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Price Elasticities from the IIASA World Agriculture Model

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ABSTRACT

Implied 2-year to 10-year price responses from the May 1984 IIASA world agriculture model are described. Net trade quantity changes with respect to percent world price changes are presented, as well as elasticities of supply, demand, net trade, and world-to-domestic price transmission. The regions include the EEC, Japan, Brazil, Argentina, Australia, Canada, Thailand, India, Egypt, Nigeria, and the world less the United States. Commodities shown are wheat, coarse grains, protein feed, ruminant meat, dairy, and other animal products. Implied second-year elasticities of net export demand facing the United States for wheat, coarse grains, and protein feed are -1.5, -1.7, and -1.5, respectively. Selected elasticities are compared with those from the 1978 GOL (grains, oilseeds, and livestock) model. Differences, particularly concerning price transmission and protein feed, are noted.

Keywords: Price elasticities, world-to-domestic price transmission, net trade, cumulative response elasticities, supply, demand, IIASA world agriculture model, 1978 GOL model, simulation.

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SUMMARY

This report describes cumulative responses to sustained world price changes for wheat, coarse grains, protein feed, ruminant meats, dairy products, and other animal products. These responses are implied by the May 1984 version of the world agriculture modelling system created at the International Institute for Applied Systems Analysis (IIASA). Researchers at IIASA continue to update the system. The discussion includes selected own- and cross-price elasticities of supply, demand, net trade, and world-to-domestic price transmission. Changes in net import quantities with respect to percentage price changes are also presented. Elasticities are contrasted with those in the 1978 grains, oilseeds, and livestock (GOL) model.

Significant differences between the elasticities in the IIASA and GOL models show up for EEC wheat supply, Japanese coarse grains demand, Brazilian protein feed supply, EEC protein feed demand, Canadian protein feed demand, and Japanese protein feed demand. Many of the differences in elasticities in the IIASA system result from IIASA's modelling of the relation between domestic and world prices. For several countries, moderate shocks to world prices induce much larger shocks in domestic prices. Many of the large price transmissions in the IIASA system, and major differences between IIASA and GOL elasticities, occur in protein feeds.

The IIASA system results imply elastic net demand for wheat, coarse grains, and protein feed with respect to own prices by the world outside the United States. This means that if the world price of any of the three commodities falls, then the United States could increase its export revenues from that crop by raising its exports to meet the higher net foreign demand. However, when the overall revenue impact of a world price change is evaluated, the effect on prices and quantities of other commodities must be taken into account. The behavior of the world outside the United States described below does not include the U.S. reaction. The total impact will be evaluated in a subsequent report.

IIASA system results imply that a 10-percent drop in world wheat prices would increase annual wheat net demand by countries outside the United States by about 7 million metric tons (MMT) over the base level in the second year. Annual coarse grain import demand would fall by about 4 MMT as a result of the wheat price drop. In the second year of a sustained drop in world wheat prices, each percentage point of the price decline would raise wheat imports by the world outside the United States about 1.5 percent.

A 10-percent decline in the world coarse grains price would imply increased annual import demand by countries outside the United States of about 11 MMT in the second year. Wheat import demand would fall 3 MMT. The elasticity of net demand for coarse grains by the world outside the United States with respect to the world price of coarse grains is -1.7 in the second year.

A similar reduction in the world protein feed price would raise net protein feed demand by 3.7 MMT of soybean meal equivalent, while cutting net coarse grains demand from countries outside the United States by 1.7 MMT. The own-price elasticity of protein feed imports by the world outside the United States is -1.5 in the second year.

The IIASA system suggests that a 10-percent fall in the world price of ruminant meats would reduce desired exports of ruminant meats by the world outside the United States. In the second year of a sustained price drop, the impact would be 0.8 MMT (carcass weight). At the same time, reduced need for feed by the world less the United States would diminish net foreign demand for coarse grains by 0.5 MMT. The response of the United States is affected by its supply and demand elasticities, and by its trade policies. These influences would naturally moderate any trade changes.

A dairy price decline of 10 percent would cause the desired exports of dairy products by the world outside the United States to fall by 3.0 MMT (fresh milk equivalent) in the second year. Desired coarse grain imports would be reduced by 0.2 MMT.

The trade response of the world less the United States to the world price of other animal products (pork, poultry, eggs, and fish) is substantial, according to the IIASA system. In the second year of a 10-percent price decline, the world outside the United States would desire to import 0.36 MMT more of the other animal products (protein equivalent; the protein content averages roughly 10 percent). Desired coarse grain imports would fall by 3 MMT. Wheat, rice, and protein feed (soymeal equivalent) import demand would each drop by 0.6 MMT. Again, these results do not take into account the response of the United States.

Price Elasticities from the IIASA World Agriculture Model

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INTRODUCTION TO THE IIASA SYSTEM

This report shows results from the May 1984 version of the world agriculture model created at the International Institute for Applied Systems Analysis (IIASA). The model is undergoing revision by researchers at IIASA. The model is a simulation system based on econometrically estimated coefficients. It was created to permit analysis of policy scenarios. The system simulates the supply-demand quantities, prices, and policies for several commodities in a number of countries.

There are 20 countries or regions in the system; they are listed in table 1. In addition, there is one simple model which covers all of the remaining countries in the world. This rest-of-world (ROW) model accounts for about 20 percent of world supply and demand. Its supply is specified as a function of time only, not price. There are 16 standard country models, including Argentina, Australia, Austria, Brazil, Canada, the EEC-9, Egypt, Indonesia, Japan, Kenya, Mexico, New Zealand, Nigeria, Pakistan, Thailand, and Turkey (6,9). 1/ The EEC-9 contains Belgium, Denmark, France, Ireland, Italy, Luxembourg, the Netherlands, the United Kingdom, and West Germany. The China model is described in (13). The model of China and the model of the European countries that make up the Council for Mutual Economic Assistance (CMEA) have similar structures. The European CMEA model covers Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and the USSR.

Table 1--Regions included in the IIASA world agriculture system

Argentina	EEC-9	New Zealand
Australia	Egypt	Nigeria
Austria	India	Pakistan
Brazil	Indonesia	Thailand
CMEA, European	Japan	Turkey
Canada	Kenya	United States
China	Mexico	Rest-of-world (ROW)

Source: (6).

1/ Underscored numbers in parentheses refer to items in the references.

Table 2 lists the 10 commodity groups, their units of measurement, and the components that make up each aggregated commodity where they are not evident (7). The system includes nine agricultural commodities and a nonagriculture commodity. The nonagriculture category includes all goods and services outside agriculture except credit and other financial instruments. Six of the commodities are used in this report; they are wheat, coarse grains, protein feed, ruminant meats, dairy, and other animal products.

The system has an annual solution. Each annual step consists of two parts: supply and demand. Supply by each country is calculated first, based on prior prices and quantities. Input levels are generally exponential functions of price ratios or gross domestic product ratios. The ratios indicate the returns to production of a particular commodity versus production of the nonagricultural commodity in the given country. The production inputs are capital, labor, land, and fertilizer. The inputs are optimally allocated among the various commodities by a mathematical programming algorithm. The allocation maximizes expected net revenue.

Table 2--IIASA system commodity list

Commodity	Units	Components
	1,000 metric tons	
Wheat	Wheat equivalent	Wheat, wheat flour
Rice	Milled equivalent	
Coarse grains	Coarse grain equivalent	Corn, sorghum, barley, oats, rye, millet, other grains, coarse grain flour
Ruminant meat	Carcass weight	Meat from cattle, sheep, goats, buffalo, donkeys, camels, horses, game
Dairy products	Fresh milk equivalent	
Other animal products	Protein equivalent	Pork, poultry, eggs, fish
Protein feed	Protein equivalent	Oilseed meal and cake, fish meal, meat meal
	Millions of 1970 dollars	
Other foods		Fats and oils, roots and tubers, pulses, sugar products, vegetables, nuts, fruits, cocoa, coffee, tea, beverages, other food
Nonfood agriculture		Fibers, hides, tobacco, other industrial crops
Nonagriculture		Gross domestic product outside agriculture

Source: (7).

In the second step, every country determines its demand and government policies. The system can calculate those levels simultaneously with endogenous world prices, or run with exogenous world prices specified before the simulation. The demand side takes supply as given. Demand for most countries is described by extended linear expenditure systems. The IIASA system reaches a general equilibrium in the sense that world markets are cleared. The system also includes complete country coverage and an exhaustive commodity list (excepting financial instruments). The equilibrium price is determined by a gradient search algorithm which can accommodate non-smooth functions, such as those affected by trade quotas (11).

A country's response to a world price is a combination of three effects. First, there is the transmission of the world price to the domestic price. This is a function of the historical short- and longrun world-to-domestic price transmission of the country. The productivity of agriculture per employee relative to nonagriculture in the country may also influence prices in this formulation. The price transmission is affected by the country's ratio of production to consumption to the extent that the country desires to maintain a given self-sufficiency ratio. Second, supply or demand elasticities with respect to domestic prices imply quantity responses. The elasticities as such are not given in the system, but they may be inferred from the supply and demand coefficients and equations. Last, government policy may modify expected production and consumption. For example, import quotas may become effective or tax rates may be adjusted to meet national budget goals.

ELASTICITIES AND NET TRADE

This report describes agricultural responses to commodity price changes in the world outside the United States, as implied by the IIASA system. The measures presented are elasticities of supply, demand, net imports, and world-to-domestic price transmission. Additional indicators shown are the net trade quantity responses to percentage changes in commodity prices. Use of the net trade response gives a more robust and usable measure of trade behavior for many individual countries than do elasticities of trade (see appendix). The net trade response of the world outside the United States is shown because it demonstrates export opportunities for U.S. producers.

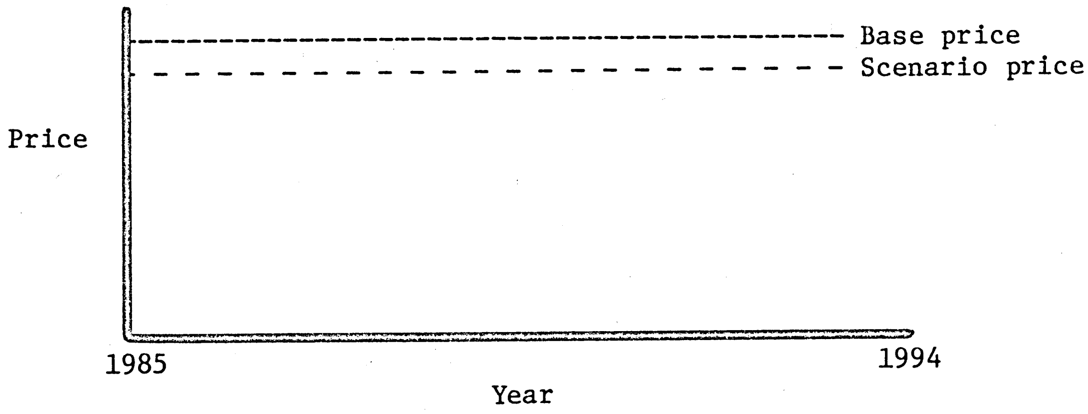
Multipliers

Analysis of the behavior of multi-period economic models has typically used multipliers. These show the ratio of the change in an endogenous variable to the change in an exogenous variable. If the shock to the exogenous variable occurs only in the initial period, the multiplier may be referred to as a delay multiplier (12,4). A sustained shock to the exogenous variable permits the calculation of a multiplier which may be called either a cumulative multiplier, a Tau-period multiplier, a dynamic multiplier, or an intermediate-run multiplier (10,12,4). The calculation of a cumulative response elasticity in this report is analogous to the calculation of a cumulative multiplier.

Scenarios

The simulation runs to determine elasticities and trade responses begin in 1985 and continue through 1994. The base simulation starts with equilibrium

Figure 1--Base and scenario prices for one commodity between 1985 and 1994



prices in 1985. These prices are exogenously held constant through 1994 (see fig. 1). Each of the 10 price change simulations lowers 1 of the 10 commodity prices by 10 percent and holds it at that lower level through 1994. Approximately the same elasticities appear when prices are raised by 10 percent. Elasticities and cross-elasticities for all 10 commodities and 21 country groups have been generated using the system.

Cumulative Response Elasticities

Elasticities are used in this report to describe the IIASA world agriculture modelling system because they are more readily usable for many purposes than are multipliers (1). Elasticities index changes so that knowledge of the level of a particular price or quantity series is not required for the user of the elasticity. This fact is particularly important because of the scaling of price series (14) in the IIASA system.

A supply elasticity describes movement along a supply curve caused by a price change. If resource adjustment is permitted after a price change, over time the supply curve itself shifts. If the total effect of movement along a supply curve as well as a shift of the supply curve is measured, a supply response elasticity may be calculated (16). The IIASA system elasticities in this report can be viewed as response elasticities in that they incorporate shifts in supply and demand curves in addition to movements along the curves.

A total elasticity may be measured when all inputs and cross prices are allowed to vary (3). The elasticities presented in this report are not total elasticities because all world prices are exogenous. Domestic prices, however, may vary if in a particular country the domestic commodity price is not closely linked to the world price. This occurs if there is a trade quota or tariff effective on the commodity.

The elasticities in this report may be described as T-period cumulative response elasticities. They are T-period elasticities in that the length of the time interval must be specified. The elasticities are cumulative because the price shock is sustained. They may be called response elasticities; in general, the supply and demand curves may shift over time.

The T-period cumulative response elasticity is the percentage quantity change over the percentage price change for the scenario versus the base run (equation 1). The own-price elasticity is described if commodity n (whose quantity change is measured) equals commodity N (whose price is changed). When commodity n is different from commodity N, the equation represents a cross-price elasticity. Each of the prices and quantities is measured in period T (8). The world-to-domestic price transmission elasticity is the percentage change in the domestic price of commodity n with respect to the percentage change in the world price of commodity N (equation 2).

The world price of commodity N is changed by the same percentage in each of the periods (equation 3). Each of the n world commodity prices is held fixed during the simulation (equation 4). This assumption may be relaxed to allow endogenous prices during the base, unshocked simulation run. The resulting elasticities are essentially the same as those that prevail with fixed world prices. Fixed price scenarios are used for this report because the resulting elasticities are somewhat smoother over time.

The symbols to be used are defined below:

$E\P P_{n,N,T}$	= Cumulative price transmission elasticity (domestic price of commodity n with respect to world price of commodity N) in period T.
$EQP_{n,N,T}$	= Cumulative response elasticity (quantity of commodity n with respect to world price of commodity N) in period T.
n	= Index of commodities in model.
N	= Commodity whose price is changed.
$\P_{b,n,t}$	= Base domestic supply or demand price for commodity n in period t, without world price shock.
$\P_{s,n,t}$	= Scenario domestic supply or demand price for commodity n in period t, with world price shock.
$P_{b,n,t}$	= Base world price for commodity n in period t, without price shock.
$P_{s,n,t}$	= Scenario world price for commodity n in period t, with price shock.
$Q_{b,n,t}$	= Base quantity for commodity n in period t, without price shock.
$Q_{s,n,t}$	= Scenario quantity for commodity n in period t, with price shock.
t	= Index of periods over which price is shocked.
T	= Interval over which sustained shock is made to price, and at the end of which the cumulative elasticity is measured.

$$EQP_{n,N,T} = \frac{(Q_{s,n,T} - Q_{b,n,T}) / Q_{b,n,T}}{(P_{s,N,T} - P_{b,N,T}) / P_{b,N,T}} \quad \text{where n may equal N} \qquad (1)$$

$$E\P P_{n,N,T} = \frac{(\P_{s,n,T} - \P_{b,n,T}) / \P_{b,n,T}}{(P_{s,N,T} - P_{b,N,T}) / P_{b,N,T}} \quad \text{where n may equal N} \qquad (2)$$

$$P_{s,N,T} / P_{b,N,T} = P_{s,N,T-t} / P_{b,N,T-t} \quad \text{for } t = 1, 2, ..., T-1 \qquad (3)$$

$$P_{b,n,T} = P_{b,n,T-t} \quad \text{for } t = 1, 2, ..., T-1 \qquad (4)$$

Wheat

Table 3 lists selected implied elasticities of supply with respect to the world wheat price. For example, the IIASA system implies that a 1-percent rise in the world wheat price induces a 0.19-percent rise in Argentina's wheat production by the second year of the new price level. By the tenth year, the new price level causes production to rise by 0.29 percent over the level that occurs in the tenth year of the base run. Commodity names in the tables are indented for cross-price elasticity rows. To illustrate, the cross-price elasticity of Canadian coarse grains supply with respect to the world wheat price changes from -0.28 to -0.40 between the second and the tenth years. The elasticity of supply by the world except the United States with respect to the world wheat price is 0.11 in the second year, and rises to 0.33 by the tenth year. The Turkey model shows some erratic elasticity changes. Limited world-to-domestic price transmission generally moderates the effect of world price changes on each country's production. Supply does not vary with world prices in the IIASA system models for the rest-of-world (ROW), for China, and for the European CMEA (East Europe and USSR).

The table includes world-to-domestic price transmission elasticities. These coefficients show the extent to which world price changes are transmitted to domestic prices (2). For example, the IIASA system implies that a 1-percent rise in the world wheat price raises the EEC domestic wheat supply price by 0.38 percent in the second year. The validity of some of these numbers is discussed later in this report. Cross-elasticities of price transmission are also included. For example, the table indicates that in the EEC, none of a world wheat price change is transmitted to the domestic coarse grains price, given the fixed world price scenario used.

Table 3--Selected elasticities of supply and price transmission with respect to world wheat price

Country	Commodity supplied	Elasticity with respect to world price of wheat				Supply price transmission elasticity	
		Year				Year	
		2	4	6	10	2	10
Argentina	Wheat	0.19	0.28	0.28	0.29	1.13	1.13
Australia	Wheat	.35	.30	.30	.31	.75	.61
Canada	Wheat	.50	.57	.51	.43	1.12	1.12
"	Coarse grains	-.28	-.30	-.33	-.40	.00	.00
EEC-9	Wheat	.41	1.00	1.12	2.60	.38	.90
"	Coarse grains	-.29	-.67	-.78	-1.54	.00	.00
"	Ruminant meat	.01	.02	.04	.06	.00	.00
Egypt	Wheat	.47	.75	.80	.81	.67	1.06
India	Wheat	.03	.10	.10	.09		
Pakistan	Wheat	.05	.12	.19	.29	.23	.57
Turkey	Wheat	.19	.14	.19	.42	.88	.73
World less U.S.	Wheat	.11	.19	.20	.33		
"	Coarse grains	-.05	-.09	-.10	-.19		

Source: IIASA world agriculture model scenario.

In general it would be expected that tenth-year responses would be more elastic than second-year reactions because resources move gradually into more profitable activities. In addition, the price transmission equations include lagged prices, which cause gradual rises in elasticities over time. The elasticities shown are chosen on the basis of significant contribution to world net trade. If a world price shock causes a large change in the supply or demand of a commodity in a particular country, the corresponding elasticity is displayed. The few countries which show constant or slightly declining elasticities over time may reflect limited opportunities to develop new land or strong time trends in supply quantities. Government policies may have target ratios of production over consumption, which affect variations in production and lower the supply elasticities. A decline in the transmission of world to domestic prices in the IIASA system's Australia model causes the decline in Australia's elasticity of wheat supply.

Table 4 gives elasticities and cross-elasticities of demand with respect to the world price of wheat. The first elasticity states that a 1-percent rise in the world price of wheat would induce Canada to drop its domestic wheat consumption by 0.34 percent by the second year. Elasticities of wheat demand by the world less the United States change from -0.06 in the second year to -0.08 in the tenth year. The IIASA system thus implies quite inelastic wheat demand. Supply is more price-elastic than demand, which does not enhance system stability.

Table 5 has elasticities of net imports with respect to the world wheat price for the world outside the United States. The own-price figures for wheat are elastic, rising from -1.49 during the second year to -3.42 in the tenth year. This implies that if the United States raises its wheat exports to meet all of the increased net import demand from the remainder of the world resulting from

Table 4--Selected elasticities of demand and price transmission with respect to world wheat price

Country	Commodity demanded	Elasticity with respect to world price of wheat				Demand price transmission elasticity	
		Year				Year	
		2	4	6	10	2	10
Canada	Wheat	-0.34	-0.35	-0.33	-0.30	1.12	1.12
"	Coarse grains	.10	.13	.17	.21	.00	.00
"	Nonagriculture	.01	.01	.01	.01		
EEC-9	Wheat	-.06	-.13	-.21	-.24	.38	.90
"	Coarse grains	.02	.04	.06	.05	.00	.00
"	Protein feed	.04	.08	.11	.14	.00	.00
India	Wheat	-.13	-.12	-.12	-.12	.39	.39
Japan	Wheat	-.27	-.33	-.35	-.37	1.00	1.00
Mexico	Wheat	-.21	-.34	-.40	-.43	.60	.99
World less U.S.	Wheat	-.06	-.07	-.08	-.08		
"	Coarse grains	.01	.01	.02	.02		
"	Protein feed	.01	.02	.02	.03		

Source: IIASA world agriculture model scenario.

Table 5--Selected elasticities of net imports with respect to world wheat price

Country	Commodity imported	Year 2	4	6	8	10
World less U.S.	Wheat	-1.49	-2.15	-2.23	-2.79	-3.42
"	Coarse grains	.59	1.02	1.17	1.46	1.91
"	Protein feed	.06	.09	.11	.12	.13

Source: IIASA world agriculture model scenario.

a 10-percent price decline for wheat, then its wheat export revenues will increase. The tenth-year cross-price effect for coarse grains is also elastic, but less responsive than the wheat elasticity. Cross-commodity quantity and price effects would reduce the positive revenue impact of a wheat price decline.

Table 6 lists selected changes in net exports (for countries which export a given commodity) and changes in net imports (for countries which import a given commodity) in response to a 10-percent decline in the world wheat price. The IIASA system results suggest that a 10-percent drop in the world wheat price would after 2 years induce a 7-million metric ton (MMT) rise in annual wheat import demand by the world outside the United States. This would be an increase in demand that could be met by the United States if it would choose to do so. The United States could increase its exports by up to 7 MMT; the actual export quantity change could be less, depending on the excess supply curve for the United States. There would be an offsetting decline of about 4 MMT in annual coarse grain import demand by the world less the United States. The validity of these numbers is significantly affected by the magnitude of the longer run response by the EEC. This issue will be examined more later.

Coarse Grains

The EEC model indicates a high supply response to the world price of coarse grains in the tenth year (table 7). The cross-elasticity of wheat supply for the EEC with respect to the world price of coarse grains appears too high in comparison to the coarse grain elasticity. The cross-price supply elasticity for wheat probably should not be much more than the coarse grain elasticity because EEC coarse grain area is only slightly larger than wheat area. The overall response of the world outside the United States is quite inelastic. This results in part from the fact that the world price is used. World price changes are in general moderated and delayed as they are transmitted to domestic prices and then to farmers' expectations. Moreover, neither China, the European CMEA (East Europe and USSR), nor the ROW (rest-of-world) in the IIASA system have supplies responsive to the world price. The own-price elasticity of coarse grain supply by the world outside the United States is calculated to be 0.07 after 2 years and 0.19 after 10 years.

Elasticities of demand with respect to the world coarse grain price are in table 8. Japan shows a quite high 10-year demand response because of high price transmission. The elasticity of coarse grain demand by the world less the United States becomes more elastic with time, changing from -0.09 after 2 years to -0.23 after 10 years.

Table 6--Selected responses of net trade to a 10-percent decline in the world wheat price

Country	Commodity traded	Year 2	4	6	8	10
		1,000 metric tons				
Exports:						
Argentina	Wheat	-231	-335	-347	-359	-370
Australia	Wheat	-651	-577	-596	-642	-666
Canada	Wheat	-1305	-1567	-1521	-1495	-1498
"	Coarse grains	891	1025	1190	1339	1488
"	Nonagriculture 1/	96	119	130	140	151
EEC-9	Wheat	-2236	-5215	-5930	-8737	-12068
India	Rice	63	168	157	153	158
Turkey	Wheat	-417	-345	-406	-795	-753
World less U.S.	Dairy 2/	224	182	33	139	151
Imports:						
EEC-9	Coarse grains	-2134	-5163	-6411	-8610	-13017
"	Ruminant meat 3/	8	23	43	55	63
"	Protein feed 4/	-20	-47	-66	-81	-92
Egypt	Wheat	147	246	280	299	310
India	Wheat	632	1014	1088	1124	1177
Japan	Wheat	220	279	312	341	371
Mexico	Wheat	140	255	323	371	410
Pakistan	Wheat	81	191	288	373	466
World less U.S.	Wheat	7330	11342	12485	16002	19632
"	Coarse grains	-3800	-6987	-8290	-11020	-15523
"	Rice	-127	-277	-283	-289	-291
"	Protein feed 4/	-61	-100	-126	-148	-167

1/ Nonagriculture in millions of 1970 dollars.
2/ Dairy in fresh milk equivalent.
3/ Ruminant meat in carcass weight.
4/ Protein feed in protein equivalent.
Source: IIASA world agriculture model scenario.

Elasticities of net imports with respect to the world coarse grains price for the world less the United States may be seen in table 9. The own-price elasticities are of comparable magnitudes to those with respect to the world wheat price. The own-price behavior of net imports of coarse grains is elastic, changing from -1.70 to -3.99 between the second and tenth years. As with wheat, the elastic IIASA system response suggests that lower world coarse grain prices would raise United States coarse grain export revenues if the United States would choose to meet all of the increased export demand. However, the impact on other commodity prices and quantities would tend to reduce the benefits of a coarse grains price drop.

Net trade responses for coarse grains appear in table 10. By the tenth year, the EEC and Japan dominate the trade responses. The IIASA model indicates that a 10-percent fall in world coarse grain prices would increase

Table 7--Selected elasticities of supply and price transmission with respect to world coarse grain price

Country	Commodity supplied	Elasticity with respect to world price of coarse grains: Year 2	Year 4	Year 6	Year 10	Supply price transmission elasticity: Year 2	Year 10
Argentina	Coarse grains	0.11	0.16	0.18	0.20	0.59	0.75
Australia	Coarse grains	.41	.62	.66	.68	1.06	1.41
Canada	Coarse grains	.25	.34	.35	.37	1.00	1.00
"	Wheat	-.17	-.15	-.14	-.12	.00	.00
EEC-9	Coarse grains	.25	.62	.96	1.18	.33	.86
"	Wheat	-.30	-.79	-1.35	-1.88	.00	.00
Japan	Dairy	-.18	-.24	-.34	-.56	.02	.33
World less U.S.	Coarse grains	.07	.12	.16	.19		
"	Wheat	-.05	-.11	-.15	-.19		
"	Protein feed	.00	-.01	-.01	-.02		
"	Dairy	-.01	-.01	-.01	-.02		

Source: IIASA world agriculture model scenario.

Table 8--Selected elasticities of demand and price transmission with respect to world coarse grain price

Country	Commodity demanded	Elasticity with respect to world price of coarse grains: Year 2	Year 4	Year 6	Year 10	Demand price transmission elasticity: Year 2	Year 10
Australia	Coarse grains	-0.50	-0.80	-0.84	-0.81	1.06	1.41
Canada	Coarse grains	-.29	-.35	-.34	-.33	1.00	1.00
EEC-9	Coarse grains	-.11	-.22	-.29	-.38	.33	.86
"	Protein feed	.10	.21	.28	.36	.00	.00
India	Coarse grains	-.25	-.35	-.35	-.34	.49	.76
Japan	Coarse grains	-.62	-1.28	-1.85	-2.73	1.60	4.21
"	Wheat	.16	.40	.57	.80	.00	.00
"	Rice	.13	.31	.45	.61	.00	.21
"	Protein feed	.37	.86	1.21	1.66	.00	.00
World less U.S.	Coarse grains	-.09	-.14	-.17	-.23		
"	Wheat	.01	.02	.02	.03		
"	Protein feed	.06	.12	.15	.20		

Source: IIASA world agriculture model scenario.

Table 9--Selected elasticities of net imports with respect to world coarse grain price

Country	Commodity traded	Year 2	4	6	8	10
World less U.S.	Coarse grains	-1.70	-2.65	-3.41	-3.86	-3.99
"	Wheat	.54	1.02	1.38	1.67	1.80
"	Protein feed	.25	.48	.65	.77	.85

Source: IIASA world agriculture model scenario.

Table 10--Selected responses of net trade to a 10-percent decline in the world coarse grain price

Country	Commodity traded	Year 2	4	6	8	10
		1,000 metric tons				
Exports:						
Argentina	Coarse grains	-281	-443	-500	-532	-557
Australia	Coarse grains	-476	-764	-832	-866	-890
Canada	Coarse grains	-1177	-1531	-1584	-1621	-1652
"	Wheat	509	511	501	504	529
"	Protein feed 1/	51	52	53	54	56
EEC-9	Wheat	1535	3842	6160	7728	8259
Japan	Rice	70	297	450	537	603
World less U.S.	Dairy 2/	-330	-502	-535	-718	-886
Imports:						
EEC-9	Coarse grains	2595	6626	9722	12247	12911
"	Protein feed 1/	-56	-125	-177	-215	-244
India	Coarse grains	794	1356	1394	1435	1473
Japan	Coarse grains	1713	3801	5893	7960	9894
"	Wheat	-123	-331	-504	-649	-780
"	Dairy 2/	-157	-212	-313	-448	-562
"	Protein feed 1/	-112	-310	-472	-609	-735
World less U.S.	Coarse grains	10888	18145	24164	29249	32382
"	Wheat	-2679	-5367	-7708	-9593	-10338
"	Rice	-252	-581	-708	-795	-804
"	Protein feed 1/	-264	-539	-762	-945	-1106

1/ Protein feed in protein equivalent.
2/ Dairy in fresh milk equivalent.
Source: IIASA world agriculture model scenario.

annual net foreign demand by 11 MMT after 2 years. There would be a corresponding 3-MMT fall in annual wheat demand. In the second year, the EEC accounts for 24 percent of coarse grains response, and Japan for 16 percent.

Protein Feed

Brazil's supply response to the world price of protein feed is quite inelastic, rising from an elasticity of 0.06 after 2 years to only 0.11 after 10 years (table 11). For further discussion of the Brazilian supply elasticity, see the section of this report on alternative elasticity comparisons for protein feed. The world-less-United States elasticity of supply is inelastic, rising from 0.03 after 2 years to 0.05 after 10 years.

Table 12 contains elasticities of demand with respect to the world price of protein feed. Demand is more elastic than supply, and the price response of demand is spread over more countries than is the supply response. The own-price elasticity of protein feed demand for the world less the United States changes from -0.36 to -0.44 between the second and tenth years. The Canadian price transmission elasticities are quite substantial.

Net import elasticities with respect to the world protein feed price are given in table 13. The own-price elasticity of protein feed imports by the world exclusive of the United States is price-responsive, rising from -1.52 in 2 years to -1.92 in 10 years. A decline in the world protein feed price would permit the United States to increase its protein export revenues, but the result on other commodity prices and quantities would offset part of the benefit. The cross-price response of coarse grains demand with respect to the protein price is inelastic, rising to 0.40 by the tenth year.

Table 14 includes net trade responses to a 10-percent reduction in protein prices. The strongest quantity response is in the EEC, at 0.78 MMT soybean meal equivalent in the second year. After 2 years, annual protein feed import demand by the world outside the United States rises from the base run level by 1.6 million metric tons of protein equivalent (about 3.7 MMT soybean meal equivalent). Annual coarse grain import demand falls by 1.7 MMT.

Table 11--Selected elasticities of supply and price transmission with respect to world protein feed price

Country	Commodity supplied	Elasticity with respect to world price of protein feed				Supply price transmission elasticity	
		Year				Year	
		2	4	6	10	2	10
Brazil	Protein feed	0.06	0.08	0.09	0.11	0.92	0.93
Canada	Protein feed	.18	.28	.32	.34	1.51	2.37
"	Wheat	-.03	-.04	-.04	-.04	.00	.00
"	Coarse grains	-.04	-.06	-.07	-.07	.00	.00
Japan	Coarse grains	.00	-.24	-.40	-.91	.00	.00
World less U.S.	Protein feed	.03	.04	.04	.05		

Source: IIASA world agriculture model scenario.

Table 12--Selected elasticities of demand and price transmission with respect to world protein feed price

Country	Commodity demanded	Elasticity with respect to world price of protein feed				Demand price transmission elasticity	
		Year				Year	
		2	4	6	10	2	10
Brazil	Protein feed	-0.41	-0.53	-0.52	-0.51	0.92	0.93
"	Coarse grains	.07	.09	.10	.10	.00	.00
"	Nonagriculture	.01	.01	.01	.01		
Canada	Protein feed	-.91	-1.61	-1.88	-2.03	1.51	2.37
"	Wheat	.09	.16	.18	.20	.00	.00
"	Coarse grains	.17	.30	.36	.41	.00	.00
EEC-9	Protein feed	-.58	-.64	-.64	-.64	.73	.73
"	Wheat	.04	.06	.06	.06	.00	.00
"	Coarse grains	.08	.10	.10	.10	.00	.00
Japan	Protein feed	-.42	-.74	-.89	-1.00	.91	1.43
"	Coarse grains	.07	.14	.16	.17	.00	.00
Mexico	Protein feed	-.41	-.65	-.72	-.74	.74	1.00
"	Coarse grains	.05	.08	.09	.10	.00	.02
World less U.S.	Protein feed	-.36	-.41	-.43	-.44		
"	Wheat	.01	.01	.01	.01		
"	Coarse grains	.02	.03	.04	.04		

Source: IIASA world agriculture model scenario.

Table 13--Selected elasticities of net imports with respect to world protein feed price

Country	Commodity traded	Year				
		2	4	6	8	10
World less U.S.	Protein feed	-1.52	-1.78	-1.87	-1.91	-1.92
"	Wheat	.08	.10	.11	.11	.13
"	Coarse grains	.26	.38	.41	.42	.40

Source: IIASA world agriculture model scenario.

Table 14--Selected responses of net trade to a 10-percent decline in the world protein feed price

Country	Commodity traded	Year 2	4	6	8	10
		1,000 metric tons				
Exports:						
Brazil	Protein feed 1/	-79	-112	-125	-138	-152
Canada	Protein feed 1/	-106	-183	-215	-231	-240
"	Wheat	117	190	221	236	246
"	Coarse grains	417	729	863	939	993
EEC-9	Wheat	196	235	241	248	303
Imports:						
Brazil	Coarse grains	-175	-247	-269	-289	-311
"	Nonagriculture 2/	-96	-112	-127	-141	-155
EEC-9	Protein feed 1/	342	390	406	421	435
"	Coarse grains	-661	-814	-827	-863	-826
Japan	Protein feed 1/	167	296	377	431	475
"	Coarse grains	-182	-437	-535	-594	-633
Mexico	Protein feed 1/	28	48	58	64	70
"	Coarse grains	-120	-194	-221	-241	-258
World less U.S.	Protein feed 1/	1626	1987	2191	2352	2495
"	Wheat	-388	-548	-605	-642	-718
"	Coarse grains	-1693	-2607	-2918	-3144	-3244
"	Rice	-104	-155	-166	-166	-159

1/ Protein feed in protein equivalent.
2/ Nonagriculture in millions of 1970 dollars.
Source: IIASA world agriculture model scenario.

Ruminant Meat

Table 15 shows supply elasticities with respect to the world ruminant meat price. Ruminant meats consist largely of beef and mutton (see table 1 for commodity definitions). The own-price supply elasticity for ruminant meats in the world less the United States rises from 0.04 in the second year to 0.07 in the tenth year. The cross-elasticity of coarse grain supply with respect to the world ruminant meat price is -0.01 in each year. New Zealand is the most price-responsive, with own-price elasticities rising from 0.24 to 0.60. Elasticities for the EEC are steady at 0.04. The supply response with respect to the world price includes the world-to-domestic price transmission, supply response to the domestic price, and domestic policies.

Demand elasticities with respect to the world ruminant meat price are presented in table 16. The elasticity of demand by the world less the United States is level at -0.09. Demand response by the EEC is also constant, with an elasticity of -0.08.

Table 15--Selected elasticities of supply and price transmission with respect to world ruminant meat price

Country	Commodity supplied	Elasticity with respect to world price of ruminant meat				Supply price transmission elasticity	
		Year				Year	
		2	4	6	10	2	10
Argentina	Ruminant meat	0.10	0.08	0.09	0.10	0.80	0.59
Brazil	Ruminant meat	.14	.24	.27	.29	.65	.99
"	Dairy	.03	.03	.04	.04	-.01	-.04
Canada	Ruminant meat	.23	.27	.30	.34	.64	.54
"	Coarse grains	-.02	-.05	-.08	-.11	.00	.00
EEC-9	Ruminant meat	.04	.04	.04	.04	.15	.15
"	Coarse grains	-.01	-.01	-.01	-.03	.00	.00
"	Dairy	-.02	-.02	-.01	-.01	.00	.02
New Zealand	Ruminant meat	.24	.37	.46	.60	1.00	1.00
"	Coarse grains	-.77	-1.06	-1.12	-1.18	.00	.00
World less U.S.	Ruminant meat	.04	.06	.06	.07		
"	Wheat	.00	-.01	-.01	.00		
"	Coarse grains	-.01	-.01	-.01	-.01		

Source: IIASA world agriculture model scenario.

Table 16--Selected elasticities of demand and price transmission with respect to world ruminant meat price

Country	Commodity demanded	Elasticity with respect to world price of ruminant meat				Demand price transmission elasticity	
		Year				Year	
		2	4	6	10	2	10
Argentina	Ruminant meat	-0.15	-0.10	-0.12	-0.11	0.80	0.59
Canada	Ruminant meat	-.35	-.30	-.30	-.29	.64	.54
"	Coarse grains	.01	.06	.09	.11	.00	.00
EEC-9	Ruminant meat	-.08	-.08	-.08	-.08	.15	.15
New Zealand	Nonagriculture	.04	.04	.04	.04		
World less U.S.	Ruminant meat	-.09	-.09	-.09	-.09		
"	Coarse grains	.00	.00	.00	.01		

Source: IIASA world agriculture model scenario.

Net trade responses to a 10-percent decline in the world ruminant meat price are displayed in table 17. Net exports by the world less the United States fall by 0.8 million metric tons (MMT) carcass weight in the second year and 1.1 MMT in the tenth year. Net nonagricultural exports by the world outside the United States rise by $150 million (1970 dollars) in the second year and $300 million (1970 dollars) in the tenth year. The ruminant meat price

Table 17--Selected responses of net trade to a 10-percent decline in the world ruminant meat price

Country	Commodity traded	Year 2	4	6	8	10
		1,000 metric tons				
Exports:						
Argentina	Ruminant meat 1/	-70	-54	-62	-63	-66
Brazil	Ruminant meat 1/	-62	-105	-126	-139	-149
Canada	Ruminant meat 1/	-83	-85	-93	-100	-105
"	Wheat	66	90	92	92	104
"	Coarse grains	67	245	367	451	519
EEC-9	Wheat	52	97	108	61	16
"	Dairy 2/	179	166	141	150	144
New Zealand	Ruminant meat 1/	-33	-52	-66	-78	-88
"	Coarse grains	102	161	185	207	228
Turkey	Wheat	23	61	78	81	84
World less U.S.	Ruminant meat 1/	-811	-908	-988	-1051	-1110
"	Dairy 2/	146	100	58	55	43
"	Nonagriculture 3/	151	172	219	258	298
Imports:						
Argentina	Nonagriculture 3/	-24	-30	-37	-43	-49
Australia	Nonagriculture 3/	-32	-32	-33	-34	-34
Brazil	Coarse grains	-46	-80	-95	-102	-105
"	Dairy 2/	30	40	45	51	56
EEC-9	Ruminant meat 1/	119	123	126	130	134
"	Coarse grains	-3	-62	-66	-123	-217
New Zealand	Nonagriculture 3/	-43	-44	-47	-49	-51
World less U.S.	Wheat	-287	-400	-431	-380	-342
"	Coarse grains	-500	-869	-1016	-1213	-1402
"	Other animal pr. 4/	-12	-8	-7	-7	-6
"	Other foods 5/	-168	-190	-177	-161	-151

1/ Ruminant meat in carcass weight.
2/ Dairy in fresh milk equivalent.
3/ Nonagriculture in millions of 1970 dollars.
4/ Other animal products; in protein equivalent.
5/ Other foods in millions of 1970 dollars.
Source: IIASA world agriculture model scenario.

affects nonagricultural trade mainly through the desire of countries to meet trade balance targets. Net coarse grain imports by the world less the United States fall by 0.5 MMT in the second year and 1.4 MMT in the tenth year in response to the sustained 10-percent decline in the world ruminant meat price. Wheat imports also fall by between 0.3 and 0.4 MMT. The IIASA scenario results show the ruminant meat price affecting a number of other commodities. Elasticities of net trade for the animal products are not shown because the net trade level by the world less the United States is small, and not well calibrated in the system (see the appendix for a discussion of the robustness of net trade elasticities).

Dairy Products

Table 18 lists elasticities of supply in response to the world dairy price. The elasticity for the world less the United States is calculated to be 0.02. This low response is partly caused by the insulation of many domestic markets from the world dairy price. New Zealand is more affected by the world price than other countries in the table; its elasticity rises from 0.12 in the second year to 0.34 in the tenth year. The EEC supply elasticity drops from 0.03 to 0.02 in the same interval. The IIASA system shows the dairy sector as being less tied to the rest of world agriculture than are ruminant meats or other animal products.

Table 19 contains dairy demand elasticities. The elasticity for the world less the United States remains at -0.04. India's demand elasticity is

Table 18--Selected elasticities of supply and price transmission with respect to world dairy price

Country	Commodity supplied	Elasticity with respect to world price of dairy products: Year 2	4	6	10	Supply price transmission elasticity: Year 2	10
Brazil	Dairy	0.09	0.07	0.07	0.07	0.18	0.14
Canada	Dairy	.05	.07	.08	.08	.11	.09
EEC-9	Dairy	.03	.02	.02	.02	.07	.05
India	Dairy	.01	.01	.01	.01		
Japan	Dairy	.07	.07	.06	.07	.12	.08
Mexico	Dairy	.03	.06	.07	.08	.14	.23
New Zealand	Dairy	.12	.20	.26	.34		
Pakistan	Dairy	.03	.04	.04	.04	.20	.20
World less U.S.	Dairy	.02	.02	.02	.02		

Source: IIASA world agriculture model scenario.

Table 19--Selected elasticities of demand and price transmission with respect to world dairy price

Country	Commodity demanded	Elasticity with respect to world price of dairy products: Year 2	4	6	10	Demand price transmission elasticity: Year 2	10
India	Dairy	-0.07	-0.07	-0.07	-0.07	0.11	0.11
Mexico	Dairy	-.04	-.06	-.07	-.06	.14	.23
World less U.S.	Dairy	-.04	-.04	-.04	-.04		

Source: IIASA world agriculture model scenario.

constant at -0.07. As in the other tables in this paper, countries are included if their price response can cause a significant change in trade of a commodity, as determined by IIASA system results. In the case of dairy demand, few countries appear to be closely tied to world prices.

Net trade responses to a 10-percent drop in the world dairy price are in table 20. The world outside the United States reduces its net exports by 2.9 MMT of fresh milk equivalent in the second year and 3.6 MMT in year ten. In the second and tenth years, coarse grain imports fall by 0.2 MMT and 0.4 MMT, respectively. Wheat imports are diminished by 0.1 MMT and 0.2 MMT.

Other Animal Products

Table 21 contains supply elasticities based on the world price of other animal products. Other animal products consist of pig meat, poultry meat, eggs, and fishery products for food use, all aggregated on the basis of their protein content. The own-price supply elasticity of other animal products for the world less the United States varies between 0.08 and 0.07 over time. The

Table 20--Selected responses of net trade to a 10-percent decline in the world dairy price

Country	Commodity traded	Year: 2	4	6	8	10
		1,000 metric tons				
Exports:						
Canada	Dairy 1/	-86	-112	-112	-117	-125
"	Coarse grains	7	39	64	78	91
EEC-9	Dairy 1/	-342	-306	-287	-316	-315
"	Wheat	33	60	53	21	36
New Zealand	Dairy 1/	-79	-131	-171	-205	-232
Turkey	Wheat	6	20	49	80	84
World less U.S.	Dairy 1/	-2853	-3045	-3227	-3453	-3634
"	Ruminant meat 2/	3	19	27	35	41
Imports:						
Brazil	Dairy 1/	110	83	91	95	97
EEC-9	Coarse grains	-18	-53	-39	-77	-75
"	Nonagriculture 3/	-47	-47	-48	-47	-45
India	Dairy 1/	301	318	335	356	379
Japan	Dairy 1/	89	87	84	95	100
Mexico	Dairy 1/	57	110	145	166	181
"	Coarse grains	-9	-29	-47	-59	-70
Pakistan	Dairy 1/	69	85	85	90	96
World less U.S.	Wheat	-86	-149	-166	-161	-182
"	Coarse grains	-182	-313	-355	-430	-447

1/ Dairy in fresh milk equivalent.
2/ Ruminant meat in carcass weight.
3/ Nonagriculture in millions of 1970 dollars.
Source: IIASA world agriculture model scenario.

Table 21--Selected elasticities of supply and price transmission with respect to world price of other animal products

Country	Commodity supplied	Elasticity with respect to world price of other animal products: Year 2	4	6	10	Supply price transmission elasticity: Year 2	10
Brazil	Oth. animal pr. 1/	0.27	0.33	0.32	0.34	1.03	0.88
"	Dairy	-.09	-.06	-.04	-.04	.03	.07
Canada	Oth. animal pr. 1/	.13	.19	.19	.21	.41	.25
EEC-9	Oth. animal pr. 1/	.27	.18	.19	.20	.61	.37
"	Ruminant meat	-.08	-.07	-.06	-.06	.00	.00
"	Dairy	-.09	-.01	-.02	-.02	.04	.10
Japan	Oth. animal pr. 1/	.16	.15	.17	.20	.81	.52
"	Dairy	-.22	-.11	-.07	-.05	.02	.05
Mexico	Oth. animal pr. 1/	.06	.10	.12	.15	.28	.31
New Zealand	Oth. animal pr. 1/	.94	.94	.94	.94	1.00	1.00
"	Dairy	-.11	-.11	-.11	-.11		
Nigeria	Oth. animal pr. 1/	.19	.22	.23	.24	.98	.95
Thailand	Oth. animal pr. 1/	.70	.73	.73	.72	1.00	1.00
"	Rice	-.13	-.11	-.11	-.11	.00	.00
"	Coarse grains	-.36	-.43	-.45	-.46	.00	.00
"	Other foods	-.28	-.45	-.48	-.49	.00	.00
World less U.S.	Oth. animal pr. 1/	.08	.07	.07	.07		
"	Ruminant meat	-.02	-.02	-.02	-.01		
"	Dairy	-.03	-.01	-.01	-.01		
"	Protein feed	.00	.01	.02	.03		
"	Other foods	-.01	-.01	-.01	-.01		

1/ Other animal products.
Source: IIASA world agriculture model scenario.

supply elasticity in the EEC drops from 0.27 in the second year to 0.20 in the tenth year. The elasticities for New Zealand and Thailand, of 0.9 and 0.7, respectively, are three to four times as large as those for Brazil, Canada, the EEC, Japan, Mexico, and Nigeria.

In table 22 there are demand elasticities with respect to the world price for other animal products, as implied by the IIASA system. The world less the United States has an elasticity of -0.11 in the second year and -0.10 in the tenth year. The cross-price elasticity of demand for coarse grains versus the other animal products price is 0.04 and 0.05 in the second and tenth years, respectively. The cross-price elasticity of protein feed demand is about 0.07 in each year, according to the IIASA system scenario. These cross-price demands are largely derived from the demand for feeding of other animals. The own-price elasticities of demand by the EEC and Japan are approximately -0.05.

Table 22--Selected elasticities of demand and price transmission with respect to the world price of other animal products

Country	Commodity demanded	Elasticity with respect to world price of other animal products				Demand price transmission elasticity	
		Year				Year	
		2	4	6	10	2	10
Brazil	Oth. animal pr. 1/	-0.31	-0.26	-0.24	-0.22	0.80	0.67
"	Coarse grains	.15	.19	.19	.22	.00	.00
Canada	Coarse grains	.06	.11	.13	.15	.00	.00
EEC-9	Oth. animal pr. 1/	-.08	-.04	-.05	-.04	.46	.27
"	Wheat	.11	.08	.09	.10	.00	.00
"	Coarse grains	.19	.13	.14	.15	.00	.00
"	Dairy	.04	.02	.03	.03	.04	.10
"	Protein feed	.26	.18	.19	.20	.00	.00
Japan	Oth. animal pr. 1/	-.08	-.04	-.05	-.03	.60	.38
"	Wheat	.10	.10	.12	.15	.00	.00
"	Rice	.06	.06	.07	.08	.01	.06
"	Coarse grains	.23	.22	.26	.31	.00	.00
"	Protein feed	.17	.17	.20	.25	.00	.01
Thailand	Oth. animal pr. 1/	-.14	-.14	-.14	-.13	1.00	1.00
"	Rice	.17	.19	.19	.20	.00	.00
"	Nonagriculture	-.04	-.07	-.07	-.07		
World less U.S.	Oth. animal pr. 1/	-.11	-.10	-.11	-.10		
"	Wheat	.02	.01	.02	.02		
"	Rice	.01	.01	.01	.02		
"	Coarse grains	.04	.04	.04	.05		
"	Dairy	.01	.01	.01	.01		
"	Protein feed	.07	.06	.06	.07		
"	Other foods	.00	.00	.00	.01		

1/ Other animal products.
Source: IIASA world agriculture model scenario.

Table 23 lays out net trade responses to a 10-percent drop in the world price for the other animal products. The other animal products price affects other agricultural subsectors strongly. The price drop induces a 0.4-MMT protein equivalent rise in net imports of other animal products by the world outside the United States. This is equivalent to roughly 4 MMT of other animal products as traded because the protein contents of these products typically range between 8 and 14 percent (17). Wheat and rice imports fall by about 0.6 MMT each. Coarse grain imports drop by 2.8 MMT after 2 years and 4.5 MMT after 10 years. Protein feed imports fall by about 0.25 MMT protein equivalent or about 0.6 MMT soybean meal equivalent. Other food imports fall by about $440 million (1970 dollars) in the second year and $340 million in the tenth year. Nonagricultural exports rise $150 million in the second year and $500 million in the tenth year. Ruminant meat exports are up 0.19 MMT (carcass weight) in the second year and 0.13 MMT in the last year. Dairy exports are 2.2 MMT (fresh milk equivalent) higher than in the base run during year two. The EEC and Japan contribute to much of the price responsiveness of the world outside the United States, according to results from these scenarios.

Table 23--Selected responses of net trade to a 10-percent decline in the world price of other animal products

Country	Commodity traded	Year 2	4	6	8	10
		1,000 metric tons				
Exports:						
Brazil	Other animal pr. 1/	-25	-27	-28	-30	-32
Canada	Other animal pr. 1/	-8	-9	-9	-10	-11
"	Coarse grains	52	206	331	403	462
"	Nonagriculture 2/	57	62	65	67	70
EEC-9	Other animal pr. 1/	-87	-57	-66	-74	-71
"	Wheat	291	221	263	476	269
"	Dairy 3/	1498	422	636	820	587
Japan	Rice	119	89	94	100	103
"	Nonagriculture 2/	99	117	119	120	120
Thailand	Other animal pr. 1/	-20	-22	-24	-27	-29
"	Rice	343	357	387	422	459
"	Coarse grains	144	186	205	223	242
"	Other foods 4/	111	192	215	234	253
World less U.S.	Ruminant meat 5/	186	156	143	136	126
"	Dairy 3/	2182	874	975	1174	903
"	Nonagriculture 2/	147	231	333	409	500
Imports:						
Brazil	Coarse grains	-418	-539	-545	-592	-642
"	Nonagriculture 2/	-8	-22	-51	-68	-82
EEC-9	Coarse grains	-1263	-1015	-1168	-1066	-1343
"	Ruminant meat 5/	-93	-80	-78	-76	-72
"	Protein feed 6/	-148	-106	-117	-136	-130
"	Nonagriculture 2/	-97	-128	-132	-118	-120
Egypt	Other animal pr. 1/	3	4	4	5	5
Japan	Other animal pr. 1/	42	36	41	45	48
"	Wheat	-68	-72	-92	-112	-130
"	Coarse grains	-608	-646	-814	-977	-1115
"	Protein feed 6/	-51	-50	-67	-84	-99
Mexico	Other animal pr. 1/	3	4	5	5	6
"	Coarse grains	-24	-79	-122	-159	-193
Nigeria	Other animal pr. 1/	4	5	5	6	6
"	Coarse grains	-47	-66	-78	-90	-96
Thailand	Nonagriculture 2/	65	119	133	144	156
World less U.S.	Other animal pr. 1/	359	340	371	400	417
"	Wheat	-569	-547	-618	-860	-690
"	Rice	-598	-578	-598	-624	-649
"	Coarse grains	-2805	-3041	-3609	-3883	-4476
"	Protein feed 6/	-279	-226	-233	-256	-253
"	Other foods 4/	-441	-407	-380	-363	-342

1/ Other animal products; in protein equivalent.
2/ Nonagriculture in millions of 1970 dollars.
3/ Dairy in fresh milk equivalent.
4/ Other foods in millions of 1970 dollars.
5/ Ruminant meat in carcass weight.
6/ Protein feed in protein equivalent.
Source: IIASA world agriculture model scenario.

ALTERNATIVE ELASTICITY COMPARISONS

Elasticities from the GOL model published in 1978 (15) are shown in tables 24 through 29. They were determined by literature review, estimation, and judgment in about 1974 to allow forecasting of the world agricultural situation in 1985. The 1978 GOL model is used because it contains a widely referenced and internally consistent set of elasticities. The coefficients in the IIASA model which imply elasticities were for the most part estimated between 1982 and 1984. The elasticities generated by the IIASA system in this report are with respect to world prices. The GOL elasticities are intended to show the response of supply and demand to domestic supply and demand prices, respectively. Therefore, in this report, each of the GOL elasticities presented is converted to an elasticity with respect to the world price. This calculation involves multiplication of the domestic elasticity by the corresponding world-to-domestic price transmission elasticity.

The IIASA system has a model for the EEC-9. The 1978 GOL has two models, one each for the EEC-6 and the EEC-3. The EEC-6 consists of Belgium, France, Italy, Luxembourg, the Netherlands, and West Germany. The EEC-3 is made up of Denmark, Ireland, and the United Kingdom. The GOL elasticities are aggregated to make them comparable to those in the IIASA system. The appendix contains a further discussion of data transformations used for these tables.

The most notable differences between the 1978 GOL model elasticities and those calculated from the IIASA system are that the IIASA system shows quite inelastic Brazilian protein feed supply, but elastic responses for EEC wheat supply, Japanese coarse grains demand, Canadian protein feed demand, EEC protein feed demand, and Japanese protein feed demand. The differences come in part from three sources: the IIASA system was estimated on data that include the high world commodity price variations after 1974; the system formulation includes the possibility of gradual movement of productive resources between commodities; and the IIASA system has complete commodity coverage. The 1978 GOL model and the IIASA system also have different world-to-domestic price transmission elasticities. The most evident distinction between the price transmission elasticities is seen for Canada, Japan, and the EEC.

Wheat

Table 24 shows elasticities of supply with respect to wheat prices. Differences between the GOL and IIASA results appear most clearly for the EEC. The own-price elasticity of wheat supply from the GOL is 0.45 and 2.60 for the IIASA simulation. The elasticity of coarse grain supply with respect to the wheat price is -0.23 in the GOL model and -1.54 in the IIASA simulation. The large coarse grains elasticity for the IIASA system partly compensates for its large wheat elasticity. The simulation indicates that 90 percent of the scenario price shock would be transmitted to producer prices in the EEC by the tenth year of the scenario. The GOL model indicates that 49 percent of a price shock is transmitted at the end of a decade of adjustment.

The GOL wheat demand elasticity for Canada of -0.05 is well below the IIASA elasticity of -0.30 (table 25). However, the IIASA Canadian elasticity is partly counterbalanced by the cross-elasticity of coarse grain demand with respect to wheat prices of 0.21. The EEC-9 elasticity is -0.24 in the IIASA system and -0.08 in the GOL. Much of the difference is due to a price transmission of 0.90 in the IIASA system versus 0.47 in the GOL.

Table 24--Selected elasticities of supply with respect to world wheat price from both 1978 GOL model and from IIASA system scenario

Country	Commodity supplied			
	Wheat		Coarse grains	
	GOL 1/	IIASA 2/	GOL 1/	IIASA 2/
Argentina	0.62	0.29		
Australia, New Zealand	.26	.32 3/		
Canada	.77	.43	-0.65	-0.40
EEC-9	.45 4/	2.60	-.23 4/	-1.54
India	.16	.09		
North Africa/Middle East, Low Income 5/	.19	.81 6/ .42 7/		
Other South Asia 8/	.06	.29 9/		

1/ For each region, aggregated from elasticity of supply with respect to domestic supply price, and elasticity of domestic supply price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
3/ Aggregated from elasticities for Australia and New Zealand.
4/ Aggregated from elasticities for EEC-6 and EEC-3.
5/ Including Egypt and Turkey.
6/ Egypt.
7/ Turkey.
8/ Including Pakistan.
9/ Pakistan.
Source: IIASA world agriculture model scenario and (15).

Table 25--Selected elasticities of demand with respect to world wheat price from both 1978 GOL model and from IIASA system scenario

Country	Commodity demanded			
	Wheat		Coarse grains	
	GOL 1/	IIASA 2/	GOL 1/	IIASA 2/
Canada	-0.05	-0.30	0.05	0.21
EEC-9	-.08 3/	-.24		
India	-.20	-.12		
Japan	-.26	-.37		
Mexico, Central America	-.18	-.43		

1/ For each region, aggregated from elasticity of nonfeed demand with respect to domestic demand price, and elasticity of domestic demand price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
3/ Aggregated from elasticities for EEC-6 and EEC-3.
Source: IIASA world agriculture model scenario and (15).

Coarse Grains

Table 26 displays selected elasticities of supply for coarse grains. IIASA's elasticity for Canada (0.37) is noticeably lower than that in the GOL (0.86). However, the models have roughly the same differences between their coarse grain and wheat elasticities with respect to the price of coarse grains. There is a noticeable problem with the IIASA cross-price elasticity for EEC wheat supply of -1.88, which is more elastic than the EEC coarse grain supply elasticity of 1.18. This implies that a decline in coarse grain production would be more than offset by a rise in wheat production, given that production levels of the two commodities are similar. An increase in total crop area in response to reduction of the coarse grains price is also unlikely.

Table 27 contains elasticities of demand with respect to coarse grains prices. The Australia-New Zealand elasticity of coarse grains demand is -0.73 according to the IIASA system, but only -0.46 in the GOL for grain as feed. A problem is most evident in Japanese coarse grain demand, where the world-to-domestic price transmission gives 4.2 times as large a price shock to the domestic price as the originating shock in the world price. This gives a correspondingly large elasticity to Japanese coarse grain demand with respect to the world price in the IIASA simulation. Both feed and food GOL elasticities are presented. The percentage of coarse grain consumption for feed is approximately 80 percent in Australia-New Zealand, 85 percent in Canada, 75 percent in the EEC, 6 percent in India, and 83 percent in Japan.

Protein Feed

Brazil has a very inelastic protein feed supply elasticity in the IIASA system (table 28). The area response to own price is actually negative, with an elasticity of -0.05, as opposed to 1.60 in the GOL model. Estimation of production response to price may have been thrown off by use of calendar year data in the IIASA model, whereas Brazil plants in one calendar year and harvests in the next. Part of the Brazilian model's inelastic protein feed supply response may result from decreasing availability of land suitable for soybean area expansion. For comparison, the 2-year Brazilian soybean supply elasticity with respect to the world soybean price implied by the Williams soybean model is 0.25, and the 10-year elasticity is 1.26 (18). The appendix contains the equations used to calculate these figures. Canada's oilseed response is also quite low at 0.34 versus 1.16 in the GOL. This takes place despite sharp price change transmission; by the tenth year, the domestic price shock is 2.4 times as large as the world price shock. Collins also finds a high price transmission into Canada (5). That research shows a first-year price transmission elasticity for soybeans of 1.80.

Table 29 gives demand elasticities with respect to protein feed prices. Canada's elasticity of protein feed demand as implied by the IIASA system is quite high. This results from the high price transmission; as with supply, Canada's domestic price shock is 2.4 times as large as the world price shock. The EEC also has a higher elasticity in the IIASA scenario. Japan's elasticity is higher than that in the GOL. Japan's price transmission from world to domestic seems quite responsive; 140 percent of a world price change is transmitted to domestic consumers.

Table 26--Selected elasticities of supply with respect to world coarse grain price from both 1978 GOL model and from IIASA system scenario

Country	Coarse grains: GOL 1/	Coarse grains: IIASA 2/	Wheat: GOL 1/	Wheat: IIASA 2/
Argentina	0.42	0.20		
Australia, New Zealand	1.24	.79 3/		
Canada	.86	.37	-0.49	-0.12
EEC-9	.45 4/	1.18	-.40 4/	-1.88

1/ For each region, aggregated from elasticity of supply with respect to domestic supply price, and elasticity of domestic supply price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
3/ Aggregated from elasticities for Australia and New Zealand.
4/ Aggregated from elasticities for EEC-6 and EEC-3.
Source: IIASA world agriculture model scenario and (15).

Table 27--Selected elasticities of demand with respect to world coarse grain price from both 1978 GOL model and from IIASA system scenario

Country	Grain: GOL 1/	Coarse grains: GOL 2/	Coarse grains: IIASA 3/	Protein feed: GOL 4/	Protein feed: IIASA 3/
Australia, New Zealand	-0.46	-0.23	-0.73 5/		
Canada	-.43	-.11	-.33		
EEC-9	-.25 6/	-.09 6/	-.38	0.46 6/	0.36
India	-.14	-.12	-.34		
Japan	-.49	-.20	-2.73	1.22	1.66

1/ For each region, aggregated from elasticity of demand for total grains as feed with respect to domestic corn demand price, and elasticity of domestic demand price with respect to world price.
2/ For each region, aggregated from elasticity of nonfeed demand for coarse grains with respect to domestic coarse grain demand price, and elasticity of domestic demand price with respect to world price.
3/ Tenth-year elasticities with respect to world price.
4/ For each region, aggregated from elasticity of demand for oilseed meal as feed with respect to domestic corn demand price, and elasticity of domestic demand price with respect to world price.
5/ Aggregated from elasticities for Australia and New Zealand.
6/ Aggregated from elasticities for EEC-6 and EEC-3.
Source: IIASA world agriculture model scenario and (15).

Table 28--Selected elasticities of supply with respect to world protein feed price from both 1978 GOL model and from IIASA system scenario

Country	Commodity supplied					
	Protein feed		Wheat		Coarse grains	
	GOL 1/	IIASA 2/	GOL 1/	IIASA 2/	GOL 1/	IIASA 2/
Brazil	2.38	0.11			-0.29	-0.01
Canada	1.16	.34	-0.15	-0.04	-.15	-.07

1/ For each region, aggregated from elasticity of supply with respect to domestic oilseed supply price, and elasticity of domestic supply price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
Source: IIASA world agriculture model scenario and (15).

Table 29--Selected elasticities of demand with respect to world protein feed price from both 1978 GOL model and from IIASA system scenario

Country	Commodity demanded			
	Protein feed		Coarse grains	
	GOL 1/	IIASA 2/	GOL 3/	IIASA 2/
Brazil	-0.47	-0.51	0.12	0.10
Canada	-.81	-2.03	.08	.20
EEC-9	-.26 4/	-.64	.09 4/	.10
Japan	-.20	-1.00	.07	.17
Mexico and Central America	-.14	-.74 5/		

1/ For each region, aggregated from elasticity of demand for oilseed meal as livestock feed with respect to domestic oilseed cake demand price, and elasticity of domestic demand price with respect to world price.
2/ Tenth-year elasticities of demand with respect to world price.
3/ For each region, aggregated from elasticity of demand for total grains as livestock feed with respect to domestic oilseed cake demand price, and elasticity of domestic demand price with respect to world price.
4/ Aggregated from elasticities for EEC-6 and EEC-3.
5/ Mexico.
Source: IIASA world agriculture model scenario and (15).

Ruminant Meat

The IIASA system has more aggregated animal product commodities than does the GOL model. This is both because the GOL model has a larger distinct commodity list, and because the IIASA system includes all commodities. Where the two systems differ in level of aggregation, the more disaggregated elasticities are combined to facilitate comparison. The methods of aggregation are shown in the appendix.

Table 30 contains a comparison of elasticities of supply with respect to the ruminant meat price. The ruminant meats, in the developed countries, consist mainly of beef and mutton (see table 1). For the countries listed, the GOL elasticities are higher than those in the IIASA model. For Argentina, the own-price supply elasticity for ruminant meat is 0.63 in the GOL and 0.10 in the IIASA system. Part of the difference is due to a higher transmission of the world-to-domestic price shock in the GOL than in the IIASA system. A similar situation holds for the EEC-9, where the GOL supply elasticity is 0.22 and that in the IIASA system is 0.04.

Table 31 shows elasticities of demand with respect to the world ruminant meat price. The same pattern holds as for supply. The GOL elasticities are larger than for the IIASA system. Much of the overall difference is caused by the presence of larger price transmission elasticities for ruminant meats in the GOL than in the IIASA system.

Table 30--Selected elasticities of supply with respect to world ruminant meat price from both 1978 GOL model and from IIASA system scenario

Country	Commodity supplied: Ruminant meat		Commodity supplied: Dairy	
	GOL 1/	IIASA 2/	GOL 1/	IIASA 2/
Argentina	0.63 3/	0.10		
Australia, New Zealand	.31 3/	.24 4/		
Brazil	.67 5/	.29		
Canada	.49 5/	.34		
EEC-9	.22 3/6/	.04	0.12 7/	-0.01

1/ For each region, aggregated from supply elasticity with respect to domestic supply price, and elasticity of domestic supply price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
3/ Aggregated from elasticities for beef and mutton.
4/ Aggregated from elasticities for Australia and New Zealand.
5/ Elasticity of beef supply with respect to beef price.
6/ Aggregated from elasticities for EEC-6 and EEC-3.
7/ Elasticity of milk supply with respect to beef price, all within the EEC-6.
Source: IIASA world agriculture model scenario and (15).

Dairy Products

Table 32 lists supply elasticities with respect to the world price of dairy products (fresh milk equivalent). The transmission of the world butter and cheese price to EEC-9 domestic prices is zero in the GOL model. Differing price transmissions into Japan explain most of the elasticity difference between the GOL and IIASA simulations for that country.

Table 31--Selected elasticities of demand with respect to world ruminant meat price from both 1978 GOL model and from IIASA system scenario

Country	Commodity demanded: Ruminant meat: GOL 1/	Ruminant meat: IIASA 2/	Coarse grains: GOL 1/	Coarse grains: IIASA 2/
Argentina	-0.46 3/	-0.11		
Canada	-.74 4/	-.29	0.31 5/	0.11
EEC-9	-.34 3/6/	-.08		

1/ For each region, aggregated from demand elasticity with respect to domestic demand price, and elasticity of domestic demand price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
3/ Aggregated from elasticities for beef and mutton.
4/ Elasticity of beef demand with respect to beef price.
5/ Elasticity of demand for grain as livestock feed with respect to beef price.
6/ Aggregated from elasticities for EEC-6 and EEC-3.
Source: IIASA world agriculture model scenario and (15).

Table 32--Selected elasticities of supply with respect to world dairy price from both 1978 GOL model and from IIASA system scenario

Country	Commodity supplied: Dairy: GOL 1/	Dairy: IIASA 2/
Australia, New Zealand	0.27	0.19 3/
Canada	.02	.08
EEC-9	.00 4/	.02
Japan	.16	.07

1/ For each region, aggregated from supply elasticity with respect to domestic supply price, and elasticity of domestic supply price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
3/ Aggregated from elasticities for Australia and New Zealand.
4/ Aggregated from elasticities for EEC-6 and EEC-3.
Source: IIASA world agriculture model scenario and (15).

Elasticities of demand with respect to the world price of dairy products are presented in table 33. For the most part, the GOL elasticities are higher than the corresponding IIASA numbers. Both systems show zero demand response in the EEC. The GOL shows an elasticity for Australia and New Zealand of -0.13, versus 0.00 for the IIASA system. These numbers are approximately the same for Japan.

Other Animal Products

Table 34 contains elasticities of supply with respect to the world price of other animal products. This category includes pork, poultry, eggs, and fish in the IIASA system (see table 1). The 1978 GOL model does not cover fish, and does not contain pork and poultry for all countries. It also does not have elasticities for eggs. The GOL shows no price transmission at all for Australia-New Zealand and Brazil. The IIASA system is probably more realistic in this regard.

Table 35 lists selected elasticities of demand with respect to the world price of other animal products. As for supply, Brazil shows no response to the world price for other animal products in the GOL. The IIASA formulation is probably more realistic. Canada's own-price elasticity is -0.34 according to the GOL, as opposed to -0.07 in the IIASA system. The EEC-9 demand elasticities for other animal products, coarse grains, and protein feed with respect to the other animal product price are more elastic in the GOL than in the IIASA system. Much of the difference is due to differing price transmissions. The transmission actually drops in the IIASA system from year 2 to year 10, changing from 0.46 to 0.27.

Table 33--Selected elasticities of demand with respect to world dairy price from both 1978 GOL model and from IIASA system scenario

Country	Commodity demanded: Dairy GOL 1/	Commodity demanded: Dairy IIASA 2/
Australia, New Zealand	-0.13 3/	0.00 4/
Canada	-.09 3/	-.02
EEC-9	.00 3/5/	.00
Japan	-.15 3/	-.02

1/ For each region, aggregated from demand elasticity with respect to domestic demand price, and elasticity of domestic demand price with respect to world price.

2/ Tenth-year elasticities with respect to world price.

3/ Aggregated from elasticities for fluid milk, butter, and cheese.

4/ Aggregated from elasticities for Australia and New Zealand.

5/ Aggregated from elasticities for EEC-6 and EEC-3.

Source: IIASA world agriculture model scenario and (15).

Table 34--Selected elasticities of supply with respect to world price of other animal products from both 1978 GOL model and from IIASA system scenario

Country	Commodity supplied: Other animal products: GOL 1/	Commodity supplied: Other animal products: IIASA 2/	Commodity supplied: Ruminant meats: GOL 1/	Commodity supplied: Ruminant meats: IIASA 2/
Australia, New Zealand	0.00 3/	0.11 4/		
Brazil	.00 3/	.34		
Canada	.27 5/	.21		
EEC-9	.22 5/6/	.20	-0.13 6/7/	-0.06
Japan	.11 5/	.20		
Mexico	.49 3/	.15		

1/ For each region, aggregated from supply elasticity with respect to domestic supply price, and elasticity of domestic supply price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
3/ Elasticity of pork supply with respect to pork price.
4/ Aggregated from elasticities for Australia and New Zealand.
5/ Aggregated from elasticities for pork and poultry with respect to pork and poultry prices.
6/ Aggregated from elasticities for EEC-6 and EEC-3.
7/ Elasticity of beef supply with respect to pork price.
Source: IIASA world agriculture model scenario and (15).

Table 35--Selected elasticities of demand with respect to world price of other animal products from both 1978 GOL model and from IIASA system scenario

Country	Commodity demanded: Other animal products: GOL 1/	Other animal products: IIASA 2/	Coarse grains: GOL 1/	Coarse grains: IIASA 2/	Protein feeds: GOL 1/	Protein feeds: IIASA 2/
Brazil	0.00 3/	-0.22	0.30 4/	0.22		
Canada	-.34 5/	-.07	.25 4/	.15		
EEC-9	-.36 5/6/	-.04	.45 4/6/	.15	1.19 6/7/	0.20
Japan	-.07 5/	-.03	.09 4/	.31	.22 7/	.25

1/ For each region, aggregated from demand elasticity with respect to domestic demand price, and elasticity of domestic demand price with respect to world price.
2/ Tenth-year elasticities with respect to world price.
3/ Elasticity of pork demand with respect to pork price.
4/ Elasticity of demand for grain as livestock feed with respect to pork price.
5/ Aggregated from elasticities for pork and poultry with respect to pork and poultry prices.
6/ Aggregated from elasticities for EEC-6 and EEC-3.
7/ Demand for oilseed meal as feed with respect to pork price.
Source: IIASA world agriculture model scenario and (15).

CONCLUSIONS

Several significant differences appear between elasticities in the 1978 GOL model and the May 1984 version of the IIASA world agriculture modelling system. Researchers at IIASA continue to update the system. In comparison to the GOL model, the IIASA system implies inelastic Brazilian protein feed supply. The IIASA system has more elastic responses than the GOL model does for EEC wheat supply, Japanese coarse grains demand, Canadian protein feed demand, EEC protein feed demand, and Japanese protein feed demand. Many of these elasticities with respect to world prices differ because of dissimilar world-to-domestic price transmission elasticities. The most evident distinction between the price transmission elasticities in the two models is found for Canada, Japan, and the EEC.

The IIASA system implies second-year elasticities of net demand facing the United States of -1.5 for wheat, -1.7 for coarse grains, and -1.5 for protein feed. Other second-year responses by the world outside the United States to sustained 10-percent world price declines are listed below. The IIASA system suggests that a drop in the world wheat price would increase net demand for U.S. wheat by 7 million metric ton (MMT) but reduce net foreign demand for coarse grains by about 4 MMT. A fall in the world price of coarse grains should raise net foreign demand for coarse grains by 11 MMT, but cut wheat demand by 3 MMT. Reduction of the world price of protein feed would lead to 3.7 MMT of additional protein feed demand facing the United States. There would be a corresponding fall of 1.7 MMT in net demand for U.S. coarse grains in the second year of a sustained 10-percent lowering of the world price of protein feed.

IIASA system results imply that a continued 10-percent fall in the world price of ruminant meats (principally beef and mutton) would reduce desired net exports of ruminant meats by the world less the United States. In the second year at the lower price, the IIASA system suggests that the impact would be 0.8 MMT (carcass weight). At the same time, net demand for U.S. coarse grains would be diminished by 0.5 MMT. Lowered dairy prices should reduce net dairy products exports by the world outside the United States by 3 MMT (fresh milk equivalent) but raise net coarse grain demand 0.2 MMT. When the world price of other animal products (pork, poultry, eggs, and fish) is diminished by 10 percent, net demand for these products facing the United States should increase by 0.36 MMT (protein equivalent; these products average roughly 10-percent protein). Net demand for coarse grains would fall 3 MMT. Demand facing the United States for wheat, rice, and protein feed (soymeal equivalent) falls 0.6 MMT for each commodity. The figures above are the result of changing only one world commodity price in each scenario. The response of the United States is not included. Supply and demand elasticities, as well as trade policies, would tend to moderate changes in U.S. trade levels.

Overall, the crop supply cumulative response elasticities tend to rise between the second and tenth years of a sustained price change. Crop demand elasticities increase by a smaller amount. Animal product elasticities grow much less than crop elasticities, or even decline. Animal product supply elasticities tend to grow more than animal product demand elasticities from the second to the tenth year. Time lags in world-to-domestic price transmission and gradual movement of inputs between production activities cause delays in supply adjustment to world prices. Price transmission lags also postpone part of demand response. According to IIASA system results, domestic crop prices are more closely linked to world prices than are animal product prices. Domestic dairy prices are especially insulated from the world price in most countries.

The effect on U.S. revenue of a change in the world price of an agricultural commodity must include the resulting impacts on prices and quantities of other commodities. Cross-commodity effects can moderate or even cancel the apparent advantage to the United States of world price declines despite quite price-responsive net foreign demand for U.S. crops. A general equilibrium analysis of the outcome of world agricultural commodity price or quantity changes will be made in a subsequent report using the IIASA system.

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APPENDIX: ELASTICITY CALCULATIONS

Direct comparison of results from the 1978 GOL model and the IIASA world agriculture modelling system is not always possible. There are differences in levels of aggregation in both commodity and region lists. Moreover, the GOL documentation lists elasticities with respect to domestic prices, while the IIASA system most readily generates elasticities with respect to world prices. The elasticities from the two models are brought to more comparable bases using aggregation relations described below. The elasticity of net trade also requires discussion. When net trade in a commodity is small with respect to changes in net trade, the elasticity of net trade is less than a robust indicator of trade responses to price changes. An alternative proposed is the net trade quantity response to a percentage price change. However, for the world less the United States, this number requires use with caution, just as the net trade elasticity does. The scenario of a desire by the rest of the world to change trade levels with the United States does not mean that the United States is necessarily in a position to accommodate.

Elasticity Aggregation by Country

The GOL and IIASA systems include different region lists. Where the regions in the two systems do not correspond, the more disaggregated regional elasticities are combined. In the equations below, elasticities of supply for countries A and B are aggregated. Total supply is the sum of supplies in each country (equation 5). The aggregated elasticity is defined to be the percent change in supply divided by the percent change in price (6). The percentage change in world price is assumed to be the same for each country. The supply elasticity for each country has the same form as the total elasticity (7). The total quantity change induced by a price change is the sum of each country's response (8). When equation (7) is solved for dS^k and substituted into equation (8), equation (9) results. Finally, the total elasticity (10) is derived by substituting (9) and (5) into (6). The percent price change cancels out. The form of equation (10) also applies to demand. The total elasticity is the quantity-weighted sum of individual country elasticities.

The quantities to be used are defined below:

- dP = Change in price
- dS^k = Change in quantity supplied in country k
- dS^T = Total change in quantity supplied by all countries
- E^k = Elasticity of supply for country k
- E^T = Total elasticity of supply
- P = Price
- S^k = Quantity supplied in country k
- S^T = Total quantity supplied by all countries.

$$S^T = S^A + S^B \qquad (5)$$

$$E^T = (dS^T/S^T)/(dP/P) \qquad (6)$$

$$E^k = (dS^k/S^k)/(dP/P) \quad \text{for each country, k} \qquad (7)$$

$$dS^T = dS^A + dS^B \qquad (8)$$

$$dS^T = (S^A E^A + S^B E^B)(dP/P) \qquad (9)$$

$$E^T = (S^A E^A + S^B E^B)/(S^A + S^B) \qquad (10)$$

Elasticity Aggregation by Commodity

The animal product commodity lists of the GOL and IIASA systems do not correspond. The list in the IIASA system is more aggregated. The algebra used in aggregation is described below. The equations below cover a specific example with two commodities, designated 1 and 2. Total aggregated supply is the sum of supply of each disaggregated commodity (equation 11). The total elasticity is the percent change in the aggregated supply over the percent change in the price (12). It is assumed that each disaggregated commodity price changes by the same percentage. The elasticity of supply of commodity i with respect to the price of commodity j is the percentage change in supply of commodity i induced by the change in price of commodity j, all divided by the percentage price change (13). The commodity subscripts i and j may be equal. The total supply change is the sum of changes caused by the own-price and cross-price effects for each commodity (14). Equation (13) may be solved for dS_{ij} and substituted into (14), yielding (15), which expresses the aggregated quantity change in terms of the disaggregated own- and cross-price elasticities. Substitution of equations (11) and (15) into (12) permits calculation of the total elasticity in terms of quantity-weighted, disaggregated elasticities (16). The same form of equation holds for demand as well as supply. It may be noted that equations (16) and (10) have similar forms.

The quantities to be used are defined below:

- dP = Change in price
- dS_{ij} = Change in supply of commodity i caused by change in price of commodity j
- dS_T = Change in aggregated supply
- E_{ij} = Elasticity of supply of commodity i with respect to price of commodity j
- E_T = Aggregated supply elasticity
- P = Price
- S_i = Quantity of commodity i supplied
- S_T = Total aggregated quantity supplied

$$S_T = S_1 + S_2 \quad (11)$$

$$E_T = (dS_T/S_T)/(dP/P) \quad (12)$$

$$E_{ij} = (dS_{ij}/S_i)/(dP/P) \quad \text{for each commodity i and j} \quad (13)$$

$$dS_T = dS_{11} + dS_{12} + dS_{22} + dS_{21} \quad (14)$$

$$dS_T = (S_1E_{11} + S_1E_{12} + S_2E_{22} + S_2E_{21})(dP/P) \quad (15)$$

$$E_T = (S_1E_{11} + S_1E_{12} + S_2E_{22} + S_2E_{21})/(S_1 + S_2) \quad (16)$$

Aggregation of Crop Area and Yield Elasticities

Crop supply response in the GOL is disaggregated in terms of area and yield. The method of aggregation is explained below. The elasticity of supply is defined in equation (17) as the ratio of change in supply to the change in price, multiplied by the ratio of price to supply level. Similarly, the elasticities of area and yield are defined in equations (18) and (19). Supply is the product of area and yield (20). The derivative of (20) with respect to price may be taken, giving (21). Equation (22) is the result of multiplying (21) by the ratio (P/S). Substitution of (20) into (22) and simplification gives (23). Equations (17), (18), (19), and (23) may be combined to give (24), which simply states that the elasticity of supply is the sum of the area and yield elasticities.

The quantities to be used are defined below:

A	= Area
dA	= Change in area
dS	= Change in supply
dP	= Change in price
dY	= Change in yield
E^A	= Elasticity of area
E^S	= Elasticity of supply
E^Y	= Elasticity of yield
P	= Price level
S	= Supply level
Y	= Yield

$$E^S = (dS/dP)(P/S) \tag{17}$$

$$E^A = (dA/dP)(P/A) \tag{18}$$

$$E^Y = (dY/dP)(P/Y) \tag{19}$$

$$S = AY \tag{20}$$

$$dS/dP = YdA/dP + AdY/dP \tag{21}$$

$$(dS/dP)(P/S) = Y(dA/dP)(P/S) + A(dY/dP)(P/S) \tag{22}$$

$$(dS/dP)(P/S) = (dA/dP)(P/A) + (dY/dP)(P/Y) \tag{23}$$

$$E^S = E^A + E^Y \tag{24}$$

World-to-Domestic Price Transmission Elasticities

The elasticities in the 1978 GOL model are in terms of domestic supply or demand prices. Those in the IIASA system scenarios described in the body of this paper are in terms of world prices. This author has attempted to put the elasticities on a comparable basis to facilitate the comparisons in this report. The elasticities in the GOL are converted to elasticities with respect to world prices by multiplying them times the ratio of percentage changes in domestic prices to percentage changes in world prices. Each ratio is calculated from the equations which express the domestic price as a function of a world price. The GOL model does not have just a single world price for each commodity group. U.S. trade prices are used in this paper to represent the world prices of wheat, coarse grains, protein feed, beef, and pork. The Australia-New Zealand trade prices are chosen for the world prices of mutton, butter, and cheese.

Several inconsistencies may be found in the documentation on the GOL price linkages, evidently because the model was frequently modified. This author made corrections to the price linkage equations to permit the comparisons in this report. The changes are believed to reflect the intentions of the researchers who created the model. However, responsibility for the choice of corrections remains with this author.

Robustness of Net Trade Elasticities

Elasticities of net trade by the world outside the United States for ruminant meats, dairy products, and other animal products are not presented in this paper. A reason for not listing certain elasticities of net trade is presented below. Net trade by the United States in these commodities tends to be quite small compared to production and consumption in the world outside the United States. In the IIASA model, the levels of net trade by the world less the United States in animal products are not well calibrated, and may even have the wrong sign when compared to actual data. These factors prevent the elasticities of net trade from being robust.

The elasticity of net trade is the percent change in net trade divided by a percent change in price (see equation 25). The key to the assertion that the elasticity of net trade may not be robust lies in the level of net trade (NT), which may approach zero and even have the wrong sign. In this case, because net trade appears in the denominator, it may cause the elasticity to become a very large positive or negative number. In fact, if net trade is zero, the elasticity is undefined. This relationship is illustrated in figures 2 and 3.

The quantities to be used are defined below:

E^{nt} = Elasticity of net trade
dNT = Change in net trade
NT = Net trade level
dP = Change in price
P = Price level

$$E^{nt} = (dNT/NT)/(dP/P) \qquad (25)$$

An informative and more robust alternative to a net trade elasticity is the net trade quantity response to a specified percentage price change. For example, see table 6, which shows the net trade responses in thousand metric tons to a 10-percent wheat price drop.

Figure 2--A hypothetical relation of net trade to price for a country

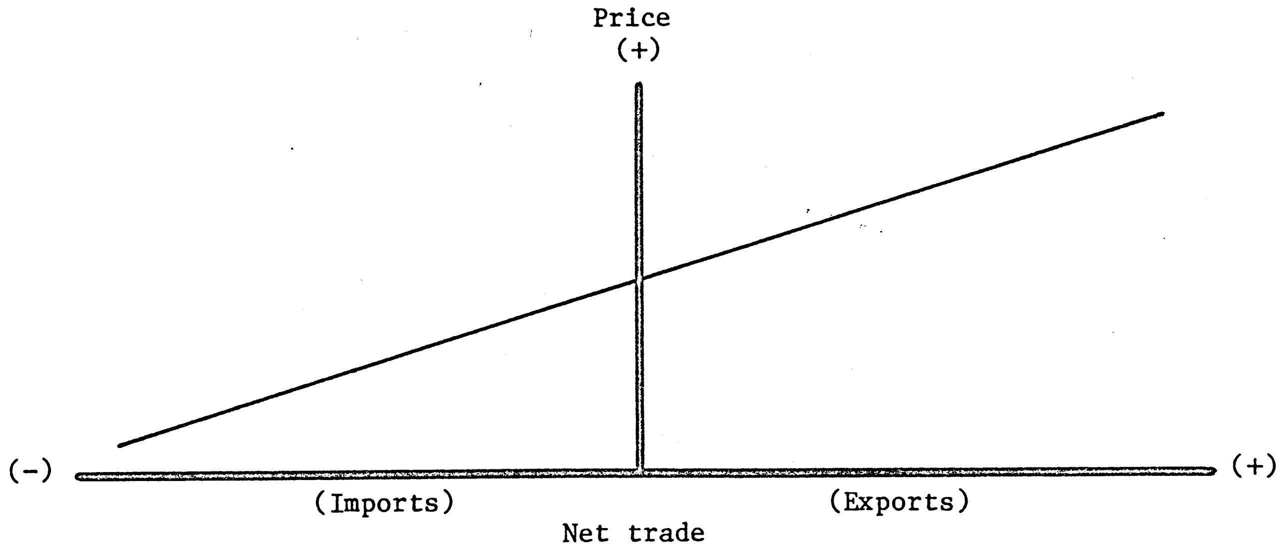
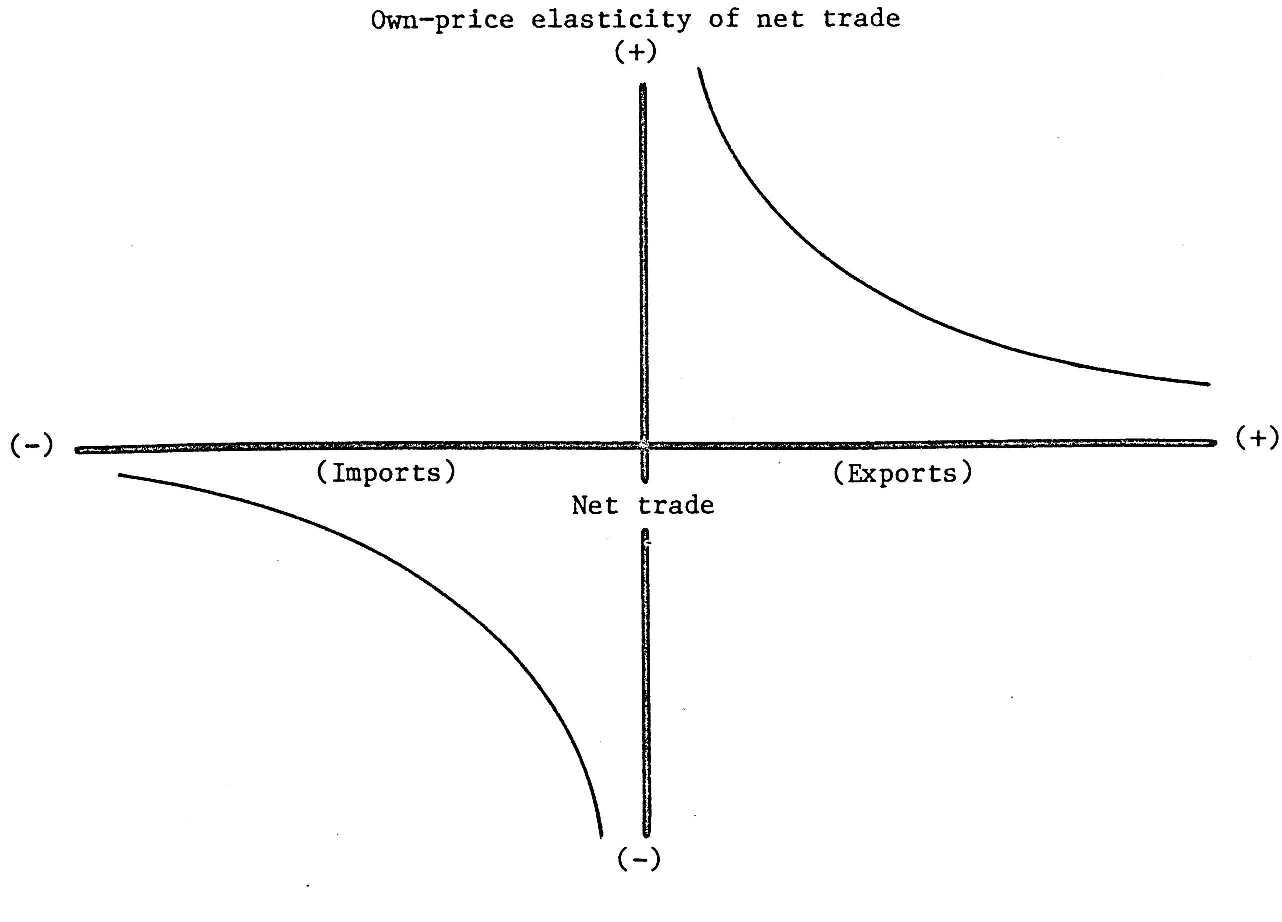


Figure 3--The own-price elasticity of net trade versus net trade level corresponding to figure 2



Brazilian Cumulative Soybean Supply Elasticities

Elasticities from the Williams Brazilian soybean model (18) were calculated using both a numerical and an analytical approach, with equal results. Two relations were examined: the world-to-domestic price spread and domestic soybean supply. Mean values were substituted for all exogenous variables. The domestic price is a function of the world price (equation 26). Current soybean supply is a function of lagged domestic soybean price and supply (equation 27). The price and quantities are expressed in natural logarithms. Combination of the exponential form of equation 27 with equation 26 yields soybean supply as an exponential function of lagged world price and lagged domestic supply (28). World prices from period t = 1, 2, ..., T are assumed to be equal and subject to a sustained price shock (29). The T-period cumulative elasticity derived from (28) and (29) is a function of the world price and the length of the time interval T (equation 30). A mean world price for soybeans of 243.63 in real cruzeiros is used in the model. Thus, it implies a second-year supply elasticity with respect to the world price of 0.25 and a tenth-year elasticity of 1.26.

The symbols to be used are defined below. The symbols in parentheses in the price and quantity definitions correspond to those in the model documentation.

- EQP_T = Cumulative elasticity of Brazilian soybean supply with respect to world price in period T.
- PS_t = Brazilian soybean producer price (= PSBBZ) in real cruzeiros in period t.
- P_t = World soybean price (= PSBXBZ) in real cruzeiros in period t.
- Q_t = Brazilian soybean production (= SSBBZ) in period t.
- t = Index of periods over which price is shocked.
- T = Interval over which sustained shock is made to price, and at the end of which the cumulative elasticity is measured.

$$PS_t = 101 + 0.3623\, P_t \qquad (26)$$

$$\ln(Q_t) = -1.483 + 0.5338 \ln(PS_{t-1}) + 0.8453 \ln(Q_{t-1}) \qquad (27)$$

$$Q_t = 0.2269\,(101 + 0.3623\, P_{t-1})^{0.5338}\,(Q_{t-1})^{0.8453} \qquad (28)$$

$$P_T = P_{T-t} \qquad \text{for } t = 1, 2, \ldots, T-1 \qquad (29)$$

$$EQP_T = \frac{0.5338\,(0.3623\, P_T)\,(1 - 0.8453^{T-1})}{(101 + 0.3623\, P_T)\,(1 - 0.8453)} \qquad (30)$$