

The World Wheat Trade Model: Specification, Estimation, and Validation

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Introduction

The wheat trade model is one of the three models in the trade modeling system developed, updated, and maintained by the Center for Agricultural and Rural Development (CARD). The other two commodity trade models are for feed grains and the soybeans complex. The three trade models are linked through cross-price linkages in the supply and demand components of these models, yet each model can be solved on a stand-alone basis. 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 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 a ten-year period. 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 those involving 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, Commission of the European Communities, and farm organizations including the National Corn Growers Association, the Iowa Corn Promotion Board, and the Iowa Soybean Promotion Board.

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

Modeling Approach

The purpose of this section is to describe the structure of the wheat model, and to explain country and regional disaggregation.

Structure and Components of the Model

A general description of the structure and country/regional disaggregation of the model is presented here. The overall structure of the model is based on the dissertation research of Mahama (1985). Other studies which were used in the development of the regional model are

Spriggs (1978, 1981) and Bailey (1987, 1989). The wheat trade model is a nonspatial partial equilibrium model: nonspatial because it does not identify trade flows between specific regions, and partial equilibrium because only one commodity is modeled.

Figure 1 illustrates the structural components of the wheat trade model. The model 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 bilateral exchange rates and transfer service margins. Where some degree of insulation of domestic prices from external market conditions exists, the free adjustment of trade flows is restricted. The price linkage equation defines the degree of price transmission of external market conditions into the internal system. Trade occurs whether price transmission is allowed or not. 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 supplied in the world market at various price levels. 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 derived as the difference between the

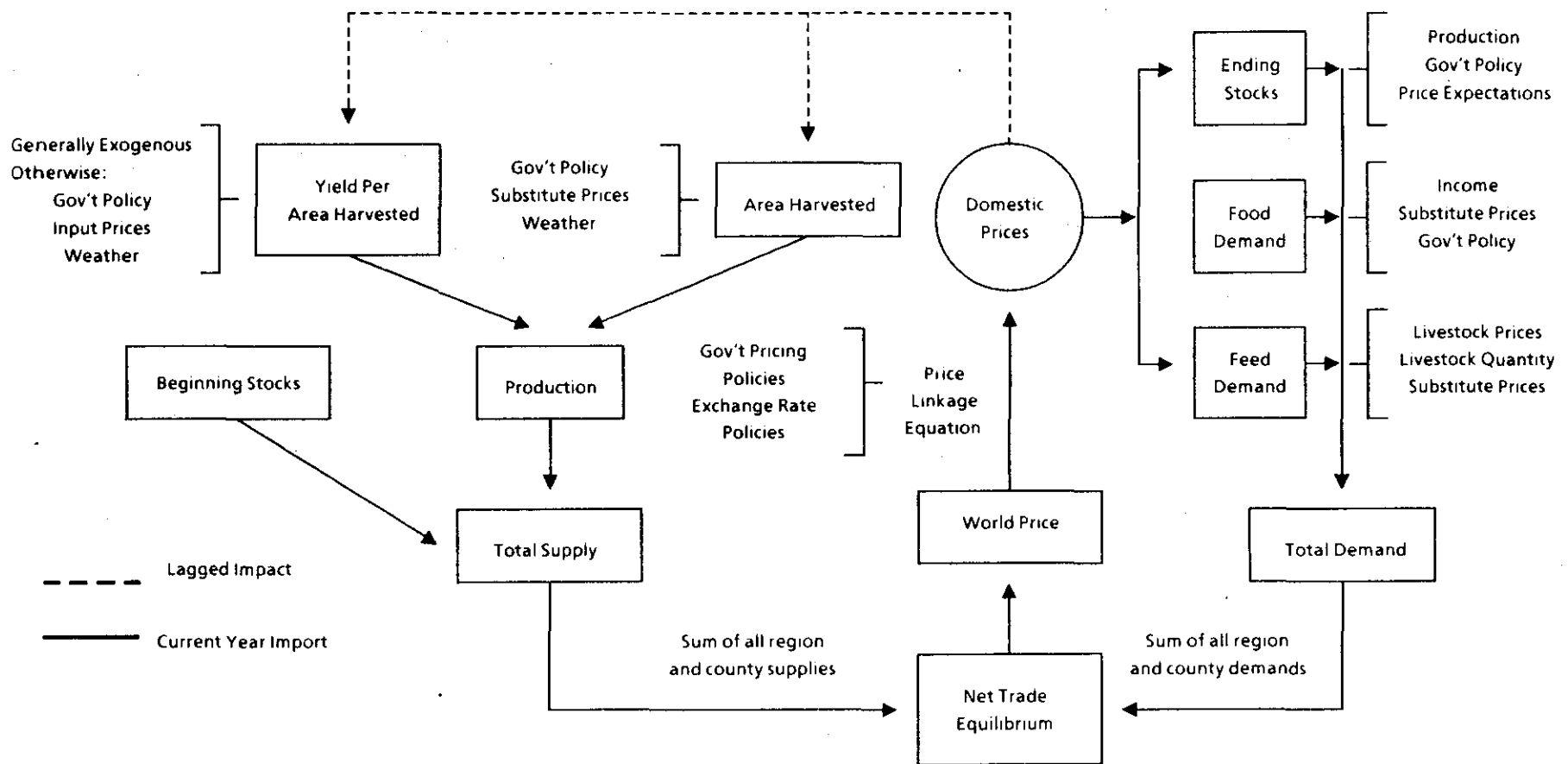


Figure 1. General representation of the structure of the world wheat trade model

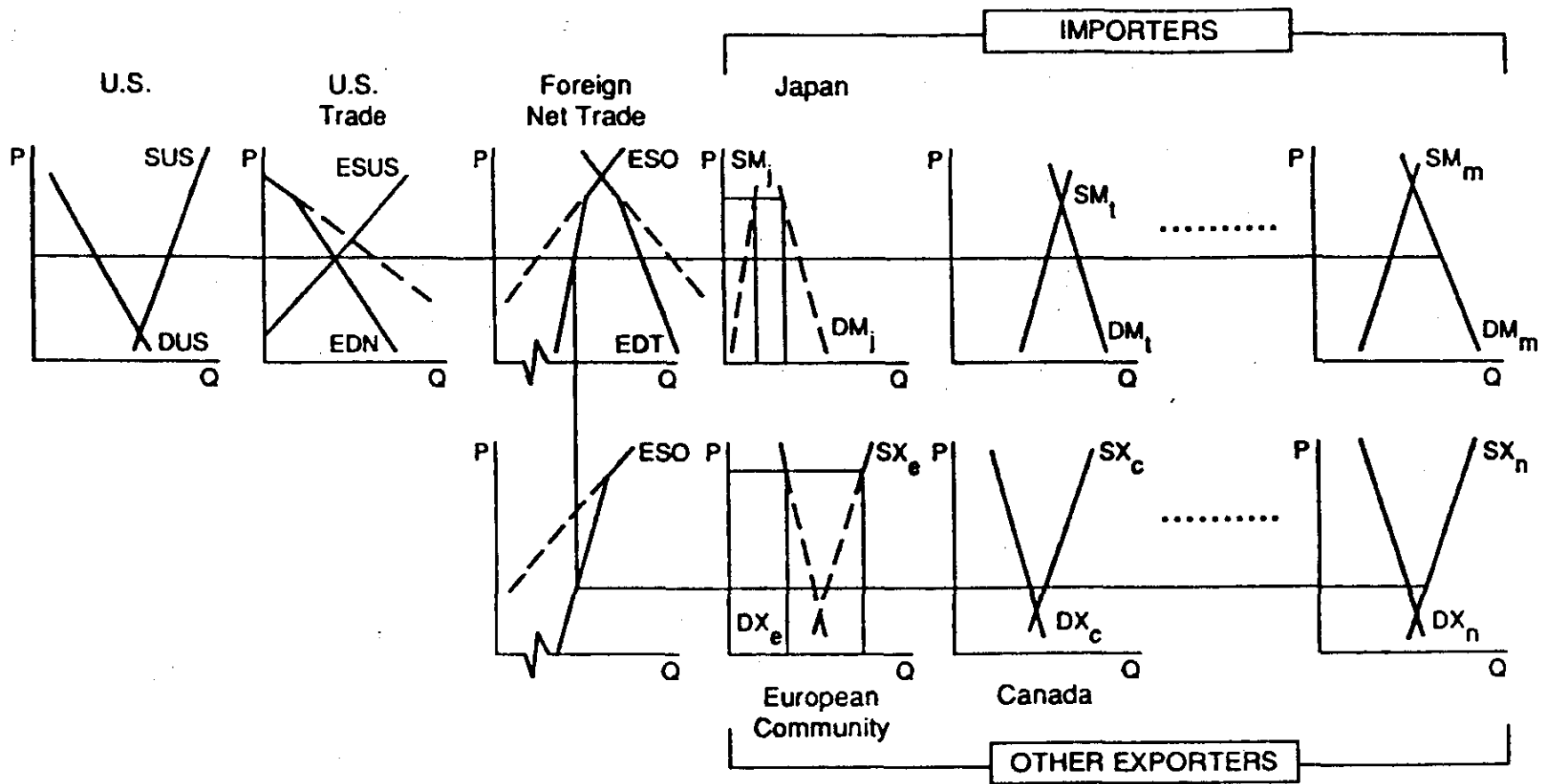


Figure 2. Determination of equilibrium prices and quantities in the CARD/FAPRI agricultural trade models

supply and demand of 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 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 competitors. The kinked and less elastic nature of the EDN is due to the restrictive trade policies pursued by some foreign countries, which insulate domestic prices from world price variability. A trade equilibrium is allowed by the clearing of excess demands and supplies generated within each region.

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

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

$i = 1, \dots, m$ importers;

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

$j = 1, \dots, n$ exporters;

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

U.S. excess supply;

$$ESUS = EDN = EDT - ESO,$$

world market equilibrium;

$$PD_i = G_i(P_u * e_i, Z_i),$$

$i = 1, \dots, m$ importers; and

$$PD_j = G_j(P_u * e_j, Z_j),$$

$j = 1, \dots, n$ exporters,

where

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

The countries and regions included in the study are the United States, Canada, Australia, Argentina, the European Community (EC-12), India, Japan, China, the USSR, Eastern Europe, Africa and the Middle East, high-income East Asian countries, other Asian countries, and other Western European countries.

Specification and Estimation

The previous sections have provided an overview of the current literature, structure of the model, and country and regional disaggregation. This section includes theoretical foundations for the

estimation of structural specification, estimation methods, data sources, and estimated equations.

Theoretical Foundations

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

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

Area Harvested,

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

Production,

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

Supply,

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

where area harvested ($AH_{i,t}$) is expressed as a function of the lagged domestic supply price of wheat ($PS_{i,t-1}$), lagged domestic price of competing crops ($PC_{i,t-1}$), government policy variable ($GP_{i,t}$), a vector of other variables that affect the acreage planted (Z_{it}). Wheat production ($PROD_{i,t}$) is equal to acreage harvested times wheat yield ($YLD_{i,t}$).

Finally, wheat supply is equal to production plus imports ($IM_{i,t}$) plus beginning stocks ($BS_{i,t}$).

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

Per capita food demand,

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

Total food demand,

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

Feed Demand,

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

Ending stocks,

$$SD_{i,t} = SD(PD_{i,t}, PROD_{i,t}, GS_{i,t}), 24v$$

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

The detailed theoretical specifications for the U.S. wheat market are discussed below.

Acreage response and supply. The estimation of the supply response to changing government commodity programs has been problematic due to the frequent adjustments made in the composition of the commodity programs, as well as changes in their underlying payment structures and acreage reduction options. The most common approach used to incorporate the influence of commodity programs is the inclusion of effective support

payment and diversion payment variables as explanatory variables in the area-planted equations, as exemplified by Houck and Ryan (1972). However, as de Gorter and Paddock (1985) note, 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 wheat supply response includes endogenous participation rates. The participation rate ([program planted and idled]/base acreage) in the model is expressed as a function of the difference between participant expected net returns (PARTENR) and nonparticipant expected net returns (NPARTENR):

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

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

Participant expected net returns (PARTENR) per acre are derived from deficiency payments, diversion payments, cash receipts from marketings, and variable cost of production and cost of maintaining idled land. The arithmetic representation of PARTENR is given by

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

The first component of the right hand side of equation (2) is expected deficiency payments. The variables that enter 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 second term is expected diversion payments, where DPR is diversion payment rate. The third component 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 wheat production per acre. The final component indicates that \$20 is expected to be spent in maintaining the land idled under acreage reduction program and paid land diversion.

Nonparticipant expected net returns are defined as

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

where the variable definitions are as given in the above two equations.

Area planted under programs (APP) is given by the identity

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

where BA is the base average.

The total land idled (IA) under the acreage reduction program and the paid land diversion program is given by the identity

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

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

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

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

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

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

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

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

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

Area harvested is defined as the identity

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

Wheat yield per acre (WY) 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 as higher target prices are assumed to induce more 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 given by:

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

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

$$WPROD = AH * WY. \quad (11)$$

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

Wheat supply is the sum of production, beginning stocks (WBI), and exogenous imports (WIM). Thus, the wheat supply identity is given by

$$WS = WPROD + WBI + WIM. \quad (12)$$

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 on the consumer theory of utility maximization subject to budget constraint. Solution of the utility maximization yields consumer demand as a function of own price, cross prices, and income. However, the restrictions (homogeneity, symmetry, cournot aggregation, and angel aggregation) derived from the demand theory are not imposed in the

estimation. The functional form of the per capita food demand (WFOOD) is given by

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

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

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

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

$$WSEED = f(AP, T). \quad (15)$$

Stocks. Total wheat inventories (WEI) are further disaggregated into Commodity Credit Corporation (CCC) inventories, Farmer-Owned Reserve (FOR)

stocks, nine-month loan program carryover, and "free" stocks unencumbered by any government program. CCC, 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 transactions motives of inventory demand theory. The speculative motive indicates that the amount of grain stored at any 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. Further, it is assumed that commercial stock holders base their expectations of future prices on 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 (WSTOCK) is specified as

$$WSTOCK = f(P_{own}, WPROD, EWPROD, GSTOCK, X_{STOCK}), \quad (16)$$

where WPROD is current wheat production, EWPROD is expected wheat 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. Wheat exports are determined as residuals:

$$WEX = WPROD + WBI + WIM - WFOOD - WFEED - WSEED - WEI.$$

The above specification of wheat demand is based on 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 on income and the available supplies mainly from production; that is,

$$QD = f(QP_t, Y_t). \quad (17)$$

A linear specification of this demand function is

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

Import demand as a residual of demand and supply becomes

$$QM_t = QD_t - QP_t.$$

Because of the lack of sufficient data for the aggregate regions--Africa and the Middle East, high-income East Asia, other Asia, and other Western Europe--only net import equations are estimated. The general specification of import demand equations for these regions are as follows:

$$QM_{t,j} = QM(Y_j, P), \quad (19)$$

where

- $QM_{t,j}$ = imports,
- Y = income, and
- P = world wheat price.

Data Sources

The data used for the analyses include wheat-use and supply-quantity data obtained from the Foreign Agricultural Service of the USDA. Macroeconomic data such as incomes, exchange rates, and inflation are obtained from the International Monetary Fund (IMF). All macroeconomic data has been converted to the appropriate crop year basis for each country or regional component. For example, a calendar year macro variable is converted to July-June crop year basis by taking a weighted average of its July to December values of the first year and January to June values of the second year. The weights are 0.5 for both the first six months and the second six months. Most of the wheat price data were derived from the Food and Agricultural Organization (FAO) price statistics. Additional price information on the United States, Canada, Australia, and the EC was obtained from the USDA Agricultural Statistics (various years), Canada Grain Trade Statistics (various years), Yearbook of the Commonwealth of Australia (various years), Herlihy et al. (1983), and The Agricultural Situation in the Community (various years).

Empirical Results

The estimated equations for the various submodels are given in this section. Reasons for the inclusion of relevant variables in an equation, the sign, and the significance of the estimated coefficients are discussed.

United States Wheat Submodel

The U.S. component of the wheat model is reported in Table 1. The estimated results are satisfactory with anticipated signs and mostly high

Table 1. Structural parameter estimates of the U.S. wheat submodel

(1.1) Wheat Program Participation Rate (Next Year)

$$\begin{aligned}
 \text{USWHEPRF} &= 0.611 + 2.055 * [\text{USWHEPNRF} \\
 &\quad (9.77) \quad (3.16) \\
 &\quad - (\text{USWHEPF} * \text{USWHEYDTF} - \text{USWHEVCF}) / \text{USPWJM} \\
 &\quad - 0.619 * \text{DM173} - 0.619 * \text{DM174} \\
 &\quad (-4.44) \quad (-4.45) \\
 &\quad - 0.618 * \text{DM175} - 0.617 * \text{DM176} \\
 &\quad (-4.44) \quad (-4.42) \\
 &\quad - 0.614 * \text{DM179} - 0.599 * \text{DM180} \\
 &\quad (-4.39) \quad (-4.22) \\
 R^2 &= 0.93 \quad \quad \quad \text{DW} = 1.09
 \end{aligned}$$

(1.2) Wheat Nonprogram Acreage (Next Year)

$$\begin{aligned}
 \text{USWHENPF} &= 48.798 - 0.893 * \text{USWHEPRF} * \text{USWHEBAF} \\
 &\quad (11.11) \quad (-16.71) \\
 &\quad \quad \quad [- 0.72] \\
 &\quad + 15.580 * (\text{USWHEPF} * \text{USWHEYDTF} - \text{USWHEVCF}) / \text{USPWJM} \\
 &\quad (1.51) \\
 &\quad [0.09] \\
 &\quad + 2.036 * \text{TRND6683} + 14.987 * \text{DM182} \\
 &\quad (11.40) \quad (3.12) \\
 R^2 &= 0.98 \quad \quad \quad \text{DW} = 1.34
 \end{aligned}$$

(1.3) Wheat Area Planted (Next Year)

$$\text{USWHEAPF} = \text{USWHENPF} + \text{USWHEPRF} * \text{USWHEBAF} * \text{USWHEPLRF}$$

(1.4) Percentage of Wheat Planted Area That is Harvested (Next Year)

$$\begin{aligned}
 \text{USWHEPHF} &= 0.850 + 2.696 * \text{USWHEPF} / \text{USPWJM} \\
 &\quad (60.98) \quad (3.08) \\
 &\quad \quad \quad [0.04] \\
 &\quad - 0.032 * \text{DM182} - 0.046 * \text{DM182} \\
 &\quad (-2.94) \quad (-2.47) \\
 R^2 &= 0.78 \quad \quad \quad \text{DW} = 2.04
 \end{aligned}$$

Table 1. Continued

(1.10) Food Use Per Capita

$$\begin{aligned}
 \text{USWHEFPC} &= 1.965 - 5.289 * \text{USWHEPF/USPWJM} \\
 &\quad (10.72) \quad (-2.97) \\
 &\quad \quad \quad [-0.03] \\
 &+ 0.356 * \text{LOG(USCE/USNPT)} - 0.090 * \text{DM17072} \\
 &\quad (4.26) \quad \quad \quad (-4.00) \\
 &\quad [0.13] \\
 &+ 0.127 * \text{DM175} + 0.120 * \text{DM1852S86} \\
 &\quad (3.71) \quad \quad \quad (6.52) \\
 R^2 &= 0.94 \quad \quad \quad \text{DW} = 1.89
 \end{aligned}$$

(1.11) Food Use

$$\text{USWHEFO} = \text{USWHEFPC} * \text{USNPT}$$

(1.12) Seed Use

$$\begin{aligned}
 \text{USWHESD} &= -917.841 + 1.324 * \text{USWHEAPF} + 0.461 * \text{TREND} \\
 &\quad (-6.66) \quad (38.86) \quad \quad \quad (6.52) \\
 &\quad \quad \quad [1.08] \\
 R^2 &= 0.997 \quad \quad \quad \text{DW} = 1.31
 \end{aligned}$$

(1.13) Free Stock

$$\begin{aligned}
 \text{USWHEFRE} &= 445.249 - 19004.800 * \text{USWHEPF/USPWJM} \\
 &\quad (2.76) \quad \quad \quad (-2.50) \\
 &\quad \quad \quad [-0.88] \\
 &+ 0.434 * \text{USWHEQP} - 0.177 * \text{USWHEQPF} \\
 &\quad (3.24) \quad \quad \quad (-1.45) \\
 &\quad [2.82] \quad \quad \quad [-1.17] \\
 &- 0.546 * (\text{USWHECCC} + \text{USWHEFOR} + \text{USWHELON}) \\
 &\quad (-6.07) \\
 &\quad [-1.21] \\
 R^2 &= 0.76 \quad \quad \quad \text{DW} = 1.15
 \end{aligned}$$

Table 1. Continued

(1.14) Wheat Ending Stocks

$$USWHEES = USWHEFRE + USWHELON + USWHECCC + USWHEFOR$$

(1.15) Wheat Gulf Port (Export) Price (Nominal)

$$WHPGPU90 = 5.735 + 43.206 * USWHEPF - 18.447 * D174$$

(1.29) (28.01) (-2.57)
[0.96]

$$R^2 = 0.98$$

$$DW = 1.46$$

(1.16) Net Export

$$USWHESMN = USWHEQP + LAG(USWHEES)$$

$$- USWHEFE - USWHEFO - USWHESD - USWHEES$$

(1.17) World Wheat Market Clearing Condition

$$USWHESMN/36.7437 + WHUXNCA - WHSMNAU - WHSMNAR/1000$$

$$- WHSMNE2/1000 = WHSMNIN + NETMJP + WHSMNSU$$

$$+ WHSMNE8 + WHSMNCN + WHSMNF1 + WHSMNOAS$$

$$+ WHSMNR4 + WHSMNOWE + WHSMNRW$$

Endogenous Variables

NETMJP	= Japan, Wheat Net Imports (mil. MT)
RGULFUS	= Real Wheat Gulf Port Prices (1975 dollars/MT)
USWHEAHF	= U.S., Wheat Area Harvested, next year (mil. ac.)
USWHEAPF	= U.S., Wheat Area Planted, next year (mil. ac.)
USWHEES	= U.S., Wheat Ending Stock (mil. MT)
USWHEFE	= U.S., Wheat Feed Use (mil. bu.)
USWHEFO	= U.S., Wheat Food Use (mil. bu.)
USWHEFPC	= U.S., Wheat Use Per Capita (bu./cap.)
USWHEFRE	= U.S., Wheat Free Stocks (mil. bu.)
USWHENPF	= U.S., Wheat Nonprogram Planted Area, next year (mil. ac.)
USWHEPF	= U.S., Wheat Market Price (US \$/bu.)

Table 1. Continued

USWHEPHF	= U.S., Wheat, Proportion of Planted Area that is Harvested, next year (%)
USWHEPRF	= U.S., Wheat, Participation Rate, next year (%)
USWHEQP	= U.S., Wheat Production (mil. bu.)
USWHEQPF	= U.S., Wheat Production, next year (mil. bu.)
USWHESD	= U.S., Wheat Seed Use (mil. bu.)
USWHESMN	= U.S., Wheat Exports (mil. bu.)
USWHEYDF	= U.S., Wheat Yield, next year (bu./ac.)
WHPGPU90	= U.S., Wheat Export Price, fob Gulf Port (US \$/MT)

Exogenous Variables

WHSMNAR	= Argentina, Wheat Net Exports (1000 MT)
WHSMNAU	= Australia, Wheat Net Exports (MMT)
WHSMN CN	= China, Wheat Net Imports (MMT)
WHSMNE2	= EEC, Wheat Net Exports (1000 MT)
WHSMNE8	= E. Europe, Wheat Net Imports (MMT)
WHSMNF1	= Africa, Wheat Net Imports (1000 MT)
WHSMNIN	= India, Wheat Net Imports (MMT)
WHSMNOAS	= Other Asia, Wheat Net Imports (1000 MT)
WHSMNOWE	= Other W. Europe, Wheat Net Imports (1000 MT)
WHSMNR4	= High-Income E. Asia, Wheat Net Imports (1000 MT)
WHSMNSU	= USSR, Wheat Net Imports (MMT)
WHUXNCA	= Canada, Wheat Net Exports (mil. MT)
DM173	= Dummy Variable: 1 in 1973, 0 otherwise
DM174	= Dummy Variable: 1 in 1974, 0 otherwise
DM175	= Dummy Variable: 1 in 1975, 0 otherwise
DM176	= Dummy Variable: 1 in 1976, 0 otherwise
DM179	= Dummy Variable: 1 in 1979, 0 otherwise
DM180	= Dummy Variable: 1 in 1980, 0 otherwise
DM182	= Dummy Variable: 1 in 1982, 0 otherwise
DM17072	= Dummy Variable: 1 from 1970-72, 0 otherwise
DM18387	= Dummy Variable: 1 from 1983-87, 0 otherwise
DM1852S86	= Dummy Variable: 1 in 1985, 2 beginning in 1986, 0 otherwise
DM1S82	= Dummy Variable: 1 in 1982 and after, 0 otherwise
DMWHESD	= Dummy Variable: 1 when wheat yields are 1 standard deviation above trend yield, -1 when below, 0 otherwise
TREND	= Calendar Year
TRND6683	= Trend from 1966-83: 1 in 1966, ..., 18 in 1983 and after
USCATNF	= U.S., Cattle on Feed, 13 States, 3rd Quarter (mil.)
USCE	= U.S., Real Personal Consumption Expenditures (bil. 1982 dollars)
CPIUS	= U.S., Consumer Price Index (1975 = 100)
USCORPF	= U.S., Corn Market Price (US \$/bu.)
USGCAU	= U.S., Grain Consuming Animal Units, Crop Year Basis (million dairy cow equivalents)

Table 1. Continued

USNPT	= U.S., Population Including Overseas Armed Forces (mil.)
USPWJM	= U.S., Wholesale Producer Price Index, June-May Year (1967 = 100)
USWHEBAF	= U.S., Wheat Base Area, Adjusted for CRP, next year (mil. ac.)
USWHECCC	= U.S., Wheat CCC Stocks (mil. bu.)
USWHEFOR	= U.S., Wheat FOR Stocks, Including Special Storage (mil. bu.)
USWHEIT	= U.S., Wheat Imports (mil. MT)
USWHELON	= U.S., Wheat Nine-Month Loan Stocks (mil. bu.)
USWHEPLRF	= U.S., Percentage of Base Acres Participants Can Plant (%)
USWHEPNRF	= U.S., Expected Wheat Participant Net Returns, next year (US \$/ac.)
USWHEITGF	= U.S., Wheat Target Price, next year (US \$/bu.)
USWHEVCF	= U.S., Wheat Variable Costs (US \$/ac.)
USWHEYDTF	= U.S., Wheat Trend Yield, next year (bu./ac.)
WHSMNRW	= Rest of the World, Wheat Net Imports (mil. MT)

R-square values. The supply side is modeled by estimating the participation rate and nonparticipant acreage. Total wheat area planted is equal to nonparticipant planted area plus participant planted area, where the latter is equal to the participation rate times the wheat base area times percent of base acres participants can plant. Acreage harvested as percentage of acreage planted is determined endogenously. Wheat yield is endogenously estimated. Wheat production is determined as area harvested times yield.

The expected participation rate (Eq. 1.1) is estimated as a function of expected participant net returns minus nonparticipant 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 the participant and nonparticipant net returns--indicate that more farmers will participate in the government program if expected participant net returns are higher than expected nonparticipant net returns; that is, the program benefits are higher. The nonparticipant wheat acreage in the next year (Eq. 1.2) is estimated as a function of the base acres of participants times participation rate and the expected nonparticipant net return. The participant base acres has the coefficient -0.9, which indicates enrollment of an additional acre in the government program will reduce the nonprogram acres by less than one. As expected, the nonparticipant net returns have a positive effect on the wheat acreage planted by nonparticipants. The acreage harvested as percentage of acreage planted (Eq. 1.4) is estimated to reflect the impacts of weather factors and also wheat price changes. Wheat yield (Eq. 1.5) is endogenously

determined as a function of real target price, base acreage set aside by participants, trend, and a dummy variable. The coefficient of target price is positive with the elasticity of 0.1, which indicates a ten percent increase in the real target price will lead to one percent increase in the yield. The base acreage set aside by participants has a positive coefficient because farmers increase the use of other inputs on the base acreage planted to increase the per acre yield. The trend variable is included to reflect the technology. The dummy variable, DMWHESD, captures the weather effect on yield. It takes the value one when actual yields are more than one standard deviation from trend yield and minus one when actual yields are less than one standard deviation from trend yield.

On the demand side, wheat feed use, food use, seed use, and stock demand are estimated separately. The explanatory variables in the feed use equation (Eq. 1.9) include own (real wheat price) and cross (real corn price) prices. Since wheat is an input in the livestock sector, the number of cattle on feed plus grain-consuming animal units is also included in the equation to reflect the demand for wheat in livestock production. Estimated coefficients show that wheat and corn are substitutes. The calculated own price elasticities of feed use is -1.28. An increase in cattle on feed will significantly increase the wheat feed use. A dummy variable for the period 1983 to 1987 represents the unexpected increase in wheat feeding which occurred during that period.

Per capita food use (Eq. 1.10) is estimated, and the aggregate food use is the product of food use per capita and the population. The estimated results show that per capita wheat consumption has the expected

negative own-price effect with elasticity of -0.03 , and positive income elasticity of 0.28 . Wheat seed use is estimated as a function of acreage planted and time trend (Eq. 1.12).

The final component of wheat demand is the free stocks demand. The estimation is based on the stock demand specification in the previous section. The explanatory variables are the current farm price, current and expected production, and government stocks. Results show that the elasticity of current farm price is -0.88 , and the free stock level is very sensitive to changes in wheat production. The coefficient of -0.546 on FOR, CCC, and nine-month loan stocks indicates that a one-bushel increase in these stocks will reduce the free stocks by about one-half bushel.

In addition to the above equations, a price linkage equation (Eq. 1.15) linking the export (Gulf port) price to the domestic wheat farm price is estimated. In Equation 1.13 the world wheat market is cleared by equating world excess demand to U.S. exports which is the excess supply of the U.S. wheat market. The U.S. market is cleared at the price which equates U.S. supplies to U.S. domestic demand plus exports.

Canada Wheat Submodel

Federal government controls on the wheat industry of Canada make the choice of economic variables to model the industry rather difficult. The following description of the industry, particularly the marketing arrangements, is intended to highlight the special features of the Canadian wheat sector. The description is based largely upon Spriggs

(1981) and Bailey (1987). The estimated equations are reported in Table 2.

The marketing system is crucial to choosing the appropriate price variable of the area response function because it determines the returns to producers and their expectations of prices. Growers sell their grain either to the Canadian Wheat Board (CWB) for export or domestic food use or to the off-board market for feed use. If sold to the CWB, producers receive an initial payment, which may be adjusted later by a final payment to yield a realized price. All producers selling to the board receive the same price for the season, regardless of when they market the grain. The final price is based on the return from domestic and export sales. The CWB also operates a delivery quota system to spread deliveries evenly from harvest to harvest and thus to help prevent overloading the distribution system.

The off-board market is free and competitive and producers receive full payment for their grain on delivery. Wheat for food and industrial use is sold by the CWB to mills at the "mill price." Until 1979 the mill price was set independently of the market; since then the price has been set equal to the export price within a bounded range. Wheat for feed use is sold primarily through the off-board market. The CWB supplies wheat to the off-board market when prices in this market rise above U.S. feed prices. Thus the price of U.S. feed grains in Montreal acts as a ceiling for Canadian feed wheat prices.

Due to this segmentation of the Canadian wheat market, no single price can clearly represent what producers respond to in an aggregate area

Table 2. Continued

(2.5) Feed Use

$$\text{WHUFECA} = 0.370 - 0.013 * \text{WHPOBCA} + 0.034 * \text{CKPMKCA}$$

(0.81)	(-1.21)	(3.31)
	[-0.60]	[1.32]

$$+ 0.006 * \text{BAPOBCA1} - 0.007 * \text{LAG(WHGPICAE)}$$

(0.65)	(-1.82)
[0.22]	[-0.38]

$$+ 0.039 * \text{LAG(WHCOTCA)}$$

(2.35)
[219.63]

$$R^2 = 0.61 \qquad \qquad \qquad \text{DW} = 2.00$$

(2.6) Seed Use

$$\text{WHUSECA} = -0.005 + 0.092 * \text{WHAHHCAE}$$

(-0.15)	(33.83)
	[1.00]

$$R^2 = 0.99 \qquad \qquad \qquad \text{DW} = 1.74$$

(2.7) Stocks

$$\text{WHCOTCA} = 0.827 + 0.606 * \text{LAG(WHCOTCA)} - 0.021 * \text{WHPXECA}$$

(0.20)	(4.40)	(-1.75)
	[0.61]	[-0.25]

$$+ 0.327 * \text{WHSRCA} + 6.43 * (\text{D67} + \text{D68} + \text{D69})$$

(2.53)	(4.42)
[0.48]	

$$R^2 = 0.92 \qquad \qquad \qquad \text{DW} = 1.95$$

(2.8) Wheat Export Price

$$\text{WHPXECA} = -7.217 + 1.141 * (\text{WHPGPU90} * \text{NIMEUCA})$$

(-0.84)	(20.10)
	[1.06]

$$-32.772 * \text{D73}$$

(-2.30)

$$R^2 = 0.96 \qquad \qquad \qquad \text{DW} = 1.45$$

Table 2. Continued

(2.9) Wheat Expected Initial Price

$$\text{WHGPICAE} = 5.662 + 0.759 * \text{LAG}(\text{WHGPICAE}) + 0.167 * \text{WHPXECA}$$

(0.76)
(5.53)
(1.74)
[0.76]
[0.23]

$$-32.294 * \text{D85}$$

(-2.49)

$$R^2 = 0.94$$

$$\text{DW} = 1.90$$

(2.10) Wheat Off-Board Price

$$\text{WHPOBCA} = 71.785 + 0.271 * \text{LAG}(\text{WHGPICAE})$$

(3.48)
(2.38)
[0.31]

$$- 2.123 * [\text{LAG}(\text{WHCOTCO}) + \text{WHSRCA}]$$

(-3.58)
[-0.70]

$$+ 0.424 * \text{WHPXECA}$$

(4.93)
[0.67]

$$R^2 = 0.98$$

$$\text{DW} = 2.33$$

(2.11) Wheat Domestic Mill Price

$$\text{WHGPMCA} = \text{MAX} [183.72, \text{MIN} (257.12, \text{WHPXECA})]$$

(2.12) Barley Expected Initial Price

$$\text{BAGPICAE} = 6.045 + 0.438 * \text{LAG}(\text{BAGPICAE})$$

(0.79)
(2.20)
[0.44]

$$+ 16.218 * (\text{CORPF} * \text{NIMEUCA}) - 27.536 * \text{D85}$$

(2.66)
(-2.21)
[0.51]

$$R^2 = 0.86$$

$$\text{DW} = 1.83$$

Table 2. Continued

(2.13) Barley Off-Board Price

$$\text{BAPOBCA1} = -5.040 + 38.482 * (\text{BARPF} * \text{NIMEUCA})$$

(-0.91) (15.96)
[1.07]

$$R^2 = 0.94 \quad \text{DW} = 1.45$$

(2.14) Rapeseed Price

$$\text{RSPM1CA} = 55.981 + 45.907 * (\text{SOYPF} * \text{NIMEUCA})$$

(-4.35) (28.94)
[1.05]

$$+ 14.614 * (\text{SOPMKU9/SOMPM44D}) - 54.679 * \text{D80}$$

(4.13) (-3.45)
[0.18]

$$R^2 = 0.99 \quad \text{DW} = 1.94$$

(2.15) Average Producer Price of Chickens

$$\text{CKPMKCA} = 14.059 + 0.174 * \text{WHPOBCA} + 12.244 * (\text{CORPF} * \text{NIMEUCA})$$

(3.25) (1.66) (2.43)
[0.22] [0.38]

$$+ 0.95 * (\text{SOMPM44D} * \text{NIMEUCA}) + 11.751 * (\text{D84} + \text{D85})$$

(2.61) (2.35)
[0.21]

$$R^2 = 0.96 \quad \text{DW} = 1.88$$

(2.16) Net Exports

$$\text{WHUXNCA} = \text{WHSPRCA} + \text{LAG}(\text{WHCOTCA}) - \text{WHUHTCA} - \text{WHUFECA} - \text{WHUSECA}$$

- WHCOTCA

Endogenous Variables

BAGPICA E = Canada, Expected Barley CWB Initial Price (CAN \$/MT)
 BAPOBCA1 = Canada, Barley Off-Board Price (CAN \$/MT)
 CKPMKCA = Canada, Chicken Average Producer Price (CAN \$/kg.)

Table 2. Continued

RSPM1CA	= Canada, Canola, Rapeseed Export Price (CAN \$/MT)
WHAHHCA	= Canada, Wheat Area Harvested (ha.)
WHAHHCAE	= Canada, Expected Wheat Area Harvested (ha.)
WHCOTCA	= Canada, Wheat Inventories (mil. MT)
WHGPICAE	= Canada, Expected Wheat CWB Initial Price (CAN \$/MT)
WHGPMCA	= Canada, Wheat Domestic Mill Rate (CAN \$/MT)
WHPGPU90	= U.S., Wheat Export Price (US \$/MT)
WHPOBCA	= Canada, Wheat Off-Board Price (CAN \$/MT)
WHPXECA	= Canada, Wheat Export Unit Value (CAN \$/MT)
WHSPRCA	= Canada, Wheat Production (mil. MT)
WHUFECA	= Canada, Wheat Feed Use (mil. MT)
WHUHTCA	= Canada, Wheat Food Use (mil. MT)
WHUSECA	= Canada, Wheat Seed Use (mil. MT)
WHUXNCA	= Canada, Wheat Net Exports (mil. MT)

Exogenous Variables

BARPF	= U.S., Barley Farm Price (US \$/bu.)
CORPF	= U.S., Corn Farm Price (US \$/bu.)
D67	= Dummy Variable: 1 in 1967, 0 otherwise
D68	= Dummy Variable: 1 in 1968, 0 otherwise
D69	= Dummy Variable: 1 in 1969, 0 otherwise
D73	= Dummy Variable: 1 in 1973, 0 otherwise
D80	= Dummy Variable: 1 in 1980, 0 otherwise
D84	= Dummy Variable: 1 in 1984, 0 otherwise
D85	= Dummy Variable: 1 in 1985, 0 otherwise
NANPDCA	= Canada, Nominal GNP (bil. CAN \$)
NARDDCA	= Canada, GNP Deflator (1980 = 1.0)
NIMEUCA	= Canada, Exchange Rate (CAN \$/US \$)
SOPM44D	= U.S., Soybean Meal Price (US \$/MT)
SOPMKU9	= U.S., Soybean Oil Price (US \$/MT)
SOYPF	= U.S., Soybean Farm Price (US \$/bu.)
WHYHHCA	= Canada, Wheat Yield (MT/ha.)

equation. As a result various prices have been used in past analyses to represent the supply response price variable. For example, Capel (1968) used the CWB international wheat agreement price, while Meilke (1976) incorporated the initial and final payments by the CWB as separate explanatory variables. In the latest analysis Spriggs (1981) used the off-board price, based on the model developed by Jolly and Martin (1978), which shows that for a producer with a profit maximizing objective the supply response price is the expected off-board price whether quotas are binding or not.

Because the majority of Canadian wheat is marketed through the CWB, the price chosen for this analysis is the CWB initial price for the coming crop year. Barley and canola are identified as substitute crops in wheat production, therefore, the expected wheat area harvested is specified as a function of the ratios of the announced (expected) CWB wheat initial price to the expected barley price, and to the current canola market price. Assuming that Canadian producers believe marketing quotas for the coming crop year will be more restrictive as carry-out stocks increase, area harvested is also specified to be a negative function of stocks. A dummy variable is included to account for the "Lower Inventories for Tomorrow" program that took wheat area out of production in 1970. To measure the short-run adjustment effects, a lagged variable is included in the equation. The estimated results show that all coefficients have expected signs and are highly significant.

The current wheat production is specified to be a product of wheat area harvested and yield per acre, where wheat area harvested is the lagged expected area harvested and yield is exogenously determined.

Wheat consumption is separated into food use, feed use, and seed use. Food use is conventionally specified as a function of the real domestic mill price and real GNP (both are deflated by the GNP deflator). However, no close substitutes for wheat in consumption are identified. The result shows that wheat price effect is insignificant in consumption, but the real income is an important determinant. The own-price elasticity and income elasticity are -0.03 and 0.32 , respectively.

Feed use is specified as a negative function of the off-board price and a positive function of the average price received for chickens. Barley is identified as a close substitute of wheat in feed use. The estimated own-price elasticity and cross-price elasticity (barley) are -0.60 and 0.22 , respectively. Initial prices and lagged inventories are also included as explanatory variables on the supposition that as the initial price increases, wheat producers who are also hog producers will deliver to the CWB rather than feed their wheat, but as farm inventories increase they will market their wheat through hogs. All estimated coefficients have the assumed signs. Seed use is specified as a function of the expected area harvested.

The final component of wheat demand is stocks. The explanatory factors of the stock level are the export price, current production, and beginning stocks. A dummy variable for years 1966 to 1969 is also included to account for the unusually high level of stocks during this period.

Price linkages are specified in Equations 2.8 to 2.14. The Canadian export price is linked to the U.S. export price in Canadian dollars, and a

dummy variable is included to account for the unprecedented commodity price increases in 1973. The expected initial price is specified as a function of the export price and the current initial price (the lagged expected initial price). Inclusion of the current initial price as an explanatory variable is based on the assumption that as it is an administratively set price it will tend to be sticky over time. The off-board price is specified to be a function of the export price, opening supplies, and the current initial price. The domestic mill price is obtained according to the administrative formula.

Price of close substitutes of wheat are endogenized in the model. The expected initial price of barley is specified as a function of the current barley initial price and the U.S. corn average price received by farmers in Canadian dollars. The off-board price of barley is a function of the U.S. barley farm price in Canadian dollars. The Canadian canola export price is specified to be a function of the U.S. soybean average price received by farmers in Canadian dollars, and the ratio of U.S. soybean oil price and U.S. soybean meal price. A dummy variable for the U.S. soybean embargo in 1980 is also included. The average producer price for chicken is specified as a function of wheat off-board price, the U.S. corn farm price in Canadian dollars, and the U.S. soybean meal price in Canadian dollars.

Australia Wheat Submodel

The wheat industry of Australia is controlled almost entirely by the Australian Wheat Board (AWB). However, unlike Canada, the AWB is

responsible for handling all the wheat. Growers receive a series of payments (usually two) for wheat delivered to the board. The total payment is based on total returns from domestic and export sales of a particular pool of grain and the provisions of the wheat stabilization program prevailing at the time.

Australia had a series of six five-year stabilization programs during the period 1948-1980. Details of these programs were obtained from various issues of the Yearbook of the Commonwealth of Australia. The first five plans (1948-1973/74) were basically similar and involved guaranteed payments and quantities and an export tax. Under these five plans all wheat delivered to the AWB was pooled and resold either to domestic mills at the home consumption price or exported at world prices. The gross return to the grower was determined as an average of returns from domestic and export sales. The provisions of a stabilization fund required either a markup or markdown of this average return. The stabilization program allowed a guaranteed quantity and price. If the average returns from export sales exceeded the guaranteed price, then an export tax was paid into the fund; otherwise, payments were made out of the fund to raise the export return to the level of the guaranteed price, which was based on cost of production.

Under the sixth plan, beginning 1974-1975, the guaranteed price was replaced by a stabilization price (SP), which was based on world prices. As before, if the per unit export returns exceeded SP, growers would pay a tax, generally equal to the price difference. When export returns fell short of SP the difference was paid out of the stabilization fund to growers without any quantity limits on total exports.

Australian area harvested is estimated as a function of wheat real farm price, sorghum real farm price, sheep numbers, and lagged area harvested. Sheep numbers in Australia have a significant negative effect upon wheat acreage. This can be explained by the fact that sheep grazing competes with wheat production for land in Australia. Table 3 presents estimates of the Australia wheat model. The coefficient of the wheat real farm price variable is insignificant and inelastic. The lagged dependent variable and sheep numbers are significant.

On the demand side, food and feed use are exogenous in the model. All stocks are held by the AWB, whose main objective is to assure adequate supplies to the domestic market. Any surpluses after this obligation has been met are exported. Stock demand is specified in this analysis as a function of production, lagged dependent variable (the beginning stock level), and two dummy variables for 1969 and 1980.

Price transmission between the U.S. Gulf port price and the Australia export price is high, with an elasticity of 0.98, and the wheat farm price is linked to the wheat export price. The sorghum farm price is endogenized and linked to the U.S. sorghum farm price in Australian dollars, with an elasticity of 1.07. Sheep numbers are endogenized as a function of lagged real wool price, real wheat farm price, real sorghum price, and lagged dependent variable. Finally, net export is derived as a residual of domestic supply and demand.

Argentina Wheat Submodel

Argentina is one of the important wheat exporting countries in the world. In recent years, Argentina has accounted for about 8 percent of

Table 3. Structural parameter estimates of the Australia wheat submodel

(3.1) Area Harvested

$$\begin{aligned}
 \text{WHAHHAU} &= 6.759 + 0.654 * \text{LAG}(\text{WHAHHAU}) \\
 &\quad (3.00) \quad (7.25) \\
 &+ 0.0001 * \text{LAG}(\text{WHPFMAU}) / \text{LAG}(\text{NARDDAU}) \\
 &\quad (1.54) \\
 &\quad [0.18] \\
 &- 0.00009 * \text{LAG}(\text{SGPFMAU}) / \text{LAG}(\text{NARDDAU}) \\
 &\quad (-0.81) \\
 &\quad [-0.10] \\
 &- 2.546 * \text{D70} - 1.898 * \text{D74} + 1.244 * \text{D83} \\
 &\quad (-3.93) \quad (-2.53) \quad (2.11) \\
 &- 0.025 * \text{LAG}(\text{SHCOTAU}) \\
 &\quad (-2.49) \\
 &\quad [-2.83] \\
 R^2 &= 0.94 \qquad \qquad \qquad \text{DW} = 2.65
 \end{aligned}$$

(3.2) Production

$$\text{WHSPRAU} = \text{WHYHHAU} * \text{WHAHHAU}$$

(3.3) Stocks

$$\begin{aligned}
 \text{WHCOTAU} &= -3.378 + 0.370 * \text{LAG}(\text{WHCOTAU}) \\
 &\quad (-6.04) \quad (5.56) \\
 &+ 0.431 * \text{WHSPRAU} + 3.757 * (\text{D68} + \text{D69}) \\
 &\quad (11.22) \quad (7.07) \\
 &\quad [1.45] \\
 &- 1.823 * \text{D86} \\
 &\quad (-2.42) \\
 R^2 &= 0.94 \qquad \qquad \qquad \text{DW} = 1.77
 \end{aligned}$$

Table 3. Continued

(3.4) Export Price

$$\text{WHPEXAU} = 4.059 + 0.973 * (\text{WHPGPU90} * \text{NIMEUAU})$$

(0.67) (17.87)
[0.98]

$$- 22.919 * (\text{D84} + \text{D85} + \text{D86}) + 23.400 * \text{D82}$$

(-3.09) (2.38)

$$R^2 = 0.97 \qquad \qquad \qquad \text{DW} = 1.35$$

(3.5) Wheat Price Linkage

$$\text{WHPFMAU} = -135.299 + 100.531 * \text{WHPEXAU}$$

(-0.40) (38.49)
[1.05]

$$-3271.930 * (\text{D72} + \text{D73}) - 1604.54 * \text{D77}$$

(-8.24) (-2.94)

$$R^2 = 0.99 \qquad \qquad \qquad \text{DW} = 2.31$$

(3.6) Consumer Price

$$\text{WHPHCAU} = 2.960 + 0.011 * \text{WHPFMAU} - 48.913 * (\text{D73} + \text{D74})$$

(0.49) (21.69) (-6.39)
[1.03]

$$- 35.036 * (\text{D78} + \text{D79}) + 33.472 * \text{D83}$$

(-4.46) (3.07)

$$R^2 = 0.98 \qquad \qquad \qquad \text{DW} = 2.10$$

(3.7) Sorghum Price Linkage

$$\text{SGPFMAU} = -301.650 + 5099.850 * (\text{SORPF} * \text{NIMEUAU})$$

(24.54)
[1.07]

$$-2691.540 * (\text{D83} + \text{D84} + \text{D85}) + 1342.000 * \text{D86}$$

(-6.07) (2.72)

$$R^2 = 0.98 \qquad \qquad \qquad \text{DW} = 2.03$$

Table 3. Continued

(3.8) Sheep Numbers

$$\text{SHCOTAU} = 17.194 + 0.813 * \text{LAG}(\text{SHCOTAU})$$

(1.03) (8.28)
[0.81]

$$- 0.0008 * \text{LAG}(\text{SGPFMAU}/\text{NARDDAU})$$

(-0.67)
[-0.06]

$$+ 0.137 * \text{LAG}[\text{LAG}(\text{GWPFMAU}/\text{NARDDAU})]$$

(2.76)
[0.23]

$$+ 0.062 * \text{LAG}(\text{GWPFMAU}/\text{NARDDAU})$$

(2.17)
[0.10]

$$- 0.002 * \text{LAG}(\text{WHPFMAU}/\text{NARDDAU})$$

(-1.62)
[-0.21]

$$+ 10.221 * (\text{D84} + \text{D85})$$

(2.17)

$$R^2 = 0.91$$

$$\text{DW} = 2.16$$

(3.9) Greasy-Wool Price

$$\text{GWPFMAU} = 83.912 - 0.409 * \text{LAG}(\text{SHCOTAU})$$

(1.36) (-1.14)
[-0.31]

$$+ 318.458 * (\text{COLFAU} * \text{NIMEUAU})$$

(8.10)
[0.75]

$$+ 91.326 * \text{D72} + 55.256 * \text{D81}$$

(5.62) (2.94)

$$+ 48.206 * \text{D73} + 52.869 * \text{D86}$$

(2.78) (2.85)

$$+ 1.020 * (\text{LTARCRUD} * \text{NIMEUAU})$$

(1.38)
[0.08]

$$R^2 = 0.98$$

$$\text{DW} = 2.00$$

Table 3. Continued

(3.10) Net Exports

$$\text{WHSMNAU} = \text{WHUDTAU} + \text{WHCOTAU} - \text{WHSPPRAU} - \text{LAG}(\text{WHCOTAU})$$

Endogenous Variables

GWPFMAU	=	Australia, Greasy-wool Producer Price (cents/kg.)
SGPFMAU	=	Australia, Sorghum Farm Price (cents/ton)
SHCOTAU	=	Australia, Sheep Numbers (millions)
WHAHHAU	=	Australia, Wheat Area Harvested (mil. ha.)
WHCOTAU	=	Australia, Wheat Ending Stocks (MMT)
WHPEXAU	=	Australia, Wheat Export Price (AUS \$/MT)
WHPFMAU	=	Australia, Wheat Farm Price (AUS \$/MT)
WHPGPU90	=	U.S., Wheat Export Price, fob Gulf Port (US \$/MT)
WHPHCAU	=	Australia, Wheat Home Consumption Price (AUS \$/MT)
WHSMNAU	=	Australia, Wheat Net Exports (MMT)
WHSPPRAU	=	Australia, Wheat Production (MMT)

Exogenous Variables

COLFAU	=	American Upland Cotton Price
D68	=	Dummy Variable: 1 in 1968, 0 otherwise
D69	=	Dummy Variable: 1 in 1969, 0 otherwise
D70	=	Dummy Variable: 1 in 1970, 0 otherwise
D72	=	Dummy Variable: 1 in 1972, 0 otherwise
D73	=	Dummy Variable: 1 in 1973, 0 otherwise
D74	=	Dummy Variable: 1 in 1974, 0 otherwise
D77	=	Dummy Variable: 1 in 1977, 0 otherwise
D78	=	Dummy Variable: 1 in 1978, 0 otherwise
D79	=	Dummy Variable: 1 in 1979, 0 otherwise
D81	=	Dummy Variable: 1 in 1981, 0 otherwise
D82	=	Dummy Variable: 1 in 1982, 0 otherwise
D83	=	Dummy Variable: 1 in 1983, 0 otherwise
D84	=	Dummy Variable: 1 in 1984, 0 otherwise
D85	=	Dummy Variable: 1 in 1985, 0 otherwise
D86	=	Dummy Variable: 1 in 1986, 0 otherwise
LTARCRUD	=	Light Arabian Crude Oil Price (US \$/bbl.)
NARDDAU	=	Australian GNP Deflator
NIMEUAU	=	Exchange Rate (AUS \$/US \$)
SORPF	=	U.S., Sorghum Farm Price (\$/bu.)
WHUDTAU	=	Australia, Wheat Total Domestic Use (MMT)
WHYHHAU	=	Australia, Wheat Yield (MT/ha)

world wheat exports. Since 1982, more than 60 percent of production has been exported. Most of the domestic wheat use is consumed as food; only a limited amount is used for feed.

Equations 4.1-4.7 in Table 4 present the estimated results of the Argentina wheat submodel. Wheat area harvested has a positive relationship with lagged wheat real farm price. The estimated short-run supply elasticity with respect to price is 0.51. Sorghum real farm price is used as a competing crop price in the acreage equation. Four dummy variables account for years in which favorable or adverse weather affected wheat area. Equation 4.2 represents total production as acreage harvested times yield per hectare.

In the Argentinean submodel, net exports are estimated as a function of production and wheat real farm price. The elasticity of exports with respect to wheat price is -0.17. Dummy variables for 1979 and 1984 are included to reflect the government policy actions in wheat exports in those years.

The real farm price of wheat in Argentina has a positive relationship with the U.S. wheat price (in terms of domestic currency), and has a negative relationship with the inflation rate in Argentina. The calculated price transmission elasticity is 0.43, indicating that only a portion of changes in U.S. prices is transmitted to farmers in Argentina. Dummy variables for years 1973, 1974, and 1975 are used to capture the effect of high export taxes and domestic price controls. The dummy variable for 1980 is used to reflect the U.S. grain embargo to the Soviet Union. Similarly, a price linkage equation for real farm price of sorghum is also estimated.

Table 4. Structural parameter estimates of the Argentina wheat submodel

(4.1) Area Harvested

$$\begin{aligned}
 \text{WHAHHAR} &= 1331.710 + 0.506 * \text{LAG}(\text{WHAHHAR}) \\
 &\quad (1.21) \quad (4.25) \\
 &\quad \quad \quad [0.51] \\
 &+ 7.821 * \text{LAG}(\text{WHPFMARR}) - 1695.310 * (\text{D70} + \text{D77}) \\
 &\quad (3.10) \quad \quad \quad (-5.10) \\
 &\quad [0.48] \\
 &+ 2073.240 * \text{D76} + 1159.430 * (\text{D82} + \text{D83}) \\
 &\quad (4.09) \quad \quad (3.16) \\
 &+ 844.287 * \text{D75} - 6.203 * \text{LAG}(\text{SGPFMARR}) \\
 &\quad (1.59) \quad \quad (-1.79) \\
 R^2 &= 0.90 \quad \quad \quad \text{DW} = 2.12
 \end{aligned}$$

(4.2) Production

$$\text{WHSRPR} = \text{WHYHHAR} * \text{WHAHHAR}$$

(4.3) Net Exports

$$\begin{aligned}
 \text{WHSMNAR} &= 4221.29 - 0.884 * \text{WHSRPR} - 1.905 * \text{WHPFMARR} \\
 &\quad (4.84) \quad (-19.84) \quad \quad \quad (-0.92) \\
 &\quad \quad \quad [-1.89] \quad \quad \quad [-0.17] \\
 &- 1396.780 * \text{D84} - 1169.810 * \text{D79} \\
 &\quad (-2.64) \quad \quad (-2.45) \\
 R^2 &= 0.98 \quad \quad \quad \text{DW} = 2.36
 \end{aligned}$$

(4.4) Sorghum Price Linkage

$$\begin{aligned}
 \text{SGPFMARR} &= 166.593 + 13.883 * (\text{SORPF} * \text{NIMECARF}/\text{WPI80AR}) * 10000 \\
 &\quad (6.38) \quad (3.79) \\
 &\quad \quad \quad [0.45] \\
 &- 12.300 * [\text{WPI80AR} - \text{LAG}(\text{WPI80AR})]/\text{LAG}(\text{WPI80AR}) \\
 &\quad (-5.22) \\
 &\quad [-0.01] \\
 &- 18.064 * (\text{D73} + \text{D75}) - 149.428 * \text{D74} \\
 &\quad (-1.09) \quad \quad \quad (-6.02) \\
 R^2 &= 0.81 \quad \quad \quad \text{DW} = 2.34
 \end{aligned}$$

Table 4. Continued

D82	=	Dummy Variable: 1 in 1982, 0 otherwise
D83	=	Dummy Variable: 1 in 1983, 0 otherwise
D84	=	Dummy Variable: 1 in 1984, 0 otherwise
NARPDAR	=	Argentina, Real GDP (1000 1980 Australes)
NIMECARF	=	Argentina, Real Exchange Rate (1980 Australes/\$)
SORPF	=	U.S. Sorghum Farm Price (\$/bu.)
WHCOTAR	=	Argentina, Wheat Ending Stocks (1000 MT)
WHYHHAR	=	Argentina, Wheat Yield (MT/ha.)
WPI80AR	=	Argentina, Wholesale Price Index (1980 = 100)

Equation 4.6 gives the estimated results for cattle numbers in Argentina. The domestic wheat use is determined as a residual; i.e., total supply minus export and stock demands.

The European Community Wheat Submodel

The Common Agricultural Policy of the EC allows domestic grain prices to vary between the target price and the intervention price. Target prices indicate price levels desired in the most grain-deficient region (Duisburg), but there is no commitment to enforce these prices. In fact, market prices are equivalent to the target price only when production falls short of domestic demand. In this situation prices are determined by import prices. Grain imports, however, are allowed only at the threshold price, which is the import price set high enough to guarantee the target price in Duisburg. The difference between the import price (Rotterdam) and the threshold price is a levy on imports. High internal EC prices relative to world prices require export subsidies. This has been the case for wheat in recent years. Koester estimates that between 1969 and 1973 the high price support policy of the EC resulted in an additional 4 million tons of wheat produced and reduced wheat utilization by 4.6 million tons.

The three important EC policy prices--target, intervention, and threshold--are determined annually and affect the actual market prices. The intervention price is a floor price and as a matter of policy is set high enough to maintain actual market prices at relatively high levels. The threshold price is a ceiling price. The comparison of the three policy prices and the producer price reveals that the producer price was

well below the intervention price in a number of years. Although the producer price may be low, actual producer receipts are higher due to subsidies. Without any data on subsidy payments the appropriate price variable to use in an area equation becomes obscured.

Table 5 gives the estimates of EC structural parameters. Wheat area harvested is specified as a function of its lagged value, soft wheat real intervention price, and Durum wheat real intervention price. Dummy variables for 1975, 1977, 1980, and 1984 are included in the equation to account for unexplained changes in area in these years. The statistical fit of the equation is satisfactory. The area harvested responds to own-price (for both soft wheat and durum wheat price) with an elasticity of 0.19.

On the demand side, feed use is specified as a function of soft wheat real threshold price, corn real threshold price, and poultry production. All estimated coefficients have expected signs and are highly significant. The own-price elasticity is -1.32 and the substitute-price elasticity is 1.19. As in the conventional specification, wheat food use is a function of its own price and real income. The estimated own-price and income elasticities are -0.07 and 0.05, respectively.

The stock demand equation is specified as a function of production, lagged stocks, and dummy variables. Poultry production is endogenized and estimated in the model. The explanatory variables are real income and corn threshold price.

Four price equations are endogenously estimated. The EC soymeal price is linked to U.S. soymeal price in ECU. Since the EC does not

Table 5. Structural parameter estimates of the EC wheat submodel

(5.1) Area Harvested

$$\begin{aligned}
 \text{WHAHHE2} &= 11028.000 + 0.090 * \text{LAG}(\text{WHAHHE2}) \\
 &\quad (5.84) \quad (0.69) \\
 &\quad \quad \quad [0.09] \\
 &+ 5.675 * (\text{WSPIEO}/\text{NARDDEO}) - 1012.360 * \text{D75} \\
 &\quad (2.10) \quad \quad \quad (-4.23) \\
 &\quad [0.09] \\
 &- 1628.680 * \text{D77} + 4.460 * (\text{WHPIEO}/\text{NARDDEO}) \\
 &\quad (-6.33) \quad \quad \quad (2.10) \\
 &\quad \quad \quad [0.10] \\
 &+ 1440.310 * \text{SHIFT80} + 436.916 * \text{D84} \\
 &\quad (5.54) \quad \quad \quad (1.90) \\
 R^2 &= 0.95 \quad \quad \quad \text{DW} = 2.39
 \end{aligned}$$

(5.2) Production

$$\text{WHSPRE2} = \text{WHAHHE2} * \text{WHYHHE2}$$

(5.3) Feed Use

$$\begin{aligned}
 \text{WHUFEE2} &= 3793.300 + 3.639 * \text{PYSPRE2} - 67.552 * \text{WSPTHEO}/\text{NARDDEO} \\
 &\quad (1.0) \quad (6.82) \quad \quad \quad (-2.64) \\
 &\quad \quad \quad [1.08] \quad \quad \quad [-1.32] \\
 &+ 67.983 * \text{COPTHEO}/\text{NARDDEO} + 3133.450 * (\text{D73} + \text{D74}) \\
 &\quad (2.53) \quad \quad \quad (7.88) \\
 &\quad [1.19] \\
 &- 7033.33 * \text{SHIFT73} + 6339.810 * \text{D83} + 8584.330 * (\text{D84} + \text{D85}) \\
 &\quad (-21.41) \quad \quad \quad (12.66) \quad \quad \quad (21.82) \\
 R^2 &= 0.99 \quad \quad \quad \text{DW} = 2.56
 \end{aligned}$$

Table 5. Continued

(5.11) Net Exports

$$\text{WHSMNE2} = \text{WHUHTE2} + \text{WHUFEE2} + \text{WHCOTE2} - \text{WHSPRE2} - \text{LAG}(\text{WHCOTE2})$$

Endogenous Variables

COPTHE0	= EC,	Corn Threshold Price (ECU/MT)
PYSPRE2	= EC,	Poultry Production (1000 MT)
SYMPFME0	= EC,	Soymeal Price (ECU/MT)
WHAHHE2	= EC,	Wheat Area Harvested (1000/ha.)
WHCOTE2	= EC,	Wheat Ending Stocks (1000 MT)
WHPGPU90	= U.S.,	U.S. Gulf Port Price (\$/MT)
WHSMNE2	= EC,	Wheat Net Imports (1000 MT)
WHSPRE2	= EC,	Wheat Production (1000 MT)
WHUFEE2	= EC,	Wheat Feed Use (1000 MT)
WHUHTE2	= EC,	Wheat Food Use (1000 MT)
WSPIE0	= EC,	Soft Wheat Intervention Price (ECU/MT)
WSPTHE0	= EC,	Soft Wheat Threshold Price (ECU/MT)

Exogenous Variables

COPIE0	= EC,	Corn Intervention Price (ECU/MT)
D67	= Dummy Variable:	1 in 1967, 0 otherwise
D68	= Dummy Variable:	1 in 1968, 0 otherwise
D72	= Dummy Variable:	1 in 1972, 0 otherwise
D73	= Dummy Variable:	1 in 1973, 0 otherwise
D74	= Dummy Variable:	1 in 1974, 0 otherwise
D75	= Dummy Variable:	1 in 1975, 0 otherwise
D76	= Dummy Variable:	1 in 1976, 0 otherwise
D77	= Dummy Variable:	1 in 1977, 0 otherwise
D82	= Dummy Variable:	1 in 1982, 0 otherwise
D83	= Dummy Variable:	1 in 1983, 0 otherwise
D84	= Dummy Variable:	1 in 1984, 0 otherwise
D85	= Dummy Variable:	1 in 1985, 0 otherwise
D86	= Dummy Variable:	1 in 1986, 0 otherwise
NANPDE2	= EC,	Nominal GDP in ECU (Bil. ECU)
NARDDE0	= EC,	GDP Deflator (1980 = 1)
NIMEUE0	= EC,	Exchange Rate (ECU/\$)
SHIFT73	= Dummy Variable:	1 in 1973, 0 otherwise
SHIFT76	= Dummy Variable:	1 in 1976, 0 otherwise
SHIFT80	= Dummy Variable:	1 in 1980, 0 otherwise
SOMPM	= U.S.,	Soymeal Price (\$/ton)
WHPIE0	= EC,	Duram Wheat Intervention Price (ECU/MT)
WHYHHE2	= EC,	Wheat Yield (MT/ha.)

pursue any restrictive trade policies in soymeal trade, the price-transmission elasticity is close to one. The soft wheat intervention price is linked to the difference between lagged intervention and Gulf port prices. The other explanatory variables in this equation are stocks and inflation. Because of the price fixing policy of the EC, the price-transmission elasticity is close to zero. The soft wheat and corn threshold prices are linked to their respective intervention prices. Finally, wheat net exports are derived as the residual of supply and demand.

India Wheat Submodel

A main feature of the Indian grain market is its segmentation into concessional and commercial markets. The government buys grain from growers, monopolizes imports, and is able to channel wheat to low-income consumers at a subsidized price using the stockpiles. The two important policy prices of grain are, therefore, the procurement price (the price at which the government buys the grain) and the resale price (the price at which the government sells the grain to ration card holders). Krishna and Chhibber (1983) estimated that since the late 1970s the government has handled only about 10 percent of total available grain, defined as the sum of production, net imports, and change in government stocks. Until 1966 imports were the main source for concessional sales. Between 1967 and 1972 the Green Revolution enabled the government to procure enough domestic wheat to increase stocks and eliminate imports as a source for concessional sales.

Although the system of grain procurement by the government varies from year to year and from region to region, it is reported that "for wheat, the details of variations in purchase systems have little significance, because Punjab and Haryana states, which contributed 60 to 90 percent of all-India procurement in the decade 1967-1977 ... have purchased most of their grain in the open market at the prevailing price, with right of preemptive purchase exercised by government agents only occasionally" (Krishna and Chhibber 1983, 15). There is, therefore, little difference between the procurement price and the market price for wheat. This suggests that farmers do not necessarily face a dual market, as consumers do.

Equations estimated for the Indian wheat market are presented in Table 6. The real gross return for wheat in the area equation is significant with the elasticity of 0.25. The substitute crop (sorghum) real gross return is also significant, with elasticity of -0.10.

On the demand side, it is estimated that during the period 1961-1978 the public system provided an average of 29 percent of wheat consumed. This large volume of concessional sales, together with wide variations in the subsidized price relative to the producer price, implies a dual market as modeled by Krishna and Chhibber. A single demand equation is estimated in this model because the data are not disaggregated according to the various domestic markets. The food demand equation has significant coefficients for own price and income. The own-price elasticity of demand is -0.38 and income elasticity is 0.76.

Stock demand is also estimated as a component of this model. The beginning level and the current crop year production are two major

Table 6. Structural parameter estimates of the India wheat submodel

(6.1) Area Harvested

$$\begin{aligned}
 \text{WHAHHIN} &= 3.494 + 0.694 * \text{LAG}(\text{WHAHHIN}) \\
 &\quad (1.52) \quad (12.12) \\
 &\quad \quad \quad [0.69] \\
 &+ 0.002 * \text{LAG}(\text{WHPFMIN}) / \text{LAG}(\text{NARDDIN}) * \text{LAG}(\text{WHYHHIN}) \\
 &\quad (5.22) \\
 &\quad [0.25] \\
 &- 0.003 * \text{LAG}(\text{SGPFMIN}) / \text{LAG}(\text{NARDDIN}) * \text{LAG}(\text{SGYHHIN}) \\
 &\quad (-2.65) \\
 &\quad [-0.10] \\
 &- 1.322 * \text{D75} + 1.515 * (\text{D83} + \text{D84}) \\
 &\quad (-3.06) \quad (4.51) \\
 R^2 &= 0.99 \qquad \qquad \qquad \text{DW} = 2.53
 \end{aligned}$$

(6.2) Production

$$\text{WHSPRIN} = \text{WHAHHIN} * \text{WHYHHIN}$$

(6.3) Domestic Use

$$\begin{aligned}
 \text{WHUDTIN} &= 18.886 - 0.007 * (\text{WHPFMIN} / \text{NARDDIN}) \\
 &\quad (3.49) \quad (-4.27) \\
 &\quad \quad \quad [-0.38] \\
 &+ 0.020 * (\text{NANPDIN} / \text{NARDDIN}) \\
 &\quad (7.96) \\
 &\quad [0.76] \\
 R^2 &= 0.97 \qquad \qquad \qquad \text{DW} = 1.66
 \end{aligned}$$

Table 6. Continued

(6.4) Stocks

$$\begin{aligned}
 \text{WHCOTIN} &= -1.0006 + 0.634 * \text{LAG}(\text{WHCOTIN}) + 0.160 * \text{WHSPRIN} \\
 &\quad (-1.19) \quad (6.26) \quad (4.19) \\
 &\quad \quad \quad [0.63] \quad \quad [0.65] \\
 &- 3.343 * (\text{D78} + \text{D79} + \text{D80}) - 2.57 * (\text{D72} + \text{D73} + \text{D74}) \\
 &\quad (-5.00) \quad \quad \quad (-3.80) \\
 &+ 3.173 * (\text{D75} + \text{D76}) \\
 &\quad (3.97) \\
 R^2 &= 0.95 \quad \quad \quad \text{DW} = 2.44
 \end{aligned}$$

(6.5) Wheat Farm Price

$$\begin{aligned}
 \text{WHPFMIN} &= 738.940 + 0.160 * \text{LAG}(\text{WHPFMIN}) \\
 &\quad (5.12) \quad (1.23) \\
 &- 351.621 * \text{LAG}(\text{WHSPRIN}) / \text{LAG}(\text{WHUDTIN}) \\
 &\quad (-2.02) \\
 &+ 0.541 * \text{WHPGPU90} * \text{NIMEUIN} \\
 &\quad (6.91) \\
 &\quad [0.51] \\
 R^2 &= 0.94 \quad \quad \quad \text{DW} = 2.28
 \end{aligned}$$

(6.6) Exports

$$\text{WHSMNIN} = \text{WHUDTIN} + \text{WHCOTIN} - \text{WHSPRIN} - \text{LAG}(\text{WHCOTIN})$$

Endogenous Variables

WHAHHIN = India, Wheat Area Harvested (mil/ha.)
 WHCOTIN = India, Wheat Ending (Stocks/MMT)
 WHPFMIN = India, Wheat Producer Price (Rupees/MT)
 WHPGPU90 = U.S., Wheat Gulf Port (\$/MT)
 WHSMNIN = India, Wheat Net Imports (MMT)
 WHSPRIN = India, Wheat Production (MMT)
 WHUDTIN = India, Wheat Domestic Use (MMT)

Table 6. Continued

Exogenous Variables

D72	= Dummy Variable: 1 in 1972, 0 otherwise
D73	= Dummy Variable: 1 in 1973, 0 otherwise
D74	= Dummy Variable: 1 in 1974, 0 otherwise
D75	= Dummy Variable: 1 in 1975, 0 otherwise
D76	= Dummy Variable: 1 in 1976, 0 otherwise
D78	= Dummy Variable: 1 in 1978, 0 otherwise
D79	= Dummy Variable: 1 in 1979, 0 otherwise
D80	= Dummy Variable: 1 in 1980, 0 otherwise
D83	= Dummy Variable: 1 in 1983, 0 otherwise
D84	= Dummy Variable: 1 in 1984, 0 otherwise
NANPDIN	= India, GDP (billion rupees)
NARDDIN	= India, GDP Deflation (1980 = 1.0)
NIMEUIN	= India, Exchange Rate (Rupees/\$)
SGPFMIN	= India, Sorghum Producer Price (Rupees/MT)
SGYHHIN	= India, Sorghum Yield (MT/ha)
WHYHHIN	= India, Wheat Yield (MT/ha)

determinants of the ending stock level. The wheat farm price is linked to U.S. Gulf port price. The price-transmission elasticity is only 0.51 because of the government's intervention in the wheat pricing policy.

Japan Wheat Submodel

Historically, wheat production in Japan declined over the period 1955 to 1971. This was due to a decline in the "cropping ratio," which is the ratio of crop area to cultivated area. The decline in the cropping ratio is said to be a result of the successful competition of the nonagricultural sector for available labor, reflected in the decline in agricultural labor from 19.3 million in 1955 to 13.1 million in 1974 (Sanderson 1978). The trend suggests a decline in the importance of wheat as a cash crop internally and therefore an increased reliance on wheat imports.

The general agricultural price policy in Japan is to maintain high support prices for basic crops (including wheat). The government purchases wheat from farmers at a high support price and, together with imported wheat, resells to consumers at a lower price. The resale price until 1974 was considered a weighted average of the support price and the import price. During the abnormally high world prices of 1974-1975 the government selling price showed only a moderate increase from previous levels. In fact, the resale price was below the import price in those years, amounting to a subsidy instead of a tax on imports.

The estimated equations for the Japanese wheat model are reported in Table 7. The resale price and income are significant in the food demand

Table 7. Structural parameter estimates of the Japan wheat submodel

(7.1) Food Use

$$\text{WHFODJP} = 4.887 - 0.005 * \text{WHRESPJP} + 0.008 * \text{INCRTJP}$$

(12.73)	(-2.75)	(5.80)
[-0.12]		[0.22]

$$R^2 = 0.95$$

$$DW = 1.50$$

(7.2) Resale Price

$$\text{WHRESPJP} = 114.112 + 0.270 * (\text{RGULFUS}/\text{REXJAPA}) - 44.155 * \text{DUM7380}$$

(9.13)	(3.32)	(-6.60)
	[0.28]	

$$R^2 = 0.84$$

$$DW = 1.87$$

(7.3) Net Imports

$$\text{NETMJP} = \text{WHFODJP} + \text{WHFEDJP} + \text{WHESTJP} - \text{WHPDNJP} - \text{LAG}(\text{WHESTJP})$$

Endogenous Variables

NETMJP = Japan, Wheat Net Imports (MMT)
 RGULFUS = U.S., Real Wheat Gulf Port Price, fob (US \$/MT)
 WHFODJP = Japan, Wheat Food Use (MMT)
 WHRESPJP = Japan, Wheat Resale Price (1000 Yen/MT)

Exogenous Variables

DUM7380 = Dummy Variable to Reflect the Shift in the Relative Levels of the Resale and International Price: 1 from 1973-80, 0 otherwise.
 INCRTJP = Japan, Real Income (Bil. 1975 yen)
 REXJAPA = Exchange Rate (US \$/Yen, 1975 = 1.0)
 WHESTJP = Japan, Wheat Ending Stocks (MMT)
 WHFEDJP = Japan, Wheat Feed Use (MMT)
 WHPDNJP = Japan, Wheat Production (MMT)

equation. The resale food price and income elasticities of food demand are -0.12 and 0.22, respectively.

Because the government sets both producer and consumer prices, both prices can be exogenous. The resale price is determined in part by the import price therefore, it is linked to the U.S. price. The price transmission elasticity is 0.28. A dummy variable is included to explain the shift in the relative levels of the resale and international prices.

Centrally Planned Economies Wheat Submodel

Regions included in the centrally planned economies submodel are the USSR, China, and Eastern Europe (Table 8). For the USSR, imports and stock changes are endogenously estimated. Domestic use is the residual. Production is exogenous. The explanatory variables in the import demand equation are the ratio of U.S. Gulf port price to light Arabian crude oil price, wheat production, and dummy variables. Since the Soviet Union is an exporter of crude oil, the higher crude oil price has a positive effect on wheat imports. The Soviet Union's wheat imports respond to world price with an elasticity of -0.79. As one would expect, wheat production has a negative effect on wheat imports. In the stock change equation, the important explanatory variable is production changes from year to year. Domestic use is total supply (production plus imports) minus stocks.

For China, wheat acreage and domestic use are endogenously estimated. Area harvested is estimated as a function of support price of grains of which wheat is a component, lagged dependent variable, and a number of dummy variables. Both lagged dependent and grain prices are significant

Table 8. Structural parameter estimates for the CPE wheat submodel

USSR

(8.1) Imports

$$\text{WHSMNSU} = 21.890 - 0.338 * \text{WHPGPU90/LTARCRUD} - 0.141 * \text{WHSPRSU}$$

(4.24) (-7.08) (-2.76)
[-0.79] [-1.60]

$$+ 15.915 * \text{D72} + 9.959 * \text{SHIFT80} + 7.191 * \text{D84}$$

(5.81) (6.08) (2.46)

$$R^2 = 0.95 \quad \text{DW} = 1.85$$

(8.2) Stocks

$$\text{WHSTCHSU} = 0.598 - 15.277 * (\text{D69} + \text{D70}) + 7.071 * (\text{D83} + \text{D84})$$

(0.55) (-4.64) (2.13)

$$+ 0.372 * [\text{WHSPRSU} - \text{LAG}(\text{WHSPRSU})]$$

(6.81)
[0.41]

$$R^2 = 0.81 \quad \text{DW} = 1.91$$

(8.3) Domestic Use

$$\text{WHUDTSU} = \text{WHSPRSU} + \text{WHSMNSU} - \text{WHSTCHSU}$$

CHINA

(8.4) Area Harvested

$$\text{WHAHHCN} = 6.690 + 0.681 * \text{LAG}(\text{WHAHHCN}) - 1.266 * (\text{D81} + \text{D82})$$

(4.23) (8.99) (-4.45)

$$- 1.199 * \text{D68} + 1.050 * (\text{D76} + \text{D78}) + 0.008 * \text{LAG}(\text{GRPFMCN})$$

(-3.58) (3.83) (3.41)

$$- 0.990 * \text{D85}$$

(-2.60)

$$R^2 = 0.98 \quad \text{DW} = 1.64$$

Table 8. Continued

(8.5) Production

$$\text{WHSPRCN} = \text{WHAHHCN} * \text{WHYHHCN}$$

(8.6) Domestic Use

$$\text{WHUDTCN} = - 63.127 + 0.830 * \text{WHSPRCN} + 13.875 * \text{LAG}(\text{NANYNCN})$$

(-2.85) (8.13) (2.90)

$$- 5.648 * \text{D85} + 3.839 * \text{D80}$$

(-2.25) (1.60)

$$R^2 = 0.99$$

$$\text{DW} = 0.99$$

(8.7) Imports

$$\text{WHSMNCN} = \text{WHUDTCN} - \text{WHSPRCN}$$

EASTERN EUROPE**(8.8) Area Harvested**

$$\text{WHAHHE8} = \text{WHSPRE8} / \text{WHYHHE8}$$

(8.9) Production

$$\text{WHSPRE8} = 2.170 + 9.567 * \text{WHYHHE8} - 3.882 * \text{D81} - 2.749 * \text{D82}$$

(1.33) (18.53) (-3.29) (-2.28)

$$R^2 = 0.96$$

$$\text{DW} = 1.64$$

(8.10) Total Domestic Use

$$\text{WHUDTE8} = 11.697 + 0.625 * \text{WHSPRE8} + 3.381 * \text{NARPDIE8}$$

(5.32) (5.33) (1.15)

[0.57] [0.09]

$$R^2 = 0.88$$

$$\text{DW} = 1.11$$

Table 8. Continued

(8.11) Imports

$$\text{WHSMNE8} = \text{WHUDTE8} + \text{WHSTCHE8} - \text{WHSPRE8}$$

Endogenous Variables

WHAHHCN	= China, Wheat Area Harvested (mil/ha.)
WHAHHE8	= E. Europe, Wheat Area Harvested (mil/ha.)
WHPGPU90	= U.S., Wheat Gulf Port Price, fob (\$/MT)
WHSMNCN	= China, Wheat Net Imports (MMT)
WHSMNE8	= E. Europe, Wheat Net Imports (MMT)
WHSMNSU	= USSR, Wheat Net Imports (MMT)
WHSPRCN	= China, Wheat Production (MMT)
WHSPRE8	= E. Europe, Wheat Production (MMT)
WHSTCHSU	= USSR, Change in Stocks (MMT)
WHUDTCN	= China, Wheat Total Domestic Use (MMT)
WHUDTE8	= E. Europe, Wheat Total Domestic Use (MMT)
WHUDTSU	= USSR, Wheat Total Domestic Use (MMT)

Exogenous Variables

D68	= Dummy Variable: 1 in 1968, 0 otherwise
D69	= Dummy Variable: 1 in 1969, 0 otherwise
D70	= Dummy Variable: 1 in 1970, 0 otherwise
D72	= Dummy Variable: 1 in 1972, 0 otherwise
D76	= Dummy Variable: 1 in 1976, 0 otherwise
D78	= Dummy Variable: 1 in 1978, 0 otherwise
D80	= Dummy Variable: 1 in 1980, 0 otherwise
D81	= Dummy Variable: 1 in 1981, 0 otherwise
D82	= Dummy Variable: 1 in 1982, 0 otherwise
D83	= Dummy Variable: 1 in 1983, 0 otherwise
D84	= Dummy Variable: 1 in 1984, 0 otherwise
D85	= Dummy Variable: 1 in 1985, 0 otherwise
GRPFMCN	= China, Aggregate Grain Price
LTARCRUD	= Light Arabian Crude Oil Price (US \$/bbl.)
NANYNCN	= China, Net Material Product Produced (Bil 1980 Yuan)
NARPDIE8	= E. Europe, Real GDP Index (1980 = 1.0)
SHIFT80	= Dummy Variable: 1 in 1980 and after, 0 otherwise
WHSPRSU	= USSR, Wheat Production (MMT)
WHSTCHE8	= E. Europe, Change in Stocks (MMT)
WHYHHCN	= China, Wheat Yield (MT/ha)
WHYHHE8	= E. Europe, Wheat Yield (MT/ha)

and have positive effects on the acreage harvested. Domestic use is estimated as a function of production and income. Both production and income have positive effects on use; income elasticity is 1.4. Imports are given as total use minus production.

For Eastern Europe, production and domestic use are endogenously estimated. Yield and two dummy variables are the explanatory variables in the production equation. Domestic use is estimated as a function of production and income. The income elasticity for domestic wheat use is 0.09.

Other Regions

Net imports equations are separately estimated for the four regions: Africa and the Middle East, high-income Eastern Asian countries, other Asian countries (excludes India), and other Western European countries (Table 9). The general specification of import demand equations is based on Equation 9 of the previous section. The explanatory variables in these net imports are the U.S. wheat farm price and the income level in each region. Dummy variables are also included in each equation to account for usual changes in imports in various years. All equations have a satisfactory fit, and the estimated coefficients are significant, with the expected signs.

Evaluation

The estimated model presented in the previous section appears to adequately reflect the structure of the world wheat market; however, the explanatory power of the model has not been fully investigated. This section reviews several measures of the model's explanatory power.

Table 9. Structural parameter estimates for the wheat submodel for other regions

AFRICA AND THE MIDDLE EAST

(9.1) Net Imports

$$\begin{aligned}
 \text{WHS MNF1} &= 15412.100 + 8575.370 * \text{D84} + 12312.200 * \text{D85} \\
 &\quad (3.49) \quad (3.85) \quad (5.71) \\
 &+ 477.588 * \text{LTARCRUD} - 5801.280 * \text{USWHEPF/USCORPF} \\
 &\quad (9.51) \quad (-1.59) \\
 &\quad [0.46] \quad [-0.43] \\
 R^2 &= 0.93 \quad \quad \quad \text{DW} = 2.14
 \end{aligned}$$

HIGH-INCOME EAST ASIA

(9.2) Net Imports

$$\begin{aligned}
 \text{WHS MNR4} &= 1823.790 + 14.144 * \text{NARPDR4} - 164.147 * \text{USWHEPF} \\
 &\quad (11.16) \quad (10.48) \quad (-2.70) \\
 &\quad \quad \quad [0.57] \quad [-0.17] \\
 &- 527.320 * (\text{D77} + \text{D78}) - 470.882 * (\text{D81} + \text{D82}) \\
 &\quad (-3.56) \quad \quad \quad (-3.05) \\
 R^2 &= 0.92 \quad \quad \quad \text{DW} = 1.80
 \end{aligned}$$

OTHER ASIA

(9.3) Net Imports

$$\begin{aligned}
 \text{WHS MNOAS} &= 5481.410 + 39.545 * \text{OASGDPS} - 842.532 * \text{LAG(USWHEPF)} \\
 &\quad (9.42) \quad (7.84) \quad (-3.62) \\
 &\quad \quad \quad [0.67] \quad [-0.26] \\
 &- 2035.350 * \text{D70} + 1894.100 * \text{D74} + 1975.280 * \text{D77} \\
 &\quad (-3.17) \quad (2.61) \quad (3.35) \\
 R^2 &= 0.92 \quad \quad \quad \text{DW} = 2.51
 \end{aligned}$$

Table 9. Continued

OTHER WESTERN EUROPE
(9.4) Net Imports

$$\begin{aligned} \text{WHSMNOWE} = & 1125.940 + 1174.51 * \text{D81} - 551.512 * \text{D84} \\ & (7.46) \quad (5.16) \quad (-2.48) \\ & - 429.015 * \text{LAG}(\text{USWHEPF}) + 742.658 * (\text{D79} + \text{D80}) \\ & (-8.09) \quad (4.53) \\ & [-42.97] \end{aligned}$$

$$R^2 = 0.89$$

$$\text{DW} = 2.15$$

Endogenous Variables

USWHEPF = U.S., Wheat Farm Price (US \$/bu.)
 WHSMNF1 = Africa, Wheat Net Imports (1000 MT)
 WHSMNOAS = Other Asia, Wheat Net Imports (1000 MT)
 WHSMNOWE = Other W. Europe, Wheat Net Imports (1000 MT)
 WHSMNR4 = High-Income E. Asia, Wheat Net Imports (1000 MT)

Exogenous Variable

D70 = Dummy Variable: 1 in 1970, 0 otherwise
 D74 = Dummy Variable: 1 in 1974, 0 otherwise
 D77 = Dummy Variable: 1 in 1977, 0 otherwise
 D78 = Dummy Variable: 1 in 1978, 0 otherwise
 D79 = Dummy Variable: 1 in 1979, 0 otherwise
 D80 = Dummy Variable: 1 in 1980, 0 otherwise
 D81 = Dummy Variable: 1 in 1981, 0 otherwise
 D82 = Dummy Variable: 1 in 1982, 0 otherwise
 D84 = Dummy Variable: 1 in 1984, 0 otherwise
 D85 = Dummy Variable: 1 in 1985, 0 otherwise
 LTARCRUD = Light Arabian Crude Oil Price (US \$/bbl.)
 NARFDR4 = High-Income E. Asia, Real GDP (bil. 1980 dollar)
 OASGDP = Other Asia, Real GDP (bil. 1980 dollar)
 USCORPF = U.S., Corn Farm Price (US \$/bu.)

The supply, demand, import demand, and price transmission elasticities are given in Tables 10-12. Performance of the model can be measured by the validity of its estimates, its ability to reproduce the actual data in a dynamic simulation, and its stability. In general, this model performs quite well.

In order to measure this model's ability to predict, a simulation of the model is run over the sample period (1967-1984). The simulation result is then compared with the actual data. Statistics measuring the model's fitting performance include root mean square (RMS) error, RMS percent error, and Theil's forecast statistics.

The RMS error measures an average error of the simulated values from the actual values. The size of RMS error is dependent upon the variable size. To eliminate this problem, RMS percent error is used instead. A useful simulation statistic related to the RMSE and applied to the evaluation of simulation results is Theil's inequality coefficient (U1). There are three different components of Theil's inequality coefficient: UM (bias error), UR (regression error), and UD (disturbance error). The bias proportion UM is an indication of systematic error, since it measures the extent to which the average values of the simulated and actual series deviate from each other. The regression proportion UR indicates the ability of the model to replicate the degree of variability in the variable of interest. The disturbance proportion UD measures the error remaining after deviations from average values and average variabilities have been accounted for. The perfect correlation of simulated values with actual values would imply the ideal distribution of inequality over the three sources as $UM = UR = 0$ and $UD = 1$.

Table 10. Summary of estimated domestic supply and demand elasticities from the wheat trade model (1982-1984)

Region	Elasticities with respect to nominal					Income
	Wheat Price	Barley Price	Sorghum Price	Corn Price	Rapeseed Price	
U.S.						
Production	0.280 ^b					
Food demand	-0.022					
Feed demand	-0.524			0.336		
Stock demand	-0.148					
Canada						
Production	0.543 ^a	-0.369 ^a			-0.147	
Food demand	-0.027					0.360
Feed demand	-0.851	0.299				
Stock demand	-0.511					
Australia						
Production	0.123 ^b		-0.068 ^b			
Argentina						
Production	0.377 ^{b,c}		-0.211 ^{b,c}			
EC						
Production	0.051					
Food demand	-0.051					0.057
Feed demand	-0.675			0.620		
India						
Production	0.210 ^b		-0.072 ^b			
Total demand	-0.203					0.744
Japan						
Food demand	-0.074 ^c					0.279
China						
Production	0.109					

^aElasticity with respect to the expected initial price.

^bElasticity with respect to one period lagged price.

^cElasticity with respect to real price.

Table 11. Estimated import demand elasticities of other regions with respect to U.S. wheat price (1982-1984)

Region	USWHEPF
Africa and Middle East (WHSMNF1)	-0.267
High-Income E. Asia (WHSMNR4)	-0.159
Other Asia (WHSMNOAS)	-0.265 ^a
Other W. Europe (WHSMNOWE)	2.270 ^a

^aElasticity with respect to one period lagged price.

Table 12. Price transmission elasticities of wheat prices of other regions with respect to U.S. wheat prices (1982-1984)

Region	WHPGPU90	RGULFUS	USWHEPF
Canada			
Wheat export price	1.021 ^a		
Australia			
Wheat export price	1.004 ^a		
Argentina			
Wheat farm price			0.506 ^b
India			
Wheat farm price	0.589 ^a		
Japan			
Wheat resale price		0.255 ^b	

Note: Price transmission elasticities for the European Community, the centrally planned economies, and the rest of the world are zero.

^aElasticity is evaluated in nominal terms.

^bElasticity is evaluated in real terms.

Table 13 presents the RMS errors and RMS percent errors, and Table 14 presents Theil's forecast statistics. Most endogenous variables have very low RMS percent errors. Out of 75 endogenous variables, 56 variables have an RMS percent error of less than 20 percent. Variables with high RMS percent errors are USWHEPRF, WHSMNE2, WHSMNIN, WHSMNSU, WHSTCHSU, WHSMNE8, and WHSMNOWE. Some of these variables are of small magnitude; thus, any small error of prediction creates a high proportion of error when such error is compared to the small actual values. The export and import variables carry high RMS errors, because they are excess supplies and excess demands. Simulation errors from other domestic variables accumulate and are transferred to the export and import variables. As indicated above, however, most of the variables have a very low RMS percent error.

Theil's forecast errors of most simulation variables are from disturbance terms rather than from intercept or regression terms. As described above, for a good fit of the model the values of UM and UR should be close to zero and UD should be close to one. This is the case for most of the variables reported in Table 13. This shows that the model performs satisfactorily.

Uses of the Model

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

Table 13. Root mean square error and root mean square percentage error from the dynamic simulation

Variable	N	RMS Error	RMS % Error
RGULFUS	17	23.828	21.296
USWHEAHF	17	4.447	7.223
USWHEAPF	17	4.983	7.074
USWHEES	17	124.380	22.105
USWHEFE	17	57.744	42.834
USWHEFO	17	6.987	1.174
USWHEFPC	17	0.031	1.174
USWHEFRE	17	124.380	45.484
USWHENPF	17	14.959	41.743
USWHEPF	17	0.628	19.299
USWHEPHF	17	0.014	1.540
USWHEPRF	17	0.219	412198
USWHEQP	17	161.100	7.988
USWHEQPF	17	170.120	8.300
USWHESD	17	6.809	8.076
USWHESMN	17	114.430	10.013
USWHEYDF	17	0.717	2.217
WHPGPU90	17	27.213	18.025
BAGPICAE	17	12.003	15.301
BAPOBCA1	17	8.449	11.828
CKPMKCA	17	5.724	6.959
RSPM1CA	17	13.677	7.095
WHAHHCA	17	0.692	8.335
WHAHHCAE	17	0.694	8.353
WHCOTCA	17	1.989	18.441
WHGPICAE	17	14.034	13.870
WHPOBCA	17	17.529	15.553
WHPXECA	17	34.321	19.360
WHSPRCA	17	1.258	8.350
WHUFECA	17	0.294	15.031
WHUHTCA	17	0.035	1.899
WHUSECA	17	0.075	9.189
WHUXNCA	17	1.509	11.614
GWPFMAU	17	13.780	13.462
SGPFMAU	17	431.190	6.194
SHCOTAU	17	20.206	13.311
WHAHHAU	17	1.209	12.999
WHCOTAU	17	0.754	25.073
WHPEXAU	17	30.471	21.069
WHPFMAU	17	2936.350	21.322
WHPHCAU	17	34.872	27.459
WHSMNAU	17	1.422	16.891
WHSRAU	17	1.531	13.015
CECOTAR	17	0.964	1.734
SGPFMARR	17	16.368	6.424

Table 13. Continued

Variable	N	RMS Error	RMS % Error
WHAHHAR	17	345.420	7.702
WHPFMARR	17	27.011	8.161
WHSMNAR	17	638.470	33.426
WHSPRAR	17	564.130	7.708
WHUDTAR	17	346.470	7.935
COPTHEØ	17	2.523	1.533
PYSPRE2	17	88.333	2.126
SMPFMEØ	17	8.000	4.806
WHAHHE2	17	138.680	0.869
WHCOTE2	17	702.400	7.720
WHSMNE2	17	1700.900	316.820
WHSPRE2	17	472.350	0.869
WHUFEE2	17	934.00	7.264
WHUHTE2	17	270.220	0.765
WSPIEØ	17	3.531	2.497
WSPTHEØ	17	5.843	3.344
WHAHHIN	17	0.805	4.250
WHCOTIN	17	0.814	13.816
WHPFMIN	17	146.660	12.265
WHSMNIN	17	1.600	507.100
WHSPRIN	17	1.068	4.163
WHUDTIN	17	1.503	5.355
NETMJP	17	0.203	3.540
WHFODJP	17	0.123	2.097
WHRESPJP	17	27.277	29.023
WHSMNSU	17	2.447	156.68
WHSTCHSU	17	3.850	119.020
WHUDTSU	17	4.620	4.740
WHAHHCN	17	0.323	1.220
WHSMNCN	17	1.809	50.663
WHSPRCN	17	0.483	1.220
WHUDTCN	17	1.848	4.015
WHAHHE8	17	0.362	3.695
WHSMNE8	17	1.459	62.553
WHSPRE8	17	1.081	3.695
WHUDTE8	17	1.393	4.256
WHSMNF1	17	1912.440	16.036
WHSMNOAS	17	736.210	10.548
WHSMNOWE	17	300.200	72.969
WHSMNR4	17	213.270	6.601

Table 14. Theil's forecast error measures

Variable	N	MSE	MSE	Decomposition		
			Bias (UM)	Reg. (UR)	Dist. (UD)	Accuracy (U1)
RGULFUS	17	567.760	0.000	0.002	0.998	0.200
USWHEAHF	17	19.779	0.001	0.007	0.992	0.071
USWHEAPF	17	24.829	0.001	0.004	0.996	0.070
USWHEES	17	15471.160	0.001	0.009	0.990	0.123
USWHEFE	17	3334.360	0.008	0.010	0.982	0.293
USWHEFO	17	48.825	0.003	0.039	0.958	0.012
USWHEFPC	17	0.001	0.005	0.011	0.984	0.012
USWHEFRE	17	15471.160	0.001	0.069	0.930	0.338
USWHENPF	17	223.760	0.001	0.168	0.831	0.277
USWHEPF	17	0.394	0.009	0.274	0.717	0.207
USWHEPHF	17	0.0002	0.001	0.016	0.983	0.015
USWHEPRF	17	0.048	0.005	0.093	0.902	0.349
USWHEQP	17	25953.680	0.013	0.052	0.934	0.078
USWHEQPF	17	28941.510	0.001	0.006	0.993	0.081
USWHESD	17	46.367	0.001	0.001	0.998	0.078
USWHESMN	17	13093.990	0.001	0.005	0.994	0.096
USWHEYDF	17	0.514	0.008	0.010	0.982	0.022
WHPGPU90	17	740.570	0.004	0.286	0.710	0.200
BAGPICA	17	144.070	0.000	0.023	0.977	0.142
BAPOBCA1	17	71.386	0.000	0.005	0.995	0.100
CKPMKCA	17	32.767	0.058	0.000	0.941	0.069
RSPM1CA	17	187.070	0.086	0.003	0.912	0.049
WHAHCA	17	0.479	0.014	0.087	0.899	0.065
WHAHCAE	17	0.482	0.012	0.085	0.903	0.065
WHCOTCA	17	3.956	0.054	0.004	0.942	0.142
WHGPICA	17	196.960	0.016	0.066	0.919	0.115
WHPOBCA	17	307.250	0.009	0.182	0.810	0.164
WHPXECA	17	1177.900	0.017	0.375	0.608	0.205
WHSPRCA	17	1.583	0.016	0.011	0.973	0.065
WHUFECA	17	0.087	0.049	0.459	0.492	0.141
WHUHTCA	17	0.001	0.012	0.000	0.988	0.019
WHUSECA	17	0.006	0.009	0.044	0.948	0.077
WHUXNCA	17	2.278	0.031	0.122	0.847	0.101
GWPFMAU	17	189.890	0.002	0.000	0.998	0.068
SGPFMAU	17	185921	0.002	0.010	0.988	0.047
SHCOTAU	17	408.260	0.042	0.348	0.611	0.136
WHAHHAU	17	1.462	0.193	0.004	0.804	0.121
WHCOTAU	17	0.569	0.351	0.148	0.501	0.166
WHPEXAU	17	928.46	0.011	0.425	0.563	0.243
WHPFMAU	17	8622143	0.016	0.453	0.531	0.243
WHPHCAU	17	1216.050	0.018	0.553	0.429	0.267
WHSMNAU	17	2.022	0.211	0.022	0.768	0.147
WHSPRAU	17	2.345	0.239	0.024	0.737	0.115

Table 14. Continued

Variable	N	MSE	MSE	Decomposition		Accuracy (U1)
			Bias (UM)	Reg. (UR)	Dist. (UD)	
CECOTAR	17	0.929	0.000	0.123	0.876	0.017
SGPFMARR	17	267.920	0.001	0.002	0.997	0.068
WHAHHAR	17	119317	0.008	0.004	0.988	0.065
WHPFMARR	17	729.590	0.002	0.258	0.740	0.080
WHSMNAR	17	407638	0.000	0.003	0.997	0.134
WHSRAR	17	318247	0.010	0.011	0.979	0.064
WHUDTAR	17	120042	0.026	0.155	0.819	0.079
COPTHEO	17	6.365	0.004	0.030	0.966	0.015
PYSPRE2	17	7802.750	0.000	0.026	0.973	0.021
SMPFME0	17	63.994	0.007	0.000	0.993	0.044
WHAHHE2	17	19233.250	0.000	0.002	0.997	0.009
WHCOTE2	17	493370	0.021	0.054	0.925	0.070
WHSMNE2	17	2893075	0.000	0.000	1.000	0.242
WHSPRE2	17	223119	0.002	0.016	0.982	0.009
WHUFEE2	17	872358	0.003	0.011	0.986	0.066
WHUHTE2	17	73019.530	0.000	0.003	0.997	0.008
WSPIE0	17	12.470	0.024	0.019	0.957	0.024
WSPTHEO	17	34.136	0.014	0.051	0.935	0.032
WHAHHIN	17	0.648	0.002	0.000	0.998	0.040
WHCOTIN	17	0.662	0.000	0.006	0.994	0.105
WHPFMIN	17	21508.610	0.035	0.378	0.587	0.123
WHSMNIN	17	2.559	0.007	0.394	0.599	0.505
WHSPRIN	17	1.141	0.002	0.001	0.997	0.035
WHUDTIN	17	2.259	0.010	0.040	0.950	0.048
NETMJP	17	0.041	0.263	0.018	0.719	0.038
WHFODJP	17	0.015	0.280	0.171	0.549	0.022
WHRESPJP	17	744.040	0.123	0.079	0.798	0.228
WHSMNSU	17	5.990	0.001	0.035	0.964	0.190
WHSTCHSU	17	14.823	0.006	0.012	0.982	0.401
WHWDTSU	17	21.344	0.007	0.227	0.767	0.047
WHAHHCN	17	0.104	0.050	0.210	0.740	0.012
WHSMNCN	17	3.273	0.009	0.046	0.945	0.228
WHSPRCN	17	0.233	0.008	0.241	0.752	0.009
WHUDTCN	17	3.416	0.013	0.053	0.933	0.031
WHAHHE8	17	0.131	0.001	0.001	0.998	0.036
WHSMNE8	17	2.128	0.010	0.067	0.924	0.432
WHSPRE8	17	1.168	0.002	0.008	0.990	0.034
WHUDTE8	17	1.940	0.012	0.000	0.988	0.040
WHSMNF1	17	3657444	0.001	0.165	0.834	0.111
WHSMNOAS	17	542012	0.033	0.013	0.955	0.077
WHSMNOWE	17	90122.640	0.000	0.067	0.933	0.556
WHSMNR4	17	45484.080	0.001	0.004	0.995	0.076

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. However, the simulation analyses are conducted on microcomputers using Lotus 1-2-3. One of the major advantages of using 1-2-3 for the simulation analysis is that it provides an opportunity for the analyst to examine the changes occurring in endogenous variables during the iterative process.

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

- "Impacts of EEC Policies on U.S. Export Performance in the 1980s." W. H. Meyers, R. Thamadoran, and M. Helmar. Chapter 6 in Confrontation or Negotiation: United States Policy and European Agriculture. New York: Associated Faculty Press, 1985.
- "Macroeconomic Impacts on the U.S. Agricultural Sector: A Quantitative Analysis for 1980-84." W. H. Meyers, M. Helmar,

S. Devadoss, R. E. Young II, and D. Blanford. Chapter 24 in Embargoes, Surplus Disposal, and U.S. Agriculture, AER Number 564, ERS/USDA, December 1986.

- "An Export Disposal Policy for Wheat and Corn Stocks by the United States: A Quantitative Analysis for 1977-1984." W. H. Meyers, S. Devadoss, and M. Helmar. Chapter 19 in Embargoes, Surplus Disposal, and U.S. Agriculture, AER Number 564, ERS/USDA, December 1986.
- "The Iowa State University FAPRI Trade Model." W. H. Meyers, S. Devadoss, and M. Helmar. Proceedings of the International Agricultural Trade Research Consortium on Agricultural Trade Modeling: The State of Practice and Research Issues, Staff Report No. AGES861215, IED/ERS/USDA, June 1987, pp. 44-56.
- "Agricultural Trade Liberalizations: Cross-Commodity and Cross-Country Impact Products." W. H. Meyers, S. Devadoss, and M. Helmar. Journal of Policy Modeling, Vol. 9, No. 3 (November 1987), pp. 455-482.
- "FAPRI Ten-Year International Agricultural Outlook, July 1987." Food and Agricultural Policy Research Institute. Staff Report #4-87. University of Missouri-Columbia and Iowa State University, Ames.
- "FAPRI Ten-Year International Agricultural Outlook, March 1988." Food and Agricultural Policy Research Institute. Staff Report

#1-88. University of Missouri-Columbia and Iowa State University, Ames.

- "Commodity Market Outlook and Trade Implications Indicated by the FAPRI Analysis." W. H. Meyers, S. Devadoss, and B. Angel. Food Aid Projections for the Decade of the 1990s. Report of an ad hoc panel meeting, National Research Council, October 6-7, 1988, pp. 98-121.
- "Agricultural Market Outlook and Sensitivity to Macroeconomic, Productivity, and Policy Changes." S. R. Johnson, W. H. Meyers, P. Westhoff, and A. Womack. CARD Working Paper #87-WP36 (November 1988). Center for Agricultural and Rural Development, Iowa State University, Ames.
- "Policy Scenarios with the FAPRI Commodity Models." CARD Working Paper #88-WP41 (December 1988). Center for Agricultural and Rural Development, Iowa State University, Ames.
- "FAPRI U.S. and World Agricultural Outlook, May 1989." Food and Agricultural Policy Research Institute. Staff Report #2-89. University of Missouri-Columbia and Iowa State University.
- "The Impact of the U.S. Export Enhancement Program on the World Wheat Market." H.G. Brooks, S. Devadoss, and W. H. Meyers. CARD Working Paper #89-WP46 (December 1989). Center for Agricultural and Rural Development, Iowa State University, Ames.

References

- Bailey, K. W. "A Structural Econometric Model of the Canadian Wheat Sector." U.S. Department of Agriculture, Economic Research Service, Technical Bulletin Number 1733, 1987.
- Bailey, K. W. "A Structural Econometric Model of the World Wheat Market." U.S. Department of Agriculture, Economic Research Service, Technical Bulletin Number 1763, 1989.
- Brandow, G. E. "Demand for Factor and Supply of Output in a Perfectly Competitive Industry." Journal of Farm Economics 44(August 1962):895-899.
- Capel, R. E. "Predicting Wheat Acreage in the Prairie Provinces." Canadian Journal of Agricultural Economics 16(June 1968):87-89.
- Commonwealth Bureau of Census and Statistics. Yearbook of the Commonwealth of Australia. Various years. Canberra, Australia.
- de Gorter, Harry, and Brian Paddock. "The Impact of U.S. Price Support and Acreage Reduction Measures on Crop Output." International Trade Policy Division, Agriculture Canada, November 18, 1985. Unpublished manuscript.
- FAO. FAO Trade Yearbook. Various years. Rome, Italy.
- Food and Agricultural Policy Research Institute, University of Missouri-Columbia and Iowa State University. 1987. "FAPRI Ten-Year International Agricultural Outlook." FAPRI Staff Report #4-87.
- Food and Agricultural Policy Research Institute, University of Missouri-Columbia and Iowa State University. 1988. "FAPRI Ten-Year International Agricultural Outlook." FAPRI Staff Report #1-88.
- Houck, J.P., and Mary E. Ryan. "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs." American Journal of Agricultural Economics 54(May 1982):184-191.
- International Monetary Fund. International Financial Statistics. Washington, D.C.: International Monetary Fund. Various years.
- Jolly, R. W., and M. E. Martin. "An Econometric Analysis of Canada's Wheat and Feed Grain Economy with Emphasis on Commercial Agricultural Policy." Economic Report 78-9. Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, 1978.

- Krishna, R., and A. Chhibber. Policy Modeling of a Dual Grain Market: The Case of Wheat in India. Washington, D.C.: International Food Policy Research Institute, 1983.
- Mahama, Ramatu. "A Stochastic Simulation of the Impact of Price Insulation Policies on World Wheat Market Stability." Ph.D. dissertation, Iowa State University, Ames, 1985.
- Meilke, K. D. "Acreage Response to Policy Variables in the Prairie Provinces." American Journal of Agricultural Economics 58(August 1976):572-577.
- Meyers, W. H., M. D. Helmar, and S. Devadoss. 1986. "FAPRI Trade Model for the Soybean Sector: Specification, Estimation and Validation." Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa. Working Paper No. 86-SR2 (Revised).
- Sanderson, F. H. Japan's Food Prospects and Policies. Washington, D.C.: Brookings Institution, 1978.
- Spriggs, J. An Econometric Analysis of Canadian Grains and Oilseeds. U.S. Department of Agriculture, Economic Research Service, Technical Bulletin No. 1662, 1981.
- Spriggs, J. An Econometric Analysis of Export Supply of Grains in Australia. U.S. Department of Agriculture, Economics, Statistics, and Cooperative Service, FAER No. 150, 1978.
- Statistics Canada. Grain Trade of Canada. Ottawa, Canada: Statistics Bureau, Agricultural Branch. Various years.