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**Agricultural Trade Modeling – The State of Practice and
Research Issues**

Liu, K. and R. Seeley, eds.

Proceedings of a Meeting of the
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USDA'S WORLD GRAIN, OILSEEDS, AND LIVESTOCK (GOL) MODEL

Karen Liu

The world grain, oilseeds, and livestock (GOL) model (of USDA's Economic Research Service) has a long and winding history. A well-known, primarily static version of the model was created, operated, and documented in the seventies. Then in the eighties, work began on a dynamic version of which several manifestations exist. There are documented detailed country models (using domestic prices and policies, although in a generic format) for several countries. These are mainframe computer models embedded in the TROLL modeling system. The Japan model is used to illustrate trade liberalization for this exercise. Then, there are simpler (world prices only) country/region models that run independently on microcomputers also linked together in TROLL on a mainframe computer. The simpler mainframe version is used for the baseline and the 5-percent U.S. supply reduction exercise. Finally, there is an experimental, small, dynamic microcomputer two-region world GOL model that is also used for the U.S. supply shortfall exercise.

Overview of the Mainframe, Simplified World GOL Model

1. The model is an annual simulation model.
2. The model has 20 major agricultural commodities.
3. The model consists of 27 countries and regions.
4. Two major model components: a set of country and regional models and a market-clearing model linking the country and regional models to solve for equilibrium world commodity prices.
5. The model calculates equilibrium prices, supply, demand, and trade for each region and commodity, based on assumptions about the supply growth rate, population, income, and major quantitative trade restraints.
6. The country model in this version is the simple standard model. The model has a minimal internal structure with limited cross-commodity links and directly uses world commodity prices in its supply and demand equations.
7. The model can be used to provide mid- to long-term projections of world food supply and demand under alternative world economic assumptions. The model can also be used to examine the impact of alternative quantitative trade restrictions on the world agricultural trade.
8. The documentation of the model, and supply and demand elasticities of each of 27 country and regional models are reported in The World Grain-Oilseeds-Livestock (GOL) Model, A Simplified Version, by K. Liu and V. Roningen, ERS Staff Report No. AGES850128, February 1985.

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9. The individual country and regional models are also available in microcomputer spreadsheets. The microcomputer version of the country/region model is reported in The World Grain, Oilseeds, and Livestock Model--A Microcomputer Version, by V. Roningen, J. Wainio, and K. Liu, ERS Staff Report No. AGES850826, September 1985.

Base Run Simulation

A base run simulation was generated by the model using 1980 as the base period. The base scenario assumes that growth of incomes in all the regions will continue to approximate recent long-term historical trends and also assumes that any applicable trade constraints will continue as in the past.

Table 1 summarizes the baseline projections for 1990, 1995, and 2000 for wheat and corn supply, demand, and net trade of different regions. Under the base assumptions, the exporting countries such as the United States, Canada, Australia-New Zealand, and Argentina remain to be the major suppliers for world grain trade. The centrally planned countries increase their imports of grains roughly in proportion to their demand increases. The developing countries' demand outpaces their supply, resulting in a continuing increase in grain imports over the projection period.

The Impact of a One-Period, 5-Percent Decline in U.S. Crop Production

This section discusses the impacts of a one-period, 5-percent reduction in U.S. crop production by using the mainframe, simplified world GOL model and a small, simple microcomputer version of the model.

Analysis With the Mainframe, Simplified World GOL Model

A first-year, 5-percent production shortfall for wheat, corn, other coarse grains, rice, and soybeans in the United States was introduced into the model by changing the value of the U.S. crop supply shift variables (exogenous variables) from the base assumption by -5 percent. The impact of such a one-period, 5-percent reduction in U.S. crop production is briefly discussed. In the model, supply is defined as production plus beginning stocks, and demand is defined as consumption plus ending stocks. Thus, price elasticities in the supply and demand equations implicitly incorporate some stock behavior. While stock behavior is implicit in the model, explicit stock movements are not separable. Therefore, the impacts of a 5-percent decline in U.S. crop production are mainly on demand, trade, and world prices.

Tables 2, 3, and 4 contain a selected set of initial multipliers and dynamic delayed multipliers of the impacts of a one-period, 5-percent decrease in U.S. crop production for wheat, corn, other coarse grains, rice, and soybeans. Table 2 summarizes the impacts of a 5-percent U.S. crop shortfall on U.S. feed and livestock sectors. The estimated initial impact from a 5-percent crop shortfall shows that domestic consumption is reduced by 2.3 percent for wheat, 3.5 for corn, and 1.6 for soybeans. Exports of wheat are reduced by 7.8 percent, corn 8.3, other coarse grain 26.5, rice 10.4, and soybeans 9.1. Livestock production was affected by the higher feed prices but in an insignificant magnitude; for example, beef production was reduced by only 0.1 percent. The estimated delayed impact multipliers show insignificant impact for these variables for the following years.

Table 1--Baseline projections for wheat and corn

Regions and components	Wheat			Corn		
	1990	1995	2000	1990	1995	2000
	<u>1,000 metric tons</u>					
United States:						
Supply	112,845	123,416	134,222	281,506	312,587	346,565
Demand	59,549	67,639	78,047	183,561	209,721	229,616
Net trade	53,297	55,777	56,175	69,211	102,865	116,949
Canada:						
Supply	41,756	47,730	54,266	--	--	--
Demand	15,909	17,165	18,867	--	--	--
Net trade	25,847	30,565	35,400	--	--	--
Australia and New Zealand:						
Supply	23,918	27,033	30,524	--	--	--
Demand	7,622	7,977	8,366	--	--	--
Net trade	16,296	19,057	22,157	--	--	--
Argentina:						
Supply	11,623	13,320	15,249	10,398	11,733	12,390
Demand	4,820	5,082	5,313	3,904	5,455	6,154
Net trade	6,803	8,238	9,936	6,494	6,278	6,236
EC-10:						
Supply	68,948	71,918	74,540	22,794	26,707	28,724
Demand	55,277	57,184	59,130	32,277	39,450	42,299
Net trade	13,671	14,734	15,411	-9,482	-12,743	-13,576
Japan:						
Supply	2,846	3,259	3,728	1,751	1,970	2,199
Demand	8,636	9,042	9,424	19,229	21,699	24,326
Net trade	-5,793	-5,784	-5,696	-17,478	-19,729	-22,127
Soviet Union:						
Supply	101,387	102,280	103,057	11,536	13,296	15,307
Demand	125,394	131,226	137,439	27,263	29,323	31,477
Net trade	-24,008	-28,947	-34,383	-15,727	-16,028	-16,170
Brazil:						
Supply	41,18	4,983	6,077	28,701	32,024	35,906
Demand	10,233	11,457	12,712	30,754	34,662	38,565
Net trade	-6,115	-6,474	-6,634	-2,053	-2,638	-2,659
Mexico:						
Supply	3,852	4,577	5,318	14,721	16,485	19,053
Demand	5,537	6,324	7,218	19,313	22,210	25,022
Net trade	-1,684	-1,747	-1,800	-4,592	-5,725	-5,969

-- = Corn is not modeled in these countries.

Table 2--Impact multipliers of a 5-percent change in U.S. crop production
on U.S. feed and livestock sectors

Item	Initial multiplier	Dynamic delay multipliers			
		Period 1	Period 2	Period 3	Period 4
		<u>Percent</u>			
Demand:					
Wheat	-2.26	0.68	0	-0.05	0.25
Corn	-3.48	.51	-.15	.05	.04
Other coarse grains	.12	-.06	-.09	.04	-.19
Rice	-.12	.09	.02	.003	.09
Soybeans	-1.60	-.14	.02	.03	.05
Exports:					
Wheat	-7.78	.40	-.38	.10	-.32
Corn	-8.33	-.98	.31	-.15	-.15
Other coarse grains	-26.54	.50	.36	-.20	.96
Rice	-10.37	-1.55	-.42	-.11	.24
Soybeans	-9.07	2.30	.42	.11	.03
Livestock supply:					
Beef and veal	-.12	.13	-.01	.01	.01
Pork	.21	-.44	.23	-.04	-.014
Poultry	-.25	-.42	.17	-.03	.01
Eggs	-.16	.12	.04	-.04	-.01

Table 3--Impact multipliers of a -5-percent change in U.S. crop
production on world prices

Item	Initial multiplier	Dynamic delay multipliers			
		Period 1	Period 2	Period 3	Period 4
		<u>Percent</u>			
World prices:					
Wheat	4.59	-1.22	0.20	0.03	-0.03
Corn	7.77	-1.38	-.07	.15	-.19
Other coarse grains	4.48	-.83	.06	.03	.22
Rice	1.08	-.59	-.07	0	-.69
Soybeans	20.23	1.51	.58	.47	.47

Table 4--Impact multipliers of a -5-percent change in U.S. crop production on international trade

Item	Initial multiplier	Dynamic delay multipliers			
		Period 1	Period 2	Period 3	Period 4
		<u>Percent</u>			
Wheat:					
Exporting countries--					
Canada	2.89	-0.32	-0.15	0.08	-0.29
Australia and New Zealand	.59	.04	-.04	.01	-.05
Argentina	.97	-1.85	-.82	-.09	-.27
EC-10	4.74	3.37	-1.18	.17	-.33
Importing countries--					
Japan	-.67	.13	0	.06	-.01
Soviet Union	-4.39	1.02	-.04	-.06	.42
Corn:					
Exporting countries--					
Argentina	1.65	1.14	-.22	-.03	-.03
Importing countries--					
Japan	-1.61	.15	.06	-.03	.05
Soviet Union	-1.33	.25	.03	-.02	.05
EC-10	-2.99	-1.33	.3	.03	.09
Other coarse grains:					
Exporting countries--					
Canada	5.57	.29	.02	.01	.42
Australia and New Zealand	.92	.39	-.04	-.004	.06
Argentina	.27	-1.29	-.55	-.11	.04
EC-10	9.5	1.32	-.04	-.03	.43
Importing countries--					
Japan	-1.36	.32	-.05	.01	-.09
Soviet Union	-8.62	1.22	-.1	.02	-.52
Soybeans:					
Exporting countries--					
Argentina	1.37	3.56	.79	.21	.13
Importing countries--					
Japan	-2.09	-.21	.01	.03	.06
Soviet Union	-1.92	-.17	-.002	.01	.04
EC-10	-.01	-.18	-.01	.01	.03

Table 3 summarizes the estimated impact on world grain prices. The initial impact multipliers of world prices for wheat, corn, other coarse grains, rice, and soybeans show the increases of these commodity prices in the world market by 4.6, 7.8, 4.5, 1.1, and 20.2 percent, respectively. Over the 4-year period, after the initial production shortfall, the impacts on the world prices dampen quickly and converge toward the original baseline value. The implied total elasticities of demand for the United States are estimated as -1.1 for wheat, -0.6 for corn, -1.1 for other coarse grains, -4.6 for rice, and -0.3 for soybeans. The implied export demand elasticities are estimated as -1.7 for wheat, -1.1 for corn, -5.9 for other coarse grains, -9.6 for rice, and -0.5 for soybeans.

Table 4 summarizes the multiplier effects on other major grain exporters and importers due to a 5-percent crop production shortfall in the United States. The exports of competitors generally are responding with increases in exports of these major grains, but the overall impact on the United States is small because their share of the market is relatively small. For the case of wheat, a 5-percent decrease in U.S. wheat production resulted in an increase in Canadian wheat exports by 2.9 percent in the first year, Australia-New Zealand wheat exports by 0.6 percent, and Argentine wheat exports by 1 percent. For importing countries, due to higher world wheat prices, Japan's wheat imports declined by 0.7 percent and Soviet Union's by 4.4 percent. The estimated delayed multipliers show a less significant impact on world trade for the following years.

Analysis with a Small Simple Microcomputer GOL Model

In addition to using the mainframe, simplified world GOL model to analyze the impacts of a U.S. crop production shortfall, a small experimental two-region model--the United States and the rest-of-the-world--has been assembled on the microcomputer. The structure and operation of this type of simple model are similar to the documented mainframe GOL model; except the world outside the United States is summarized in one single model. Tables 5 and 6 give the elasticities and parameters contained in the model. The model contains only simple supply equations with own- and cross-price elasticities and growth rates and per capita demand equations with own-, cross-price, and income elasticities.

Figures 1 and 3 give the percentage change in price resulting from a 5-percent U.S. crop shortfall in 1985. The implied total elasticities of demand for wheat and corn are shown. The changes in exports and implied export demand elasticities are shown in figures 2 and 4. The implied short-term export elasticity for wheat is -2.2 as compared with -1.7 in the mainframe model. The implied short-term export demand elasticity for corn is estimated at -3.5 as compared with -1.1 in the mainframe model. The differences in the implied export demand elasticity estimates between the two models are mainly due to elasticities used in the model. In the small two-region model, the elasticities for the United States are obtained from the Food and Agricultural Policy Simulator (FAPSIM) U.S. national model of ERS. They are much more elastic than those used in the mainframe GOL version.

Trade Liberalization

Scenarios of increased trade restriction could crudely be analyzed with the simplified GOL model by increasing nontariff trade restrictions. Since the model uses world prices instead of individual country's internal prices in the

Table 5--Elasticities and parameters for the U.S. grain, oilseeds, and livestock model

GOL supply elasticities and growth rates

GOL prod- uct	Current supply (own) price elast.	Lagged supply (own) price elast.	Supply elast. cross product	Current supply cross price elast.	Lagged supply cross price elast.	Annual supply growth rate	Supply a share of
BF	0.21	-0.1	CN	-0.06	0.05	0.015	
PK	-.1	-.09	CN	.06	-.03	.002	
ML	-.2	.1	CN	.15	-.06	-.039	
PM	-.07	.2	CN	-.05	-.1	.037	
PE	.03	-.03	SM	.02	-.02	.001	
WH	.1	.44	CG	-.2	.031		
CN	.05	.45	WH	-.02	-.17	.025	
CG	.1	.3	WH	-.05	-.1		
RI	.01	.14	CT	-.1	.035		
SB	.3	.22	CN	-.05	-.1	.04	
OS	.11	.1	WH	.05	-.05	.035	
SM							TDSB
SO							TDSB
OM							TDOS
OO							TDOS
DB	.1	.05	DC	.01	-.02		TSDC
DC	-.04	.07	SM	-.01	.02	.035	
DO	-.02	-.01	DC	.2	-.05		TSDC
CT	.08	.4	SB		-.23	-.005	
SU	.05	.15	WH		-.1	-.004	

Commodity group symbols

BF	-	Beef & Veal
PK	-	Pork
ML	-	Mutton & Lamb
PM	-	Poultry--Meat
PE	-	Poultry--Eggs
WH	-	Wheat
CN	-	CorN
CG	-	Coarse Grains other than corn
RI	-	Rice
SB	-	SoyBeans
OS	-	Other oilSeeds
SM	-	SoyMeal
SO	-	SoyOil
OM	-	Other Meals
OO	-	Other Oils
DB	-	Dairy--Butter
DC	-	Dairy--Cheese
DO	-	Dairy--Other products
CT	-	CoTton
SU	-	SUGar
TD	-	Total Demand
TS	-	Total Supply

GOL demand elasticities

GOL prod- uct	Current demand (own) price elast.	First demand elast. cross product	First current demand cross price elast.	Second demand elast. cross product	Second current demand cross price elast.	Second lagged demand cross price elast.	Meal in crush equat.	Oil in crush equat.	Crush margin elast.	Crush demand growth rate	Real (per capita) income elast.
BF	-0.3	PK	0.1								0.2
PK	-.6	PM	.2								-.2
ML	-.6	BF	.3								-2.8
PM	-.4	BF	.05								.2
PE	-.3	BF	.1								-.1
WH	-.6	BF	-.2								-.23
CN	-1.3	CG	.2	PK	0.04	-0.08					-.2
CG	-.9	CN	.12	BF	.27	-.01					-1.4
RI	-.4	BF	-.2								1
SB							SM	SO	0.2	0.04	
OS							OM	OO	.05	.04	
SM	-.4	CG	.1	BF	.06	.06					1.6
IO	-.4	DB	.07								1.4
OM	-.4	SM	.2	BF	.03	.05					1
OO	-.4	SO	.2								.5
DB	-.3	BF	-.1								-.4
DC	-.24										.1
DO	-.3	WH	-.04								.15
CT	-.5	BF	.02								-2.5
SU	-.2	CN	.02								-.8

Table 6--Elasticities and parameters for the rest-of-the-world grain, oilseeds, and livestock model

GOL supply elasticities and growth rates

GOL prod- uct	Current supply (own) price elast.	Lagged supply (own) price elast.	Supply elast. cross product	Current supply cross price elast.	Lagged supply cross price elast.	Annual supply growth rate	Supply a share of
BF	0.04	-0.03	CN	0.05	0.04	0.02	
PK	-.10	.10	CN	-.05	.03	.04	
ML	.07	-.11	CG	.05	.01	.01	
PM	.10	.20	CN	-.05	-.08	.05	
PE	.06	.02	SM	.01	.01	.03	
WH	.05	.10				.02	
CN	.06	.20	WH	-.02	-.02	.04	
CG	.15	.20	WH		-.10	.02	
RI	.01	.10	CN		-.05	.03	
SB	.25	.15	CG	-.02	-.05	.04	
OS	.25	.15	WH	.01	.01	.04	
SM							TDSB
SO							TDSB
OM							TDOS
OO							TDOS
DB	.01	.01	DC	-.01	-.01		TSDC
DC	.01	.10	CG	.02	.01	.03	
DO	.01	.01	DC	-.01	-.01		TSDC
CT	.05	.10	CG		-.03	-.02	
SU	.01	.03	RI		.03	-.03	

Commodity group symbols

BF	-	Beef & Veal
PK	-	Pork
ML	-	Mutton & Lamb
PM	-	Poultry--Meat
PE	-	Poultry--Eggs
WH	-	Wheat
CN	-	Corn
CG	-	Coarse Grains other than corn
RI	-	Rice
SB	-	SoyBeans
OS	-	Other oilSeeds
SM	-	SoyMeal
SO	-	SoyOil
OM	-	Other Meals
OO	-	Other Oils
DB	-	Dairy--Butter
DC	-	Dairy--Cheese
DO	-	Dairy--Other products
CT	-	Cotton
SU	-	Sugar
TD	-	Total Demand
TS	-	Total Supply

GOL demand elasticities

GOL prod- uct	Current demand (own) price elast.	First demand elast. cross product	First current demand cross price elast.	Second demand elast. cross product	Second current demand cross price elast.	Second lagged demand cross price elast.	Meal in crush equat.	Oil in crush equat.	Crush margin elast.	Crush demand growth rate	Real (per capita) income elast.
BF	-0.20	PK	0.06								0.20
PK	-.40	PM	-.10								.20
ML	-.20	PK	.07								-.20
PM	-.20	PK	-.05								.50
PE	-.20										-.30
WH	-.20	RI	-.20								.23
CN	-.40	CG	-.05	PK	-0.08	-0.04					.30
CG	-.40	CN	.10	BF	.07	-.02					-.05
RI	-.20	CG	-.02								.20
SB							SM	SO	0.20	0.04	
OS							OM	OO	.10	.04	
SM	-.50	OM	.19	BF	.07	.07					1.10
SO	-.40	OO	.20								1.50
OM	-.40	CN	.05	BF	.04	-.02					.60
OO	-.30	DB	-.05								1.00
DB	-.30	RI	.01								.01
DC	-.40	RI	-.01								.20
DO	-.30	RI	-.04								.40
CT	-.20	RI	-.01								.05
SU	-.20	WH	-.04								-.30

Figure 1--U.S. wheat production: Effects of a 5-percent decline in 1985

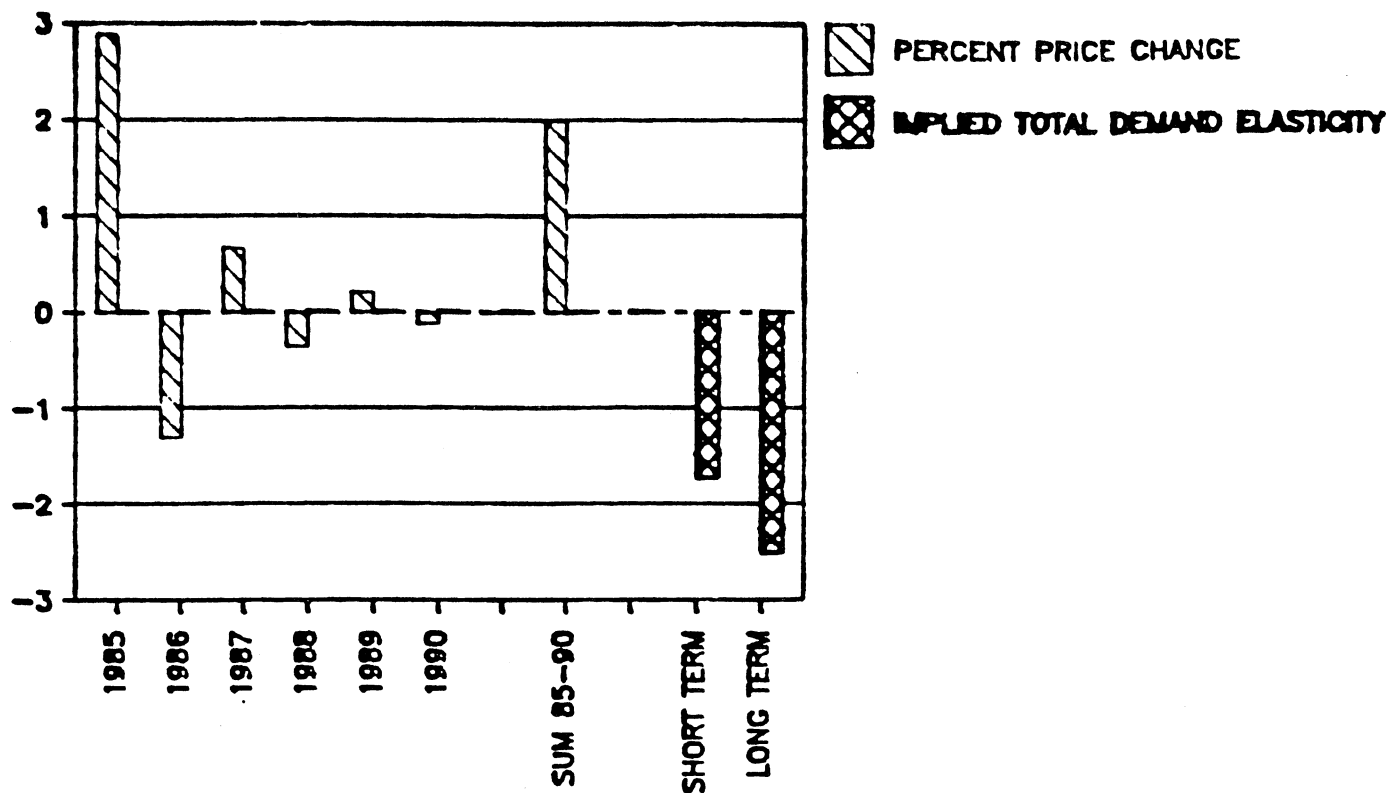


Figure 2--U.S. wheat export response to a 5-percent decline in production

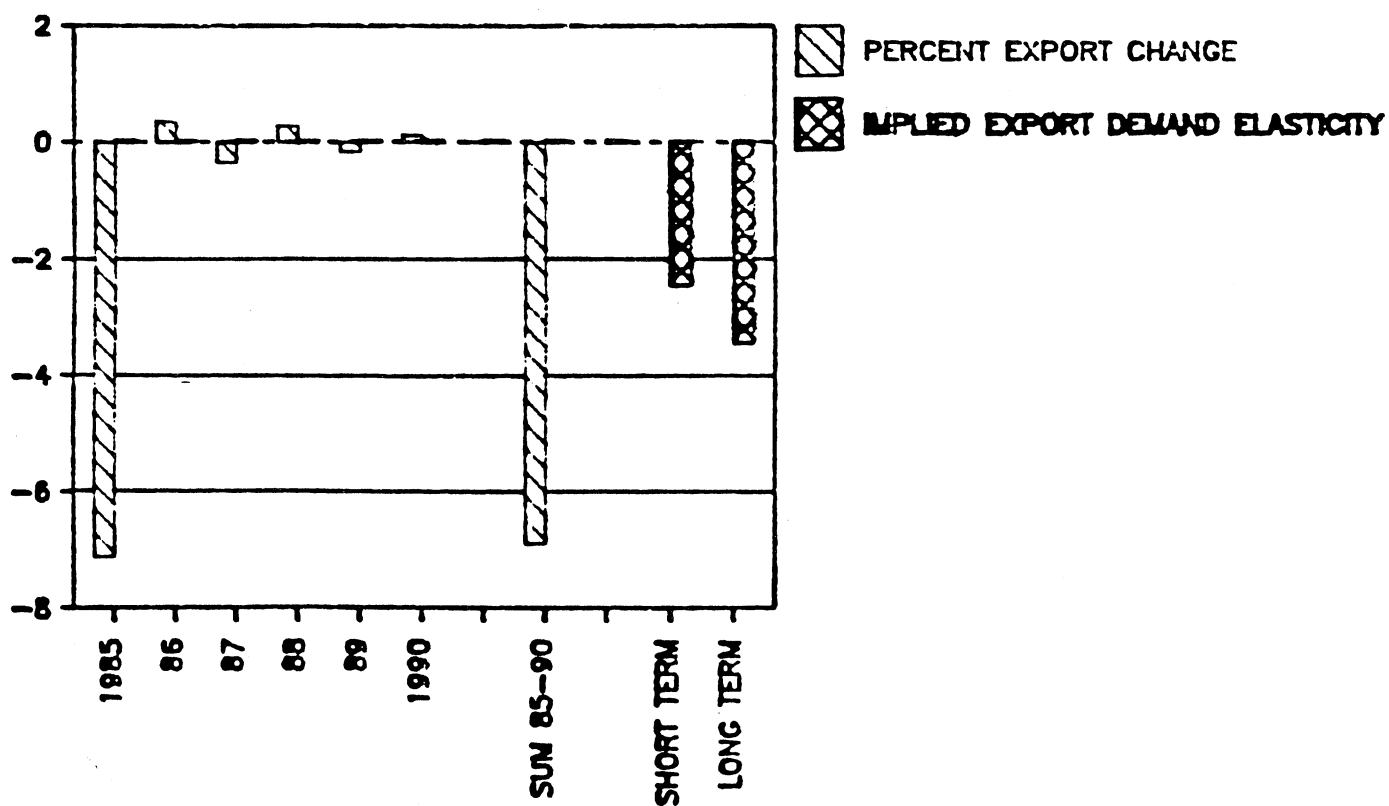


Figure 3--U.S. corn production: Effects of a 5-percent decline in 1985

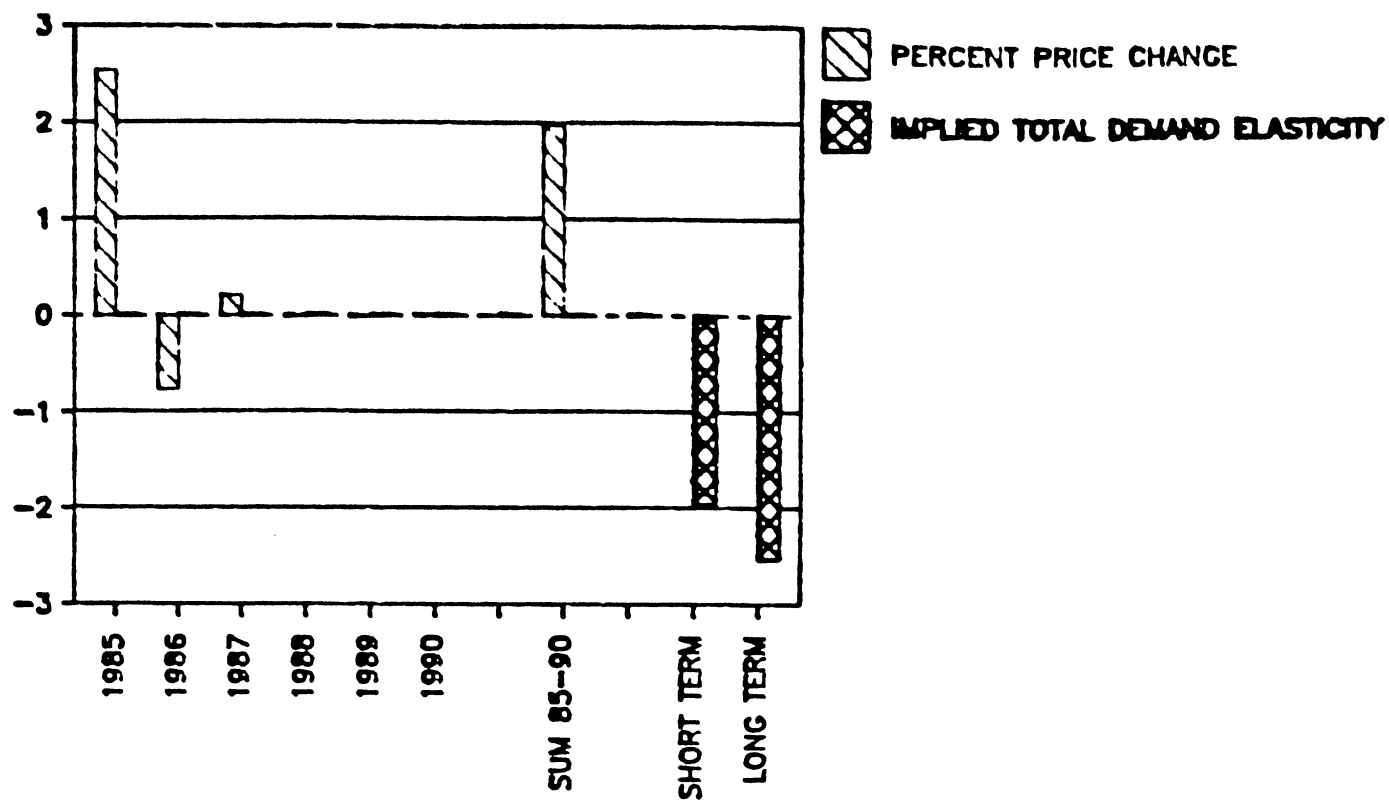
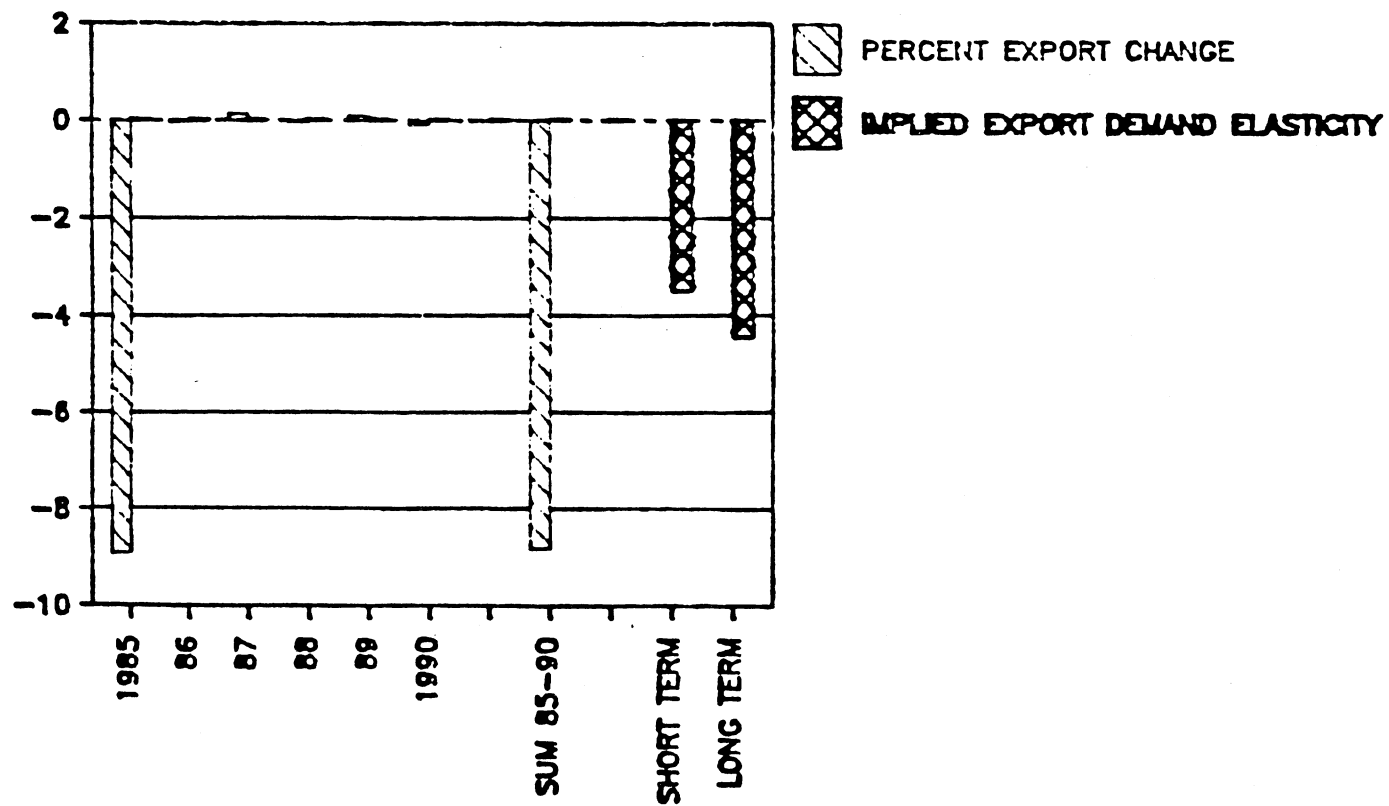


Figure 4--U.S. corn export response to a 5-percent decline in production



supply and demand equations, estimates of shifts in supply or demand due to changes in policies such as tariffs, subsidies, or taxes could be incorporated into the model to analyze the impact of tariff-related trade policies. The simplified model, however, designed basically for long-term projection, lacks the detailed structure needed for policy analysis.

Detailed country models have been developed for the United States, Canada, and Japan, however, that incorporate a generic policy structure. In the detailed country models, price-linkage relationships in the domestic currency are maintained. Alternative trade policies, such as tariff and nontariff trade restrictions, can be analyzed. The following section summarizes the results of a partial trade liberalization study using the single-country Japanese model.

Analysis of Alternative Beef Import Policies in Japan 1/

The Japan GOL model was used to quantify the effects of alternative beef import policies in Japan. Four policy alternatives were simulated: (1) continuation of the current beef import policy, (2) a modest expansion of the import quota (20-percent increase above the base assumption), (3) complete removal of beef import restrictions, and (4) a reduced level of the ad valorem tariff on beef imports.

A simulation based on the assumption of continuing current beef import policy for the period 1981-90 produced a base run. Three alternative scenarios were then tested over the same period to show the effects on the beef sector and other livestock commodities and the derived demand for feed grain for 1985-90 (table 7).

A comparison of the simulation of the small liberalization of beef import quota case with the base run shows beef imports increased about 20 percent, while the quantity demand for beef increased about 4 percent. Beef production decreased slightly, and the demand price decreased about 5 percent. The cross effects on other sectors are small in this case. Demand for pork and poultry decreased about 1.3 and 0.4 percent, and imports decreased about 15 and 4 percent, respectively. Effects on prices and feed demand are insignificant under this case.

Under the scenario of free trade in beef after 1981 (that is, complete removal of tariff and nontariff barriers for beef imports), the simulation results show significant differences from the base. Beef imports increased by an average of 100 percent over the base (starting from a very small base), and domestic demand for beef increased by 22 percent with a lower domestic demand price (24 percent lower than the base). Beef production decreased about 5 percent. The impacts on other commodity sectors varied. Pork and poultry markets were affected most among livestock commodities. The decline in beef prices, resulting from increased beef imports, had the effect of increasing beef consumption while adversely affecting the demand for pork and poultry meat. Demand for pork decreased about 6 percent, while imports decreased by

1/ This section is part of "An Evaluation of the Effects of Reducing Beef Import Restrictions in Japan" by K. Liu, paper presented at the AAEE annual meetings, Ames, IA, Aug. 1985. The model is documented in: A Grain, Oilseed, and Livestock Model of Japan, Karen Liu, ERS Staff Report No. AGES850627, Aug. 1985.

53 percent. Demand for poultry meat decreased by 3 percent, and imports of poultry meat decreased about 22 percent. The results show little or no dampening effects, however, on their prices. The production of these livestock products also declined, which resulted in slightly less feed demand for livestock, and, thus, slightly less feed grain imports.

Under the scenario of a 20-percent ad valorem tariff on Japan's beef imports, the simulation results show that the beef demand price decreased about 19 percent from the base. Beef imports increased by about 77 percent, while quantity demanded increased 17 percent, and beef production decreased about 3

Table 7--Selected simulation results from alternative beef trade policies of Japan

Impacted variable	Average change from current restricted beef trade scenario, 1985-90		
	Small liberalization	Free trade	20 percent <u>ad valorem</u>
	of beef import quota	scenario	on beef imports
	<u>Trillion yen</u>		
1990 consumer welfare increase	0.4	3.4	2.6
	<u>Percent</u>		
Livestock:			
Beef--			
Demand price	-5	-24	-19
Demand quantity	4	22	17
Supply quantity	-.9	-5	-3
Imports	20	100	77
Pork--			
Demand price	-.3	-4	-2
Demand quantity	-1.3	-6	-5
Supply quantity	0	-1	-.8
Trade quantity	-15	-53	-49
Poultry--			
Demand price	--	--	--
Demand quantity	-.4	-3	-2
Supply quantity	--	--	--
Trade quantity	-4	-22	-16
Feed grains:			
Corn--			
Feed demand	-.4	-2	-1.6
Imports	-.3	-2	-1.6
Other coarse grains--			
Feed demand	-.4	-2	-1.8
Imports	-.4	-2	-1.9

-- = Negligible value in percentage terms.

percent. Cross-effects on other commodity sectors were less significant than under the unrestricted trade case. Demand for pork and poultry meat decreased about 5 percent and 2 percent, respectively. Again, little dampening effects were projected for other livestock product prices and feed demand.

The gain in consumers' welfare is estimated in nominal terms for 1990. The estimated gains in consumers' welfare are 0.4 trillion yen under the small liberalization of import quota, 2.6 trillion yen under the 20-percent ad valorem tariff case, and 3.4 trillion yen under the unrestricted trade case. These estimates could overstate the gain in consumers' welfare under alternative scenarios because the import prices were exogenously projected. The cross-effects on other commodity markets, however, could have adverse impacts. The decline in beef prices adversely affects the demand for other livestock products, resulting in a decline in the incomes of domestic pork and poultry producers.