PB84-148642

FAER-193 STRONG DOLLAR DAMPENS DEMAND FOR U.S. FARM EXPORTS, / J. LONGMIRE, ET AL. ECONOMIC RESEARCH SERVICE, WASHINGTON, DC. INTERNATIONAL ECONOMICS DIV. DEC 83 41P

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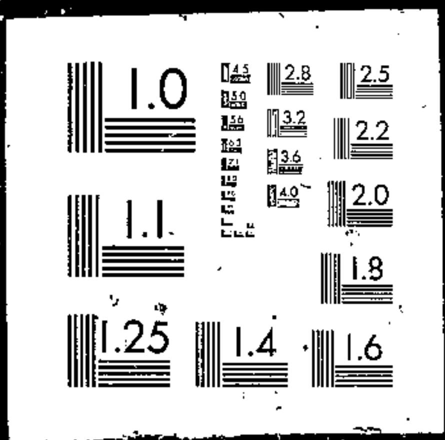

PB84-148642

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(U.S.) Economic Research Service, Washington, DC

Dec 83

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. FAER-193	2.	3. Recipient's Accession No. PB84 148642

4. Title and Subtitle
Strong Dollar Dampens Demand for U.S. Farm Exports

5. Report Date
December 1983

6.

7. Author(s)
Jim Longmire and Art Morey

8. Performing Organization Rept. No.
FAER-193

9. Performing Organization Name and Address
International Economics Division
Economic Research Service
U.S. Department of Agriculture
Washington, D.C. 20250

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

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17. Document Analysis a. Descriptors

Economic analysis
Exports
Corn
Wheat
Soybeans
Foreign trade

b. Identifiers/Open-Ended Terms

Exchange rates
Government stocks program
Cross-commodity effects
Imperfect price transmission

Prices as of 1/1/83:
Paper:
Fiche: $4.50
Cost codes are: for Paper and A01 for Fiche

c. COSATI Field/Group 02-B; 05-C

18. Availability Statement:	19. Security Class (This Report)	21. No. of Pages
National Technical Information Service 5285 Port Royal Road, Springfield, VA 22161	Unclassified	40
	20. Security Class (This Page) Unclassified	22. Price See box 17

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

United States
Department of
Agriculture

Economic
Research
Service

Foreign
Agricultural
Economic Report
Number 193

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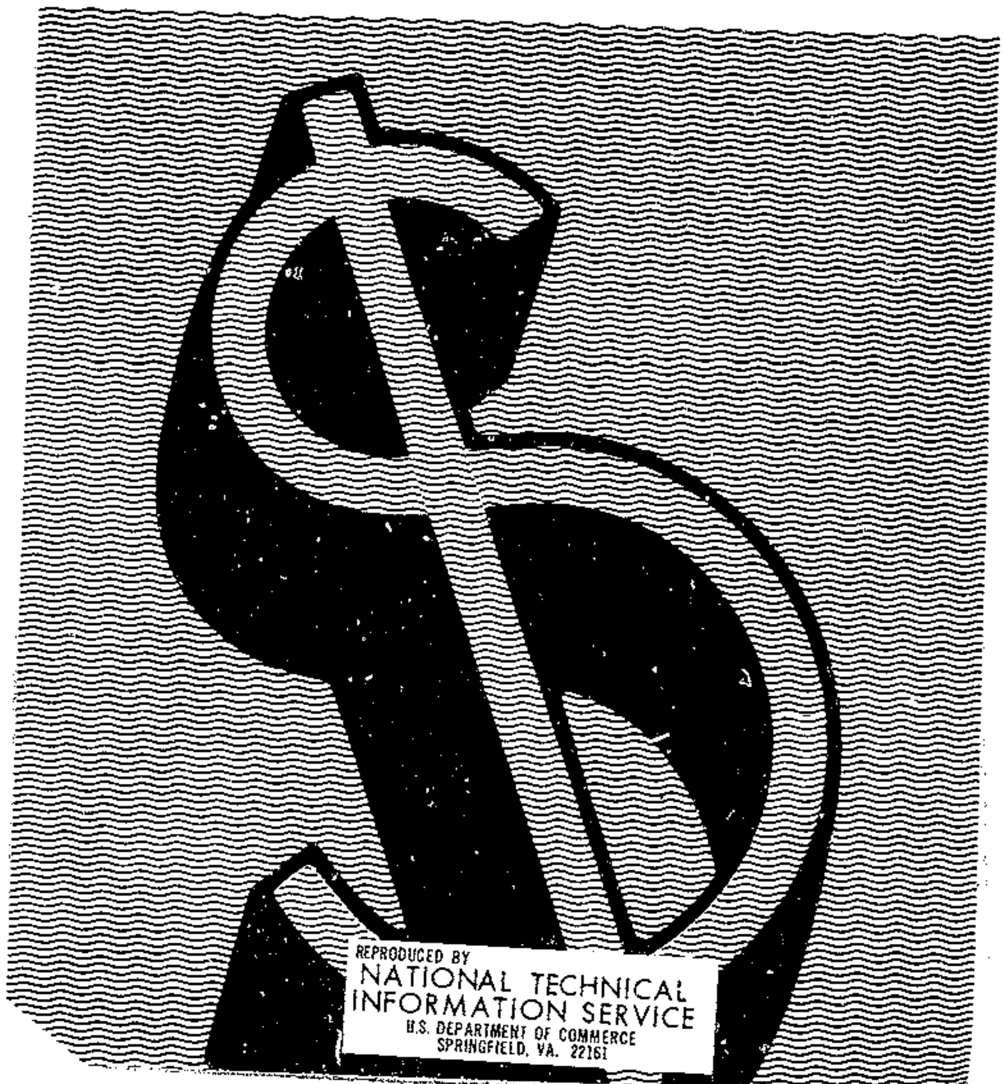

Strong Dollar Dampens Demand for U.S. Farm Exports, by Jim Longmire and Art Morey. International Economics Division, Economic Research Service, U.S. Department of Agriculture. Foreign Agricultural Economic Report No. 193.

Abstract

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Keywords: Exchange rates, trade, Government stocks program, wheat, corn, soybeans, cross-commodity effects, imperfect price transmission

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Washington, D.C. 20250 December 1983

Contents

Summary

With the dollar's rise in value against foreign currencies in the early 1980's, U.S. farm exports are sagging and commodity stocks are abundant. U.S. exports of wheat, corn, and soybeans were reduced by about $3 billion in 1981-82 as a result of the strengthening of the dollar. That decline translates into a volume of 16 million tons; corn exports alone were nearly 10 million tons less.

By contrast, when the dollar dropped in value in the 1970's, U.S. farmers saw their best years ever for exports. The dollar depreciated against foreign currencies by about 30 percent in the 1970's and U.S. farm exports soared.

Other factors are at work as well in international trade, but a model we developed helps to assess the effect of changes in the exchange rate on U.S. exports of wheat, corn, and soybeans. Overall, the model estimates that a 20-percent rise in the value of the dollar will cause farm exports to drop by 16 percent.

Fluctuations in the exchange rate affect the level of Government stockpiles of grain as well. The impact of a real exchange rate fluctuation with a U.S. farm stocks program in operation is analyzed in the paper. In essence, when prices are at the loan rates, further appreciation of the U.S. dollar will divert grain away from exports and into farm program stocks. The opposite occurs with a depreciation of the U.S. dollar.

U.S. farm program prices are fixed in nominal terms. In real terms, however, the loan rates for wheat and corn were steady or increased in 1980-82. Thus, in terms of foreign currency, the loan rates increased approximately in line with the real appreciation of the U.S. dollar. Roughly 20 million tons of grain entered farm program stocks in the past 2 years as a direct consequence of the loan rate being approximately stable in real terms while the U.S. dollar appreciated by about 20 percent. These grain stocks are valued at some $2 billion, and represent about a quarter of the buildup of total U.S. stocks of grain estimated to have been carried over into the 1983 crop year.

Provisions permitting greater flexibility in setting the loan rate would have prevented some of that large stock buildup. Alternatives to the current methods of fixing the loan rates (and target

prices), to be more in line with market circumstances should be developed and thoroughly evaluated.

The enhanced price competitiveness of the U.S. agricultural export sector in the 1970's, which was brought on by relatively loose monetary policy, was probably one of the main reasons for the boom in farm exports over that period. This boom was cut off by much tighter monetary policy in the early 1980's. With large stocks and falling grain exports, more direct ways of boosting U.S. agricultural exports are being implemented or are under consideration. Our judgment is, however, that the direction of macroeconomic policy has had, and will have, much more significance for the U.S. farm export sector than will the more direct policy interventions.

Strong Dollar Dampens Demand for U.S. Farm Exports

Jim Longmire
Art Morey*

Introduction

The U.S. dollar's appreciation against foreign currencies in the early 1980's has had the same effect as an export tax—a reduced market for U.S. exports. As the dollar dropped in value in the 1970's, U.S. farm exports soared; in the early 1980's, as the dollar rose in value, U.S. farm exports dropped. We developed a model that isolates the effect of exchange rate fluctuations on major U.S. farm exports: wheat, corn, and soybeans. The model suggests that a 20-percent rise in the value of the dollar will reduce farm exports by 16 percent. In applying the model, we estimate that the recent appreciation of the dollar cost U.S. farmers about $3 billion in export sales in 1981-82; nearly two-thirds of the lost sales were for corn. Conversely, the 1970's boom in U.S. farm exports seems to have been fueled by the decline in the international value of the dollar—a decline on the order of 30 percent.

Other factors are at work as well in influencing international farm trade: weather, crop availability, private and Government stockpiles, and surpluses from prior years. A complete model of U.S. agricultural markets should treat the agricultural sector as simultaneously determined within the overall macroeconomy. That implies, however, that, with an open trading economy, like the United States, macroeconomic models of both the United States and the rest of the world need to be developed, including their international linkages. To do that is an almost insurmountable task. The evidence, though, suggests that the direction of causality is largely from the macroeconomy to the agricultural sector (*3, 9*).[1] Drawing

*Jim Longmire is an assistant director with Australia's Bureau of Agricultural Economics, and was on leave to ERS at the time of this research. Art Morey is an economist with ERS.

[1]Italicized numbers in parentheses refer to sources cited in references at the end of this report.

on this evidence, we treat the macroeconomy as exogenous in this paper. Our focus, therefore, is on the impact of exchange rate movements on the U.S. agricultural markets for wheat, corn, and soybeans with important macroeconomic factors taken as given.

There have been three notable attempts to quantify the impact of fluctuating exchange rates on U.S. agriculture (*16, 7, 5*). Although each focused on the exchange rate impact on prices of the major farm exports, the means of quantifying the impact remains unresolved in at least three important aspects:

- *Magnitude of the Impact.* Johnson, Grennes, and Thursby calculated that a devaluation of 10 percent of the U.S. dollar against all other currencies leads to a 6.9-percent increase in the price of wheat (*16*). Chambers and Just found elasticities of price response with respect to an exchange rate movement to exceed unity (ignoring signs) in the cases of wheat, corn, and soybeans (*5*). The longrun elasticities also exceeded unity (in absolute terms) for corn and soybeans. The issue of whether the exchange rate impact on price should be permitted to exceed unity has not been fully resolved. Chambers and Just were critical of studies that imposed an a priori restriction that the proportionate impact of an exchange rate fluctuation on price should fall on the interval 0 to -1 (*4*). Johnson contends, however, that a proportionate exchange rate impact exceeding unity "seems not to be theoretically acceptable" (*14*).

- *Additional Impact of U.S. Farm Programs.* Collins, Meyers, and Bredahl introduced the impact of price-distorting programs in foreign markets for agricultural commodities through the use of price transmission elasticities (*7*). The U.S. farm program, particularly the stocking and support pricing, can be an important determinant of U.S. exports and prices of farm commodities in certain years. Therefore, analysis of exchange rate effects without the U.S. farm program explicitly accounted for will be lacking in policy relevance and could be biased if the policy impact is ignored.

- *Impact of Cross-Commodity Demand and Supply Effects.* No cross-commodity demand and supply effects have been included in the empirical analyses, except in treating all other commodities as part of a basket of goods used to construct a price index for deflating own-price effects. In addition, the wider macroeconomic relationships associated with an exchange rate shift have not been permitted to vary. These include such factors as real incomes and the overall rate of inflation.

Comparison with Recent Events

Since 1980, the U.S. dollar has appreciated strongly on an agricultural trade-weighted basis. In nominal terms, the appreciation exceeded 30 percent in 1981 and 1982; in real terms, the U.S. dollar appreciated by about 20 percent (table 1). On a general trade-weighted basis, the nominal appreciation of the dollar from 1980 to

Table 1—Agricultural trade-weighted indices of the foreign exchange value of the U.S. dollar[1]

Year	Total	Soybeans	Wheat	Corn
		April 1971 =100		
1970	102.10	102.40	101.29	102.38
1971	98.98	98.25	99.84	98.65
1972	91.19	88.21	94.29	89.80
1973	82.74	77.75	87.15	80.61
1974	79.12	74.53	82.07	77.01
1975	76.92	71.33	80.52	74.66
1976	77.97	73.33	80.66	76.89
1977	75.30	69.99	76.93	73.79
1978	70.02	63.28	72.76	67.10
1979	71.00	62.62	74.35	67.27
1980	72.58	64.59	76.95	68.89
1981	79.82	75.33	79.47	77.90
1982	87.10	83.93	85.51	87.15
		Percent change per year		
1971	-3.06	-4.05	-1.43	-3.65
1972	-7.87	-10.23	-5.55	-8.97
1973	-9.27	-11.86	-7.57	-10.24
1974	-4.37	-4.14	-5.83	-4.46
1975	-2.78	-4.29	-1.90	-3.06
1976	1.36	2.81	.18	2.99
1977	-3.42	-4.55	-4.63	-4.03
1978	-7.01	-9.58	-5.42	-9.06
1979	1.40	-1.05	2.18	.25
1980	2.22	3.14	3.50	2.41
1981	10.81	16.60	7.83	13.02
1982	9.12	11.42	7.60	11.87

[1]Adjusted by the Consumer Price Index of the countries involved.

Computed by David Stallings, World Analysis Branch, International Economics Division, ERS.

1982 was lower than on an agricultural basis, only 26 percent, while the real appreciation was slightly higher, 24 percent.

Using our model, we can give a broad indication of the direct impact on export prices, exports, and farm program stocks of an inflation-adjusted appreciation of the U.S. dollar of the order of 20 percent over 2 years. We assumed the change in the real value of the U.S. dollar across the board was 10 percent for 2 years in succession. We fixed the demand elasticity for stocks of wheat and corn at -4, to account for participation rates being well less than one in the farm stocks program.

The impact of the real exchange rate change after 2 years is presented in table 2. To convey a perspective on the magnitudes

Table 2—Impact of real appreciation of U.S. dollar, 10 percent per annum, 1980-82

Item	Export price	Average farm price[1]
	1980 dollars/metric ton	
Real price[2]:		
Wheat	-6.85	-31
Corn	-6.20	-44
Soybeans	-18.30	-99
	Predicted change	Actual change
	Million metric tons	
Export volume:		
Wheat	-4.9	3.7
Corn	-9.5	-5.2
Soybeans	-1.5	5.9
	Constant 1980 million dollars	
Real export value:		
Wheat	-1,140	-880
Corn	-1,530	-3,040
Soybeans	-710	-910
	Million metric tons	
Carryover stocks:		
Wheat	6.9	12.9
Corn	13.0	61.3
Soybeans	0.7	6.6

[1]Prices used for 1982-83 were wheat, $3.45/bu; corn, $2.25/bu; and soybeans, $5.50/bu.
[2]Rates of inflation used were 1980-81 to 1981-82, 7.8 percent, and 1981-82 to 1982-83, 5 percent.

involved, actual changes from 1980-81 to 1981-82 are presented. The predicted changes are different from the actual changes because the model predicts only those changes that are attributable to shifts in the exchange rates.

Although a large share of the actual changes are not explained by the model, the changes directly attributable to the exchange rate movements are sizable, particularly for the decline in the value of exports of grains and for the increases in farm program stocks. While the volume and price effects will be somewhat sensitive to the elasticities of stock demand used, the change in value of farm exports of wheat, corn, and soybeans will be less sensitive.

The results in table 2 give some perspective to the importance of the real appreciation of the U.S. dollar on the grain markets since 1980. But there were also other factors in the United States and overseas influencing export prices, exports, and farm program stocks; some of those factors include other macroeconomic influences, noticeably the higher real price of credit in the United States and overseas, the low and negative rates of real income growth, and the large crops harvested in the United States.

Inflation-Adjusted Exchange Rates

A key factor affecting the nominal exchange rate between currencies is the difference in rates of inflation between countries (*12, 24, 19*). Over the longer term, according to the purchasing power parity theory, macroeconomic forces will lead to adjustments in the rates of inflation or in nominal exchange rates or both so that the inflation-adjusted exchange rates remain unchanged. However, other factors also affect inflation-adjusted exchange rates, such as real shifts in the demand or supply of traded goods and services in an economy, unanticipated policy shifts, and unanticipated short-term capital movements. These and other factors (like price rigidities in labor and goods markets) prevent differences in rates of inflation between countries from being the sole reason for nominal exchange rate movements.

The relationship between a nominal exchange rate and an inflation-adjusted exchange rate is as follows. The law of one price says, using a two-country case, that

$$Pu = Ea \cdot Pa \qquad (1)$$

where: P = price of a commodity denoted in local currency,
u = United States,
a = another country,
E = nominal exchange rate between the United States and country a (\$US per \$$a$).

Introducing inflation into equation 1, the above definition still holds as follows:

$$Pu/CPIu = [\,Ea \cdot CPIa/CPIu\,] \cdot Pa/CPIa. \tag{2}$$

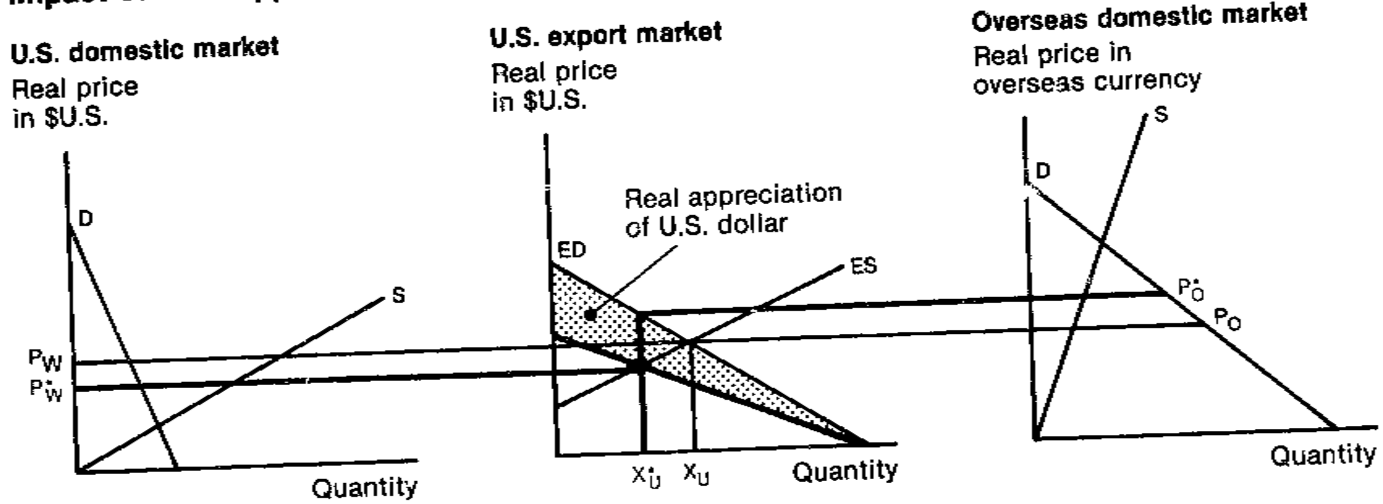
The term in brackets is the inflation-adjusted or real exchange rate for country a. A real exchange rate shift can be caused by changes in any of the three variables in brackets in equation 2 relative to the other two. For example, a nominal appreciation, while the rates of inflation in both countries are equal, translates into a real appreciation. However, if a nominal appreciation is simply reflecting the differences in rates of inflation, the real exchange rate remains unchanged. A nominal appreciation can be associated with a real depreciation if the difference between the rate of inflation in the United States relative to that in the other country is greater than the nominal appreciation. An index of movements in the inflation-adjusted exchange rate can be calculated on a bilateral or multilateral basis, in the same way that bilateral or multilateral nominal exchange rates (or indexes) are calculated.

The above discussion and example emphasize the importance of accounting for inflation in any model of agricultural markets designed to analyze impacts of exchange rate movements. Simply put, all price and income variables in demand and supply functions must be deflated by the overall rate of inflation, or take account of inflation in some other way.

Figure 1 shows how a real appreciation of the dollar affects trade and prices in the U.S. domestic market, the U.S. export market, and the overseas domestic market. In both the U.S. and overseas domestic markets, domestic demand (D) and domestic supply (S) functions are drawn. The horizontal summation of these domestic functions provides the export supply (ES) and export demand (ED) schedules for U.S. corn exports. With no trade barriers and no transportation costs, the equilibrium world (and U.S.) price will be P_w, and the equilibrium level of U.S. exports will be X_u, which is equal to imports of corn by the overseas country in this simplified

Figure 1

Impact of Real Appreciation of the U.S. Dollar



Real appreciation of the U.S. dollar lowers the U.S. price, raises the overseas price, and reduces export volume.

Note: The green shows the effect of appreciation of the dollar.

two-country model. Note that the three markets are depicted in real terms, with rates of inflation taken as given.

Now assume that there is a real appreciation of the U.S. dollar against the overseas currency. Analytically, this is equivalent to imposing an ad valorem export tax. The export demand schedule for U.S. corn rotates downward from ED (to form the green triangle in the figure) since the overseas purchasers of U.S. corn must forego more goods in terms of the overseas currency in order to purchase a given amount of goods in terms of U.S. dollars. U.S. exports decline to X_u^* as a result of the real appreciation, and the dollar price (in real U.S. dollars) declines to P_w^*. The real price of corn denoted in terms of foreign currency, therefore, increases to P_o^*, since the overseas currency has depreciated in real terms against the U.S. dollar.

Cross-Commodity Effects

For wheat, corn, and soybeans, relatively high substitutability in both supply and demand means that cross-commodity effects can be an important consideration in exchange rate effects. Two approaches have been developed to analyze cross-commodity effects when studying exchange rate effects on a commodity market. The first involves accounting for all cross-price effects on supply and demand directly. The second involves accounting for a limited number of the most important cross-price effects directly and accounting for all other cross-price effects by deflating prices and incomes in the supply and demand equations by a general index of prices.

The case in which all cross-commodity effects are included specifically in demand and supply functions was presented by Chambers and Just (*4*). They claimed that when all cross-commodity effects are accounted for, the price effects of an exchange rate change should not be confined to lie on the interval 0 to -1. However, in considering all price and income effects, Chambers and Just essentially developed a macroeconomic model of an economy involving interdependencies between the general level of prices, incomes, and exchange rates. For the more narrowly defined scope of this paper, we use the framework developed by Bredahl (*1*).

Bredahl's analysis involved two commodities (corn and soybeans) and two countries, one of which operated a variable import levy.

We have already illustrated in figure 1 the effects of a real appreciation on trade and prices when no cross-commodity price effects are accounted for. Now we allow for cross-commodity effects in supply and demand (without the import levy). Take the same case as Bredahl in which soybeans are a substitute for corn (*1*). Because soybeans substitute for corn in supply and demand, the demand schedule for corn will not remain stable when exchange rates shift. This is because the real price of soybeans is also likely to be affected by the exchange rate shift and this will shift the demand for and supply of corn accordingly. On the assumption that the cross-price effects of the dollar's appreciation will reduce the real price of soybeans in the United States and raise it in the overseas domestic market, domestic demand for corn in the United States is lowered, while it is raised in the overseas market. Similarly, the supply of corn in the United States is increased, but lowered in the overseas market. The net impact of the cross-price effects will depend upon the relative magnitudes of the own-price and cross-price elasticities in both the U.S. market and the overseas market.

Bredahl developed a (rather complicated) formula expressing the impact of an exchange rate shift on price in terms of relevant own-price and cross-price elasticities of excess demand and supply[2]. He showed that the direction of price change will be opposite that of the currency movement if the own-price elasticities exceed the cross-price elasticities. When all cross-price elasticities are equal to own-price elasticities, the exchange rate impact will be zero, with no real income effects. Because of cross-price effects, we cannot predict *a priori* the direction and magnitude of change in exports and prices resulting from an exchange rate shift. This corresponds with the argument of Chambers and Just that the elasticity of the exchange rate on price should not be confined to the interval 0 to -1 (*4*).

A further implication of allowing for cross-price elasticities in a model of markets for wheat, corn, and soybeans is that, over the longer term, the exchange rate impacts on prices of the commodities will tend to equalize. This follows from the hypothesis that prices of near substitutes will tend to equalize in a simultaneously

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[2]While Bredahl's analysis involved the case of a variable import levy on corn in the importing country, his model can be applied more generally to the free trade case.

determined market when the time period is sufficiently lengthy to permit production and consumption to adjust.

Exchange Rates and the U.S. Farm Program

Commercial stockholding performs the function of, among other things, carrying over supplies of commodities not consumed within a year. Commercial carryover is expected to be negatively related to price of the commodity and positively related to the level of production.

From the point of view of exchange rate impacts on a commodity market, a more elastic stocks demand tends to make the aggregate demand for a commodity more responsive to price. This implies that the overall price impact of an exchange rate shift will be less as the elasticity of stocks demand increases. The relative elasticities of export demand and export supply determine how much of the exchange rate shift is reflected in export prices and how much is reflected in import prices in the overseas economy.[3]

The presence of stocks also implies that an exchange rate impact will be spread over more than one time period. Any short-term buildup of stocks implies that prices in later years will be lower than they otherwise would have been since a release of stocks increases total supplies of commodities.

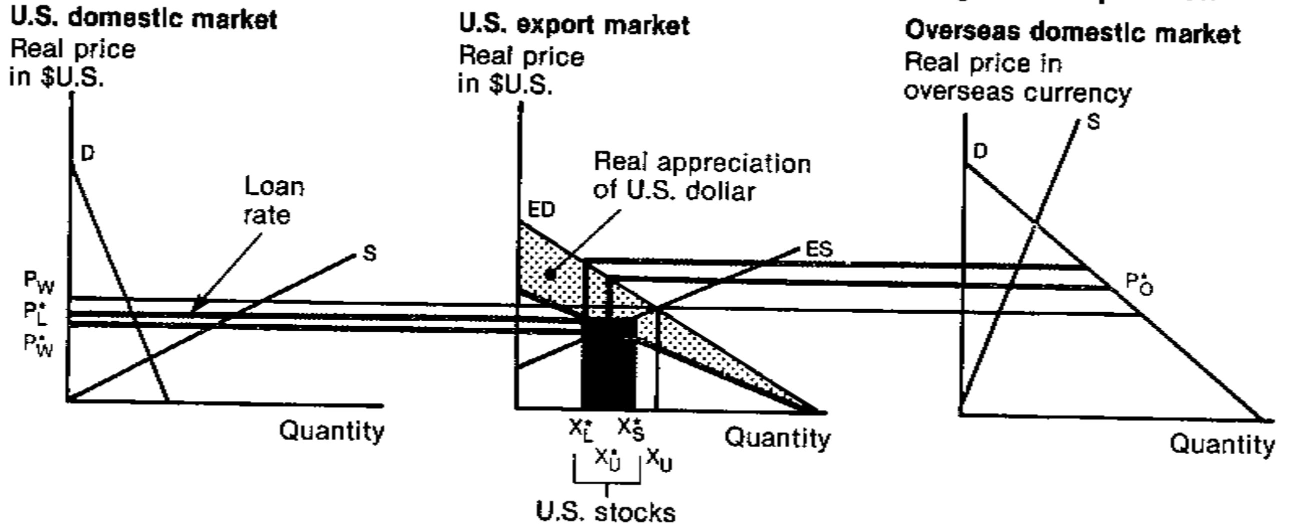
The U.S. farm program involves a complex set of stockholding, income support, and production diversion provisions designed to add to the elasticity of overall stocks demand (*15*). With the U.S. farm program, the elasticity of stocks demand is probably quite high when prices are near the loan rates. Lattimore and Zwart estimate the elasticity of demand for wheat entering farm program stocks to be -11.8 (*18*). The farm program stocks act as a further buffer to exchange rate impacts in the short term.

Figure 2 presents a simplified two-country model in which equilibrium in world trade in wheat was initially at real price Pw and at a level of U.S. exports X_u. With a real appreciation of the U.S. dollar the export demand schedule for U.S. wheat again rotates counter-

[3]Through the formula: Change in export price = Change in the exchange rate x [elasticity of export demand/(elasticity of export demand plus elasticity or export supply)].

Figure 2

Impact of Real Appreciation of the U.S. Dollar with a U.S. Loan Program in Operation



Given an appreciating U.S. dollar, U.S. stocks program raises U.S. and overseas prices while reducing export volume.

Note: The green shows the effect of the appreciation of the dollar. Gray lines show the effect of the stocks program.

clockwise. Without a U.S. farm program, the new equilibrium will be at the same points as in figure 1, that is at U.S. price P_w^* and a level of U.S. exports of X_u^*. The real price of the commodity to the importing country increases to P_o^*, as in figure 1.

Now consider the introduction of a U.S. Government stocks program in which, for simplicity, the United States places all wheat in stocks at a price P_L^*. Since the loan rate (P_L^*) exceeds price P_w^* in this case, U.S. prices fall only to the support level. The remainder of the adjustment to a real appreciation of the U.S. dollar is then thrust on to the level of stocks under the program. In figure 2, U.S. farm program stocks build to the amount $X_s^*-X_L^*$, while exports are $X_u^*-X_L^*$ less than in the case where no farm stocks program is implemented. Any further appreciation of the U.S. dollar will simply shift more grain into stocks and there will be no further domestic price adjustment in the United States.

In the overseas market, the price of the commodity is higher than what it would have been with lower stocks or with no farm program stocks. This emphasizes the point that when the loan rate (in real terms) is not adjusted to allow for real exchange rate effects, the farm program becomes a stronger bidder for grain relative to the overseas buyer when the real value of the U.S. dollar increases. Thus grain is bid away from export markets and into farm program stocks.

Extensions of the above example would allow for the complexities of the farm program provisions, for cross-price effects, and for later release of the farm program stocks onto the market. We did not specify all the intricacies of the U.S. farm program in the analysis because of the many complications involved. We specified the U.S. farm program as a loan program with a high elasticity of stocks demand when prices are near the loan rate. Such an assumption provides a reasonable approximation to the exchange rate effects.

Results

As a starting point, and to relate the results of our analysis to the earlier studies, we computed the impact multipliers for the case in which cross-price elasticities of demand and supply were fixed at zero.[4] We also assumed stocks demand was totally unresponsive

[4]The impact multiplier indicates the percentage change in the endogenous variable (prices, exports, and stocks in the tables) associated with a given change in the exogenous variable (e.g., the exchange rate).

to price and production levels and that the elasticity of nominal price transmission was unity initially.

The results are presented in table 3, which shows the percentage changes in real prices, exports, and stocks in the United States to an across-the-board 10-percent real appreciation of the U.S. dollar in year 1 and no change for the remaining years of the calculations (years 2-20). The incremental changes in prices, exports, and stocks are shown for individual years 1 to 5 and for the intervals 6-10 and 11-20. The totals of the incremental percentage changes over the 20-year period are also shown. The impact multiplier for wheat in year 1 can be compared with the results of Johnson, Grennes, and Thursby (*16*, table 2). Their calculated impact of a 10-percent real depreciation on U.S. wheat prices of 6.9 percent (using 1973-74 as a base year) compares with our calculated impact of -8.2 percent with a 10-percent appreciation under Nerlovian expectations.[5]

[5]The tables show the results of the model under different sets of assumptions. The rational expectations case assumes that farmers' planting decisions are based solely on expected prices, whereas the Nerlovian case assumes that farmers' decisions are based on prices during the past 4 years, but with more emphasis on the 2 most recent years.

Table 3—Simulated impact of 10-percent real appreciation of U.S. dollar, cross price and stock demand elasticities at zero

Item	Year							
	1	2	3	4	5	6-10	11-20	Total
	Percent change							
Rational expectations:								
Wheat price	-9.52	0	0	0	0	0	0	-9.52
Corn price	-6.53	0	0	0	0	0	0	-6.53
Soybean price	-5.27	0	0	0	0	0	0	-5.27
Wheat exports	-6.66	0	0	0	0	0	0	-6.66
Corn exports	-13.06	0	0	0	0	0	0	-13.06
Soybean exports	-8.8	0	0	0	0	0	0	-8.8
Nerlovian expectations:								
Wheat price	-8.15	.12	.03	.04	-.03	-.01	0	-8.00
Corn price	-6.01	.15	.05	.05	-.03	0	0	-5.79
Soybean price	-5.12	.24	.08	.08	-.04	-.01	0	-4.77
Wheat exports	-3.26	-1.16	-.56	-.56	0	0	0	-5.54
Corn exports	-8.40	-1.56	-.77	-.77	0	0	0	-11.50
Soybean exports	-5.94	-1.03	-.50	-.49	0	0	0	-7.96

The other points worthy of additional comment from table 3 are:

- The responsiveness of the wheat price exceeds that of corn, which in turn exceeds that of soybeans. This reflects the greater elasticity of response in demand and supply for corn and soybeans, which leads to a lower overall price adjustment, even though a higher share of the price adjustment occurs in the United States.

- The response of export volume of corn is greater than 10 percent, thus emphasizing that export volume is not confined to lie in the interval 0 to 10 percent.

- As would be expected, the rational expectations response is instantaneous. In contrast, the Nerlovian response is spread over several years, with some dampened cyclical behavior. Most of the response occurs in the first 2 years, however.

Non-Zero Cross-Price Elasticities

The first extension of the basic model was to set the cross-price elasticities to the parameter levels described in the appendix. As outlined earlier, the exchange rate impacts now become determined by the relativities between own- and cross-price elasticities of demand and supply (table 4).

Table 4—Simulated impact of 10-percent real appreciation of U.S. dollar, cross price elasticities at parameter levels and stock demand elasticities at zero

Item	Year							
	1	2	3	4	5	6-10	11-20	Total
	Percent change							
Rational expectations:								
Wheat price	-7.26	0	0	0	0	0	0	-7.26
Corn price	-6.66	0	0	0	0	0	0	-6.66
Soybean price	-6.29	0	0	0	0	0	0	-6.29
Wheat exports	-2.79	0	0	0	0	0	0	-2.79
Corn exports	-2.41	0	0	0	0	0	0	-2.41
Soybean exports	-2.78	0	0	0	0	0	0	-2.78
Nerlovian expectations:								
Wheat price	-7.31	.04	.01	.01	-.01	-.01	0	-7.27
Corn price	-6.60	-.03	-.01	-.02	0	0	0	-6.66
Soybean price	-6.25	-.02	-.01	-.01	0	0	0	-6.29
Wheat exports	-1.63	-.58	-.28	-.29	0	0	0	-2.78
Corn exports	-2.81	.20	.10	.10	0	0	0	-2.41
Soybean exports	-2.55	-.12	-.05	-.06	0	0	0	-2.78

Two important points come out of a comparison of the results of table 3 with table 4. First, the magnitudes of price response are relatively unchanged. The addition of cross-price effects tends to increase the impact of an exchange rate change on corn and soybean prices, while dampening the effect on wheat prices. This emphasizes the fact that when products can substitute for one another, both in supply and demand, there will be a tendency for prices to move together over the longer term in response to an across the board exchange rate movement. Second, in contrast to the case of zero cross-price effects, the level of exports responds much less to an exchange rate shock when cross-price shifts of demand and supply are considered. This point is not brought out in earlier studies.

Commercial Stocks Demand

Elasticities of commercial stock demand were set at their parameter levels (see appendix) in the next extension of the model. In this case, the year-to-year responses take on more importance.

The longer run impact of an exchange rate appreciation on prices and exports after introducing commercial stockholding is approximately zero (table 5). This longrun neutrality of stocks emphasizes the short-term role of stocks in absorbing a shock like an appreciation of the U.S. dollar. Changes in stocks clearly retard the rate of adjustment of price to an exchange rate shift in the short term. In the first year, commercial stock demand displaces both domestic and export demand. The net effect is for exports to decline more strongly than when no stockholding demand exists. Later releases of stocks tend to offset the initial loss of exports but eventually exports settle at or near their levels established in response to shifts in the exchange rate. Although commercial stockholding slows the rate of adjustment of price, well over 90 percent of the adjustment occurs within the first 2 years, with about 70 percent or more of the price adjustment occurring in the first year.

Imperfect Price Transmission

To approximate the pricing policies in a number of overseas markets that insulate domestic prices from world price movements, the elasticities of nominal price transmission were fixed at levels well less than one (see appendix). The basic effect of introducing price-distorting policies is to insulate the overseas domestic mar-

Table 5—Simulated impact of 10-percent real appreciation of the U.S.dollar, cross-price elasticities and stock demand elasticities at parameter levels

Item	Year							
	1	2	3	4	5	6-10	11-20	Total
	Percent change							
Rational expectations:								
Wheat price	-6.36	-0.58	-0.23	-0.07	-0.02	-0.01	0	-7.27
Corn price	-5.13	-1.15	-.29	-.08	-.02	-.01	0	-6.68
Soybean price	-4.73	-1.17	-.29	-.08	-.02	-.01	0	-6.30
Wheat exports	-5.11	2.08	.15	.06	.02	0	0	-2.80
Corn exports	-4.49	1.54	.34	.09	.03	.01	0	-2.48
Soybean exports	-4.14	0.96	.26	.06	.02	.01	0	-2.83
Wheat stocks	4.82	0.65	.22	.06	.02	.01	0	5.78
Corn stocks	5.45	1.25	.34	.09	.03	.01	0	7.17
Soybean stocks	4.70	1.18	.31	.08	.03	.01	0	6.31
Nerlovian expectations:								
Wheat price	-6.26	-.70	-.26	-.08	.02	.02	0	-7.26
Corn price	-5.02	-1.20	-.34	-.11	-.02	.01	0	-6.68
Soybean price	-4.59	-1.28	-.35	-.10	0	0	0	-6.32
Wheat exports	-4.27	1.96	-.19	-.20	.08	-.01	0	-2.79
Corn exports	-4.81	1.60	.47	.20	.06	0	0	-2.48
Soybean exports	-3.94	.84	.22	.02	.01	0	0	-2.85
Wheat stocks	5.50	.36	.07	-.13	-.03	-.02	0	5.48
Corn stocks	5.18	1.42	.44	.17	.01	0	0	7.12
Soybean stocks	4.58	1.34	.35	.09	-.02	-.02	0	6.32

kets from world price fluctuations and to thrust the adjustments onto those markets not insulated (*13, 17, 29*). In effect, the price-distorting policies lower the elasticity of export demand for U.S. commodities. In response to shifts of domestic supply and demand, attributable to weather, for example, U.S. prices will be more variable if other countries insulate their domestic prices from world prices.

In contrast, the impact of a more inelastic export demand for U.S. commodities is that a smaller change in U.S. export prices results from a given exchange rate shift. This can be demonstrated using the formula for calculating the impact of an export tax on price.

$$dPx = dt\,[e_{xd}/(e_{xd} + e_{xs}), \qquad (3)$$

where: dPx = change in export price,
dt = change in ad valorem tax,
e = elasticity of export demand (xd) or export supply (xs) respectively.

From this formula, we can deduce that, as the elasticity of export demand declines, the impact of exchange rate fluctuations on export price will decline. In the extreme case of a perfectly inelastic export demand schedule, there will be no impact on export price. This is the same point made by Collins, Meyers, and Bredahl in discussing price insulation in overseas markets (*7*).

The results of setting the elasticities of nominal price transmission at less than unity are reported in table 6. Initially, U.S. export prices respond less to exchange rate shifts than when there is perfect nominal price transmission. The greater inelasticity of export demand leads to smaller impacts of an exchange rate shift on exports and commercial stocks, too. At the same time, the real prices from the point of view of the rest of the world are slightly higher.

Farm Programs

To simulate the impact of an exchange rate change when U.S. agricultural prices are near their support levels so that farm program

Table 6—Simulated impact of 10-percent real appreciation of the U.S. dollar, cross price and stock demand elasticities at parameter levels, less-than-perfect nominal price transmission

Item	Year							
	1	2	3	4	5	6-10	11-20	Total
	Percent change							
Rational expectations:								
Wheat price	-4.43	-0.75	-0.36	-0.13	-0.05	-0.01	0	-5.73
Corn price	-4.34	-1.12	-.33	-.11	-.03	-.01	0	-5.94
Soybean price	-4.34	-1.09	-.31	-.09	-.03	-.01	0	-5.87
Wheat exports	-3.33	1.26	.06	.04	.02	0	0	-1.95
Corn exports	-4.14	1.17	.31	.10	.03	.02	0	-2.51
Soybean exports	-4.27	.86	.25	.08	.03	.01	0	-3.04
Wheat stocks	3.54	.73	.31	.11	.04	.01	0	4.74
Corn stocks	4.62	1.22	.39	.12	.05	.02	0	6.42
Soybean stocks	4.15	1.12	.34	.11	.03	.02	0	5.77
Nerlovian expectations:								
Wheat price	-4.35	-.82	-.44	-.15	-.01	.2	0	-5.57
Corn price	-4.39	-1.15	-.46	-.13	-.03	0	0	-6.16
Soybean price	-4.25	-1.19	-.34	-.10	-.01	0	0	-5.89
Wheat exports	-2.82	1.21	-.14	-.12	-.04	-.01	0	-1.92
Corn exports	-4.38	1.24	.39	.18	.05	.01	0	-2.51
Soybean exports	-3.97	.71	.18	0	.02	0	0	-3.06
Wheat stocks	3.91	.62	.28	0	-.03	0	0	4.78
Corn stocks	4.47	1.31	.45	.17	.04	-.01	0	6.43
Soybean stocks	4.17	1.20	.33	.08	0	0	0	5.78

stocks accumulate, we raised the elasticities of stocks demand for wheat and corn to -10. We assumed that soybeans remained above the range of prices inducing program stocks of that commodity, so we did not alter the elasticity of stocks demand for soybeans in the United States nor did we alter the elasticity of commercial stocks demand in the rest of the world. We assumed that the farm program applies continuously over the 20-year period of the analysis.

The chief results are presented in table 7. With a much more price-responsive demand for stocks, an exchange rate appreciation shifts grain into U.S. farm program stocks. Because the loan rate underpins the U.S. market, production and consumption in the United States adjust less than when prices are permitted to decline with no loan rate. Thus, the bulk of the initial adjustment to the exchange rate appreciation occurs in export volumes of grain. After the first year, export volumes rebound, but the longer term impact is for exports to decline slightly more than without farm program stockholding.

Table 7—Simulated impact of 10-percent real appreciation of U.S. dollar, cross-price and price transmission elasticities at parameter levels, government stocks program applying continuously

Item	Year							
	1	2	3	4	5	6-10	11-20	Total
	Percent change							
Rational expectations:								
Wheat price	-1.40	-0.77	-0.65	-0.50	-0.43	-1.23	-0.70	-5.68
Corn price	-1.68	-1.01	-.74	-.54	-.40	-1.03	-.51	-5.91
Soybean price	-3.01	-.84	-.47	-.33	-.25	-.65	-.33	-5.88
Wheat exports	-7.18	2.35	.19	.30	.30	.81	.70	-2.53
Corn exports	-8.56	1.35	1.05	.74	.55	1.36	.65	-2.86
Soybean exports	-4.37	.51	.21	.13	.10	.25	.12	-3.05
Wheat stocks	13.85	8.77	7.95	6.95	5.98	13.85	11.60	68.95
Corn stocks	17.20	13.13	9.95	7.77	6.17	17.5	9.58	81.30
Soybean stocks	2.37	.91	.58	.41	.32	.84	.43	5.86
Nerlovian expectations:								
Wheat price	-1.22	-.74	-.69	-.62	-.49	-1.32	-.65	-5.73
Corn price	-1.60	-1.11	-.78	-.57	-.41	-1.06	-.52	-6.05
Soybean price	-3.14	-.78	-.36	-.27	-.26	-.73	.33	-5.87
Wheat exports	-6.15	1.79	-.23	-.03	.34	1.35	.70	-2.23
Corn exports	-8.54	1.14	1.04	.79	.62	1.40	.68	-2.87
Soybean exports	-3.97	.38	.05	-.01	.80	.30	.13	-2.32
Wheat stocks	12.15	8.33	8.38	7.96	6.83	20.21	11.20	75.06
Corn stocks	16.22	13.26	10.32	8.20	6.33	17.86	9.67	81.86
Soybean stocks	2.78	.67	.38	.29	.36	.95	.45	5.88

The pattern of price adjustment with farm program stockholding demand for wheat and corn applied continuously should be contrasted with the case in which it applies for 2 years only (table 8). In the first case, prices continue to adjust to an exchange rate change over an exceptionally long time frame. Nevertheless, the total price impacts converge toward those without farm program stockholding. In the case where the stockholding program is "switched off" after 2 years, accumulated farm program stocks released onto the market induce a quicker price decline and more rapid adjustment of production, consumption, and exports toward the new equilibrium.

The U.S. farm program stocks have implications for prices in the rest of the world (table 9). Real prices in the rest of the world remain 1.6-2.5 percent higher with a U.S. farm program than without. For the United States, real prices are some 1.5-3.6 percent higher. Thus, in this simplified case, the U.S. farm stocks program does little, if anything, to improve the relative price position of the U.S. farmer versus farmers overseas.

Table 8—Simulated impact of 10-percent real appreciation of U.S. dollar, cross-price and price transmission elasticities at parameter levels, and government stocks program applying for 2 years, then removed

Item	Year							
	1	2	3	4	5	6-10	11-20	Total
	Percent change							
Rational expectations:								
Wheat price	-1.40	-0.77	-2.40	-0.85	-0.3	-0.17	0	-5.89
Corn price	-1.68	-1.01	-2.34	-.68	-.24	-.14	0	-6.09
Soybean price	-3.01	-.84	-1.22	-.57	-.21	-.12	0	-5.97
Wheat exports	-7.18	2.35	.26	.13	.05	.07	0	-4.32
Corn exports	-8.56	1.35	3.44	.72	.24	.13	0	-2.68
Soybean exports	-4.37	.51	.26	.35	.15	.08	0	-3.02
Wheat stocks	13.85	8.77	2.33	.84	.30	.18	0	26.27
Corn stocks	17.24	13.09	2.87	.99	.36	.21	0	34.76
Soybean stocks	2.38	.91	1.66	.66	.24	.14	0	5.99
Nerlovian expectations:								
Wheat price	-1.22	-.74	-2.80	-1.12	-.23	-.16	0	-6.27
Corn price	-1.60	-1.11	-2.56	-.72	-.20	-.03	0	-6.22
Soybean price	-3.14	-.78	-1.06	-.62	-.27	-.09	-.1	-6.06
Wheat exports	-6.15	1.79	-1.91	.37	.16	-.12	0	-5.86
Corn exports	-8.54	1.14	3.46	.88	.25	.10	.1	-2.61
Soybean exports	-3.97	.38	.05	.22	.19	.13	0	-3.00
Wheat stocks	12.15	8.33	2.97	1.01	.05	.35	-.1	24.76
Corn stocks	16.22	13.25	3.25	1.02	.26	.03	0	34.03
Soybean stocks	2.78	.67	1.32	.74	.37	.11	0	5.99

Table 9 —Simulated impact on real prices in the United States and rest of the world in first 2 years following an appreciation of the U.S. dollar, with and without U.S. farm program stockholding

Item	Change in real price of:					
	Wheat		Corn		Soybeans	
	U.S.	World	U.S.	World	U.S.	World
	Percent change					
Without farm program:						
Nerlovian	-5.2	2.2	-5.6	3.2	-5.4	3.7
Rational	-5.2	2.2	5.5	3.2	-5.4	3.7
With farm program:						
Nerlovian	-1.9	4.0	-2.7	5.7	-3.9	5.4
Rational	-1.6	3.8	-2.7	5.6	-3.8	5.3

Policy Implications

The above analysis highlights the significance of the recent real appreciation of the U.S. dollar for export prices, exports, and farm program stocks. Throughout the analysis we focused on exchange rates adjusted for inflation. Macroeconomic forces were taken as given and unaffected by economic developments in agricultural markets of concern.

Because of our approach, we cannot draw broad conclusions from our analysis about U.S. macroeconomic policy and its overall implications for agriculture. Using the same line of argument as O'Mara, Carland, and Campbell (*21*), we can conclude that the real appreciation of the U.S. dollar since 1980 has made the agricultural export sector of the U.S. economy less competitive than the export sectors of other countries, relative to their positions at the end of the 1970's. However, from 1970-79, the real value of the U.S. dollar, based on various agricultural trade-weighted indexes, declined by 25-30 percent (table 1). That decline enhanced the price competitiveness of the U.S. agricultural export sector in the 1970's and was a major reason for U.S. gains in world market shares (on a volume basis) for wheat and corn during the 1970's.

The shifting price competitiveness of the U.S. agricultural sector induced by fluctuations in the real exchange rate raises an important issue for U.S. agricultural policy decisionmaking. Since U.S. agricultural exports gained an implicit export subsidy of up to 30 percent by the end of the 1970's relative to the early part of the decade because of the declining value of the dollar, the boom of exports over this period must be seen in part as a phenomenon brought on by relatively loose monetary policy. Tighter monetary policy in the early 1980's cut off the export boom.

Policymakers have looked to other ways to offset the decline of exports, such as increased export promotion and subsidized credit on export sales. An important issue yet to be analyzed is how these methods of boosting U.S. agricultural exports line up against the declines induced by the strength of the dollar and other macroeconomic factors associated with the tight monetary policy of the United States. It is our judgment that the macroeconomic factors have had, and will have, a much greater impact on U.S. farm program stocks, farm exports, and agricultural prices than many of the more direct export subsidy arrangements currently in place or under consideration. Thus, the decisions concerning macroeconomic policy will be of vital concern to U.S. agriculture and to developments in U.S. agricultural policy over the next few years.

With regard to the U.S. farm program, our analysis has one major implication. If support prices tend to be inflexible in real terms and remain above the market-clearing level, an appreciation of the exchange rate will shift grain away from farm exports and into farm program stocks. We estimate that an additional $2 billion worth of grain moved into farm program stocks as a direct result of the real appreciation of the U.S. dollar over the past 2 years; that amounts to about one-sixth of the total budgetary outlays (around $12 billion) in fiscal 1983 for agriculture.

The large buildup of U.S. farm program stocks since 1980 is the result of a combination of factors. Policymakers and administrators now have difficulty judging when to release these stocks. From our analysis, the release will push prices lower than what they would otherwise have been. The grain futures markets have probably, to some extent, discounted current price for anticipated later stock releases. However, uncertainty about the timing of the release implies that there will be a significant price-depressing factor affecting the grains and soybeans complexes in the next year.

It should be noted that stocks of grain in other exporting countries have not increased to anywhere near the extent of the increase in U.S. grain stocks since 1980. Reasons for this include changeable weather and different stocking policies of different countries. From our analysis, shifting real exchange rates between the United States and other grain exporters and importers are also likely to have been a significant factor. This is particularly so when the U.S. loan rates, after allowing for inflation, have either been relatively stable or higher. One answer to the difficulty of a large and unanticipated stocks buildup under the U.S. farm program is to adjust the loan rate in real terms on a more flexible basis.

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Appendix: Analytical Model

The model used in our analysis was based on the earlier work by Collins, Meyers, and Bredahl (*7*). The main attraction of their approach was that they formally accounted for inflation in their analysis of exchange rate impacts on key U.S. agricultural exports.

Three extensions have been made to their structural equations in order to meet some of the objections raised by Chambers and Just (*4*). The extensions

- Allow for cross-price effects (among wheat, corn, and soybeans) in both demand and supply.
- Allow for alternative expectations operators in the supply equations.
- Allow for stockholding, including U.S. farm program stocks.

The last two of these three extensions emphasize the dynamics of the impact of an exchange rate shift on export prices, exports, and stocks. Thus, we use dynamic multipliers to summarize the quantitative impacts of an exchange rate shift.

The structural model for our analysis is as follows:

$$Dij = Dij[Pi1/CPIi, Pi2/CPIi, Pi3/CPIi, Yi/CPIi, Xij] \quad (1)$$

$$Sij = Sij[W(Pi1/CPIi), W(Pi2/CPIi), W(Pi3/CPIi), Tij] \quad (2)$$

$$Kij = kij[Pij/CPIij, Sij, Lij] \quad (3)$$

$$Pij = Gij[Eij \cdot Puj] \quad (4)$$

$$Suj\text{-}Duj\text{-}[Kuj\text{-}Kuj(\text{-}1)] = {}_{i=2,n}\,[Dij\text{-}Sij] + {}_{i=2,n}\,[Kij\text{-}Kij(\text{-}1)] \quad (5)$$

where

D = quantity demanded,
S = quantity supplied,
K = level of stocks,
G = price transmission mechanism between nominal U.S. price and nominal price in the overseas domestic market,

Y = income of consumers,
X, T, L = exogenous shifters of the relevant functions,
W = expectations operator,
i = u (United States), i = 2 (rest of world),
j = 1,2,3. 1=wheat, 2=corn, 3=soybeans.

For each country (or region), and for each commodity, there exist standard equations for domestic demand, domestic supply, and stocks demand, as well as an equation linking domestic prices to world prices. Equilibrium is ensured in the domestic and import and export markets through the market-clearing relationship (equation 5). Key exogenous variables in the model are the nominal exchange rates and inflation rates by country. Key parameters of the model are own-price and cross-price elasticities of demand and supply, own-price elasticities of stocks demand, and elasticities of nominal price transmission.

The dynamic features of the model are affected in two ways. First, the market-clearing mechanism ensures that all stocks carried over from the current year will be injected into future supplies. Current stocking decisions will, therefore, have an impact into the future as the grain is released back onto the market. Second, the expectations operators can take on different lag structures through the weights attached to current and past prices. We adopted three different expectations operators, in which the weights attached to current and lagged prices are as follows:

- cobweb, where $w = [0,1,0,0]$,
- Nerlovian, where $w = [.5,.25,.125,.125]$,
- rational, where $w = [1,0,0,0]$,
  and $w = [w(t), w(t-1), w(t-2), w(t-3)]$, where $w(t-i)$ is the weight attached to price $t-i$ in forming the expected price in year t.

These operators represent extreme cases. The cobweb model was employed in earlier studies so we used it for purposes of comparison. Because the elasticity of export demand for U.S. commodities exceeds the elasticity of export supply, the cobweb model results were unusable. Also, we believe that the real world does not follow a simple cobweb response. Thus, we do not present the cobweb model results. The other extreme is the rational expectations case, in which crop-planting decisions are based solely on current prices. Since crop-planting decisions are made at the beginning of the year, this specification approximates the rational expectations model postulated by Muth and Fisher (*8, 20*). The approximation comes from placing all weight upon current price, which implies that producers are able to predict the equilibrium price at planting time as predicted by the model of the market faced by the farmer. It also implies that the farmer is able to account fully for the impact on the market of the exchange rate shift. Given the link between cash and futures prices, the rational model becomes a more realistic proposition, since futures prices in the real world will discount for the impact of an exchange rate shift very rapidly. As an alternative to the above two extreme expectations models, we employed a Nerlovian adaptive expectations model with exponentially declining weights. Of the three cases, some combination of the Nerlovian and rational expectations probably best approximates reality.

With nonlinearities in the alternative expectations formulations for supply, we used simulation analysis to calculate the dynamic multipliers. The demand, supply, stocks demand, and price transmission equations in the above model were expressed in percentage change terms, partly to simplify the specification of parameter values. It also meant that the base assumptions for the key exogenous variables could be fixed at zero percentage change. This meant that no actual exchange rate indexes or rates of inflation had to be used. Note also that shifting the percentage change in nominal exchange rates while holding inflation rates constant (keeping their percentage change at the base level of zero) implies an equivalent percentage change in the inflation-adjusted exchange rate.

For a solution method of the model we used the Troll computing simulation package. To solve nonlinear models, a Newton-type solution procedure is used within Troll. The Testmod experimental program package in Troll was then used to compute the dynamic multipliers of the system. The program works as follows. An initial base solution to the model is simulated over the period of the data. A "perturbed" solution is then computed over the same data period. The exogenous variables can be perturbed in any way requested by the Troll user. Initially, we raised the nominal exchange rate between the United States and the rest of the world by 10 percent in year 1 and made no other changes to the exogenous variables. The dynamic multipliers computed from this experiment are comparable to the dynamic multipliers that are calculated in the final form of a linear system of equations (*26*).

Level of Aggregation

To encapsulate the essential features of the world grain markets, we used a two-region model of the world market—the United States and the rest of the world. This degree of aggregation is clearly subject to some aggregation error, since it ignores commodity policy differences between countries and it implies that demand and supply responses can be summarized by single-elasticity parameters. Note also that the market relationships specified are for one level of the market only, the export or wholesale level. Marketing margins between different levels of the market are thus ignored. On balance, the advantages of the smaller more aggregate model were judged to outweigh the costs of further disaggregation. The level of aggregation is the same as that used in the earlier analyses of exchange rate changes on U.S. agriculural export prices. Our analysis focuses on deviations from the base year levels of production, consumption, stocks, and prices. The data we used for the base year represent average levels of production, consumption, and stocks for the years 1979-80 to 1981-82 (app. table 1). The data were rounded and adjusted so that net change in world carryover stocks implied by the consumption and production levels would be zero. Since the above data provide the base year shares of the world market, which determine elasticities of export demand and supply, small adjustments of the levels will affect these elasticities (and therefore the exchange rate impacts) only marginally. The base year data were extrapolated for 20 years at the levels presented in appendix table 1.

Model Parameters

The earlier studies of the impact of exchange rate movements provide us with basic parameters of own-price elasticities of demand for wheat, corn, and soybeans. Collins, Meyers, and Bredahl employed the following parameters and we adopted them since they broadly correspond with a number of other studies (*7*). Cross-price elasticities of demand were specified after reference to a number of previous studies (*27, 28*). Estimated cross-price elasticities are less readily available from previous studies and the empirical estimates vary quite widely. We adopted the parameters in appendix table 2.

Appendix table 1—Base-year levels for the United States and the rest of the world

Item	United States	Rest of world
	Million metric tons	
Production:		
Wheat	75	370
Corn	195	225
Soybeans	52	32
Consumption:		
Wheat	25	420
Corn	130	290
Soybeans	32	52
Stocks:		
Wheat	25	60
Corn	35	20
Soybeans	10	5
	$ U.S./metric ton	
Price:		
Wheat	170	n.s.
Corn	125	n.s.
Soybeans	250	n.s.

n.s. = not specified.

Appendix table 2—Own-price and cross-price elasticities of demand

Elasticity with respect to price of:	Wheat	Corn	Soybeans
Wheat	-0.20	0.05	0.05
Corn	.05	-.40	.10
Soybeans	.05	.10	-.40

Since real incomes were assumed to remain unchanged, income elasticities of demand were not required.

We adopted more responsive elasticities of supply than those used by Collins, Meyers, and Bredahl (*7*). Other studies suggested that elasticities of supply response were higher, particularly over the longer term (*27, 28*). The supply elasticities we employed are shown in appendix table 3.

These elasticities of demand and supply were applied both to the domestic markets of the United States and the rest of the world.

Elasticities of carryover stock demand can be broken into two categories, commercial stock demand and Government program stock demand. We assumed that the U.S. commercial stockholding is more price responsive than that of the rest of the world. Using Lattimore and Zwart (*18*) as a guide, the elasticity of commercial stocks demand for wheat for the United States was set at -1.0, the same elasticity as used by Sharples (*25*), and -0.5 for the rest of the world. Elasticities of carryover stocks demand for corn and soybeans were fixed at zero for the rest of the world, while they were fixed at -1.0 for the United States. For both regions, we assumed that a 1-percent increase in production of a particular commodity would lead to a 1-percent increase in carryover stocks, over and above the price-responsive commercial stockholding demand (*18*).

Appendix table 3—Price elasticities of supply

Elasticity with respect to price of:	Wheat	Corn	Soybeans
Wheat	0.40	-0.15	-0.05
Corn	-.15	.40	-.30
Soybeans	-.05	-.30	.40

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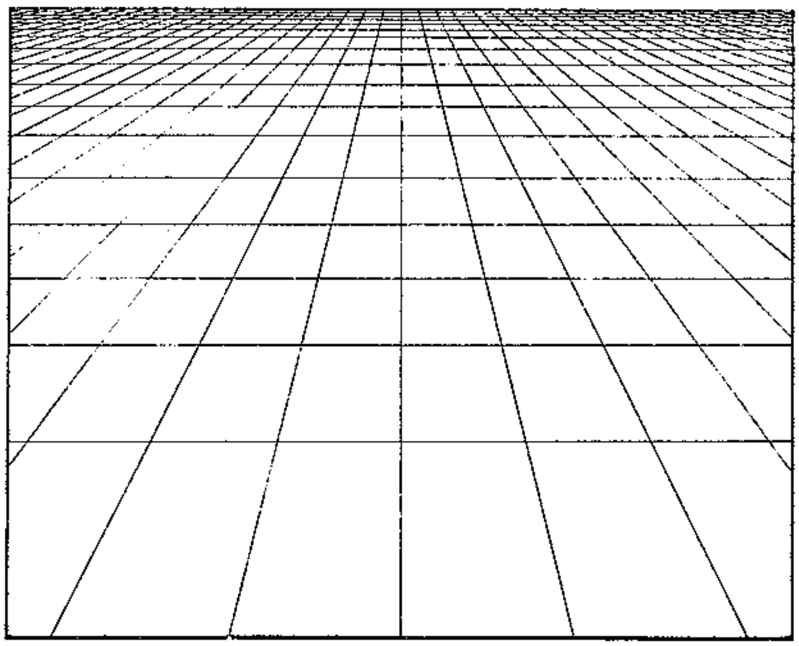

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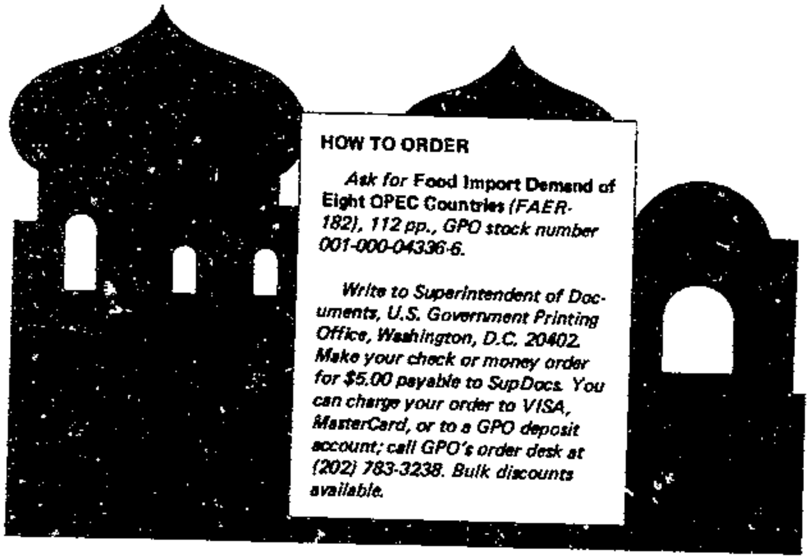

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