THE DEMAND AND SUPPLY OF U.S. AGRICULTURAL EXPORTS: THE CASE OF WHEAT, CORN, AND SOYBEANS

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Abstract

The demand for and supply of U.S. wheat, corn, and soybean exports is specified in a dynamic framework. Obtained results indicate differences in the export behavior of each product. U.S. corn exports are elastic, while U.S. soybean exports exhibit an inelastic response. For wheat, the derived elasticity of export demand had a positive sign. Hypothesis testing validated the dynamic structure of the estimated models in all markets. Stability properties were confirmed in export markets of corn and soybeans, but results were inconclusive for the wheat market. Adjustment coefficients indicate that exports and export prices do not adjust immediately to their equilibrium levels. Multiplier impacts indicate a stable path of convergence for all markets, with minimal impact of exogenous shocks on wheat and corn exports and export prices. Soybean export prices exhibit a significant response to changes in domestic export capacity, but minimal response to other exogenous shocks.

Key words: U.S. wheat, corn, soybean exports; export elasticities; market stability.

The 1980s have been characterized by the significant decline in U.S. agricultural exports. Their total value dropped from its peak of 43 billion dollars in 1981 to 26 billion dollars in 1986. The combined value of wheat, corn, and soybean exports dropped from 22 to 10 billion dollars during the same period (USDA, *Foreign Agricultural Trade of the United States*, Calendar Year Sup., 1982-86). Although the decline of these three products was not as drastic in volume terms (in 1986, wheat, corn, and soybeans still represented 70 percent of total U.S. exports compared to 75 percent in 1981), their share of the total value of U.S. farm exports declined from 50 percent to 38 percent.

This deterioration in U.S. agricultural trade performance has been attributed to several factors. Central among them was the increasing integration of U.S. agriculture into the domestic and international macroeconomies (Rausser; Freebairn et al.). U.S. fiscal and monetary policies, through their impact on interest rates and exchange rates, negatively affected U.S. competitiveness in agricultural markets (Rausser et al.; Orden). Domestic farm policies accentuated the problem since their rigid structure did not facilitate rapid adjustment to changing market conditions (Paarlberg et al.). In addition, and unlike the 1970s, the international trade environment further contributed to the decline in U.S. farm exports. This environment is characterized by slower growth rates in importing countries, the severe debt problem of developing nations that prompted efforts to improve their balance of trade, the transformation of many net importers into net exporters of agricultural commodities, and trade barriers resulting from protectionist agricultural policies in most developed countries (U.S. Congress, OTA). Interaction of these factors resulted in a combination of overproduction and sluggish world demand that had a further negative impact on U.S. agricultural exports.

As a consequence of these developments, the improvement in the export performance of U.S. agriculture became a central issue in the debate over the Food Security Act of 1985. The responsiveness of U.S. farm ex-

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ports to market conditions was linked to this issue since the selection of export enhancing policies depends on assumptions made by policy makers concerning the elasticities facing the demand for U.S. agricultural exports (Abbott). Thus, the potential impact of a decrease in the nonrecourse loan rate of a commodity depends on its export demand elasticity. Elastic export demand implies that export revenue will increase when export prices decrease, while the opposite is true for the inelastic export demand case. In addition, government intervention in agricultural markets will tend to insulate producers from fluctuations in world prices. Thus, the price transmission elasticity also becomes an important empirical issue in the estimation of export demand elasticities (Bredahl et al.).

Empirical estimates of price elasticities of export demand exhibit such wide variations that the selection of the optimal policy for U.S. exports becomes a difficult task. These variations are the result of differences in the methods of estimation, in the specification of the export demand equation or the structure of the models employed, and in the time period covered by the data on which estimation is based (Gardiner and Dixit). Often, empirical studies derive export demand elasticities by specifying an export demand equation for U.S. agricultural exports. Yet, single equation estimates of the price elasticities of demand and supply can be weighted averages of the "true" demand and supply elasticities and, as a result, biased downward (Orcutt). This bias will be eliminated only under the assumption that either the export supply elasticity is infinite or the demand function is stable while the supply function shifts around it (Goldstein and Khan, 1984).

If such an assumption cannot be made, there remain two options. The first is to solve the specified model for its reduced form and estimate the latter by ordinary least squares. This requires, however, that the model is just identified, a condition which is seldom met in empirical studies. Alternatively, one could estimate the model using simultaneous equation methods by explicitly incorporating export supply equations into export demand models (Goldstein and Khan, 1978; 1984). The present study applies the latter option in estimating the responsiveness of U.S. farm exports to changes in market conditions.

More specifically, the objectives of this analysis are: a) to estimate the price and income elasticities of demand and the price elasticity of supply for U.S. wheat, corn, and soybean exports; b) to evaluate dynamic properties of export demand and supply for these products; and c) to draw conclusions concerning the policy implications of the obtained results.

In the following section, the model utilized in this analysis is specified. Then, data and the estimation procedure are explained, and empirical results are discussed. The dynamic properties of the estimated models are assessed in the penultimate section, while the last section deals with conclusions and policy implications.

MODEL SPECIFICATION

Given the nature of agricultural production and the market structure of most traded agricultural products, it seems appropriate that a dynamic framework be adopted in the analysis of the simultaneous determination of the supply and demand for U.S. agricultural exports. The model described here is based on the assumption that agricultural markets adjust sluggishly to their equilibrium values. In order to render the model compatible with this assumption, a first-order adjustment process was adopted (Goldstein and Khan, 1978). Under this assumption, export quantities, X_t, adjust to the difference between demand for exports in period t and the actual flow of exports in period t-1, while export prices, PX_t, adjust to conditions of excess supply. In particular,

(1a) $D\ln X_t = \gamma (\ln X_t^d - \ln X_{t-1})$, and

(1b) $D\ln PX_t = \delta (\ln X_t - \ln X_t^s)$,

where X^d and X^s represent export demand and export supply, D is the difference operator, and γ and δ are adjustment coefficients.

The reader should notice here that the coefficients of adjustment γ and δ can take any positive value. This is so because (1a) and (1b) are differential equations (in a trivial sense), as opposed to difference equations, in which case the adjustment coefficients would be bounded by zero and unity.

In equation (1a), γ denotes the degree to which exported quantities respond to the difference between demand at period t and actual flow at the previous period. The coefficient δ of equation (1b) reflects the rate of response of export prices to conditions of excess supply. Stated otherwise, δ denotes the power to which the ratio of the desired to the actual supply of exports is raised if equation (1b) is written in its initial form, i.e., $(PX_t/PX_{t-1}) = (X_t/X_t^S)^{\delta})$. Note that if this ratio is less than one (indicating excess supply of exports), then export prices will decline. The opposite holds if this ratio exceeds unity, in which case prices will increase in response to the excess demand of exports.[1]

Demand for exports from an individual country is specified as a function of its relative export price and the real income of its trading partners and is given by the following double-logarithmic form:

$$(2)\ \ln X_t^d = a_0 + a_1 \ln(PX/PXW)_t + a_2 \ln YW_t.$$

X^d represents the quantity of exports demanded, PX is a real index of the country's export price, PXW a real trade weighted index of the average export prices of its competitors, and YW a trade weighted average index of the real income of the trading partners of this country. Due to the double-logarithmic form of equation (2), a_1 and a_2 are the relative price and real income elasticities.

Export supply, which is specified as a function of the real export price and the exporting capacity of the country in question, is given by

$$(3)\ \ln X_t^S = b_0 + b_1 \ln(PX/P)_t + b_2 \ln Y_t,$$

where X^S represents the quantity of exports supplied, P is the domestic price index, Y an index of domestic exporting capacity (production plus stocks), and parameter b_1 corresponds to the price elasticity of export supply. Normalization of (3) with respect to PX yields

$$(4)\ \ln PX_t = c_0 + c_1 \ln X_t^S + c_2 \ln Y_t + c_3 \ln P_t.$$

Setting $X^d = X^s$ and substituting (2) into (1a) and (4) into (1b) yields the following system of equations that needs to be empirically estimated:

$$(5a)\ \ln X_t = \alpha_0 + \alpha_1 \ln(PX/PXW)_t + \alpha_2 \ln YW_t + a_3 \ln X_{t-1}, \text{ and}$$

$$(5b)\ \ln PX_t = \beta_0 + \beta_1 \ln X_t + \beta_2 \ln P_t + \beta_3 \ln Y_t + \beta_4 \ln PX_{t-1}.$$

Elasticities and adjustment coefficients are recovered from the estimated structural parameters of (5a)-(5b). The relative price (a_1) and real income (a_2) elasticities of export demand are equal to $\alpha_1/(1-\alpha_3)$ and $\alpha_2/(1-\alpha_3)$, respectively. The price elasticity of export supply (b_1) is equal to $(1-\beta_4)/\beta_1$, while the coefficients of adjustment are found as $\gamma = 1-\alpha_3$ and $\delta = \beta_1/\beta_4$.

DATA AND ESTIMATION PROCEDURE

Annual data covering the 1966-85 calendar year period were used in the present study. Indexes of the volume of U.S. exports for wheat, corn, and soybeans, and of the level of production and stocks of these commodities (the variables X and Y of the estimated model) were constructed from unpublished U.S. Department of Agriculture data (USDA) and are available from the authors. U.S. export prices (PX) are U.S. Gulf prices, adjusted for domestic inflation, and were obtained from the *International Financial Statistics* of the International Monetary Fund (IMF) for wheat and corn and from the *Foreign Agricultural Circular: Oilseeds and Products* (USDA, FAS) for soybeans. The world export price index (PXW) was found by using the method described by Houthakker and Magee. Thus, $PXW = \sum_k \sigma_k PX_k$, where k corresponds to U.S. competitors and σ_k is the k^{th} share of total exports of the k^{th} exporter in world markets. In this study, U.S. competitors were Argentina, Australia, and Canada in wheat, Argentina and Thailand in corn, and Argentina and Brazil in soybeans.[2] Export prices for

[1]Since dynamic adjustment occurs in continuous time, equations (1a) and (1b) are approximations to a theoretical dynamic model expressed in continuous time as $(d/dt)\ln X(t) = \lambda[\ln X^d(t) - \ln X(t)]$, $\lambda > 0$. The discrete approximation of the above expression is $D\ln X_t = \lambda[M\ln X^d - M\ln X_t]$, where $M = 0.5\ (1 + L)$ and L is the lag-operator, $LX_t = X_{t-1}$ (Sargan).

[2]The European Community (EC) has become one of the major wheat exporters in recent years. However, since its domestic price is set at levels that are higher than world prices, its exports are heavily subsidized. Selecting an appropriate export price for the EC requires detailed data on the level of EC export subsidies that are generally not available. Furthermore, for most of the period on which estimates are based, the EC was a net importer of wheat, and its inclusion as a separate U.S. competitor would tend to ignore this fact. To account for these problems, it was assumed that the EC export price is incorporated in the average world price level (PXW). This is consistent with the EC practice of setting subsidy levels such that EC wheat sells at world price levels.

Argentina, Australia, and Canada for wheat, and Thailand for corn are available from IMF. Since export prices for Argentina in corn, and Brazil and Argentina in soybeans are not reported in IMF, per unit values of exports obtained from the *Trade Yearbook* (Food and Agriculture Organization) were used as export prices.

All prices are expressed in U.S. dollars, adjusted for exchange rate fluctuations and domestic inflation. Effective consumer price indexes for each exporting region were computed as CPE = $(CPI/100)/(ER_t/ER_0)$, where CPE is the effective consumer price index, CPI is the domestic consumer price index, and ER is the exchange rate of the local currency per U.S. dollar. Consumer price and exchange rate indexes for all countries and group of countries were constructed from data found in the *International Financial Statistics* (IMF).[3]

Real income indexes of U.S. importers were also constructed from IMF data. Since IMF reports real growth rates for the developed and the developing countries, the weights of these groups for each exported U.S. commodity, based on annual export data published in the *Commodity Trade Statistics* of the United Nations and the *Foreign Agricultural Trade of the United States* (USDA), were determined first. Then, these weights were used to obtain the weighted average world income growth rate facing U.S. exports.

To render the model estimable, a stochastic error term was additively appended to each

TABLE 1. STRUCTURAL EQUATION ESTIMATES OF U.S. EXPORT DEMAND AND SUPPLY MODELS FOR WHEAT, CORN, AND SOYBEANS (BASED ON 1966–85 ANNUAL DATA)

Variable	Wheat	Corn	Soybeans
Intercept	−0.517	−2.982	−0.172
	(−0.546)[a]	(−2.486)	(−0.321)
$(PX/PXW)_t$	0.436	−1.245	−0.389
	(0.657)	(−1.661)	(−1.668)
YW_t	0.648	1.323	0.710
	(2.153)	(3.023)	(2.213)
X_{t-1}	0.412	0.279	0.347
	(1.916)	(1.266)	(1.271)
Intercept	1.097	2.356	1.320
	(0.961)	(2.595)	(1.168)
X_t	1.268	0.554	1.603
	(4.797)	(3.084)	(1.856)
P_t	−0.379	−0.114	−0.374
	(−1.674)	(−0.503)	(−1.030)
Y_t	−0.602	−0.418	−1.320
	(−1.197)	(−1.912)	(−1.470)
PX_{t-1}	0.586	0.488	0.775
	(3.364)	(2.393)	(3.550)
h - statistic[b]			
demand equation	1.399	1.030	0.190
supply equation	0.263	1.035	0.274
System R^2	0.855	0.938	0.949

[a] Numbers in parentheses are t-statistics.

[b] The h-statistic, is calculated as, $h - \varrho\,[n/(1-nV(b))]^{1/2}$, where ϱ denotes the autocorrelation parameter, n the number of observations, and V(b) the variance of the lagged dependent variable of interest. When $nV(b) > 1$, which was the case for all supply equations and the soybean demand equation, an asymptotically equivalent statistic was utilized. Note that since the sample consists of 19 observations, the h-figures should be interpreted with caution. Details about the testing procedure can be found in Durbin and therein referenced material.

[3]The process of selection of an exchange rate measurement appropriate for agricultural trade raises important questions, especially in the case where countries with levels of domestic inflation like Argentina's and Brazil's are involved (Dutton and Grennes). As a result, constructing effective consumer price indexes will be an appropriate way of dealing with real exchange rate differences only under the assumption that the data on which these indexes were based are accurate. We chose IMF data as the best available for this purpose.

equation. It was assumed that the error terms possess classical statistical properties. Three Stage Least Squares (3SLS) was used to estimate the parameters of the model (5a)-(5b).

EMPIRICAL RESULTS

Export demand elasticities estimated in this study reflect not only economic conditions, but also the degree of government intervention in each market. Disaggregating the effects of these two sources of price response would require explicit estimation of the U.S. price transmission elasticities. Since our study is based on aggregate data for major U.S. competitors, treating explicitly the price transmission elasticity would also require the aggregation of policies for countries with different levels of government intervention, and such a task was not possible with the available data.[4]

Parameter estimates of the models estimated for U.S. exports of wheat, corn, and soybeans are reported in Table 1. Most of these parameters are statistically significant at reasonable significance levels. Dynamic simulation tends to confirm this conclusion since the fit of predicted to observed values for all three commodities was very high. Percent Root Mean Squared Errors (RMSE) ranged from 2.2% to 4.2% for export quantities and from 2.8% to 5.2% for export prices. Parameter signs are as expected, with the exception of the α_1 coefficient of the wheat equation and the β_2 coefficients of the export supply equations.[5]

Table 2 reports the price elasticities of export demand (ϵ) and export supply (η), income elasticities of export demand (θ), and coefficients of adjustment for exports (γ) and export prices (δ) that were recovered from the structural parameters of the model. Note that (ϵ) is a relative price elasticity, measuring the responsiveness of the demand for exports to changes in the ratio of domestic export prices to the export prices of major competitors, while (θ) measures the responsiveness of the demand for exports to changes in the real income of importers of U.S. farm exports. Finally, (η) measures the responsiveness of U.S. export supply to changes in real U.S. export prices.

The interpretation of the demand elasticity for U.S. wheat exports deserves special attention. One of the estimated coefficients on which the above elasticity is based is not statistically significant at generally accepted levels and has a positive sign. Since this elasticity is derived from a ratio of two estimated coefficients, the issue of its statistical significance is irrelevant, although confidence intervals for such elasticities can be constructed (Miller et al.). However, the positive sign of the export demand elasticity for wheat is certainly disturbing.

TABLE 2. ESTIMATED ELASTICITIES AND ADJUSTMENT COEFFICIENTS OF EXPORT DEMAND AND EXPORT SUPPLY FOR U.S. WHEAT, CORN, AND SOYBEAN MODELS (BASED ON 1966–85 ANNUAL DATA)

Elasticity	Wheat	Corn	Soybeans
ϵ	0.741	−1.727	−0.596
θ	1.102	1.835	1.087
η	0.326	0.924	0.140
γ	0.588	0.721	0.653
δ	2.164	1.135	2.068

ϵ = relative price elasticity of export demand.

θ = income elasticity of export demand.

η = price elasticity of export supply.

γ = adjustment coefficient of export demand to export flows.

δ = adjustment coefficient of export price to excess export supply.

[4]For the specific countries whose prices are used in the derivation of PXW, empirical evidence suggests a U.S. price transmission elasticity very close to one in the soybean market, in which the degree of government intervention is very limited (Meyers et al.). This is also true for the price transmission elasticity with respect to wheat prices of Canada and Australia, and corn prices of Thailand. For exporters used in this study, empirical evidence provided in Meyers et al. indicates that the U.S. price transmission elasticity with respect to the corn price of Argentina is the only one whose value is low (0.28). This confines any potential problems of our study to the importers' side. Although the impact of government policies on import behavior of major U.S. importers (EC, Japan) is significant, this impact has remained constant over most of the period covered in our study and, further, has been the same for the U.S. and its competitors.

[5]The inclusion of the EC as a competitor could result in findings that more accurately reflect actual market conditions. However, for reasons mentioned earlier, this did not prove possible in this study.

There are some possible explanations for these results. Price formation in wheat trade has been an area in which empirical analysis has failed to provide conclusive results, in spite of the application of a variety of competing models (Gilmour and Fawcett). This can be attributed to the oligopolistic structure of the world wheat market (Schmitz et al.; Sarris and Freebairn; Paarlberg and Abbott). Due to the market structure and to the strategic nature of the commodity, wheat import demand often includes non-price considerations on the part of importers (such as differentiation of the sources of imports and existing trade agreements) in addition to the search for the lowest price offer. Furthermore, export price changes of major exporters are not only linked to relative costs, but also to the price movements of competitors. Thus, the complexity of the interaction of wheat export price changes among major exporters would seem to indicate that the model applied in this study has its limitations given the market structure for wheat.[6]

The derived export demand elasticities for corn and soybeans do not contradict *a priori* expectations about their sign. They seem, however, to indicate differences in the response for U.S. exports of these products. Export demand for corn is elastic, with a value of −1.73 for the relative price elasticity, while soybean exports are demand inelastic, with the corresponding value of the export demand elasticity being −0.60. The value of the corn elasticity is higher than most values of estimated elasticities surveyed in Gardiner and Dixit (Table 3). However, as mentioned above, the estimated export demand elasticity of the present study is a relative price elasticity. It is not, therefore, directly comparable to the above mentioned estimates. The derived export demand elasticity for soybeans is within the range of results previously obtained. In fact, all reported estimates of this elasticity derived from simultaneous equation methods have values similar to or lower than the value derived in the present study.[7] On the other hand, OLS estimates were in all cases higher, thus resulting in the high "mean" value of this elasticity reported in Table 3.

The values of the income elasticities of export demand for wheat and soybeans were close to unity, while corn was income elastic with a value of 1.84 for the corresponding elasticity. Although export demand income elasticities are not generally available in empirical literature, income elasticities of import demand reported in Figueroa and Webb in 1986 indicate lower income response for wheat imports than corn imports in all estimated

TABLE 3. COMPARISON OF U.S. EXPORT DEMAND ELASTICITY ESTIMATES DERIVED FROM VARIOUS EMPIRICAL STUDIES[a]

	Wheat	Corn	Soybeans
Estimate of this study	0.74	−1.73	−0.60
Minimum value reported in Gardiner and Dixit	−0.15	−0.16	−0.14
Maximum value reported in Gardiner and Dixit	−3.13	−0.47	−2.00
"Mean" value reported in Gardiner and Dixit[b]	−0.60	−0.27	−0.96

[a] Elasticity estimates of this study are compared to export demand elasticities empirically estimated and reported in Gardiner and Dixit. Notice that the export demand elasticities derived in the present study are not directly comparable to the export demand elasticities reported in the above study. The export demand elasticity of the present study is a relative price elasticity, measuring the response of U.S. exports to changes in the ratio of the U.S. export price to the trade weighted export price of U.S. competitors.

[b] The "mean" value is the simple arithmetic mean of the reported export demand elasticities.

[6] Alternative specifications of the wheat equation that attempted to capture demand shifts in the post-1973 period and the impact of the 1974-1975 and 1980 embargoes on U.S. exports to the Soviet Union did not yield results that were qualitatively different from the ones reported in Table 1.

[7] In 1988, Davison and Arnade reported export demand and income elasticities for soybeans very similar to those derived in the present analysis (−0.52 and 1.02, respectively).

TABLE 4. RESULTS OF HYPOTHESIS TESTING FOR THE DYNAMIC STRUCTURE OF THE U.S. WHEAT, CORN, AND SOYBEAN EXPORT DEMAND AND SUPPLY MODELS

Model	Number of restrictions	Value of test statistic	Chi-square value[a]
Wheat	2	21.810	9.210
Corn	2	11.828	9.210
Soybeans	2	18.324	9.210

[a] At the .01 level of significance.

regions. Based on this information, results of the present analysis do not contradict *a priori* expectations. The same is true for the estimated income elasticity for soybeans. In this product, a low value for income elasticity can be expected given that most U.S. exports have as their major destination the developed world (mainly the EC and Japan).

U.S. export supply response for wheat and soybeans is inelastic. Corn export supply, on the other hand, is characterized by an elasticity value close to unity. A higher export supply elasticity for corn than soybeans should be expected, given the fact that stocks are very low in the latter product, and this expectation is confirmed by the obtained results. The magnitude of the soybean elasticity, however, indicates that U.S. soybean exports are mainly driven by changes in their export demand because export supply is very inelastic. In all three models, U.S. export supply is less elastic than export demand, thus indicating market stability. (The next section further elaborates upon this point by evaluating the stability properties of the estimated models.)

Estimated rates of adjustment for export quantities and export prices are also reported in Table 2. The coefficients of adjustment for exports are less than one, implying that exports do not adjust instantaneously and further justifying the dynamic structure of the model. For export prices, estimated adjustment coefficients (δ) exceed unity.

STABILITY PROPERTIES

Since one of the major assumptions of the present analysis was that export prices and quantities adjust sluggishly to their equilibrium levels, a detailed investigation of the dynamic properties of the models was deemed necessary. In particular, the dynamic structure of the empirical models was tested by employing the Chi-square testing procedure (Gallant and Jorgenson). The null hypothesis that immediate adjustment of export quantities and prices prevails in the export markets of the commodities in question was tested. The test was carried out by restricting the coefficients of the lagged endogenous variables (i.e., X_{t-1} and PX_{t-1} in [5a] and [5b], respectively) to equal zero. Calculated test statistics were found to be higher than their corresponding Chi-square values, thus indicating the rejection of the null hypothesis of immediate adjustment. Details about the test can be found in Table 4.

Further, stability conditions of the estimated models were evaluated by transforming the system (5a)-(5b) into state-space,

$$(6)\ Y_t = AY_{t-1} + BX,$$

where Y_t and Y_{t-1} are vectors of endogenous and lagged endogenous variables, respectively. In this system, X is a vector of exogenous variables, and A is the adjustment matrix, while B denotes the matrix of coefficients of exogenous variables. Information on the stability of each model can be derived by calculating the characteristic roots of the endogenous part of the structural model:

$$(7a)\ \ln X_t - \hat{\gamma}\hat{a}_1 \ln PX_t - (1 - \hat{\gamma})\ln X_{t-1} = 0,$$

and

$$(7b)\ \ln PX_t - [\hat{\delta}/(1 + \hat{\delta}\hat{\beta}_1)]\ln X_t - [1/(1 + \hat{\delta}\hat{\beta}_1)]\ln PX_{t-1} = 0,$$

where ^ denotes an estimated coefficient.

Calculated characteristic roots of each model and their respective moduli and damping periods are reported in Table 5. Note that sufficient conditions for stability require that the modulus of each characteristic root lies within the unit circle. Results indicate that corn and soybean exports exhibit stability. However, stability could not be confirmed for the export market of wheat, since the modulus of one of the characteristic roots exceeded unity (1.96). This result is attributed to the positive sign obtained for the α_1 parameter of the wheat export demand equation.

Finally, dynamic properties of estimated systems, more specifically the impact of exogenous shocks on the dynamic path of en-

TABLE 5. CALCULATED CHARACTERISTIC ROOTS, MODULI, AND DAMPING PERIODS OF ENDOGENOUS VARIABLES' ADJUSTMENT MATRICES FOR U.S. EXPORT DEMAND AND SUPPLY MODELS OF WHEAT, CORN, AND SOYBEANS

Model	Characteristic Root Real Part	Imaginary Part	Modulus	Damping Period
Wheat	0.276		0.276	3.622
	1.956		1.956	0.511
Corn	0.227	± 0.171i	0.284	3.519
Soybeans	0.346	± 0.215i	0.407	2.455

dogenous variables, were evaluated by measuring impact, interim, and total multipliers (Chow). Reported values of multipliers for the estimated models indicate that exogenous unit shocks in the wheat and corn markets result in endogenous variables converging after the first five periods, with the impact of these shocks being minimal in most cases (Table 6). Soybean export prices exhibit a slower rate of convergence and higher values of total multipliers than wheat and corn, but still exhibit a stable path of convergence. Ratios of total to interim multipliers, which indicate the immediate effect of an exogenous shock on an endogenous variable, are a little over 20 percent in all three models. Increases in world export prices of competitors (PXW) or in income of importers (YW) have a greater impact on U.S. export prices than on U.S. export quantities in all three models. The impact of domestic export capacity (Y) or domestic prices (P) on U.S. export prices of wheat or corn is minimal. Soybeans, on the other hand, indicate a significant response to changes in domestic export capacity, which is not surprising given that they are an intermediate product with domestic crushing an alternative to their export.

SUMMARY AND CONCLUSIONS

The responsiveness of U.S. exports of wheat, corn, and soybeans was estimated by incorporating the simultaneous interaction of their demand and supply. Results indicate that all three estimated models fitted the observed data for the 1966–85 period well. Further, these results exhibit important dif-

TABLE 6. ESTIMATED IMPACT, INTERIM, AND TOTAL MULTIPLIERS OF THE WHEAT, CORN, AND SOYBEAN MODELS

Lag in Years	Unit increase in PXW X	PX	Unit increase in YW X	PX	Unit increase in Y X	PX	Unit increase in P X	PX
Wheat								
0	0.1799	0.5525	0.2670	0.8200	0.0000	−0.3529	0.0000	−0.2222
5	0.0021	0.0692	0.0032	0.1027	0.0000	−0.0244	0.0000	−0.0154
10	0.0000	0.0052	0.0000	0.0077	0.0000	−0.0017	0.0000	−0.0011
15	0.0000	0.0004	0.0000	0.0005	0.0000	−0.0001	0.0000	−0.0001
19	0.0000	0.0000	0.0000	0.0000	0.0000	−0.0000	0.0000	−0.0000
Total	0.7425	2.2749	1.1020	3.3764	0.0000	−1.4550	0.0000	−0.9160
Corn								
0	−0.3470	−0.5286	0.3686	0.5615	0.0000	−0.2038	0.0000	−0.0554
5	−0.0006	−0.0212	0.0006	0.0225	0.0000	−0.0056	0.0000	−0.0015
10	−0.0000	−0.0006	0.0000	0.0006	0.0000	−0.0002	0.0000	−0.0000
15	−0.0000	−0.0000	0.0000	0.0000	0.0000	−0.0000	0.0000	−0.0000
19	−0.0000	−0.0000	0.0000	0.0000	0.0000	−0.0000	0.0000	−0.0000
Total	−1.7262	−1.8665	1.8337	1.9827	0.0000	−0.8157	0.0000	−0.2218
Soybeans								
0	−0.1349	−0.6993	0.2462	1.2759	0.0000	−1.0231	0.0000	−0.2897
5	−0.0007	−0.2434	0.0012	0.4441	0.0000	−0.2858	0.0000	−0.0809
10	−0.0000	−0.0682	0.0000	0.1245	0.0000	−0.0798	0.0000	−0.0226
15	−0.0000	−0.0191	0.0000	0.0348	0.0000	−0.0223	0.0000	−0.0063
19	−0.0000	−0.0089	0.0000	0.0162	0.0000	−0.0104	0.0000	−0.0029
Total	−0.5955	−4.2399	1.0865	7.7353	0.0000	−5.8644	0.0000	−1.6607

X = Exports, PX = Export Price, PXW = World Export Price, YW = Weighted Importers' Income, Y = Index of Export Capacity, and P = Domestic Price Index.

ferences in the export behavior of each commodity. Export demand was elastic for corn and inelastic for soybeans, while for wheat the derived elasticity of export demand had a positive sign. This problematic result of the wheat export demand can be attributed to the oligopolistic structure of the world wheat market, which has also hampered efforts to measure export demand response in previous empirical research. Income elasticities of export demand were close to unity for wheat and soybeans, while corn exhibited elastic response to income changes in importing regions. Export supply was elastic for wheat and soybeans and nearly unitary elastic for corn.

Hypothesis testing validated the dynamic structure of estimated models in all markets. Stability properties were confirmed in export markets of corn and soybeans, but stability results were inconclusive for the wheat market. Adjustment coefficients indicate that exports and export prices do not adjust immediately to their equilibrium levels. Multiplier impacts indicate a stable path of convergence for all markets, with a minimal impact of exogenous shocks on wheat and corn exports and export prices. Soybean export prices exhibit significant response to changes in domestic export capacity, but minimal response to other exogenous shocks.

Results of this analysis, obtained by empirically estimating within the same methodological framework export demand and supply models of three products with quite different market characteristics, suggest important policy conclusions concerning the appropriate export enhancing policy for these products. First, the different export price responsiveness of each product implies that the rather uniform decline of U.S. farm exports in the first half of the 1980s cannot be reversed with the use of uniform policies for each agricultural product.

Elastic price response for corn export demand indicates that lowering its loan rate would have a significant impact in increasing the volume and value of U.S. corn exports. This conclusion is consistent with recent trends in U.S. corn exports and provides a clear indication that the loan rate decreases implemented by the 1985 Farm Bill were in the right direction for this specific commodity. U.S. soybean export response, on the other hand, is not elastic. Consequently, a drop in U.S. soybean prices would result in decreasing export revenues, despite the increase in export volume. Recent trends in soybeans, however, indicate lower than normal levels of stocks and expectations for price increases. Thus, the inelastic price response of soybean exports could be expected to generate increased export revenues despite the increasing short-run trend in soybean prices.

The inconclusive results of the wheat model with respect to the U.S. price elasticity of export demand reflect the strategic behavior that characterizes major wheat exporters. As long as government interventions are widespread in agricultural trade, wheat can be expected to be among the commodities most affected by policies whose application implies that non-price considerations are an important determinant in wheat trade flows. In this respect, the escalating subsidy war between the U.S. and the EC in world wheat markets is an indication of the recognition of this reality by the two sides. Such a policy can certainly create short-run gains in export markets. However, in the long run the impact of the reliance on subsidization for increased exports for wheat can only be detrimental both for U.S. and EC budgets and for U.S.-EC agricultural trade relations.

Second, results indicate that export quantities and prices do not adjust instantaneously to their equilibrium levels. Although all three commodities exhibit a stable path of convergence, implied lags in their adjustment have important implications for policy decisions. If short-run considerations dominate in domestic farm income decisions, observed delays in the realization of farm policy objectives or the associated costs of adjustment may lead to policy reversals that could have been avoided if the lags in these adjustments had been explicitly recognized. Thus, there may not be an immediate adjustment to policy changes contained in the Food Security Act of 1985, but the effects in the export market may be evident before the expiration of the legislation.

Finally, estimation of models for U.S. competitors for the same products would provide better understanding of the complex interactions in export markets. Data limitation prevented the extension of this analysis to include behavior of U.S. competitors. However, the estimated models for U.S. wheat, corn, and soybean exports provide useful methodological conclusions that can be utilized in further trade policy research.

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