FAPRI Trade Model for Feed Grains: Specification, Estimation, and Validation

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Introduction

This model was developed to quantify the trade and policy linkages for feed grains among the major importing and exporting regions. It is intended primarily for use in making intermediate-term projections and conducting policy impact analysis. Thus it is a relatively small partial equilibrium model but incorporates the most basic supply, demand, price, and policy variables in the feed grains sector.

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

Structure and Components of the Model

The feed grain model is designed as a dynamic nonspatial equilibrium model, since the major concern is not one of origin and destination of the feed grains traded but of the net quantity traded by each regions. The basic elements of a nonspatial equilibrium supply and demand model are illustrated in Figure 1. Net imports and exports are determined in the model but not trade flows between specific regions. The summation of net demands of importers (EDT) less the net supplies of other exporters (ESO) is the net excess demand facing the U.S. market (EDN). The necessary components of this model are detailed in the following equations:

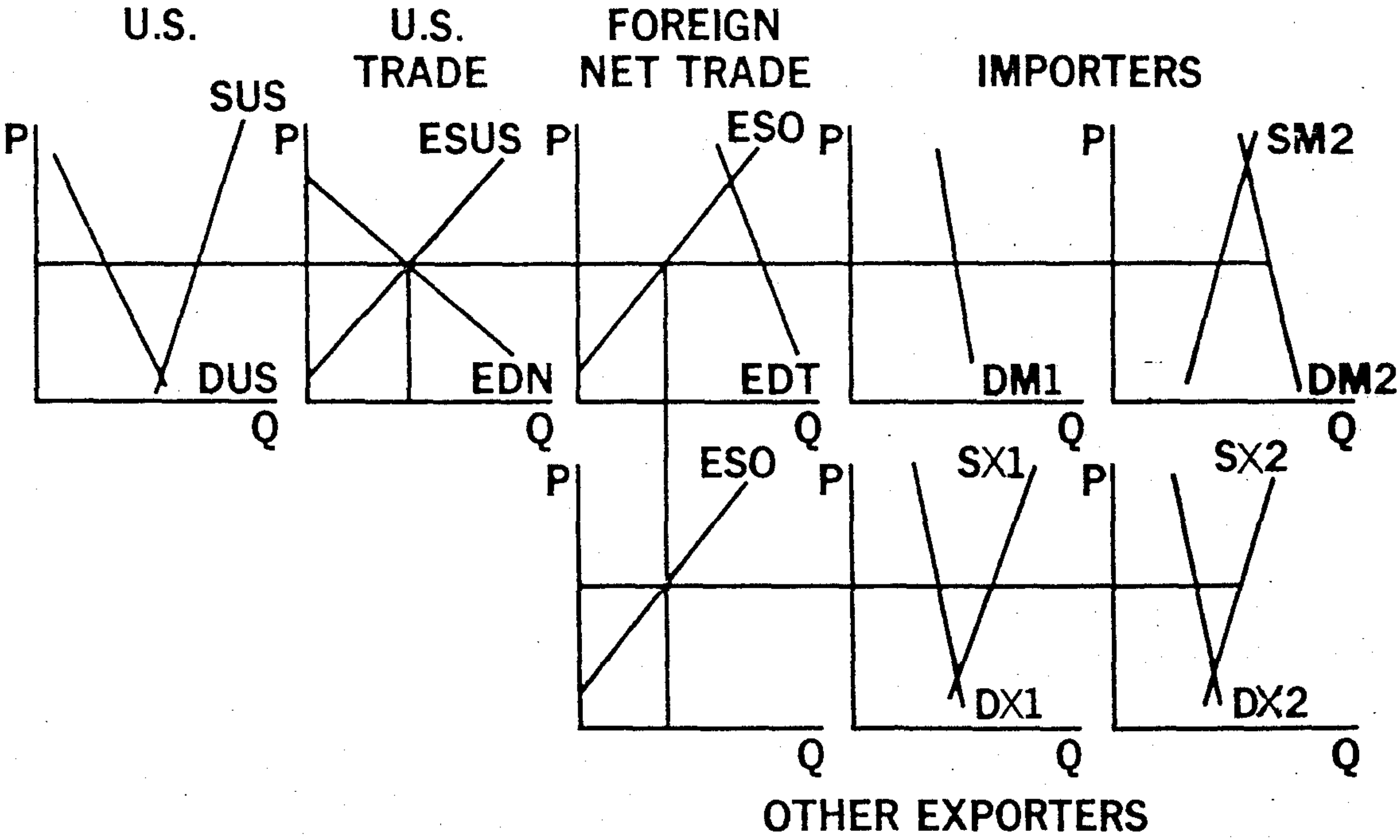


FIGURE 1. Illustration of regional supply and demand model

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

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

$$(3)\quad ESUS = h_u(P_u, Z_u) - f_u(P_u, X_u) \qquad \text{United States Exports}$$

$$(4)\quad ESUS = EDT - ESO \qquad \text{World Market Equilibrium}$$

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

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

where

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

Commodity Components

The feed grains sector is more complex than depicted here because it includes four distinct but closely related markets for corn, barley, sorghum, and oats. Within this group of feed grain crops supply and demand of the one or two most important crops have been modeled. Net import demands (export supply) of the endogenous commodities are added (with a weight equal to one) to the exogenous net trade of the minor commodities to find the net imports (exports) for all feed grains. The world market equilibrium identity is defined in terms of aggregate commodity of feed grains. A simple aggregation of feed grains is used in order to correspond to standard data reports issued by the USDA.

Regional Components

The feed grain model includes thirteen regions in differing levels of detail. The most complete submodels are for the United States, Canada, European Community, Argentina, Australia, and Thailand, where both supply and demand components are endogenous. The South Africa submodel consists of a net export function, with production exogenous. The demand side is modeled for the USSR, Spain, and Japan, but production is exogenous. Eastern Europe, High Income East Asia, and an aggregation of the rest of the world are exogenous regions. Submodels are planned for these regions in future expansions of the model. Table 1 summarizes the commodity and regional components that are endogenous and exogenous. Those countries for which parameters have not been directly estimated with econometric techniques have been assigned price and income response elasticities based on the best judgement of trade modeling specialists. These elasticities are converted to net import elasticities and reported in Appendix Table A.1.

Supply and Demand Components

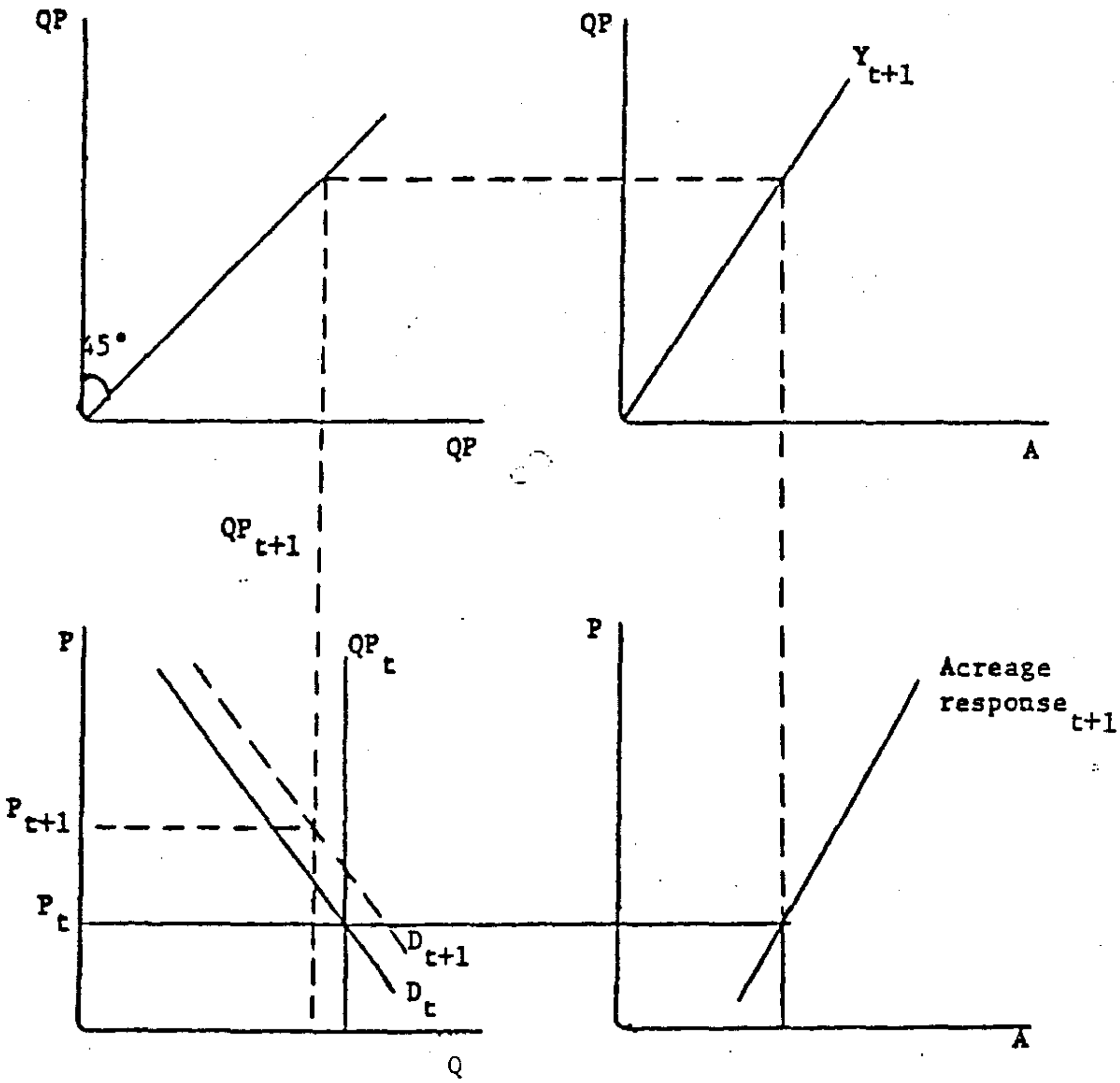
The acreage planted in any given year is not determined by the prices in that year but by expectations based on previous year prices and the policies announced in advance of planting. The corn yields in the two largest commercial markets are determined by current input prices and policy factors. Basically, supply for the current period is predetermined by information available during the previous period (Figure 2).

Feed grain is mainly used as feed and therefore the demand for feed grain is specified as a derived demand. The portion of feed grain directly consumed for food is rather small compared to total usage. In the EC and the United States, however the feed grain processed for nonfeed uses is significant and rising. Therefore the feed grain not used for feed in these regions is determined endogenously in the model. Where possible inventory behavior has been endogenized. In the remaining regions changes in stocks are exogenous.

Price Linkages

In the regions where internal prices are not insulated from the world market, domestic prices are linked to the U.S. corn, sorghum, or barley price. Bilateral exchange rates are included in the linkage equations. The U.S.

FIGURE 2. Illustration of dynamic interaction of soybean supply and demand



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

EN = Endogenous
EX = Exogenous

Table 1. Regional Components of Feed Grain Model

Country	Commodity	Area	Yield	Food Demand	Feed Demand	Stock	Total Consumption	Trade (net)
U.S.	Corn	EN	EN	EN	EN	EN		EN
	Sorghum, Barley, and Oats							EX
Canada	Corn	EN	EX					
	Barley	EN	EX					
	Corn and Barley					EX	EN	EN
	Sorghum and Oats							EX
Australia	Barley	EN	EX			EX	EN	EN
	Sorghum, Barley, and Oats							EX
Argentina	Corn	EN	EN			EX	EN	EN
	Sorghum	EN	EN			EX	EN	EN
	Barley and Oats							EX
Thailand	Corn and Sorghum	EN	EX			EX	EN	EN
	Barley and Oats							EX

EN = Endogenous
EX = Exogenous

Table 1. Regional Components of Feed Grain Model, Continued

Country	Commodity	Area	Yield	Food Demand	Feed Demand	Stock	Total Consumption	Trade (net)
South Africa	Feed Grain							EN
EC	Corn	EX	EN	EN	EN	EX		EN
	Barley	EN	EX	EN	EN	EX		EN
	Oats and Sorghum							EX
Spain	Corn	EX	EX			EX	EN	EN
	Sorghum, Barley, and Oats							EX
USSR	Feed Grains	EX	EX			EX	EN	EN
Japan	Corn and Sorghum	EX	EX			EN	EN	EN
	Barley and Oats							EX
High Income East Asia	Feed Grain							EX
Eastern Europe	Feed Grain							EX
Rest of the World	Feed Grain							EX

corn, sorghum, and barley prices are linked, so ultimately world feed grain prices are determined in relationship to the U.S. corn price.

Feed Grains Model Specification and Estimation

Annual data from 1967 to 1982 are used for estimating the model parameters. The model is mostly linear, however, fundamental identities, as well as many other basic variables (e.g. relative prices) form ratios that render the model nonlinear. Because of the nonlinearities and simultaneous nature of the model, nonlinear two stage least square is used for estimation of the parameters. The principal component technique is used to allow the first stage estimation since the number of exogenous variables in the model exceeds the number of data periods. Nine principal component estimators are calculated from all exogenous variables and are then used as instrumental variables in the second stage. The estimation results are reported in Tables 2-10, including R-square, Durbin Watson (DW), t-statistics, and elasticities. (Tables are presented following each country's discussion and variable definitions are given below the tables.) The following discussion describes the results of each country's domestic sector. The performance and validation of the whole model will then be considered.

United States Submodel: The United States is by far the largest exporter in the feed grain market. About 70 percent of world corn imports are supplied by the United States. Corn is the major feed grain export, although sorghum is starting to increase its share both in the domestic and export market. For the study period it is observed that corn and other feed grains are covered by the government agricultural policy program to provide various levels of protection to the feed grain growers. The major policies that are explicitly considered in this model are diversion payments and effective support rate for corn.

Corn acreage planted in the next period is significantly influenced by the ratio of expected effective support price for corn to soybean farm price, the relative value of expected diversion payment for corn with respect to corn farm price, the ratio of corn to soybean net returns per acre, the corn acreage planted in current year (see Equation 2.1).

The ratio of expected effective support price for corn to soybean farm price has a positive influence upon corn acreage as expected. Higher corn support prices induce producers to plant corn, while higher soybean prices induce farmers to plant more soybeans and less corn. The soybean effective support price was not used in this equation because the soybean price received by farmers has been above the soybean support price throughout most of the historical period; producers may mainly consider the farm price instead of the effective support price while making their planting decisions. The corn-to-soybean net returns ratio also displays a positive relationship with corn acreage. Acreage response is fairly inelastic with respect to the relative price as reflected by the net returns ratio. An increase in the ratio of expected diversion payment to farm price for corn will significantly decrease corn acreage planted. The estimated elasticity is -0.07.

Equation (2.2) is the identity for calculating corn acreage harvested in the next period, which is equal to expected acreage planted times the expected harvest rate. Expected corn production is derived in Equation (2.3) as expected acreage harvested times expected yield.

In the food demand equation (Equation 2.4), the real farm price for corn shows the right sign, even though it is statistically insignificant. The personal expenditures spent on nondurable goods and services is a very significant determinant of the food demand for corn.

The feed demand for corn is estimated as a function of real prices of corn, soymeal, and wheat, grain consuming animal units, the livestock price index, and the lagged feed demand for corn (see Equation 2.5). The demand elasticity with respect to corn price, soymeal price, and wheat price are -0.50, 0.10, 0.16, respectively. Grain consuming animal units (GCAUTST) and the livestock price (LIVIFE) are positively related to corn feed demand. Increase in livestock numbers will require more corn for feed. Higher livestock prices leads to more feed demand as livestock producers increase their herd sizes.

Equation (2.6) estimates ending commercial stocks including those under nine-month loan. The price elasticity of -1.40 is close to the elasticity of -1.24 obtained by Center for National Food and Agricultural Policy at University of Missouri and to -1.21 by Morton (1982) for feed grains. The coefficient on the government stocks, reserve plus CCC, is almost the same as Morton's 0.259 for feedgrains and is also consistent with the coefficient Baumes and Womack (1980) obtained in their analysis on private stocks of corn. These results indicate that a one-bushel increase in government stocks reduce private stocks by about 0.40 bushel, thus increasing total carryover by 0.60 bushel. Expected production in next year has a negative effect upon commercial ending stocks not only through expected price but also through producers' precautionary motive for holding inventory. On the other hand, current production is positively related to the level of ending stocks because larger levels of production may drive down the market price. The Production Credit Association's interest rate (IPCA) reflects the general market interest rate and acts as a measure of the opportunity cost for carrying stocks, and therefore, has a negative influence on ending stocks.

Equation (2.7) is the identity expressing total ending stocks as the sum of commercial ending stocks and the government stocks (the farmer-owned reserve ending stocks and the CCC ending stocks). Equation (2.8) is the domestic market clearing condition defining total supply equals total demand. Equation (2.9) is the world market clearing equation, which defines U.S. corn exports as equal to total world corn export minus competitors' total corn exports. Equations (2.10) and (2.11) represent net returns with three-year moving average yield for corn and soybeans, respectively.

Table 2. Corn model equations, United States

	Equation	R^2	D.W.
(2.1)	$\text{CORSAE} = 36.11 + \underset{\substack{(1.40)\\ {[0.04]}}}{8.87} * \left(\frac{\text{CORPEE}}{\text{SOYPF}}\right) - \underset{\substack{(-16.54)\\ {[-0.07]}}}{42.58} * \left(\frac{\text{CORPDE}}{\text{CORPF}}\right) + \underset{\substack{(2.24)\\ {[0.03]}}}{2.36} * \left(\frac{\text{CORNRE}}{\text{SNRE}}\right) + \underset{(8.52)}{0.51} * \text{LAG(CORSAE)}$	0.96	2.09
(2.2)	$\text{CORHAE} = \text{CORSAE} * \text{HARVPCT}$		
(2.3)	$\text{CORPGRE} = \text{CORHAE} * \text{CORSYGRE}$		
(2.4)	$\text{CORDH} = \underset{(8.23)}{222.49} - \underset{\substack{(-1.47)\\ {[-0.09]}}}{45.20} * \left(\frac{\text{CORPF}}{\text{WHEIWE}}\right) + \underset{\substack{(20.11)\\ {[0.75]}}}{0.35} * \text{CENE}$	0.98	1.40
(2.5)	$\text{CORDF} = 980.73 - \underset{\substack{(-3.04)\\ {[-0.50]}}}{1321.41} * \left(\frac{\text{CORPF}}{\text{FPINDEX}}\right) + \underset{\substack{(2.34)\\ {[0.10]}}}{3.77} * \left(\frac{\text{SOMPM}}{\text{FPINDEX}}\right) + \underset{\substack{(1.52)\\ {[0.16]}}}{322.02} * \left(\frac{\text{WHEPF}}{\text{FPINDEX}}\right) + \underset{\substack{(0.71)\\ {[0.40]}}}{16.31} * \text{GCAUTST} + \underset{\substack{(2.08)\\ {[0.13]}}}{276.50} * \text{LIVIFE} + \underset{(2.48)}{0.47} * \text{LAG(CORDF)}$	0.90	2.62

Table 2. (Continued)

	R^2	D.W.
(2.6) CORHCCE = 1930.60 − 825.71 * (CORPF / WHEIWE) − 0.29 * (CORHPRRE + CORHHUN)	0.82	2.65
(−8.60) (−5.23)		
[−1.40] [−0.20]		
− 0.07 * CORPGRE + 0.043 * LAG(CORPGRE) − 1.35 * IPCA		
(−3.50) (1.95) (−0.10)		
[−0.60] [0.36] [−0.02]		
(2.7) CORHT = CORHCCE + (CORHPRRE + CORHHUN)		
(2.8) CORDF = (CORPGR + LAG(CORHT) + CORMI) − (CORDH + CORHT + CORMX + CORDS)		
(2.9) CORMX = CORXTOT − (CORMXCC − CORMESR) + CORMXSPR + CORMG		
(2.10) CORNRE = [CORPF * (CORSYGR + LAG(CORSYGR) + 2 LAG(CORSYGR))/3] − CORVC		
(2.11) SNRE = [SOYPF * (SOYSY + LAG(SOYSY) + 2 LAG(SOYSY))/3] − SOYVC		

The U.S., Variable names and definitions[a]

Endogenous

CORDF: Corn feed demand, million bushels, UMAGDB
CORDH: Corn food demand, million bushels, UMAGDB
CORHAE: Corn next year acreage harvested, million acres, UMAGDB
CORHCCE: Corn, ending commercial stocks (including carryover under loan), million bushels, UMAGDB
CORHT: Corn, total ending stocks, million bushels, UMAGDB
CORMX: Corn, total U.S. exports, million bushesl, UMAGDB
CORNRE: Corn net return, $/acre
CORPF: Corn, price received by farmers, $/bushel
CORPGRE: Corn, next year production, million bushels
CORSAE: Corn next year acreage planted, million acres

Exogenous

CENI: Personal consumption expenditures next year, nondurable goods and services, billion dollars, UMAGDB.
CORDS: Corn, seed demand, million bushels, UMAGDB
CORHHUN: Corn, ending CCC (uncommitteed) stocks, million bushels
CORHPRRE: Corn, ending farmer-owned reserve stocks, million bushels
CORMESR: Corn, Soviet Union net imports from non-U.S. sources, 1000 metric tons
CORMG: Corn, total U.S. PL480 and AID exports, million bushels
CORMI: Corn, total U.S. imports, million bushels
CORMXCC: Corn, exports of South Africa, Argentina, and Thailand, 100 metric tons
CORMXSPR: Corn, total U.S. exports to Soviet Union and PRC, million bushels
CORPD1: Corn, expected effective diversion payment, $/bushel
CORPE1: Corn, expected effective price support, $/bushel
CORSYGR: Corn, yield for current year, bushel/acre
CORSYGRE: Corn, yield for nest year, bushel/acre
CORVC: Corn, variable costs of production, $/acre
CORXTOT: Corn, world export demand, million bushels
D80: Dummy variable, 1980=1, other years =0
D81: Dummy variable, 1981=1, other years =0
D82: Dummy variable, 1982=1, other years =0
FPINDEX: Farm price index, 1972=1, Ag. Prices-Annual Summary
GCAUTST: Grain consuming animal units, cal. year, UMAGDB
HARVPCT: Corn, expected harvest rate, %, computed
IPCA: PCA interest rate on loans, %, Ag. statistics
LIVIF1: Livestock price index, 1953-57 farm prices, 1966=1, UMAGDB
SNRE: Soybean, net returns per acre, $/acre, computed
SOMPM: Soymeal price, 44% protein, $/ton, UMAGDB
SOYPF: Soybean, price received by farmers, $/bushel
SOYSY: Soybean yield, bushel/acre
SOYVC: Soybean, variable costs of production, $/acre
WHEIW1: Wholesale price index, 1967=1
WHEPF: Wheat, average price received by farmers, July-June, $/bushel

<u>Canadian Submodel</u>: Since Canada is one of the major exporters of feed grains, the revenue of Canadian farmers largely depends on world prices. Furthermore, to protect the farmers from low prices, the Canadian Wheat Board (CWB) sets initial prices for barley and wheat delivered to CWB at a quota level set by CWB for each farmer. The initial prices set by the CWB are important since they determine the acreage allocation between wheat and barley. Farmers can also sell their products in the open market. The open market prices are called off-board prices. Since these two prices influence the acreage allocation they are included in the equation for barley acreage harvested. Wheat price enters this equation as a substitute price. The dummy variable for the year 1971 reflects the effect of the "Lower Inventory for Tomorrow" program. This equation does not have good fit. The own price elasticity of corn acreage harvested is estimated at 0.74. Barley total production is given as acreage harvested times yield per acre.

CWB does not exercise its policy over the corn market. Corn and barley are produced in different regions of Canada. The soybean is the substitute crop for corn in production. Therefore soybean price is included in the corn acreage. The other variables that enter the corn acreage equation are corn price, time trend, and a dummy variable. The own price elasticity is 0.26 and substitute price elasticity -0.21; both are very reasonable. The time trend is very significant in this equation. Corn total production is obtained by multipling the acreage and yield.

Table 3. Feed grain model equations, Canada

		R^2	D.W.
(3.1)	BAAHHCA = -88823.9 + 47.58*YEAR + 7167.97*LAG(BAPOBCA/WPIFPFCA)	0.5284	1.69
(t)	(-0.28) (0.30) (0.87)		
e	[0.744]		
	- 144.66*(BAPINCAP/WHPINCA) + 407.55*DM17374 - 0.926*OAAHHCA		
(t)	(-0.04) (0.63) (-0.51)		
e	[-0.023]		
	- 3421.38*LAG(WHPFMCA/WPIFPFCA) + 1052.995*DM171;		
(t)	(-1.09) (1.41)		
e	[-0.467]		
(3.2)	BASPRSA = BAYIHCA*BAAHHCA;		
(3.3)	COAHHCA = -101891 + 381.12*LAG(COPFMCA/WPIFPFCA) - 131.60*LAG(SBPFMCA/WPIFPFCA)	0.9497	1.02
(t)	(-12.76) (0.99) (-0.70)		
e	[0.264] [-0.205]		
	+ 51.925*YEAR - 38.35*DM17374);		
(t)	(12.89) (-0.40)		
(3.4)	COSPRCA = COYIHCA*COAHHCA;		
(3.5)	CBUDTCA = -3584.79 + 562.58*LVCACCA - 1754.57*(BAPOBCA/WPIFPFCA)	0.8982	1.99
(t)	(-0.90) (2.61) (-0.29)		
e	[-0.075]		
	+ 1442.56*(SMPWHCA/WPIFPFCA) + 39.503*CPILVCA + 952.1588*(WHPFMCA/WPIFPFCA);		
(t)	(1.87) (1.74) (0.27)		
e	[0.142] [0.248] [0.054]		

Table 3, continued

	R^2	D.W.
(3.6) COPFMCA = 3.089 + 0.9895*(COPFMU9*NIMEUCA); (t) (0.61) (18.63) e [0.959]	0.9036	1.78
(3.7) BAPOBCA = 13.545 + 0.816*(BAPFMU9*NIMEUCA); (t) (1.96) (11.80) e [0.84]	0.9128	1.10
(3.8) CBSMNCA = CBUDTCA - BASPRCA - COSPRCA + COCOTCA + BACOTCA - LAG(BACOTCA) - LAG(COCOTCA);		
(3.9) FGSMNCA = CBSMNCA + OSSMNCA;		

Canada, Variable names and definitions

Endogenous

BAAHHCA = Barley area harvested, 1000 ha, USDA
BAPOBCA = Off-board barley price, CA $/MT, Ag. Canada
BASPRSA = Barley production, 1000 MT, USDA
CBSMNCA = Corn and barley net imports, 1000 MT, USDA
CBUDTCA = Corn and barley domestic use, 1000 MT, USDA
COAHHCA = Corn area harvested, 1000 ha, USDA
COPFMCA = Corn producer price, CA $/MT, FAO
COSPRCA = Corn production, 1000 MT, USDA
FGSMNCA = Feed grain net imports, 1000 MT, USDA

Exogenous

BACOTCA = Barley ending stocks, 1000 MT, USDA
BAPINCAP = Barley initial price, CA $/MT, Ag. Canada
BAYIHCA = Barley yield MT/ha, USDA
COCOTCA = Corn yield, MT/ha, USDA
CPILVCA = Weighted average livestock product price index, FAO
DM171 = Dummy variable equal to one for 1971, otherwise zero
DM17374 = Dummy variable equal to one for 1973 and 1974, otherwise zero
LVCACCA = Grain consuming animal units, 1000 head
NIMEUCA = Exchange rate, CA $/US $, IMF-IFS
OAAHHCA = Oats area harvested, 1000 ha, USDA
OSSMNCA = Oats and sorghum net imports, 1000 MT, USDA
SBPFMCA = Soybean producer price, CA $/MT, Ag. Canada
SMPWHCA = Wholesale soymeal price, CA $/MT, Ag. Canada
WHPFMCA = Wheat producer price, CA $/Mt, FAO
WHPINCAP = Wheat initial price, CA $/MT, Ag. Canada
WPIFPFCA = Farm wholesale price index, FAO
YEAR = Year variable from 1967 to 1982

On the demand side, total domestic use of corn and barley as an aggregate is modeled. Wheat price and soymeal price enter this equaiton as substitute prices. The other variables included in this equation are barley price, livestock product price, and livestock animal units. The own price elasticity is -0.08 and cross price elasticities are 0.14 for soymeal price and 0.05 for wheat price. Equation 3.6 links Canadian corn price to U.S. corn price and 3.7 links Canadian barley price to U.S. barley price. The feed grain equilibrium identity is given in Equation 3.8.

Australia Submodel: Australia traditionally has been exporting barley, which is the major feed grain crop produced in this region. Wheat and barley are substitute crops both in production and consumption. The barley acreage equation features barley price, wheat price, lagged acreage, and two dummy variables for 1968 and 1971-1972. These dummy variables represent the switch in the Australian government domestic policies toward barley production. The own price elasticity is 0.34 and cross price elasticity is -0.29. As in the case of other regions, total production is given as acreage harvested times yield.

On the demand side, only total use of barley is modeled. This equation does not have a good fit. The own price elasticity of total use is -1.17 and cross price elasticity is 0.78. Equation 4.4 links the Australian barley price to the U.S. barley price. The equilibrium identity is given in Equation 4.5. The feed grain net trade is the sum of barley, sorghum, oats, and corn net trade, which is given in Equation 4.6.

Table 4. Feed grain model equations, Australia

		R^2	D.W.
(4.1) BAAHHAU =	947.91 - 8.50*DM17172 + 5.75*LAG(BAPFMAU/CPIAU)	0.7040	1.92
(t)	(1.07)(-0.03) (0.84)		
e	[0.344]		
	- 464.806*DM168 - 4.22*LAG(WHPFMAU/CPIAU) + 0.56*LAG(BAAHHAU);		
(t)	(-0.83) (-0.72) (2.51)		
e	[-0.29]		
(4.2) BASPRAU =	BAAHHAU*BAYIHAU;		
(4.3) BAUDTAU =	1662.37 - 10.32*(BAPFMAU/CPIAU) + 5.97*(WHPFMAU/CPIAU) - 53.687*DM170	0.2977	1.42
(t)	(4.34) (-1.80) (1.29) (-0.19)		
e	[-1.168] [0.776]		
	- 241.769*DM182;		
(t)	(-0.90)		
e			
(4.4) BAPFMAU =	-17.95 + 1.47*(BAPFMU9*NIMEUAU);	0.9071	0.89
(t)	(-1.75)(11.30)		
e	[1.121]		
(4.5) BASMNAU =	BAUDTAU - BASPRAU + BACOTAU - LAG(BACOTAU);		
(4.6) FGSMNAU =	BASMNAU + SOSMNAU;		

Australia, Variable names and definitions

Endogenous

BAAHHAU = Barley area harvested, 1000 ha, USDA
BAPFMAU = Barley producer price, AUS $/MT, FAO
BASPRAU = Barley production, 1000 MT, USDA
BASMNAU = Barley net imports, 1000 MT, USDA
BAUDTAU = Barley domestic use, 1000 MT USDA
FGSMNAU = Feed grain net imports, 1000 MT, USDA

Exogenous

BACOTAU = Barley ending stocks, 1000 MT, USDA
BAYIHAU = Barley yield, MT/ha, USDA
CPIAU = Consumer price index, IMF-IFS
DM168 = Dummy variable equal to one for year 1968, zero otherwise
DM170 = Dummy variable equal to one for year 1970, zero otherwise
DUM182 = Dummy variable equal to one for year 1982, zero otherwise
DUM17172 = Dummy variable equal to one for the years 1971 and 1972, zero otherwise
NIMEUAU = Exchange rate, AUS $/US $, IMF-IFS
SOSMNAU = Sorghum, oats, and corn net imports, 1000 MT, USDA

WHPFMAU = Wheat producer price, AUS $/MT, FAO

Argentina Submodel: Argentina is a major competitor of the United States in the feed grain export market. Argentina earns its foreign exchange through its agricultural exports and has a good potential to increase its production. Agricultural export is also a source of revenue for the government through the export tax. The corn area is influenced by both corn nd sorghum prices. The dummy variable DM17179 in the acreage equation is to capture the effect of drought in 1971 and 1979. The own price elasticity is 1.10 and the cross price elasticity is -.97. The yield is determined in the model and is estimated as a function of time trend and a dummy variable. The total production is given as acreage harvested times yield.

Nonfeed use of corn is very small and hence total use of corn is modeled. The corn total use is estimated as a function of corn price and sorghum price. Since corn is fed to hogs, hog ending stock is included in the corn feed demand.

For Argentina sorghum crop, in addition to corn, is also modeled. The sorghum acreage equation features sorghum price and dummy variables. Sorghum yield is estimated as a function of time trend and a dummy variable. Sorghum is fed to cattle. Therefore cattle numbers are included in the feed demand equation. The price linkage equations and market identities are given from Equations 5.9 to 5.13.

Table 5. Feed grain model equations, Argentina

		R^2	D.W.
(5.1)	COAHHAR = 1136.19 + 0.43*LAG (COAHHAR) + 13.735*LAG(COPFMAR/WPIAR)	0.5949	1.97
(t)	(0.52) (1.57) (2.64)		
e	[1.10]		
	- 13.85*LAG(SGPFMAR/WPIAR) - 344.82 * DM171179;		
(t)	(-1.61) (-0.85)		
e	[-0.97]		
(5.2)	COYIHAR = -152.84 + 0.0788*YEAR - 0.934*DM171591;	0.6085	2.26
(t)	(-3.31) (3.37) (-2.84)		
(5.3)	COSPRAR = COYIHAR*COAHHAR;		
(5.4)	COUDTAR = 2876.30 - 475.187*(COPFMAR/SGPFMAR) + 282.87*HGCOTAR	0.6608	2.88
(t)	(2.53) (-0.82) (1.03)		
e	[-0.145] [0.35]		
	- 734.34*DM170175 + 404.02*DM17173;		
(t)	(-2.34) (1.32)		
(5.5)	SGAHHAR = 210.368 + 0.184*LAG(SGPFMAR/WPIAR)	0.8670	2.12
(t)	(0.31) (0.07)		
e	[0.10]		
	- 809.399*DM171179 + 380.025*DM166570 + 362.32*DM1812;		
(t)	(-4.49) (4.54) (2.78)		
e			
(5.6)	SGYIHAR = -203.101 + 0.104*YEAR - 0.6385*DM171179;	0.9230	2.14
(t)	(-11.06) (11.21) (-4.84)		

Table 5, continued

```
                                                                                     R^2         D.W.

(5.7) SGSPRAR = SGYIHAR*SGAHHAR;

(5.8) SGUDTAR = -9891.52 - 6.37*(SGPFMAR/WPIAR) + 1.84*(COPFMAR/WPIAR)               0.6954      3.10
         (t)     (-3.16)(-1.27)                   (0.46)
          e             [-3.178]                  [0.978]

                + 221.524*CECOTAR + 1206.46*DM17073 + 3.23*(WHPFMAR/WPIAR);
         (t)       (3.84)             (3.99)           (2.47)
          e        [5.44]                              [2.52]

(5.9) COPFMAR = COPDFAR + (CORPF*39.368*NAMEUAR);

(5.10) SGPFMAR = SGPDFAR + (SGPFMU9*NAMEUAR);

(5.11) COSMNAR = COUDTAR + COCOTAR - COSPRAR - LAG(COCOTAR);

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

(5.13) FGSMNAR = SGSMNAR + COSMNAR + OBSMNAR;
```

Argentina, Variable names and definitions

Endogenous

COAHHAR = Corn area harvested, 1000 ha, USDA
COPFMAR = Corn producer price, Peso/MT, FAO
COSMNAR = Corn net imports, 1000 MT, USDA
COSPRAR = Corn production, 1000 MT, USDA
COUDTAR = Corn total domestic use, 1000 MT, USDA
COYIHAR = Corn yield, MT/ha, USDA
FGSMNAR = Feed grain net imports, 1000 MT, USDA
SGAHHAR = Sorghum area harvested, 1000 MT, USDA
SGPFMAR = Sorghum producer price, Peso/MT, World Bank
SGSMNAR = Sorghum net imports, 1000 MT, USDA
SGSPRAR = Sorghum production, 1000 MT, USDA
SGUDTAR = Sorghum domestic feed use, 1000 MT, USDA
SGYIHAR = Sorghum yield, MT/ha, USDA

Exogenous

CECOTAR = Ending stock of cattle, 1000 head, World Bank
COCOTAR = Ending stocks, 1000 MT, USDA
COPDFAR = Corn price differential, Peso/MT, Calculated
DM1812 = Dummy variable equal to one in 1981 and 1982, zero otherwise
DM166570 = Dummy variable equal to one in 1966, two in 1967,..., five in 1970, zero otherwise
DM170175 = Dummy variable equal to one in 1970 and 1975, zero otherwise
DM17073 = Dummy variable equal to one from 1970 to 1973, zero otherwise
DM17173 = Dummy variable equal to one in 1971 and 1979, zero otherwise
DM171591 = Dummy variable equal to one in 1971, 1975, 1979 and 1981, zero otherwise
DM171179 = Dummy variable equal to one in 1971 and 1979, zero otherwise
HGCOTAR = Hog ending stock, mil. head, World Bank
NAMEUAR = Exchange rate, Peso/US $, IMF-IFS
OBSMNAR = Oats and barley net imports, 1000 MT, USDA
SGCOTAR = Sorghum ending stocks, 1000 MT, USDA
SGPDFAR = Sorghum price differentials, Peso/MT, Calculated
WHPFMAR = Wheat producer price, Peso/MT, FAO
WPIAR = Wholesale price index, IMF-IFS

YEAR = Year variable from 1967 to 1982

Thailand Submodel: Like Argentina, Thailand earns most of its foreign exchange through export of agricultural products. Thailand's major exports include rice, cassava, corn, and sorghum. Even though sorghum was introduced not very logn ago, the production of sorghum has been increasing very significantly. Sorghum and corn are combined together in the model. The aggregate area planted for sorghum and corn features real corn price, time increasing trend in Thailand feed grain production, and real cassava and rice prices as substitute prices. Both cassava and rice compete for the planted acreage with feed grains. Table 6 reports the estimated results. The statistical properties of this equation are good, with 97 percent of the historical variations in the acreage harvested explained. The total production is given in the identity 6.2.

The domestic use of sorghum and corn is estimated as a function of real income, ratio of corn price over cassava price, and livestock product prices. The elasticity of the ratio of corn price over cassava price is -0.15. The income elasticity is 2.1. Equation 7.4. links the Thailand corn price to the U.S. corn price. The last two equations in Table 6 express the feed grain net trade formation.

Table 6. Feed grain model equation, Thailand

		R^2	D.W.
(6.1)	CSAHHTH = -1757.41 + 89.696*YEAR - 0.113*LAG(KVPFMTH/CPITH)	0.9704	2.00
(t)	(-10.05) (10.22) (-0.62)		
e	[-0.057]		
	+ 0.18*LAG(COPFMTH/CPITH) - 0.14*LAG(RIPFMTH_/CPITH);		
(t)	(1.82) (-2.06)		
e	[0.303] [-0.284]		
(6.2)	CSSPRTH = CSAHHTH*CSYIHTH;		
(6.3)	CSUDTTH = -621.56 + 2.34*(NANPDTH/CPITH)	0.9557	2.70
(t)	(-4.09) (3.75)		
e	[2.095]		
	+ 0.845*CPILVTH - 27.03*(COPFMTH/KVPFMTH);		
(t)	(0.79) (-1.27)		
e	[0.252] [-0.145]		
(6.4)	COPFMTH = -185.54 + 0.987*(COPFMTH/KVPFMTH);	0.8792	1.10
(t)	(-1.02) (9.80)		
e	[1.12]		
(6.5)	CSSMNTH = CSUDTTH - CSSPRTH + CSCOTTH - LAG(CSCOTTH);		
(6.6)	FGSMNTH = CSSMNTH + OBSMNTH;		

Thailand, Variable names and definitions

Endogenous

COPFMTH = Corn producer price, Baht/MT, FAO
CSAHHTH = Corn and sorghum area harvested, 1000 ha, USDA
CSSMNTH = Corn and sorghum net imports, 1000 MT, USDA
CSSPRTH = Corn and sorghum production, 1000 MT, USDA
CSUDTTH = Corn and sorghum total domestic use, 1000 MT, USDA
FGSMNTH = Feed grain net imports, 1000 MT, USDA

Exogenous

CPILVTH = Livestock product price index, FAO
CPITH = Consumer price index, IMF-IFS
CSCOTTH = Corn and sorghum ending stock, 1000 MT, USDA
CSUDTTH = Corn and sorghum total domestic use, 1000 MT, USDA
CSYIHTH = Corn and sorghum yield, MT/ha, USDA
KVPFMTH = Cassava producer price, Baht/MT, FAO
NANPDTH = GNP, purchase value, Bill Baht, IMF-IFS
NIMEUTH = Exchange rate, Baht/US $, IMF-IFS
OBSMNTH = Oats and barley net imports, 1000 MT, USDA
RIPFMTH = Rice producer price, Baht/MT, FAO

South Africa Submodel: Although South Africa is being considered as an exporter, in some years, because of the severe drought it has become a net importer. Only the net export equation is modeled for South Africa, which was originally developed by Denbaly (1984). Net export is estimated as a function of production, ending stocks, and incomes. The estimated results are reported in Table 7. This equation has good statistical property. The income elasticity of import is 2.01.

Table 7. Feed grain model equation, South Africa

	R^2	D.W.
(7.1) FGSMNZA = 1168.85 - 0.67*FGSPRZA - 1.01*LAG(FGCOTZA)	0.9694	2.54
(t) (2.49)(-18.24) (-7.70)		
e [2.58]		
+ 0.0967*(NANPGZA/CPIZA);		
(t) (7.00)		
e [2.01]		

South Africa, Variable names and definitions

Endogenous
FGSMNZA = Feed grain net imports, 1000 MT, USDA

Exogenous
CPIZA = Consumer price index, IMF-IFS
FGCOTZA = Feed grain ending stocks, 1000 MT, USDA
FGSPRZA = Feed grain production, 1000 MT, USDA
NANPGZA = Nominal GNP, mil. of Rand, IMF-IFS

European Communities (10) Submodel: The European Communities traditionally have been a large customer for U.S. feed grain. EC exports of barley, except for two years of the period covered in this study, have been increasing steadily. In the corn market a declining trend in the corn import by the EC is observed. For example, the corn import declined by 50 percent from 1980 to 1982. This decline in the corn import is due to the recent substitution of corn glutten soymeal and soft wheat in feed use. In the past year the EC has actually become a net exporter of feed grains.

The EC feed grain market is completely insulated from the world feed grain market. There are a set of policy prices such as target, threshold, and intervention prices* that are used in the insulation process. Since these prices are announced prior to the planting season, farmers formulate their planting decisions based on these prices. Figure 3 illustrates the formation of the feed grain import demand of the EC. Since threshold prices are minimum import price they are also close to wholesale prices and hence are used in modeling the EC feed grain market. Because of the importance of corn and barley in the EC, only the markets related to these two commodities are modeled in this study.

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*See Appendix

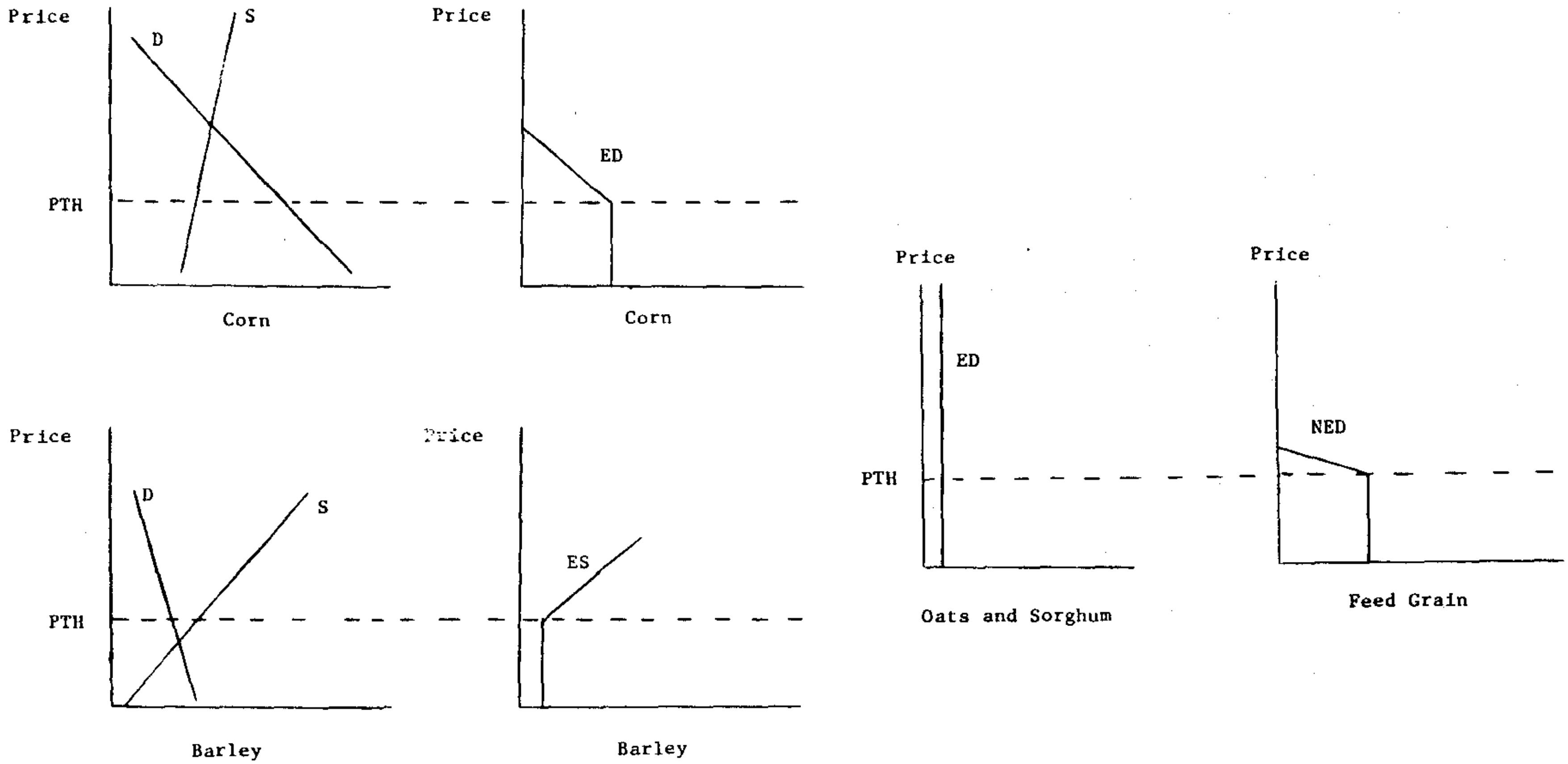


Figure 3. Formation of EC(10) Feed Grain Net Import Demand

PTH = Threshold price   Note: Corn and barley threshold price are assumed equal in this graph.
S= supply   NED = Net Import Demand   ED = excess demand
D = demand   ES = excess supply

Oats and sorghum acreage is included as an explanatory variable in the barley acreage equation to reflect the substitution that has taken place . The other variables that enter the barley acreage equation are barley threshold price and a dummy variable. The estimated equations are presented in Table 8. The barley threshold price is insignificant and has an elasticity of 0.70. The oats acreage is significant at the 5 percent level. Barley total production is given as acreage times yield.

For corn, yield is endogenized instead of acreage because the growth in production is due to a yield increase. Corn yield is estimated as a function of corn threshold price, fertilizer price, time trend for technology, and a dummy variable. The ratio of corn threshold price over fertilizer price is significant at the 5 percent level and implies a price elasticity of 0.39 for corn yield. Corn total production is obtained by multiplying the acreage and the yield.

On the demand side, feed use and food use equations are estimated for both corn and barley equations. Food use of corn and barley has been increasing significantly. Corn domestic food use features real corn threshold price, which is highly significant and has an elasticity of -0.71. Corn food use is estimated as a function of real income, a dummy variable, and the ratio of corn threshold price over soymeal price. The income elasticity is 0.88.

Barley real threshold price and real income enter the barley food use equation. Both variables are very significant. The price and income elasticities of barley food demand are -0.39 and 0.58, respectively. The barley food demand features real income, real barley threshold price, and real soymeal price as substitute price. The own price and cross price elasticities are -0.26 and 0.025, respectively. The net imports of corn, barley, and feed grains are derived from the identities in the last three equations of Table 8.

Table 8. Feed grain model equations, European Communities(10)

		R^2	D.W.
(8.1)	BAPTHEO = 3.04 + 0.985*COPTHEO;	0.9986	1.11
(t)	(1.92)(97.13)		
e	[0.98]		
(8.2)	COUHTEO = 10838.16 - 31.33*(COPTHEO/CPIEO);	0.7773	1.68
(t)	(15.99) (-7.10)		
e	[-0.705]		
(8.3)	COUFEEO = 3629.70 + 17.75*(NANPDEO/CPIEO) - 1169.3*(COPTHEO/SMPIMEO)	0.8204	2.11
(t)	(0.93) (6.30) (-0.67)		
e	[0.88] [-0.05]		
	+ 337.786*DM180;		
(t)	(0.30)		
(8.4)	COYIHEO = -368.97 + 0.188*YEAR + 1.335*(COPTHEO/CPIFPREO) + 0.679*DM1812;	0.8633	2.43
(t)	(-2.75) (2.81) (1.39)		
e	[0.394] [2.57]		
(8.5)	COSPREO = COYIHEO*COAHHEO;		
(8.6)	BAAHHEO = 10726.51 + 4.29*BAPTHEO - 0.7985*OSAHHEO - 479.65*DM1812;	0.7969	2.18
(t)	(6.32) (0.89) (-1.94) (-2.11)		
e	[0.70]		
(8.7)	BASPREO = BAYIHEO*BAAHHEO;		

Table 8. continued

```
                                                                              R^2         D.W.

(8.8) BAUHTEO = 7237.45 - 24.01*(BAPTHEO/CPIEO) + 4.793*(NANPDEO/CPIEO);     0.8568       1.13
        (t)       (4.36) (-5.91)                  (3.68)
         e               [-0.389]                 [0.58]


(8.9) BAUFEEO = 30936.83 + 1.645*(NANPDEO/CPIEO) - 49.255*(BAPTHEO/CPIEO)   0.7980       1.53
        (t)       (10.11) (0.67)                   (-5.46)
         e                [0.066]                  [-0.263]

                + 4.187*(SMPIMEO/CPIEO);
        (t)      (0.80)
         e       [0.025]

(8.10) COSMNEO = COUFEEO + COUHTEO - COSPREO - LAG(COCOTEO) + COCOTEO;

(8.11) BASMNEO = -BASPREO + BACOTEO - LAG(BACOTEO) + BAUHTEO + BAUFEEO;

(8.12) FGSMNEO = COSMNEO + BASMNEO + OASMNEO + SGSMNEO;
```

European Communities(10), Variable names and definitions

Endogenous

BAAHHEO = Area harvested, 1000 ha, USDA
BAPTHEO = Barley threshold price, ECU/MT, Eurostat
BASMNEO = Barley net imports, 1000 MT, USDA
BASPREO = Barley production, 1000 MT, USDA
BAUFEEO = Domestic feed use, 100 MT, USDA
BAUHTEO = Domestic food use, 1000 MT, USDA
COSMNEO = Corn net imports, 1000 MT, USDA
COSPREO = Corn production, 1000 MT, USDA
COUFEEO = Corn domestic feed use, 100 MT, USDA
COUHTEO = Corn domestic food use, 1000 MT, USDA
COYIHEO = Corn yield, MT/ha, USDA
FGSMNEO = Feed grain net imports, 1000 MT, USDA

Exogenous

BACOTEO = Ending stocks, 1000 MT, USDA
BAYIHEO = Barley yield, MT/ha, USDA
COAHHEO = Area harvested, 1000 ha, USDA
COCOTEO = Ending stocks, 1000 MT, USDA
COPTHEO = Corn threshold price, ECU/MT, FAO
CPIEO = Consumer price index, USDA
CPIFREO = Fertilizer price index, USDA
DM1812 = Dummy variable equal to one in 1981 and 1982, zero otherwise
DM180 = Dummy variable equal to one in 1980, zero otherwise
NANPDEO = GDP nominal, bill of ECU, USDA
OASMNEO = Oats net imports, 1000 MT, USDA
OSAHHEO = Oats and sorghum are harvested, 1000 ha, USDA
SGSMNEO = Sorghum net imports, 1000 MT, USDA
SMPIMEO = Soymeal import price, ECU/MT, USDA
YEAR = Year varible from 1966 to 1982

Spain Submodel: Spain is one of the large importers in the world feed grain market. The income growth in Spain has caused an increase in meat demand, which has led to a higher demand for feed grains. The major feed grain imported by Spain is corn and most of the corn import originates from the United States. Since production of corn in Spain is very small, corn production is considered exogenous in the model. Only total domestic use of corn is modeled. Real corn price and real income enter the corn domestic use equation.

Table 9 reports the estimated results of the Spain submodel. The price elasticity of corn demand is -0.21 and income elasticity of corn demand is 1.14. The price transmission is given in Equation 9.2. Feed grain net imports is derived from the equilibrium identity 9.3.

Table 9. Feed grain model equation, Spain

		R^2	D.W.
(9.1)	COUDTES = 1004.01 - 0.062*(COPFMES/CPIES) + 0.448*(NANPGES/CPIES);	0.9032	1.55
(t)	(0.41)(-1.14) (4.24)		
e	[-0.2056] [1.135]		
(9.2)	COPFMES = 2487.47 + 1.277*(COPFMU9*NIMEUES);	0.8685	0.75
(t)	(2.56) (9.30)		
e	[0.752]		
(9.3)	COSMNES = COUDTES - COSPRES + COCOTES - LAG(COCOTES);		
(9.4)	FGSMNES = COSMNES + SBSMNES_;		

Spain, Variable names and definitions

Endogenous
COPFMES = Corn producer price, Peseta/MT, FAO
COSMNES = Corn net import, 1000 MT, USDA
COUDTES = Corn total use, 1000 MT, USDA
FGSMNES = Feed grain net import, 1000 MT, USDA

Exogenous
COCOTES = Corn ending stock, 1000 MT, USDA
COSPRES = Corn production, 1000 MT, USDA
CPIES = Consumer price index, IMF-IFS
NANPGES = Nominal GNP, million peseta, IMF-IFS
SBSMNES = Sorghum, barley, and oats net import, 1000 MT, USDA

Soviet Union Submodel: Until 1970 the Soviet Union was a significant net exporter of feed grains. Since then, because of unstable weather and the economic policies of the Soviet Union, it has become a major net importer of feed grains. The major feed grains grown traditionally in the Soviet Union are oats and barley, but corn has been introduced into the Soviet agriculture in the past two decades. The grain embargo of 1980 has significantly changed Soviet Union policies toward grain imports. Those changes include the change in the cropping pattern, i.e., moving away from the crops that are abundant in the world market, like wheat, to the crops that are supplied by fewer large suppliers in the world market, like corn.

Feed grain production in the Soviet Union is assumed to be exogenous since not enough data were available. Feed grains are largely used for feed and their use is constrained by production and imports. Income is a significant factor that influences the feed demand through increased demand for meat products. Therefore, income, feed grain acreage harvested, and feed grain yield enter the feed demand equation. The estimated results are reported in Table 10. Both acreage and yield are significant in that equation. Equation 10.2 represents the net import demand of feed grain as a result of an equilibrium identity.

Table 10. Feed grain model equations, Soviet Union

Equation	R^2	D.W.
(10.1) FGUDTSU = -68072.9 - 1733.85*DM171 + 23.97*NANPGSU + 1.799*FGAHHSU	0.9718	2.18
(t) (-6.48) (-0.42) (2.13) (5.57)		
e [0.374]		
+ 24047.34*FGYIHSU;		
(t) (5.66)		
e		
(10.2) FGSMNSU = FGUDTSU + FGCOTSU - (FGAHHSU*FGYIHSU) - LAG(FGCOTSU);		

Soviet Union, Variable names and definitions

Endogenous

FGSMNSU = Feed grain net import, 1000 MT, USDA
FGUDTSU = Feed grain total use, 1000 MT, USDA

Exogenous

DM171 = Dummy variable equal to 1 for 1971, zero otherwise
FGAHHSU = Feed grain area harvested, 1000 ha, USDA
FGCOTSU = Feed grain ending stock, 1000 MT, USDA
FGYIHSU = Feed grain yield, MT/ha, USDA
NANPGSU = Real income, Soviet Union, billion of 1980 US $, CIA

Japan Submodel: Similarly to the Thailand submodel, in the Japanese submodel sorghum and corn are combined together. Barley is the major feed grain crop produced in Japan. Its production and consumption, however, have been declining very significantly. Corn and sorghum are the major feed grain imports used in the feed mixture. Over 95 percent of the total use of corn and sorghum is imported and most of the imports come from the United States. It is reasonable to assume therefore that production of these crops is exogenous.

Total domestic use, which is primarily feed use, is endogenized in the model. Rice production is highly subsidized, which results in excess accumulation of stock. Government policy encourages the substitution of rice for the corn and sorghum in feed use. Because of this government policy rice fed to livestock enters the domestic use equation. The other variables included in the equation are real corn price, real soymeal price, and grain consuming animal unit. This equation has excellent statistical properties, with R^2 of 0.97. The own price elasticity is -0.20 and cross price elasticity is 0.16. Japanese corn price is linked to the U.S. corn price in Equation 11.2.

The other behavioral equation in the Japanese submodel is the stock demand equation. To protect the Japanese beef market from higher grain prices, government holds grain stocks. Because of this government policy livestock product prices and grain consuming animal units are included in the stock demand equation to reflect the factors determining the government policy. The other variables that enter this equation are real sorghum price and corn wholesale price. The lagged stock demand corn price elasticity is -0.45 and livestock product price elasticity is 0.96. Equations 11.4 and 11.5 are feed grain imports derived from the equilibrium identity.

Table 11. Feed grain model equations, Japan

```
                                                                                            R2          D.W.

(11.1) SCUDTJP = -4151.72 - 1.62*RIUFEJP + 2.02*(SMPWHJP/WPIJP)                              0.9667      2.03
          (t)      (-1.65)(-3.45)         (1.87)
           e                              [0.157]

                 + 0.899*LVCACJP - 0.06*LAG(COPWHJP/WPIJP);
          (t)      (11.17)         (-2.28)
           e                       [-0.198]

(11.2) SCCOTJP = -385.667 + 0.086*LAG(SCCOTJP) - 0.0052*(SGPFMJP/WPIJP)                      0.9013      1.45
          (t)      (-0.33)  (0.31)                (-1.05)
           e                                      [-0.46]

                 + 0.075*LVCACJP + 2.977*LAG(LVPREJP) - 0.013*LAG(COPWHJP/WPIJP)
          (t)      (1.50)          (1.54)               (-1.05)
           e                       [0.956]              [-0.46]

                 - 479.88*DM812
          (t)      (-2.50)

(11.3) COPWHJP = 2236.66 + 1.25*(COPFMU9*NIMEUJP);                                           0.7660      2.07
          (t)              (6.64)
           e               [0.968]

(11.4) SCSMNJP = SCUDTJP + SCCOTJP - SCSPRJP - LAG(SCCOTJP);

(11.5) FGSMNJP = SCSMNJP + OBSMNJP;
```

Japan, Variable names and definitions

Endogenous

COPWHIP = Corn wholesale imported price, Yen/MT, Feed Monthly
FGSMNJP = Feed grain net imports, 1000 MT, USDA
SCCOTJP = Sorghum and corn ending stocks, 1000 MT, USDA
SCSMNJP = Corn and sorghum net imports, 1000 MT, USDA
SCUDTJP = Corn and sorghum total domestic use, 1000 MT, USDA

Exogenous

DM1812 = Dummy variable equal to one in 1981 and 1982, zero otherwise
LVCACJP = Grain consuming animal units, 1000 head
LVPREJP = Livestock retail price, calculated from MERC
NIMEUJP = Exchange rate, Yen/$ US, IMF-IFS
RIUFEJP = Rice feed use, 1000 MT, USDA
SGPFMJP = Sorghum producer price, Peso/MT, USDA
SMPWHJP = Wholesale soymeal price, Yen/MT, Feed Monthly
WPIJP = Wholesale price index, IMF-IFS

Rest of the World: The regions of the world not explicitly modeled are Eastern Europe, High Income East Asia, and other regions. The other regions are aggregated as one region in the Rest of the World. The net imports of these three regions, i.e., Eastern Europe, High Income East Asia, and Rest of the World enter the world trade equilibrium as exogenous variables.

For the convenience of readers the supply and demand elasticities of the model are summarized in Tables 12 and 13. Price transmission elasticities are given in Table 14.

Table 12. Summary of Estimated Production Elasticities from the Feed Grains Trade Model

Regions and Components	Elasticities of— Corn Price	Sorghum Price	Barley Price	Wheat Price	Soybean Price	Cassava Price	Rice Price
U.S.							
Corn	0.04				-0.04		
Canada							
Barley			0.74	-0.47			
Corn	0.26				-0.20		
Australia							
Barley			0.34	-0.29			
Argentina							
Sorghum		0.10					
Corn	1.10	-0.97					
Thailand							
Corn and Sorghum	0.30					-0.06	-0.28
EC(10)							
Corn	0.39						
Barley			0.70				

Table 13. Summary of Estimated Domestic Demand Elasticities from the Feed Grains Trade Model

Regions and Components	Elasticities of: Corn Price	Sorghum Price	Barley Price	Soymeal Price	Wheat Price	Cassava Price	Livestock Product Price	Income
U.S.								
Corn food	-0.09							0.75
Corn feed	-0.50			0.10	0.16		0.13	
Corn stock	-1.40							
Canada								
Barley and corn total use			-0.08	0.14	0.05		0.25	
Australia								
Barley total use			-1.16		0.78			
Argentina								
Corn total use	-0.14	0.14						
Sorghum total use	0.98	-3.17						
Thailand								
Corn and sorghum total use	-0.14					0.14	0.25	
South Africa								
Feed grain net import								2.00
EC(10)								
Corn feed	-0.05			0.05				0.88
Corn food	-0.70							
Barley feed			-0.26	0.03				0.06
Barley food			-0.39					0.58
Spain								
Corn	-0.21							
Soviet Union								
Feed grain total use								0.37
Japan								
Corn and sorghum total use	-0.20			0.16				
corn and sorghum stock	-0.46	-0.45					0.95	

Table 14. Price transmission elasticities of feed grain prices with respect to U.S. feed grain prices

Country	U.S. Corn Price	U.S. Barley Price	U.S. Sorghum Price
Canada			
Barley		0.84	
Corn	0.96		
Australia			
Barley		1.12	
Argentina			
Corn	1.10		
Sorghum			1.14
Thailand			
Corn	1.12		
South Africa			
Feed grain	0.00	0.00	0.00
EC(10)			
Corn	0.00		
Barley		0.00	
Spain			
Corn	0.75		
USSR			
Feed grain	0.00	0.00	0.00
Japan			
Corn	0.97		

Validation and Performance of the Model

Performance of the model can be measured by the validity of its estimates, its ability to reproduce the actual data in a dynamic simulation, and its stability. As mentioned in the previous section, some of the key parameter estimates did not have good statistical properties. This indicates that some equations in the model would have to be respecified. However, because of the time limit, the current model is dynamically simulated for the purpose of validation. Given the large size of the model and the nature of the estimates, validation statistics are not quite good but are reasonable. The model validation was conducted with the econometric model before the synthetic elasticities of Appendix Table A.1 was added.

Statistics measuring the model's simulation performance include residual 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 often used instead. Theil's statistics are also used to measure simulation performance of a model. There are three different components: UM (bias error), UR (regression error), and UD (disturbance error). The bias proportion UM is an indication of systematic error, since it measures the extent to which the average value of the simulated and actual series differ 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 three sources as UM = UR = 0 and UD = 1.

Table 15 presents the RMS errors and RMS percent error and Table 16 presents Theil's forecast statistics. Out of 70 endogenous variables 14 variables have RMS percent error less than 0.20. Variables with high RMS percent errors are FGSMNZA, BASMNEO, SGSMNAR, COSMNAR, FGSMNAU, CBSMNCA, FGSMNCA, and BAUDTAU. 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 error because they are excess supplies and excess demands. Simulation errors from other domestic variables accumulate and are transfered to the export and import variables.

Theil's forecast errors of most simulation variables are 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 one. Variables which have high UR are generally the same variables which have the high RMS percent errors mentioned above.

The actual and simulated values of a few selected variables are plotted in Figures 4-11. Overall, this model's performance is not quite good. Further work to improve the model structure is underway.

Table 15. STATISTICS OF FIT

VARIABLE	N	RMS ERROR	RMS % ERROR
BASMNE0	15	880.93	449.62
BAPTHE0	15	1.30815	1.10793
COUHTE0	15	399.38	7.38816
BAUFEE0	15	726.58	2.79221
COUFEE0	15	1495.19	7.36599
COYIHE0	15	0.23572	4.83096
BAAHHE0	15	167.61	1.76186
BAUHTE0	15	448.57	5.06555
COSMNE0	15	1829.31	18.45849
FGSMNE0	15	1905.73	27.87112
CORPF	15	0.17356	7.18062
CORHCC1	15	106.90	20.17853
CORHT	15	106.91	17.73625
CORNRE	15	16.36255	13.31503
SNRE1	15	0.67041	0.67317
RSCNRE	15	0.15871	13.53178
RCOPDPF	15	0.01050	4.08875
CORSA1	15	2.20074	3.04926
CORPGR1	15	191.21	3.41383
FGSMNU9	15	4399.44	9.01978
COSMNU9	15	4399.44	10.70982
CORMX	15	176.11	11.15376
CORDH	15	21.60923	3.72767
CORDF	15	152.08	4.13621
BAPFMU9	15	9.48538	11.44564
SGPFMU9	15	4.47822	6.48265
COAHHAR	15	399.87	13.54061
COYIHAR	15	0.34294	12.21037
COUDTAR	15	220.94	6.39958
SGAHHAR	15	134.07	6.90390
SGYIHAR	15	0.13891	4.93232
SGUDTAR	15	242.43	13.32689
COPFMAR	15	179831	8.91961
SGPFMAR	15	116888	9.36736
FGSMNAR	15	1675.44	22.31157
COSMNAR	15	1522.71	30.37025
SGSMNAR	15	552.85	32.30136
BAPOBCA	15	13.44133	13.51921
BAAHHCA	15	606.12	13.63175
COAHHCA	15	51.24075	7.45527
CBUDTCA	15	530.24	5.23722
COPFMCA	15	10.51898	10.24992
CBSMNCA	15	1651.71	76.80596
FGSMNCA	15	1651.71	77.93079
BAAHHAU	15	239.49	11.56546

Table 15. (continued)

VARIABLE	N	RMS ERROR	RMS % ERROR
BAUDTAU	15	298.19	26.02651
BAPFMAU	15	12.45261	13.91192
BASMNAU	15	379.34	45.19572
FGSMNAU	15	379.34	25.67595
CSAHHTH	15	76.58507	6.87784
CSUDTTH	15	80.22816	14.20474
COPFMTH	15	168.41	12.22021
CSSMNTH	15	150.96	7.38550
FGSMNTH	15	150.96	7.38550
FGSMNZA	15	293.74	43.74157
SCUDTJP	15	559.99	5.04397
SCCOTJP	15	168.55	18.64710
COPWHJP	15	3652.35	12.85756
SCSMNJP	15	618.61	5.68814
FGSMNJP	15	618.61	5.07591
FGSMNSU	15	2538.81	109.04
FGUDTSU	15	2538.81	3.15034
COUDTES	15	470.64	8.16037
COPFMES	15	1528.42	13.03149
COSMNES	15	636.23	17.63816
FGSMNES	15	636.23	15.87765
CSSPRTH	15	163.90	6.87784
BASPRAU	15	299.24	11.56546
COSPRAR	15	1634.00	18.74617
SGSPRAR	15	485.67	8.96621
COSPRCA	15	283.69	7.45527
BASPRCA	15	1310.13	13.63175
COSPRE0	15	662.67	4.83096
BASPRE0	15	667.64	1.76186

Table 16. THEIL FORECAST ERROR STATISTICS

VARIABLE	N	MSE	MSE DECOMPOSITION BIAS (UM)	REG (UR)	DIST (UD)	INEQUALITY U1
BASMNE0	15	776034	0.002	0.211	0.787	0.3857
BAPTHE0	15	1.71127	0.000	0.000	1.000	0.0083
COUHTE0	15	159507	0.054	0.201	0.745	0.0643
BAUFEE0	15	527912	0.015	0.004	0.981	0.0280
COUFEE0	15	2235581	0.110	0.139	0.750	0.0715
COYIHE0	15	0.05557	0.000	0.001	0.999	0.0443
BAAHHE0	15	28094.69	0.000	0.002	0.998	0.0179
BAUHTE0	15	201219	0.018	0.058	0.924	0.0522
COSMNE0	15	3346363	0.050	0.000	0.950	0.1517
FGSMNE0	15	3631798	0.039	0.139	0.822	0.1500
CORPF	15	0.03012	0.001	0.189	0.810	0.0786
CORHCC1	15	11428.05	0.035	0.204	0.760	0.1583
CORHT	15	11429.69	0.035	0.070	0.895	0.0799
CORNRE	15	267.73	0.003	0.115	0.881	0.1461
SNRE1	15	0.44945	0.444	0.062	0.494	0.0065
RSCNRE	15	0.02519	0.000	0.206	0.794	0.1449
RCOPDPF	15	.00011033	0.002	0.249	0.749	0.0554
CORSA1	15	4.84327	0.044	0.058	0.897	0.0287
CORPGR1	15	36562.30	0.109	0.047	0.844	0.0307
FGSMNU9	15	19355049	0.178	0.000	0.822	0.0930
COSMNU9	15	19355049	0.178	0.000	0.822	0.1078
CORMX	15	31014.52	0.203	0.001	0.796	0.1093
CORDH	15	466.96	0.093	0.070	0.837	0.0392
CORDF	15	23127.17	0.005	0.016	0.979	0.0382
BAPFMU9	15	89.97251	0.000	0.096	0.904	0.1032
SGPFMU9	15	20.05449	0.001	0.193	0.805	0.0558
COAHHAR	15	159892	0.003	0.280	0.718	0.1241
COYIHAR	15	0.11761	0.000	0.027	0.973	0.1229
COUDTAR	15	48814.32	0.000	0.001	0.999	0.0628
SGAHHAR	15	17974.23	0.000	0.000	1.000	0.0653
SGYIHAR	15	0.01930	0.000	0.002	0.997	0.0527
SGUDTAR	15	58771.58	0.003	0.002	0.995	0.1071
COPFMAR	15	3.23E+10	0.115	0.828	0.057	0.0136
SGPFMAR	15	1.37E+10	0.107	0.861	0.032	0.0094
FGSMNAR	15	2807087	0.000	0.149	0.851	0.1878
COSMNAR	15	2318633	0.000	0.355	0.645	0.2835
SGSMNAR	15	305644	0.000	0.146	0.854	0.1597
BAPOBCA	15	180.67	0.002	0.078	0.921	0.1411
BAAHHCA	15	367379	0.013	0.232	0.755	0.1314
COAHHCA	15	2625.61	0.004	0.007	0.990	0.0697
CBUDTCA	15	281157	0.000	0.006	0.994	0.0475
COPFMCA	15	110.65	0.002	0.183	0.815	0.1082
CBSMNCA	15	2728157	0.007	0.523	0.470	0.4837

Table 16. (continued)

VARIABLE	N	MSE	MSE DECOMPOSITION BIAS (UM)	REG (UR)	DIST (UD)	INEQUALITY U1
FGSMNCA	15	2728157	0.007	0.517	0.475	0.4686
BAAHHAU	15	57354.61	0.001	0.038	0.962	0.1051
BAUDTAU	15	88919.88	0.000	0.299	0.701	0.2452
BAPFMAU	15	155.07	0.004	0.122	0.874	0.1278
BASMNAU	15	143897	0.017	0.316	0.668	0.2402
FGSMNAU	15	143897	0.017	0.268	0.716	0.1485
CSAHHTH	15	5865.27	0.000	0.001	0.999	0.0540
CSUDTTH	15	6436.56	0.000	0.000	1.000	0.1095
COPFMTH	15	28363.50	0.001	0.068	0.931	0.1036
CSSMNTH	15	22789.98	0.001	0.046	0.953	0.0693
FGSMNTH	15	22789.98	0.001	0.046	0.953	0.0693
FGSMNZA	15	86282.32	0.000	0.033	0.967	0.0990
SCUDTJP	15	313588	0.000	0.001	0.999	0.0420
SCCOTJP	15	28410.18	0.001	0.023	0.976	0.1311
COPWHJP	15	13339659	0.000	0.010	0.990	0.1158
SCSMNJP	15	382680	0.000	0.003	0.997	0.0463
FGSMNJP	15	382680	0.000	0.010	0.990	0.0417
FGSMNSU	15	6445572	0.000	0.004	0.996	0.2249
FGUDTSU	15	6445572	0.000	0.001	0.999	0.0317
COUDTES	15	221500	0.009	0.047	0.945	0.0826
COPFMES	15	2336058	0.004	0.075	0.920	0.1337
COSMNES	15	404783	0.002	0.113	0.885	0.1687
FGSMNES	15	404783	0.002	0.006	0.992	0.1427
CSSPRTH	15	26862.60	0.002	0.001	0.998	0.0569
BASPRAU	15	89547.00	0.005	0.069	0.927	0.1097
COSPRAR	15	2669953	0.000	0.259	0.741	0.1854
SGSPRAR	15	235878	0.000	0.006	0.994	0.0861
COSPRCA	15	80478.93	0.004	0.000	0.996	0.0689
BASPRCA	15	1716441	0.010	0.117	0.873	0.1228
COSPRE0	15	439129	0.000	0.011	0.989	0.0428
BASPRE0	15	445737	0.000	0.004	0.996	0.0187

FIG 4. CORN PRODUCTION, U.S.

(Actual VS. Predicted)

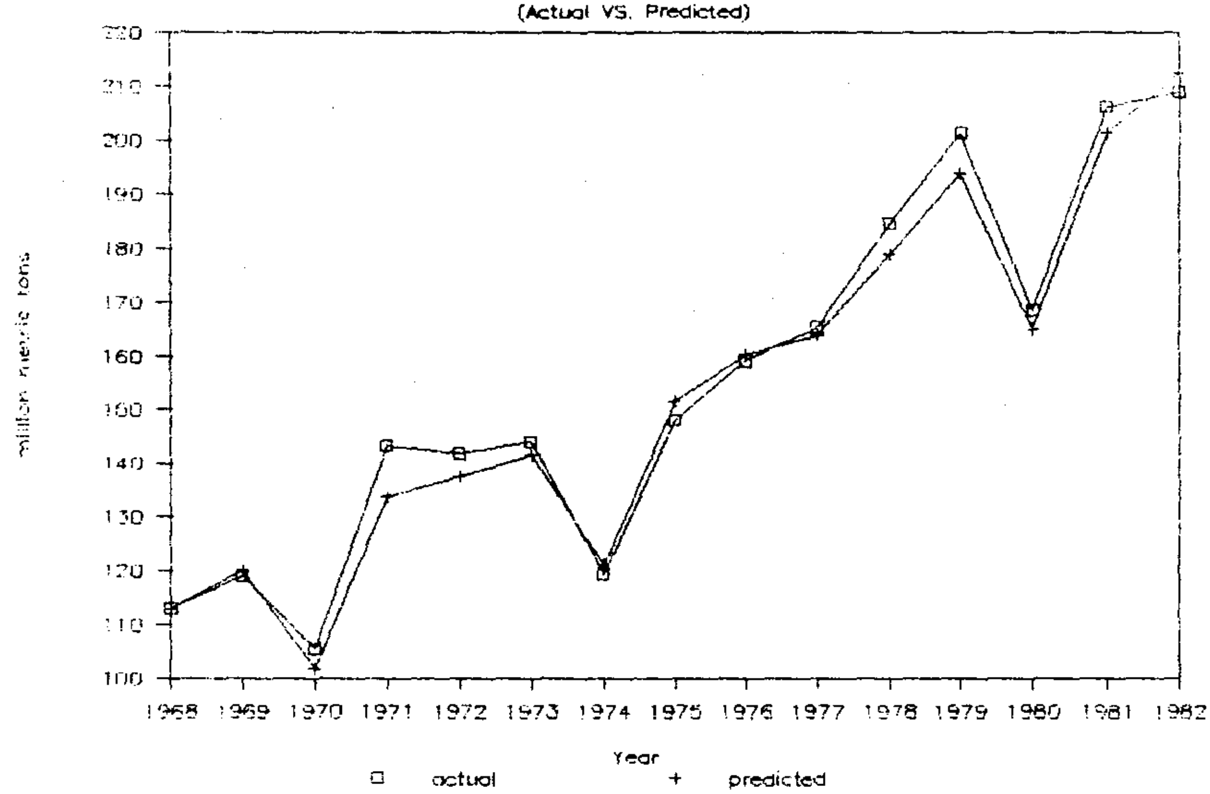


FIG 5. CORN FARM PRICE, U.S.

(Actual VS. Predicted)

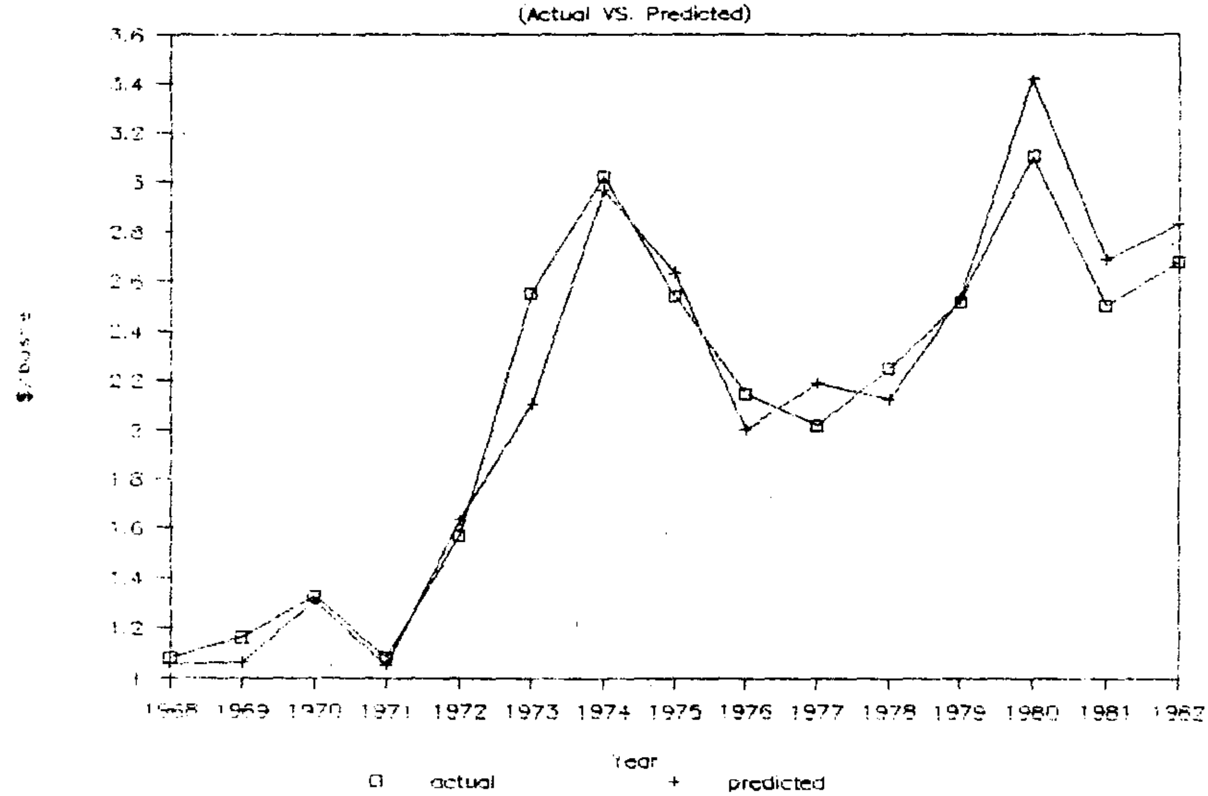


FIG 6. CORN EXPORTS, U.S.

(Actual VS. Predicted)

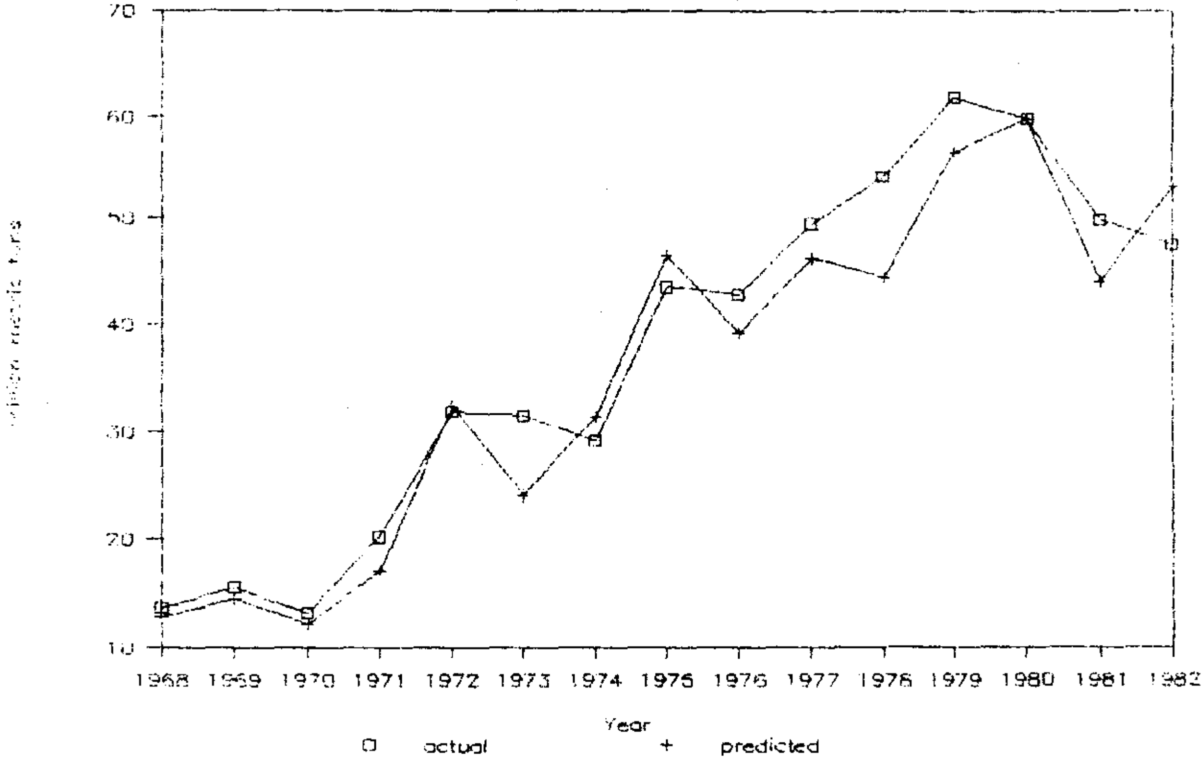


FIG 7. CORN NET EXPORTS, ARGENTINA

(Actual VS. Predicted)

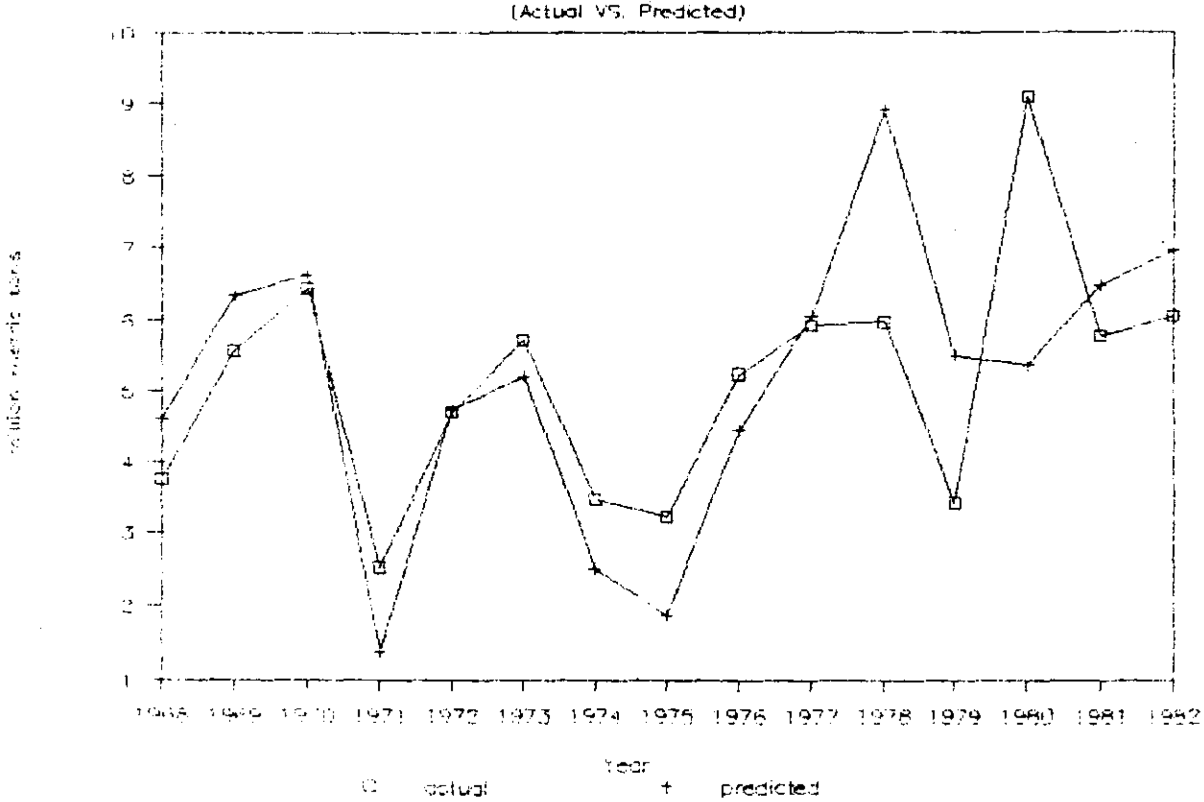


FIG 8. CORN & BARLEY EXPORTS, CANADA

(Actual VS. Predicted)

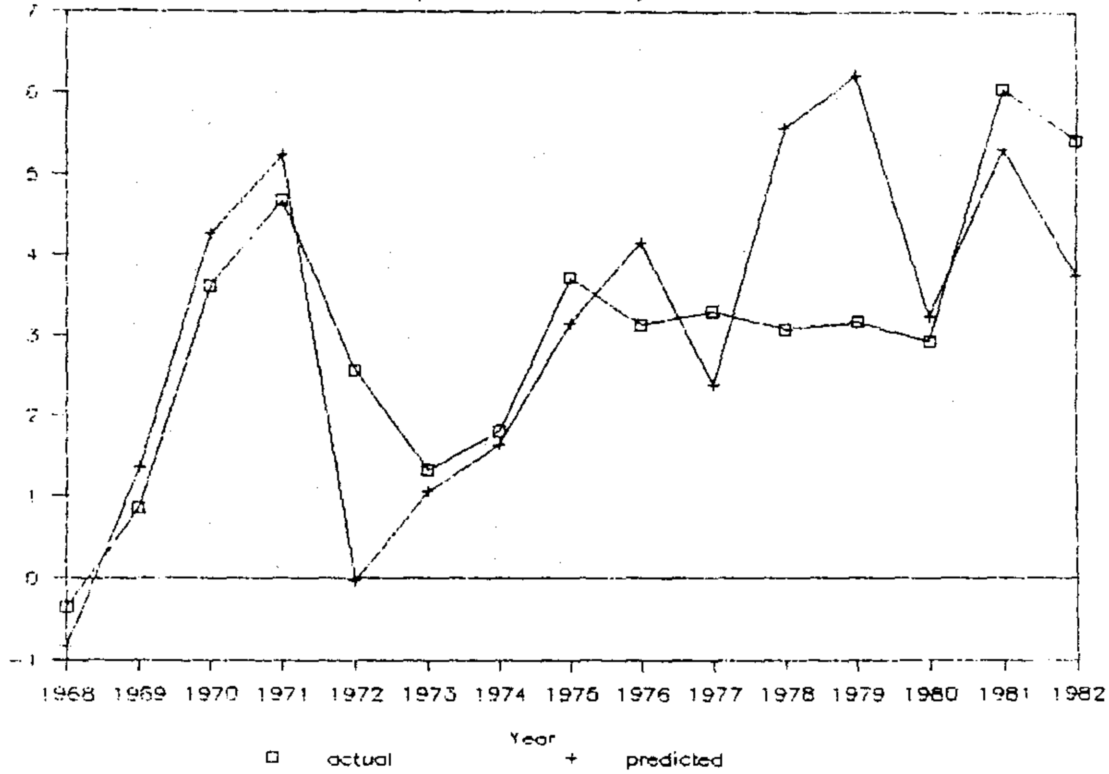


FIG 9 BARLEY NET EXPORTS, AUSTRALIA

(Actual VS. Predicted)

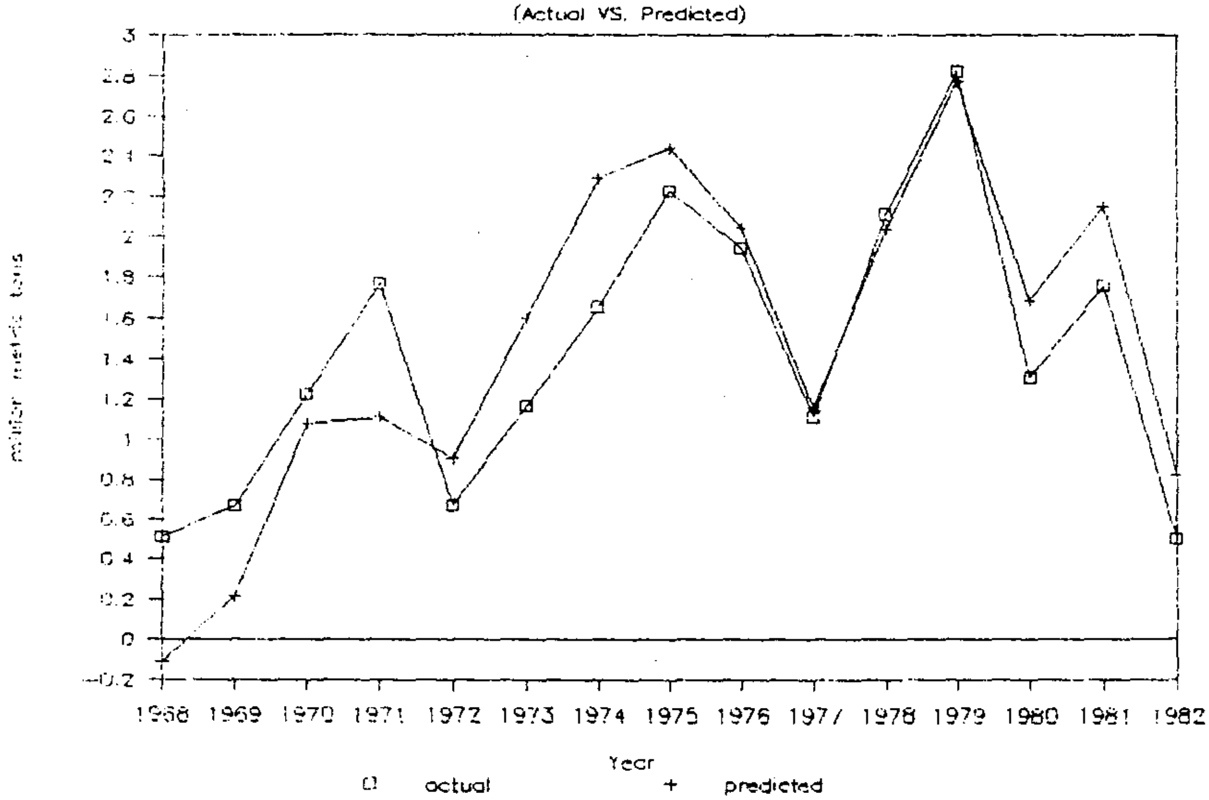


FIG 10 CORN & SORGHUM EXPORT, THAILAND
(Actual VS. Predicted)

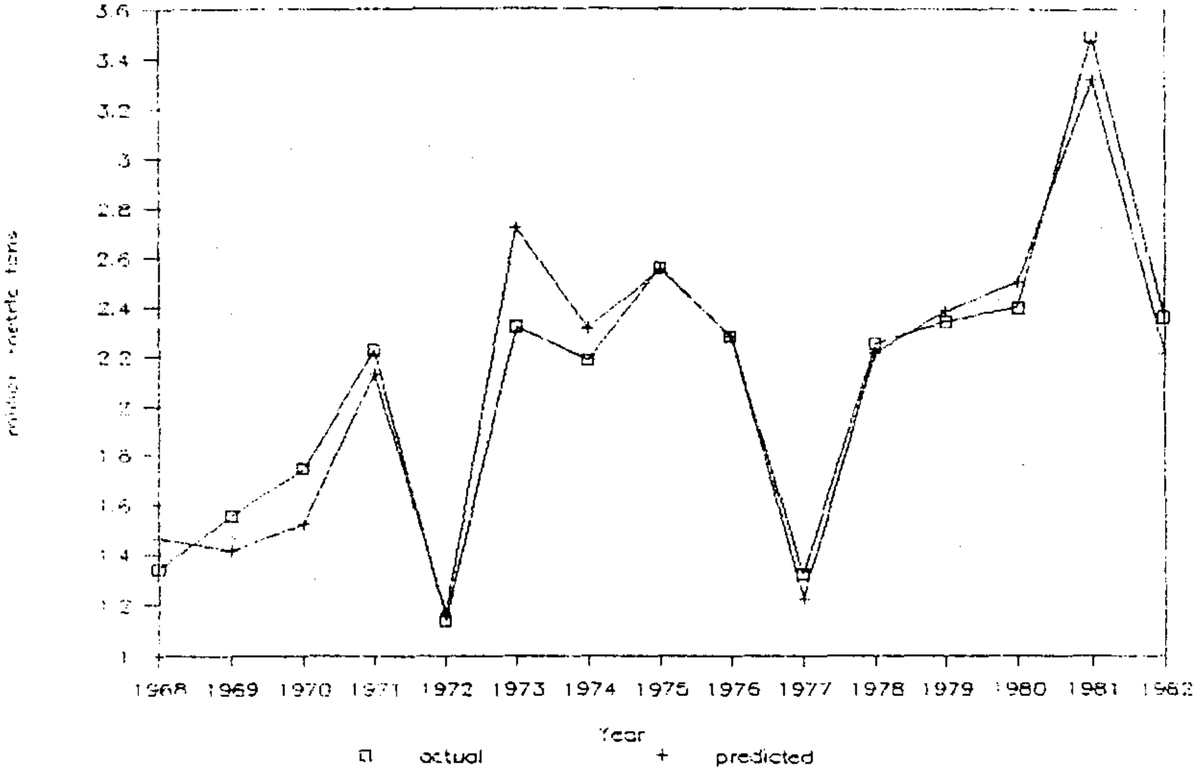


FIG 11 FEED GRAIN EXPORTS, S.AFRICA
(Actual VS. Predicted)

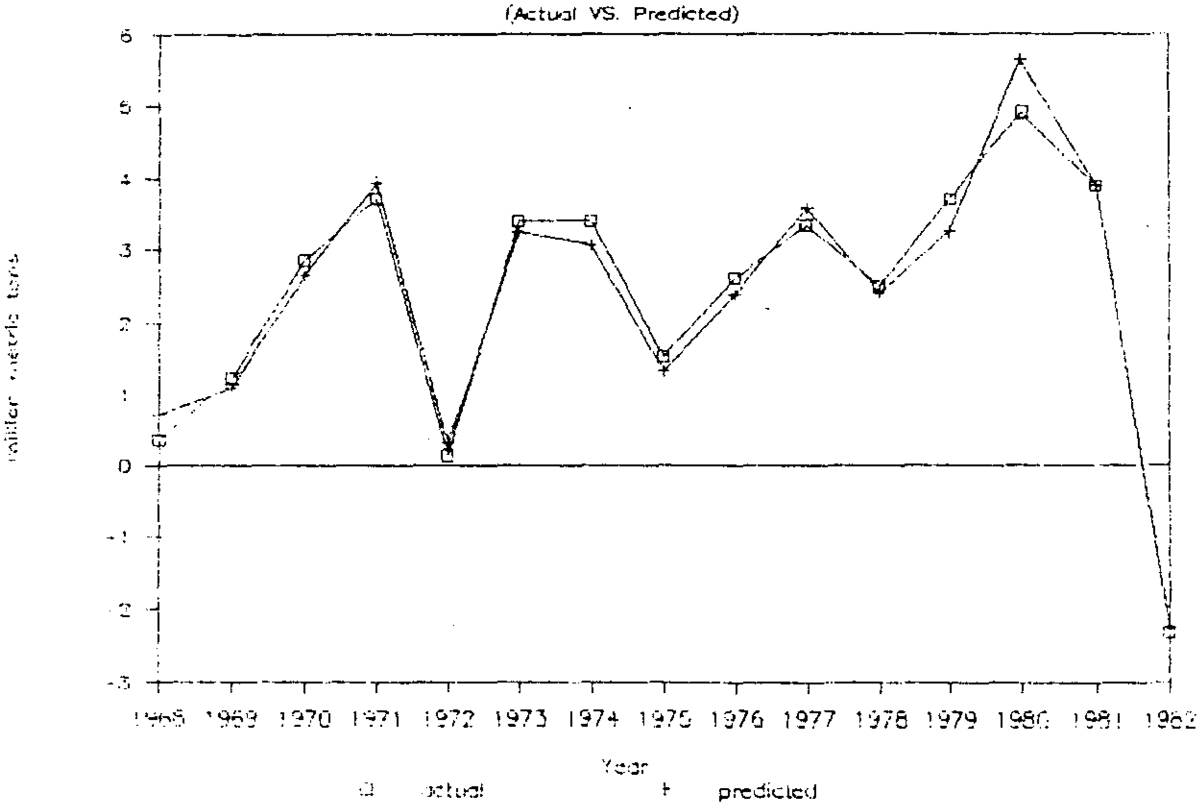


FIG 12. CORN NET IMPORTS, E.C.

(Actual VS. Predicted)

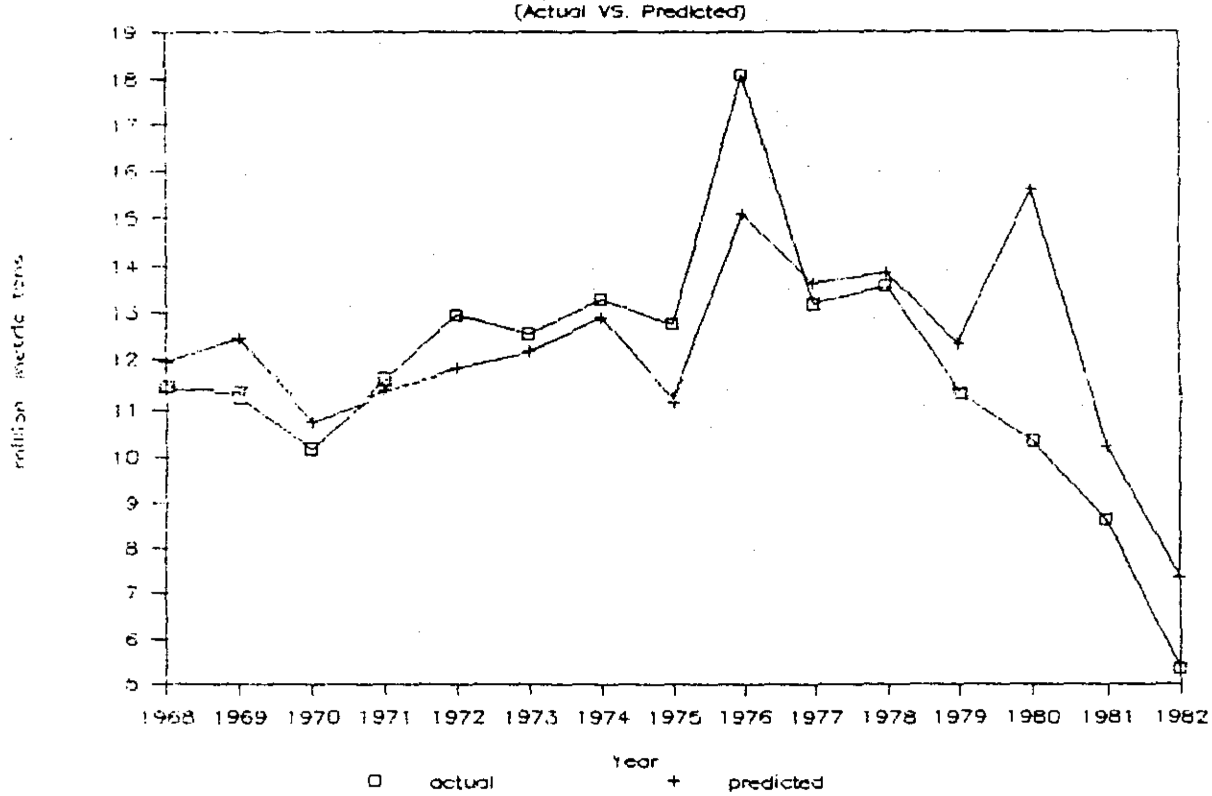


FIG 13. CORN & SORGHUM IMPORTS, JAPAN

(Actual VS. Predicted)

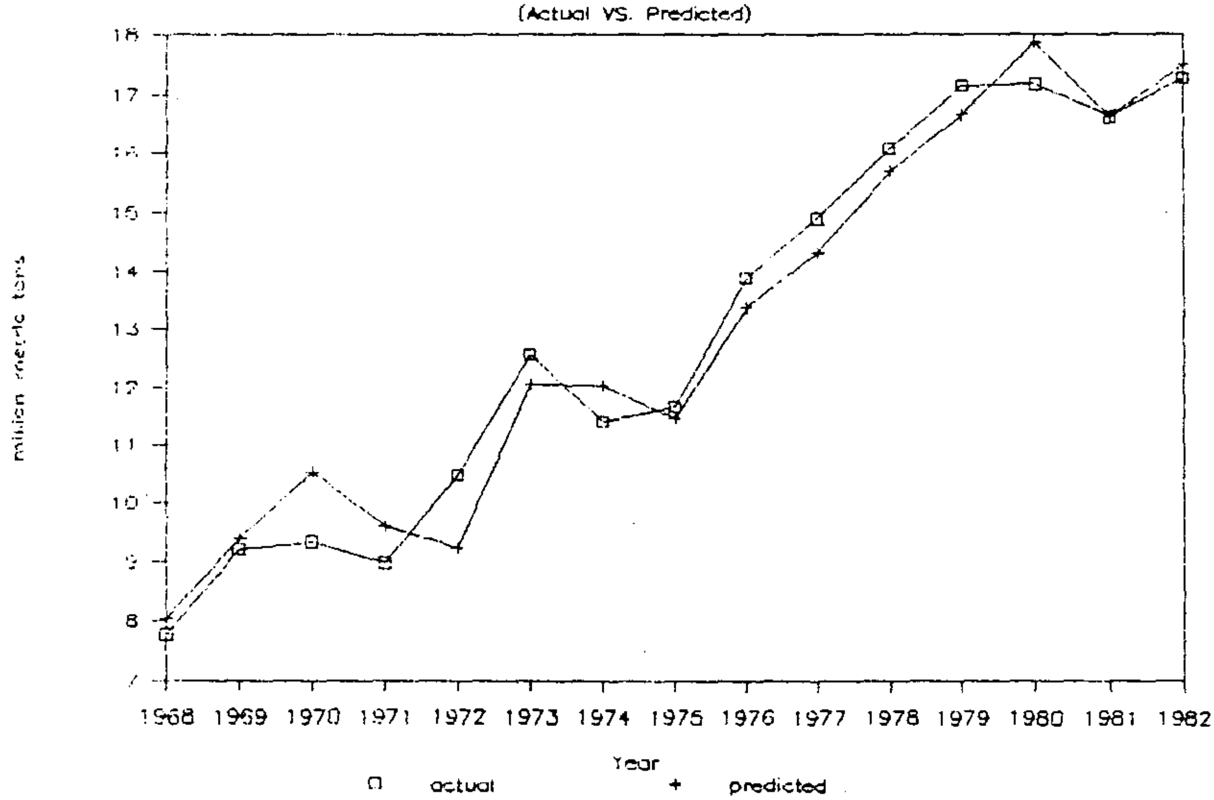


FIG 14. CORN NET IMPORTS, SPAIN
(Actual VS. Predicted)

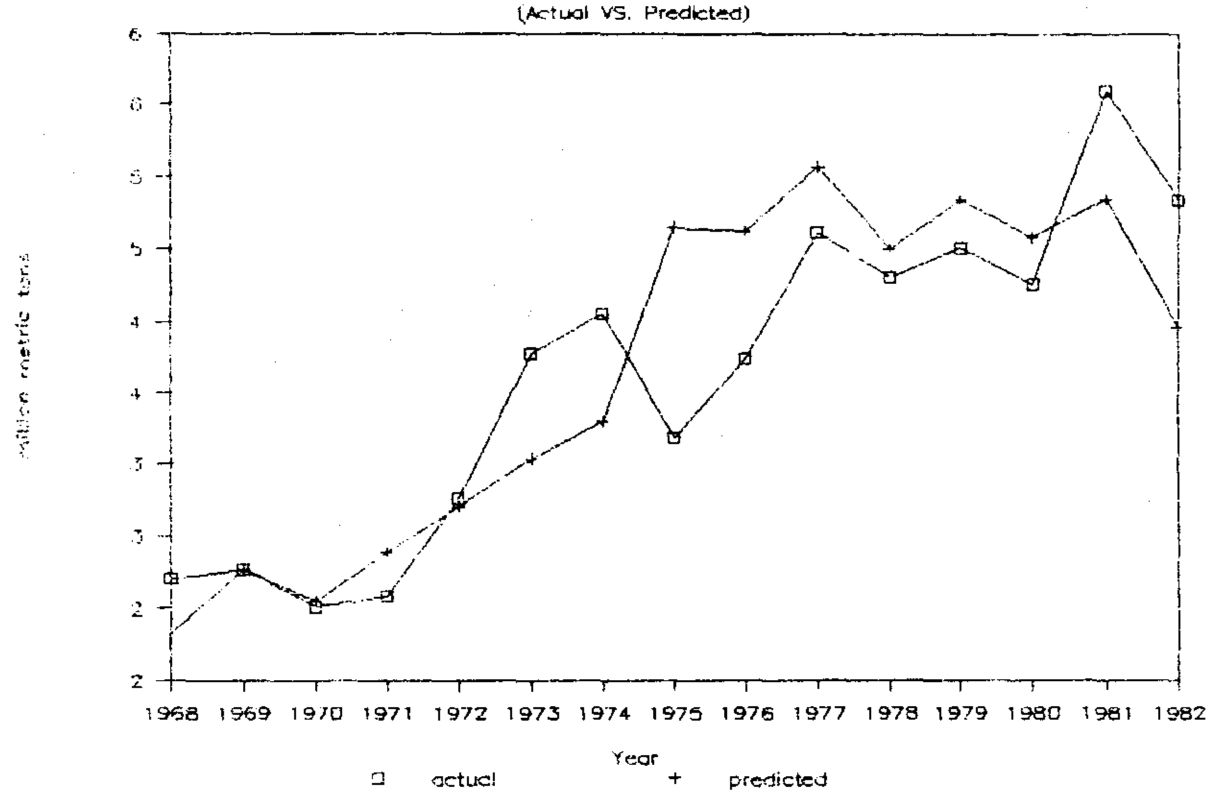
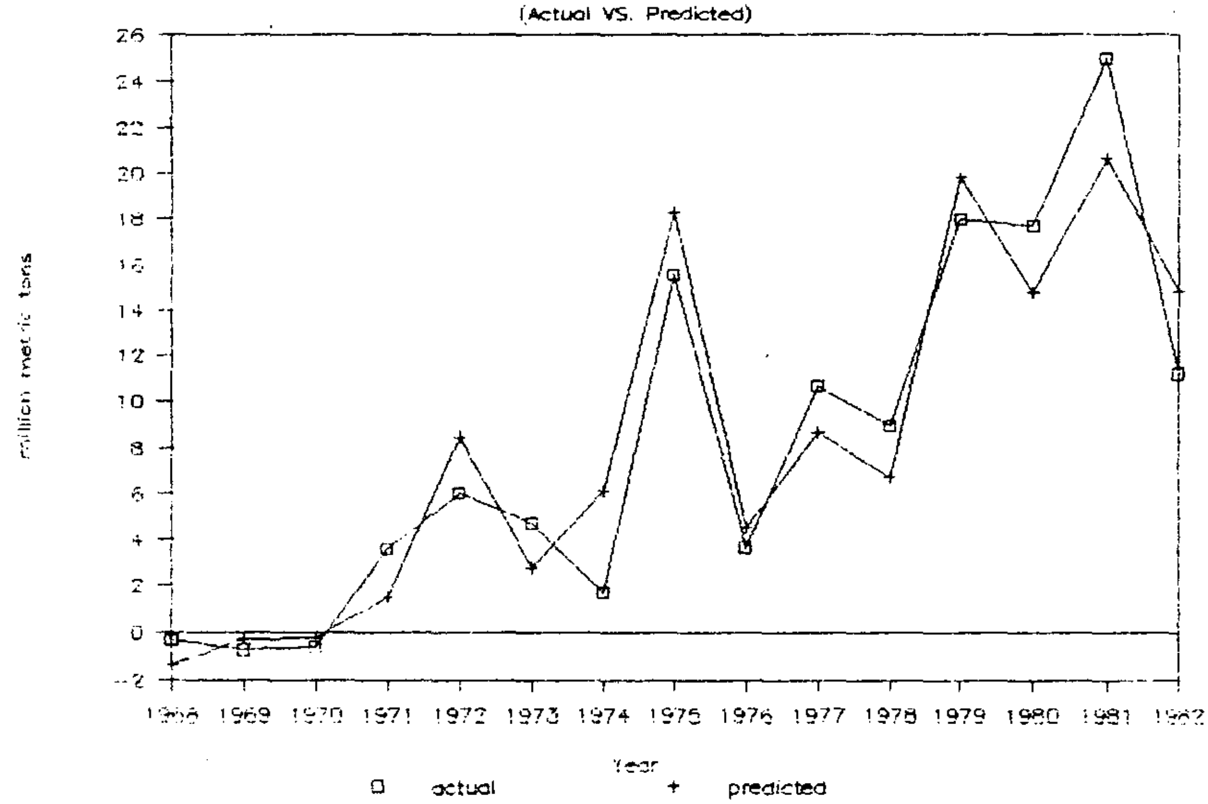


FIG 15. FEED GRAINS NET IMPORTS, USSR
(Actual VS. Predicted)



Appendix

EC Market

The six original members: France, Germany, Italy, Belgium, Luxemburg, and the Netherlands established the European Economic Community (EEC) in 1959, following the Rome Treaty. The Common Agricultural Policy (CAP) was initiated in 1962 and, after going through a transition period, was uniformly adopted in 1967. The objectives of the CAP are stated as:

- Raising agricultural productivity
- Maintaining rural standard of living at an adequate level
- Stabilizing markets
- Assuring regular supplies
- Maintaining reasonable prices

These objectives have been met through price policies ranging from variable levy to export subsidy, all aiming at insulation from world prices.

Cereals, which include feed grain, have been one of the first groups of agricultural commodities for which the support prices have been introduced. The three major prices for grains, set directly by CAP, are:

- Intervention price, which is the minimum guarantee price at which EC authorities will purchase the grain from producers at their designated stations.
- Target price, which is based on intervention price at Deuisberg (the most grain deficient area), farmers' income, production and utilization of various grains within the EC, and the development of trade with nonmember countries.
- Threshold price, which is equal to the target price minus the sum of the transportation cost from Rotterdam to Deuisberg and the importers' profit margin.

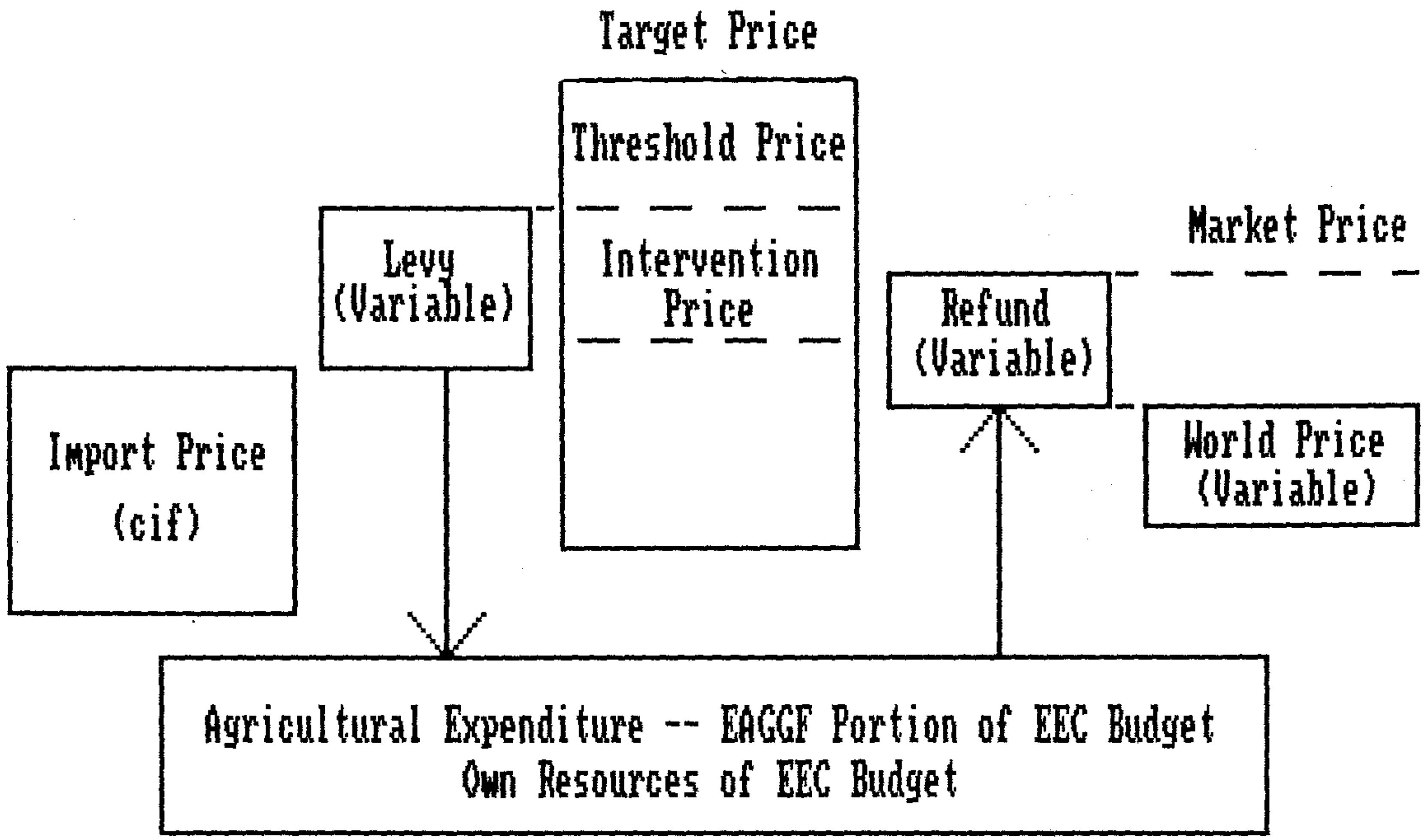


Figure A.1. Levy and Fund System for Grain

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

Region	Net Imports (1)	Domestic Consumption (2)	(2)/(1)	$\frac{(2)-(1)}{(1)}$	n Income Elas.	$\left(n \times \frac{(2)}{(1)}\right)$ Adj. Income Elas.	e_d Demand Elas.	e_s Supply Elas.	e_i Price Trans.	Adj. Net* Imp. Elas.
	1000 MT									
FEED GRAINS										
High Income East Asia	8263.0	9513.0	1.151	0.151	0.45	0.518	-0.7	0.2	0.6	-0.502
East Europe	3390.0	70891.0	20.912	19.912	0.35	7.32	-0.3	0.2	0.5	-5.128
ROW**	27500.0	17600.0	7.057	6.057	0.40	2.82	-0.5	0.2	0.25	-1.100

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

**rest of world includes all countries and regions not listed in Tables 13, 14, and A.1.

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