The FAPRI Modeling System at CARD: A Documentation Summary

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FAPRI is a joint policy analysis program at Iowa State University and the University of Missouri-Columbia, with funding from the universities and a federal congressional grant through CSRS/USDA. Codirectors of FAPRI at the University of Missouri are Abner Womack and Jon Brandt, and codirectors at Iowa State University are Stanley Johnson and William Meyers.

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Introduction

Large-scale modeling systems have long been viewed as potentially valuable tools for evaluating farm policy. They have received increased attention in recent years, in part because of the added complexity of U.S. farm programs and the fuller integration of the U.S. farm sector with nonfarm sectors and world agricultural commodity markets. Instability in the world economy, changed macroeconomic policies, credit and debt positions, and agricultural trade regulations have significant impacts on U.S. agriculture in the short run and more pronounced long-run implications. It is important that policy models explicitly address these complexities of agriculture if they are to be successfully applied in policy design and evaluation.

The large-scale effort at multimarket commodity modeling by the Center for Agricultural and Rural Development (CARD, at Iowa State University) and the Center for National Food and Agricultural Policy (CNFAP, at the University of Missouri-Columbia) is sponsored largely by the Food and Agricultural Policy Research Institute (FAPRI). Established in 1984 by a U.S. congressional appropriation, FAPRI is a joint university policy analysis program carried out by CNFAP and CARD. One objective of FAPRI is to develop and maintain a comprehensive database and modeling system for policy analysis. The domestic crops models are maintained by both FAPRI centers. CNFAP also maintains an annual livestock model, while CARD maintains a quarterly livestock model and crops trade models. The scope of the FAPRI policy modeling system includes estimation of domestic and foreign supply, use and prices for major crop and livestock commodities, government program parameters and costs, net farm income, and consumer price impacts.

Scope of Modeling System

The commodity and policy analysis system consists of an integrated set of models used to provide quantitative evaluations of national and international agricultural policies, as well as other exogenous factors that affect U.S. and world agriculture. The objective of the system is to determine the consequences of alternative farm policy and program proposals for agricultural commodity markets and the U.S. agricultural sector. The components of the FAPRI models:

1. Quarterly livestock models that generate estimates of U.S. supply, demand, and prices for beef, pork, broilers, and turkeys. Annual livestock models also are maintained for the same sectors, plus dairy.
2. Domestic crops models that estimate U.S. supply, demand, and prices for corn, wheat, soybeans, soybean meal, soybean oil, sorghum, barley, oats, cotton, and rice.
3. World trade models for feed grains, wheat, and the soybean complex that estimate supply, demand, prices, and trade for major trading countries and regions. Trade models for rice, cotton, and other commodities are under development.

4. A U.S. government cost model that estimates fiscal year costs of domestic agricultural programs.
5. A net farm income model that estimates cash receipts, production costs, and net farm income for U.S. agriculture.

History of the FAPRI models

The models began with a general framework, estimated econometrically. They have been augmented by a number of student dissertations completed at Iowa State University, the University of Missouri, and the University of Minnesota. Developments of different phases or aspects of the models have been in large measure stimulated by inadequacies in existing models and expanded or different types of policy analysis requirements. The extensive work at Iowa State University on international commodity market models was, in fact, a response to requirements for fuller analysis of international markets and policies of other trading countries.

The current version of the quarterly livestock models is the result of continuous modifications of models initially developed at the University of Missouri. The current livestock models incorporate biological restrictions on supply in order to capture the constraints imposed by nature on the production process. The method for incorporating biological restrictions in the supply functions was based on work by Johnson and MacAulay (1982). The biological restrictions provide a priori information for the estimation of stock-flow relationships governing the different phases of livestock production.

The domestic crops models are based on earlier econometric models developed by Houck, Ryan, and Subotnik (1972), Womack (1976), Baumes and Meyers (1980), Meyers and Hacklander (1979), as well as more recent model development at CARD by Schouten (1985), Skold (1987), and Skold and Westhoff (1988), and at CNFAP by Young (1986). One of the distinguishing features of the current domestic crops models is the endogenization of commodity program participation rates. Participation rates depend on the expected per acre net returns of participants and nonparticipants (de Gorter and Paddock 1985). The estimated participation rates and commodity program parameters are major determinants of planted acreage.

The international components and the overall structure of the soybean and soybean products trade model are based on a dissertation by Huyser (1983). The general structures of the wheat and feed-grains trade models were developed in dissertation research by Mahama (1985) and Bahrenian (1987), respectively. These trade models have a domestic supply and demand structure in each of the countries and regions. Market interaction occurs across countries and across commodities through price linkages and net trade identities.

The government cost model has gone through several revisions. The origin of the model can be traced to one developed at the University of Missouri. The current version of the net farm income model is a refined and extended version of this model, which was estimated by Karnovitz et al. (1985).

This report documents the models for quarterly domestic livestock and annual domestic crops, world commodity markets, government cost, and net farm income. The following section provides an overview of the modeling system. The third section describes the theoretical framework and general specifications for the system. The fourth section provides detail on data sources and estimation procedures. The final section discusses recent applications and uses of the models.

Modeling Approach

This section reviews the general structure and modeling approach used in the models. Specification and structure of each individual component or model in the system are further detailed in the theory section.

Design of System

The general linkages among models in the system are depicted in Figure 1. Each model can be solved individually, but in general they are solved iteratively to obtain a simultaneous solution, given government policy provisions, macroeconomic conditions, and assumptions about weather and other exogenous factors. A solution is obtained when supply equals demand in each market, and the same vector of prices and other endogenous variables is obtained for all component models. For example, the equilibrium corn price generated in the domestic crops model is utilized in the livestock, world trade, government cost, and net farm income models. The corn exports determined in the world trade models must be used in the domestic crops models. Livestock numbers and prices generated

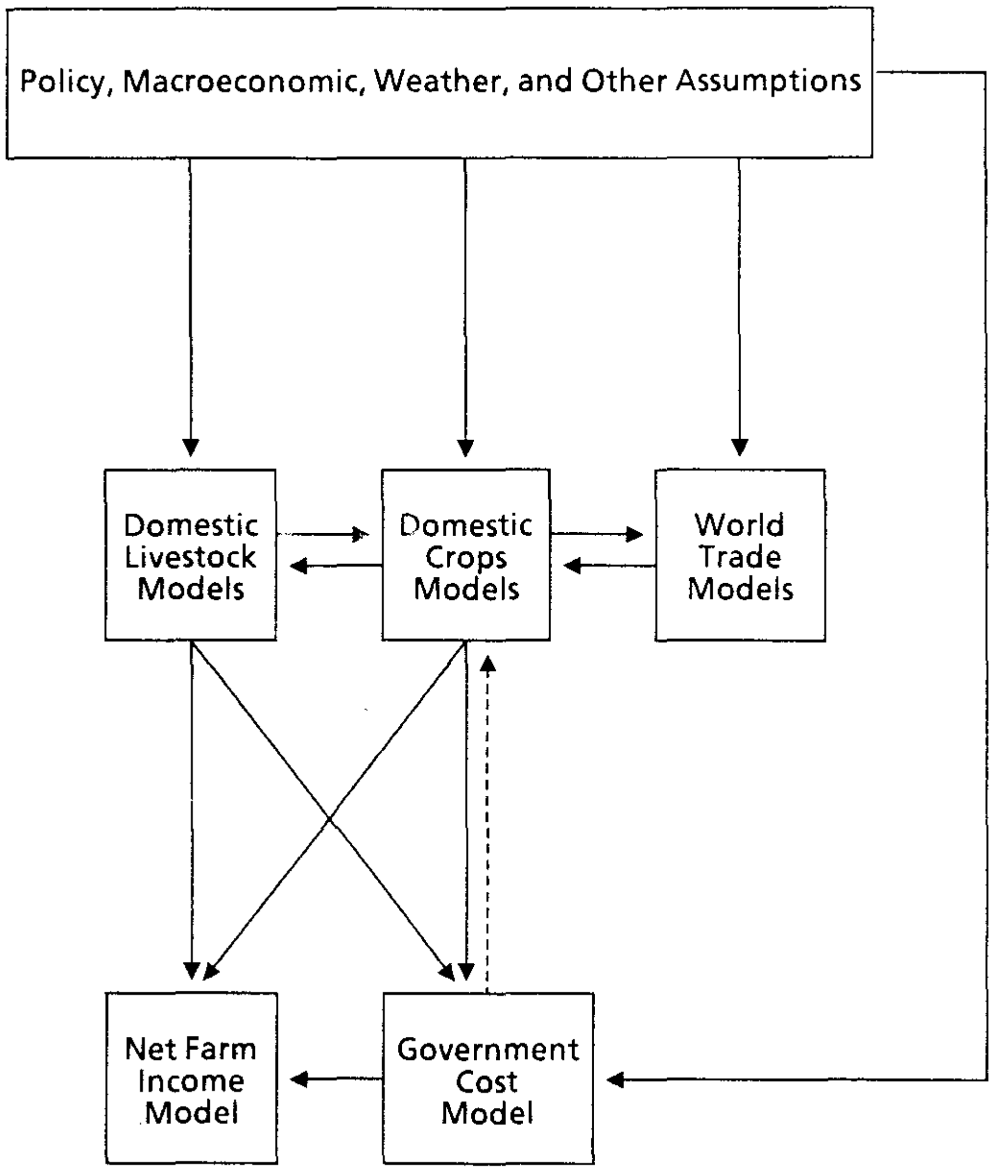

Figure 1. CARD/FAPRI policy modeling system

in the livestock models are important factors affecting corn feed demand in the crops models.

The quarterly nature of the livestock models further complicates the interaction between the livestock and domestic crops models. The prices of corn and soybean meal used in the livestock models are estimated on a crop-year basis. To integrate the crop and livestock models, it is necessary to convert these prices into representative quarterly values. Linkages from the livestock models to the domestic crops models are through three livestock indexes. These are grain-consuming animal units, high-protein animal units, and an index of livestock product prices. Quarterly values of livestock numbers and prices must be aggregated to construct the crop year indexes.

Thus, complex interactions are included between the domestic crops and world trade models, and between the domestic livestock and crops models. The government cost model is essentially recursive, conditioned on outcomes of the domestic crop and livestock models. The net farm income model is also recursive and is conditioned on the other domestic models and exogenous prices of major farm inputs.

Theory and Specification

This section sketches the theoretical foundations for the structural specifications of the FAPRI modeling system. The intent is to indicate the basis for the econometric specifications. Added detail on model structure can be found in the referenced papers documenting the system.

Domestic Livestock Models

This section presents the structural specifications for the quarterly models of the U.S. livestock sector: beef, pork, chicken, and turkey. In Figure 2, the interactions among these models are depicted. Detailed descriptions of the structure, estimation, and validation of beef, pork, and poultry models are provided in Grundmeier et al. (1989); Skold, Grundmeier, and Johnson (1989); and Jensen et al. (1989), respectively. The annual models are not described but are documented in two reports by Brandt et al. (1985a and 1985b).

Supply. The supply components of the livestock models capture both expansion and contraction in production by including behavioral equations that govern the respective sectoral breeding or hatching decisions. Biological constraints are introduced in the supply components to capture the nature of the production processes. The lag structures in the supply blocks are governed by the biological sequences in the respective production processes. The method for incorporating biological restrictions in the supply functions was first developed for a quarterly beef model by Johnson and MacAulay (1982).

The structural specification for the supply component to be reviewed is that of beef. Specifications of supply components for the other livestock models differ from the beef model on the basis of the individual industry and the physical nature of the production processes. The supply block of the beef model uses behavioral equations to represent breeding herd decisions. Calves can move to the breeding herd, to stocker-cattle

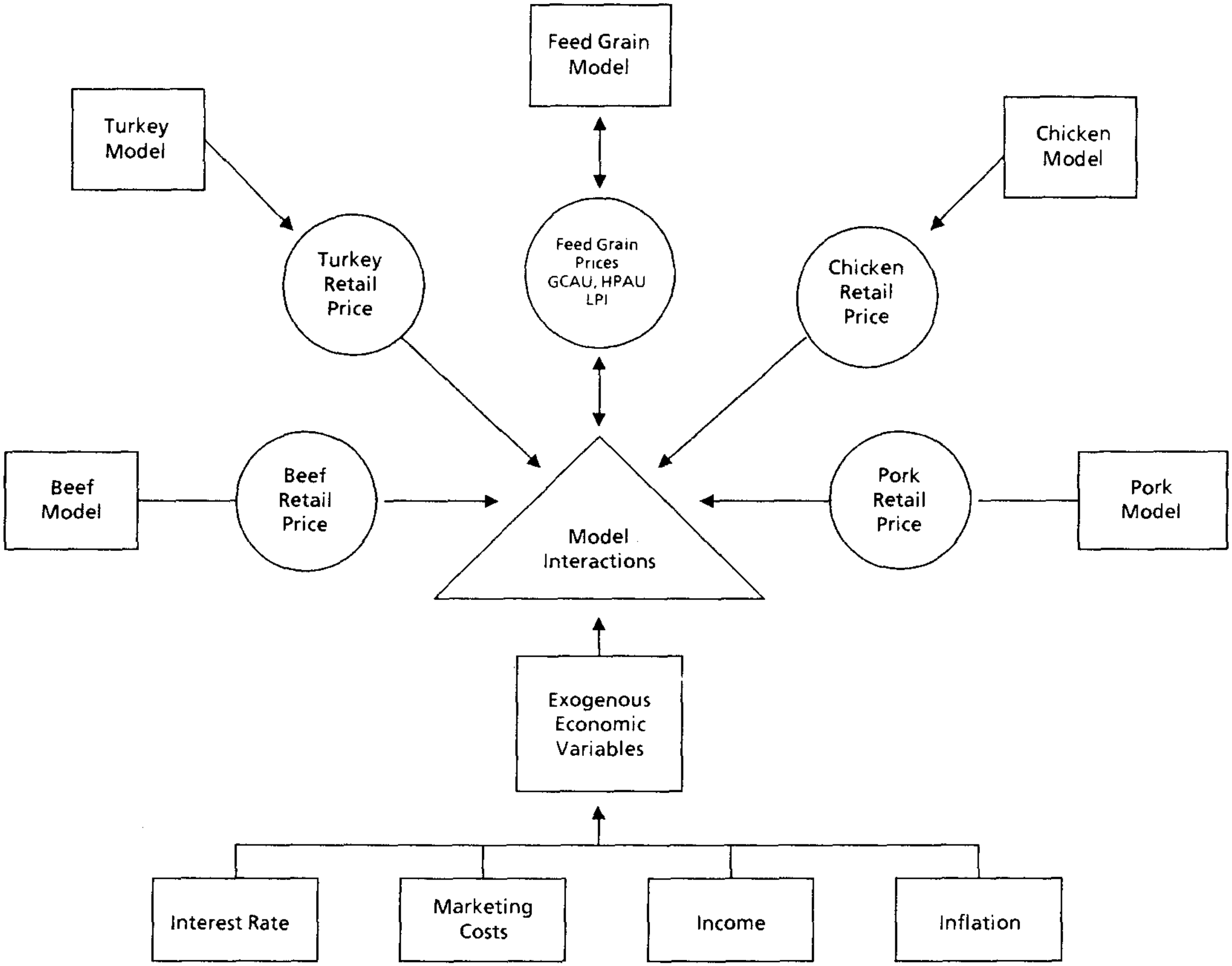

Figure 2. Livestock sector linkages for the FAPRI system

and nonfed slaughter, or to feedlots for subsequent slaughter. Slaughter from fed and nonfed sources and inventory culling, along with a weight equation estimation based on behavior, provide the industry supply of beef.

A logistic functional form is used to specify heifers added to the breeding herd (HEIFERS), so that the number of heifers added is bounded from above by the total number of calves in the calf crop lagged four through seven quarters, CALF4. This specification, originally developed by Johnson and MacAulay (1982), introduces a biological restriction and also represents producer decisions on herd expansion and contraction. The breeding herd equation is expressed as

$$\text{HEIFERS} = \text{CALF4} \,/\, [1 + \exp(\text{PSS4, PCO4, RIFCL}, X_{\text{HEIFERS}})], \qquad (1)$$

where PSS4 is the slaughter steer price (output price), PCO4 is the corn price (input price), RIFCL is the real interest rate (a proxy for inventory cost), and X_{HEIFERS} is a vector of exogenous variables that influence the addition of heifers to the breeding herd. PSS4, PCO4, and RIFCL are included as the average of the lagged values for the previous three through six quarters.

The other behavioral component determining the breeding herd is cow slaughter (CSLT), the outflow of breeding herd stock. The cow slaughter equation has the same logistic functional form as the heifers added to the breeding herd equation. Cow slaughter is bounded from above by the total cow herd (COWHERD), which provides an implicit biological restriction.

The same set of conditioning variables as for heifers is used, but the time frame is shifted forward by two quarters. The functional relationship for the cow slaughter equation is

$$CSLT = COWHERD / [1 + \exp(PSS4, PCO4, RIFCL, X_{CSLT})], \qquad (2)$$

where X_{CSLT} is a vector of other variables that affect cow slaughter.

The cow herd is determined by an identity, the sum of the lagged cow herd and the lagged heifers, less the lagged cow slaughter. The lagged cow herd is multiplied by 0.995 to account for an assumed 2 percent annual death loss. This identity is

$$COWHERD_t = 0.995 \cdot COWHERD_{t-1} + HEIFERS_{t-1} - CSLT_{t-1}. \qquad (3)$$

The beef cow herd (BEEFCOW) is solved simply by an identity that subtracts the exogenous dairy cows (DAIRYCOW) from the cow herd:

$$BEEFCOW = COWHERD - DAIRYCOW. \qquad (4)$$

The calf crop (CALFCROP) is specified as a technical relationship that incorporates biological restrictions of the type first advanced by Johnson and MacAulay (1982). This relationship is

$$CALFCROP = f(COWHERD \cdot D1, COWHERD \cdot D2, COWHERD \cdot D3, COWHERD \cdot D4), \qquad (5)$$

where Di is 1 in the i^{th} quarter and is 0 otherwise.

Identities are used to estimate three categories of calves in the model. The calf crop lightweights (CALF2), calf crop medium weights

(CALF4), and calf crop heavyweights (CALF5) contain the sum of calf crops lagged two through five quarters, four through seven quarters, and five through eight quarters, respectively:

$$CALF2_t = CALFCROP_{t-2} + CALFCROP_{t-3} + CALFCROP_{t-4} + CALFCROP_{t-5}, \quad (6)$$

$$CALF4_t = CALFCROP_{t-4} + CALFCROP_{t-5} + CALFCROP_{t-6} + CALFCROP_{t-7}, \quad (7)$$

$$CALF5_t = CALFCROP_{t-5} + CALFCROP_{t-6} + CALFCROP_{t-7} + CALFCROP_{t-8}. \quad (8)$$

The 13-state figure for cattle placed on feed (CATPL13) is expressed as a function of the calf crop lagged two through five quarters (CALF2), the lagged slaughter steer price, the lagged price of corn, and a vector of other variables ($X_{CATPL13}$) that affect cattle placement. The functional form of the cattle-placed-on-feed equation is as follows:

$$CATPL13 = f(CALF2, PSS4_{t-1}, PCO4_{t-1}, X_{CATPL13}). \quad (9)$$

The number of cattle on feed in 13 states (CATNF13) is determined by the identity

$$CATNF13_t = CATNF13_{t-1} + CATPL13_{t-1} - CATFM13_{t-1}, \quad (10)$$

where CATFM13 is the fed cattle marketings in 13 states.

The outflows from the feedlots or the level of fed cattle marketings, 13 states, is determined by the level of cattle on feed and the number of placements in the same quarter. Economic variables in the fed marketings equation are the slaughter steer price, corn price, and the real interest rate. The functional relationship is

$$CATFM13 = f[(CATNF13 + CATPL13), PSS4, PCO4, RIFCL]. \quad (11)$$

Fed cattle slaughter (FEDSLT) is determined by the level of fed marketings and a vector of other variables (X_{FEDSLT}). The biological ratio, FEDSLT/CATFM13, estimated from the sample is detrended since it exhibited a downward trend in the early years of the sample. The behavioral relationship of this equation is

$$FEDSLT = f(CATFM13, X_{FEDSLT}). \quad (12)$$

Nonfed slaughter (NFSLT) is determined by the calf crop lagged five through eight quarters (CALF5), the 600- to 700-pound feeder steer price (PFCL4), the corn price (PCO4), and a vector of other variables (X_{NFSLT}). Both PFCL4 and PCO4 are included as the average of the lagged values from the previous one through four quarters. Thus, the behavioral relationship for the nonfed slaughter equation is

$$NFSLT = f(CALF5, PFCL4, PCO4, X_{NFSLT}). \quad (13)$$

The average carcass weight of commercial production (AVECW) is expressed as a function of total slaughter, FEDSLT + NFSLT + CSLT + BSLT, and the slaughter steer price, PSS4. BSLT represents bull slaughter. The functional form of this equation is

$$AVECW = f[(FEDSLT + NFSLT + CSLT + BSLT), PSS4]. \quad (14)$$

Commercial beef production (BPROD) is determined by an identity that multiplies the average carcass weight by total slaughter. Total beef production (TOTBSP) is simply commercial beef production plus on-farm production (FPD). The identities for both commercial beef production and total beef production are

$$BPROD = AVECW \cdot (FEDSLT + NFSLT + CSLT + BSLT), \text{ and} \quad (15)$$

$$TOTBSP = BPROD + FPD. \quad (16)$$

Demand. The discussion of the structural specification of demand is general. The specifications for individual livestock models vary depending on the special characteristics; e.g., lagged price response. Price determination in the livestock model is assumed to occur at the retail level. Livestock production is essentially fixed in the short run, and hence the determination of retail price depends on the location of the demand curve. The retail price is then linked to the farm price through a margin equation. The behavioral relationship for the margin equation is

$$MARGIN = f(RPL, X_{MARGIN}), \quad (17)$$

where MARGIN represents the real retail-farm margin, RPL is the real retail price of the livestock product of interest, and X_{MARGIN} is a vector of other variables that influence the margin. The real farm price (RFP) is given by the identity

$$RFP = RPL - MARGIN. \quad (18)$$

Demand functions used in the livestock sector models are dynamic and follow the precepts of consumer behavior. Habit formation in consumption may lead to delayed responses, and thus protract the adjustment process. This underlying inertia in consumption implies that consumer behavior dynamics should be explicitly introduced into the specification of the demand component. In the demand structures for the livestock components, the dynamics are introduced using a structure proposed by Anderson and Blundell (1982).

Per capita retail demand (RLD) components used in the livestock models incorporate persistence in consumption. A log-linear functional form, used for computational and expositional convenience, is based on approximating properties developed numerically. The general specification of retail demand is

$$\Delta_4 \log RLD_t = D + \sum_{j=1}^{k} B_j \, \Delta_4 \log X_{jt} + (\alpha - 1)[\log RLD_{t-4} - \sum_{j=1}^{k} \epsilon_{ij} \log X_{t-4}] + e_t. \qquad (19)$$

Dynamics in consumption enters through a fourth-order lag (Δ_4) on the quantity consumed (RLD), and in the other demand conditioning variables (X_t). Short-run behavior is captured in the B_j terms, and the speed of the adjustment process is governed by α-1. The long-run parameters are ϵ_{ij}'s. Because the livestock models are linked through retail prices, per capita retail demand was estimated in a system of demand equations for beef, pork, and chicken. Thus, the retail prices of pork, beef, and chicken enter as conditioning variables in the demand system. Other conditioning variables include per capita food expenditures and the consumer price index of food, a proxy for all competing food products. This set of conditioning variables is implied by a two-stage budgeting process. A homogeneity restriction is imposed for the short-run parameters, as consumers would be aware of relative price changes in the short run. The homogeneity and symmetry restrictions are imposed on long-run behavior, as consumers over this period can be presumed to have the ability to fully discern relative price and income shifts.

The other demand component is closing cold-storage stocks (LEI). The functional form of this equation is

$$LEI = f(RPL, TLP, LIM, LBI), \tag{20}$$

where TLP is the production of the livestock product, LIM is the imports, and LBI is the beginning stocks. The retail price has a negative effect on ending stocks because as price increases, packers are less willing to hold excessive stocks. Total supply, imports, and beginning stocks have a positive influence on ending stocks; as these variables increase, given existing demand, ending supply will invariably increase.

The market clearing identity equates supply and demand; i.e.,

$$TLC = TLSP + LBI - LEI + LIM - LEXP - MILC, \tag{21}$$

where TLC is total consumption (per capita retail demand times population), TLSP is total supply, LEXP is exports, and MILC is military use. Important demand and supply elasticities in the FAPRI livestock models are summarized in Tables 1 and 2.

Domestic Crop Models

Commodities modeled in the domestic crop models are corn, wheat, soybeans, soymeal, soybean oil, sorghum, barley, oats, cotton, and rice. A general structural specification representative of that used in the domestic crops models is given below. Detailed documentation is provided by Westhoff et al. (1989).

Acreage Response and Supply. The estimation of the response by domestic supply to changing government commodity programs has been problematic; commodity programs have undergone frequent adjustments, with accompanying changes in their underlying payment structures and acreage reduction provisions. Earlier models often incorporated the influence of commodity programs by including effective support payment and diversion payment variables in the equations for area planted. However, these composite variables ignore the voluntary nature of the commodity programs and impose questionable restrictions on the effects of changing policy parameters.

The estimation of crop supply response in the FAPRI models endogenizes the commodity program participation rate. The participation rate (defined for purposes of the model as [program planted and idled acres]/base acreage) is modeled as a function of the difference between participant expected net returns (PARTENR) and nonparticipant expected net returns (NPARTENR):

Table 1. Summary of supply elasticities from livestock models estimation (period 1967-1986)

Beef	
Fed	0.13
Nonfed	-0.53
Total	-0.03, 0.16[a]
Pork	0.03, 0.50[a]
Chicken	
Placement	0.17
Hatching	0.14
Production	0.10
Turkey	
Hatching	0.26
Production	0.23

Note: Supply elasticities are computed at 1984-86 mean values.

[a]Long-run elasticity.

Table 2. Summary of demand elasticities from livestock models, with homogenity and symmetry imposed in long run and homogenity imposed in the short run (estimation period 1967-1986)

		Beef	Pork	Chicken	Expenditure
Beef	SR	-0.52	0.23	-0.14	0.43
	LR	-0.80	0.30	-0.028	1.06
Pork	SR	0.42	-0.70	-0.06	0.19
	LR	0.62	-0.60	0.13	0.68
Chicken	SR	0.06	0.19	-0.63	0.0004
	LR	-0.17	0.34	-1.05	1.24

SOURCE: Grundmeier et al. 1989; Jensen et al. 1989; Skold, Grundmeier, and Johnson 1989.

Note: SR and LR represent short-run and long-run, respectively. Demand elasticities are computed at the mean value for the estimation period.

$$PART = f(PARTENR - NPARTENR), \tag{22}$$

where PART is the 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 per acre are derived from deficiency payments, diversion payments, cash receipts from marketings, the variable cost of production, and the cost of maintaining idled land. The arithmetical representation of PARTENR is

$$\begin{aligned} PARTENR = {} & \max\{0, [TP - \max(LR, LFP)]\} \cdot PY \cdot (1 - ARPR - PLDR) \\ & + DPR \cdot PY \cdot PLDR + \max(LR, LFP) \cdot TY \cdot (1 - ARPR - PLDR) \\ & - VC \cdot (1 - ARPR - PLDR) - 20 \cdot (ARPR + PLDR). \end{aligned} \tag{23}$$

The first component of the right-hand side of equation (23) is the expected deficiency payment. The variables that enter into the expected deficiency payment 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 second term is the expected diversion payment, where DPR is the diversion payment rate. The third component in equation (23) is market return, where TY is the trend yield. The fourth component is variable cost of production from planted acreage, where VC is variable cost of production per acre. The final component indicates 20 dollars as the average cost of maintaining the land idled under acreage reduction and paid land diversion.

Nonparticipant expected net returns are defined as

$$NPARTENR = LFP \cdot TY - VC, \tag{24}$$

where the variable definitions are as given above. Area planted under programs (APP) is given by the identity

$$APP = PART \cdot (1 - ARPR - PLDR) \cdot BA, \tag{25}$$

where BA is base acres. The total land idled (IA) by acreage reduction and paid land diversion is

$$IA = PART \cdot (ARPR + PLDR) \cdot BA, \tag{26}$$

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

Nonprogram planted acres (APNP) is expressed as the behavioral relationship

$$APNP = f(NPARTNR, OCENR, APP, IA, LAPNP), \tag{27}$$

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

$$AP = APP + APNP. \tag{28}$$

The ratio of area harvested to area planted (AH/AP) is estimated as the behavioral/technical relationship

$$AH/AP = f(T, LFP, X_{AH/AP}), \tag{29}$$

where T represents the time trend, and $X_{AH/AP}$ represents a vector of other variables that affect the AH/AP ratio. Area harvested is defined by

$$AH = AP(AH/AP). \tag{30}$$

Crop yield per acre (CY) is expressed as a function of government policy parameters such as target prices (TP) and idled acreage (IA), plus a time trend (T) to represent technological progress and other factors (X_{CY}). Target prices have a positive effect on yield--higher target prices are assumed to induce more input usage. Land seleced for idling is assumed to be less productive than that remaining in production; therefore, an increase in land idling is expected to increase average yields. The yield equation is

$$CY = f(TP, IA, T, X_{CY}). \tag{31}$$

Crop production (CPROD) is defined as a product of acres harvested and yields per acre:

$$CPROD = AH \cdot CY. \tag{32}$$

Expected net returns are affected significantly by policy parameters. The incorporation of the program participation decision, which depends on expected net returns, in the determination of planted acres provides a means of analyzing effects of commodity policy parameter changes on participation rates, acreage planted, yields, production, and planted area and production of alternative crops.

Crop supply is the sum of production, beginning stocks (CBI), and imports (CIM); i.e.,

$$CS = CPROD + CBI + CIM. \tag{33}$$

For each crop, demand is disaggregated to a number of categories. For wheat and feed grains, major demand components include food use, feed use, seed use, stocks, and exports. For soybeans, the categories are crush, other domestic uses, exports, and stocks; while for soybean meal and soybean oil, demand consists of domestic use, exports, and stocks. Cotton demand is divided into domestic mill use, exports, and stocks. Rice use is for food, seed, industrial processing, exports, stocks, and a residual category. The specification of demand equations depends on the commodity and demand component of interest.

Domestic Disappearance. The theoretical specification for food use is based on consumer theory. Solution of the utility maximization yields consumer demand as a function of own price, prices of competing or substitute commodities, and income. However, the restrictions (homogeneity, symmetry, Cournot aggregation, and Engel aggregation) derived from the demand theory are not imposed in the estimation of food demand for crops. The functional form of per capita food demand (CFOOD) is

$$CFOOD = f(P_{own}, P_{cross}, RPCE, X_{food}), \tag{34}$$

where P_{own} represents own price of the commodity in real terms, P_{cross}

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

Since feed is used as an input in livestock production, the theoretical specification of feed demand follows from the theory of derived demand. Thus, feed demand (CFEED) is expressed as a function of the real price of the commodity (P_{own}), the real price of competing feed products (P_{cfeed}), livestock product prices (PL), livestock numbers (LN), and a vector of other variables (X_{feed}). The form of feed demand is

$$CFEED = f(P_{own}, P_{cfeed}, PL, LN, X_{feed}). \quad (35)$$

Demand for seed use (CSEED) is specified as a function of acreage planted (AP) and a time trend (T); i.e.,

$$CSEED = f(AP, T). \quad (36)$$

The above general specifications of domestic disappearance equations are modified appropriately to meet the special characteristics of the commodities included in the FAPRI models. For example, in the case of soybeans, crush demand primarily depends on crushing margins; i.e., on the difference between the value of meal and oil obtained when soybeans are crushed and the value of raw soybeans.

Stocks. Total crop inventories (CEI) 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. The CCC inventories, FOR stocks, and nine-month loan stocks are exogenous in the model; however, in policy analysis applications these stock levels are adjusted to reflect factors ranging from loan rates and market prices to participation rates and the availability of generic certificates.

The free (or private) stocks are endogenized using speculative and transactions motives of inventory demand. The speculative motive indicates that the amount of grain stored at any given time depends on 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. Furthermore, it is assumed that commercial stockholders base their expectations of future prices on expected production and government stocks. The transactions motive indicates that the amount of grain stored is determined by the level of current output. Using these two motives for storage, the behavioral relationship for free stocks (CSTOCK) is

$$CSTOCK = f(P_{own}, CPROD, ECPROD, GSTOCK, X_{STOCK}), \qquad (37)$$

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

Exports. In the domestic crops models, U.S. exports (CEX) are determined by semireduced form equations that reflect the price responsiveness in the trade models. U.S. exports are determined by the trade models when the entire modeling system is used to derive projections or conduct policy analysis. Specification of export equations is explained in more detail in the discussion of trade models. The semireduced equations in the domestic crops models facilitate the iteration between the domestic and international commodity models. They also make it possible to use the domestic crop models independently of the trade models to analyze the effects of policy or other shocks that have major effects only for the United States.

The domestic market equilibrium is at the price that equates total supply to total demand. The associated identity is

$$CPROD + CBI + CIM = CFOOD + CFEED + CSEED + CEI + CEX. \qquad (38)$$

A general structure of a domestic crop model is illustrated in Figure 3. However, each model has its own particular specialized structure. Figure 3 can be divided into two sections. The left-hand side of the figure sketches the process of determining supply of the commodity. The right-hand side identifies the demand components. The model balances supply and demand to determine price.

At the bottom of the diagram the exogenous variables used in the commodity models are identified. The word exogenous should be emphasized. Each model is capable of operation on a stand-alone basis. For example, assumptions about future livestock supplies may be made and a crop model may be solved as conditioned by the assumptions. However, in the

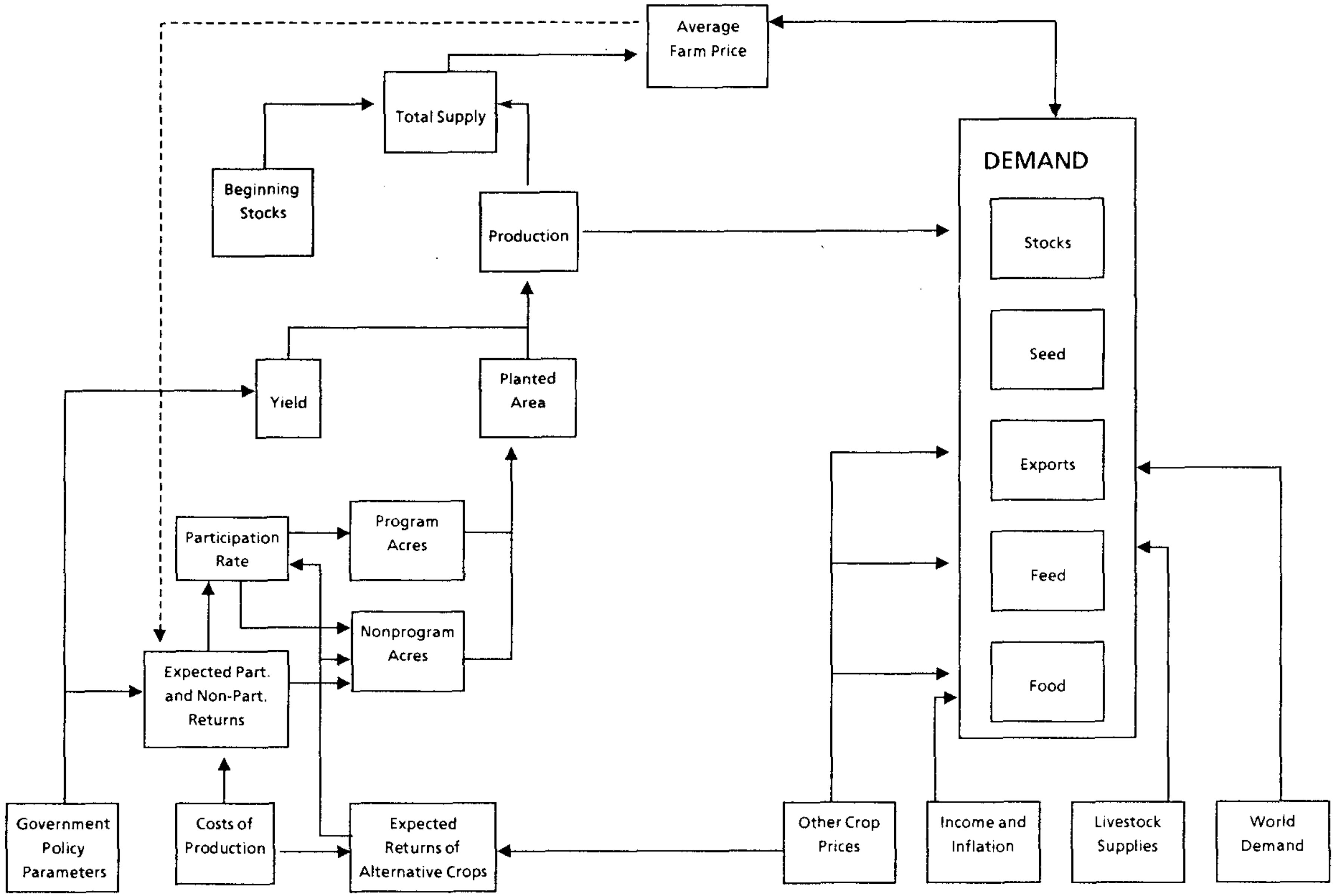

Figure 3. General Structure of U.S. domestic crops models

interactive environment in which these models generally function, livestock supplies, world demand, and other crop prices are endogenously determined. The only exogenous variables when the system is operated in this mode are the government policy parameters, macroeconomic variables, and the prices determining costs of production. All supply and demand equations in the domestic crops models are estimated in quantity dependent form. Crop prices are determined interactively, as equilibrium is reached when supply equals demand for each crop. Key elasticities from the domestic crop models are provided in Table 3.

Trade Models

The agricultural trade models are dynamic, nonspatial, partial equilibrium, and econometric. They include wheat, sorghum, other feed grains (corn, barley, and oats), and soybeans. The models are nonspatial in that they do not identify trade flows between specific regions; the intent is to identify net quantities traded by country or region. They are partial equilibrium models because only one commodity is included in each model and resource market outcomes are presumed exogenous. However, the prices of the individual commodities appear in other commodity models as substitutes or complements in supply and/or demand.

While each trade model can be operated independently, the trade modeling system also can be integrated with cross-commodity and cross-country interactions. The linkages between countries and commodities are designed to reflect the simultaneity of the price determination process in the respective commodity markets. A simultaneous

Table 3. Domestic crop model elasticities (evaluated at 1988 values of all variables)

		Wheat Price	Corn Price	Soybean Price	Soymeal Price	Soy oil Price	Sorghum Price	Barley Price	Oats Price	Cotton Price	Rice Price	Own Target	Planting Rate[1]
Wheat	Part. Rate	-0.75										0.86	0.54
	Planted	0.20										-0.14	0.59
	Production	0.20										-0.06	0.55
	Dom. Use	-0.13	0.07										
	Free Stock	-0.66											
Corn	Part. Rate		-0.43	-0.39								0.98	0.71
	Planted		0.10	0.03								-0.12	0.38
	Production		0.08	0.02								0.07	0.32
	Dom. Use	0.03	-0.11		0.03								
	Free Stock		-0.50	-0.02									
Soybean	Planted		-0.08	0.29								-0.17[2]	-0.12[2]
	Production		-0.07	0.27								-0.16[2]	-0.11[2]
	Dom. Use		-0.01	-1.51	1.15	0.49							
	Free Stock		0.03	-0.46									
Soymeal	Dom. Use		0.02		-0.12								
	Free Stock		0.01	0.11	-0.14	-0.04							
Soy oil	Dom. Use					-0.05							
	Free Stock		0.01	-4.04	3.03	1.50							
Sorghum	Part. Rate						-0.21					0.23	0.20
	Planted						0.27					0.10	0.83
	Production						0.27					0.32	0.70
	Dom. Use	0.46	0.47				-1.32	0.02					
	Free Stock						-0.55						
Barley	Part. Rate							-0.33				0.32	0.28
	Planted							0.31				0.08	0.64
	Production							0.31				0.08	0.62
	Dom. Use	0.09						-0.25					
	Free Stock							-0.44					
Oats	Planted		-0.25										
	Production		-0.23						0.57				
	Dom. Use		0.01						-0.40				
	Free Stock	-0.86	0.71						-0.78				
Cotton	Part. Rate									-1.76		1.82	1.09
	Planted									0.36		0.14	0.73
	Production									0.36		0.14	0.73
	Dom. Use									-0.08			
	Free Stock									-0.50			
Rice	Planted										0.10		0.77
	Production										0.10		0.77
	Dom. Use	0.03						0.01			-0.03		
	Free Stock										-0.26		

[1] The planting rate is defined as 1 - ARP rate - PLD rate.
[2] Soybean elasticities with respect to the corn target price and the corn planting rate.

solution of the four models can be obtained consistent with market clearing equilibria of the four commodities. Figure 4 illustrates the linkages among the trade models, as well as the regional and country detail in each model.

As in the domestic models, a descriptive, econometric approach is employed in the structural specifications, which imposes few prior constraints in parameter estimation. While the functional forms of the equations in the models are generally linear, identities and other basic relationships that are introduced--such as relative prices--result in nonlinearities.

The basic elements of a nonspatial equilibrium commodity supply and demand model are illustrated in Figure 5. The U.S. export supply curve (ESUS) represents the difference between (1) the domestic supply (SUS) and demand (DUS) in the United States and (2) the quantity supplied to the world market at alternative price levels. Other exporters' supply and demand schedules are represented in the lower panel. ESO is the combined excess supply of all competing exporters, derived as the difference between the supply and the demand for all the exporters. The import demand schedule (EDT) of all importers is their total demand minus the total supply. Other competitors' export supply and importers' import demand are represented in the middle of the figure in 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 competitors. The kinked nature of the EDN reflects the restricted trade

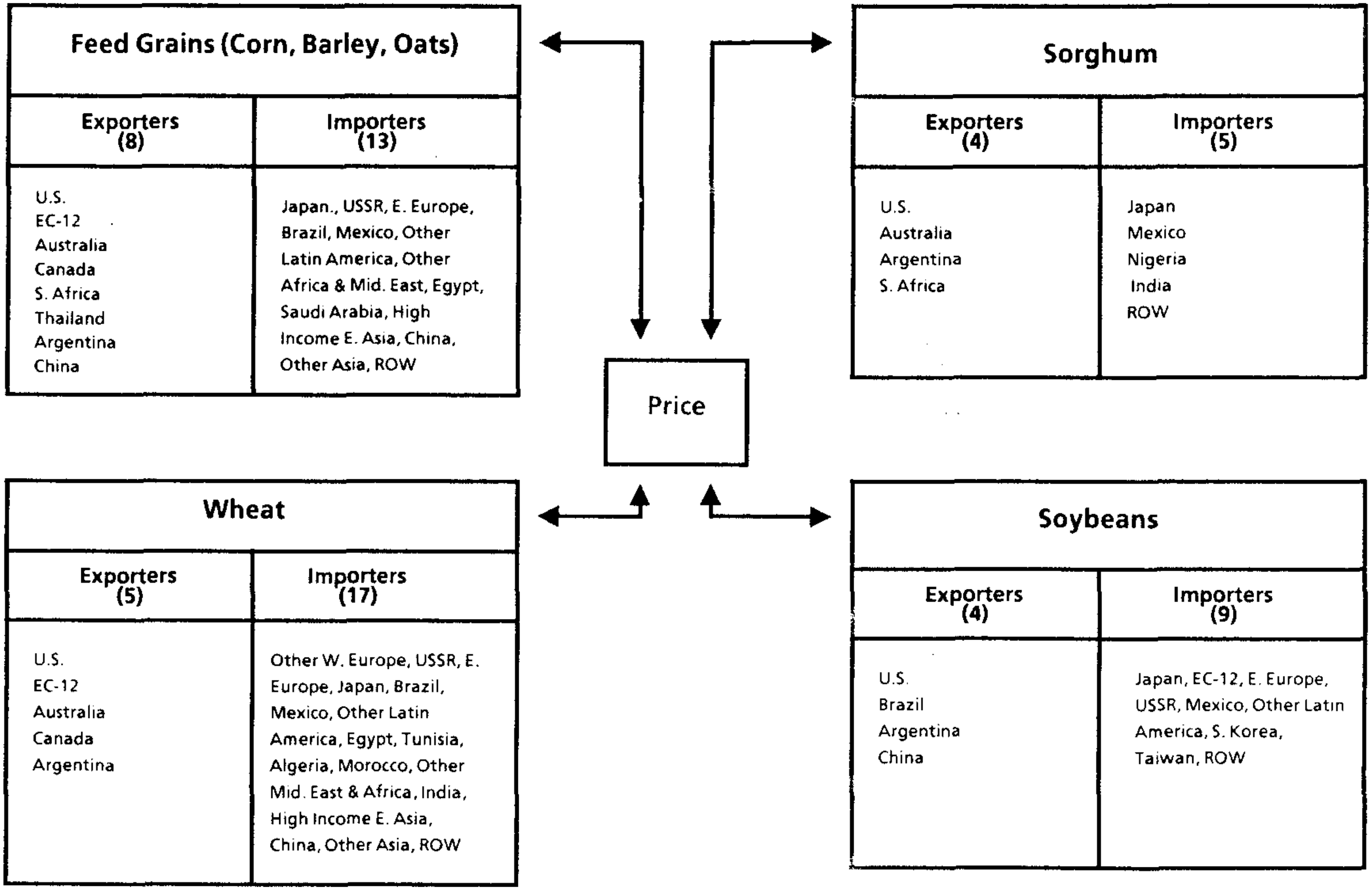

Figure 4. CARD/FAPRI world agricultural trade models (annual econometric system)

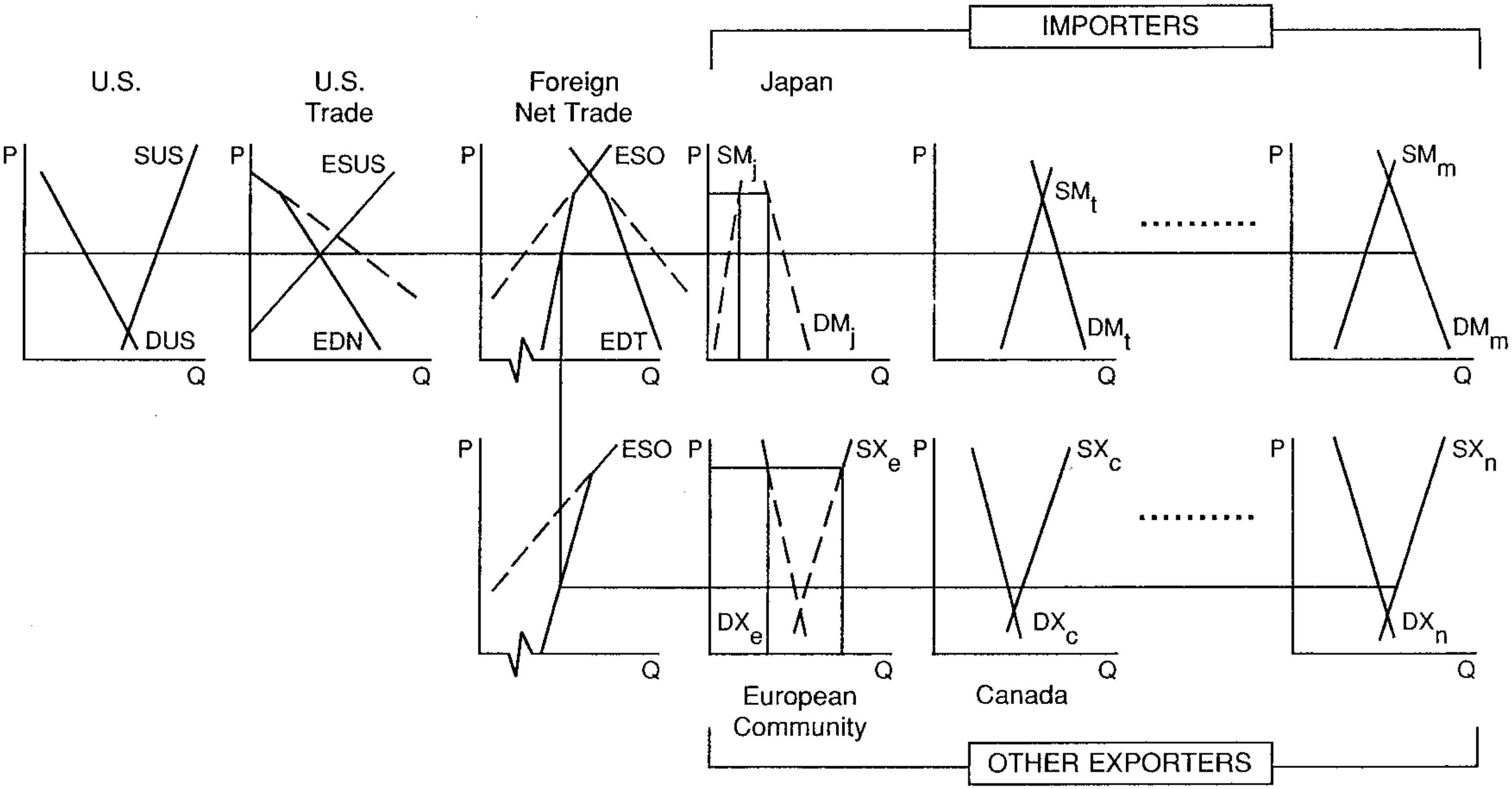

Figure 5. Determination of equilibrium prices and quantities in the FAPRI agricultural trade models

policies of some foreign countries, which insulate domestic prices from world prices. The trade equilibrium is achieved by the clearing of excess demands and supplies.

The structural specifications of the U.S. components in the trade models are the same as in the U.S. domestic crop models, except for the export equations. In the trade models, U.S. exports are set equal to imports by importing countries minus exports by other exporting countries. The structural specifications of foreign countries are similar to those of the United States, but the levels of detail vary. The essential components of these trade models are specified in the equations below. To simplify exposition, the notation used is general and different from that used in domestic crop models.

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

$i = 1, \ldots, m$ importers; (39)

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

$j = 1, \ldots, n$ exporters; (40)

$$ESUS = S_u(P_u, X_{4u}) - [FOD_u(P_u, X_{1u}) + FED_u(P_u, X_{2u}) + SD_u(P_u, X_{3u})]$$

U.S. excess supply; (41)

$$ESUS = EDN = EDT - ESO$$

world market equilibrium; (42)

$$PD_i = G_i(P_u \cdot e_i, Z_i)$$

$i = 1, \ldots, m$ importers; (43)

$$PD_j = G_j(P_u \cdot e_j, Z_j) \qquad j = 1, \ldots, n \text{ exporters}; \qquad (44)$$

where FOD is domestic food demand; FED is domestic feed demand; SD is domestic stock demand; S is domestic supply; EDT is excess demand function of all importers; ESO is excess supply function of all exporters, excluding the United States; EDN (EDT - ESO) is the export demand facing the United States; ESUS is excess supply function of the United States; PD is domestic market price; PS is domestic supply price; P_u is U.S. Gulf port price; e is exchange rate; Z is a vector of policy variables and transport cost that influence the price transmission; X_k is a vector of demand shifters (k = 1, ..., 3); and X_4 is a vector of supply shifters.

The mathematical representation in equations (39)-(44) is general and varies by commodity. For soybeans specifically, the complexity of the model is increased by the addition of the soymeal and soy oil product sectors.

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 (equations 43 and 44). Except where they are set by the government, domestic prices are linked to world prices through price linkage equations. These equations include bilateral exchange rates and transfer or service margins. Where some degree of insulation of domestic prices from external markets exists, the free adjustment of trade flows is restricted. Price linkage equations define the degree of price transmission from external markets to the domestic system. Trade occurs whether a full price transmission is allowed or not.

The quantity traded adjusts only to domestic conditions if prices are not transmitted.

The feed-grain model includes 21 countries and regions in varying levels of detail. In countries or regions where production is important, supply has been endogenized; in countries with little domestic production, such as Japan, domestic supply is exogenous. The demand components of the domestic models are endogenous for all countries.

The sorghum model includes eight countries and one region. In the United States, Argentina, Australia, Nigeria, Mexico, India, and South Africa, both the demand and the supply components are endogenous. There is very little production of sorghum in Japan; therefore, Japanese sorghum production is exogenous, while demand is endogenous. In the category called the rest of the world (ROW), production and net import equations are estimated.

The wheat model includes 22 countries and regions. In 16 countries and regions both production and demand functions are estimated. In the Soviet Union, Eastern Europe, and Japan, production is exogenous while domestic demand is endogenous. The Other Western Europe and High-income East Asia regions each consist of a net import function. The rest of the world is exogenous.

The soybean model includes 13 countries and regions. In the United States, Argentina, Brazil, Japan, Taiwan, South Korea, China, Mexico, Eastern Europe, and the rest of the world, soybean production and demand are modeled endogenously. In the Soviet Union, Eastern Europe, and the

EC-12, soybean production is exogenous but the demand side is endogenous.

Soymeal and soy oil production are determined by the amount of crush and crushing yields in each country or region. Soybeans generally are crushed, and the meal is used in animal feed. However, in South Korea, Japan, Taiwan, and China, soybean food products are important to the diet; hence, soybean food use equations are estimated for these countries also. Generally, soymeal demand is modeled as a feed demand equation, and soy oil demand is modeled as a final demand. The exception is for Argentina, where soymeal and soy oil net export equations are specified and domestic demand for these two products consists of the market clearing identities.

Detailed descriptions of the soybean, feed grains, and wheat trade models and their estimation and validation statistics are provided in Meyers, Helmar, and Devadoss (n.d.); Helmar, Devadoss, and Meyers (n.d.); and Devadoss, Helmar, and Meyers (n.d.); respectively. (Elasticities reported in these documentations may differ from those reported in this summary report, because this report documents the model as of summer 1988.)

U.S. export demand elasticities with respect to U.S. prices are summarized in Tables 4 and 5. The reported elasticities incorporate price transmission, demand, and supply responses in all exporting and importing regions included in the model.

Government Cost Model

Programs accounting for more than 90 percent of the net cost of government agricultural programs are explicitly included in the FAPRI

Table 4. U.S. short-run export demand elasticities (evaluated at 1988 values of all variables)

	Wheat Price	Corn Price	Soybean Price	Soymeal Price	Soy oil Price	Sorghum Price	Barley Price	Oats Price	Cotton Price	Rice Price
Wheat	-0.30	0.06		0.02						
Corn	0.06	-0.38		0.06						
Soybeans			-0.60	0.46	0.21					
Soymeal			1.51	-1.55	-0.52					
Soy oil			2.67	-2.06	-1.66					
Sorghum		0.92				-1.05				
Barley	0.24	0.24					-0.67			
Cotton									-0.27	
Rice	0.14									-1.19

Table 5. U.S. long-run export demand elasticities (evaluated at 1988 values of all variables)

	Wheat Price	Corn Price	Soybean Price	Soymeal Price	Soy oil Price	Sorghum Price	Barley Price	Oats Price	Cotton Price	Rice Price
Wheat	-0.85	0.34	0.13	0.02						
Corn	0.21	-0.70	0.15	0.04						
Soybeans			-0.99	0.65	0.38					
Soymeal			1.73	-1.68	-0.86					
Soy oil			3.18	-2.61	-2.26					
Sorghum	0.51	0.99				-1.92	0.11			
Barley	0.24	0.24					-0.67			
Cotton									-0.27	
Rice	0.33									-2.62

government cost model. Eight major program crops are covered: corn, wheat, soybeans, cotton, rice, sorghum, barley, and oats. In addition, the model estimates costs of the Conservation Reserve (CR) and the dairy program, as well as net interest costs of government farm programs. Given assumed levels of other net program costs, the model provides estimates of net Commodity Credit Corporation outlays on a fiscal year basis.

The government cost model is primarily a set of accounting relationships. Deficiency and diversion payments can be computed directly given the commodity policy parameters and the prices, quantities, and participation rates determined in the domestic crops models. Program costs of the CR depend on the number of acres enrolled and the average rental rate. Dairy program costs depend primarily on the support price and associated CCC net removals.

Commodity loan programs and generic certificate use mean the government cost model must be more than just an accounting tool. To estimate loan program costs, a number of behavioral relationships that are not in other FAPRI models must be introduced. Generic certificates complicate the computation of cash program costs, and they have real impacts on loan activity, program participation, and market prices. Thus, there is feedback from the government cost model to the domestic crop models.

The structure and the operation of the FAPRI government cost model are detailed in Westhoff and Meyers (1988). The current version of the model has been used to develop government cost estimates for FAPRI baseline projections and various policy analyses over the past two years. Since the model can be used to develop fiscal year cost estimates reflecting the same accounting framework as the CCC, it facilitates effective communication with those involved in the policy process.

Net Farm Income Model

The FAPRI net farm income model primarily transforms the output of the domestic crops, livestock, and government cost models into estimates of cash receipts, production costs, and net farm income. While the model relies heavily on accounting relationships, it also utilizes estimated equations to reflect behavioral/technical relationships and to adjust for five other factors:

1. Marketing-year prices and quantities generated by the domestic crop model must be converted to calendar-year estimates of crop receipts.
2. Estimates must be developed of cash receipts for commodities that are not included in the FAPRI modeling system, such as sugar, vegetables, and fruit. These commodities account for about one half of total crop receipts.
3. Production costs must be estimated, based on price levels, interest rates, crop production, feed use, feed prices, feeder livestock prices, tax rates, and a number of other factors.
4. Farm use of crop and livestock products, the operation of government loan programs, and a number of other factors mean that seemingly obvious accounting relationships do not hold. Estimated

equations are often used when all the factors needed for a complete accounting cannot be identified.

5. Inventories generated by the crop models are on crop-year basis, which must be converted to a calendar-year basis. For the livestock sector, changes in the value of livestock inventories should be taken into account in computing the net farm income.

The net farm income model has been used for several years in preparing baseline projections and in conducting policy evaluations. The current version of the model is based on a model estimated by Karnovitz et al. (1985). The model will be respecified and reestimated in the near future to reflect improved information and changes in USDA accounting standards.

Data and Estimation Procedures

This section reviews data sources, and estimation procedures, and it presents selected elasticity estimates from the FAPRI modeling system.

Domestic Livestock Models

The quarterly data for the endogenous variables in the four livestock models (beef, pork, broiler, and turkey) derive from publications in the USDA Agricultural Statistics Board Series; specifically, Agricultural Prices, Cattle, and Livestock Slaughter. Economic Research Service publications used include Livestock and Meat Statistics and the Livestock and Poultry Situation and Outlook Report. Other sources of data include the Agricultural Letter of the Federal Reserve Bank of Chicago (various issues), the Agricultural Finance Databook of the Federal Reserve System (various issues), and from the U.S. Department of Commerce, the Consumer Price Index: Detailed Report, Survey of Current Business, and Employment and Earnings (various issues).

The data for the livestock models include 80 quarterly observations, 1967 through 1986. Single-equation estimation procedures are used in the supply block of the four livestock models. Single-equation estimation also is employed in the price equations for feeder cattle and slaughter steers, retail-farm margin, and cold-storage stock equations in the beef model, and for retail-farm margin, and cold storage stock equations in the pork model. The methods used for these equations are nonlinear least squares, restricted least squares, and generalized least squares. Parameters for the heifers added and cow slaughter equations use Almon lag estimation techniques to deal with the collinearity and resulting imprecision (Johnston 1984). The retail demand equations are estimated within a demand system that includes equations for per capita consumption of beef, pork, chicken, and turkey. In the demand block, iterative seemingly unrelated regression is used to generate estimates that asymptotically approach the maximum likelihood estimates. Supply and demand elasticities estimated from the livestock models are presented in Tables 1 and 2.

Domestic Crops Models

The supply, use, and price data for all the commodities come from various issues of USDA Agricultural Statistics. Policy variables (target prices, loan rates, and participation rates) were collected from fact sheets published by the Agricultural Stabilization and Conservation Service (ASCS). The domestic macroeconomic variables such as inflation, income, exchange rates, and population are from publications and databases prepared by the Wharton Econometric Forecasting Association (WEFA).

The supply specifications for the domestic crops models use annual data from 1966 to 1986, and the demand specifications use data from 1965 to 1985. The estimation method employed is ordirary least squares. All supply and demand equations are estimated in quantity-dependent form. Key elasticities from the domestic crops models are presented in Table 3.

Trade Models

The data sources and estimation methods for the domestic components of the trade models are the same as for the domestic crop models. Supply and use data for foreign countries come from the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture. The data derive from FAS tapes and the following circulars: World Grain Outlook and Situation Report (several issues) and Oil Seed and Products Outlook (several issues). Prices are from the Food and Agricultural Organization of the United Nations (FAO), Canada Grain Trade Statistics (various years), Agriculture Canada's Feed and Agriculture Regional Model, Quarter Forecast (FARM) publication, and EC Grains, Oilseeds, and Livestock: Selected Statistics, 1960-80 (USDA, ERS, Statistical Bulletin No. 703, 1983). Macroeconomic data are from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Macroeconomic data for Taiwan come from the Statistical Data Book 1987 by the Council for Economic Planning and Development, Republic of China.

The period used for the estimation of the trade models generally ranges from 1965 to 1986; however, some equations have shorter time periods because of unavailability of data. Ordinary least squares was used for the estimation in all cases. Elasticity estimates from the trade models are reported in Appendix Tables A.1-A.7.

Applications and Uses of the Model

This section discusses the applicability of the FAPRI modeling systems to policy analysis. The general experience in operating the models and in applying the system also is described.

The FAPRI models are flexible; they function in an environment highly interactive with policy analysis, but they are also capable of being operated independently. SAS and AREMOS--an econometric package developed by the WEFA Group--are generally used for estimation and applications of the system. Most simulation analyses are conducted on microcomputers using LOTUS 1-2-3, thereby allowing analysts to examine the interactions among model components and the changes occurring in each variable during the iterative process. In general, at least five analysts operate various components of the system during the process of policy or projection analysis.

The FAPRI models have been used extensively to examine impacts of domestic and foreign farm policies; trade policies; and macroeconomic, climatic, and other exogenous shocks. Domestic farm policy scenarios evaluated with the models have ranged from restrictive mandatory supply control programs to complete eliminations of domestic farm programs in the United States and other major trading countries. Trade policies examined by using the models range from export subsidy and tariff analyses to multilateral trade liberalization. The impacts of changes in macroeconomic variables such as income growth, inflation rate, and exchange rate--as well as of exogenous shocks such as yield changes--have been evaluated routinely with these models.

A major annual use of the models is to generate ten-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 for analyzing policy impacts and for communicating the empirical content of the modeling system to those who use the results. The baseline is also important to the operating mode for the system in that the microcomputer spreadsheets are calibrated to it. This operational mode has been a key to the timely production of policy analysis and to the training of policy analysts.

Requests for policy research have come from both houses of the U.S. Congress, the National Governors' Association, the National Association of State Legislators, the U.S. Department of Agriculture, the U.S. Agency for International Development, Agriculture Canada, the Commission of the European Communities, and national farm organizations. Among these are the National Corn Growers Association, the National Association of Wheat Growers, the National Cattlemen's Association, the National Pork

Producers' Council, the America Farm Bureau, and the American Soybean Association.

Appendix

Table A.1. Summary of estimated production elasticities from the feed-grains trade model

Country/ Region	Corn Price	Sorghum Price	Barley Price	Wheat Price	Soybean Price	Rapeseed Price	Wool Price
	Elasticity with respect to						
United States							
Corn[a]	0.10				0.03		
Sorghum[a]		0.27					
Barley[a]			0.31	-0.36			
Canada							
Barley			0.47			-0.25	
Corn	0.19				-0.17		
Australia							
Barley			0.60	-0.46			-0.20
Sorghum		0.50	-0.40	-0.35			
Argentina							
Sorghum		0.92		-0.67			
Corn	0.36				-0.21		
Thailand							
Corn	0.16	-0.14					
S. Africa							
Corn	0.05						
Sorghum		0.96		-0.82			
EC-12							
Corn	0.14						
Barley			0.08				
India							
Sorghum		0.11		-0.18			
HIEA[b]							
Feed grains	0.27						
Other Asia							
Feed grains	0.81						
Brazil							
Feed grains	0.29			-0.28	-0.02		
Mexico							
Feed grains	0.09						
Sorghum		0.67		-0.80			
Other Latin America							
Feed grains	0.37			-0.22			
Egypt							
Corn	0.11			-0.08			
Nigeria							
Sorghum	-0.57	0.57					

Table A.1. Continued

Country/ Region	Corn Price	Sorghum Price	Barley Price	Wheat Price	Soybean Price	Rapeseed Price	Wool Price
	-----	-----	-----	Elasticity with respect to	-----	-----	-----
Other Africa							
Feed grains	0.03						
ROW[c]							
Feed grains	0.16				-0.16		
Sorghum		0.15					

NOTE: Feed grains includes corn, barley, and oats. Elasticities are evaluated at 1982-84 mean values.

[a]1987 elasticities.

[b]High-income East Asia.

[c]Differing sets of countries were used in determining feed grains and sorghum production.

Table A.2. Summary of estimated domestic demand elasticities from the feed-grains trade model

Country/ Region	Corn Price	Sorghum Price	Barley Price	Soymeal Price	Wheat Price	Income
	Elasticity with respect to					
United States						
Corn food	-0.16				0.09	1.54
Corn feed	-0.27			0.06	0.05	
Corn stock	-0.60					
Sorghum feed	0.54	-1.51			0.49	
Sorghum stock		-1.35				
Barley non-feed use[a]			-0.01			0.09
Barley feed use[a]			-0.38		-0.16	
Barley stocks[a]			-0.36			
Canada						
Barley use			-0.12	0.11		0.40
Corn Use	-0.56		0.37	0.17		0.80
Australia						
Barley total use			-1.27		0.66	0.38
Sorghum total use			-1.51			
Argentina						
Corn total use	-0.31	0.44				0.18
Sorghum total use	1.79	-2.56				0.31
Thailand						
Corn feed use	-0.13					1.92
South Africa						
Corn total use	-0.37					0.29
Sorghum total use		-0.30				0.95
EC-12						
Corn total use	-0.27			0.09		0.58
Barley feed			-0.17			0.26
Barley food			-0.27			0.76
USSR						
Feed grains total use	-0.07					0.22
E. Europe						
Total feed grains						0.11

Table A.2. Continued

Country/ Region	Corn Price	Sorghum Price	Barley Price	Soymeal Price	Wheat Price	Income
	----------------------Elasticity with respect to---------------					
China						
Total feed grains use						0.01
Japan						
Corn	-0.26			0.16		0.98
Sorghum	0.48	-0.43				0.67
HIEA[b]						
Feed grains total use	-0.09					0.99
Other Asia						
Total feed grains use	-0.01					0.17
Brazil						
Total feed grains use	-0.13					0.49
Mexico						
Sorghum		-0.60				0.87
Total feed grains use	-0.28				0.28	0.36
Other Latin America						
Feed grains imports	-0.88			0.07	0.72	2.09
Egypt						
Total corn use						0.46
Saudi Arabia						
Total barley use						0.65
Other Africa						
Total feed grains use						0.22
ROW[c]						
Feed grains total use			-0.48		0.22	0.68
Sorghum total use	0.34	-0.27		0.02		0.22

NOTE: Elasticities are evaluated at 1982-84 mean values.

[a]1987 elasticity.

[b]High-income East Asia.

[c]Differing sets of countries were used in determining feed grains and sorghum demand.

Table A.3. Key price transmission elasticities of feed-grains prices with respect to U.S. feed-grains prices

Country/ Region	U.S. Corn Price	U.S. Barley Price	U.S. Sorghum Price
Canada			
Barley		0.87	
Corn	0.93		
Australia			
Barley		1.05	
Sorghum			1.07
Argentina			
Corn	0.62		
Sorghum			0.44
Thailand			
Corn	1.01		
South Africa			
Corn	1.26		
Sorghum			0.83
Japan			
Corn	0.94		
Brazil			
Corn	0.52		
Mexico			
Corn	0.16		
Sorghum			0.42
Egypt			
Corn	0.70		

NOTE: Elasticities are evaluated based on 1982-84 mean values.

Table A.4. Summary of estimated domestic supply and demand elasticities from the wheat trade model

Country/ Region	Wheat Price	Barley Price	Sorghum Price	Corn Price	Soybean Price	Rapeseed Price	Thailand Rice Price	Income
	Elasticity with respect to							
United States								
Production[a]	0.28							
Food demand	-0.03							0.28
Feed demand	-1.28			0.79				
Stock demand	-0.88							
Canada								
Production	0.60	-0.40						
Food demand	-0.03					-0.20		
Feed demand	-0.60	0.22						0.32
Australia								
Production	0.18		-0.10					
Exports	0.98							
Argentina								
Producton	0.48		-0.27					
Exports	0.17							
EC-12								
Production	0.19							
Feed demand	-1.32			1.19				0.97
Food demand	-0.07							0.05
Other Western Europe								
Import demand	-0.43							
USSR								
Import demand	-0.79							
Eastern Europe								
Total use								0.09
China								
Production	0.01[b]							
Total use								0.24
Japan								
Total use	-0.12							0.22
India								
Production	0.25		-0.10					
Total demand	-0.38							0.76
HIEA[c]								
Import demand	-0.17							0.57

Table A.4. Continued

Country/ Region	Wheat Price	Barley Price	Sorghum Price	Corn Price	Soybean Price	Rapeseed Price	Thailand Rice Price	Income
			Elasticity with respect to					
Other Asia								
Production	0.06						-0.04	
Total demand	-0.12						0.12	0.66
Brazil								
Production	0.72			-0.49				
Total demand	-0.50							0.59
Mexico								
Production	0.19		-0.11					
Total demand	-0.16			0.10				0.95
Other Latin America								
Production	0.35				-0.31			
Total demand	-0.11			0.15				0.61
Algeria								
Production	0.07							
Total demand	-0.29							0.55
Egypt								
Production	0.15							
Total demand								0.72
Morocco								
Production	0.06			-0.06				
Total demand	-0.44							0.81
Tunisia								
Production	0.09							
Imports	-0.17							1.63
Other Africa								
Production	0.03							
Total demand								0.46

NOTE: Elasticities are evaluated at 1982-84 mean values.

[a]1987 elasticities.

[b]Elasticity with respect to aggregate grain and wheat price, of which wheat price is a component.

[c]High-income East Asia.

Table A.5. Key price transmission elasticities of wheat prices of other regions with respect to U.S. Gulf port wheat price

Country/Region	Elasticity
Canada	
Wheat export price	1.06
Australia	
Wheat export price	0.98
Argentina	
Wheat farm price	0.43
EC-12	
Wheat intervention price	0.02
Japan	
Wheat resale price	0.28
India	
Wheat farm price	0.29
Brazil	
Wheat farm price	0.10
Algeria	
Wheat farm price	0.57
Egypt	
Wheat farm price	0.30
Morocco	
Wheat farm price	0.28

NOTE: Elasticities are evaluated at 1982-84 mean value.

Table A.6. Summary of estimated supply and demand elasticities from the soybean trade model

Country/ Region	Elasticity with respect to—					
	Soybean Price	Soymeal Price	Soy oil Price	Crushing Margin	Corn Price	Income
United States						
Production[a]	0.29				-0.08	
Soybean crush				0.59		
Soybean stocks	-0.65					
Soymeal demand		-0.18			0.05	
Soy oil demand			-0.11			0.58
Soy oil stocks			-0.24			
Brazil						
Production	0.20					
Soybean crush				0.04		
Soymeal demand		-0.11			0.91	0.50
Soy oil demand			-0.10			1.48
Argentina						
Production	0.49					
Soybean crush				0.01		
Soymeal exports						-1.26
Soy oil exports						-0.69
China						
Production	0.12[b]					
Soybean demand						0.12
EC-12						
Soybean crush				0.05		
Soymeal demand		-0.12			0.17	0.67
Soy oil demand			-0.13			1.78
USSR						
Soymeal demand						2.51
Soy oil imports			-1.76			3.48
Eastern Europe						
Production	0.47					
Soybean crush				0.71		
Soymeal demand						1.43
Soy oil demand						1.06
Japan						
Production	0.41					
Soybean crush				0.06		
Soybean food	-0.05					0.25
Soymeal demand		-0.12				0.45
Soy oil demand			-0.07			0.77

Table A.6. Continued

Country/ Region	Soybean Price	Soymeal Price	Soy oil Price	Crushing Margin	Corn Price	Income
	---Elasticity with respect to---					
S. Korea						
Production	0.25					
Soybean crush				0.14		
Soybean food	-0.24					0.52
Soymeal demand		-0.83				1.09
Soy oil demand			-0.84			1.44
Taiwan						
Production	0.20					
Soybean crush				0.21		
Soybean food	-0.06					0.29
Soymeal demand		-0.22				0.75
Soy oil demand			-0.56			0.62
Mexico						
Production	0.61					
Soybean crush				0.43		
Soymeal demand		-0.28				1.95
Soy oil demand			-0.20			1.94
ROW						
Production	0.19					
Soybean crush				0.01		
Soymeal demand		-0.34				1.44
Soy oil demand			-0.26			1.16

NOTE: Elasticities are evaluated at 1982-84 mean values.

[a]1987 elasticities.

[b]Grain and oilseed aggregated price, of which soybean is part.

Table A.7. Price transmission elasticities of soybean, soymeal, and soy oil prices of other regions with respect to U.S. prices

Country/Region	Soybean Price	Soymeal Price	Soy oil Price
Brazil	1.11	1.00	1.00
Argentina	0.18	0.90	1.02
EC-12	0.90	0.90	1.02
Eastern Europe	0.94	0.94	1.04
Japan	0.95	0.72	0.57
S. Korea	1.36	1.09	0.82
Taiwan	0.50	1.18	0.51
Mexico	0.36	0.30	1.00
ROW	1.00	1.00	1.00

NOTE: Elasticities are evaluated at 1982-84 mean values.

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