FOOD}) \) is

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

where \( P_{own} \) represents the own price of the commodity in real terms, \( P_{cross} \) represents the real price of competing goods, \( \text{RPCE} \) 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 \( (\text{FEED}) \) 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 \( (P_L) \), livestock numbers \( (LN) \), and a vector of other variables \( X_{feed} \). Thus, the functional form of feed demand is

\[
\text{FEED} = f(P_{own}, P_{cfeed}, P_L, LN, X_{feed}). \tag{14}
\]

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

\[
\text{SEED} = f(AP, T). \tag{15}
\]
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

\[ \text{STOCK} = f(P_{\text{own}}, \text{PROD}, E\text{PROD}, \text{GSTOCK}, X_{\text{STOCK}}), \]  

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

Exports. Feed-grain exports are determined as residuals:

\[ \text{EX} = \text{PROD} + \text{BI} + \text{IM} - \text{FOOD} - \text{FEED} - \text{SEED} - \text{EI}. \]
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,

\[ QD = f(QP_t, Y_t). \]  \hspace{1cm} (17)

A linear specification of this demand function is

\[ QD_t = \alpha_0 + \alpha_1 Y + \alpha_2 QP_t, \quad \alpha_1 > 0, \text{ and } 0 < \alpha_2 < 1. \]  \hspace{1cm} (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)

\[\text{COMPRU9F} = 0.561 + 0.770(\text{CONRPU9F} - (0.8 \times \text{CONRNU9F}) + 0.2 \times \text{SBNRNU9F})/\text{PWSAU9} - 0.594 \times \text{DM173} - 0.6 \times \text{DM174} + 0.615 \times \text{DM175} - 0.535 \times \text{DM176} - 0.559 \times \text{DM179} - 0.568 \times \text{DM180}\]

\[R^2 = 0.85 \quad DW = 1.65\]

(1.2) Participants Corn Expected Net Return

\[\text{CONRPU9F} = \max(\text{COPTGU9F} - \max(\text{COPLNU9F}, \text{COPFMU9}), 0) \times (1 - \text{COMARU9F} - \text{COMPLU9F}) + \text{CODPRU9F} \times (1 - \text{COMARU9F} - \text{COMPLU9F}) - \text{COVCAU9F}(1 - \text{COMARU9F} - \text{COMPLU9F}) - 20(\text{COMARU9F} + \text{COMPLU9F})\]

(1.3) Nonparticipants Corn Expected Net Return

\[\text{CONRNU9F} = \text{COPFMU9} \times (1 - \text{COMARU9F} - \text{COMPLU9F}) - \text{COVCAU9F}\]

(1.4) Soybeans Expected Net Return

\[\text{SBNRNU9F} = \text{SBPFMU9} \times (1 - \text{COMARU9F} - \text{COMPLU9F}) - \text{SBVCAU9F}\]

(1.5) Corn Nonprogram Acreage (Next Year)

\[\text{COAPNU9F} = 82.741 - 0.963 \times \text{COAPFU9F} - 0.743(\text{COAIAU9F} + \text{COCRPU9F}) + 5.050 \times \text{CONRNU9F}/\text{PWSAU9} - 2.814 \times \text{SBNRNU9F}/\text{PWSAU9}\]

\[R^2 = 0.85 \quad DW = 1.65\]
Table 1. Continued

<table>
<thead>
<tr>
<th>Equation</th>
<th>Corn Program Acreage (Next Year)</th>
<th>Total Corn Area Planted (Next Year)</th>
<th>Corn Area Harvested as a Proportion of Area Planted (Next Year)</th>
<th>Corn Area Idled</th>
<th>Total Corn Area Harvested</th>
<th>Corn Yield (Next Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$COAPPU9F = COMPRU9F \times COABAU9F(1 \times COMARU9F - COMPLU9F)$</td>
<td>$COAPAU9F = COAPPU9F + COAPNU9F$</td>
<td>$COAHPU9F = 0.800 - 0.043 DM182 + 0.020 \log(\text{TREND-1959})$</td>
<td>$COAHAU9F = COAPAU9F \times COAHPU9F$</td>
<td>$COAIAU9F = COABAU9F \times \text{COMPRU9F}(\text{COMARU9F} + \text{COMPLU9F})$</td>
<td>$COYHAU9F = 211.400 + 2134.020 \text{COPTGU9F/PWSAU9}$</td>
<td></td>
</tr>
<tr>
<td>$R^2 = 1.00$</td>
<td>$DW = 2.40$</td>
<td>$(28.75)$</td>
<td>$(3.70)$</td>
<td>$(1.90)$</td>
<td>$(5.20)$</td>
<td>$(1.46)$</td>
</tr>
</tbody>
</table>
Table 1. Continued

\[ + 83.272 \log(\text{TREND} - 1945) + 0.092 \text{ COAIAU9F} + \text{ COCROPU9F} \]
\[ (9.46) \quad (0.50) \]
\[ + 10.604 \text{ DMCOYU9F} - 20.804 \text{ DM182} \]
\[ (3.95) \quad (2.63) \]

\[ R^2 = 0.92 \quad \text{DW} = 2.35 \]

1.12) Corn Production (Next Year)

\[ \text{COSPRU9F} = \text{COAHAU9F} \times \text{COYHAU9F} \]

1.13) Corn Feed Use

\[ \text{COUFEU9G} = 40.505 - 1749.760 \frac{\text{COPFMU9}}{\text{PWSAU9}} \]
\[ (3.20) \quad (5.91) \]
\[ [-0.29] \]
\[ + 2374.48 \frac{\text{LVPIU9}}{\text{PWSAU9}} - 0.430 (\text{WHUFEU9} \times 60/56 + \text{SGUFEU9}) \]
\[ (2.04) \quad (2.22) \]
\[ [0.29] \quad [-0.14] \]
\[ + \text{BAUFEU9} \times 48/56 + \text{OAUFEU9} \times 32/56) / \text{GCAUU9} \]
\[ + 10.230 \log(\text{TREND} - 1959) + 4.941 \frac{\text{SMPFMU9}}{\text{PWSAU9}} \]
\[ (4.13) \quad (1.28) \]
\[ [0.06] \]
\[ + 14.430 \text{ DM173} - 6.735 \text{ DM176} \]
\[ (4.72) \quad (3.46) \]

\[ R^2 = 0.89 \quad \text{DW} = 3.08 \]

1.14) Total Corn Feed Use

\[ \text{COUFEU9} = \text{COUFEU9G} \times \text{GCAUU9} \]

1.15) Corn Food Use

\[ \text{COUOFU9C} = 5.900 - 0.337 \frac{\text{COPFMU9}}{(2.763 \times \text{SUPRTU9}/25.805)} \]
\[ (10.40) \quad (2.12) \]
\[ [-0.14] \]
Table 1. Continued

+ 4.071 LOG(CESAU9/DEPOPU9)  
(16.82)  
(1.59)  

- 2.530 DM1S83 LOG(CESAU9/DEPOPU9) + 0.345 DM1S80  
(1.85)  
(5.88)  
[-0.99]  

+ 5.900 DM1S83  
(1.89)  

R² = 0.99      DW = 1.80

(1.16) Total Corn Food Use

COUOFU9 = COUOFU9 * DEPOPU9

(1.17) Corn Gasohol Use

COUGAU9 = 0.000 - 4772.700 DM1S80 * COPFMU9/PWFSAU9  
(0.00)  
(2.67)  
[-0.11]  

+ 602.730 DM1S79 * LOG(TREND - 1965)  
(8.12)  

- 1580.690 DM1S79 + 12.871 TRND8184  
(8.01)  
(2.20)  

R² = 0.99      DW = 2.76

(1.18) Corn Seed Use

COUSDU9 = 296.314 + 0.280 COAPAU9F + 0.150 TREND  
(5.51)  
(13.88)  
(5.40)  
[1.20]  

R² = 0.95      DW = 1.72

(1.19) Total Corn Domestic Use

COUTOU9 = COUFEU9G + COUOFU9 + COUGAU9 + COUSDU9
Table 1. Continued

(1.20) Corn Free Stocks

\[ \text{COFREU9} = 465.703 - 31056.000 \ \text{COPMFU9/PWSAU9} - 0.053 \ \text{COSPRU9F} \]
\[ (1.47) \quad (1.89) \quad (1.74) \]
\[ [-1.64] \quad [-0.66] \]

\[ + 0.147 \ \text{LAG(COSPRU9F)} + 231.238 \ \text{DM1875} \]
\[ (3.92) \quad (2.12) \]
\[ [1.83] \]

\[ - 0.313(\text{CO9LNU9} + \text{COCCCU9} + \text{COFORU9}) \]
\[ (7.46) \]
\[ [-0.68] \]

\[ R^2 = 0.85 \quad \text{DW} = 1.94 \]

(1.21) Corn Total Stocks

\[ \text{COCOTU9} = \text{COFREU9} + \text{CO9LNU9} + \text{COFORU9} + \text{COCCCU9} \]

(1.22) Corn Gulf-Port Price

\[ \text{COPOBU9} = 1.0913 \ \text{CORPF} \times 39.368 + 5.8374 \]

(1.23) Corn Domestic Market Equilibrium

\[ \text{COSPRV9} + \text{LAG(COCOTU9)} + \text{COSMTU9} = \text{COUFUEU9} + \text{COUFOU9} + \text{COUXTU9} \]
\[ + \text{COCOTU9} + \text{COURSU9} \]

(1.24) Sorghum Participation Rate

\[ \text{SGMPRU9} = 26.685 + 1.153(\text{SGENRPU9} - \text{SGNRNU9})/\text{PWSAU9} - 0.013 \ \text{TREND} \]
\[ (1.68) \quad (1.87) \quad (1.65) \]

\[ + 0.314 \ \text{DM172} - 0.600 \ \text{DM174} - 0.586 \ \text{DM175} \]
\[ (2.41) \quad (4.62) \quad (4.55) \]

\[ - 0.573 \ \text{DM176} - 0.635 \ \text{DM177} - 0.554 \ \text{DM180} \]
\[ (4.47) \quad (4.78) \quad (4.31) \]
Table 1. Continued

\[-0.507 \text{ DM181} \]
\[(3.82)\]

\[R^2 = 0.91 \quad \text{DW} = 1.67\]

(1.25) **Sorghum Participant Net Return**

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

\[\times \text{SGYHPU9}(1 - \text{SGMARU9} - \text{SMPLU9}) + \text{SGDPRU9} \times \text{SGYHPU9} \times \text{SMPLU9}\]

\[+ \max(\text{SGPLNU9}, \text{LAG(SGPFMU9)}) \times \text{SGYHTU9}(1 - \text{SGMARU9})\]

\[- \text{SMPLU9} - \text{SGVCAU9}(1 - \text{SGMARU9} - \text{SMPLU9})\]

\[-20(\text{SGMARU9} + \text{SMPLU9})\]

(1.26) **Wheat Net Return**

\[\text{WHNRNU9} = \text{LAG(WHPFMU9)} \times \text{WHYHTU9} - \text{WHVCAU9}\]

(1.27) **Sorghum Nonparticipant Net Returns**

\[\text{SGNRNU9F} = \text{SGPFMU9} \times \text{SGYHTU9F} - \text{SGVCAUF} \]

(1.28) **Sorghum Area Planted by Participants**

\[\text{SGAPPU9} = \text{SGMPRU9} \times \text{SGABAU9}(1 - \text{SGMARU9} - \text{SMPLU9})\]

(1.29) **Sorghum Area Planted by Nonparticipants**

\[\text{SGAPNU9} = 19.783 + 8.691 \text{SGNRNU9/PWSAU9} - 1.096 \text{WHNRNU9/PWSAU9}\]

\[(20.03) \quad (3.42) \quad (0.43)\]

\[+ 0.868 \text{SGAPPU9} - 0.747 \text{SGIAAU9} + \text{SGCRPU9}\]

\[(17.89) \quad (8.66) \quad [-0.47] [-0.19]\]

\[-5.557 \text{DM1S74} - 2.851 \text{DM173} + 2.070 \text{DM185}\]

\[(11.07) \quad (4.09) \quad (3.53)\]

\[R^2 = 0.99 \quad \text{DW} = 2.35\]
Table 1. Continued

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

\[ SGAIAU9 = SGABAU9 \times SGMPRU9(SGARU9 + SGPLU9) \]

(1.31) Sorghum Total Area Planted

\[ SGAAPU9 = SGAPPU9 + SGAPNU9 \]

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

\[ SGAHPU9 = 0.544 + 0.023 DMSGYU9 + 0.103 \text{ LOG(TREND - 1959)} \]

\[ R^2 = 0.76 \quad \text{DW} = 1.56 \]

(1.33) Sorghum Total Area Harvested

\[ SGAHAU9 = SGAAPU9 \times SGAHPU9 \]

(1.34) Sorghum Yield

\[ SGYHAU9 = 1369.810 + 0.171 \text{TREND} + 806.744 \text{ SGPTGU9/PWSAU9} \]

\[ + 8.422 \text{ DMSGYU9} \]

\[ R^2 = 0.78 \quad \text{DW} = 2.64 \]

(1.35) Sorghum Production

\[ SGSPRU9 = SGAHAU9 \times SGYHAU9 \]

(1.36) Sorghum Feed Use

\[ SGUFEU9 = 568.311 - 115318.000 \text{ SGPMU9/PWSAU9} \]

\[ (2.43) \quad (2.59) \quad [-2.08] \]
Table 1. Continued

\[ + 60406.300 \ COPFMU9/PWSAU9 + 17993.500 \ WHPMU9/PWSAU9 \]
\[ (1.50) \quad (1.67) \]
\[ [1.21] \quad [0.47] \]
\[ + 38.731 \ CATNFU9 - 15,952 \ TRND6783 \]
\[ (1.68) \quad (3.98) \]
\[ [0.65] \]
\[ R^2 = 0.66 \quad DW = 1.64 \]

(1.37) Sorghum Food, Seed, and Industrial Use

\[ SGUFOU9 = 14.803 - 1857.54 \ SGPFMU9/PWSAU9 \]
\[ (7.84) \quad (1.30) \]
\[ [-1.42] \]
\[ + 949.118 \ BAPF MU9/PWSAU9 + 567.415 \ COPFMU9/PWSAU9 \]
\[ (1.48) \quad (0.57) \]
\[ [0.71] \quad [0.48] \]
\[ + 14.652 \ DM185 \]
\[ (6.61) \]
\[ R^2 = 0.81 \quad DW = 2.04 \]

(1.38) Sorghum Free and Nine-Month Loan Stocks

\[ SGF9LU9 = 51.677 + 0.395 \ LAG(SGF9LU9) - 14294.5 \ SGPFMU9/PWSAU9 \]
\[ (0.39) \quad (2.02) \quad (1.92) \quad [-1.51] \]
\[ + 0.230 \ SGSF1U9 - 0.234(SGCCCU9 + SGFORU9) \]
\[ (2.30) \quad (2.01) \]
\[ [1.97] \quad [-0.38] \]
\[ R^2 = 0.60 \quad DW = 1.70 \]

(1.39) Sorghum Total Stocks

\[ SGCOTU9 = SGCCCU9 + SGFORU9 + SGF9LU9 \]

(1.40) Sorghum Price Linkage Equation

\[ SGFOBU9 = 5.90457 + 44.7348 \ SORPF \]
Table 1. Continued

(1.41) Sorghum Domestic Market Equilibrium

\[
SGSPRU9 + \text{LAG}(SGCOTU9) + SGSMTU9 = SGUFU9 + SGUFOU9 + SGUXNU9 + SGCOTU9
\]

(1.42) World Market Equilibrium

\[
SGUXNU9 = SGSMNAR + SGSMAU + SGSMZA + SGSMMX + SGSMMNG + SGSMNIN + SGSMNROW + SGSTDIS
\]

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)

\[R^2 = 0.91 \quad DW = 1.75\]

(1.44) Barley Participant Net Returns

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

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

+ \max[BAPLNU9, \text{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**

\[
BAAPPU9 = BAMPRU9 \times BAABA9(1 - BAMARU9 - BAMPLU9)
\]

(1.47) **Barley Area Planted by Nonparticipants**

\[
BAAPNU9 = 10.303 + 12.083 \times BANRNU9/FWJMU9 - 0.908 \times BAAPPU9 \\
\quad (15.20) \quad (1.68) \quad (10.95) \\
\quad [0.35] \quad [-0.39]
\]

\[
- 0.553 \times DM1874(BAIAAU9 + BACRP9) + 2.706 \times DM1884 \\
\quad (2.07) \quad (4.27)
\]

\[
- 411.320 \times (WHNRNU9/49 + OANRNU9/27 \times 0.5)/PWJMU9 \\
\quad (1.86) \quad [-0.42]
\]

\[R^2 = 0.93 \quad DW = 1.40\]

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

\[
BAAIAU9 = BAABA9 \times BAMPRU9(BAMARU9 + BAMPLU9)
\]

(1.49) **Barley Total Area Planted**

\[
BAAPAU9 = BAAPPU9 + BAAPNU9
\]

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

\[
BAAHPU9 = 0.917 - 0.037 \times DM180 + 0.035 \times DM18183 - 0.038 \times DM185 \\
\quad (301.61) \quad (2.98) \quad (4.53) \quad (3.04)
\]

\[R^2 = 0.72 \quad DW = 1.67\]

(1.51) **Barley Total Area Harvested**

\[
BAAHAU9 = BAAPAU9 \times BAAHPU9
\]

(1.52) **Barley Yield**

\[
BAYHAU9 = -1528.970 + 0.795 \times TREND + 4.504 \times DMBAYU9 \\
\quad (9.48) \quad (9.76) \quad (5.21)
\]
Table 1. Continued

\[
+ 424.511 \text{ BAPTU9/PWJMU9} + 2.653 \text{ DM171} \\
(1.03) \quad (0.60) \\
[0.07]
\]

\[ R^2 = 0.90 \quad DW = 2.15 \]

(1.53) Barley Production
\[
\text{BASPRU9} = \text{BAHAU9} \times \text{BAYHAU9}
\]

(1.54) Barley Feed Use
\[
\text{BAUFU9} = 120.627 + 0.638 \text{ LAG(BAUFU9)} \\
- 16246.500 \text{ BAPMU9/PWJMU9} + 9325.640 \text{ COPMU9/PWJMU9} \\
(2.93) \quad (2.31) \\
[-0.66] \quad [0.43]
\]
\[
+ 1068.560 \text{ WHFPU9/PWJMU9} + 31.705 \text{ DM18285} \\
(0.39) \quad (2.85) \\
[0.06]
\]

\[ R^2 = 0.90 \quad DW = 2.32 \]

(1.55) Barley Per Capita Food, Seed, and Industrial Use
\[
\text{BAUFU9C} = 0.243 - 1.234 \text{ BAPMU9/PWJMU9} \\
(2.97) \quad (1.20) \\
[-0.02]
\]
\[
+ 0.220 \text{ LOG(CUSM9/DEPU9)} + 0.049 \text{ DM1S78} \\
(5.30) \quad (6.06) \\
[0.31]
\]
\[
- 0.017 \text{ TRND8185} \\
(8.15)
\]

\[ R^2 = 0.95 \quad DW = 2.16 \]

(1.56) Barley Total Food, Seed, and Industrial Use
\[
\text{BAUFU9} = \text{BAUFU9C} \times \text{DEPU9}
\]
Table 1. Continued

(1.57) Barley Free and Nine-Month Loan Stocks

\[ \begin{align*}
BAF9LU9 &= 72.526 + 0.349 \text{LAG}(BAF9LU9) - 7600.720 \text{BAFMU9/PWJMU9} \\
&\quad (0.69) \quad (2.10) \quad (2.43) \\
&\quad [-0.48] \\
&\quad + 0.300 \text{BASPRU9} - 0.632(\text{BACCUU9} + \text{BAFORU9}) \\
&\quad (1.72) \quad (2.94) \\
&\quad [0.89] \quad [-0.20] \\
&\quad - 48.099 \text{DM18183} \\
&\quad (3.04) \\
R^2 &= 0.73 \quad \text{DW} = 2.12
\end{align*} \]

(1.58) Barley Total Stocks

\[ \begin{align*}
\text{BACOTU9} &= \text{BAF9LU9} + \text{BACCUU9} + \text{BAFORU9}
\end{align*} \]

(1.59) Barley Exports

\[ \begin{align*}
\text{BAUXTU9} &= -200 \text{BAFMU9} + 100 \text{COPFMU9} + 40 \text{WHPFMU9} + \text{BAUXEU9}
\end{align*} \]

(1.60) Barley Domestic Market Equilibrium

\[ \begin{align*}
\text{BASPRU9} + \text{LAG}(\text{BACOTU9}) + \text{BASMTU9} &= \text{BAUFOU9} + \text{BAUFEU9} + \text{BAUXTU9} \\
&\quad + \text{BACTOU9} + \text{BAURSU9}
\end{align*} \]

Oats

(1.61) Oats Participation Rate

\[ \begin{align*}
\text{OAMPRU9} &= 0.000 + 5.215(\text{OANRPU9} - \text{OANRNU9})/\text{PWJMU9} \ast \text{DM1S82} \\
&\quad (0.00) \quad (4.96) \\
&\quad + 0.202 \text{DM1S82} \\
&\quad (9.00) \\
R^2 &= 0.83 \quad \text{DW} = 2.22
\end{align*} \]
Table 1. Continued

(1.62) Oats Participant Net Returns

\[
OANRPU9 = \max(\text{OAPTGU9} - \max(\text{OAPLNU9}, \text{LAG(OAPFMU9)}), 0) \\
\quad \times \text{OAYHPU9}(1 - \text{OAMARU9} - \text{OAMPLU9}) + \text{OADPRU9} \times \text{OAYHPU9} \times \text{OAMPLU9} \\
\quad + \max(\text{OAPLNU9}, \text{LAG(OAPFMU9)}) \times \text{OAYHTU9}(1 - \text{OAMARU9} - \text{OAMPLU9}) \\
\quad - \text{OAVCAU9}(1 - \text{OAMARU9} - \text{OAMPLU9}) \\
\quad - 20(\text{OAMARU9} + \text{OAMPLU9})
\]

(1.63) Oats Nonparticipant Net Returns

\[
OANRNU9F = \text{OAPFMU9} \times \text{OAYHTU9} - \text{OAVCAU9}
\]

(1.64) Oats Area Planted by Participants

\[
OAAPU9 = \text{OAMPRU9} \times \text{OAABAU9}(1 - \text{OAMARU9} - \text{OAMPLU9})
\]

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

\[
OAAIAU9 = \text{OAABAU9} \times \text{OAMPRU9}(\text{OAMARU9} + \text{OAMPLU9})
\]

(1.66) Oats Area Planted by Nonparticipants

\[
OAAPNU9 = \text{OAAHAU9} - \text{OAPPU9}
\]

(1.67) Oats Total Area Planted

\[
OAAPU9 = 7.783 + 0.666 \text{OAHAU9} + 0.164 \text{COAIAU9} - 6.283 \text{DM183} \\
(10.08) \quad (9.64) \quad (6.58) \quad (5.73) \\
\quad \quad \quad [0.47] \quad \quad \quad [0.10]
\]

\[R^2 = 0.95 \quad DW = 1.35\]

(1.68) Oats Total Area Harvested

\[
OAAHAU9 = 13.560 + 0.195 \text{LAG(OAHAU9)} + 18.835 \text{OANRNU9}/\text{PWJMU9} \\
(3.22) \quad (0.87) \quad \quad \quad (2.76) \quad \quad \quad [0.22]
\]
Table 1. Continued

\[
- 0.480 \text{ OAAIAU9} + \text{ OACRP}U9 - 0.434 \text{ TRND7186} \\
(0.84) \quad (2.95) \\
[-0.01]
\]

\[
- 230.106(\text{CONRNU9/101} + \text{ SENRNU9/96} + \text{ BANRNU9/43})/\text{PWJMU9} \\
(2.75) \\
[-0.26]
\]

\[R^2 = 0.95 \quad \text{DW} = 1.99\]

(1.69) **Oats Yield**

\[
\text{OAYHAU9} = -938.112 + 0.501 \text{ TREND} + 5.270 \text{ DMOAYU9} \\
(6.74) \quad (7.12) \quad (7.11)
\]

\[R^2 = 0.81 \quad \text{DW} = 2.91\]

(1.70) **Oats Production**

\[
\text{OASPRU9} = \text{ OAAHAU9} \times \text{ OAYHAU9}
\]

(1.71) **Oats Feed Use**

\[
\text{OAUFEU9} = 868.822 - 49237.300 \text{ OAPFMU9/PWJMU9} \\
(37.90) \quad (8.91) \\
[-0.52]
\]

\[
+ 14173.500 \text{ COPFMU9/PWJMU9} - 21.787 \text{ TRND7186} - 65.391 \text{ DM17780} \\
(5.25) \quad (24.15) \quad (6.41) \\
[0.27]
\]

\[R^2 = 0.98 \quad \text{DW} = 2.47\]

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

\[
\text{OAUFOU9C} = 1.116 - 2.920 \text{ OAPFMU9/PWJMU9} + 1.224 \text{ OAAPAU9F/DEPOPU9} \\
(5.34) \quad (0.91) \quad (3.27) \\
[-0.04] \quad [0.24]
\]

\[
- 0.376 \text{ LOG(CEJMU9/DEPOPU9)} \\
(4.71) \\
[-0.95]
\]

\[R^2 = 0.95 \quad \text{DW} = 1.86\]
Table 1. Continued

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

\[ OAUFOU9 = OAUFOU9C \times DEPOPU9 \]

(1.74) Oats Free and Nine-Month Loan Stocks

\[ OAF9LU9 = -38.842 + 0.382 \text{LAG(OAF9LU9)} \]
\[ (1.10) \quad (2.91) \]
\[ - 14470.900 \text{OAPFMU9/PWJMU9} + 0.440 \text{OASPRU9} \]
\[ (4.38) \quad [1.16] \]
\[ [-0.35] \]
\[ - 0.203(\text{OACCCU9} + \text{OAFORU9}) \]
\[ [-0.04] \]

\[ R^2 = 0.97 \quad DW = 1.75 \]

(1.75) Oats Total Stocks

\[ OACOTU9 = OACCCU9 + \text{OAFORU9} + \text{OAF9LU9} \]

(1.76) Oats Imports

\[ OASMNU9 = -22.854 + 22.840 \text{OAPFMU9/COPFMU9} + 37.841 \text{DM1S83} \]
\[ (2.91) \quad (1.67) \quad (12.11) \]
\[ - 44.715 \text{DM173} \]
\[ (7.82) \]

(1.77) Oats Domestic Market Equilibrium

\[ \text{OASPRU9} + \text{LAG(OACOTU9)} + \text{OASMTU9} = \text{OAUFOU9} + \text{OAXTU9} + \text{OACOTU9} + \text{OAURSU9} \]

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

\[ \text{FGUXNU9} = \text{COUXNU9} + 21.772 \text{BAUXNU9} + 14.515 \text{OAUUXNU9} \]
Table 1. Continued

(1.79) World Market Equilibrium

\[ FGUXNU9 = FGSMNAR + FGSMNAU + FGSMNCA + FGSMNTH + FGSMNE2 + FGSMNZA + FGSMNJP + FGSMNSU + FGSMNE8 + FGSMNCR + FGSMN4 + FGSMNBR + FGSMMNX + FGSMNEG + FGSMNSA + FGSMNNO + FGSMNFO + FGSMNSO + FGSMNROW + FGSTDIS \]

Endogenous Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAAHAU9</td>
<td>Barley area harvested, mil. ac.</td>
</tr>
<tr>
<td>BAAPU9</td>
<td>Barley harvested area/planted area</td>
</tr>
<tr>
<td>BAAIAU9</td>
<td>Barley area idled by ARP, PLD programs, mil. ac.</td>
</tr>
<tr>
<td>BAAPA9</td>
<td>Barley area planted, mil. ac.</td>
</tr>
<tr>
<td>BAAIPI9</td>
<td>Barley area planted by nonparticipants, mil. ac.</td>
</tr>
<tr>
<td>BAPF9PU9</td>
<td>Barley area planted by participants, mil. ac.</td>
</tr>
<tr>
<td>BACOTU9</td>
<td>Barley total ending stocks, mil. bu.</td>
</tr>
<tr>
<td>BAF9LU9</td>
<td>Barley free and 9-month loan stocks, mil. bu.</td>
</tr>
<tr>
<td>BAMPRU9</td>
<td>Barley model participation rate, equals (ARP + PLD + program planted area)/program base</td>
</tr>
<tr>
<td>BANRNU9</td>
<td>Barley expected net returns to nonparticipants, $/ac.</td>
</tr>
<tr>
<td>BANRNU9F</td>
<td>Barley expected nonparticipant net returns, next year, $/ac.</td>
</tr>
<tr>
<td>BANRP9</td>
<td>Barley expected net returns to program participants, $/base</td>
</tr>
<tr>
<td>BAPFMU9</td>
<td>Barley farm market price, $/bu.</td>
</tr>
<tr>
<td>BASPRU9</td>
<td>Barley production, mil. bu.</td>
</tr>
<tr>
<td>BAUFEU9</td>
<td>Barley feed use, mil. bu.</td>
</tr>
<tr>
<td>BAUF0U9</td>
<td>Barley food, seed, and industrial use, mil. bu.</td>
</tr>
<tr>
<td>BAUF0UC</td>
<td>Barley per-capita food, seed and industrial use, bu./capita</td>
</tr>
<tr>
<td>BAYHAU9</td>
<td>Barley yield per harvested acre, bu./ac.</td>
</tr>
<tr>
<td>COAHAU9F</td>
<td>Corn area harvested, next year, mil. ac.</td>
</tr>
<tr>
<td>COAHPU9F</td>
<td>Corn harvested area/planted area, next year</td>
</tr>
<tr>
<td>COAIU9</td>
<td>Corn acreage idled by ARP, PLD programs, mil. ac.</td>
</tr>
<tr>
<td>COAIU9F</td>
<td>Corn acreage idled by ARP, PLD programs, next year, mil. ac.</td>
</tr>
<tr>
<td>COAP9F</td>
<td>Corn area planted, next year, mil. ac.</td>
</tr>
<tr>
<td>COAPP9F</td>
<td>Corn area planted by nonparticipants, next year, mil. ac.</td>
</tr>
<tr>
<td>COCP9F</td>
<td>Corn area planted by participants, next year, mil. ac.</td>
</tr>
<tr>
<td>COCOTU9</td>
<td>Corn total ending stocks, mil. bu.</td>
</tr>
<tr>
<td>COFEU9</td>
<td>Corn free stocks, mil. bu.</td>
</tr>
<tr>
<td>COMPRU9F</td>
<td>Corn model participation rate, equals (ARP + PLD + program planted area)/program base, next year</td>
</tr>
<tr>
<td>CONRNU9</td>
<td>Corn expected nonparticipant net returns, $/ac.</td>
</tr>
<tr>
<td>CONRP9F</td>
<td>Corn expected net returns to participants, next year, $/base ac.</td>
</tr>
<tr>
<td>COSPRU9F</td>
<td>Corn production, next year, mil. bu.</td>
</tr>
<tr>
<td>COFEU9G</td>
<td>Corn feed use per GCAU, bu./GCAU</td>
</tr>
</tbody>
</table>
Table 1. Continued

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUFOU9</td>
<td>Corn food, seed and industrial use, mil. bu.</td>
</tr>
<tr>
<td>COUGAU9</td>
<td>Corn gasohol use, mil. bu.</td>
</tr>
<tr>
<td>COUOFU9</td>
<td>Corn food (nonfeed, nongasohol, nonseed) use, mil. bu.</td>
</tr>
<tr>
<td>COUSDU9</td>
<td>Corn seed use, mil. bu.</td>
</tr>
<tr>
<td>COYHAU9F</td>
<td>Corn yield per harvested acre, next year, bu./ac.</td>
</tr>
<tr>
<td>COUTOU9</td>
<td>Total corn domestic use, mil. bu.</td>
</tr>
<tr>
<td>COPOBU9</td>
<td>Corn Gulf Port price $/mt.</td>
</tr>
<tr>
<td>CORPF</td>
<td>Corn farm price $/bu.</td>
</tr>
<tr>
<td>OAAHAU9</td>
<td>Oats area harvested, mil. ac.</td>
</tr>
<tr>
<td>OAAIAU9</td>
<td>Oats area idled by ARP, PLD program, mil. ac.</td>
</tr>
<tr>
<td>OAAPAU9</td>
<td>Oats area planted, mil. ac.</td>
</tr>
<tr>
<td>OAAPAU9F</td>
<td>Oats area planted, next year, mil. ac.</td>
</tr>
<tr>
<td>OAPNU9</td>
<td>Oats area planted by nonparticipants, mil. ac.</td>
</tr>
<tr>
<td>OAPPU9</td>
<td>Oats area planted by participants, mil. ac.</td>
</tr>
<tr>
<td>OACOTU9</td>
<td>Oats total ending stocks, mil. bu.</td>
</tr>
<tr>
<td>OAF9LU9</td>
<td>Oats free and 9-month loan stocks, mil. bu.</td>
</tr>
<tr>
<td>OAMPRU9</td>
<td>Oats model participation rate, equals (ARP + PLD + program planted area)/program base</td>
</tr>
<tr>
<td>OANRN9</td>
<td>Oats expected net returns to nonparticipants, $/ac.</td>
</tr>
<tr>
<td>OANRP9</td>
<td>Oats expected net returns to participants, $/base ac.</td>
</tr>
<tr>
<td>OAPFMU9</td>
<td>Oats farm market price, $/bu.</td>
</tr>
<tr>
<td>OASMNU9</td>
<td>Oats net imports, mil. bu.</td>
</tr>
<tr>
<td>OASFRU9</td>
<td>Oats production, mil. bu.</td>
</tr>
<tr>
<td>OAUFBU9</td>
<td>Oats feed use, mil. bu.</td>
</tr>
<tr>
<td>OAUFBU9C</td>
<td>Oats per-capita food, seed and industrial use, bu./capita</td>
</tr>
<tr>
<td>OAYHAU9</td>
<td>Oats yield per harvested acre, bu./ac.</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>Soybean expected net returns, next year, $/ac.</td>
</tr>
<tr>
<td>SGAHAU9</td>
<td>Sorghum area harvested, mil. ac. (1)</td>
</tr>
<tr>
<td>SGAI9U9</td>
<td>Sorghum harvested area/sorghum planted area (8)</td>
</tr>
<tr>
<td>SGAPNU9</td>
<td>Sorghum acreage idled by ARP, PLD programs, mil. ac. (1)</td>
</tr>
<tr>
<td>SGAPPU9</td>
<td>Sorghum area planted, mil. ac. (1)</td>
</tr>
<tr>
<td>SGAPNU9F</td>
<td>Sorghum area planted by nonparticipants, mil. ac. (1)</td>
</tr>
<tr>
<td>SGAPP9U9</td>
<td>Sorghum area planted by participants, mil. ac. (1)</td>
</tr>
<tr>
<td>SGLOTU9</td>
<td>Sorghum total ending stocks, mil. bu. (1)</td>
</tr>
<tr>
<td>SG99LU9</td>
<td>Sorghum free and 9-month loan stocks, mil. bu. (1)</td>
</tr>
<tr>
<td>SMFRU9</td>
<td>Sorghum model participation rate, equals (ARP + PLD + program planted area)/program base (8)</td>
</tr>
<tr>
<td>SGNRNU9</td>
<td>Sorghum expected net returns to nonparticipants, $/ac. (8)</td>
</tr>
<tr>
<td>SGPNRU9</td>
<td>Sorghum expected net returns to participants, $/base ac. (8)</td>
</tr>
<tr>
<td>SGPOBU9</td>
<td>Sorghum Gulf Port price, $/mt</td>
</tr>
<tr>
<td>SGSPRU9</td>
<td>Sorghum production, mil. bu. (1)</td>
</tr>
<tr>
<td>SGUEBU9</td>
<td>Sorghum feed use, mil. bu. (1)</td>
</tr>
<tr>
<td>SGUF9U9</td>
<td>Sorghum food, seed and industrial use, mil. bu. (1)</td>
</tr>
<tr>
<td>SGUXNU9</td>
<td>Sorghum exports, mil. bu. (1)</td>
</tr>
<tr>
<td>SGYHAU9</td>
<td>Sorghum yield per harvested acre, bu./ac. (1)</td>
</tr>
<tr>
<td>SORPF</td>
<td>Sorghum farm price, $/bu.</td>
</tr>
<tr>
<td>WHN9NU9F</td>
<td>Wheat expected net returns to nonparticipants, next year, $/ac.</td>
</tr>
<tr>
<td>FGUXNU9</td>
<td>U.S., net feed-grain exports, 1000 mt.</td>
</tr>
</tbody>
</table>
Table 1. Continued

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGSMNAR</td>
<td>Argentina, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNAU</td>
<td>Argentina, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNTH</td>
<td>Thailand, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNE2</td>
<td>EC, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNZA</td>
<td>South Africa, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMJJP</td>
<td>Japan, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNSU</td>
<td>Soviet Union, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNE8</td>
<td>Eastern Europe, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNCN</td>
<td>China, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMN44</td>
<td>High Income East Asia, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNBR</td>
<td>Brazil, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNXM</td>
<td>Mexico, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNEG</td>
<td>Egypt, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNSA</td>
<td>Saudi Arabia, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNNO</td>
<td>Other Latin America, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNFO</td>
<td>Other Africa and Middle East, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNOS</td>
<td>Other Asia, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>FGSMNROW</td>
<td>Rest of the World, feed-grain imports, 1000 mt.</td>
</tr>
<tr>
<td>GSGMNAU</td>
<td>Australia, sorghum imports, 1000 mt.</td>
</tr>
<tr>
<td>GSGMNAU</td>
<td>South Africa, sorghum imports, 1000 mt.</td>
</tr>
<tr>
<td>GSGMNMX</td>
<td>Mexico, sorghum imports, 1000 mt.</td>
</tr>
<tr>
<td>GSGMNGG</td>
<td>Nigeria, sorghum imports, 1000 mt.</td>
</tr>
<tr>
<td>GSGMNIN</td>
<td>India, sorghum imports, 1000 mt.</td>
</tr>
<tr>
<td>SGUXNU9</td>
<td>U.S., sorghum exports, 1000 mt.</td>
</tr>
<tr>
<td>SGXNSROW</td>
<td>ROW, sorghum imports, 1000 mt.</td>
</tr>
</tbody>
</table>

**Exogenous Variables**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAABAU9</td>
<td>Barley program acreage base, mil. ac.</td>
</tr>
<tr>
<td>BACCCU9</td>
<td>Barley CCC stocks, mil. bu.</td>
</tr>
<tr>
<td>BACPRU9</td>
<td>Barley program base enrolled in the CRP, mil. ac.</td>
</tr>
<tr>
<td>BADPRU9</td>
<td>Barley diversion payment rate, $/bu.</td>
</tr>
<tr>
<td>BAFORU9</td>
<td>Barley FOR stocks, mil. bu.</td>
</tr>
<tr>
<td>BAMARU9</td>
<td>Barley model ARP rate, equals ARP area/(ARP + PLD + program planted area)</td>
</tr>
<tr>
<td>BAMPLU9</td>
<td>Barley model PLD rate, equals PLD area/(ARP + PLD + program planted area)</td>
</tr>
<tr>
<td>BAPNU9</td>
<td>Barley loan rate, $/bu.</td>
</tr>
<tr>
<td>BAPTGU9</td>
<td>Barley target price, $/bu.</td>
</tr>
<tr>
<td>BASMTU9</td>
<td>Barley imports, mil. bu.</td>
</tr>
<tr>
<td>BAUSRU9</td>
<td>Barley statistical discrepancy, mil. bu.</td>
</tr>
<tr>
<td>BAUTXU9</td>
<td>Barley exports, mil. bu.</td>
</tr>
<tr>
<td>BAVCAU9</td>
<td>Barley variable production costs--includes family labor and interest on variable expenses, $/ac.</td>
</tr>
<tr>
<td>BAVCAU9F</td>
<td>Barley variable production costs, next year, $/ac.</td>
</tr>
<tr>
<td>BAYHRU9</td>
<td>Barley program yield, bu./ac.</td>
</tr>
<tr>
<td>BAYHTU9</td>
<td>Barley trend yield, bu./ac.</td>
</tr>
</tbody>
</table>
Table 1. Continued

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM181:</td>
<td>1 in 1981; 0 otherwise</td>
</tr>
<tr>
<td>DM18183:</td>
<td>1 from 1981-1983; 0 otherwise</td>
</tr>
<tr>
<td>DM182:</td>
<td>1 in 1982; 0 otherwise</td>
</tr>
<tr>
<td>DM18285:</td>
<td>1 from 1982-1985; 0 otherwise</td>
</tr>
<tr>
<td>DM183:</td>
<td>1 in 1983; 0 otherwise</td>
</tr>
<tr>
<td>DM18385:</td>
<td>1 from 1983-1985; 0 otherwise</td>
</tr>
<tr>
<td>DM18387:</td>
<td>1 from 1983-1987; 0 otherwise</td>
</tr>
<tr>
<td>DM18485:</td>
<td>1 in 1984 and 1985; 0 otherwise</td>
</tr>
<tr>
<td>DM185:</td>
<td>1 in 1985; 0 otherwise</td>
</tr>
<tr>
<td>DM1NPRGF:</td>
<td>1 when no program in the next years 1973-1976, 1979-1980; 0 otherwise</td>
</tr>
<tr>
<td>DM1S73:</td>
<td>1 beginning in 1973; 0 otherwise</td>
</tr>
<tr>
<td>DM1S74:</td>
<td>1 beginning in 1974; 0 otherwise</td>
</tr>
<tr>
<td>DM1S75:</td>
<td>1 beginning in 1975; 0 otherwise</td>
</tr>
<tr>
<td>DM1S77:</td>
<td>1 beginning in 1977; 0 otherwise</td>
</tr>
<tr>
<td>DM1S78:</td>
<td>1 beginning in 1978; 0 otherwise</td>
</tr>
<tr>
<td>DM1S79:</td>
<td>1 beginning in 1979; 0 otherwise</td>
</tr>
<tr>
<td>DM1S80:</td>
<td>1 beginning in 1980; 0 otherwise</td>
</tr>
<tr>
<td>DM1S81:</td>
<td>1 beginning in 1981; 0 otherwise</td>
</tr>
<tr>
<td>DM1S82:</td>
<td>1 beginning in 1982; 0 otherwise</td>
</tr>
<tr>
<td>DM1S83:</td>
<td>1 beginning in 1983; 0 otherwise</td>
</tr>
<tr>
<td>DM1S84:</td>
<td>1 beginning in 1984; 0 otherwise</td>
</tr>
<tr>
<td>DM1S85:</td>
<td>1 beginning in 1985; 0 otherwise</td>
</tr>
<tr>
<td>DMBAYU9:</td>
<td>Barley yield dummy: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise</td>
</tr>
<tr>
<td>DMCOYU9F:</td>
<td>Corn yield dummy, next year: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise</td>
</tr>
<tr>
<td>DMCTYU9F:</td>
<td>Cotton yield dummy, next year: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise</td>
</tr>
<tr>
<td>DMOAYU9:</td>
<td>Oats yield dummy: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise</td>
</tr>
<tr>
<td>DMSBYU9F:</td>
<td>Soybean yield dummy, next year: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise</td>
</tr>
<tr>
<td>DMSGYU9:</td>
<td>Sorghum yield dummy: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise</td>
</tr>
<tr>
<td>DMWHYU9F:</td>
<td>Wheat yield dummy, next year: 1 if 1 s.d. above trend; -1 if 1 s.d. below; 0 otherwise</td>
</tr>
<tr>
<td>FBPMIU9:</td>
<td>Fiber price index (Yanagishima)</td>
</tr>
<tr>
<td>GCAUU9:</td>
<td>Grain-consuming animal units, crop year basis</td>
</tr>
<tr>
<td>HAPUU9:</td>
<td>High-protein animal units, crop year basis</td>
</tr>
<tr>
<td>LVPIU9:</td>
<td>Livestock price index, crop year basis</td>
</tr>
<tr>
<td>OAAABAU9:</td>
<td>Oats program acreage base, mil. ac.</td>
</tr>
<tr>
<td>OACCCU9:</td>
<td>Oats CCC stocks, mil. bu.</td>
</tr>
<tr>
<td>OACRPFU9:</td>
<td>Oats program base enrolled in the CRP, mil. ac.</td>
</tr>
<tr>
<td>OADPRU9:</td>
<td>Oats diversion payment rate, $/bu.</td>
</tr>
<tr>
<td>OAFORU9:</td>
<td>Oats FOR stocks, mil. bu.</td>
</tr>
<tr>
<td>OAMARU9:</td>
<td>Oats model ARP rate, equals ARP area/(ARP + PLD + program planted area)</td>
</tr>
</tbody>
</table>
Table 1. Continued

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAMPLU9</td>
<td>Oats model PLD rate, equals PLD area/(ARP + PLD + program planted area)</td>
</tr>
<tr>
<td>OAPLNU9</td>
<td>Oats loan rate, $/bu.</td>
</tr>
<tr>
<td>OAPGTGU9</td>
<td>Oats target price, $/bu.</td>
</tr>
<tr>
<td>OASMTU9</td>
<td>Oats total imports, mil. bu.</td>
</tr>
<tr>
<td>OAURSU9</td>
<td>Oats statistical discrepancy, mil. bu.</td>
</tr>
<tr>
<td>OAUXTU9</td>
<td>Oats total exports, mil. bu.</td>
</tr>
<tr>
<td>OAVCAU9</td>
<td>Oats variable production costs--includes family labor and interest on variable expenses, $/ac.</td>
</tr>
<tr>
<td>OAYHPU9</td>
<td>Oats program yield, bu./ac.</td>
</tr>
<tr>
<td>OAYHTU9</td>
<td>Oats trend yield, bu./ac.</td>
</tr>
<tr>
<td>PW</td>
<td>U.S. wholesale price index, 1967=100</td>
</tr>
<tr>
<td>PWAJU9</td>
<td>U.S. wholesale price index, Aug.-July year, cal. 1967=100</td>
</tr>
<tr>
<td>PWFSAU9</td>
<td>Producer price index for fuels, etc., Sept.-Aug. year, calendar 1967=100</td>
</tr>
<tr>
<td>PWJMU9</td>
<td>U.S. wholesale price index, June-May year, cal. 1967=100</td>
</tr>
<tr>
<td>PWSAU9</td>
<td>U.S. wholesale price index, Sept.-Aug. year, cal. 1967=100</td>
</tr>
<tr>
<td>SBPFMU9</td>
<td>Soybean variable production costs--includes family labor and interest on variable expenses, next year $/ac. (7)</td>
</tr>
<tr>
<td>SBVCAU9F</td>
<td>Soybean variable production costs--includes family labor and interest on variable expenses, next year $/ac. (7)</td>
</tr>
<tr>
<td>SBYHTU9F</td>
<td>Soybean trend yield, next year, bu./ac. (8)</td>
</tr>
<tr>
<td>SMFFMU9</td>
<td>Soybean meal market price, 44% protein, Decatur, $/ton</td>
</tr>
<tr>
<td>SGABAU9</td>
<td>Sorghum program acreage base, mil. ac. (1)</td>
</tr>
<tr>
<td>SGCCCU9</td>
<td>Sorghum CCC stocks, mil. bu. (1)</td>
</tr>
<tr>
<td>SGCRPU9</td>
<td>Sorghum program base enrolled in the CRP, mil. ac. (6)</td>
</tr>
<tr>
<td>SGDPRU9</td>
<td>Sorghum diversion payment rate, $/bu. (2)</td>
</tr>
<tr>
<td>SGFORU9</td>
<td>Sorghum FOR stocks, mil. bu. (1)</td>
</tr>
<tr>
<td>SGMARU9</td>
<td>Sorghum model ARP rate, equals ARP area/(ARP + PLD + program planted area) (8)</td>
</tr>
<tr>
<td>SGHPLU9</td>
<td>Sorghum model PLD rate, equals PLD area/(ARP + PLD + program planted area) (8)</td>
</tr>
<tr>
<td>SGPLNU9</td>
<td>Sorghum loan rate, $/bu. (1)</td>
</tr>
<tr>
<td>SGPTGU9</td>
<td>Sorghum target price, $/bu. (1)</td>
</tr>
<tr>
<td>SGSMNU9</td>
<td>Sorghum imports, mil. bu. (1)</td>
</tr>
<tr>
<td>SGURSU9</td>
<td>Sorghum statistical discrepancy, mil. bu. (8)</td>
</tr>
<tr>
<td>SGUXEU9</td>
<td>Sorghum export demand shifter, mil. bu. (8)</td>
</tr>
<tr>
<td>SGVCAU9</td>
<td>Sorghum variable production costs--includes family labor and interest on variable expenses, $/ac. (7)</td>
</tr>
<tr>
<td>SGVCAU9F</td>
<td>Sorghum variable production costs--includes family labor and interest on variable expenses, $/ac. (7)</td>
</tr>
<tr>
<td>SGYHPU9</td>
<td>Sorghum program yield, bu./ac. (1)</td>
</tr>
<tr>
<td>SGYHTU9</td>
<td>Sorghum trend yield, bu./ac. (8)</td>
</tr>
<tr>
<td>SUPRTU9</td>
<td>Granulated sugar retail price, cents/lb.</td>
</tr>
<tr>
<td>TREND</td>
<td>Calendar year.</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>TRND8587</td>
<td>Trend from 1985-1987; 0 until 1984; 1 in 1985, 2 in 1986, 3 in 1987 and after.</td>
</tr>
<tr>
<td>WHPPFMU9</td>
<td>Wheat farm market price, $/bu.</td>
</tr>
<tr>
<td>WHUFEU9</td>
<td>Wheat feed use, mil. bu.</td>
</tr>
<tr>
<td>WHVCAU9F</td>
<td>Wheat variable production costs--includes family labor and interest on variable expenses, next year, $/ac.</td>
</tr>
<tr>
<td>WHYHTU9F</td>
<td>Wheat trend yield, next year, bu./ac.</td>
</tr>
<tr>
<td>FGSTDUS</td>
<td>Feedgrain statistical discrepancy</td>
</tr>
<tr>
<td>SGSTDIS</td>
<td>Sorghum statistical discrepancy</td>
</tr>
<tr>
<td>TRND8587</td>
<td>Trend from 1985-1987; 0 until 1984; 1 in 1985, 2 in 1986, 3 in 1987 and after.</td>
</tr>
<tr>
<td>WHNRRN9F</td>
<td>Wheat expected net returns to nonparticipants, next year, $/ac.</td>
</tr>
<tr>
<td>WHPPFMU9</td>
<td>Wheat farm market price, $/bu.</td>
</tr>
<tr>
<td>WHUFEU9</td>
<td>Wheat feed use, mil. bu.</td>
</tr>
<tr>
<td>WHVCAU9F</td>
<td>Wheat variable production costs--includes family labor and interest on variable expenses, next year, $/ac.</td>
</tr>
<tr>
<td>WHYHTU9F</td>
<td>Wheat trend yield, next year, bu./ac.</td>
</tr>
</tbody>
</table>
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

\[ BAAHCA = 2412.850 + 0.519 \text{LAG}(BAAHCA) \]
\[ + 16.548 \text{LAG}(BAPOBCA/NARDDCA) - 3.811 \text{LAG}(RSPFMCA/NARDDCA) \]
\[ + 1286.530 \text{D71} + 609.629 \text{D84} \]
\[ - 0.592 \text{OAAHCA} \]
\[ + 1458.010 \text{BARESCA} \]
\[ R^2 = 0.29 \quad \text{DW} = 1.98 \]

(2.2) Barley Production

\[ BASPRCA = BAAHCA \times BAYHHCA \]

(2.3) Barley Domestic Use

\[ BAUDTCA = -48.141 - 6.734 \text{BAPOBCA/NARDDCA} \]
\[ + 2.759 \text{SMPFMCA/NARDDCA} + 382.406 \text{LVCACCA} \]
\[ - 1364.54(\text{D67} + \text{D68}) - 765.259(\text{D80} + \text{D81} + \text{D82} + \text{D83} + \text{D84}) \]
\[ R^2 = 0.94 \quad \text{DW} = 2.13 \]

(2.4) Barley Off-Board Price

\[ BAPOBCA = 11.180 + 38.524 \text{BARPF} \times \text{NIMEUCA} + 20.803 \text{D73} \]
\[ R^2 = 0.95 \quad \text{DW} = 1.47 \]
Table 2. Continued

(2.5) Rapeseed Farm Price

\[
RSPM1CA = -55.981 + 45.9068 \text{SOYPF} \times \text{NIMEUCA}
+ 14.6135 \text{SOPMXU9/SOMPM} - 54.6791 \text{D80}
\]

(2.6) Soybean Farm Price

\[
SBPFMCA = -4.005 + 36.877 \text{SOYPF} \times \text{NIMEUCA} + 47.406 \text{D85}
\]

\[
R^2 = 0.99 \quad \text{DW} = 2.55
\]

(2.7) Soy Meal Price

\[
SMPFMCA = 13.212 + 1.139 \text{SOMPM} \times \text{NIMEUCA} + 49.840 \text{D73}
\]

\[
R^2 = 0.94 \quad \text{DW} = 1.96
\]

(2.8) Grain-consuming Animal Units

\[
LVCACCA = 12.559 + 0.026 \text{NANPDCA/NARDDCA} - 0.005 \text{BAPOBCA/NARDDCA}
\]

\[
+ 0.915 \text{D7175} - 1.818(\text{D76} + \text{D77} + \text{D78})
\]

\[
+ 1.486(\text{D82} + \text{D83} + \text{D84})
\]

\[
R^2 = 0.97 \quad \text{DW} = 2.15
\]

(2.9) Barley Imports

\[
BASMNCA = \text{BAUDTCA} + \text{BACOTCA} - \text{BASPRCA} - \text{LAG(BACOTCA)}
\]
### Table 2. Continued

#### 2.10 Corn Acreage Harvested

\[
\text{COAHHCA} = 604.672 + 0.683 \text{LAG(COAHHCA)} \\
(3.12) \quad (6.88)
\]

\[
+ 1.106 \text{LAG(COPFMCA/NARDDCA)} - 0.469 \text{LAG(SBPFMCA/NARDDCA)} \\
(2.13) \quad (1.79) \quad [0.19] \quad [-0.17]
\]

\[
- 0.162 \text{OAAHHCA} + 114.916 \text{D81} \\
(3.38) \quad (3.15)
\]

\[R^2 = 0.99 \quad \text{DW} = 2.58\]

#### 2.11 Corn Production

\[
\text{COSPRCA} = \text{COAHHCA} \times \text{COYHHCA}
\]

#### 2.12 Corn Domestic Use

\[
\text{COUDTCA} = -5785.060 - 19.830 \text{COPFMCA/NARDDCA} \\
(5.73) \quad (3.10) \quad [-0.56]
\]

\[
+ 2.717 \text{SMFFMCA/NARDDCA} + 13.376 \text{BAPOBCA/NARDDCA} \\
(2.09) \quad (2.24) \quad [0.17] \quad [0.37]
\]

\[
+ 514.468 \text{LVCAACCA} + 1428.720 \text{SHIFT77} \\
(9.21) \quad (5.69) \quad [2.17]
\]

\[
- 1082.380 \text{D71 + D72} \\
(3.82)
\]

\[R^2 = 0.98 \quad \text{DW} = 2.43\]

#### 2.13 Corn Stocks

\[
\text{COCOTCA} = -220.811 + 0.609 \text{LAG(COCOTCA)} - 0.849 \text{COPFMCA/NARDDCA} \\
(1.18) \quad (4.82) \quad (0.82) \quad [-0.14]
\]

\[
+ 0.170 \text{COSPRCA} + 278.557 \text{D75 + D76} - 422.117 \text{D81} \\
(4.69) \quad (3.36) \quad (3.54) \quad [0.92]
\]
Table 2. Continued

\[-663.341 \text{ D83} \]
\[
(5.00)
\]
\[R^2 = 0.98 \quad DW = 2.35\]

(2.14) Corn-Price Linkage

\[\text{COPFMCA} = 6.801 + 36.932 \text{ CORPF } \times \text{ NIMEUCA} \]
\[
(2.21) \quad (31.61)
\]
\[\text{CORPF} \times \text{ NIMEUCA} \]
\[R^2 = 0.98 \quad DW = 1.56\]

(2.15) Corn Imports

\[\text{COSMNCA} = \text{COUDTCA} + \text{COCOTCA} - \text{COSPRCA} - \text{LAG(COCOTCA)}\]

(2.16) Feed-Grain Imports

\[\text{FGSMNCA} = \text{BASMNCA} + \text{COSMNCA} + \text{OASMNCA}\]

Endogenous Variables

- \text{BAAHHCA} = \text{Canada, Barley Planted Area, 1000 ha}
- \text{BAYHHCA} = \text{Canada, Barley Yield, MT/ha}
- \text{BASPRCA} = \text{Canada, Barley Production, 1000 MT}
- \text{BAUDTCA} = \text{Canada, Domestic Barley Consumption, 1000 MT}
- \text{BAPOBCA} = \text{Canada, Domestic Barley Off-Board Price, can $/MT}
- \text{RSPPFMCA} = \text{Canada, Rapeseed Price Received by Farmers, can $/MT}
- \text{SBPPFMCA} = \text{Canada, Soybean Price, can $/MT}
- \text{SMPPFMCA} = \text{Canada, Soymeal Price, can $/MT}
- \text{WHPOBCA} = \text{Canada, Wheat Off-Board Price, can $/MT}
- \text{LVCACCA} = \text{Canada, Grain Consuming Animal Units}
- \text{BARPF} = \text{Barley Price, can $/MT}
- \text{COAHHCA} = \text{Canada, Corn Area Harvested, 1000 ha}
- \text{COYHHCA} = \text{Canada, Corn Yield, MT/ha}
- \text{COSPRCA} = \text{Canada, Expected Corn Production, 1000 MT}
- \text{COUDTCA} = \text{Canada, Domestic Corn Use, 1000 MT}
- \text{COCOTCA} = \text{Canada, Corn Ending Stocks, 1000 MT}
- \text{COSNMCA} = \text{Canada, Corn Imports, 1000 MT}
- \text{COFFMCA} = \text{Canada, Farm-Level Corn Price, $/MT}
Table 2. Continued

**Exogenous Variables**

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

$$\text{BAAHHAU} = 1181.580 + 0.551 \text{LAG(BAAHHAU)}$$
$$+ 0.116 \text{LAG(BAPFMAU/NARDDAU)}$$
$$- 0.076 \text{LAG(WHPFMAU/NARDDAU)}$$
$$- 1.955 \text{LAG(GWPFMAU/NARDDAU)} - 665.054 \text{D67}$$
$$- 88.180 \text{D73} + 610.208 (\text{D83} + \text{D84} + \text{D85})$$

$$R^2 = 0.91 \quad \text{DW}(1) = 1.41 \quad \text{DW}(2) = 2.31$$

(3.2) Barley Production

$$\text{BASPRAU} = \text{BAAHHAU} \times \text{BAYHHAU}$$

(3.3) Domestic Barley Uses

$$\text{BAUDTAU} = 1540.550 - 0.128(\text{BAPFMAU/NARDDAU})$$
$$+ 0.056(\text{WHPFMAU/NARDDAU})$$
$$+ 3.752(\text{WANPDAU/NARDDAU}) + 335.239 \text{D81}$$
$$- 602.548(\text{D84} + \text{D85} + \text{D86}) - 318.71 \text{D69}$$

$$R^2 = 0.87 \quad \text{DW}(1) = 1.57 \quad \text{DW}(2) = 2.07$$
Table 3. Continued

### (3.4) Barley Ending Stocks

\[
BACOTAU = 794.707 - 0.038(BAPFMAU/NARDDAU) \\
\hspace{1cm} (7.66) (-5.17) \\
\hspace{1cm} [-1.85]
\]

\[
+ 0.189 \text{LAG}(BACOTAU) - 353.629 \text{SHIFT79} \\
\hspace{1cm} (1.69) (-7.92) \\
\hspace{1cm} [0.19]
\]

\[
+ 119.724(D80 + D82) - 212.868(D72 + D77) \\
\hspace{1cm} (2.08) (-4.11)
\]

\[ R^2 = 0.87 \quad DW(1) = 2.32 \quad DW(2) = 1.46 \]

### (3.5) Barley Prices

\[
BAPFMAU = -283.784 + 556C.210(BARPF * NIMEUAU) \\
\hspace{1cm} (-0.51) (17.57) \\
\hspace{1cm} [1.05]
\]

\[
+ 3200.200 D82 - 3872.090(D84 + D85) \\
\hspace{1cm} (3.67) (-4.96)
\]

\[ R^2 = 0.96 \quad DW(1) = 1.41 \quad DW(2) = 1.39 \]

### (3.6) Sheep Inventory

\[
SHCOTAU = 17.337 + 0.811 \text{LAG}(SHCOTAU) \\
\hspace{1cm} (1.04) (8.27)
\]

\[
- 0.001 \text{LAG}(SGPFMAU/NARDDAU) \\
\hspace{1cm} (-0.63) [-0.06]
\]

\[
+ 0.062 \text{LAG}(GWPFMAU/NARDDAU) + 0.137 \text{LAG}[\text{LAG}(GWPFMAU/NARDDAU)] \\
\hspace{1cm} (2.16) (2.75) \\
\hspace{1cm} [0.10] [0.23]
\]

\[
- 0.002 \text{LAG}(WHFPMAU/NARDDAU) + 10.24(D84 + D85) \\
\hspace{1cm} (-1.63) [-2.21]
\]

\[ R^2 = 0.91 \quad DW(1) = 2.15 \quad DW(2) = 1.48 \]
Table 3. Continued

(3.7) Greasy-wool Farm Price

\[
\text{GWPFMAU} = 83.910 + 318.458(\text{COLFAU} \times \text{NIMEUAU}) \\
(1.35) \quad (8.10) \\
[0.75]
\]

\[+ 1.020(\text{LTARCRUD} \times \text{NIMEUAU}) - 0.409 \text{LAG(SHCOTAU)} \]
\[(1.38) \quad (-1.14) \quad [0.08]
\]

\[+ 91.326D72 + 55.869D86 + 55.256D81 + 48.206D73 \]
\[(5.62) \quad (2.89) \quad (2.94)
\]

\[R = 0.98 \quad \text{DW}(1) = 1.99 \quad \text{DW}(2) = 2.49\]

(3.8) Barley Net Imports

\[
\text{BASMNAU} = \text{BAUDETAU} + \text{BACOTAU} - \text{BASPRAU} - \text{LAG(BACOTAU)}
\]

(3.9) Sorghum Prices

\[
\text{SGPFMAU} = -301.650 + 5099.850(\text{SORPF} \times \text{NIMEUAU}) \\
(-0.87) \quad (24.54)
\]

\[+ 2691.54(D83 + D84 + D85) + 1342D86 \]
\[(-6.07) \quad (2.72)
\]

\[R^2 = 0.98 \quad \text{DW}(1) = 2.03 \quad \text{DW}(2) = 2.75\]

(3.10) Sorghum Area Harvested

\[
\text{SGAHHAU} = 277.240 + 0.809 \text{LAG(SGAHHAU)} + 0.025 \text{LAG(SGPFMAU/NARDDAU)} \\
(3.40) \quad (14.56) \quad (3.24)
\]

\[+ 0.014 \text{LAG(WHPFMAU/NARDDAU)} - 0.018 \text{LAG(BAPFMAU/NARDDAU)} \]
\[(1.97) \quad (2.86) \quad [-0.35] \quad [-0.40]
\]

\[+ 124.448D80 - 247.635D73 - 188.930D77 \]
\[(3.51) \quad (5.68) \quad (4.42)
\]

\[R^2 = 0.98 \quad \text{DW}(1) = 1.78 \quad \text{DW}(2) = 2.32\]
<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3.11)</td>
<td>Sorghum Production</td>
<td>$\text{SGSPRAU} = \text{SGAHHAU} \times \text{SGYHHAU}$</td>
</tr>
<tr>
<td>(3.12)</td>
<td>Sorghum Stock</td>
<td>$\text{SGCOTAU} = 6.468 + 0.288 \text{LAG}(\text{SGCOTAU}) + 0.028 \text{SGSPRAU}$ $\begin{pmatrix} \text{(2.63)} \ \text{(1.68)} \end{pmatrix} + 93.584D72 + 108.016(D76 + D77 + D79)$ $\begin{pmatrix} \text{(3.45)} \ \text{(6.02)} \end{pmatrix} - 51.736D84$ $\begin{pmatrix} \text{(1.87)} \end{pmatrix}$ $R^2 = 0.84$ $\text{DW(1)} = 2.48$ $\text{DW(2)} = 1.90$</td>
</tr>
<tr>
<td>(3.13)</td>
<td>Sorghum Imports</td>
<td>$\text{SGSMNAU} = 977.377 - 0.047(\text{SGPFMAU}/\text{NARDAU})$ $\begin{pmatrix} \text{(3.50)} \ \text{(2.40)} \end{pmatrix} - 1.098 \text{SGSPRAU} - 176.122(D73 + D74)$ $\begin{pmatrix} \text{(12.17)} \ \text{(1.63)} \end{pmatrix}$ $R^2 = 0.93$ $\text{DW(1)} = 1.78$ $\text{DW(2)} = 2.12$</td>
</tr>
<tr>
<td>(3.14)</td>
<td>Market Equilibrium</td>
<td>$\text{SGUDTAU} = \text{SGSPRAU} + \text{LAG}(\text{SGCOTAU}) + \text{SGSMNAU} - \text{SGCOTAU}$</td>
</tr>
<tr>
<td>(3.15)</td>
<td>Wheat Farm Price</td>
<td>$\text{WHFFMAU} = -135.300 + 100.531 \text{WHEXAU} - 3271.930(D72 + D73)$ $\begin{pmatrix} \text{(0.40)} \ \text{(38.49)} \end{pmatrix} - 1604.540D77$ $\begin{pmatrix} \text{(8.24)} \end{pmatrix}$ $R^2 = 0.99$ $\text{DW(1)} = 2.31$ $\text{DW(2)} = 1.29$</td>
</tr>
</tbody>
</table>
Table 3. Continued

(3.16) Wheat Export Price

\[ WHPEXAU = 4.059 + 0.973 \times WHPGPU90 \times NIMEUAU + 23.400 \times D82 \]
\[ - 22.92(D84 + D85 + D86) \]
\[ R^2 = 0.97 \quad DW(1) = 1.35 \quad DW(2) = 2.55 \]

(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
- SGAAHHAU = 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, Bill $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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D74</td>
<td>1 in 74, 0 otherwise</td>
</tr>
<tr>
<td>D76</td>
<td>1 in 76, 0 otherwise</td>
</tr>
<tr>
<td>D79</td>
<td>1 in 79, 0 otherwise</td>
</tr>
<tr>
<td>D80</td>
<td>1 in 80, 0 otherwise</td>
</tr>
<tr>
<td>D81</td>
<td>1 in 81, 0 otherwise</td>
</tr>
<tr>
<td>D82</td>
<td>1 in 82, 0 otherwise</td>
</tr>
<tr>
<td>D83</td>
<td>1 in 83, 0 otherwise</td>
</tr>
<tr>
<td>D84</td>
<td>1 in 84, 0 otherwise</td>
</tr>
<tr>
<td>D85</td>
<td>1 in 85, 0 otherwise</td>
</tr>
<tr>
<td>COSMNAU</td>
<td>Corn Imports, 1000 MT</td>
</tr>
<tr>
<td>OASMNAU</td>
<td>Oats Imports, 1000 MT</td>
</tr>
<tr>
<td>SGYHHAU</td>
<td>Sorghum Yield, MT/ha</td>
</tr>
</tbody>
</table>

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

\[ \text{COAHHAR} = 1130.980 + 4.059 \text{LAG(COPFMARR)} \]
\[ (2.51) \quad (3.65) \]
\[ -1.084 \text{LAG(SBPFMARR)} + 0.49 \text{LAG(COAHHAR)} \]
\[ (-2.67) \quad (3.55) \]
\[ + 553.482 \text{D72} - 473.278(\text{D71 + D79}) \]
\[ (2.32) \quad (-2.58) \]
\[ R^2 = 0.83 \quad DW(1) = 1.90 \]

(4.2) Corn Production

\[ \text{COSPRAR} = \text{COAHHAR} \times \text{COYHHAR} \]

(4.3) Domestic Corn Use

\[ \text{COUDTAR} = -915.573 - 3.647 \text{COPFMARR} \]
\[ (-0.51) \quad (-1.37) \]
\[ + 6.473 \text{SGPFMARR} + 0.184 \text{COSPRAR} \]
\[ (1.70) \quad (6.58) \]
\[ [0.44] \quad [0.45] \]
\[ + 47.910 \text{CECOTAR} + 650.868 \text{D83} \]
\[ (1.84) \quad (2.62) \]
\[ [0.78] \]
\[ + 753.055 \text{D71} - 905.072 \text{D70} - 715.797 \text{SHIFT75} \]
\[ (3.25) \quad (-3.63) \quad (-4.62) \]
\[ R^2 = 0.89 \quad DW(1) = 2.55 \]

(4.4) Corn Ending Stocks

\[ \text{COCOTAR} = 1137.360 - 2.973 \text{COPFMARR} + 0.017 \text{COSPRAR} \]
\[ (6.26) \quad (-6.43) \quad (1.38) \]
\[ [-2.94] \quad [0.50] \]
Table 4. Continued

- 367.522(D78 + D79 + D80) - 284.210 D83
  (-5.57) (-2.85)
- 243.050(D71 + D73)
  (-3.30)

R² = 0.85  DW(1) = 2.76

(4.5) Corn Prices

\[ \text{COPFMARR} = 154.329 + 21.800(\text{CORPF} \times \text{NIMECARM/WPI80AR} \times 10,000) \]
  (3.69) (4.08) [0.62]
- 10.876[\text{WPI80AR} - \text{LAG(WPI80AR)}/\text{LAG(WPI80AR)}]
  (-2.90) [-0.07]
- 233.557 D74 - 83.510(D73 + D75)
  (-5.93) (-3.06)

R² = 0.76  DW(1) = 2.18

(4.6) Livestock Ending Inventories

\[ \text{CECOTAR} = 26.777 + 0.0005 \text{NARPDAR} - 0.024 \text{SGPFMARR} \]
  (4.04) (2.20) (-2.82) [0.23] [-0.10]
- 2.953 D70 + 2.65(D75 + D76 + D77)
  (-2.65) (3.22)

R² = 0.96  DW(1) = 1.57

(4.7) Corn Net Imports

\[ \text{COSMNAR} = \text{COUDTAR} + \text{COCOTAR} - \text{COSPRAR} - \text{LAG(COCOTAR)} \]

(4.8) Sorghum Area Harvested

\[ \text{SGAHHAR} = 993.659 + 0.474 \text{LAG(SGAHHAR)} + 5.615 \text{LAG(SGPFMARR)} \]
  (1.81) (3.84) (2.72) [9.15]
Table 4. Continued

\[ -4.150 \text{LAG(WHPFMARR)} + 958.860 \text{SGRESAR} \]
\[ \text{(2.76)} \quad \text{(5.11)} \]
\[ [-0.67] \]
\[ -576.571 \text{D72} + 864.013(\text{D81} + \text{D82}) \]
\[ \text{(2.46)} \quad \text{(3.77)} \]
\[ \text{R}^2 = 0.85 \quad \text{DW(1)} = 1.82 \]

(4.9) **Sorghum Production**

\[ \text{SGSPRAR} = \text{SGAHHAR} * \text{SGYHHAR} \]

(4.10) **Sorghum Domestic Use**

\[ \text{SGUDTAR} = 694.595 + 52.330 \text{CECOTAR} - 23.477 \text{SGPFMARR} \]
\[ \text{(0.38)} \quad \text{(2.14)} \quad \text{(4.79)} \]
\[ \text{[1.35]} \quad \text{[-2.56]} \]
\[ + 13.306 \text{COPFMARR} + 693.536 \text{D82} \]
\[ \text{(3.99)} \quad \text{(2.30)} \]
\[ \text{[1.79]} \]
\[ + 900.100(\text{D70} + \text{D72}) + 1659.790 \text{D73} \]
\[ \text{(3.51)} \quad \text{(4.96)} \]
\[ \text{R}^2 = 0.83 \quad \text{DW(1)} = 2.39 \]

(4.11) **Sorghum Stocks**

\[ \text{SGCOTAR} = 342.603 + 0.127 \text{LAG(SGCOTAR)} - 0.897 \text{SGPFMARR} \]
\[ \text{(4.58)} \quad \text{(1.31)} \quad \text{(3.11)} \]
\[ \text{[-1.30]} \]
\[ + 107.303 \text{D77} - 120.302(\text{D79} + \text{D83}) + 338.460 \text{D81} \]
\[ \text{(2.42)} \quad \text{(3.63)} \quad \text{(7.546)} \]
\[ + 161.907 \text{D84} \]
\[ \text{(3.469)} \]

(4.12) **Sorghum Farm Price**

\[ \text{SGPFMARR} = 166.593 + 13.883 \text{SORPF} * \text{NIMECARF/WPI80AR} * 10,000 \]
\[ \text{(6.38)} \quad \text{(3.79)} \quad \text{[0.44]} \]
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)

R² = 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)

R² = 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)

R² = 0.85  DW(1) = 2.06
Table 4. Continued

(4.16) Argentine Feed-Grain Imports

\[ \text{FGSMNAR} = \text{COSMNAR} + \text{BASMNAR} + \text{OASMNAR} \]

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
- COFFMAR = Argentina, Corn Farm Prices, 1980 Pesos/MT
- CECOTAR = Argentina, Cattle Ending Inventories, mil. head
- COSMNAR = Argentina, Corn Net Imports, 1000 MT
- SGAAHAR = Argentina, Sorghum Area Harvested, 1000 ha
- SSGPRAR = Argentina, Sorghum Production, 1000 MT
- SGUDTAR = Argentina, Total Domestic Sorghum Use, 1000 MT
- SGCOTAR = Argentina, Sorghum Ending Stocks, 1000 MT
- SGFFMAR = Argentina, Sorghum Farm Price, 1980 Pesos/MT
- SGSMNAR = Argentina, Sorghum Net Imports, 1000 MT
- SBFMMAAR = 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
- NARPDAAR = Argentina, Real GDP, 1980 Australes
- NIMECARF = Commercial Exchange Rate, 1980 Australes/U.S. $
- D70 = 1 \text{ in } 1970, 0 \text{ otherwise}
- D71 = 1 \text{ in } 1971, 0 \text{ otherwise}
- D72 = 1 \text{ in } 1972, 0 \text{ otherwise}
- D73 = 1 \text{ in } 1973, 0 \text{ otherwise}
- D74 = 1 \text{ in } 1974, 0 \text{ otherwise}
- D75 = 1 \text{ in } 1975, 0 \text{ otherwise}
- D76 = 1 \text{ in } 1976, 0 \text{ otherwise}
- D77 = 1 \text{ in } 1977, 0 \text{ otherwise}
- D78 = 1 \text{ in } 1978, 0 \text{ otherwise}
- D79 = 1 \text{ in } 1979, 0 \text{ otherwise}
- D80 = 1 \text{ in } 1980, 0 \text{ otherwise}
- D81 = 1 \text{ in } 1981, 0 \text{ otherwise}
- D82 = 1 \text{ in } 1982, 0 \text{ otherwise}
- D83 = 1 \text{ in } 1983, 0 \text{ otherwise}
- D84 = 1 \text{ in } 1984, 0 \text{ 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

\[ \text{BAAHHE2} = 5564.110 + 0.578 \text{LAG(BAAHHE2)} \]
\[ + 4.356 \text{BAPIEO/NARDDEO} - 0.578 \text{OSAHHE2} + 523.498 \text{D75} \]
\[ + 452.063 \text{D7781} + 492.411 \text{DEC9} \]

\[ R^2 = 0.99 \quad \text{DW} = 2.39 \]

(5.2) Barley Production

\[ \text{BASPRE2} = \text{BAAHHE2} \times \text{BAYHHE2} \]

(5.3) Barley Nonfeed Use

\[ \text{BAUHTE2} = 4683.180 - 9.620 \text{BAPTHEO/NARDDEO} \]
\[ + 3.080 \text{NANPDE2/NARDDEO} + 731.148(\text{D74} + \text{D75}) \]

\[ R^2 = 0.96 \quad \text{DW} = 1.83 \]

(5.4) Barley Feed Use

\[ \text{BAUFEE2} = 22070.900 - 20.219 \text{BAPTHEO/NARDDEO} - 3701.070 \text{SHIFT81} \]
\[ + 1794.350(\text{D77} + \text{D78}) - 1785.150(\text{D74} + \text{D75}) \]
\[ + 1.641 \text{POSPRE2} \]

\[ R^2 = 0.97 \quad \text{DW} = 2.80 \]
Table 5. Continued

(5.5) Barley Stocks

\[
BACOTE2 = 2454.460 + 0.196 \text{LAG}(BACOTE2) + 1369.490 D82 \\
(4.18) \quad (1.06) \quad (2.99)
\]

\[- 1088.480(D69 + D71 + D72 + D73) + 0.151 \text{BARESE2} \]
\[\quad (4.16) \quad (3.89) \quad [0.02]
\]

\[+ 2101.180 D84 + 1339.140 D85 \]
\[\quad (4.45) \quad (2.30)
\]

\[R^2 = 0.87 \quad DW = 1.62\]

(5.6) Barley Imports

\[BASMNE2 = BAUFEE2 + BANHTE2 + BACOTE2 - BASPRE2 - \text{LAG}(BACOTE2)\]

(5.7) Corn Acreage Harvested

\[COAHHE2 = 1381.610 + 0.827 \text{LAG}(COAHHE2) - 0.373 OSAHHE2 \\
(3.35) \quad (9.05) \quad (2.89)
\]

\[- 759.870 D76 - 288.497(D80 + D81 + D83) \]
\[\quad (8.08) \quad (4.78)
\]

\[+ 2.440 \text{COPIEO/NARDDEO} \]
\[\quad (1.95) \quad [0.14]
\]

\[R^2 = 0.94 \quad DW = 1.46\]

5.8 Corn Production

\[COSPRE2 = COAHHE2 \times COYHHE2\]

5.9 Corn Domestic Use

\[Coudte2 = 33770.200 - 35.153 \text{COPTHEO/NARDDEO} \]
\[\quad (3.75) \quad (2.03) \quad [-0.27]\]
Table 5. Continued

\[ + 11.1038 \text{SMPFMEO/NARDDEO} - 1.068 \text{WHUFEE2} - 2400.280 \text{D75} \]
\[ (3.94) \quad (11.76) \quad (1.77) \]
\[ [0.09] \quad [-0.44] \]

\[ - 3834.570(\text{D80} + \text{D81} + \text{D82}) + 5.073 \text{PYSPRE2} \]
\[ (4.54) \quad (4.70) \]
\[ [0.64] \]

\[ R^2 = 0.96 \quad DW = 1.36 \]

**5.10 Corn Stocks**

\[ \text{COCOTE2} = 4945.430 - 10.099 \text{COPTHEO/NARDDEO} + 0.055 \text{COSPREE2} \]
\[ (3.09) \quad (3.47) \quad (1.14) \]
\[ [-0.77] \quad [0.30] \]

\[ + 2144.240 \text{D74} - 1698.670(\text{D83} + \text{D84}) \]
\[ (5.99) \quad (6.02) \]

\[ + 653.991(\text{D76} + \text{D77}) \]
\[ (2.47) \]

\[ R^2 = 0.92 \quad DW = 1.87 \]

**5.11 Corn Imports**

\[ \text{COSMNE2} = \text{COUDTE2} + \text{COCOTE2} - \text{COSPREE2} - \text{LAG(COCOTE2)} \]

**5.12 Pork Production**

\[ \text{POSPRE2} = 5936.120 + 2.161 \text{NANPDE2/NARDDEO} \]
\[ (4.42) \quad (6.18) \quad (0.54) \]

\[ - 7.682 \text{BAPTHEO/NARDDEO} + 1168.570 \text{SHIFT80} \]
\[ (3.26) \quad (5.18) \quad [-0.21] \]

\[ - 0.465 \text{SMPFMEO/NARDDEO} \]
\[ (0.71) \quad [-0.01] \]

\[ R^2 = 0.98 \quad DW = 1.61 \]
Table 5. Continued

(5.13) Poultry Production

\[ PYSPRE2 = 1375.180 + 1.655 \frac{NANPDE2}{NARDDEO} \]
\[ (2.40) \quad (11.23) \]
\[ - 4.465 \frac{COPTHEO}{NARDDEO} + 654.949 \text{SHIFT80} \]
\[ (4.76) \quad (6.73) \]
\[ [0.90] \]

\[ R^2 = 0.99 \quad DW = 2.09 \]

(5.14) Soy Meal Price

\[ SMPFME2 = 15.910 + 1.130 \text{SOMP} \cdot \text{NIMEUEO} \]
\[ (2.72) \quad (20.29) \]
\[ [0.90] \]

\[ R^2 = 0.98 \quad DW = 2.59 \]

(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
- BAUFFE2 = 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**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAPIEO</td>
<td>EC Barley Intervention Price, ECU/MT</td>
</tr>
<tr>
<td>NARDDDEO</td>
<td>EC GDP Deflator, 1980=1.0</td>
</tr>
<tr>
<td>OSAHHE2</td>
<td>EC Oats Area Harvested, 1000 ha</td>
</tr>
<tr>
<td>BARESE2</td>
<td>Deviation from trend production, 1000 MT</td>
</tr>
<tr>
<td>BAPTHEO</td>
<td>EC Barley Threshold Price, ECU/MT</td>
</tr>
<tr>
<td>NANPDE2</td>
<td>EC GNP, Bil ECU</td>
</tr>
<tr>
<td>COPIEO</td>
<td>EC Corn Intervention Price, ECU/MT</td>
</tr>
<tr>
<td>COPTHEO</td>
<td>EC Corn Threshold Price, ECU/MT</td>
</tr>
<tr>
<td>WHUFEE2</td>
<td>EC Wheat Feed Use, 1000 MT</td>
</tr>
<tr>
<td>D69</td>
<td>1 in 1969 and 0 otherwise</td>
</tr>
<tr>
<td>D70</td>
<td>1 in 1970 and 0 otherwise</td>
</tr>
<tr>
<td>D71</td>
<td>1 in 1971 and 0 otherwise</td>
</tr>
<tr>
<td>D72</td>
<td>1 in 1972 and 0 otherwise</td>
</tr>
<tr>
<td>D73</td>
<td>1 in 1973 and 0 otherwise</td>
</tr>
<tr>
<td>D74</td>
<td>1 in 1974 and 0 otherwise</td>
</tr>
<tr>
<td>D75</td>
<td>1 in 1975 and 0 otherwise</td>
</tr>
<tr>
<td>D76</td>
<td>1 in 1976 and 0 otherwise</td>
</tr>
<tr>
<td>D77</td>
<td>1 in 1977 and 0 otherwise</td>
</tr>
<tr>
<td>D78</td>
<td>1 in 1978 and 0 otherwise</td>
</tr>
<tr>
<td>D79</td>
<td>1 in 1979 and 0 otherwise</td>
</tr>
<tr>
<td>D80</td>
<td>1 in 1980 and 0 otherwise</td>
</tr>
<tr>
<td>D81</td>
<td>1 in 1981 and 0 otherwise</td>
</tr>
<tr>
<td>D82</td>
<td>1 in 1982 and 0 otherwise</td>
</tr>
<tr>
<td>D83</td>
<td>1 in 1983 and 0 otherwise</td>
</tr>
<tr>
<td>D84</td>
<td>1 in 1984 and 0 otherwise</td>
</tr>
<tr>
<td>D85</td>
<td>1 in 1985 and 0 otherwise</td>
</tr>
<tr>
<td>D7781</td>
<td>1 from 77-81, 0 otherwise</td>
</tr>
<tr>
<td>DEC9</td>
<td>1 after 1972, 0 otherwise</td>
</tr>
<tr>
<td>SHIFT80</td>
<td>1 after 1979, 0 otherwise</td>
</tr>
<tr>
<td>SHIFT81</td>
<td>1 after 1980, 0 otherwise</td>
</tr>
</tbody>
</table>
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

\[
\text{COAHHTH} = -1286998 + 0.094 \times \text{LAG(COPFMTH/NARDDTH)} \\
\quad (26.27) \quad (1.58) \\
\quad [0.16] \\
- 0.086 \times \text{LAG(SGPFMTH/NARDDTH)} - 164.472 \times D778 \\
\quad (0.75) \quad (3.93) \\
\quad [-0.14] \\
- 67.928(D76 + D77) + 169762 \times \text{LOG(TREND)} + 141.930 \times D71 \\
\quad (1.78) \quad (22.26) \quad (2.84) \\
\quad + 84.120 \times D74 \\
\quad (1.66) \\
R^2 \quad 0.99 \quad DW = 2.07
\]

(6.2) Corn Production

\[
\text{COSPRTH} = \text{COAHHTH} \times \text{COYHHTH}
\]

(6.3) Corn Feed Use

\[
\text{COUFETH} = -160.041 - 0.027 \times \text{COPFMTH/NARDDTH} + 3.350 \times \text{PLSPRTH} \\
\quad (1.17) \quad (0.44) \quad (6.38) \\
\quad [-0.12] \quad [0.92] \\
\quad + 0.110 \times \text{COSPRTH} - 139.223 \times D7073 \\
\quad (2.20) \quad (2.82) \quad [0.61] \\
\quad + 222.858 \times D80 - 116.460 \times D81 \\
\quad (2.85) \quad (1.28) \\
R^2 \quad 0.98 \quad DW = 2.14
\]

(6.4) Corn Stocks

\[
\text{COCOTTH} = 268.164 + 0.117 \times \text{LAG(COCOTTH)} \\
\quad (3.24) \quad (0.69) \\
\quad - 0.082 \times \text{COPFMTH/NARDDTH} + 123.953 \times D70 \\
\quad (2.49) \quad (2.44) \quad (2.44) \\
\quad [-1.45] 
\]
Table 6. Continued

\begin{align*}
+ 129.343(D75 + D82) - 101.245 D73 \\
(2.05)
\end{align*}

\[ R^2 = 0.75 \quad DW = 1.39 \]

(6.5) Corn Imports

\[ \text{COSMTH} = \text{COUFETH} + \text{COUHTTH} + \text{COCOTTH} - \text{COSPRTH} - \text{LAG(COCOTTH)} \]

(6.6) Poultry Production

\begin{align*}
\text{PLSPRTH} &= 45.019 - 0.036 \frac{\text{COPFMTH}}{\text{NARDDTH}} \\
(1.40) & \quad (3.00) \\
& \quad [-0.61] \\
+ 0.483 \frac{\text{NANPDTH}}{\text{NARDDTH}} - 60.914 D7679 \\
(16.61) & \quad (5.21) \\
& \quad [2.09]
\end{align*}

\[ R^2 = 0.96 \quad DW = 2.17 \]

(6.7) Corn Price-Linkage Equation

\begin{align*}
\text{COPFMTH} &= 24.950 + 34.758 \frac{\text{CORPF}}{\text{NIMEUTH}} - 592.534 D73 \\
(0.18) & \quad (11.97) \\
& \quad [1.00]
\end{align*}

\[ R^2 = 0.91 \quad DW = 1.18 \]

(6.8) Sorghum Price Linkage

\begin{align*}
\text{SGPFMTH} &= 127.000 + 0.833 \frac{\text{COPFMTH}}{\text{D74}} - 222.369 D74 \\
(2.91) & \quad (27.75) \\
& \quad (3.38) \\
& \quad [0.86] \\
+ 683.487(D81 + D82) \\
(13.47)
\end{align*}

\[ R^2 = 0.99 \quad DW = 1.18 \]
Table 6. Continued

Endogenous Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COAHHTH</td>
<td>Thailand, corn area harvested, 1000 ha</td>
</tr>
<tr>
<td>COCOTTH</td>
<td>Thailand, corn ending stocks, 1000 MT</td>
</tr>
<tr>
<td>COUFETH</td>
<td>Thailand, corn feed use, 1000 MT</td>
</tr>
<tr>
<td>COSPRTH</td>
<td>Thailand, corn production, 1000 MT</td>
</tr>
<tr>
<td>COSMNTH</td>
<td>Thailand, corn imports, 1000 MT</td>
</tr>
<tr>
<td>COPFMTH</td>
<td>Thailand, corn farm price, baht/MT</td>
</tr>
<tr>
<td>SGPFMTH</td>
<td>Thailand, sorghum farm price, baht/MT</td>
</tr>
<tr>
<td>PLSPRTH</td>
<td>Thailand, poultry production, 1000 MT</td>
</tr>
</tbody>
</table>

Exogenous Variables

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

\[
\text{COAHHZA} = 2031.360 + 0.512 \text{LAG(COAHHZA)} - 988.149 \text{D72} \\
\quad + 456.140 \text{D73} - 266.049 \text{SHIFT78} - 193.934(\text{D68} + \text{D69}) \\
\quad + 0.883 \text{LAG(COPFMZA/NARDDZA)} \times \text{LAG(COYHHZA)} \\
R^2 = 0.95 \quad DW = 1.36
\]

(7.2) Corn Use

\[
\text{COUDTZA} = 6046.490 + 33.690 \text{NANPDZA/NARDDZA} \\
\quad + 942.812 \text{SHIFT73} + 676.624(\text{D81} + \text{D82}) \\
\quad - 17.979 \text{COPFMZA/NARDDZA} \\
R^2 = 0.96 \quad DW = 1.17
\]

(7.3) Corn Production

\[
\text{COSPRZA} = \text{COAHHZA} \times \text{COYHHZA}
\]

(7.4) Corn Stocks

\[
\text{COCOTZA} = 12.903 + 0.265 \text{COSPRZA} - 6.495 \text{COPFMZA/NARDDZA} \\
\quad + 302.226 \text{D68} + 1382.990 \text{D80} \\
R^2 = 0.98 \quad DW = 1.36
\]
Table 7. Continued

(7.5) **Corn Farm Price**

\[
\text{COPFMZA} = -15.642 + 59.187 \text{ CORPF} \times \text{ NIMEUZA} \\
(2.79) \ (20.77) \ [1.26]
\]

\[-33.210 \text{ D84} - 37.339(\text{D73} + \text{D74} + \text{D75}) \]
\[(2.63) \ (6.06)\]

\[R^2 = 0.98 \quad \text{DW} = 2.15\]

(7.6) **Corn Imports**

\[\text{COSMNZA} = \text{COUDTZA} + \text{COCOTZA} - \text{COSPRZA} - \text{LAG(COCOTZA)}\]

(7.7) **Sorghum Area Harvested**

\[\text{SGAHHZ}
\[ = 217.154 + 0.020 \ \text{LAG}(\text{SGPFMZ}/\text{NARDDZ}) \]
\[(3.75) \ (9.75) \ [0.95]
\]

\[+ 95.774 \ \text{D71} + 126.415 \ \text{D73} - 0.011 \ \text{LAG(WHPFMZ}/\text{NARDDZ}) \]
\[(4.38) \ (5.50) \ (3.60) \ [-0.82]\]

\[\text{SGSPRZA} = \text{SGAHHZ} \times \text{SGYHHZ} \]

(7.8) **Sorghum Production**

\[\text{SGSPRZ}
\[ = 16.646 - 0.008 \ \text{SGPFMZ}/\text{NARDDZ} \]
\[(0.15) \ (2.32) \ [-0.30]\]

\[+ 5.400 \ \text{NANPDZ}/\text{NARDDZ} + 0.193 \ \text{SGSPRZA} \]
\[(3.50) \ (3.04) \ [0.95] \ [0.26]\]

(7.9) **Sorghum Use**

\[\text{SGUDTZA} = 16.646 - 0.008 \ \text{SGPFMZ}/\text{NARDDZ} \]
\[(0.15) \ (2.32) \ [-0.30]\]

\[+ 5.400 \ \text{NANPDZ}/\text{NARDDZ} + 0.193 \ \text{SGSPRZA} \]
\[(3.50) \ (3.04) \ [0.95] \ [0.26]\]
Table 7. Continued

\[ + 133.729 D80 \]
\[ (2.92) \]
\[ R^2 = 0.88 \quad DW = 1.86 \]

(7.10) Sorghum Stocks

\[
SGCOTZA = 16.706 + 0.316 SGSPRZA - 86.100(D70 + D71) \\
(0.49) (8.06) (4.27) \] 
[1.51]
\[ - 151.896 D83 - 0.004 SGPFMZA/NARDDZA \]
\[ (3.85) (1.50) \] 
[(-0.48)]

\[ R^2 = 0.87 \quad DW = 2.51 \]

(7.11) Sorghum Farm Price

\[
SGPFMZA = 1050.390 + 0.933 SGPFMU9 \ast NIMEUZA \\
(2.28) (12.70) \] 
[0.83]
\[ - 2471.500 D74 + 3982.420 D82 + 1782.540 D69 \]
\[ (4.09) (5.65) (2.83) \]
\[ - 1693.660 D72 \]
\[ (2.79) \]

\[ R^2 = 0.98 \quad DW = 2.04 \]

(7.12) Sorghum Imports

\[
SGSMNZA = SGUDTZA + SGCOTZA - SGSPRZA - LAG(SGCOTZA) \]

(7.13) Wheat Farm Price

\[
WHPFMZA = 1827.880 + 4729.080 WHEFF \ast NIMEUZA \\
(2.74) (12.90) \] 
[0.85]
Table 7. Continued

\[ + 5446.900(D80 + D81 + D82) - 5752.210(D73 + D74 + D75) \]
\[ (5.90) \quad (7.60) \]

\[ R^2 = 0.98 \quad DW = 2.34 \]

(7.14) Feed-Grain Imports

\[ FGSMNZ = COSMNZA + BASMNZA + OASMNZ \]

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** = South 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
- **SGSMNZ** = South Africa, Sorghum Imports, 1000 MT
- **WHPPFMA** = South Africa, Wheat Farm Price, Rand/MT
- **FGSMNZ** = 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

\[
FGSPRSU = -43847.900 + 50542.900 FGYHHSU \\
\quad (-4.96) \quad (10.59) \\
+ 0.446 \text{LAG}(FGUDTSU) - 11050.200(D70 + D71) \\
\quad (7.62) \quad (-3.16)
\]

\[R^2 = 0.93\quad DW(1) = 1.57\quad DW(2) = 2.04\]

(8.2) Feed-Grain Area Harvested

\[FGAHHHU = \frac{FGSPRSU}{FGYHHSU}\]

(8.3) Feed-Grain Domestic Uses

\[
FGUDTSU = -26713 - 16961.100 \text{CORPF/LTARCRUD} \\
\quad (-0.87) \quad (-2.27) \\
+ 613.463 \text{CECOTSU} + 0.635 \text{FGSPRSU} \\
\quad (2.47) \quad (10.12) \\
- 7345.85(D82 + D83) \\
\quad (-3.15)
\]

\[R^2 = 0.98\quad DW(1) = 2.32\quad DW(2) = 1.99\]

(8.4) Feed-Grain Ending Stocks

\[
FGCOTSU = 962.328 + 0.071 \text{FGPRESSU} \\
\quad (1.69) \quad (5.17) \\
+ 0.787 \text{LAG}(FGOTSU) - 4242.930 D77 \\
\quad (5.71) \quad (-5.11) \\
+ 2118.360 D84 \\
\quad (2.78)
\]

\[R^2 = 0.83\quad DW(1) = 1.55\quad DW(2) = 1.97\]
Table 8. Continued

(8.5) Animal Inventories

\[
\text{CECOTSU} = 34.586 + 0.023 \, \text{NANPGSU} + 0.430 \, \text{LAG(CECOTSU)} \\
\begin{array}{ll}
(5.42) & (5.52) \\
[0.26]
\end{array}
\]

\[R^2 = 0.99 \quad DW(1) = 1.89 \quad DW(2) = 2.53\]

(8.6) Feed-Grain Net Imports

\[
\text{FGSMNSU} = \text{FGUDTSU} + \text{FGCOTSU} - \text{FGSPRSU} - \text{LAG(FCGOTSU)}
\]

Endogenous Variables

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

Exogenous Variables

\begin{align*}
\text{TREND} & = \text{Time Trend} \\
\text{LTARCRUD} & = \text{Light Arabian crude oil price (U.S. $/bbl.)} \\
\text{NANPGSU} & = \text{Soviet Union, real GDP, 1995 SUS} \\
\text{FGPRESSU} & = \text{Deviation of actual production from trend production} \\
\text{D70} & = 1 \text{ in 1970 and 0 Otherwise} \\
\text{D71} & = 1 \text{ in 1971 and 0 Otherwise} \\
\text{D77} & = 1 \text{ in 1977 and 0 Otherwise} \\
\text{D82} & = 1 \text{ in 1982 and 0 Otherwise} \\
\text{D83} & = 1 \text{ in 1983 and 0 Otherwise}
\end{align*}
Table 9. Structural parameter estimates of the Chinese feed-grains submodel

(9.1) **Feed-Grain Area Harvested**

\[
FGAHHCN = 13512.500 + 873.488 \text{ FGYHHCN (5.03) (2.44)} \\
+ 0.264 \text{ LAG(FGAHHCN)} + 2477.420 \text{ D75 (1.67) (4.58)} \\
+ 3423.170(\text{D76 + D77 + D78 + D79 + D80}) (5.35) \\
- 1172.690 \text{ D85} + 1832.590 \text{ D81 (-2.14) (2.33)} \\
R^2 = 0.97 \quad DW(1) = 1.49 \quad DW(2) = 1.61
\]

(9.2) **Feed-Grain Production**

\[
FGSPRCN = FGAHHCN \times \text{ FGYHHCN}
\]

(9.3) **Feed-Grain Domestic Uses**

\[
FGUDTCN = 1943.290 + 0.854 \text{ FGSPRCN (1.56) (37.65)} \\
+ 16.716 \text{ HOCOTCN} + 4800.920 \text{ D7883 (2.34) (8.72)} \\
R^2 = 0.998 \quad DW(1) = 1.58 \quad DW(2) = 2.13
\]

(9.4) **Hog Inventories**

\[
HOCOTCN = 107.554 + 0.086 \text{ NANYNCN (4.84) (3.07)} \\
+ 0.352 \text{ LAG(HOCOTCN)} + 50.817 \text{ SHIFT71 (2.64) (4.33)} \\
+ 25.160 \text{ D79 (2.21)} \\
R^2 = 0.96 \quad DW(1) = 1.76 \quad DW(2) = 2.26
\]
Table 9. Continued

(9.5) Feed-Grain Net Imports

\[ \text{FGSMNCN} = \text{FGUDTCN} - \text{FGSPRCN} \]

Endogenous Variables

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

Exogenous Variables

- \( \text{NANYNCN} = \text{China, net material product produced, bil 1980 yuan} \)
- \( \text{D75} = 1 \text{ in 1975 and } 0 \text{ Otherwise} \)
- \( \text{D76} = 1 \text{ in 1976 and } 0 \text{ Otherwise} \)
- \( \text{D77} = 1 \text{ in 1977 and } 0 \text{ Otherwise} \)
- \( \text{D78} = 1 \text{ in 1978 and } 0 \text{ Otherwise} \)
- \( \text{D79} = 1 \text{ in 1979 and } 0 \text{ Otherwise} \)
- \( \text{D80} = 1 \text{ in 1980 and } 0 \text{ Otherwise} \)
- \( \text{D7883} = 1 \text{ from 78-83, } 0 \text{ Otherwise} \)
- \( \text{SHIFT71} = 1 \text{ after 1970, } 0 \text{ Otherwise} \)
Table 10. Structural parameter estimates of the Eastern European feed-grains submodel

(10.1) **Feed-Grain Production**

\[ \text{FGSPRE} = 2538.060 + 10085.100 \, \text{FGYHHE} + 0.211 \, \text{LAG(FGUDTE)} + 3315.710 \, \text{D75} \]
\[ + 2713.390 \, \text{D79} \]
\[ R^2 = 0.98 \quad \text{DW(1)} = 2.16 \quad \text{DW(2)} = 2.47 \]

(10.2) **Feed-Grain Uses**

\[ \text{FGUDTE} = -6599.810 + 0.741 \, \text{FGSPRE} + 386.514 \, \text{HOCOTE} - 5549.630 \, \text{SHIFT81} \]
\[ + 2709.450 \, \text{D85} \]
\[ R^2 = 0.98 \quad \text{DW(1)} = 1.46 \quad \text{DW(2)} = 1.35 \]

(10.3) **Feed-Grain Ending Stocks**

\[ \text{FGCCOTE} = -2150.610 + 0.092 \, \text{FGSPRE} + 0.097 \, \text{LAG(FGCCOTE)} + 763.352 \, \text{D69} \]
\[ - 687.101(\text{D72} + \text{D73} + \text{D74}) + 717.713(\text{D84} + \text{D85}) \]
\[ R^2 = 0.97 \quad \text{DW(1)} = 2.02 \quad \text{DW(2)} = 2.84 \]

(10.4) **Hog Inventories**

\[ \text{HOCOTE} = 1.082 + 16.519 \, \text{NARPDIE} \]
\[ [0.52] \quad (2.25) \]
Table 10. Continued

\[ + 0.413 \text{LAG(HOCOTE8)} + 0.0004 \text{LAG(FGUDTE8)} \]
\[ (2.67) \quad (2.62) \]
\[ + 5.762 D75 + 4.096 D77 - 4.281 D85 \]
\[ (3.55) \quad (2.49) \quad (-2.09) \]
\[ R^2 = 0.99 \quad DW(1) = 1.80 \quad DW(2) = 2.64 \]

(10.5) Feed-Grain Net Imports

\[ \text{FGSMNE8} = \text{FGUDTE8} + \text{FGCOTE8} - \text{FGSPRE8} - \text{LAG(FGCOTE8)} \]

Endogenous Variables

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

Exogenous Variables

- \text{NARPDIE8} = Eastern Europe; Real GDP Index; 1980 = 1.0
- \text{D69} = 1 in 1969 and 0 Otherwise
- \text{D72} = 1 in 1972 and 0 Otherwise
- \text{D73} = 1 in 1973 and 0 Otherwise
- \text{D74} = 1 in 1974 and 0 Otherwise
- \text{D75} = 1 in 1975 and 0 Otherwise
- \text{D79} = 1 in 1979 and 0 Otherwise
- \text{D84} = 1 in 1984 and 0 Otherwise
- \text{D85} = 1 in 1985 and 0 Otherwise
- \text{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

\[ \text{COUDTJP} = -538.000 - 0.0265 \text{COVIMJP/NARDDJP} \]
\[ (-0.12) \quad (-1.00) \]
\[ [-0.11] \]
\[ + 1606.720 \text{HOCOTJP} \]
\[ (1.85) \]
\[ [1.42] \]
\[ - 0.9335 \text{SGUDTJP} - 1.0536 \text{RIUFEJP} \]
\[ (-6.21) \quad (-3.37) \]
\[ [-0.39] \quad [-0.07] \]
\[ + 2.2860 \text{PYSRJP} \]
\[ (0.52) \]
\[ [0.20] \]
\[ R^2 = 0.99 \quad DW = 2.41 \]

(11.2) Corn Ending Stocks

\[ \text{COCOTJP} = 619.000 + 0.4741 \text{LAG(COCOTJP)} \]
\[ (1.63) \quad (1.92) \]
\[ [0.44] \]
\[ - 0.0085 \text{COVIMJP/NARDDJP} \]
\[ (-1.26) \]
\[ [-0.40] \]
\[ + 300.130 \text{SHIFT73} \]
\[ (1.69) \]
\[ R^2 = 0.83 \quad DW = 2.84 \]

(11.3) Corn Import Value

\[ \text{COVIMJP} = 4266.37 + 1.0252 \text{COPOBU9} * \text{NIMEUJP} \]
\[ (2.66)(16.77) \]
\[ [0.87] \]
\[ - 8515.57 \text{D73} \]
\[ (-4.91) \]
\[ R^2 = 0.95 \quad DW = 1.78 \]
Table 11. Continued

(11.4) Corn Net Import

\[ \text{COSMNJP} = \text{COCOTJP} + \text{COUDTJP} - \text{COSPRJP} - \text{LAG(COCOTJP)} \]

(11.5) Barley Area Harvested

\[ \text{BAAHHJP} = -70.2894 + 0.8950 \text{ LAG(BAAHHJP)} \]
\[ (-2.90) \quad (22.29) \]
\[ + 0.0006 \text{ BAPGFJP/NARDDJP} \]
\[ (3.65) \quad [0.50] \]
\[ R^2 = 0.98 \quad \text{DW} = 1.17 \]

(11.6) Barley Production

\[ \text{BASPRJP} = \text{BAAHHJP} \times \text{BAYHHJP} \]

(11.7) Barley Imports

\[ \text{BASMNJP} = 781.960 + 0.0064 \text{ NANPDJP/NARDDJP} \]
\[ (1.30) \quad (5.61) \]
\[ - 0.0272 \text{ BAPRSJP/NARDDJP} \]
\[ (-5.59) \quad [-1.09] \]
\[ + 0.0140 \text{ COVIMJP/NARDDJP} + 559.3300 D7677 \]
\[ (2.24) \quad (6.02) \]
\[ R^2 = 0.93 \quad \text{DW} = 1.80 \]

(11.8) Barley Stock

\[ \text{BACOTJP} = -79.3835 + 0.5373 \text{ LAG(BACOTJP)} \]
\[ (-0.81) \quad (2.97) \]
\[ [0.50] \]
### Table 11. Continued

<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 0.2412 BASMNJP</td>
<td></td>
<td>(2.53)</td>
<td>[0.67]</td>
<td></td>
</tr>
<tr>
<td>R² = 0.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DW = 1.93</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### (11.9) Barley Feed Use

\[
BAUFEJP = 355.520 - 0.0065 \text{ BAPRSJP}/\text{NARDDJP} \\
(1.01) (-1.97) [-0.29]
\]

\[
+ 0.0081 \text{ COVIMJP}/\text{NARDDJP} \\
(1.98) [0.28]
\]

\[
+ 0.9803 \text{ PYSPRJP} \\
(8.47) [0.71]
\]

R² = 0.95 \quad DW = 1.53

#### (11.10) Barley Equilibrium Condition

\[
BAUHTJP = BASPRJP + BASMNJP + \text{LAG(BACOTJP)} - BAUFEJP - BACOTJP
\]

#### (11.11) Sorghum Imports

\[
SGSMNJP = 232.710 - 0.2161 \text{ SGPOBU9} \times \text{NIMEUJP}/\text{NARDDJP} \\
(0.20) (-1.88) [-1.78]
\]

\[
+ 0.2161 \text{ COPOBU9} \times \text{NIMEUJP}/\text{NARDDJP} \\
(2.17) [1.87]
\]

\[
+ 407.200 \text{ HOCOTJP} \\
(5.15) [0.87]
\]

\[
+ 869.670 \text{ D7679} - 1232.300 \text{ D8083} \\
(4.24) (-5.41)
\]

R² = 0.94 \quad DW = 2.20
Table 11. Continued

(11.12) Sorghum Stocks

\[ SGCOTJP = -57.1494 + 0.5308 \text{LAG}(SGCOTJP) \]
\[ (-0.61) \quad (2.74) \]
\[ + 0.0561 \text{SGSMNJP} \]
\[ (2.02) \quad [0.65] \]
\[ R^2 = 0.62 \quad DW = 2.01 \]

(11.13) Sorghum Equilibrium Condition

\[ SGUDTJP = \text{SGSMNJP} + \text{LAG}(SGCOTJP) - SGCOTJP \]

(11.14) Hog Inventories

\[ HOCOTJP = -22.6137 + 0.5071 \text{LAG}(HOCOTJP) \]
\[ (-1.52) \quad (2.78) \]
\[ - 0.00004 \text{COVIMJP/NARDDJP} \]
\[ (-2.75) \quad [-0.17] \]
\[ + 2.3213 \text{LOG}(NANPDJP/NARDDJP) \]
\[ (1.76) \]

(11.15) Poultry Production

\[ PYSPRJP = -2520.170 + 0.7362 \text{LAG}(PYSPRJP) \]
\[ (-1.23) \quad (5.71) \]
\[ - 0.0035 \text{COVIMJP/NARDDJP} \]
\[ (-2.79) \quad [-0.16] \]
\[ + 240.05 \text{LOG}(NANPJP/NARDDJP) \]
\[ (1.38) \]
Table 11. Continued

(11.16) Feed-Grain Imports

\[ FGSMNJJP = COSMNJP + BASMNJP + OASMNJJP \]

**Endogenous Variables**

- **BAAHHJP**: Japan, barley area harvested, 1000 hectares
- **BACOTJP**: Japan, barley ending stocks, 1000 metric tons
- **BASMNJJP**: Japan, barley net imports, 1000 metric tons
- **BASPRJJP**: 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
- **COVIMJJP**: 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
- **FYSPRJP**: Japan, poultry production, cal. year, 1000 metric tons
- **SGCOTJP**: Japan, sorghum ending stocks, 1000 metric tons
- **SGSMNJJP**: Japan, sorghum net imports, 1000 metric tons
- **SGUDTJP**: Japan, sorghum domestic use, 1000 metric tons

**Exogenous Variables**

- **BAPGFJP**: 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, $/metric ton
- **COSPRJP**: Japan, corn production, 1000 metric tons
- **D73**: Dummy variable, 1 in 1973, 0 otherwise
- **D7677**: Dummy variable, 1 in 1976 and 1977, 0 otherwise
- **D7679**: Shift variable, 1 from 1976-79, 0 otherwise
- **D8083**: Shift variable, 1 from 1980-83, 0 otherwise
- **DOPOPJP**: Japan, population, million
- **NANPDPJP**: Japan, gross domestic product, billion Yen
- **NARDJP**: Japan, gross domestic product deflator, 1980=100
- **NIMEUJP**: Japan, bilateral exchange rate, period average, Yen/$
- **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
94

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 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

\[
FGAHHBR = 8410.300 + 0.259 \text{LAG}(FGAHHBR) \\
(4.03) \quad (2.65)
\]
\[
+ 0.554 \text{LAG}(COPFMRBR) - 0.274 \text{LAG}(WHPPFMRB) \\
(4.14) \quad (3.68)
\]
\[
[0.29] \quad [-0.28]
\]
\[
- 0.018 \text{LAG}(SBPFMRBR) + 1687.950 \text{DM85} \\
(0.44) \quad (3.84)
\]
\[
[-0.16]
\]
\[
+ 1255.330 \text{DM81} - 1551.800 \text{DM72} \\
(3.11) \quad (4.09)
\]
\[
R^2 = 0.95 \quad DW = 1.98
\]

(12.2) Feed-Grain Production

\[
FGSPRBR = FGAHHBR \times FGYHBR
\]

(12.3) Feed-Grain Use

\[
FGUDTBR = 9790.180 + 0.884 \text{NANPDBR/NARDDR} \\
(0.48) \quad (11.00)
\]
\[
[0.49]
\]
\[
- 0.377 \text{COPFMRBR} + 3212.420 \text{DM79S} \\
(1.81) \quad (6.59)
\]
\[
[-0.13]
\]
\[
+ 3007.840 \text{DM71} \\
(4.27)
\]
\[
R^2 = 0.98 \quad DW = 2.37
\]

(12.4) Feed-Grain Imports

\[
FGSMNBR = FGUDTBR + FGCOTBR - FGSPRBR - \text{LAG}(FGCOTBR)
\]
### Table 12. Continued

#### (12.5) Corn Farm Price

\[
\text{COPFMRBR} = 2304.480 + 20416.400 \ \text{COPFMU9} \times \text{NIMEUBR}/\text{NARDDBR} \\
(5.44) \quad (7.97) \quad [0.52]
\]

\[
+ 1525.310(D77 + D78 + D79) + 2217.080 \ D82 \\
(7.02) \quad (7.22)
\]

\[
+ 1381.720(D71 + D72)
\]

\[R^2 = 0.91 \quad \text{DW} = 1.44\]

#### (12.6) Wheat Farm Price

\[
\text{WHPFMRBR} = 5336.550 + 0.502 \ \text{LAG(WHPFMRBR)} \\
+ 5973.040(\text{WHEPF} \times \text{NIMEUBR})/\text{NARDDBR} \\
- 2355.990 \ \text{LAG(WHSPRBR/WHUDTBR)} + 2386.490 \ D84 \\
- 1976.840(D78 + D79)
\]

#### (12.7) Soybean Farm Price

\[
\text{SBPFMRBR} = 2286.600 + 0.544 \ \text{SBPFMU} \times 36.744 \ \text{NIMEUBR}/\text{NARDDBR} \\
(1.74) \quad (5.65) \quad [0.72]
\]

\[
\times 1000 + 7231.790 \ D72 + 5306.360 \ D75 \\
(7.96) \quad (5.96)
\]

\[
+ 2970.680 \ D82 - 2803.060 \ D66 \\
(3.35) \quad (3.08)
\]

\[R^2 = 0.92 \quad \text{DW} = 1.98\]

**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

WHFFMRBR = Brazil, real wheat price, 1980 C2/MT
SBFFMRBR = Brazil, real soybean price, 1980 C2/MT

Exogenous Variables

FGCOTBR = Brazil, feed-grains stocks, 1000 MT
FGYHBR = 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

\[
FGSPRMX = -8433.290 + 9415.450 \text{FGYHMX} + 0.748 \text{LAG(FGAHHMX)} \\
\quad - 1921.540(D82 + D84) + 0.198 \text{LAG(COPFMMXR)} \\
(4.60) \quad (15.26) \quad (4.60) \quad (6.38) \quad (1.41) \quad [0.08]
\]

\[R^2 = 0.95 \quad DW = 2.33\]

(13.2) Feed-Grain Area Harvested

\[FGAHHMX = FGSPRMX/FGYHMX\]

(13.3) Feed-Grain Domestic Use

\[
FGUOTMX = 8866.240 - 2536.480 \text{COPFMMXR}/\text{WHPFMMXR} \\
(3.96) \quad (1.09) \quad [-0.28] \\
+ 7.042 \text{POSFRMX} + 1777.270 D77 + 1952.300(D80 + D81) \\
(6.55) \quad (2.05) \quad (3.23)
\]

\[R^2 = 0.90 \quad DW = 2.04\]

(13.4) Feed-Grain Stocks

\[
FGCOTMX = -1360.420 + 0.215 \text{LAG(FGCOTMX)} + 0.197 \text{FGSPRMX} \\
(3.94) \quad (2.21) \quad (4.97) \quad [2.86] \\
+ 1233.340 \text{D80} - 623.537 \text{D78} - 473.300 \text{D84} \\
(5.81) \quad (2.97) \quad (2.27)
\]

\[R^2 = 0.90 \quad DW = 1.93\]

(13.5) Corn Farm Price

\[
COPFMMXR = 2536.360 + 0.315 \text{LAG(COPFMMXR)} + 8.094 \text{COPFMU9} \\
(2.61) \quad (1.87) \quad (1.49) \quad [0.16]
\]
Table 13. Continued

* NIMEUX/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)

\[ R^2 = 0.88 \quad \text{DW} = 2.41 \]

(13.6) Wheat Farm Price

\[ \text{WHPFMMXR} = 945.483 + 0.741 \text{LAG(WHPFMMXR)} \]
\[ (1.70) \quad (6.11) \]

\[ + 1137.180\text{(NARDDMX - LAG(NARDDMX))}/\text{LAG(NARDDMX)} \]
\[ (2.61) \quad [-0.08] \]

\[ + 901.418 D74 + 594.963 D75 + 805.780 D83 \]
\[ (2.58) \quad (2.97) \]

\[ R^2 = 0.95 \quad \text{DW} = 1.88 \]

(13.7) Pork Production

\[ \text{POSPRMX} = 675.916 + 0.172 \text{NANPDMX}/\text{NARDDMX} \]
\[ (3.11) \quad (6.41) \quad [0.87] \]

\[ + 0.140 \text{LAG(COPFMMXR)} - 143.988 D71 + 177.264 D75 \]
\[ (4.26) \quad (2.08) \quad (2.67) \quad [-0.88] \]

\[ R^2 = 0.96 \quad \text{DW} = 2.39 \]

(13.8) Feed-Grain Imports

\[ \text{FGSMNMX} = \text{FGCOTMX} + \text{FGUDTMX} - \text{FGSPRMX} - \text{LAG(FGCOTMX)} \]
Table 13. Continued

<table>
<thead>
<tr>
<th>Equation</th>
<th>R²</th>
<th>DW</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ NIMEUMX/NARDDMX - 1180.260 \ (NARDDMX) ] [ (2.51) ] [ [-0.08] ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ - \text{LAG(NARDDMX)}/\text{LAG(NARDDMX)} - 601.006(\text{D72} + \text{D73}) ] [ (2.40) ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ + 668.376 \ \text{D67} - 731.143 \ \text{D81} ] [ (2.03) ] [ (2.31) ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ R² = 0.88 \quad \text{DW} = 2.41 ]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**(13.6) Wheat Farm Price**

\[ \text{WHPFMMX} = 945.483 + 0.741 \ \text{LAG(WHPFMMX)} \] \[ (1.70) \] \[ (6.11) \]
\[ + 1137.180(\text{NARDDMX} - \text{LAG(NARDDMX)})/\text{LAG(NARDDMX)} \] \[ (2.61) \] \[ [-0.08] \]
\[ + 901.418 \ \text{D74} + 594.963 \ \text{D75} + 805.780 \ \text{D83} \] \[ (2.58) \] \[ (2.97) \]

\[ R² = 0.95 \quad \text{DW} = 1.88 \]

**(13.7) Pork Production**

\[ \text{POSPRMX} = 675.916 + 0.172 \ \text{NANPDMX}/\text{NARDDMX} \] \[ (3.11) \] \[ (6.41) \] \[ [0.87] \]
\[ + 0.140 \ \text{LAG(COPFMMX)} - 143.988 \ \text{D71} + 177.264 \ \text{D75} \] \[ (4.26) \] \[ (2.08) \] \[ (2.67) \] \[ [-0.88] \]

\[ R² = 0.96 \quad \text{DW} = 2.39 \]

**(13.8) Feed-Grain Imports**

\[ \text{FGSMNMMX} = \text{FGCOTMX} + \text{FGUDTMX} - \text{FGSPRMX} - \text{LAG(FGCOTMX)} \]
Table 13. Continued

(13.13) Sorghum Farm Price

\[ \text{SGPFMMXR} = 2292.740 + 0.004 \text{ SGPFMU9} * \text{NIMEUMX/NARDDMX} \]
\[ (9.97) \quad (5.37) \]
\[ [0.42] \]
\[ - 2157.700 \left( \text{NARDDMX} - \text{LAG(NARDDMX)} \right) / \text{LAG(NARDDMX)} \]
\[ (14.40) \quad [-0.18] \]
\[ - 545.397 \text{ D73} + 468.452 \text{ D75} \]
\[ (3.45) \quad (3.10) \]
\[ R^2 = 0.96 \quad DW = 1.65 \]

(13.14) Sorghum Imports

\[ \text{SGSMNMX} = \text{SGUDTMX} + \text{SGCOTMX} - \text{SGSPRMX} - \text{LAG(SGCOTMX)} \]

Endogenous Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGSPPRMX</td>
<td>Mexico, Feed-Grain Production, 1000 MT</td>
</tr>
<tr>
<td>FGAHHMX</td>
<td>Mexico, Feed-Grain Area Harvested, 1000 ha</td>
</tr>
<tr>
<td>FGUDTMX</td>
<td>Mexico, Feed-Grain Domestic Use, 1000 MT</td>
</tr>
<tr>
<td>COPFMFX</td>
<td>Mexico, Corn Farm Price, 1980 pesos/MT</td>
</tr>
<tr>
<td>WHPPFMXR</td>
<td>Mexico, Wheat Farm Price, 1980 pesos/MT</td>
</tr>
<tr>
<td>PGSPPRMX</td>
<td>Mexico, Pork Production, 1980 pesos/MT</td>
</tr>
<tr>
<td>FGCOTMX</td>
<td>Mexico, Feed-Grain Stocks, 1000 MT</td>
</tr>
<tr>
<td>FGSMNMX</td>
<td>Mexico, Feed-Grain Imports, 1000 MT</td>
</tr>
<tr>
<td>SGAHHMX</td>
<td>Mexico, Sorghum Area Harvested, 1000 ha</td>
</tr>
<tr>
<td>SGSPRMX</td>
<td>Mexico, Sorghum Production, 1000 MT</td>
</tr>
<tr>
<td>SGUDTMX</td>
<td>Mexico, Sorghum Domestic Use, 1000 MT</td>
</tr>
<tr>
<td>SGCOTMX</td>
<td>Mexico, Sorghum Stocks, 1000 MT</td>
</tr>
<tr>
<td>SGPFMMXR</td>
<td>Mexico, Sorghum Farm Price</td>
</tr>
</tbody>
</table>

Exogenous Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGYHHMX</td>
<td>Mexico, Feed-Grain Yield, MT/ha</td>
</tr>
<tr>
<td>NARDDMX</td>
<td>Mexico, GDP Deflator, 1980 = 1.0</td>
</tr>
<tr>
<td>NIMEUMX</td>
<td>Mexico, Exchange Rate, pesos 1$</td>
</tr>
<tr>
<td>NANPDMX</td>
<td>Mexico, GDP, mil pesos</td>
</tr>
<tr>
<td>D67</td>
<td>1 in 1967 and 0 Otherwise</td>
</tr>
<tr>
<td>D71</td>
<td>1 in 1971 and 0 Otherwise</td>
</tr>
<tr>
<td>D72</td>
<td>1 in 1972 and 0 Otherwise</td>
</tr>
<tr>
<td>Year</td>
<td>Condition</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>1973</td>
<td>D73 = 1 in 1973 and 0 Otherwise</td>
</tr>
<tr>
<td>1974</td>
<td>D74 = 1 in 1974 and 0 Otherwise</td>
</tr>
<tr>
<td>1975</td>
<td>D75 = 1 in 1975 and 0 Otherwise</td>
</tr>
<tr>
<td>1977</td>
<td>D77 = 1 in 1977 and 0 Otherwise</td>
</tr>
<tr>
<td>1978</td>
<td>D78 = 1 in 1978 and 0 Otherwise</td>
</tr>
<tr>
<td>1979</td>
<td>D79 = 1 in 1979 and 0 Otherwise</td>
</tr>
<tr>
<td>1980</td>
<td>D80 = 1 in 1980 and 0 Otherwise</td>
</tr>
<tr>
<td>1981</td>
<td>D81 = 1 in 1981 and 0 Otherwise</td>
</tr>
<tr>
<td>1982</td>
<td>D82 = 1 in 1982 and 0 Otherwise</td>
</tr>
<tr>
<td>1983</td>
<td>D83 = 1 in 1983 and 0 Otherwise</td>
</tr>
<tr>
<td>1984</td>
<td>D84 = 1 in 1984 and 0 Otherwise</td>
</tr>
</tbody>
</table>
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

\[
\text{COSPREG} = -634.338 + 0.760 \text{LAG(COSPREG)} + 321.735 \text{COYHHEG} \\
(1.03) \quad (6.00) \quad (2.44)
\]

\[+ 336.531 \text{LAG(COPFMEG/NARDDEG)} \]
\[ (1.25) \quad [0.11] \]

\[- 256.604 \text{LAG(WHPFMEG/NARDDEG)} + 323.852 \text{DM178} \]
\[ (0.65) \quad (2.99) \quad [-0.07] \]

\[+ 240.775 \text{DM180} \]
\[ (2.18) \]

\[R^2 = 0.97 \quad DW = 2.07 \]

(14.2) Corn Area Harvested

\[\text{COAHHEG} = \text{COSPREG}/\text{COYHHEG} \]

(14.3) Corn Domestic Use

\[\text{COUDTTEG} = -468.468 + 12.065 \text{NANPDEG/NARDDEG} \]
\[ (0.62) \quad (2.57) \quad [0.46] \]

\[+ 1271.100 \text{DM184} + 0.805 \text{COSPREG} - 257.171 \text{D79} \]
\[ (6.23) \quad (1.66) \quad (1.24) \quad [0.65] \]

\[+ 565.047 \text{D85} \]
\[ (2.85) \]

\[R^2 = 0.99 \quad DW = 1.59 \]

(14.4) Corn Stocks

\[\text{COCOTEG} = 1298.830 - 598.080(\text{COPFMEG/NARDDEG}) \times \text{SHIFT73} \]
\[ (52.09) \quad (4.43) \quad [-0.24] \]

\[+ 0.347 \text{COSPREG} \times \text{SHIFT73} - 370.817 \text{DM179} \]
\[ (7.62) \quad (5.47) \]
Table 14. Continued

\[ -190.284(DM177 + DM176) \]

\[ R^2 = 0.95 \quad DW = 1.99 \]

(14.5) Corn Farm Price

\[ \text{COPFMEG} = -133.801 + 40.817 \text{ COPFMU9 } \times \text{ NIMEUEG} \]
\[ (2.98) \quad (4.92) \quad [0.70] \]

\[ + 134.098 \text{ LAG(COUDTEG/COSPREG)} - 23.663 \text{ DM178} \]
\[ (2.98) \quad (1.82) \quad [2.42] \]

\[ R^2 = 0.92 \quad DW = 1.35 \]

(14.6) Corn Imports

\[ \text{COSMNEG} = \text{COUDTEG} + \text{COCOTEG} - \text{COSPREG} - \text{LAG(COCOTEG)} \]

(14.7) Feed-Grain Imports

\[ \text{FGSMNEG} = \text{COSMNEG} + \text{BASMNEG} \]

Endogenous Variables

\begin{align*}
\text{COSPREG} &= \text{Egypt, Corn Production, 1000 MT} \\
\text{COAHHEG} &= \text{Egypt, Corn Area Harvested, 1000 ha} \\
\text{COUDTEG} &= \text{Egypt, Corn Domestic Use, 1000 MT} \\
\text{COCOTEG} &= \text{Egypt, Corn Stocks, 1000 MT} \\
\text{COPFMEG} &= \text{Egypt, Corn Farm Price, pounds/MT} \\
\text{COSMNEG} &= \text{Egypt, Corn Imports, 1000 MT} \\
\text{FGSMNEG} &= \text{Egypt, Feed-Grain Imports, 1000 MT}
\end{align*}

Exogenous Variables

\begin{align*}
\text{COYHHEG} &= \text{Egypt, Corn Yield, MT/ha} \\
\text{NARDDEG} &= \text{Egypt, GDP Deflator, 1980=100} \\
\text{WHPPFMEG} &= \text{Egypt, Wheat Farm Price, pounds/MT} \\
\text{NANPDEG} &= \text{Egypt, GDP, mil.pounds} \\
\text{NIMEUEG} &= \text{Egypt, Exchange Rates} \\
D79 &= 1 \text{ in 1979 and 0 Otherwise}
\end{align*}
Table 14. Continued

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>D85</td>
<td>$1$ in 1985 and $0$ Otherwise</td>
</tr>
<tr>
<td>D176</td>
<td>$1$ in 1976, $0$ Otherwise</td>
</tr>
<tr>
<td>D177</td>
<td>$1$ in 1977, $0$ Otherwise</td>
</tr>
<tr>
<td>D178</td>
<td>$1$ in 1978, $0$ Otherwise</td>
</tr>
<tr>
<td>D179</td>
<td>$1$ in 1979, $0$ Otherwise</td>
</tr>
<tr>
<td>D184</td>
<td>$1$ in 1984, $0$ Otherwise</td>
</tr>
<tr>
<td>SHIFT73</td>
<td>$1$ after 1972, $0$ Otherwise</td>
</tr>
</tbody>
</table>
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
\[
\text{SGAHHIN} = 14200.100 + 0.218 \text{LAG}(\text{SGAHHIN}) \\
(8.05) \quad (2.06)
\]
\[
+ 2.895 \text{LAG}[(\text{SGPFMIN/NARDDIN}) \times \text{SGYHHIN}] \\
(4.31) \quad [0.11]
\]
\[
+ 1162.740(D68 + D69) - 1.433 \text{LAG}[(\text{WHPFMIN/NARDDIN}) \times \text{WHYHHIN}] \\
(4.31) \quad (4.62) \quad [-0.18]
\]
\[
- 1652.700 \ D74 + 700.813 \ D79 - 1147.010 \ D72 \\
(2.51) \quad (4.13)
\]
\[R^2 = 0.95 \quad \text{DW} = 1.98\]

(15.2) Sorghum Production
\[
\text{SGSPRIN} = \text{SGAHHIN} \times \text{SGYHHIN}
\]

(15.3) Sorghum Domestic Use
\[
\text{SGUOTIN} = 1277.310 + 0.892 \text{SGSPRIN} + 643.314(D67 + D68 + D69) \\
(2.72) \quad (19.68) \quad (3.63) \quad \text{[0.87]}
\]
\[R^2 = 0.96 \quad \text{DW} = 1.92\]

(15.4) Sorghum Stocks
\[
\text{SGCOTIN} = 59.918 + 0.293 \text{LAG}(\text{SGCOTIN}) + 0.032 \text{SGSPRIN} \\
(0.39) \quad (5.02) \quad (2.10) \quad \text{[0.42]}
\]
\[
+ 763.250 \ D77 + 325.024(D73 + D74 + D75 + D76) \\
(8.15) \quad (6.60)
\]
\[
+ 336.723 \ D78 \\
(3.44)
\]
\[R^2 = 0.94 \quad \text{DW} = 2.10\]
Table 15. Continued

(15.5) Sorghum Real Price

\[
SGPFMIN = 1953.370 + 0.861 \text{LAG(SGPFMIN)} \\
(2.65) \text{(12.39)}
\]

\[
- 1894.350 \text{SGSPRIN/SGUDTIN} + 179.487 \text{D71} - 448.156 \text{D74} \\
(2.68) \quad (1.80) \quad (4.28)
\]

\[R^2 = 0.96 \quad DW = 2.49\]

(15.6) Sorghum Imports

\[
SGSMNIN = \text{SGUDTIN} + \text{SGCOTIN} - \text{SGSPRIN} - \text{LAG(SGCOTIN)}
\]

Endogenous Variables

- SGAAHHIN = 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

<table>
<thead>
<tr>
<th>(16.1) Sorghum Area Harvested</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGAHHNG = 1772.790 + 0.191 LAG(SGAHHNG) - 1807.930 D72</td>
</tr>
<tr>
<td>(1.25) (1.67) (8.45)</td>
</tr>
<tr>
<td>- 752.201 SHIFT80 + 3646.560 LAG(SGPFMNG/COPFMNG)</td>
</tr>
<tr>
<td>(1.45) (1.66) [0.57]</td>
</tr>
<tr>
<td>- 756.556 D67 - 908.218 D74</td>
</tr>
<tr>
<td>(3.60) (4.30)</td>
</tr>
<tr>
<td>$R^2 = 0.94$ $\text{DW} = 2.44$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(16.2) Sorghum Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGSPRNG = SGAHHNG * SCYHHNG</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(16.3) Sorghum Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGUDTNG = 129.776 + 0.968 SGSPRNG - 0.056 SGPFMNG/NARDDNG</td>
</tr>
<tr>
<td>(1.85) (58.04) (0.38) [0.97] [-0.003]</td>
</tr>
<tr>
<td>$R^2 = 1.00$ $\text{DW} = 2.70$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(16.4) Sorghum Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGPFMNG = 195.819 + 85.252 SHIFT79</td>
</tr>
<tr>
<td>(0.64) (10.16)</td>
</tr>
<tr>
<td>- 164.038 LAG(SGSPRNG/SGUDTNG) + 25.062 SHIFT71</td>
</tr>
<tr>
<td>(0.53) (4.09) [-1.41]</td>
</tr>
<tr>
<td>+ 65.202 NARDDNG</td>
</tr>
<tr>
<td>(5.69) [0.35]</td>
</tr>
<tr>
<td>$R^2 = 0.99$ $\text{DW} = 1.30$</td>
</tr>
</tbody>
</table>
Table 16. Continued

(16.5) Corn Price

\[
\text{COPFMNG} = 14.423 + 0.966 \times \text{SGPFMNG} + 9.964 \times \text{SHIFT}71 \\
(8.49) (28.28) (5.11)
\]

\[
- 27.198 \times \text{SHIFT}79 \\
(6.17)
\]

\[
R^2 = 1.00 \quad DW = 1.67
\]

(16.6) Corn Imports

\[
\text{SGSMNNG} = \text{SGUDTNG} + \text{SGCCTNG} - \text{SGSPRNG} - \text{LAG(SGCOTNG)}
\]

Endogenous Variables

\[
\begin{align*}
\text{SGAHHNG} &= \text{Nigeria, Sorghum Area Harvested, 1000 ha} \\
\text{SGSPRNG} &= \text{Nigeria, Sorghum Production, 1000 MT} \\
\text{SGPFMNG} &= \text{Nigeria, Sorghum Farm Price, Naira/MT} \\
\text{COPFMNG} &= \text{Nigeria, Corn Farm Price, Naira/MT} \\
\text{SGUDTNG} &= \text{Nigeria, Sorghum Domestic Use, 1000 MT} \\
\text{SGSMNNG} &= \text{Nigeria, Sorghum Imports, 1000 MT}
\end{align*}
\]

Exogenous Variables

\[
\begin{align*}
\text{SGYHHNG} &= \text{Nigeria, Sorghum Yield, MT/ha} \\
\text{NARDDNG} &= \text{Nigeria, GDP Deflator, 1980=1.0} \\
\text{D67} &= 1 \text{ in 1967 and 0 Otherwise} \\
\text{D72} &= 1 \text{ in 1972 and 0 Otherwise} \\
\text{D74} &= 1 \text{ in 1974 and 0 Otherwise} \\
\text{SHIFT}71 &= 1 \text{ after 1970, 0 Otherwise} \\
\text{SHIFT}79 &= 1 \text{ after 1978, 0 Otherwise} \\
\text{SHIFT}80 &= 1 \text{ after 1979, 0 Otherwise}
\end{align*}
\]
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

<table>
<thead>
<tr>
<th>(17.1) Barley Domestic Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>[\text{BAUDTSA} = -866.522 + 3.453 \text{EGSPRSA} + 921.522 \text{SHIFT74} ]</td>
</tr>
<tr>
<td>( (6.44) ) ( (27.61) ) ( (5.75) )</td>
</tr>
<tr>
<td>[ R^2 = 0.99 \quad \text{DW} = 1.47 ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(17.2) Egg Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>[\text{EGSPRSA} = -118.971 + 0.685 \text{LAG(EGSPRSA)} ]</td>
</tr>
<tr>
<td>( (1.15) ) ( (7.75) )</td>
</tr>
<tr>
<td>[ + 4.699 \text{SHIFT82} \ast \text{LTARCRUD} \ast \text{NIMEUSA/NARDDSA} ]</td>
</tr>
<tr>
<td>( (5.44) )</td>
</tr>
<tr>
<td>[ + 201.016 \text{D81} - 260.198 \text{D82} - 162.801 \text{D79} ]</td>
</tr>
<tr>
<td>( (4.89) ) ( (5.78) ) ( (4.71) )</td>
</tr>
<tr>
<td>[ + 0.001 \text{SHIFT75} \ast \text{NANPDSA/NARDDSA} + 118.971 \ast \text{SHIFT74} ]</td>
</tr>
<tr>
<td>( (2.92) )</td>
</tr>
<tr>
<td>[ R^2 = 1.00 \quad \text{DW} = 2.35 ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(17.3) Barley Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{BASMNSA} = \text{BAUDTSA} + \text{BACOTSA} - \text{BASPRSA} - \text{LAG(BACOTSA)} ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(17.4) Feed-Grain Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{FGSMNSA} = \text{BASMNSA} + \text{COSMNSA} ]</td>
</tr>
</tbody>
</table>

**Endogenous Variables**

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

**Exogenous Variables**

- \text{LTARCRUD} = \text{Saudi Arabia, Crude Oil Price, \$ per bbl}
- \text{NIMEUSA} = \text{Saudi Arabia, Exchange Rate, Riyals/\$}
Table 17. Continued

<table>
<thead>
<tr>
<th>Description</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>NARDDSA = Saudi Arabia, GDP Deflator</td>
<td>1980=1.0</td>
</tr>
<tr>
<td>NANPDSA = Saudi Arabia, GDP, mil Riyals</td>
<td></td>
</tr>
<tr>
<td>BACOTSA = Saudi Arabia, Barley Imports, 1000 MT</td>
<td></td>
</tr>
<tr>
<td>COSMNSA = Saudi Arabia, Corn Imports, 1000 MT</td>
<td></td>
</tr>
<tr>
<td>D81 = 1 in 1981 and 0 Otherwise</td>
<td></td>
</tr>
<tr>
<td>SHIFT74 = 1 after 1973, 0 Otherwise</td>
<td></td>
</tr>
<tr>
<td>SHIFT75 = 1 after 1974, 0 Otherwise</td>
<td></td>
</tr>
<tr>
<td>SHIFT82 = 1 after 1981, 0 Otherwise</td>
<td></td>
</tr>
</tbody>
</table>
Table 18. Structural parameter estimates of the high-income East Asian feed-grains submodel

(18.1) Feed-Grain Area Harvested

\[ FGAHHR4 = -85.308 + 0.848 \text{LAG}(FGAHR4) \]
\[ + 48.692 \text{LAG}(\text{CORPF/NARDDU9} \times \text{NIMERUUS}) - 196.049 \text{D76} \]
\[ - 96.520 \text{D85} \]
\[ R^2 = 0.97 \quad \text{DW} = 1.93 \]

(18.2) Feed-Grain Production

\[ FGSPRR4 = FGAHHR4 \times FGYHHR4 \]

(18.3) Feed-Grain Domestic Use

\[ FGUDTR4 = 494.539 - 159.844 \text{CORPF/NARDDU9} \times \text{NIMERUUS} \]
\[ + 45.511 \text{NARPDRR4} + 1111.520(D78 + D82) - 818.368 \text{D85} \]
\[ R^2 = 0.99 \quad \text{DW} = 1.64 \]

(18.4) Feed-Grain Stocks

\[ FGCOTR4 = -448.384 + 0.782 \text{LAG}(FGCOTR4) \]
\[ - 13.654 \text{CORPF/NARDDU9 NIMERUUS} + 0.544 \text{FGSPRR4} \]
\[ R^2 = 0.84 \quad \text{DW} = 1.71 \]
Table 18. Continued

(18.5) Feed-Grain Imports

\[ FGSNMR4 = FGUDTR4 + FGCTR4 - FGSPRR4 - \text{LAG(FGCOTR4)} \]

**Endogenous Variables**

- \( FGAHHR4 = \text{High-Income East Asia, Feed-Grains Area Harvested, 1000 ha} \)
- \( FGSPRR4 = \text{High-Income East Asia, Feed-Grains Production, 1000 MT} \)
- \( FGUDTR4 = \text{High-Income East Asia, Feed-Grains Domestic Use, 1000 MT} \)
- \( FGCOTR4 = \text{High-Income East Asia, Feed-Grains Stocks, 1000 MT} \)
- \( FGSNMR4 = \text{High-Income East Asia, Feed-Grains Imports, 1000 MT} \)

**Exogenous Variables**

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

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

\[R^2 = 0.94 \quad \text{DW} = 2.85\]

#### (19.2) Feed-Grain Area Harvested

\[
FGAHHSO = \frac{FGSPRSO}{FGYHHSO}
\]

#### (19.3) Feed-Grain Domestic Use

\[
FGUDTSO = 763.642 + 0.834 \text{ FGSPRSO} + 13.174 \text{ NARPDSO} \\
(0.94) \quad (12.67) \quad (5.11) \quad \text{[0.17]}
\]

\[-130.900 \text{ CORPF} - 1517.620 \text{ D75} \\
(0.90) \quad (4.71) \quad [-0.01]
\]

\[R^2 = 0.99 \quad \text{DW} = 2.26\]

#### (19.4) Feed-Grain Imports

\[
FGSMNSO = FGUDTSO + FGCOTSO - FGSPRSO - \text{LAG(FGCOTSO)}
\]

### 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

\[
FGSPRFO = -17989.700 + 0.621 \text{LAG}(FGSPRFO) \\
\quad + 425.437 \text{LAG}(CORPF) + 25849.700 \text{FGYHHF0} \\
\quad (4.36) \quad (6.88) \\
\quad (0.79) \quad (6.07) \\
\quad [0.03] \quad [1.05]
\]

\[
R^2 = 0.95 \quad \text{DW} = 1.32
\]

(20.2) Feed-Grain Area Harvested

\[
FGAHHFO = \frac{FGSPRFO}{FGYHHF0}
\]

(20.3) Feed-Grain Domestic Use

\[
FGUDTFO = -2952.890 + 10.710 \text{NARPDOFO} + 0.916 \text{FGSPRFO} \\
\quad + 131.100 \text{SHIFT79} * \text{LTARCRUD} + 2326.950 \text{DB3} \\
\quad (0.99) \quad (2.96) \quad (5.69) \\
\quad (0.22) \quad [0.84] \\
\quad (3.63) \quad (1.71) \\
\quad \quad - 2507.450 \text{DBO} \\
\quad (1.80)
\]

\[
R^2 = 0.97 \quad \text{DW} = 1.77
\]

(20.4) Feed-Grain Stocks

\[
FGCOTFO = -4740.590 + 0.143 \text{LAG}(FGCOTF0) - 65.499 \text{CORPF} \\
\quad + 0.266 \text{FGSPRFO} \\
\quad (4.87) \quad (0.93) \quad (0.31) \\
\quad (5.28) \quad [0.93] \\
\quad [-0.05]
\]

\[
R^2 = 0.87 \quad \text{DW} = 2.08
\]
Table 20. Continued

(20.5) Feed-Grain Imports

\[ \text{FGSMNFO} = \text{FGUDTFO} + \text{FGCOTFO} - \text{FGSPRFO} = \text{LAG}(\text{FGCPTFO}) \]

### Endogenous Variables

- \( \text{FGSPRFO} \): Other Africa and Middle East, Feed-Grains Production, 1000 MT
- \( \text{FGAHHFO} \): Other Africa and Middle East, Feed-Grains Area Harvested, 1000 AC
- \( \text{FGUDTFO} \): Other Africa and Middle East, Feed-Grains Domestic Use, 1000 MT
- \( \text{FGCOTFO} \): Other Africa and Middle East, Feed-Grains Stocks, 1000 MT
- \( \text{FGSMNFO} \): Other Africa and Middle East, Feed-Grains Imports, 1000 MT

### Exogenous Variables

- \( \text{FGYHHFO} \): Other Asia and Middle East, Feed Grains Yield, MT/ha
- \( \text{NARPDFOF} \): Other Asia and Middle East, GDP, 1980 $US
- \( \text{LTARCRUD} \): Light Arabian crude oil price (U.S. $/bbl)
- \( \text{SHIFT79} \): 1 after 1978, 0 Otherwise
- \( \text{D80} \): 1 in 1980 and 0 Otherwise
- \( \text{D83} \): 1 in 1983 and 0 Otherwise
Table 21. Structural parameter estimates of the "other Latin America" feed-grains submodel

(21.1) Feed-Grain Production

\[ \text{FGSPRNO} = 1756.370 + 0.589 \text{LAG(FGSPRNO)} \]
\[ = 1179.560 \text{LAG(CORPF)} - 548.130 \text{LAG(WHEPF)} \]
\[ - 820.788 D76 + 436.605 D79 \]
\[ R^2 = 0.94 \quad \text{DW} = 1.47 \]

(21.2) Feed-Grain Stocks

\[ \text{FGCOTNO} = 717.277 + 0.184 \text{LAG(FGCOTNO)} + 0.181 \text{FGSPRNO} \]
\[ = 537.875 D80 - 191.124 D85 + 322.949 (D77 + D81) \]
\[ R^2 = 0.94 \quad \text{DW} = 2.02 \]

(21.3) Feed-Grain Imports

\[ \text{FGSMNNO} = -1463.100 + 24.455 \text{NARPDNO} - 6728.830(\text{CORPF/SOMPM}) \]
\[ + 821.078(D80 + D81 + D82 + D83) - 554.892 \text{LAG(CORPF)} \]
\[ + 379.717 \text{LAG(WHEPF)} \]
\[ R^2 = 0.97 \quad \text{DW} = 1.87 \]

(21.4) Feed-Grain Domestic Use

\[ \text{FGUDTNO} = \text{FGSPRNO} + \text{LAG(FGCOTNO)} + \text{FGSMNNO} - \text{FGCOTNO} \]
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

\[ \text{FGAHHROW} = 361.005 + 0.873 \text{LAG(FGAHHROW)} \]
\[ (2.18) \quad (9.73) \]
\[ + 1.514 \text{LAG(CORPF \* NIMERUUS)} - 1.238 \text{LAG(WHEPF \* NIMERUUS)} \]
\[ (2.39) \quad (2.57) \]
\[ [0.16] \quad [-0.16] \]
\[ + 127.641(\text{D79 + D81}) \]

\[ R^2 = 0.94 \quad \text{DW} = 1.91 \]

(22.2) Feed-Grain Production

\[ \text{FGSPRROW} = \text{FGAHHROW} \times \text{FGYHHROW} \]

(22.3) Feed-Grain Domestic Use

\[ \text{FGUDTROW} = 4514.460 - 21.985 \text{BARPF \* NIMERUUS} + 17.422 \text{REGRDPFG} \]
\[ (2.88) \quad (2.84) \quad (3.15) \]
\[ [-0.48] \quad [0.68] \]
\[ + 6.847 \text{WHEPF \* NIMERUUS} + 3693.470 \text{DAT6977} \]
\[ (1.50) \quad (10.64) \]
\[ [0.22] \]
\[ - 1963.060(\text{D71 + D72}) \]
\[ (3.47) \]

\[ R^2 = 0.90 \quad \text{DW} = 2.95 \]

(22.4) Feed-Grain Stocks

\[ \text{FGCOTROW} = 1614.650 + 0.400 \text{LAG(FGCOTROW)} + 0.333 \text{FGSPRROW} \]
\[ (2.02) \quad (4.97) \quad (3.60) \]
\[ [0.98] \]
\[ - 3.361 \text{BARPF \* NIMERUUS} - 3415.710 \text{SHIFT74} \]
\[ (1.29) \quad (6.60) \]
\[ [-0.23] \]

\[ R^2 = 0.98 \quad \text{DW} = 2.39 \]
Table 22. Continued

(22.5) Feed-Grain Imports

$$\text{FGSMNROW} = \text{FGUDTROW} + \text{FGCOTROW} - \text{FGSPRROW} - \text{LAG(FGCOTROW)}$$

(22.6) Sorghum Area Harvested

$$\begin{align*}
\text{SGAHHROW} &= 2696.380 + 0.652 \text{LAG(SGAHHROW)} \\
&\quad + 100323.000 \text{LAG(SORPF/NARDDU9)} + 2851.820 \text{D85} \\
&\quad - 2987.720 \text{D76} + 1651.370 \text{D73} \\
&\quad + 1950.950(\text{D67} + \text{D69} + \text{D70} + \text{D71}) \\
\end{align*}$$

$$R^2 = 0.94 \quad DW = 2.32$$

(22.7) Sorghum Production

$$\text{SGSPRROW} = \text{SGAHHROW} \times \text{SGYHHROW}$$

(22.8) Sorghum Domestic Use

$$\begin{align*}
\text{SGUDTROW} &= 2341.870 + 0.787 \text{SGRDPRE} + 0.733 \text{SGSPRROW} \\
&\quad - 275076.000 \text{SORPF/NARDDU9} + 308263.000 \text{CORPF/NARDDU9} \\
&\quad + 227.612 \text{SOMPM/NARDDU9} - 1502.510(\text{D77} + \text{D78} + \text{D79}) \\
&\quad + 2859.320 \text{D81} - 3131.590 \text{D85} \\
\end{align*}$$

$$R^2 = 0.97 \quad DW = 2.48$$
Table 22. Continued

(22.9) Sorghum Stocks

\[ SGCOTROW = -2054.910 + 0.219 \text{LAG}(SGCOTROW) + 0.122 \text{SGSPRROW} \]
\[ + 1167.640 \text{SHIFT76} + 917.285 D81 \]
\[ - 546.914(D83 + D84) \]
\[ R^2 = 0.94 \quad DW = 1.55 \]

(22.10) Sorghum Imports

\[ SGSMNROW = SGUDTROW + SGCOTROW - SGSPPROW - \text{LAG}(SGCOTROW) \]

Endogenous Variables

- FGAHHROW = ROW, Feed-Grains Area Harvested, 1000 ha
- FGSPPROW = ROW, Feed-Grains Production, 1000 MT
- FGUDTROW = ROW, Feed-Grains Domestic Use, 1000 MT
- FGCOTROW = ROW, Feed-Grains Stock, 1000 MT
- FGSPPROW = ROW, Feed-Grains Imports, 1000 MT
- SGAAHROW = ROW, Sorghum Area Harvested, 1000 ha
- SGSPROW = 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
- NIMETU = 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>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D77</td>
<td>1 in 1977 and 0 Otherwise</td>
</tr>
<tr>
<td>D78</td>
<td>1 in 1978 and 0 Otherwise</td>
</tr>
<tr>
<td>D79</td>
<td>1 in 1979 and 0 Otherwise</td>
</tr>
<tr>
<td>D81</td>
<td>1 in 1981 and 0 Otherwise</td>
</tr>
<tr>
<td>D83</td>
<td>1 in 1983 and 0 Otherwise</td>
</tr>
<tr>
<td>D84</td>
<td>1 in 1984 and 0 Otherwise</td>
</tr>
<tr>
<td>D85</td>
<td>1 in 1985 and 0 Otherwise</td>
</tr>
<tr>
<td>DAT6977</td>
<td>1 from 69-77, 0 Otherwise</td>
</tr>
<tr>
<td>SHIFT74</td>
<td>1 after 1973, 0 Otherwise</td>
</tr>
<tr>
<td>SHIFT76</td>
<td>1 after 1975, 0 Otherwise</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.(^a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>0.53</td>
<td>-0.32</td>
<td>-0.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>-0.25</td>
<td>-0.31</td>
<td>1.05</td>
<td></td>
<td></td>
<td></td>
<td>-0.21</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td>0.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.09</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td>0.35</td>
<td></td>
<td>-0.27</td>
<td></td>
<td></td>
<td>-0.14</td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td>0.16</td>
<td>-0.14</td>
<td>-0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-1.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EC-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.02</td>
<td>-0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed grains</td>
<td>0.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.22</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed grains</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.16</td>
<td>-0.25</td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.17</td>
<td></td>
</tr>
</tbody>
</table>
Table 23. Continued

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigeria</td>
<td>-0.59</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-income East Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed grains</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed grains</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Africa and Middle East</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed grains</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Latin America</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed grains</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed grains</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.08</td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\)1989/90 elasticities.
Table 24. Summary of estimated domestic demand elasticities from the feed-grains trade model

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Corn Price</th>
<th>Sorghum Price</th>
<th>Barley Price</th>
<th>Oats Price</th>
<th>Soy Meal Price</th>
<th>Wheat Price</th>
<th>Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn food</td>
<td>-0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.09</td>
</tr>
<tr>
<td>Corn feed</td>
<td>-0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.59</td>
</tr>
<tr>
<td>Corn stocks</td>
<td>-1.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum nonfeed</td>
<td>0.48</td>
<td>-1.42</td>
<td>0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum feed</td>
<td>1.21</td>
<td>-2.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum stocks</td>
<td>-1.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley nonfeed</td>
<td>0.43</td>
<td></td>
<td></td>
<td>-0.02</td>
<td></td>
<td></td>
<td>0.31</td>
</tr>
<tr>
<td>Barley feed</td>
<td></td>
<td>-0.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley stocks</td>
<td></td>
<td>0.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats nonfeed</td>
<td>0.27</td>
<td></td>
<td></td>
<td>-0.04</td>
<td></td>
<td></td>
<td>-0.95</td>
</tr>
<tr>
<td>Oats feed use</td>
<td></td>
<td>-0.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats stocks</td>
<td></td>
<td>-0.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley use</td>
<td>-0.24</td>
<td>-0.09</td>
<td></td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn use</td>
<td></td>
<td>0.14</td>
<td></td>
<td>0.10</td>
<td></td>
<td></td>
<td>0.82</td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley use</td>
<td>-0.81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>Barley stocks</td>
<td></td>
<td>-5.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.40</td>
</tr>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn use</td>
<td>-0.25</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn stocks</td>
<td>-1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum use</td>
<td>2.58</td>
<td>-3.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum stocks</td>
<td>-1.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EC-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn use</td>
<td>-0.58</td>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
<td>0.41</td>
<td>0.19</td>
</tr>
<tr>
<td>Corn stocks</td>
<td>-0.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley feed</td>
<td></td>
<td>-0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>Barley food</td>
<td></td>
<td>-0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn feed use</td>
<td>-0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn stocks</td>
<td>-0.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.88</td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn use</td>
<td>-0.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>Corn stocks</td>
<td>-0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum use</td>
<td></td>
<td>-0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td>Sorghum stocks</td>
<td></td>
<td>-0.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USSR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total feed-grain use</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total feed-grain use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
</tbody>
</table>
Table 24. Continued

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Corn Price</th>
<th>Sorghum Price</th>
<th>Barley Price</th>
<th>Oats Price</th>
<th>Soy Meal Price</th>
<th>Wheat Price</th>
<th>Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Europe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td>Total feed grains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn use</td>
<td>-0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>Corn stocks</td>
<td>-0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.51</td>
</tr>
<tr>
<td>Sorghum use</td>
<td>0.52</td>
<td>-0.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.42</td>
</tr>
<tr>
<td>Barley use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.61</td>
</tr>
<tr>
<td>Feed-grain use</td>
<td>-0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum use</td>
<td></td>
<td>-0.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.94</td>
</tr>
<tr>
<td>Feed-grain use</td>
<td>-0.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td>Egypt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.48</td>
</tr>
<tr>
<td>Corn stocks</td>
<td>-0.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>Barley use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nigeria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum use</td>
<td>-0.002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIEAa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed-grain use</td>
<td>-0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.05</td>
</tr>
<tr>
<td>Feed-grain stock</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.22</td>
</tr>
<tr>
<td>Feed-grain use</td>
<td>-0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Africa and Middle East</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>Feed-grain stocks</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Latin America</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed-grain imports</td>
<td></td>
<td>-0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.32</td>
</tr>
<tr>
<td>ROWb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed-grain use</td>
<td>-0.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.23</td>
</tr>
<tr>
<td>Feed-grain stocks</td>
<td>-0.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.84</td>
</tr>
<tr>
<td>ROWb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum use</td>
<td>0.22</td>
<td>-0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.29</td>
</tr>
</tbody>
</table>

*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

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>U.S. Corn Price</th>
<th>U.S. Barley Price</th>
<th>U.S. Sorghum Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td></td>
<td>1.04</td>
</tr>
<tr>
<td>Corn</td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td></td>
<td>1.01</td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td>1.02</td>
</tr>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td>0.49</td>
</tr>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>1.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td>0.95</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.16</td>
<td></td>
<td>0.39</td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>0.86</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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:


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

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MEAN</th>
<th>MEAN %</th>
<th>MEAN ABS</th>
<th>RMS</th>
<th>RMS %</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPRU9F</td>
<td>0.06867</td>
<td>954160995</td>
<td>0.07143</td>
<td>0.12399</td>
<td>82540.05</td>
</tr>
<tr>
<td>COYHAU9F</td>
<td>0.07222</td>
<td>0.07222</td>
<td>0.07222</td>
<td>0.13417</td>
<td>0.13422</td>
</tr>
<tr>
<td>CONRN9F</td>
<td>-1.87805</td>
<td>-1.53586</td>
<td>22.69363</td>
<td>29.44899</td>
<td>25.75262</td>
</tr>
<tr>
<td>CONRPU9F</td>
<td>2.90509</td>
<td>1.89494</td>
<td>11.69931</td>
<td>16.62321</td>
<td>12.81442</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>-1.63E-05</td>
<td>-1.21E-05</td>
<td>3.24E-05</td>
<td>3.82E-05</td>
<td>3.22E-05</td>
</tr>
<tr>
<td>COAI9F</td>
<td>0.07222</td>
<td>0.07229</td>
<td>0.07222</td>
<td>0.13422</td>
<td>0.13422</td>
</tr>
<tr>
<td>COAPPU9F</td>
<td>-5.31338</td>
<td>-8.52318</td>
<td>5.41716</td>
<td>9.38806</td>
<td>14.87173</td>
</tr>
<tr>
<td>COAPAU9F</td>
<td>-1.87805</td>
<td>-1.53586</td>
<td>22.69363</td>
<td>29.44899</td>
<td>25.75262</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>-1.63E-05</td>
<td>-1.21E-05</td>
<td>3.24E-05</td>
<td>3.82E-05</td>
<td>3.22E-05</td>
</tr>
<tr>
<td>COAI9F</td>
<td>0.07222</td>
<td>0.07229</td>
<td>0.07222</td>
<td>0.13422</td>
<td>0.13422</td>
</tr>
<tr>
<td>COAPPU9F</td>
<td>-5.31338</td>
<td>-8.52318</td>
<td>5.41716</td>
<td>9.38806</td>
<td>14.87173</td>
</tr>
<tr>
<td>COAPAU9F</td>
<td>-1.87805</td>
<td>-1.53586</td>
<td>22.69363</td>
<td>29.44899</td>
<td>25.75262</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>-1.63E-05</td>
<td>-1.21E-05</td>
<td>3.24E-05</td>
<td>3.82E-05</td>
<td>3.22E-05</td>
</tr>
<tr>
<td>COAI9F</td>
<td>0.07222</td>
<td>0.07229</td>
<td>0.07222</td>
<td>0.13422</td>
<td>0.13422</td>
</tr>
<tr>
<td>COAPPU9F</td>
<td>-5.31338</td>
<td>-8.52318</td>
<td>5.41716</td>
<td>9.38806</td>
<td>14.87173</td>
</tr>
<tr>
<td>COAPAU9F</td>
<td>-1.87805</td>
<td>-1.53586</td>
<td>22.69363</td>
<td>29.44899</td>
<td>25.75262</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>-1.63E-05</td>
<td>-1.21E-05</td>
<td>3.24E-05</td>
<td>3.82E-05</td>
<td>3.22E-05</td>
</tr>
<tr>
<td>COAI9F</td>
<td>0.07222</td>
<td>0.07229</td>
<td>0.07222</td>
<td>0.13422</td>
<td>0.13422</td>
</tr>
<tr>
<td>COAPPU9F</td>
<td>-5.31338</td>
<td>-8.52318</td>
<td>5.41716</td>
<td>9.38806</td>
<td>14.87173</td>
</tr>
<tr>
<td>COAPAU9F</td>
<td>-1.87805</td>
<td>-1.53586</td>
<td>22.69363</td>
<td>29.44899</td>
<td>25.75262</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>-1.63E-05</td>
<td>-1.21E-05</td>
<td>3.24E-05</td>
<td>3.82E-05</td>
<td>3.22E-05</td>
</tr>
<tr>
<td>COAI9F</td>
<td>0.07222</td>
<td>0.07229</td>
<td>0.07222</td>
<td>0.13422</td>
<td>0.13422</td>
</tr>
<tr>
<td>COAPPU9F</td>
<td>-5.31338</td>
<td>-8.52318</td>
<td>5.41716</td>
<td>9.38806</td>
<td>14.87173</td>
</tr>
<tr>
<td>COAPAU9F</td>
<td>-1.87805</td>
<td>-1.53586</td>
<td>22.69363</td>
<td>29.44899</td>
<td>25.75262</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>-1.63E-05</td>
<td>-1.21E-05</td>
<td>3.24E-05</td>
<td>3.82E-05</td>
<td>3.22E-05</td>
</tr>
<tr>
<td>COAI9F</td>
<td>0.07222</td>
<td>0.07229</td>
<td>0.07222</td>
<td>0.13422</td>
<td>0.13422</td>
</tr>
<tr>
<td>COAPPU9F</td>
<td>-5.31338</td>
<td>-8.52318</td>
<td>5.41716</td>
<td>9.38806</td>
<td>14.87173</td>
</tr>
<tr>
<td>COAPAU9F</td>
<td>-1.87805</td>
<td>-1.53586</td>
<td>22.69363</td>
<td>29.44899</td>
<td>25.75262</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>-1.63E-05</td>
<td>-1.21E-05</td>
<td>3.24E-05</td>
<td>3.82E-05</td>
<td>3.22E-05</td>
</tr>
<tr>
<td>COAI9F</td>
<td>0.07222</td>
<td>0.07229</td>
<td>0.07222</td>
<td>0.13422</td>
<td>0.13422</td>
</tr>
<tr>
<td>COAPPU9F</td>
<td>-5.31338</td>
<td>-8.52318</td>
<td>5.41716</td>
<td>9.38806</td>
<td>14.87173</td>
</tr>
<tr>
<td>COAPAU9F</td>
<td>-1.87805</td>
<td>-1.53586</td>
<td>22.69363</td>
<td>29.44899</td>
<td>25.75262</td>
</tr>
<tr>
<td>SBNRNU9F</td>
<td>-1.63E-05</td>
<td>-1.21E-05</td>
<td>3.24E-05</td>
<td>3.82E-05</td>
<td>3.22E-05</td>
</tr>
<tr>
<td>COAI9F</td>
<td>0.07222</td>
<td>0.07229</td>
<td>0.07222</td>
<td>0.13422</td>
<td>0.13422</td>
</tr>
<tr>
<td>VARIABLE</td>
<td>MEAN</td>
<td>MEAN %</td>
<td>MEAN ABS</td>
<td>RMS</td>
<td>RMS %</td>
</tr>
<tr>
<td>----------</td>
<td>------</td>
<td>--------</td>
<td>----------</td>
<td>-----</td>
<td>-------</td>
</tr>
<tr>
<td>BAAAPAU9</td>
<td>0.34562</td>
<td>3.98160</td>
<td>0.44560</td>
<td>0.61027</td>
<td>6.91151</td>
</tr>
<tr>
<td>BAAAPPU9</td>
<td>0.24937</td>
<td>1.30E+10</td>
<td>0.72619</td>
<td>1.04515</td>
<td>1368144</td>
</tr>
<tr>
<td>BAAHAU9</td>
<td>0.35370</td>
<td>4.40200</td>
<td>0.41305</td>
<td>0.57008</td>
<td>7.01706</td>
</tr>
<tr>
<td>BASPRU9</td>
<td>17.67088</td>
<td>4.40235</td>
<td>20.24538</td>
<td>28.89350</td>
<td>7.01728</td>
</tr>
<tr>
<td>BAUFU9C</td>
<td>0.0053626</td>
<td>0.09433</td>
<td>0.00777799</td>
<td>0.00889251</td>
<td>1.24202</td>
</tr>
<tr>
<td>BAUPRUC</td>
<td>13.9467</td>
<td>9.00888</td>
<td>16.09727</td>
<td>22.04687</td>
<td>15.32927</td>
</tr>
<tr>
<td>BAUFU9</td>
<td>0.10110</td>
<td>0.09433</td>
<td>1.71159</td>
<td>1.95750</td>
<td>1.24202</td>
</tr>
<tr>
<td>BASPRU9</td>
<td>17.67088</td>
<td>4.40235</td>
<td>20.24538</td>
<td>28.89350</td>
<td>7.01728</td>
</tr>
<tr>
<td>BAUFU9</td>
<td>0.10110</td>
<td>0.09433</td>
<td>1.71159</td>
<td>1.95750</td>
<td>1.24202</td>
</tr>
<tr>
<td>BAUPRUC</td>
<td>13.9467</td>
<td>9.00888</td>
<td>16.09727</td>
<td>22.04687</td>
<td>15.32927</td>
</tr>
<tr>
<td>BAUFU9</td>
<td>0.10110</td>
<td>0.09433</td>
<td>1.71159</td>
<td>1.95750</td>
<td>1.24202</td>
</tr>
<tr>
<td>VARIABLE</td>
<td>MEAN ERROR</td>
<td>MEAN % ERROR</td>
<td>MEAN ABS ERROR</td>
<td>RMS ERROR</td>
<td>RMS % ERROR</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>--------------</td>
<td>----------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>BACOTAU</td>
<td>24.44326</td>
<td>35.06320</td>
<td>49.84557</td>
<td>61.42801</td>
<td>71.96216</td>
</tr>
<tr>
<td>BASMNAU</td>
<td>20.14492</td>
<td>1.59662</td>
<td>444.22</td>
<td>519.42</td>
<td>43.07005</td>
</tr>
<tr>
<td>BASFRAU</td>
<td>-18.23222</td>
<td>0.43686</td>
<td>379.33</td>
<td>424.00</td>
<td>15.35142</td>
</tr>
<tr>
<td>BAUDTAU</td>
<td>-6.43738</td>
<td>-0.33170</td>
<td>148.59</td>
<td>175.84</td>
<td>14.50796</td>
</tr>
<tr>
<td>SGAHHAU</td>
<td>53.14331</td>
<td>9.47890</td>
<td>53.14331</td>
<td>62.88104</td>
<td>10.88122</td>
</tr>
<tr>
<td>SSCOTAU</td>
<td>3.70495</td>
<td>24.39559</td>
<td>18.52019</td>
<td>23.07295</td>
<td>57.61360</td>
</tr>
<tr>
<td>SGSMNAU</td>
<td>-148.35</td>
<td>9.47890</td>
<td>148.35</td>
<td>167.51</td>
<td>40.43437</td>
</tr>
<tr>
<td>SGSPRAU</td>
<td>99.38495</td>
<td>10.093</td>
<td>23.07295</td>
<td>382.73</td>
<td>10.88121</td>
</tr>
<tr>
<td>SGAUDTAU</td>
<td>51.60305</td>
<td>-11.31733</td>
<td>70.45686</td>
<td>87.66370</td>
<td>33.39873</td>
</tr>
<tr>
<td>FGSMMNAU</td>
<td>139.42</td>
<td>-3.05921</td>
<td>563.50</td>
<td>668.73</td>
<td>42.66939</td>
</tr>
<tr>
<td>BASPOBCA</td>
<td>202.8116</td>
<td>0.54735</td>
<td>6.26217</td>
<td>7.92956</td>
<td>8.77397</td>
</tr>
<tr>
<td>RSPM1CA</td>
<td>-2.81771</td>
<td>-2.15721</td>
<td>11.87021</td>
<td>14.75276</td>
<td>13.10470</td>
</tr>
<tr>
<td>RBPM1CA</td>
<td>0.04871</td>
<td>-0.35294</td>
<td>11.57364</td>
<td>13.42926</td>
<td>4.62647</td>
</tr>
<tr>
<td>RBSPM1CA</td>
<td>0.35494</td>
<td>0.36192</td>
<td>6.08269</td>
<td>7.16184</td>
<td>3.51171</td>
</tr>
<tr>
<td>SGSPRAU</td>
<td>99.38495</td>
<td>10.093</td>
<td>23.07295</td>
<td>382.73</td>
<td>10.88121</td>
</tr>
<tr>
<td>SGSPRAU</td>
<td>-82.25</td>
<td>-7.43129</td>
<td>990.12</td>
<td>1210.85</td>
<td>11.00054</td>
</tr>
<tr>
<td>SGAHHAU</td>
<td>3.70495</td>
<td>9.47890</td>
<td>53.14331</td>
<td>62.88104</td>
<td>10.88122</td>
</tr>
<tr>
<td>SGPFMTH</td>
<td>920.97</td>
<td>-37.39976</td>
<td>1130.90</td>
<td>1227.26</td>
<td>56.43200</td>
</tr>
<tr>
<td>SGPFMTH</td>
<td>-71.73199</td>
<td>-2.04701</td>
<td>201.01</td>
<td>264.60</td>
<td>16.4253</td>
</tr>
<tr>
<td>COAHHTH</td>
<td>0.96853</td>
<td>0.10968</td>
<td>23.78098</td>
<td>29.50723</td>
<td>2.13320</td>
</tr>
<tr>
<td>COCTH</td>
<td>12.48812</td>
<td>41.24080</td>
<td>35.69294</td>
<td>46.73291</td>
<td>113.96</td>
</tr>
<tr>
<td>COSMTH</td>
<td>-3.06458</td>
<td>3.57175</td>
<td>59.29414</td>
<td>80.13329</td>
<td>13.73385</td>
</tr>
<tr>
<td>COSMNTH</td>
<td>29.37212</td>
<td>92.36064</td>
<td>260.95</td>
<td>334.11</td>
<td>212.07</td>
</tr>
<tr>
<td>COSPRTH</td>
<td>10.32121</td>
<td>1.12483</td>
<td>123.84</td>
<td>143.91</td>
<td>4.07227</td>
</tr>
<tr>
<td>COUETH</td>
<td>46.94623</td>
<td>1.40351</td>
<td>352.33</td>
<td>403.78</td>
<td>7.53465</td>
</tr>
<tr>
<td>FGSMNTH</td>
<td>-3.06458</td>
<td>0.30431</td>
<td>74.43764</td>
<td>84.23098</td>
<td>2.21188</td>
</tr>
<tr>
<td>SMPFMEO</td>
<td>920.97</td>
<td>-37.39976</td>
<td>1130.90</td>
<td>1227.26</td>
<td>56.43200</td>
</tr>
<tr>
<td>POSPRE2</td>
<td>84.65281</td>
<td>0.97707</td>
<td>185.17</td>
<td>257.55</td>
<td>2.75616</td>
</tr>
<tr>
<td>PYSPRE2</td>
<td>7.02062</td>
<td>0.24773</td>
<td>95.43399</td>
<td>113.98</td>
<td>2.51521</td>
</tr>
<tr>
<td>BAAHHHE2</td>
<td>45.78286</td>
<td>6.21946</td>
<td>62.1946</td>
<td>75.26013</td>
<td>0.60754</td>
</tr>
<tr>
<td>BACOT2E</td>
<td>-59.42174</td>
<td>-0.28830</td>
<td>294.37</td>
<td>432.96</td>
<td>13.22900</td>
</tr>
<tr>
<td>BASMNE2</td>
<td>129.66</td>
<td>-10.03089</td>
<td>554.13</td>
<td>759.40</td>
<td>138.67</td>
</tr>
<tr>
<td>BASF2E</td>
<td>-154.23</td>
<td>-0.37000</td>
<td>210.78</td>
<td>253.43</td>
<td>0.60754</td>
</tr>
<tr>
<td>BAUF2E</td>
<td>60.05552</td>
<td>0.20640</td>
<td>458.53</td>
<td>559.87</td>
<td>1.70558</td>
</tr>
<tr>
<td>BAUHTE2</td>
<td>-54.76520</td>
<td>-0.57528</td>
<td>196.47</td>
<td>224.00</td>
<td>2.27752</td>
</tr>
<tr>
<td>COAHHTH</td>
<td>42.15126</td>
<td>1.12887</td>
<td>66.27192</td>
<td>83.54807</td>
<td>2.21188</td>
</tr>
<tr>
<td>COCT2E</td>
<td>9.23924</td>
<td>0.31244</td>
<td>199.19</td>
<td>253.61</td>
<td>6.89681</td>
</tr>
<tr>
<td>COSM2E</td>
<td>-247.37</td>
<td>-1.64972</td>
<td>742.35</td>
<td>917.93</td>
<td>4.76636</td>
</tr>
<tr>
<td>COSPR2E</td>
<td>184.02</td>
<td>1.12887</td>
<td>311.41</td>
<td>382.73</td>
<td>2.21188</td>
</tr>
<tr>
<td>COUDT2E</td>
<td>-86.47077</td>
<td>-0.19969</td>
<td>871.39</td>
<td>1013.55</td>
<td>2.71480</td>
</tr>
<tr>
<td>FGSMM2E</td>
<td>-117.72</td>
<td>-1.59481</td>
<td>1113.03</td>
<td>1464.77</td>
<td>7.58780</td>
</tr>
<tr>
<td>VARIABLE</td>
<td>MEAN ERROR</td>
<td>MEAN % ERROR</td>
<td>MEAN ABS ERROR</td>
<td>RMS ERROR</td>
<td>RMS % ERROR</td>
</tr>
<tr>
<td>-------------</td>
<td>------------</td>
<td>--------------</td>
<td>----------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>COPFMZAJ</td>
<td>0.05098</td>
<td>3.58590</td>
<td>16.11529</td>
<td>19.49860</td>
<td>19.24701</td>
</tr>
<tr>
<td>SGPFMZAJ</td>
<td>-55.18451</td>
<td>0.12009</td>
<td>724.64</td>
<td>926.53</td>
<td>10.27966</td>
</tr>
<tr>
<td>WHPFMZAJ</td>
<td>0.2194</td>
<td>3.27492</td>
<td>836.45</td>
<td>955.12</td>
<td>10.34514</td>
</tr>
<tr>
<td>COAHZAJ</td>
<td>45.16524</td>
<td>1.02598</td>
<td>89.77749</td>
<td>109.78</td>
<td>2.51424</td>
</tr>
<tr>
<td>COTAZJ</td>
<td>29.17369</td>
<td>90.81157</td>
<td>193.05</td>
<td>234.34</td>
<td>318.59</td>
</tr>
<tr>
<td>COSMADJ</td>
<td>-141.18</td>
<td>72.94787</td>
<td>624.87</td>
<td>723.71</td>
<td>209.51</td>
</tr>
<tr>
<td>COSPRZJ</td>
<td>59.33890</td>
<td>1.02597</td>
<td>199.97</td>
<td>267.85</td>
<td>2.51423</td>
</tr>
<tr>
<td>CUDTJ</td>
<td>-122.07</td>
<td>-2.05976</td>
<td>376.72</td>
<td>422.68</td>
<td>6.62516</td>
</tr>
<tr>
<td>SGARHZJ</td>
<td>-1.47730</td>
<td>0.56699</td>
<td>28.45731</td>
<td>34.2767</td>
<td>13.57640</td>
</tr>
<tr>
<td>SPSNZJ</td>
<td>-8.24531</td>
<td>0.56698</td>
<td>45.28777</td>
<td>52.99357</td>
<td>13.57639</td>
</tr>
<tr>
<td>SUDTJ</td>
<td>1.41498</td>
<td>0.80535</td>
<td>23.65482</td>
<td>30.33212</td>
<td>10.78082</td>
</tr>
<tr>
<td>GOVIMJP</td>
<td>-117.874</td>
<td>-3.76374</td>
<td>2888.91</td>
<td>3697.15</td>
<td>10.74402</td>
</tr>
<tr>
<td>HOCOTUJ</td>
<td>0.03356</td>
<td>0.31994</td>
<td>1.13286</td>
<td>0.1552</td>
<td>1.83212</td>
</tr>
<tr>
<td>PYSUFRJ</td>
<td>5.77171</td>
<td>0.26998</td>
<td>17.55612</td>
<td>25.2639</td>
<td>2.46884</td>
</tr>
<tr>
<td>BACOTUJ</td>
<td>0.33259</td>
<td>3.74783</td>
<td>77.16546</td>
<td>100.75</td>
<td>21.79072</td>
</tr>
<tr>
<td>BASMNJP</td>
<td>-22.47168</td>
<td>-1.43244</td>
<td>66.30237</td>
<td>82.69094</td>
<td>6.01666</td>
</tr>
<tr>
<td>BASPRJ</td>
<td>-44.68392</td>
<td>-13.93462</td>
<td>60.39135</td>
<td>68.31218</td>
<td>22.77608</td>
</tr>
<tr>
<td>BAUFJP</td>
<td>-21.92299</td>
<td>-1.50804</td>
<td>50.47059</td>
<td>59.00623</td>
<td>4.70508</td>
</tr>
<tr>
<td>BAUTUJ</td>
<td>-54.62503</td>
<td>-12.47661</td>
<td>103.49</td>
<td>114.21</td>
<td>23.89764</td>
</tr>
<tr>
<td>COCTPJ</td>
<td>168.98</td>
<td>0.93260</td>
<td>512.41</td>
<td>556.62</td>
<td>5.72282</td>
</tr>
<tr>
<td>COSMNZJ</td>
<td>172.58</td>
<td>0.88589</td>
<td>473.96</td>
<td>515.43</td>
<td>5.45140</td>
</tr>
<tr>
<td>CUDTJ</td>
<td>172.58</td>
<td>0.88589</td>
<td>473.96</td>
<td>515.43</td>
<td>5.45140</td>
</tr>
<tr>
<td>SGOTZJ</td>
<td>-65.99527</td>
<td>-12.87387</td>
<td>80.68662</td>
<td>103.84</td>
<td>21.71774</td>
</tr>
<tr>
<td>SGSNZJ</td>
<td>-81.79503</td>
<td>-0.95404</td>
<td>285.76</td>
<td>357.88</td>
<td>9.18196</td>
</tr>
<tr>
<td>SUDZJ</td>
<td>-82.03387</td>
<td>-1.04283</td>
<td>277.88</td>
<td>325.09</td>
<td>8.48398</td>
</tr>
<tr>
<td>FGSNZJ</td>
<td>146.51</td>
<td>0.66294</td>
<td>492.03</td>
<td>539.47</td>
<td>4.71434</td>
</tr>
<tr>
<td>CECOTZJ</td>
<td>0.06775</td>
<td>0.05239</td>
<td>0.53056</td>
<td>0.62991</td>
<td>0.56746</td>
</tr>
<tr>
<td>FAGHJSJ</td>
<td>-1132.64</td>
<td>-2.56960</td>
<td>1692.19</td>
<td>2205.09</td>
<td>4.79826</td>
</tr>
<tr>
<td>FGCTSJ</td>
<td>600.69</td>
<td>29.70951</td>
<td>671.03</td>
<td>853.68</td>
<td>57.70396</td>
</tr>
<tr>
<td>FGSMNJ</td>
<td>869.61</td>
<td>37.80022</td>
<td>1990.87</td>
<td>2555.17</td>
<td>85.52086</td>
</tr>
<tr>
<td>FGPZJSU</td>
<td>-1966.77</td>
<td>-2.56960</td>
<td>2837.04</td>
<td>3889.23</td>
<td>4.79826</td>
</tr>
<tr>
<td>FGDSZJ</td>
<td>-1258.51</td>
<td>-1.51838</td>
<td>3269.60</td>
<td>3531.58</td>
<td>4.21887</td>
</tr>
<tr>
<td>HOCOTUJ</td>
<td>-0.54917</td>
<td>-0.83040</td>
<td>1.15896</td>
<td>1.39307</td>
<td>2.22625</td>
</tr>
<tr>
<td>FGSREZJ</td>
<td>-516.22</td>
<td>-0.98467</td>
<td>761.80</td>
<td>975.20</td>
<td>1.85660</td>
</tr>
<tr>
<td>FGCOTUJ</td>
<td>-56.65738</td>
<td>-1.19541</td>
<td>213.90</td>
<td>261.19</td>
<td>10.66911</td>
</tr>
<tr>
<td>FGDEZJ</td>
<td>-707.17</td>
<td>-1.20285</td>
<td>1459.72</td>
<td>1646.37</td>
<td>2.94752</td>
</tr>
<tr>
<td>FGSMNE8</td>
<td>-232.64</td>
<td>1.41096</td>
<td>1295.86</td>
<td>1497.74</td>
<td>29.43054</td>
</tr>
<tr>
<td>FGAHHE8</td>
<td>-142.42</td>
<td>-0.98467</td>
<td>214.93</td>
<td>264.95</td>
<td>1.85660</td>
</tr>
<tr>
<td>HOCOTCN</td>
<td>-0.99679</td>
<td>-0.20085</td>
<td>8.12983</td>
<td>9.54447</td>
<td>3.41679</td>
</tr>
<tr>
<td>FAGHHCN</td>
<td>-169.20</td>
<td>-0.76442</td>
<td>336.81</td>
<td>459.65</td>
<td>2.08013</td>
</tr>
<tr>
<td>FGDTCN</td>
<td>-521.51</td>
<td>-1.03281</td>
<td>1037.19</td>
<td>1209.82</td>
<td>2.53285</td>
</tr>
<tr>
<td>FGPSRCN</td>
<td>-275.44</td>
<td>-0.76442</td>
<td>714.58</td>
<td>903.88</td>
<td>2.08013</td>
</tr>
<tr>
<td>FGSNCN</td>
<td>-244.43</td>
<td>1050.81</td>
<td>809.98</td>
<td>924.53</td>
<td>318.08</td>
</tr>
<tr>
<td>FAGHHR4</td>
<td>8.13678</td>
<td>3.15196</td>
<td>34.93972</td>
<td>41.85965</td>
<td>8.67651</td>
</tr>
<tr>
<td>FGCOTR4</td>
<td>-111.67</td>
<td>-1.37005</td>
<td>279.65</td>
<td>319.60</td>
<td>22.41220</td>
</tr>
<tr>
<td>FGDETR4</td>
<td>-96.42578</td>
<td>-1.70712</td>
<td>220.87</td>
<td>276.67</td>
<td>4.93346</td>
</tr>
<tr>
<td>VARIABLE</td>
<td>MEAN ERROR</td>
<td>MEAN % ERROR</td>
<td>MEAN ABS ERROR</td>
<td>RMS ERROR</td>
<td>RMS % ERROR</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
<td>--------------</td>
<td>----------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>FGSPRR4</td>
<td>26.27451</td>
<td>3.15197</td>
<td>85.49704</td>
<td>104.71</td>
<td>8.67652</td>
</tr>
<tr>
<td>FGSMNR4</td>
<td>-102.74</td>
<td>-2.56359</td>
<td>224.86</td>
<td>259.53</td>
<td>6.75907</td>
</tr>
<tr>
<td>COPFMRBR</td>
<td>292.29</td>
<td>4.15136</td>
<td>813.37</td>
<td>1054.05</td>
<td>16.28529</td>
</tr>
<tr>
<td>WHPFMRBR</td>
<td>301.65</td>
<td>2.68680</td>
<td>517.73</td>
<td>671.55</td>
<td>6.05587</td>
</tr>
<tr>
<td>SBPFMRBR</td>
<td>851.19</td>
<td>5.94966</td>
<td>1734.37</td>
<td>2604.20</td>
<td>19.41611</td>
</tr>
<tr>
<td>FGAHBR</td>
<td>184.43</td>
<td>1.08443</td>
<td>486.42</td>
<td>592.42</td>
<td>3.40010</td>
</tr>
<tr>
<td>FGUDTBR</td>
<td>219.08</td>
<td>1.08443</td>
<td>486.42</td>
<td>592.42</td>
<td>3.40010</td>
</tr>
<tr>
<td>FGSPRRB</td>
<td>296.25</td>
<td>1.08443</td>
<td>486.42</td>
<td>592.42</td>
<td>3.40010</td>
</tr>
<tr>
<td>FGSMNRB</td>
<td>-77.17444</td>
<td>22.43592</td>
<td>1065.61</td>
<td>1434.82</td>
<td>249.46</td>
</tr>
<tr>
<td>COPFMXR</td>
<td>40.90076</td>
<td>1.35796</td>
<td>1135.12</td>
<td>1201.15</td>
<td>38.69064</td>
</tr>
<tr>
<td>SGPFMMXR</td>
<td>-1135.12</td>
<td>-37.71501</td>
<td>1135.12</td>
<td>1201.15</td>
<td>38.69064</td>
</tr>
<tr>
<td>WHPFMXR</td>
<td>171.35</td>
<td>4.72296</td>
<td>217.85</td>
<td>279.58</td>
<td>8.48418</td>
</tr>
<tr>
<td>POSPRMX</td>
<td>-176.87</td>
<td>-22.32433</td>
<td>176.87</td>
<td>191.12</td>
<td>23.36837</td>
</tr>
<tr>
<td>FGAHHMX</td>
<td>-60.35520</td>
<td>-0.64541</td>
<td>186.39</td>
<td>205.33</td>
<td>2.58348</td>
</tr>
<tr>
<td>FGCTMX</td>
<td>-58.97374</td>
<td>-1.89149</td>
<td>114.12</td>
<td>126.96</td>
<td>31.42600</td>
</tr>
<tr>
<td>FGUDTMX</td>
<td>-1276.96</td>
<td>-10.07792</td>
<td>1314.68</td>
<td>1761.95</td>
<td>13.85476</td>
</tr>
<tr>
<td>FGSPRRMX</td>
<td>-74.53489</td>
<td>-0.64541</td>
<td>219.54</td>
<td>241.02</td>
<td>2.58347</td>
</tr>
<tr>
<td>FGSMNMX</td>
<td>-1190.01</td>
<td>-76.30048</td>
<td>1298.07</td>
<td>1568.24</td>
<td>20.65143</td>
</tr>
<tr>
<td>SGAAHNG</td>
<td>366.15</td>
<td>-32.71025</td>
<td>380.09</td>
<td>418.13</td>
<td>37.70080</td>
</tr>
<tr>
<td>SGCOTIN</td>
<td>1032.18</td>
<td>226.37</td>
<td>1032.18</td>
<td>1116.38</td>
<td>323.20</td>
</tr>
<tr>
<td>COPFMEG</td>
<td>5.07662</td>
<td>8.03033</td>
<td>10.27258</td>
<td>13.41314</td>
<td>17.50329</td>
</tr>
<tr>
<td>COSPREG</td>
<td>-6.69008</td>
<td>-0.48274</td>
<td>82.52108</td>
<td>97.09313</td>
<td>3.32049</td>
</tr>
<tr>
<td>COUDTEG</td>
<td>75.33648</td>
<td>1.188+13</td>
<td>213.63</td>
<td>409.64</td>
<td>1.24E+09</td>
</tr>
<tr>
<td>COAHINEG</td>
<td>136.40</td>
<td>7.95968</td>
<td>225.47</td>
<td>389.36</td>
<td>25.10591</td>
</tr>
<tr>
<td>COAH!IEG</td>
<td>-2.68619</td>
<td>-0.48274</td>
<td>21.63005</td>
<td>25.46592</td>
<td>3.31804</td>
</tr>
<tr>
<td>FGSPRNO</td>
<td>2.01817</td>
<td>-0.37386</td>
<td>15.52853</td>
<td>22.62711</td>
<td>8.43879</td>
</tr>
<tr>
<td>BAUDTSA</td>
<td>-3.86641</td>
<td>-14.09296</td>
<td>234.14</td>
<td>328.24</td>
<td>312.30</td>
</tr>
<tr>
<td>BASMNSA</td>
<td>-3.86641</td>
<td>-90.0681</td>
<td>234.14</td>
<td>328.24</td>
<td>636.70</td>
</tr>
<tr>
<td>FGSMNSA</td>
<td>-3.86641</td>
<td>11.59490</td>
<td>234.14</td>
<td>328.24</td>
<td>138.82</td>
</tr>
<tr>
<td>SGPFMNG</td>
<td>0.41599</td>
<td>1.67139</td>
<td>5.41618</td>
<td>7.01691</td>
<td>8.56454</td>
</tr>
<tr>
<td>COPFMNG</td>
<td>0.51871</td>
<td>1.16258</td>
<td>4.85304</td>
<td>6.65848</td>
<td>6.52481</td>
</tr>
<tr>
<td>SGAHNG</td>
<td>-28.16769</td>
<td>-0.39456</td>
<td>72.70190</td>
<td>92.79794</td>
<td>1.69217</td>
</tr>
<tr>
<td>SGUDTNG</td>
<td>-2.85629</td>
<td>-0.4921</td>
<td>56.55966</td>
<td>63.70818</td>
<td>1.74207</td>
</tr>
<tr>
<td>SGSPRNG</td>
<td>-13.03162</td>
<td>-0.39455</td>
<td>50.19004</td>
<td>66.49798</td>
<td>1.69218</td>
</tr>
<tr>
<td>SGAHIN</td>
<td>-215.25</td>
<td>-1.31587</td>
<td>263.40</td>
<td>313.52</td>
<td>1.92876</td>
</tr>
<tr>
<td>SGCTIN</td>
<td>-23.08123</td>
<td>-3.14143</td>
<td>35.39889</td>
<td>43.53019</td>
<td>6.55774</td>
</tr>
<tr>
<td>SGUDTIN</td>
<td>-208.12</td>
<td>-2.02908</td>
<td>254.94</td>
<td>286.24</td>
<td>2.78533</td>
</tr>
<tr>
<td>SGSPRIN</td>
<td>-145.01</td>
<td>-1.31587</td>
<td>176.73</td>
<td>212.59</td>
<td>1.92876</td>
</tr>
<tr>
<td>FGSPRN0</td>
<td>71.43142</td>
<td>1.46564</td>
<td>328.34</td>
<td>396.58</td>
<td>6.22965</td>
</tr>
<tr>
<td>FGCTN0</td>
<td>36.04320</td>
<td>16.23362</td>
<td>97.17264</td>
<td>110.91</td>
<td>31.90571</td>
</tr>
<tr>
<td>FGSMN0</td>
<td>-116.92</td>
<td>-7.94362</td>
<td>256.09</td>
<td>296.75</td>
<td>17.50903</td>
</tr>
<tr>
<td>FGUDTN0</td>
<td>-55.83711</td>
<td>-0.58254</td>
<td>201.45</td>
<td>248.46</td>
<td>3.13738</td>
</tr>
<tr>
<td>FGSPRT0</td>
<td>396.55</td>
<td>1.72737</td>
<td>1176.69</td>
<td>1487.44</td>
<td>5.49464</td>
</tr>
<tr>
<td>FGCTOTP0</td>
<td>0.02511</td>
<td>6.54349</td>
<td>442.86</td>
<td>585.90</td>
<td>23.21762</td>
</tr>
<tr>
<td>FGUDTOP0</td>
<td>399.61</td>
<td>1.66028</td>
<td>1207.67</td>
<td>1561.68</td>
<td>5.34979</td>
</tr>
<tr>
<td>VARIABLE</td>
<td>MEAN ERROR</td>
<td>MEAN % ERROR</td>
<td>MEAN ABS ERROR</td>
<td>RMS ERROR</td>
<td>RMS % ERROR</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>--------------</td>
<td>----------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>FGSMNF0</td>
<td>11.52385</td>
<td>13.99406</td>
<td>866.92</td>
<td>1000.44</td>
<td>60.27547</td>
</tr>
<tr>
<td>FGAHHF0</td>
<td>377.93</td>
<td>1.72738</td>
<td>1080.67</td>
<td>1374.42</td>
<td>5.49465</td>
</tr>
<tr>
<td>FGSPRS0</td>
<td>73.24111</td>
<td>0.41848</td>
<td>525.77</td>
<td>643.72</td>
<td>3.20084</td>
</tr>
<tr>
<td>FGUDTS0</td>
<td>-70.81785</td>
<td>-0.32963</td>
<td>584.13</td>
<td>668.81</td>
<td>3.21444</td>
</tr>
<tr>
<td>FGSMNS0</td>
<td>-144.06</td>
<td>-11.05999</td>
<td>214.30</td>
<td>259.18</td>
<td>71.09976</td>
</tr>
<tr>
<td>FGAHHS0</td>
<td>53.94412</td>
<td>0.41847</td>
<td>440.84</td>
<td>535.62</td>
<td>3.20084</td>
</tr>
<tr>
<td>FGAIHROW</td>
<td>-45.87889</td>
<td>-1.74856</td>
<td>67.80092</td>
<td>77.29219</td>
<td>2.96423</td>
</tr>
<tr>
<td>FGCCOTROW</td>
<td>-115.89</td>
<td>-5.54915</td>
<td>211.60</td>
<td>255.68</td>
<td>15.24383</td>
</tr>
<tr>
<td>FGUDTROW</td>
<td>167.89</td>
<td>2.29260</td>
<td>710.09</td>
<td>826.81</td>
<td>7.90393</td>
</tr>
<tr>
<td>FGSPFRROW</td>
<td>-181.82</td>
<td>-1.76893</td>
<td>272.42</td>
<td>310.43</td>
<td>2.98389</td>
</tr>
<tr>
<td>FGSMNROW</td>
<td>330.48</td>
<td>-18.42145</td>
<td>721.14</td>
<td>951.29</td>
<td>46.55936</td>
</tr>
<tr>
<td>SGAHHROW</td>
<td>52.09708</td>
<td>0.56373</td>
<td>383.08</td>
<td>455.45</td>
<td>3.08652</td>
</tr>
<tr>
<td>SGCCOTROW</td>
<td>38.00612</td>
<td>2.19138</td>
<td>114.76</td>
<td>140.28</td>
<td>9.41128</td>
</tr>
<tr>
<td>SGUDTROW</td>
<td>-133.31</td>
<td>-0.52061</td>
<td>428.77</td>
<td>613.24</td>
<td>2.65435</td>
</tr>
<tr>
<td>SGSPFRROW</td>
<td>63.73288</td>
<td>0.56371</td>
<td>488.17</td>
<td>576.47</td>
<td>3.08652</td>
</tr>
<tr>
<td>SGSMNROW</td>
<td>-207.86</td>
<td>-4.67129</td>
<td>492.28</td>
<td>615.37</td>
<td>14.61896</td>
</tr>
<tr>
<td>CORPF</td>
<td>0.03741</td>
<td>-1.46265</td>
<td>0.24210</td>
<td>0.31271</td>
<td>12.26411</td>
</tr>
<tr>
<td>SORPF</td>
<td>0.0094152</td>
<td>0.27313</td>
<td>0.18472</td>
<td>0.23280</td>
<td>9.55658</td>
</tr>
<tr>
<td>BARPF</td>
<td>0.03279</td>
<td>-1.41571</td>
<td>0.11502</td>
<td>0.13712</td>
<td>6.30999</td>
</tr>
<tr>
<td>SGPOBU9</td>
<td>-0.68248</td>
<td>-0.66109</td>
<td>7.48562</td>
<td>10.00379</td>
<td>8.76890</td>
</tr>
<tr>
<td>OAPFMU9</td>
<td>-0.01929</td>
<td>-2.09989</td>
<td>0.13018</td>
<td>0.14497</td>
<td>10.07583</td>
</tr>
<tr>
<td>BAPFMU9</td>
<td>-0.03279</td>
<td>-1.41571</td>
<td>0.11502</td>
<td>0.13712</td>
<td>6.30999</td>
</tr>
<tr>
<td>SGPFMU9</td>
<td>0.02186</td>
<td>1.23003</td>
<td>0.19654</td>
<td>0.25456</td>
<td>10.82247</td>
</tr>
</tbody>
</table>
REFERENCES


FAO. FAO Trade Yearbook. Various years. Rome, Italy.


