A Reexamination of the U.S. Export Demand for Soybeans and Soybean Products

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Abstract: *This paper addresses the question of whether the export demand for soybeans and soybean products changed structurally over the 1950 to 1992 period as the U.S. agricultural sector became more integrated with the rest of the world economy. The results suggest that export demands were stable for soybeans, soybean meal and soybean oil over the sample period. Moreover, it is possible to infer conclusively that the long-run soybean and soybean product export price elasticities were in the elastic range. The implications include that for each one percent reduction in the price of soybeans, soybean meal and/or soybean oil brought about through a government program, exports increased by more than one percent, leading to a reduction in the variability of soybean and soybean product prices and sales and an increase in the net farm income of soybean producers.*

Key Words and Phrases: *Export demand, Export price elasticities, Soybeans, Soybean meal, Soybean oil.*

For more than half a century, U.S. agriculture has been considered a model of technical efficiency and productivity growth and, at the same time, an economically depressed sector. The economic difficulties have been identified as "the farm problem." One solution to the farm problem, and the one currently employed, is government intervention in the agricultural sector.

Among the programs that have been implemented as a result of this intervention are several targeting export markets (Ackerman and Smith). The programs have generally been aimed at expanding export markets by providing export price subsidies necessitated either to counter the effects of domestic agricultural policies that support prices above competitors' prices or to counter the effects of competitors who subsidize their exports.

How effective are these export programs in reaching the desired goal of enhancing exports which, in turn, ostensibly increase both the price received by the farmer as well as sales, thereby expanding net farm income? An understanding of this issue requires an understanding of the factors driving the export demand (Bickerton and Glauber; Schaub *et al.*).

This, in turn, requires an empirical estimation of the relationship between exports and the factors influencing these exports (Gardner, 1992). This is the subject of what follows. While much of the discussion is general, in order to reduce the number of issues specific to individual commodities to manageable proportions, only soybeans and soybean products will be studied.[1]

Central to an understanding of the government's effectiveness in dealing with the farm problem through export markets is the question of the price elasticity of export demand for the various agricultural commodities produced in the United States (Gardner, 1987; Shane and Witzke). If, for example, the export demand is price elastic, then any increase in the price, all other things remaining unchanged, will lead to a reduction in the quantity exported, a reduction in the net revenue, and an increase in the subsidy. Alternatively, if the export demand is price inelastic then a reduction in the quantity exported will lead, *ceteris paribus*, to a rise in net farm income (Abbott).

Added to the concern about the relative magnitude of export price elasticities is the contention that the elasticities have been changing over time. Thus, for example, it has been argued that "As exports have grown (in both an absolute and a relative sense), total demand for American agricultural products has become more price responsive" (Council of Economic Advisors, p. 140). This is so because the U.S. agricultural sector has become significantly more interdependent with the world economy than it was, say, prior to 1970 (Schuh; Uri *et al.*, 1993b).

A primary concern, then, is whether the export demand is price elastic or inelastic and whether the elasticity has changed over time. It is not the objective here to develop a new functional specification for export demand nor present a different approach to estimation. Rather, what shall be done is to use an existing export demand specification in conjunction with the most recently available data and investigate the structural stability of the estimated relationships.

Export Demand Specification

The export demand specification used in this study will be a partial equilibrium specification following closely, but not perfectly, the model developed by Chambers, and Chambers and Just. Export demand is expressed in terms of the demand and supply by importing and exporting countries with the result that export demand is based on excess demand.

The general export demand relationship used by Chambers and Just is

$$EX_t = f(EX_{t-1}, \mathbf{P}_t, ER_t, Q_t, Y_t, \varepsilon_t) \quad (1)$$

where EX denotes the quantity demanded for export, **P** denotes a vector of real prices of the commodity and its substitutes, ER denotes the exchange rate variable, Q denotes non-U.S. production, prices, and/or stocks of the agricultural commodity, Y_t denotes the income of the importing country, ε denotes the stochastic term, and t denotes the time period.

One departure from the Chambers and Just specification concerns the exchange rate variable. They use a weighted average exchange rate measure across all currencies relative to the dollar. However, it is what happens to the exchange rate of the dollar relative to the currencies of other potential importing and exporting countries that is of relevance (Bessler and Babula). For this reason, the exchange rate variable used must be commodity specific and not the aggregate measure of Chambers and Just (Heien and Pick; Sarwar and Anderson).

Soybeans. The soybean export demand equation is specified such that the quantity of soybeans exported (EXB) is a function of the quantity of soybeans exported in the previous period (EXB_{t-1})[2], the U.S. price of soybeans (PB), the U.S. price of corn (PC), the non-United States exports of soybeans (EXPORTB), the income of importing countries (GDP), and the exchange rate applicable to soybeans (ERS).

Prior expectations suggest that soybean export demand should be positively related to exports in the previous period, positively related to the price of corn, a frequent substitute for soybeans (Office of Technology Assessment), and the level of national income in importing countries.[3] This demand should be inversely related to the price of soybeans (due to substitution effects), the exports of soybeans by other exporting countries, and the exchange rate (Kumar and Whitt).

The annual data on soybean exports from the United States in bushels were obtained from the U.S. Department of Agriculture's Economic Research Service (USDA ERS) *Fats and Oils Situation and Outlook Report* (now the *Oils Crops Situation and Outlook Report*) and cover the period 1950 through 1992. The price of soybeans is the No. 1 yellow soybean price at Chicago and the data are from the USDA ERS *Fats and Oils Situation and Outlook Report.*[4] The price of corn is the No. 3 yellow corn price at Chicago in dollars per bushel and was taken from the USDA ERS *Feed Situation and Outlook Report.* Both of the prices are in real terms, being deflated by the Gross Domestic Product Implicit Price Deflator (1987=100). Non-U.S. exports of soybeans in metric tons come from the *Trade Yearbook* of the United Nations' Food and Agriculture Organization and the income variable is measured as the real gross domestic product (GDP) of Organization for Economic Cooperation and Development (OECD) countries (exclusive of U.S. GDP) and were taken from *OECD*

Annual Statistics. The exchange rate variable is a real trade weighted rate (1985=100) for the soybean export market as compiled by the U.S. Department of Agriculture's Economic Research Service (Duncan).

Soybean Meal. The soybean meal export demand relationship is analogous to that of the soybean export demand equation with three modifications. Soybean meal exports (EXM) are used in place of soybean exports, the price of soybean meal (PM) replaces the price of soybeans, and the non-U.S. exports of soybean meal (EXPORTM) is substituted for the non-U.S. exports of soybeans. The annual data on soybean meal exports from the United States in short tons were obtained from the USDA ERS *Fats and Oils Situation and Outlook Report*. The price of soybean meal series is the average wholesale price at Decatur for a 44 percent protein content and is from the USDA ERS *Fats and Oils Situation and Outlook Report*. Non-U.S. exports of soybean meal in metric tons come from the *Trade Yearbook* of the United Nations' Food and Agriculture Organization. It is anticipated that there will be an inverse relationship between the price of soybean meal and soybean meal exports and between non-U.S. exports of soybean meal and U.S. exports due to substitution effects. The U.S. price of corn is retained in the specification because corn is a substitute livestock feed in most areas (Meyers and Hacklander).

Soybean Oil. The soybean oil export demand relationship is similar to that of the soybean export demand equation with a few exceptions. Soybean oil exports (EXO) are used in place of soybean exports, the price of soybean oil (PO) replaces the price of soybeans, and the non-U.S. exports of soybean oil (EXPORTO) is substituted for the non-U.S. exports of soybeans. The annual data on soybean oil exports from the United States in pounds were obtained from the USDA ERS *Fats and Oils Situation and Outlook Report*. The price of soybean oil is the average wholesale price of crude soybean oil at Decatur and the series is from the USDA ERS *Fats and Oils Situation and Outlook Report*. Non-U.S. exports of soybean meal in metric tons come from the *Trade Yearbook* of the United Nations' Food and Agriculture Organization. It is anticipated that there will be a negative relationship between the price of soybean oil and soybean oil exports and between non-U.S. exports of soybean oil and U.S. exports due to substitution effects.

A weighted average price for oils other than soybean oil (PA) was used in place of the U.S. price of corn found in the export demand specifications for soybeans and soybean meal. These other oils are often substitutes for soybean oil (McCormick, Davison and Hoskin). The series was computed from data found in the USDA ERS *Fats and Oils Situation and Outlook Report*.

Note that the sample period in the estimation covers 1950 to 1992, different from the 1969 to 1977 sample period used by Chambers and Just. By extending the sample period into the 1990s, it is anticipated that the effects of the dynamics of the soybean and soybean product markets, such as the growing international interdependence in agriculture in the 1980s, will be better revealed.

A Few Caveats

Before presenting the estimation results for the models developed here, several issues need to be addressed. First, in the model formulations for soybeans, soybean meal and soybean oil, dynamic specifications are used whereby the quantity exported is a function of the quantity exported in the previous period and a set of other explanatory variables. An important question is whether these specifications are supportable based on the data. Additionally, an additive specification is hypothesized. Is there any reason to prefer this specification over another? Concerning the issue of whether there is a dynamic adjustment, this was examined by defining the null hypothesis to be the specification where there is no lagged export demand variable and the alternative to be the specification where there is a one period lag. The results of a zero restriction test (a conventional F test) strongly suggest that a model specification incorporating a lag of one period[5] between the current period export demand and previous period export demand is appropriate for soybeans, soybean meal and soybean oil.[6] This means that importing countries in the aggregate do not completely adjust their consumption of soybeans, soybean meal, and soybean oil within the current period to changes in the prices of soybeans and soybean products, the prices of substitutes, the level of the gross domestic product, and the exchange rate.

Next, the null hypothesis that the appropriate specification is a linear one versus a linear-in-logarithms was investigated. This issue was examined using a statistical test suggested by Davidson and MacKinnon. The test indicated that for soybeans, soybean meal, and soybean oil, the null hypothesis could not be accepted.[7] The process was reversed whereby the null hypothesis was that the appropriate specification is a linear-in-logarithms versus an alternative hypothesis of a linear specification.[8] In this instance, the null hypothesis could not be rejected. Consequently, the linear-in-logarithms specification was used in the estimation for the export demand relationships.

A second factor warranting consideration concerns whether there is an identifiable substitution of other agricultural commodities for soybeans, soybean meal and soybean oil. To investigate this, a test for directional causality was used (Geweke). To determine whether changes in the prices of substitutes impacted the export demand for soybeans, soybean meal and soybean oil, the current period export quantity of soybeans (soybean meal, soybean oil) was regressed on eight lagged values of soybean (soybean meal, soybean oil) exports (corresponding to exports in eight previous periods). This gave the restricted estimates used in performing the causality test. Subsequently, current period exports of soybeans (soybean meal, soybean oil) was regressed on eight lagged values of soybean (soybean meal, soybean oil) exports and six lagged values of the price of the substitute agricultural commodity. This gave the unrestricted estimates. For the soybean export demand equation, the computed value of the relevant partial F-statistic was 8.70; for the soybean meal export demand equation, the computed value was 6.96; and for the soybean oil export demand equation, the computed value was 7.75. The critical value at the 5 percent level is $F_{(8, 29)} = 2.28$. Hence, it is possible to identify from the data the substitution of other agricultural commodities for soybeans, soybean meal and soybean oil separately.

Close examination of the substitutability issue is important because there is a relatively high degree of collinearity between the price of soybeans and the price of corn, between the price of soybean meal and the price of corn, and between the price of soybean oil and the price of other oils. Over the 1950 to 1992 period, the correlation between the price of soybeans and the price of corn is 0.78. For the price of soybean meal and the price of corn it is 0.75, and between the price of soybean oil and the price of other oils it is 0.83. Also, the variance-decomposition proportions (Belsley, Kuh and Welsch) between each of the paired combinations are greater than 0.70, indicating a collinearity problem. The high degree of collinearity is probably one reason why statistically significant coefficient estimates are not obtained for the price of the substitute product variables even though the causality test indicates that substitution does take place in the export markets for soybeans, soybean meal and soybean oil.

Testing for Structural Stability

Given the changing interrelationship between U.S. agriculture and the world economy over the period of study, an important issue is whether the increased interdependence noted by Schuh has affected the U.S. export demand for soybeans and soybean products. A number of events during the sample period potentially served to alter the underlying nature of the export demand for U.S. soybeans and soybean products. For example, the 1970s saw the emergence of Brazil and Argentina as exporters of soybeans and soybean products. Thus, Brazil, which had minimal soybean exports in 1970, accounted for nearly 17 percent of total world exports in 1992, while Argentina, which had no soybean exports before 1975, accounted for almost 5 percent of total world exports in 1992 (Crowder and Davison; U.S. Department of Agriculture, July, 1993). Comparable values are observed for soybean meal and soybean oil. These export gains have been almost completely at the expense of U.S. soybean exports since, between 1981 and 1991, total world exports of soybeans remained virtually unchanged (U.S. Department of Agriculture, July, 1993).[9]

Another factor potentially serving to affect the export demand for U.S. soybeans and soybean products is the expansion in the agricultural support mechanism of the European Community (EC). Between 1984 and 1988, EC budget expenditures for the oilseed sector (including soybeans) more than tripled. Producer incentives for growing oilseeds increased further because of a decline in the support prices for grains relative to oilseeds. Producers in the EC have increased soybean output at an average annual rate of 18 percent over the past ten years (Bickerton and Glauber; U.S. Department of Agriculture, August 1993).

Yet another factor potentially affecting the export demand for soybeans and soybean products was the change from a fixed exchange rate to a floating exchange rate during the sample period. In July, 1944, at Bretton Woods, New Hampshire, the major industrial countries established the International Monetary Fund (IMF) whose main responsibility, as detailed in the Articles of Agreement at that time, was to oversee and administer a dollar-based, fixed exchange rate system (Grennes). This system prevailed until 1973 when substantial inflation in the United States and an uneasiness concerning the apparent disequilibrium levels of prevailing exchange rates resulted in its abandonment (Yeager).

To analyze the issue of whether there have been structural changes in the underlying export demand relationships, the stability of these relationships must be studied. Stability is defined here in the statistical sense of the estimated coefficients on the explanatory variables remaining constant over time. A method of determining whether a regression relationship is constant over a given time period has been developed by Brown, Durbin and Evans.[10] The results of the Brown, Durbin and Evans test suggest that for the estimated export demand equations, the underlying structural relationships did not significantly change over the period 1950 through 1992 (complete details available from the authors). For soybean meal exports, the structural relationship came close to destabilizing in the late 1960s and early 1970 but did not.

The implications of these results suggest that events over the past three decades have left virtually unchanged the magnitude of the impact that variations in such things as agricultural commodity prices, exchange rates and national income have had on the quantities of soybeans, soybean meal and soybean oil exported from the United States. Consequently, for example, changing from a fixed exchange rate to a flexible exchange rate regime did not alter the quantitative effect that exchange rates have on the export demand for soybeans, soybean meal and soybean oil.

Empirical Estimates

The export demand relationships for soybeans, soybean meal and soybean oil were fit to the time series data previously discussed. An iterative, seemingly unrelated, regression approach involving all three export demand relationships was used to obtain the estimates (Judge *et al.*). This was the approach selected in order to achieve any gain in estimate efficiency possible through the coincident use of the residuals from the empirical relationships. Also, a term was included to capture first order serial correlation which was present. A test of the residuals for higher order serial correlation indicated that none was present. An instrumental variable was used for the lagged dependent variable (Bowden and Turkington).

The coefficient estimates of the export demand equations for soybeans, soybean meal and soybean oil are reported in Table 1. The values in parentheses below the coefficient estimates are the standard errors of the estimates. The signs on the estimated relationships are, for the most part, consistent with *a priori* expectations and most of the variables included in the functional specifications are statistically significant. Thus, for example, soybean exports are negatively related to the price of soybeans, the exports of soybeans by other countries, and the exchange rate applicable to soybeans and directly related to soybean exports in the previous period and the gross domestic product of importing countries. The statistically significant (at the 5 percent level) relationship between the price of corn and soybean exports was not found. As noted previously, this is probably due to the collinearity between the price of soybeans and the price of corn. For the soybean meal export demand equation, all of the explanatory factors, with the exception of the price of corn, are statistically significantly different from zero. In the soybean oil export demand equation, not only is the price of other oils not statistically significant, but the exchange rate likewise is not statistically significantly different from zero at the 5 percent level. This is probably because export programs affecting soybeans typically target soybean oil to the exclusion of soybeans and soybean meal so any exchange rate effects are obfuscated by government programs.

Table 1.
Estimates of Export Demand for Soybean, Soybean Meal, and Soybean Oil

Variable	Soybean (EXB)	Soybean Meal (EXM)	Soybean Oil (EXO)
Intercept	4.352	1.165	1.201
	(1.659)[a]	(0.511)	(0.569)
Lagged Export Demand	0.698	0.731	0.729
(EXB_{t-1}, EXM_{t-1}, or EXO_{t-1})	(0.054)	(0.053)	(0.065)
Own Price	-0.410	-0.392	-0.352
(PB, PM, or PO)	(0.125)	(0.133)	(0.157)
Corn Price (PC)	0.049	0.038	
	(0.067)	(0.057)	
Weighted Average Price of			-0.055
Non-Soybean Oils (PA)			(0.047)
Non-U.S. Soybean	-0.344		
Exports (EXPORTB)	(0.095)		
Non-U.S. Soybean Meal		-0.327	
Exports (EXPORTM)		(0.085)	
Non-U.S. Soybean Oil			-0.322
Exports (EXPORTO)			(0.094)
Income of Importing	0.309	0.334	0.381
Countries (GDP)	(0.051)	(0.054)	(0.059)
Exchange Rate (ERS)	-0.136	-0.130	0.037
	(0.062)	(0.057)	(0.082)
R^2	0.966	0.937	0.835
Durbin h-statistic	0.955	0.907	1.376
Standard Error of Regression	1.629	1.002	1.352

[a]Standard Errors of the Estimates in Parentheses.

The fit of the data to the equations measured by the coefficient of determination is relatively high which is not surprising since time series data are used in the estimation and these data possess significant trends.

The Durbin h-statistic indicates the absence of first order serial correlation for each of the equations (Johnston).

There is a wide variety of inferences that can be drawn from the estimation results. For the considerations at hand, however, the discussion is centered on whether the price elasticities of export demand are in the elastic region of the export demand function.

The long-run elasticity from a first order distributed lag specification used in this study can be calculated as (1/(1 - a)) times the short-run elasticity where a is the estimated coefficient on the lagged dependent variable. Table 2 presents the estimated long-run price elasticities together with gross domestic product elasticities and the exchange rate elasticities. Standard errors of the long-run elasticity estimates are given in parentheses.

Table 2.
Long Run Export Elasticity Estimates

Commodity	Own Price Elasticity	GDP Elasticity	Exchange Rate Elasticity
Soybeans	-1.36	1.02	-0.43
	(0.14)[a]	(0.19)	(0.19)
Soybean Meal	-1.49	1.24	-0.48
	(0.21)	(0.19)	(0.13)
Soybean Oil	-1.29	1.40	0.14
	(0.13)	(0.26)	(0.49)

[a]Standard Errors of the Estimates in Parentheses.

The results are interesting from the point of view that they do allow for a definitive assessment of the inelastic/elastic export price elasticity debate. For each of the commodities considered, the export price elasticity is unequivocally elastic when considered in conjunction with the associated confidence interval. Consequently, it is possible to conclude that while the short-run estimates indicate an inelastic export demand for soybeans, soybean meal and soybean oil, the long-run estimates are consistent with elastic export demands. Thus, a one percent increase (decrease) in the price of soybeans, soybean meal or soybean oil in the long run results in more than a one percent decrease (increase) in the quantity of soybeans, soybean meal or soybean oil exported. Moreover, the null hypothesis that the long-run export price elasticities for soybeans, soybean meal and soybean oil are equal cannot be rejected at the 5 percent level.

Tests of the null hypothesis that the long-run gross domestic product elasticities are inelastic are inconclusive. The null hypothesis that they are equal to each other cannot be rejected at the 5 percent level. The exchange rate elasticities, for both soybeans and soybean meal, are in the inelastic region. For soybean oil, the long-run export elasticity is not statistically significantly different than zero. The null hypothesis that the soybean and soybean meal export elasticities are equal cannot be rejected at the 5 percent level.

A Comparison

How do the elasticity estimates obtained here compare with those of others? Ray and Parvin, using a single equation model for soybeans based on data prior to 1975, obtain a long-run soybean price export elasticity of -1.95 while Bredahl, Meyers and Collins, using a system of equations, get a long-run soybean price export elasticity of -0.47. Sarwar and Anderson, as part of a simultaneous equations market model for soybean exports using data for 1955 to 1985, estimate an average long-run soybean price export elasticity of -1.54. Chambers and Just, as part of the simultaneous equations model, report a long-run export elasticity estimate of -0.29 for soybeans. Arnade and Davison estimated a linear equation model for six countries importing U.S. soybeans using data covering the period 1963 to 1986 and found a very low average soybean export price elasticity of -0.10.

Heien and Pick, based on a simultaneous equations system of exporters and importers, estimate an average soybean meal export price elasticity of -2.4. There is a clear indication of an elastic export demand.

Conclusion

This study began by addressing the farm problem in the United States and the apparent need for the federal government to intervene in the export markets for agricultural commodities. Two programs currently target soybean oil, but there are none that apply directly to soybeans or soybean meal. One type of program is a government-offered credit guarantee. Eligible countries are approved for credit guarantee allocations for purchases of soybean oil each fiscal year. The result of the credit guarantee program is not so much to affect the price paid by an importer for soybean oil or alter the other factors identified as impacting the export demand for soybean oil as it is to increase the aggregate demand for soybean oil (Bickerton and Glauber). Between 1978 and 1992, almost 18 percent of soybean oil exports annually were made under this program (Crowder and Davison; U.S. Department of Agriculture, July, 1993).

The program that directly impacts the price of soybean oil in the export market is the Export Enhancement Program (EEP) authorized under the Food Security Act of 1985. Under the EEP, the Commodity Credit Corporation (CCC) targets countries for subsidized sales of U.S. commodities. Two factors concerning the EEP associated with soybean oil are relevant to the current investigation. First, there will be a net increase in soybean oil exports as a result of the program. Second, since the demand for soybean oil increases, there will be an increase in the domestic (U.S.) price of soybean oil since there is just a single market for soybean oil in the United States and not two separate markets—one for the domestic market and one for the export market (Uri *et al.*, 1993a). Finally, it is not clear when the price of soybean oil increases as a result of an EEP sale. That is, does the price increase occur when the sale is announced, when it is actually consummated or perhaps at some point in between? This issue has not been studied adequately (it is a topic for future study) and, hence, a definitive answer cannot be provided at this time. Consequently, this timing issue will not be directly addressed. It will be subsumed in the analysis.

Given that the EEP effectively reduces the export price of soybean oil, each one percent reduction in the price of soybean oil will increase soybean oil exports by more than one percent, leading to an expansion in net revenue received and, consequently, an increase in net farm income, all other things given.[11] This, in conjunction with the considerable variability in net farm income associated with domestic prices and sales of soybean oil,[12] results in more stability in the price of soybean oil, soybean oil sales, and net farm income than would have been the case in the absence of the EEP.[13]

Given the results of the foregoing empirical analysis, an expansion of the EEP to cover soybeans and soybean meal would be expected to reduce the variability in soybean and soybean meal prices and sales and increase net farm income. Furthermore, based on the long-run elasticity estimates reported in Table 2, pursuing a policy to stabilize exchange rates will yield minimal results while promoting the economic growth of soybean and soybean-product-importing countries will result in somewhat larger effects.

Notes

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Washington, DC. The views expressed are those of the authors and do not necessarily represent the policies of the U.S. Department of Agriculture or the views of other U.S. Department of Agriculture staff members. The authors would like to thank the anonymous referees for helpful suggestions.

1. Virtually all soybeans produced for export in the United States are exported as either whole beans, soybean meal or soybean oil. Very few soybeans are used directly in livestock feed, human food or other industrial processes. Although obtained simultaneously in the processing operation, soybean meal and soybean oil are sold in virtually independent markets. Soybean meal is used largely as livestock feed, being commercially prepared as well as being mixed in rations on the farm. Soybean oil, on the other hand, is one of the major components of the edible vegetable oil complex which also includes canola, corn, cottonseed, peanut, sunflower and other oils. The manufacture of soybean meal and soybean oil from whole soybeans (nominally referred to as crushing) is a physical and chemical (solvent extraction) process with relatively fixed technological coefficients. An average 60 pound (27.2 kilogram) bushel (for Number 1 yellow soybeans) yields 47-48 pounds (21.3-21.8 kilograms) of meal and 10-11 pounds (4.5-5.0 kilograms) of oil, both relatively homogeneous products at the wholesale level (Schaub *et al.*). Actual yields vary somewhat as changes occur in bean varieties, growing conditions and oil extraction technology. At any given time, however, soybean meal and soybean oil yields per bushel can be considered fixed, soybean meal and soybean oil being joint products obtained in a relatively constant ratio.

2. The appropriateness of including a lagged term in the soybean export demand relationship as well as the export demand relationships for the soybean products to capture the dynamics in the market will be subject to an empirical examination. It is included here to make the discussion complete.

3. The national income variable is reflecting changes in the demand for the products in which soybeans (soybean meal and soybean oil) are used. Thus, the export demand for soybeans and soybean products is a derived demand. That is, the demand for soybeans and soybean products is not based on any intrinsic desire for the soybeans themselves, but rather on the need to use the soybean meal to feed livestock and to use the soybean oil in such activities as cooking. The livestock and prepared foods are, in turn, sold to other processors (e.g., meat

packers) or to final consumers directly. This means that the demand for soybeans and soybean products is determined in the final markets by the demand and supply for the products being sold. Thus, the derived demand for soybeans and soybean products is based on the elements that generate the supply and demand for the final products in which soybeans and soybean products are used. The national income variable is a proxy for factors impacting the supply and demand for final products.

4. The No. 1 yellow soybean price at Chicago is used because the U.S. soybean price at Rotterdam (probably a better export price measure) is available only back to 1970. The correlation between the Chicago and Rotterdam prices between 1970 and 1992, however, is 0.99 so it is likely that little estimate bias is introduced due to the measurement error. Analogous comments and correlations hold for soybean meal and soybean oil prices.

5. Longer lags were also considered but they proved to be statistically insignificant. Also, lags on the various explanatory variables of up to four periods were considered. In no instance was a distributed lag on any of the explanatory variables indicated.

6. The computed F statistic for a linear-in-logarithms specification was 5.31 while for a linear specification it was 5.76 for the soybean export demand equation. Corresponding values for the soybean meal export demand equation were 5.39 and 5.64, respectively, and for the soybean oil export demand equation, 6.20 and 6.98, respectively. The critical value of the F-distribution at the 5 percent level is 4.12.

7. The computed J-test statistic for the soybean export demand equation was 6.28, the computed J-test statistic for the soybean meal export demand equation 5.19, and the computed J-test statistic for the soybean oil export demand equation was 6.02. The critical chi-square value at the 5 percent level is 3.84.

8. The computed J-test statistic for soybean export demand was 2.32, the computed J-test statistic for soybean meal export demand was 3.05, and the computed J-test statistic for soybean oil export demand was 2.99. The critical chi-square value at the 5 percent level is 3.84.

9. Note that the export demand relationships contain a term for non-U.S.-produced soybean, soybean meal and soybean oil exports. At issue here is whether the magnitude of the responsiveness of U.S. exports to

changes in non-U.S.-produced soybean and soybean product exports has changed.

10. Most other statistical tests designed to ascertain whether a regression relationship over the sample horizon is stable have been limited either to the use of dummy variables when a change in the relationship is suspected or to splitting the sample period at that point and performing a Chow test (Chow). Both of these techniques require *a priori* knowledge of the point in time when the function shifts and this information might not be available.

11. Between 1988 and 1992, approximately 15 percent of soybean oil exports annually were made under EEP certificates (U.S. Department of Agriculture, July, 1993).

12. Between 1980 and 1992, soybean oil ranged in nominal price from a low of 13.9 cents per pound (September, 1985) to a high of 39.0 cents per pound (May, 1983). Over the same period, crude soybean oil production varied between a low of 732 million pounds (August, 1981) and a high of 1,188 million pounds (October, 1990) (Commodity Research Bureau).

13. Between 1980 and 1985, the standard deviation associated with the average monthly price of crude soybean oil in tank cars (f.o.b. Decatur) was 14.9 cents per pound. Between 1986 and 1992 (the period when the EEP for soybean oil was in operation), the standard deviation was 2.89 cents per pound. For crude soybean oil production between 1980 and 1985, the standard deviation of monthly production was 43.3 million pounds while for the period 1986 through 1992, the standard deviation was 32.8 million pounds. While no claim can be made that the entire reduction in the variability of price and crude soybean oil production is a result of the implementation of the EEP, it appears likely that at least some of it is.

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