Competitiveness of U.S. Agricultural Exports: A Market Share Approach

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#6792

Abstract

Competitiveness of United States exports in the world agricultural market is analyzed through a simple market share model. The effect on market shares of relative prices and lagged market shares is estimated using logistic and standard normal functions. Imports of wheat, corn and soybeans into nine major national markets are considered. The effects of time and country aggregation are analyzed. The Soviet Union shows one of the most consistent patterns of price response for all products.

Key words: agricultural trade competitiveness; market share approach; wheat, corn and soybeans.

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I. Introduction

The responsiveness of demanders to export prices remains an important issue. During the period 1980-85 the decline in the U.S. share of world grain exports was often attributed to non-competitive prices brought about by price support programs and the rising value of the dollar. Recent discussions of the effect of the falling value of the dollar and the effect of export subsidies by the United States and the European Community are also related to price responsiveness.

A closely related issue is whether products (such as wheat) exported by different countries are perfect or imperfect substitutes. Spatial equilibrium models assume perfect substitution and models using Armington-type demand systems assume that products are imperfect substitutes. A commonly used empirical measure of substitutability is the elasticity of substitution (Blandford, Johnson). One possible reason for violations of the Law of One Price that have frequently been observed in the empirical literature is that products are differentiated or imperfect substitutes (Officer; Goodwin; Jabara and Schwartz).

The use of market share models (Sirhan and Johnson; Blandford) can also provide some insight into the product differentiation issue. An objective of this paper is to provide some information about the extent of product differentiation and lagged adjustment by importers in world markets for wheat, corn and soybeans. The presence of lagged adjustment could indicate some inertia in international markets due to non-profit motives by bureaucrats or adjustment costs faced by profit-motivated agents. Simple models are used to measure price responsiveness. Market share (MS) models are estimated with

logistic and standard normal equations for nine import markets taking into account the problems associated with inconsistent ordinary least squares estimation. In addition, the paper considers the sensitivity of results to time aggregation by comparing quarterly and annual results. The effects of country aggregation are also investigated by treating the European Community as a single unit and estimating separate effects for each of its member countries. A final question considered is whether countries with state trade, such as the Soviet Union and China, respond systematically to relative prices.

II. Theoretical Framework

The theoretical foundation of the MS model[1] is related to Telser's study of the demand for branded goods. He developed a probabilistic theory of demand in which consumers tend to switch purchases from brands whose prices have risen to brands whose price have fallen. The analogy of Telser's model to international trade is made under the presumption that the importing countries would transfer purchases from the exporting country whose prices have risen to those whose prices have fallen. This theory postulates the existence of transition probabilities, i.e., probabilities of moving from one import source to the other. It is assumed that the utility functions of consumers include qualities of commodities that are identifiable with their exporting countries, that is, the imported commodities are close but not perfect substitutes.

The probability a_{ij} that import purchases from export country i during period t-s, s = 1, 2, ... r are substituted for import purchases from export country j during period t is:[2]

$$(1)\quad a_{ij} = f_{ij}\,(P_{1t}, \ldots P_{it}, P_{jt}, \ldots P_{nt}; P_{1,t-1}, \ldots P_{n,t-1}; \ldots P_{1,t-r}, \ldots P_{n,t-r}).$$

The substitution away from importing goods from country i towards importing those from country j is a function of the price in country i (P_{it}), price in the competing country (P_{jt}), all the other prices from the remaining competing countries during time t and the lagged prices. An increase in the price of exports from country i, other prices unchanged, increases the probability of a transition of exports from country i to country j.

The probability of transition from country i to its competitor j increases and approaches one as the difference between the prices charged by these countries increases. In the context of the Rosett friction model, the transition probability a_{ij} is a limited-dependent variable not related to the independent variables over some finite range. This interval represents a possible friction in which the changes in P_i and P_j do not cause any shift in the probability of purchases from country i to country j because of product differentiation.

The behavior of the import market share is represented by a distributed lag model in which present imports depend probabilistically on past imports. Justification for using a distributed lag to model the import share is based on the belief that some inertia exists in international grain markets. The importance of lagged adjustment may depend on whether data is quarterly or annual.

The import market share of country i is a function of the import transition probability a_{ij} and the lagged import market shares $m_{i,t-s}$, with $s = 1, \ldots r$. As the difference between prices from countries i and j increases, the import transition probability a_{ij} increases and import market share from country i diminishes. If lagged adjustment by importers exists,

import market share of country i will be positively related to past import shares and the following equation is obtained:

(2) $m_{it} = b_{0i} + b_{11i}m_{i,t-1} + b_{12i}m_{i,t-2} + \ldots + b_{1ri}m_{i,t-r} + b_{2i}P_{it}$,

where: m_{it} = import market share of country i at time t;

$m_{i,t-1}$ = import market share of country i at time t-1;

$m_{i,t-2}$ = import market share of country i at time t-2;

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$m_{i,t-r}$ = import market share of country i at time t-r;

P_{it} = ratio of country i's import price from an export country relative to an average price from all the competing export countries.

Equation (2) says that the actual import share is a function of lagged import market shares and the relative current export prices. The assumptions underlying the estimation of equation (2) are: (i) The utility functions of importers include qualities of commodities that are identifiable with their exporting countries; (ii) The imported commodities are close but not perfect substitutes, so an increase in the price of the American product will not lead to its disappearance from the import market; (iii) If prices of an exporting country change, buyers will change their purchase but in a gradual rather than an instantaneous fashion; (iv) The supply of imports is perfectly elastic, meaning that the importing countries are small relative to their trading partners and therefore price is predetermined or exogenous.

III. Estimation Procedure

The use of market share models has been useful to analyze the competitiveness of American exports (Sirhan and Johnson; Blandford). Sirhan and Johnson developed a partial adjustment model to generate a reduced-form equation which expresses the import market share as a function of the lagged market share and relative prices. Market share equations were estimated by ordinary least squares. Blandford followed a similar procedure using either a linear or log linear functional form.

The logistic and standard normal functions are used here to generate empirical estimates of the market share approach. The logistic and standard normal functions are very close in the mid-range, but the logistic distribution has slightly heavier tails (Amemiya). Although they have been used frequently in cases where the dependent variable is binary and then referred to as logit and probit analysis, one need not confine their use to the binary variables. In practice, they can be used to estimate models with limited-dependent variables as well (Maddala). Being distribution functions, they are bounded between 0 and 1. Since import market share is clearly a limited dependent variable, whose range has a lowerbound of 0 and an upperbound of 1, the use of least squares would result in inefficient estimates and imprecise predictions (Judge).

Maximum likelihood estimates of both logistic and standard normal functions are to be obtained. The LIMDEP software (Greene) is used to estimate these equations.

The sources of data used are a quarterly data set for wheat and corn from 1970:1 to 1983:4 from Figueroa and an annual data set collected from various governmental publications for wheat, corn and soybeans from 1960 to 1985.

IV. Empirical Results and Comparison with Previous Estimates

The empirical results are presented in Tables 1 - 4. Equation (2) was estimated using logistic and standard normal functions considering only one lagged import market share.[3] With respect to the import price ratio, an arithmetic mean was used to account for the price from the competing countries.[4]

Logistic and standard normal estimation of equation (2) were performed imposing a zero-intercept constraint, since this restriction led to coefficient signs compatible with theory and with higher significance levels.[5]

Table 1 shows the estimated price responses for wheat and corn using the quarterly data set. The hypothesis that import market shares are inversely related to the relative import prices was confirmed in 41 out of 42 wheat equations, by looking at the negative price coefficients from the logistic estimation. Thirty-two equations out of 42 were significant at 0.05 or better level. The corn regressions generated a negative sign for the import price ratio in 24 out of 25 equations; 16 of these equations had extremely high significance levels (lower than 0.01) and 3 others had 0.07 or lower significance levels. In percentage terms, 96 percent of the wheat and corn equations presented the hypothesized sign and 76 percent of them were significant at 0.05 or better levels.

The other hypothesis under consideration is that the actual import share of an importing country is positively related to the past import share. Table 2 shows that the coefficient on the lagged import market share was positive in 33 out of 42 wheat equations that were estimated with a logistic model. From these equations, 13 were significant at a 0.15 or lower significance level. With respect to corn, 24 coefficients out of 25 had the hypothesized positive

value, although only 9 were significant at a 0.15 or lower significance level. In percentage terms, 78% of the wheat regressions and 96% of the corn regressions confirmed the hypothesized positive sign on the lagged import share coefficient, but only 31% and 36% were significant for wheat and corn respectively.

In the case of wheat, China, the Soviet Union, and Egypt showed a consistent and significant pattern of price response for all sources of imports. Lagged adjustment for wheat was found mainly for China, Egypt, and Taiwan. For corn, China and the USSR again showed a consistent price response for all exporting countries. Lagged market shares were most important for corn exported by the United States.

The standard normal results for wheat and corn turned out to be very similar to the logistic results. That was expected, since these distributions are very similar. It does not matter much whether the logistic or standard normal model is used, except in cases where the data are heavily concentrated in the tails due to the characteristics of the problem being studied (Amemiya).

Estimation of the market share model was also done with annual data for U.S. exports of corn, wheat and soybeans from 1960 to 1985, mainly to examine the sensitivity of results to the use of quarterly versus annual data. Table 3 presents the logistic and standard normal estimation of equation (2) subject to the zero-intercept restriction.[6]

The import markets are the European Community, Japan, and the USSR. Estimated results are shown treating the European Community as a single aggregate in addition to results for individual member countries. The hypothesized negative price coefficient was confirmed in all equations with the exception of Japanese imports of wheat and soybeans and Denmark imports of soybeans. The lagged

import share turned out to be positive in all equations, except the European Community's imports of wheat and Italy and United Kingdom's imports of wheat. The Soviet Union was very responsive to import prices in all markets, showing 0.04, 0.06 and 0.0009 significance levels for wheat, corn and soybeans, respectively. Belgium/Luxembourg, Germany, Italy and United Kingdom had significant (0.05) price responses in the wheat market. Price responses from Belgium/Luxembourg, France, Germany and Portugal were significant at 0.09 or lower in the corn markets. Thus, for wheat four out of seven EC member countries showed a significant price response even though the EC aggregate showed no significant price response. For corn four out of seven EC members showed a significant price response even though the EC aggregate showed none. Only Portugal had a significant price coefficient in the soybean market. These results may indicate how aggregating over countries may conceal the price responses of individual countries.

Portugal was the only importing country that presented a significant (0.1) lagged response for American wheat. With respect to American corn, most importing countries showed significant (0.05) lagged adjustment. In the case of American soybean exports, Belgium/ Luxembourg, Portugal and Spain had significant (0.1) lagged shares. Thus, lagged responses were significant for some EC countries and products even though they were not for the EC aggregate.

A comparison between quarterly and annual results for U.S. corn and wheat imported by the European Community, Japan and USSR is shown in Table 4. As can be seen, both annual and quarterly results (which are from different data sets) showed that the Soviet Union is consistently responsive to price changes for both corn and wheat. In general, the results do not show the same sensitivity

to time aggregation as found by Blandford.[7] The only difference is that the EC price response for wheat is significant using quarterly data but not for annual data.

V. Conclusion

Estimation of simple market share models for wheat and corn indicates that relative prices and lagged adjustment are important for most countries. The data provide some support for treating the products as imperfect substitutes. There are some differences between results using quarterly and annual data, but the differences are less dramatic than reported in earlier work. However, the results for the European Community suggest that country aggregation may be more important than time aggregation. This result may have practical significance since it is common in empirical work to use large regional aggregates such as Asia or Latin America. Finally, the consistent price responsiveness found in the Soviet Union and China may indicate that state traders are similar in some respects to private buyers.

Footnotes

1. A similar rationale for the model is provided by Case. Constant market-shares analysis is a different trade framework that mainly ascribes favorable or unfavorable export growth either to a country's export structure or to its competitiveness. See Leamer and Stern and Richardson for further references on this subject.

2. Other variables such as credit and political relations between the importing and exporting country may also affect the import transition probability.

3. Preliminary, logistic and standard normal estimations of the market share model incorporated more lagged import market share variables, but since none of the higher lagged coefficients were significant, they were not considered in the final version.

4. Some preliminary estimation used a weighted average, but the pattern of results were not sensitive to the index form. However, higher significance levels were obtained using an arithmetic average.

5. A Wald test was applied to see how costly it was to impose the intercept restriction. It turned out that only 3 of 67 wheat and corn equations rejected the null hypothesis of zero intercept at 0.05 significance level (Fontes).

6. Since the Wald test failed to reject the null hypothesis of zero intercept in all 32 equations at 0.05 significance level, the estimations reported are subject to the intercept constraint.

7. A comparison of the results of this paper with Blandford's quarterly and annual results is shown in the appendix.

Table 1. Estimated price responses for wheat and corn: Logistic and Standard Normal[a] procedures using quarterly data (1970:1 - 1983:4)

	Wheat exporters						Corn exporters			
Import markets	U.S.	Argentina	Australia	Canada	EC	ROW	U.S.	Argentina	EC	ROW
Egypt	-1.82**		-1.36**		-2.33**	-2.88**	0.23			-1.67**
	-1.11**		-0.84**		-1.35**	-1.65**	0.14			-1.00**
EC	-1.78**	-4.72**	-4.90**	-1.34	-0.66	-2.80**	-0.80	-2.82**	-0.75	-4.42**
	-1.06*	-2.34**	-2.58**	-0.81	-0.41	-1.61**	-0.50	-1.61**	-0.46	-2.44**
Japan	-0.15		-2.00**	-0.84		-3.79**	-0.15	-4.38**		-2.80**
	-0.09		-1.18**	-0.52		-2.08**	-0.04	-2.25**		-1.61**
China	-2.10**	-3.05**	-2.22**	-1.38**	-3.77**	-4.15**	-1.92**	-2.71**		-2.67**
	-1.24**	-1.65**	-1.33**	-0.86**	-1.93**	-2.28**	-1.12**	-1.54**		-1.55**
Korea	2.72		-3.99**			-2.81**	-0.35	-2.79**		-3.25**
	1.56		-2.13**			-1.62**	-2.20	-1.51**		-1.85**
Taiwan	-0.56		-3.01**	-3.18**		-2.24**	-1.41**	-3.45**		-0.94*
	-0.31		-1.70**	-1.68**		-1.31**	-0.87**	-1.91**		-0.58*
USSR	-1.68**	-2.61**	-3.14**	-1.34**	-4.04**	-1.56**	-1.30**	-2.00**	-2.24**	-0.00**
	-1.02**	-1.64**	-1.79**	-0.81**	-2.08**	-0.94**	-0.80**	-1.20**	-1.19**	-1.33**
ROW	-0.23	-2.98**	-2.15**	-1.64**	-10.06**	-1.96**				
	-0.14	-1.64**	-1.23**	-0.96**	-5.57**	-1.14**				
Mexico	-0.57			-3.32**		-2.08**	-0.05	-3.74**		-1.71**
	-0.36			-1.17**		-1.23**	-0.04	-1.98**		-1.04**

**0.05 significance level
*0.1 significance level

[a]The second set of numbers in each import market refers to the standard normal estimation.

Table 2. Estimated lagged quantity responses for wheat and corn: Logistic and Standard Normal[a] procedures using quarterly data (1970:1 - 1983:4)

	Wheat exporters						Corn exporters			
Import markets	U.S.	Argentina	Australia	Canada	EC	ROW	U.S.	Argentina	EC	ROW
Egypt	2.75**		-2.40*		4.04**	-0.28	1.28			0.53
	1.69**		1.48**		2.32**	-0.18	0.77			0.29
EC	-0.08	30.16	13.90	0.48	1.68	-1.17	1.68	5.68	1.12	-4.76
	-0.06	12.11	7.16	0.26	1.05	-0.61	1.05	3.09	0.67	-2.09
Japan	0.68		2.01	-0.58		-5.58	2.56	10.80		3.28
	0.43		1.12	-0.35		-2.58	1.44	5.10		1.79
China	3.20**	4.69	2.89*	2.90**	18.55	3.75	3.94**	3.46**		1.38
	1.89**	-0.04	1.74*	1.81**	8.24	1.86	2.32**	2.01**		0.75
Korea	-0.74		1.44			-3.07	2.54**	3.22		3.06
	-0.40		0.72			-1.54	1.49**	1.59		1.68
Taiwan	2.18*		2.40	4.22		2.29*	2.96**	3.02		1.61
	1.28*		1.29	1.73		1.30*	1.82**	1.69		1.00
USSR	2.67**	1.34	4.77	1.69	15.32	1.52	2.65**	1.50	0.49	1.02
	1.62**	0.73	2.61	1.01	6.69	0.88	1.62**	0.92	0.25	0.89
ROW	0.77	3.68	2.82	1.47	1.13	-0.87				
	0.48	1.82	1.41	0.75	0.34	-0.43				
Mexico	1.71**			5.16		1.51	1.35	8.45**		1.24
	1.05**			2.58		0.85	0.84	4.52**		0.75

**0.05 significance level
*0.1 significance level

[a]The second set of numbers in each import market refers to the standard normal estimation.

Table 3. Estimated price and lagged quantity responses for wheat, corn and soybeans imported from U.S.: Logistic and Standard Normal[a] procedures using annual data (1960 - 1985)

	Price responses			Lagged quantity responses		
Import markets	Wheat	Corn	Soybeans	Wheat	Corn	Soybeans
EC	-1.32	-1.22	-0.57	-1.02	2.55	2.47
	-0.81	-0.76	-0.33	-0.56	1.59	1.48
Belg/Lux	-2.36**	-2.02*	-1.17	2.66	4.13**	3.23**
	-1.40**	-1.20*	-0.70	1.61	2.46**	1.97**
France	-1.66	-2.40**	-0.71	2.17	1.42	1.98
	-1.01	-1.41**	-0.44	1.30	0.84	1.22
Germany	-2.17**	-2.23*	-0.58	1.99	4.30**	1.28
	-1.28**	-1.36*	-0.36	1.12	2.61**	0.60
Italy	-1.67*	-1.40	-0.91	-0.05	2.32	2.70
	-0.99*	-0.86	-0.53	-0.07	1.43	1.61
Netherlands	-1.15	-2.19		1.81	4.53**	
	-0.70	-1.29		1.11	2.67**	
Portugal	-1.11	-2.22**	-1.60**	2.81*	4.62**	3.66**
	-0.66	-1.32**	-0.98**	1.70*	2.74**	2.19**
U. Kingdom	-1.98**	-1.32	-0.44	-0.42	2.43	1.07
	-1.18**	-0.82	-0.27	-0.13	1.51	0.66
Spain		-1.34	-0.72		2.74*	2.52*
		-0.82	-0.45		1.67*	1.54
Denmark			0.14			1.62
			0.08			0.98
Japan	0.05	-0.86	0.49	0.21	2.65	1.46
	0.03	-0.52	0.26	0.13	1.62	0.91
USSR	-2.61**	-2.12**	-3.07**	4.52*	4.15**	5.64
	-1.54**	-1.29**	-1.74**	2.65*	2.50**	3.15

**0.05 significance level
*0.1 significance level

The second set of numbers in each import market refers to the standard normal estimation.

Table 4. Quarterly vs. annual comparison for corn and wheat imported from U.S.[b]

Import markets	Quarterly data: 1970:2 - 1983:4		Annual data: 1960-1985	
	P response	Lagged Q response	P response	Lagged Q response
		CORN		
EC	-0.80	1.68	-1.22	2.55
Japan	-0.15	2.56	-0.86	2.65
USSR	-1.29**	2.65**	-2.12**	4.14**
		WHEAT		
EC	-1.78*	-0.18	-1.32	-1.02
Japan	-0.15	0.68	0.05	0.21
USSR	-1.68**	2.67**	-2.61**	4.52*

**0.05 significance level
*0.1 significance level

[b]The comparison is related to the logistic estimation

Appendix Table 1. Price and lagged share responsiveness in market share model using quarterly data (1970:1-1983:4): a comparison with Blandford's results

Price responsiveness

Commodity	Blandford	Fontes et al
Wheat	USSR	USSR
	Egypt	Egypt
	Mexico	China
	Korea	
	Taiwan	
	Japan	
Corn	Egypt	China
	Japan	USSR
	Mexico	Taiwan

Sources: Blandford, Tables 1 and 2

Lagged share responsiveness

Commodity	Blandford	Fontes et al
Wheat	China	China
	Egypt	Egypt
	Taiwan	Taiwan
	Mexico	Mexico
	USSR	USSR
Corn	China	China
	Korea	Korea
	Taiwan	Taiwan
	USSR	USSR
	Mexico	Mexico

Sources: Blandford, Tables 1 and 2

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