U.S. Grain Exports and the Value of the Dollar

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Abstract. *This article examines the changes in grain exports from 1973 to 1985 A simplified three-country trade model is introduced as a framework for analyzing U S grain trade, world grain trade, and market price when changes in two real effective exchange rates occur an exchange rate based on U S trade with grain importers and an exchange rate based on global trade of grain competitors Although collinearity in the data series makes implementation of the theoretical model difficult, evidence suggests that the cumulative effect of a 1-percent depreciation (appreciation) in the value of the dollar was to expand (contract) U S wheat exports in the range of 2 3 percent and to expand feed grain exports in the range of 1 4 percent Wheat exports have adjusted to real exchange rate changes only over a long period of 10 - 12 quarters Feed grain exports have been quicker to adjust to real exchange rate changes, but there are significant lagged effects*

Keywords *Grain, international trade, exchange rates*

U S grain exports have dropped dramatically in the eighties The value of U S exports of wheat and wheat products dropped from a historical peak of $8 1 billion in 1981 to $4 5 billion in 1985, a 44-percent decrease The decline for feed grains has been of a similar magnitude, from $10 4 billion to $6 8 billion Moreover, the U S share of the world market for grains fell from 54 to 39 percent over the period

One possible explanation for deteriorating exports has been the sustained appreciation of the U S dollar in the early eighties Measured in trade-weighted terms against the currencies of other wheat and feed grain exporters, inflation-adjusted effective exchange rates increased 43 and 58 percent, respectively, from 1979 to 1985 The dollar similarly appreciated 46 and 64 percent against the weighted average of currencies of countries that import U S wheat and feed grains

A testable hypothesis is that changes in the value of the dollar inversely affect grain exports An increase (decrease) in the value of the dollar, all else constant, decreases (increases) grain exports Because the United States supplies much of the world grain market, changes in the real exchange rate affect the world price of grain When the dollar appreciates, the own-currency price of grain increases for export competitors and grain importers Export competitors are encouraged to export, and importers are less eager to import at higher prices Unless export supplies of competitors are highly responsive to the price change, total world grain exports decrease The United States loses both in grain exports and market share

Our purpose is to investigate the effect of changes in the value of the dollar on U S grain exports We focus on the direct effect of a change in the dollar's value on the international price of grain The analysis is, therefore, based on a partial equilibrium model of the world grain market It abstracts from indirect effects of exchange rate changes on grain trade

We address the following questions

1 What are the relevant parameters for analyzing the effect of changes in the value of the dollar on U S grain exports? This question requires us to consider the value of the dollar as weighted against both export competitors and grain importers

2 How long does it take for changes in the value of the dollar to affect grain export levels? Exchange rate changes influence both excess supply of exporters and excess demand of importers Given the seasonality of grain production, sunk investments in specific capital stocks, and agricultural policies of the U S and foreign governments that produce market distortions, exchange rate changes are likely to influence export levels only over a long period

3 Given the experience of the floating exchange rate period, what is the quantitative effect of a specified exchange rate on grain exports? How much confidence can be attributed to this number?

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To answer question 1, we present a trade model that theoretically evaluates the effect of changes in the value of the dollar on grain exports The model includes three countries the U S grain exporter, the rest-of-world (ROW) exporter, and the ROW importer Changes in the value of the dollar are measured against both the ROW exporter and the ROW importer The exchange rates are used in the reduced-form version of the model to answer questions 2 and 3

Model Structure

We use a partial-equilibrium trade model to simplify tracing the effects of changes in macroeconomic variables and U S agricultural policy on grain exports We assume competitive markets and no backward linkages from agricultural exports to exchange rates Domestic demand in exporting countries and domestic supply in the importing country are assumed to be perfectly inelastic so that concentration is focused on trade flows [1] All variables in the model are in real terms, the volume of trade is affected by real importer income and real prices Furthermore, the United States is one of the grain exporters, and the world price of grain is quoted in dollars

Supply of U S grain exports (Q^A_s) is based on the real price of grain (wp) and U S agricultural policy, that is, the real target price (tp) and the real support price (sp)

$$Q^A_s = S^A(wp,tp) - L^A(sp/wp) \tag{1}$$

where $S^A(wp,tp)$ and $L^A(sp/wp)$ represent excess supply from current production and the flow of grain into public stocks, respectively If the real price of grain (wp) increases, farmers are encouraged to allocate more resources to this commodity, and grain production will rise (Conversely, if the price of other goods and services increases more than grain prices, farmers will turn to these higher priced commodities, and grain supply will diminish) Higher target prices (tp) increase deficiency payments that in turn augment exports The ratio of support to actual grain price, sp/wp, determines the flow into public stocks If the support price rises relative to the grain price, farmers will place more of their product in public stocks rather than in exports, hence, the negative sign before L^A

The ROW export supplier bases its supply decision to the world market on the local price of grain

$$Q^F_s = S^F(ef \cdot wp) \tag{2}$$

where the supplier's price is converted to local currency by ef, defined as the real foreign currency price of the dollar Use of the real exchange rate automatically translates the world price of grain into the real price for the ROW exporter [2] When the dollar depreciates (appreciates), the foreign supplier's domestic price of grain falls (rises), and the quantity supplied will decline (increase)

Excess demand for grain exports (Q_d) depends on the importer's real income (y) and the importer's grain price in local currency

$$Q_d = D(y, em \cdot wp) \tag{3}$$

where em represents the importer's price of the dollar [3] If grain is a normal good for world importers, an income increase would augment foreign demand Similarly, if the local currency price of grain declines, perhaps because of a dollar depreciation, the quantity demanded will increase

By definition, total world exports equal the sum of U S and other countries' exports

$$Q_s = Q^A_s + Q^F_s \tag{4}$$

Finally, the market clearing condition is·

$$Q = Q_s = Q_d \tag{5}$$

or world excess supply equals excess demand

Comparative Statics

Equations 1-3 are assumed to be continuous functions To determine the effect of small changes in the system, we have logarithmically differentiated the five equations

$$Q^A_s{}^* = (\alpha_1\sigma^A + \alpha_2\pi)wp^* + \alpha_1\Phi(tp)^* - \alpha_2\pi(sp)^* \tag{6}$$

[1]Real income changes in the exporting countries are also assumed not to affect domestic demand Most major grain exporting nations are developed countries for which the income elasticity for grain would be expected to be lower than that for most grain importers To simplify the algebra, we implicitly assume that the income elasticity in the exporting countries is zero

[2]In this model, the real price of U S grain (wp) is the nominal price (wpn_{us}) divided by the wholesale price index (wpi_{us}) The real exchange rate is the nominal exchange rate ejn (measured as currency units of country j per dollar) adjusted for the ratio of the U S wpi to the foreign wpi, that is, $ej = (ejn) \cdot (wpi_{us}/wpi_j)$ The law of one price translates the nominal U S price into the nominal foreign price $(ejn) \cdot (wpn_{us}) = wpn_j$ Multiplication of the real U S grain price by the real exchange rate yields the real price of grain denominated in foreign currency units as follows

$$(ej) \cdot (wp) = (ejn) \cdot (wpi_{us}/wpi_j) \cdot (wpn_{us}/wpi_{us}) = wpn_j/wpi_j$$

[3]Note that ef and em are two distinct exchange rates Although both measure the value of the U S dollar, ef does so in terms of the ROW *competitor's* currency, and em, in terms of the ROW *importer's* currency

where a superscript * on a variable indicates the percentage change in that variable, and where

σ^A = export supply elasticity with respect to price for country A,
π = stock supply elasticity with respect to the ratio of support to actual price,
Φ = export supply elasticity with respect to the target price, and
$\alpha_1 = S^A/Q^A_s$, $\alpha_2 = L^A/Q^A_s$

$$Q^F_s{}^* = \sigma^F(wp^* + ef^*) \quad (7)$$

where σ^F = foreign supply elasticity with respect to the local price,

$$Q_d{}^* = -\cap(em^* + wp^*) + \delta y^* \quad (8)$$

where
$\cap$ = import demand elasticity with respect to local price, and
δ = import demand elasticity with respect to income,

$$Q^* = Q_s{}^* = Q_d{}^* \quad (9)$$

$$Q_s{}^* = \Theta^A Q^A_s{}^* + \Theta^F Q^F_s{}^* \quad (10)$$

where $\Theta^i = Q^i_s/Q_s$, or market share

Reduced-form equations for price, export volume, and market share can be derived from equations 6-10 A change in the exogenous variables affects the endogenous variables in several ways First, the world price equals

$$wp^* = -\frac{\Theta^A\alpha_1\Phi}{\Omega}tp^* + \frac{\Theta^A\alpha_2\pi}{\Omega}sp^* - \frac{\Theta^F\sigma^F}{\Omega}ef^* - \frac{\cap}{\Omega}em^* + \frac{\delta}{\Omega}y^* \quad (11)$$

where $\Omega = \Theta^A\alpha_1\sigma^A + \Theta^A\alpha_s\pi + \Theta^F\sigma^F + \cap$ A depreciation in the real value of the dollar, ef* or em*, increases the real dollar grain price because the importer demands more U S commodities and the ROW exporter supplies less grain to the world market However, the real grain price to the importer and to the ROW exporter in terms of their own currencies is lower Hence, the quantity demanded is more for the importer, and the quantity supplied is less for the exporter

The export volume (12) and market share (13) equations for the United States are

$$Q^{A*} = \frac{\alpha_1\Phi(\Theta^F\sigma^F+\cap)}{\Omega}tp^* - \frac{\alpha_2\pi(\Theta^F\sigma^F+\cap)}{\Omega}sp^* - \frac{\Theta^F\sigma^F(\alpha_1\sigma^A+\alpha_2\pi)}{\Omega}ef^* - \frac{\cap(\alpha_1\sigma^A+\alpha_2\pi)}{\Omega}em^* + \frac{\delta(\alpha_1\sigma^A+\alpha_2\pi)}{\Omega}y^* \quad (12)$$

$$\Theta^{A*} = \frac{\Theta^F\alpha_1\Phi(\sigma^F+\cap)}{\Omega}tp^* - \frac{\Theta^F\alpha_2\pi(\sigma^F+\cap)}{\Omega}sp^* - \frac{\Theta^F\sigma^F(\alpha_1\sigma^A+\alpha_2\pi+\cap)}{\Omega}ef^* - \frac{\Theta^F\cap(\alpha_1\sigma^A+\alpha_2\pi-\sigma^F)}{\Omega}em^* + \frac{\Theta^F\delta(\alpha_1\sigma^A+\alpha_2\pi-\sigma^F)}{\Omega}y^* \quad (13)$$

A real decrease in the value of the dollar for importers and/or exporters unambiguously increases trade volume share for the U S exporter, all else constant (Note the negative signs on the exchange rate terms in equation 12) World importers purchase more grain as they believe that the real (local) price has declined because of the dollar depreciation The import demand ($\cap$), the export supply (for both exporters, σ^A and σ^F), the stock supply (π) elasticities, and the initial market share (Θ^F) determine the magnitude of the effect

U S agricultural policy alters export price and quantity responsiveness, depending on the closeness of the loan rate to the world market price and participation rate in the programs Increases in the support price directly influence world grain prices, but inversely affect U S exports Rather than exporting more grain, U S producers increase the flow of grain into public stocks Conversely, the target price acts as an export subsidy Increases in the target price reduce the dollar grain price but augment U S exports[4] The

[4]The effect of the target price on exports could be moderated by the effect of land diversion requirements for deficiency payment eligibility However, this issue is not straightforward As Love and others (5) have noted, if farmers are indifferent to program participation, an increase in the diversion requirement will cause them to leave the program, in which case they increase the acreage they plant On the other hand, if farmers are inclined to participate, then an increase in the diversion requirement will lead them to divert more acreage to stay in the program Although this issue has relevance to this study, it is not incorporated into the model Italicized numbers in parentheses refer to items in the References at the end of this article

effect of the policy instruments taken together is an empirical question The target price could partially, fully, or more than offset the support price

Estimation Procedure

We use equation 12 to investigate how changes in the value of the dollar affect U S grain exports and to empirically analyze these relationships Equation 12 is integrated to yield

$$\ln Q^A = a_0 + a_1 \cdot \ln(em) + a_2 \cdot \ln(ef) + a_3 \cdot \ln(y) + a_4 \cdot \ln(tp) + u \quad (14)$$

where u is the error term, which is assumed to be normally distributed with an expected value of zero, a_0 is the constant of integration, and the other variables are defined as before[5] The model maintains that changes in U S grain exports vary directly with changes in the real target price and importer income and vary inversely with changes in the real loan rate and in both real exchange rates The structural parameters shown in equation 12 are implicit in the regression coefficients

Two issues complicate the estimation of equation 14 the dynamics and the collinearity of the variables Large price fluctuations may change quantity supplied only slightly in the short term First, fixed costs in agriculture tend to be high because agricultural capital has no readily available alternate uses outside agriculture Second, movements in exchange rates, as well as in support and target prices, may not be transmitted quickly to ROW exporters or importers Third, the agricultural sector is subject to government-imposed policy distortions Changes in exchange rates or U S policy instruments may not affect foreign internal agricultural prices in any set, predictable manner Nonetheless these changes will affect the opportunity cost of insulating a nation's agricultural sector These issues strongly argue for the specification of lagged effects of exchange rates and policy variables on trade Therefore, it is important to determine how long exchange rate and policy changes will affect export levels

[5]Note that this specification implicitly assumes that the error structure of the model is multiplicative rather than additive This assumption means that the slopes rather than the positions of the excess supply and demand functions are random Turnovsky has shown that the assumption of multiplicative disturbances derives naturally from underlying supply and demand relationships (8) His results do not necessarily generalize to the case of *excess* supply and demand functions For our purposes, however, we simplify the analysis by assuming that the primary source of random variation is from production, to the exclusion of the other sources of consumption and flows into public stocks

Collinearity among some of the explanatory variables makes the estimation of equation 14 difficult The two exchange rate variables tend to move in the same direction over the flexible rate period For wheat, the correlation of the logarithms of the competitor and importer exchange rates is 0 86 For feed grains, the correlation is 0 77 The domestic policy instruments (target and support prices) have been typically adjusted at the same time and in the same direction For wheat, the correlation of the target and support prices is 0 96 For feed grains, it is 0 97 The correlation between these variables obscures the contribution of each variable to changes in grain export levels

The approach we employ is to drop from equation 14 one of the variables from each set of correlated variables The interpretation of the corresponding regression coefficients will then change For the exchange rate variable, the regression coefficient would now account for the sum of the import price elasticity and the competitor supply elasticity weighted by its share of the market For the domestic policy variable, the regression coefficient is a weighted average of the difference between the domestic supply elasticity with respect to the target price and the stock elasticity with respect to the support price The sign on the latter coefficient cannot be determined a priori because it involves the difference of two nonnegative elasticities The sign depends on whichever effect is stronger during the estimation period

The error term of a revised version of equation 14 becomes correlated with each of the respective coefficients on the exchange rate and domestic policy variables Consider equations 15 and 16, which reflect the proposed relationship between the exchange rates and between the domestic policy instruments

$$\ln(ef) = b_{10} + b_{11} \cdot \ln(em) + e_1 \quad (15)$$

$$\ln(sp) = b_{20} + b_{21} \cdot \ln(tp) + e_2 \quad (16)$$

If one were to assume that $b_{10} = b_{20} = o$ and $b_{11} = b_{21} = 1$, then equation 14 would become

$$\ln Q^A = a_0 + (a_1 + a_2) \cdot \ln(ef) + a_3 \cdot \ln(y) + (a_4 + a_5) \cdot \ln(sp) + u - a_1 e_1 - a_5 e_2 \quad (17)$$

The error terms of equations 15 and 16 are included in the error structure of equation 17 If we simultaneously estimate equation 15, 16, and 17 and use the correlation across equations, the efficiency of the estimates should improve

The theoretical model (via equation 11) also maintains that the world price of grain varies directly with the support price and importer income and it varies inversely with exchange rates and target price Using the same reasoning as in equation 17, we can express this relationship as

$$\ln(wp) = c_0 + c_1 \cdot \ln(ef) + c_2 \cdot \ln(y) + c_3 \cdot \ln(sp) + z \quad (18)$$

C_1 is expected to be negative, c_2 is expected to be positive, and c_3 can be either, depending on the strength of relevant elasticities The error term z includes the effects of e_1 and e_2 of equations 15 and 16, respectively Because equations 17 and 18 are derived from the same theoretical structure, consideration of cross-equation correlation between them should improve the efficiency of both sets of coefficient estimates

The export competitor exchange rate was included in equation 17 rather than the importer exchange rate This choice may be considered arbitrary Although we report estimation results for both exchange rates, we emphasize the competitor exchange rate for two reasons First, agricultural economists have ignored the competitor exchange rate *(2)* One of our implicit goals is to redress this omission Second, as Wilson has noted *(12)*, the concern with competitiveness in world grain markets (especially wheat) has emphasized dynamic relationships among the major grain exporters The choice of which exchange rate to use implicitly recognizes the major source of competition to the United States The choice of the competitor exchange rate focuses more directly on the export supply responses of major competitors We will describe importer behavior to the extent that the two exchange rates are collinear

Estimation Results

We estimate equations 15, 16, 17, and 18 using Zellner's seemingly unrelated regression (SUR) technique for the 1973Q1 to 1985Q4 period for both wheat and feed grains We chose this period to coincide with the flexible exchange rate period The volume of U S wheat exports, the dollar price, and target and support prices are from various issues of the Economic Research Service's (ERS) *Wheat Situation and Outlook Report (11)* Likewise, U S feed grain volume, the dollar price of corn, and target and support prices of corn are from various issues of the *Feed Situation and Outlook Report (10)* A proxy for real world income excluding the United States' is calculated from gross national product (GNP) and price data published in various issues of *International Financial Statistics (3)*[6] The importer exchange rate is published in *Agricultural Outlook (9)* It is based on a weighted average of bilateral exchange rates of 38 countries to which the United States exports wheat and corn Weights are determined by the average of the 1976-78 wheat and corn export shares of each country The competitors' exchange rate is based on export competitors' share of world wheat and corn exports, excluding the United States, for 1979-81 The major ROW wheat exporters are Canada, France, Argentina, and Australia The major ROW corn exporters are Argentina, France, the Netherlands, South Africa, and Thailand[7]

As explained earlier, the exchange rate and domestic policy instruments are expected to affect grain export levels only after a considerable lag We used both Akaike's *(1, 4)* final predictor error criterion (FPE) and Pagano and Hartley's *(6)* criterion to determine the appropriate lag lengths for the exchange rate and policy variables We considered a maximum of 12 lags beyond the current period for each explanatory variable

For wheat, both the FPE and Pagano and Hartley's criteria imply that ROW income should have no lags, whereas the support price and real global exchange rate (ef) should have 12- and 10- period lags, respectively For feed grains, Pagano and Hartley's test implies that ROW income should have no lags, whereas the support and real global exchange rate (ef) should have 12- and 11-period lags, respectively The FPE criterion indicates that the optimal lag combination is 12 for the support price and zero for the exchange rate Although this result seemingly contradicts the hypothesis of long adjustment to exchange rate changes, the FPE value for the combination of 12 lags on both variables is not significantly greater than the minimum FPE given by the case with no lags Estimation results for the long and zero lag specifications appear below

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[6]According to the theoretical model, the appropriate income variable should account for changes in economic activity in countries that import grain However, real income data for those countries are not available on a quarterly basis As an alternative, a proxy variable has been chosen It is derived from the unweighted summation of quarterly real GNP levels expressed in 1980 dollars for the following countries Belgium, Canada, France, Japan, Italy, Netherlands, Sweden, Switzerland, and West Germany The data for these countries on an annual basis for 1970-82 have been compared to annual real income based on a trade weighted average of those countries that import U S wheat and corn The contemporaneous correlation between the series is very high, equalling 0 98 and 0 99, respectively No lag/lead correlation (up to 3 years considered) is ever greater than 0 78 On this basis, we make the assumption that the quarterly series used in this study is an appropriate proxy for studying the effect of rest-of world income on the demand for U S grain

[7]Both exchange rate series are available from ERS

The equation results (with standard errors in parentheses) follow

Wheat

Export Volume

$$\ln Q^A_t = \underset{(4.24)}{29.45} - \underset{(0.08)}{0.29}\, D1_t - \underset{(0.08)}{0.88}\, D2_t - \underset{(0.08)}{0.10}\, D3_t$$

$$- \underset{(0.32)}{2.45}\, \Sigma \ln ef_{t-i} - \underset{(0.53)}{1.99} \ln y_t + \underset{(0.72)}{3.63}\, \Sigma \ln sp_{t-i} \qquad (19)$$

$R^2 = 0.799$
SE $= 0.18$
DW $= 1.22$
(The Di's are seasonal dummy variables.)

Exchange Rates

$$\ln ef_t = \underset{(0.33)}{0.42} + \underset{(0.08)}{0.93} \ln em_t \qquad (20)$$

$R^2 = 0.736$
SE $= 0.06$

Policy Variables

$$\ln sp_t = \underset{(0.16)}{0.07} + \underset{(0.13)}{0.74} \ln tp_t \qquad (21)$$

$R^2 = 0.396$
SE $= 0.11$

Price

$$\ln wp_t = \underset{(1.84)}{9.61} - \underset{(0.25)}{0.54} \ln ef_t - \underset{(0.32)}{0.55} \ln y_t - \underset{(0.16)}{1.31} \ln sp_t \qquad (22)$$

$R^2 = 0.768$
SE $= 0.14$
DW $= 0.96$

Export Volume (Using Target Price)

$$\ln Q^A_t = \underset{(4.05)}{7.62} - \underset{(0.08)}{0.40}\, D1_t - \underset{(0.07)}{0.91}\, D2_t - \underset{(0.08)}{0.29}\, D3_t$$

$$- \underset{(0.34)}{2.28}\, \Sigma \ln ef_{t-i} + \underset{(0.58)}{0.76} \ln y_t + \underset{(0.46)}{2.06}\, \Sigma \ln tp_{t-i} \qquad (23)$$

$R^2 = 0.761$
SE $= 0.20$
DW $= 1.38$

Feed Grains

Export Volume (long lag on exchange rate)

$$\ln Q^A_t = \underset{(1.33)}{-16.48} - \underset{(0.07)}{0.01}\, D1_t - \underset{(0.06)}{0.53}\, D2_t - \underset{(0.07)}{0.04}\, D3_t$$

$$- \underset{(0.19)}{1.45}\, \Sigma \ln ef_{t-i} + \underset{(0.23)}{3.43} \ln y_t - \underset{(0.27)}{1.99}\, \Sigma \ln sp_{t-i} \qquad (24)$$

$R^2 = 0.85$
SE $= 0.13$
DW $= 2.11$

Export Volume (zero lag)

$$\ln Q^A_t = \underset{(1.81)}{-16.38} + \underset{(0.07)}{0.06}\, D1_t - \underset{(0.07)}{0.57}\, D2_t + \underset{(0.07)}{0.05}\, D3_t$$

$$- \underset{(0.17)}{1.28} \ln ef_t + \underset{(0.32)}{3.30} \ln y_t - \underset{(0.35)}{1.89}\, \Sigma \ln sp_{t-i} \qquad (25)$$

$R^2 = 0.88$
SE $= 0.11$
DW $= 1.84$

Exchange Rates

$$\ln ef_t = \underset{(0.42)}{0.12} + \underset{(0.10)}{1.06} \ln em_t \qquad (26)$$

$R^2 = 0.576$
SE $= 0.12$

Policy Variables

$$\ln sp_t = \underset{(0.06)}{-0.04} + \underset{(0.07)}{0.91} \ln tp_t \qquad (27)$$

$R^2 = 0.405$
SE $= 0.10$

Price

$$\ln wp_t = -\underset{(0.18)}{0.59} \ln ef_t + \underset{(0.11)}{0.56} \ln y_t - \underset{(0.19)}{0.78} \ln sp_t \qquad (28)$$

$R^2 = 0.243$
SE $= 0.22$
DW $= 0.27$

Results from equation 19 indicate that a 1-percent change in the effective real exchange rate is accompanied by a mean response of -2.45 percent in the volume of U.S. wheat exports over an 11-quarter period (including the current period). Based on a standard deviation on the coefficent of 0.32, there is a 90-percent probability that the elasticity is between -1.9 and -3.0 for the sample period.

Results from equation 24 indicate that a 1-percent change in the effective real exchange rate is accompanied by a mean response of -1 45 percent in the volume of U S feed grain exports over a 12-quarter time horizon Based on a standard deviation on the coefficient of 0 19, there is a 90-percent probability that the elasticity is between -1 1 and -1 8 Results from the zero lag exchange rate specification indicate a mean response of -1 28 percent with a 90-percent confidence interval between -1 00 and -1 56

The sign and magnitude of the coefficients in the exchange rate equations (20 and 26) and in the policy variable equations (21 and 27) conform to expectations the intercept terms are close to zero and the slope coefficients are close to 1 In the price equations (22 and 28), the coefficients on the real exchange rate variable are negative and the absolute values are less than 1, as expected The signs on the remaining coefficients in both equations are consistent with those in the export volume equations (19, 24, and 25)

The other variables specified in the equations affect grain exports as well The effect of changes in ROW income on wheat exports is significantly negative -1 99, with a standard deviation of 0 53 This result is the opposite of what was hypothesized Barring specification error, this result may indicate a trend toward import substitution during the sample period This result may also indicate increases in food aid when ROW income decreases However, when the target price is used as a proxy for domestic policy (equation 23), the sign on the income coefficient is indistinguishable from zero, and the sum of the exchange rate coefficients is close to the value in equation 19 This regression result suggests that the negative sign on the income coefficient may result from collinearity with the policy variable For feed grain exports, the effect of ROW income is significantly positive as expected 3 43, with a standard deviation of 0 23 [8]

As for the policy variable, the sum of the support-price coefficients equals 3 63 in the wheat volume equation (19) Recall, a higher support price is expected to reduce U S wheat exports However, a higher target price would be anticipated to increase U S wheat supply and thereby partially, fully, or more than offset the effect of the loan rate With the support-price variables incorporating the effect of target prices, the implication of the positive coefficient sign is that the contribution of the target price to export promotion is greater than the depressing effect of the support price In equation 23, the target price is included rather than the support price The lag-length selection criteria indicate 12 lags on the exchange rate, 12 lags on the target price, and zero lags on ROW income Findings indicate a significantly positive coefficient on the policy variable, although its value (2 18) is smaller The exchange rate elasticity is about the same for this specification the 90 percent confidence interval is between -1 70 and -2 86 [9] As mentioned previously, the ROW income coefficient cannot be distinguished from zero

For the feed grain equation, the sum of the support-price coefficents equals -1 99, with a standard deviation of 0 27 Therefore, support prices have reduced exports more than target prices have expanded them [10]

Response Time of Exports from Exchange Rate Changes

It is hard to determine when the exchange rate begins to affect grain export volume because of the high degree of collinearity within each exchange rate series When explanatory variables have linear associations, the estimates of their coefficients generally have large sampling errors The estimate of a single parameter may be far from its true value as a result For the exchange rate based on wheat competitors, it is not until the seventh lagged quarter that the correlation with the current value falls below 0 5 For the exchange rate based on feed grain competitors, it is not until the fifth lagged quarter that the correlation with the current value falls below 0 5

[8]These income coefficients should not be interpreted as import income elasticities As shown in equation 12, the coefficient represents the product of the import income elasticity and the U S export supply elasticity adjusted by the weighted sum of domestic and foreign net export elasticities Assuming a fairly elastic U S export response to price (which is consistent with the residual supplier hypothesis), the magnitudes of the income response in equations 19, 23, and 24 are not extreme

[9]We have also estimated the wheat equation including both support and target prices Pagano and Hartley's procedure indicates that adding one series, given the inclusion of the other, adds nothing to the regression Nonetheless, we include both series lagged 12 quarters The sum of both sets of policy coefficients is positive, but cannot be distinguished from zero The income coefficient is indistinguishable from zero as well The sum of the exchange rate coefficients, however, is significantly negative (2 16), with a 90-percent confidence interval of 1 10 to 3 22 Although these results support the exchange rate hypothesis, the specification is not justified on the basis of either the FPE or the Pagano and Hartley's criterion

[10]A complicating factor for 1981-83 crop years was that the support price for the Farmer-Owned Reserve (FOR) was somewhat higher than the Commodity Credit Corporation (CCC) loan rate For wheat, the higher support price was effective from 1980Q3 to 1983Q2 For corn, the higher support price was effective from 1980Q4 to1983Q3 We re-estimated the export volume equations incorporating the higher support price series In this modification, the support-price coefficient for wheat decreased to 2 88 from 3 63 while the support price coefficient for feed grains decreased in absolute terms to 1 53 from 1 99 In both equations, the sum of the exchange rate coefficients remained approximately the same For wheat, the sum equaled -2 40 (compared with 2 45), and for feed grains, the sum equaled 1 68 (compared with 1 45) The exchange rate effect is robust across these policy parameters

One way to treat a multicollinearity problem is to use nonsample information A commonly used method in lagged times series is placing a polynomial degree restriction on the impact of the variables within the series This specification assumes that the lag weights within series can be specified by a continuous function, which in turn can be approximated by the evaluation of a polynomial function at discrete points (7) The polynomial specification smooths the impact of the exchange rate change on export volume over the lag period, and the degrees of freedom are increased

We have used Pagano and Hartley's criterion to select the appropriate polynomial degree (6) Pagano and Hartley's criterion indicates a first-order polynomial specification for the exchange rate for wheat competitors and a second-order polynomial specification for the exchange rate for feed grain competitors Tables 1 and 2 show estimation results for the exchange rate coefficients for the wheat and feed grain equations For wheat, the negative correlation between exchange rate changes and export volume is not evident until the fifth and sixth quarters after the exchange rate change The effect becomes more negative and significant toward the end of the period For feed grains, the second-order polynomial specification emphasizes the immediate effect of the exchange rate on export volume The expected negative effect is strongest in the first year after the exchange rate change

Table 1—Effect of exchange rate changes on volume of U.S. wheat exports over time

Period	Change in wheat exports due to 1-percent change in exchange rate	Standard deviation
0	0 36	0 19
1	28	16
2	19	13
3	11	10
4	02	07
5	- 06	04
6	- 14	04
7	- 23	05
8	- 31	08
9	- 40	11
10	- 48	15
11	- 57	18
12	- 65	21

Table 2—Effect of exchange rate changes on volume of U.S. feed grain exports over time

Period	Change in wheat exports due to 1-percent change in exchange rate	Standard deviation
0	-0 36	0 12
1	- 42	07
2	- 25	04
3	- 12	04
4	01	05
5	06	06
6	10	06
7	11	05
8	08	04
9	02	05
10	- 07	08
11	- 19	13

Differing Sample Periods

The parameter estimates may be sensitive to the selection of the sample period We chose 1973-85 to correspond to the flexible exchange rate period and to incorporate the latest available data Other sample periods could have been used Table 3 compares 90-percent confidence interval estimates for the wheat and feed grain equations for the following sample periods 1973Q1-1985Q4 (the base), 1974Q1-1985Q1, 1973Q1-1984Q4, and 1973Q1-1983Q4

The primary effect of dropping the observations for 1973 is to widen the interval for the income and support-/target-price coefficients in the wheat equation Otherwise, the interval estimates are fairly close

Deleting observations for either 1985 or 1984 and 1985 produces more striking results Except for the income and support-price coefficients in the feed grain equation, the interval estimates become wider However, the interval in most cases for the base sample falls within the wider bounds of the reduced-size samples Therefore, the results from the base period cannot be rejected

The most important feature of including the 1985 observations is the narrowing of the confidence-interval estimates Although not shown, this narrowing is due to much lower standard errors on the various regression coefficients

Importer-Based Exchange Rate Measure

The importer exchange rate can be used as a proxy for changes in the value of the dollar instead of the competitor exchange rate Re-estimation of equations 19, 23, and 24 when em is used instead of ef follow

Table 3—Parameter interval estimates for differing sample periods[1]

Commodity	Variable coefficient	Sample period	Lower bound	Upper bound
Wheat	ef	1973Q1-1985Q4	–3 00	–1 90
		1974Q1-1985Q4	–3 48	–1 86
		1973Q1-1984Q4	–3 53	68
		1973Q1-1983Q4	–7 80	– 48
	y	1973Q1 1985Q4	–2 90	–1 08
		1974Q1-1985Q4	–2 25	1 25
		1973Q1-1984Q4	–3 14	1 52
		1973Q1-1983Q4	–6 29	33
	sp	1973Q1-1985Q4	2 40	4 86
		1974Q1-1985Q4	77	3 81
		1973Q1-1984Q4	44	4 62
		1973Q1-1983Q4	1 59	7 83
Wheat	ef	1973Q1-1985Q4	–3 10	–1 24
		1974Q1-1985Q4	–3 63	–1 37
		1973Q1-1984Q4	–1 70	1 02
		1973Q1-1983Q1	–6 72	1 86
	y	1973Q1-1985Q4	– 64	2 08
		1974Q1-1985Q4	– 64	7 22
		1973Q1-1984Q4	– 35	2 53
		1973Q1-1983Q4	–2 11	2 81
	tp	1973Q1-1985Q4	84	3 36
		1974Q1-1985Q4	–3 17	3 16
		1973Q1-1984Q4	27	2 63
		1973Q1-1983Q4	06	4 88
Feed grains	ef	1973Q1 1985Q4	–1 78	–1 12
		1974Q1 1985Q4	–1 92	–1 06
		1973Q1-1984Q4	–1 49	31
		1973Q1 1983Q4	–2 63	1 01
	y	1973Q1-1985Q4	3 04	3 82
		1974Q1-1985Q4	2 83	4 11
		1973Q1 1984Q4	2 58	3 72
		1973Q1-1983Q4	2 48	4 06
	sp	1973Q1-1985Q4	–2 45	–1 52
		1974Q1-1985Q4	–2 88	–1 18
		1973Q1 1984Q4	–2 46	–1 22
		1973Q1-1983Q4	–2 63	–1 19

[1]Reported at 90-percent confidence interval

Wheat

Export Volume

$$\ln Q^{A}_{t} = \underset{(10\ 88)}{53\ 22} - \underset{(0\ 13)}{0\ 37\ D1_t} - \underset{(0\ 12)}{0\ 95\ D2_t} - \underset{(0\ 11)}{0\ 11\ D3_t}$$

$$- \underset{(0\ 53)}{2\ 38\ \Sigma \ln em_{t\,i}} - \underset{(1\ 17)}{4\ 81 \ln y_t} + \underset{(0\ 56)}{2\ 05\ \Sigma \ln sp_{t\,i}} \qquad (29)$$

$R^2 = 0\ 804$
SE $= 0\ 18$
DW $= 1\ 29$

Export Volume (Using Target Price)

$$\ln Q^{A}_{t} = \underset{(7\ 59)}{25\ 47} - \underset{(0\ 11)}{0\ 30\ D1_t} - \underset{(0\ 10)}{0\ 85\ D2_t} - \underset{(0\ 11)}{0\ 24\ D3_t}$$

$$- \underset{(0\ 41)}{1\ 85\ \Sigma \ln ef_{t\,i}} - \underset{(0\ 88)}{1\ 68 \ln y_t} + \underset{(0\ 59)}{1\ 81\ \Sigma \ln tp_{t\,i}} \qquad (30)$$

$R^2 = 0\ 813$
SE $= 0\ 17$
DW $= 1\ 72$

Feed Grain

Export Volume

$$\ln Q^A_t = \underset{(5\ 07)}{-9\ 01} + \underset{(0\ 10)}{0\ 02}\ D1_t - \underset{(0\ 11)}{0\ 60}\ D2_t - \underset{(0\ 12)}{0\ 08}\ D3_t$$

$$- \underset{(0\ 27)}{1\ 22}\ \Sigma \ln em_{t-i} + \underset{(0\ 64)}{2\ 11} \ln y_t + \underset{(0\ 40)}{0\ 07}\ \Sigma \ln sp_{t-i} \quad (31)$$

R^2 = 0 813
SE = 0 14
DW = 1 92

Except for the feed grain support-price variable, the signs on the coefficients in equations 29, 30, and 31 are the same as those for equations 19, 23, and 24 The closeness of the corresponding exchange rate coefficients lends support to the earlier findings

Conclusions

We have examined changes in grain exports from 1973 to 1985 We introduced a three-country trade model as a framework for analyzing U S grain trade, world grain trade, and market price when there are changes in two real effective exchange rates (1) an exchange rate based on U S trade with grain importers and (2) an exchange rate based on global trade of grain competitors We considered the effects of changes in ROW real income and U S target and support prices The empirical analysis is based on reduced-form equations derived from the structural equations

The elasticity of U S wheat exports with respect to exchange rate changes is between 1 70 and 2 86 This result comes from equation 23 in which the target price is used as the proxy for domestic policy Other specifications give a similar exchange rate response All results, as well as those reported below for feed grains, depend on the inclusion of 1985 data Without 1985 data, the coefficient values have greater variance The range of confidence regarding the magnitude of the effects has to be wider Moreover, most of the evidence suggests that exchange rate changes affect wheat exports only over a long lag of 10-12 quarters

The elasticity of U S feed grain exports with respect to exchange rate changes is between -1 10 and -1 80 This result comes from equation 24 Alternative specifications (equations 25 and 31) give roughly the same result Feed grain estimates for all specifications are in line with theory These results include the strong positive effect of ROW income and the negative effect of the loan rate Finally, evidence suggests that most changes in the exchange rate affect exports within the first year of the change in the exchange rate

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