Export Elasticities for US and Brazilian Soyabeans: Weighted-Market-Share Approach

Cecil W. Davison and Carlos A. Arnade[1]

Abstract: Price and income elasticities for imports of US and Brazilian soyabeans by each of the eight major world soyabean importers and the rest of the world were weighted by their shares of the respective soyabean markets and summed to approximate total price and income elasticities for US and Brazilian soyabean exports. This weighted-market-share technique was applied to elasticity estimates derived from two different procedures: Sirhan and Johnson's market-share approach and direct estimation. Estimates from both procedures indicated that, in the short run (1 year) during 1972-85, soyabean exports from the USA were inelastic with respect to price; from Brazil they were elastic with respect to price; and from both countries they were elastic with respect to income.

Introduction

The price elasticity of demand is important to policy makers interested in expanding agricultural exports and increasing revenues to farmers. If the demand for agricultural exports is elastic, then lowering the export price will increase exports and sales revenue. Consequently, both policy makers and researchers are interested in elasticity estimates that most accurately reflect price and quantity responses in the market. Published estimates of US soyabean export elasticities range from inelastic to elastic, with no consensus on the appropriate range. This paper presents a new approach for estimating such elasticities, and gives the results for US and Brazilian soyabean exports.

Background

Gardiner and Dixit (1987) reviewed 16 estimates of the short-run price elasticity of demand for US soyabean exports, ranging from -0.14 to -2.00 and published during 1971-84. The price elasticity is expected to differ among commodities and change with time. Typically, estimates for a particular commodity vary because of differences in estimation methods, assumptions in the analysis, time period of estimation, type of data (quarterly or annual), and quality of data available to researchers. Variations in assumptions, time periods, and data are expected among published elasticity estimates, and can obscure variations due to the methods employed and data aggregation. The research summarized by Gardiner and Dixit includes the estimation methods of direct estimation, calculation, and simulation.

Direct estimation and other approaches that use aggregate data (commodity-specific export demand data added across country-specific markets) in one or a few equations to estimate export demand equations and elasticities are subject to inherent problems that include the following:

1. Elasticities vary across countries. An aggregate response estimate does not reveal the different responses in individual markets. This becomes important as markets and market shares change over time.
2. Simultaneous-equation bias is likely when a producer's exports are aggregated. Imports of US soyabeans by one or two countries may not influence US prices, but aggregate US exports may.

These problems associated with aggregate data in estimation and the inconclusive range of published elasticity estimates for US soyabean exports highlight the need for a better estimation approach with credible results.

New Estimation Approach

Sirhan and Johnson (1971) used a market-share approach to estimate price elasticities in two US cotton markets. Their approach is extended in this study by identifying all the world's major soyabean importers, which collectively took over 85 percent of all US and Brazilian soyabean exports during the estimation period, and using market-specific (disaggregated) data in estimating elasticities for US and Brazilian soyabeans in each of those markets. A single rest-of-the-world equation, estimated for the remainder of the US and Brazilian market, is subject to aggregate-data problems, but they have now been confined to an estimate associated with less than 15 percent of the exports.

Elasticity estimates from each of these markets are then weighted by their respective share of the US and Brazilian export market and totalled to approximate an export demand elasticity for the USA and Brazil across all markets. For comparison, this weighted-market-share method is also applied to elasticity estimates from direct estimation of imports of US and Brazilian soyabeans by these major world markets.

Method

World soyabean importers were ranked for 1980-85 to identify current markets. The top eight (EC-9, Japan, Spain, China, Mexico, USSR, South Korea, and Portugal) imported 83 percent of all soyabean exports during that period. Following previous research (Davison and Arnade, 1987), the estimating equations were specified two ways, as linear and log-linear (Cobb-Douglas) combinations of the independent variables. Since the fits of the linear functions were generally not better than the logarithmic ones, the latter were used for this analysis. The equations were specified as:

$$(1)\quad Y = a_0 X_1^{a_1} X_2^{a_2}, \ldots, X_n^{a_n} e^u,$$

and estimated in the form:

$$(2)\quad \log Y_i = \log a_{0i} + a_{1i} \log X_{1i} + a_{2i} \log X_{2i}, \ldots, + a_{5i} \log X_{5i} + u_1, \text{ and}$$

$$(3)\quad \log Z_i = \log b_{0i} + b_{1i} \log X_{1i} + b_{2i} \log X_{2i}, \ldots, + b_{5i} \log X_{5i} + u_2,$$

where:

Y_i = total soyabean imports by a country-specific (ith) market;

Z_i = exporter's share of that market (e.g., imports of US soyabeans/total soyabean imports in the ith country);

X_{1i} = exporter's soyabean price ($i = 1$ for the US gulf and $i = 2$ for Brazil, Jan.-Dec. average, \$/t, in Table 1);

X_{2i} = per capita real GNP in the ith country and, for the rest of the world, per capita total reserves minus gold divided by industrial country CPI;

X_{3i} = pigmeat production in the ith country (1,000 t);

X_{4i} = real exchange rate (foreign currency units divided by foreign CPI per US dollar divided by the US CPI), and, for the rest of the world, Special Drawing Rights divided by industrial country CPI per dollar divided by the US CPI;

X_{5i} = freight rate ratio (rate from US gulf to ith market divided by the rate from Argentina), or, for the EC-9 and South Korea, soyabean supply in the ith country (beginning stocks plus production);

a_{ji}, b_{ji} = fixed parameters; and

u_i = normally distributed random errors.

To expand the degrees of freedom and reflect the influence of floating exchange rates, data were selected for 1972-85. Macroeconomic data (GNP, exchange rates, and CPI indexes) came from the International Monetary Fund (1986); population, price, soyabean stocks and production, and livestock data came from the US Department of Agriculture (1986); soyabean exports (imports) from United Nations trade data tapes; and freight rates from the International Wheat Council (1981-85 and 1986). Zellner's (1962) unrestricted seemingly unrelated regression, using annual data, provided individual estimates of the parameters on the exogenous variables (*X*'s).

In the market-share approach used by Sirhan and Johnson, the price elasticity of an exporter in a specific market equals the sum of the price elasticities from the total import equation and the market-share equation. Since the parameters estimated in this specification are elasticity estimates, the price elasticity of demand for an exporter to the *i*th country is a_{1i} plus b_{1i}, from equations *(2)* and *(3)*. The elasticity estimate from the *i*th country is then weighted by its share of the exporter's 1972-85 market, and added to other similarly weighted elasticity estimates from the rest of the exporter's markets to a total price elasticity approximation for that exporter.

The price elasticity of demand for imports of US and Brazilian soyabeans was also estimated directly, using:

$$(4)\ \log W_i = \log c_{0i} + c_{1i} \log X_{1i} + c_{2i} \log X_{2i}, \ldots, + c_{5i} \log X_{5i} + u_3,$$

where W_i represents imports of US and Brazilian soyabeans by the *i*th country.

Results

Estimators and *t*-values from the regression estimations of the total-soyabean-import and the exporter-share equations are presented in Table 1. Elasticity estimates, added from the estimators in Table 1, are presented in Table 2, where they are weighted by market shares and totalled to get aggregate elasticity approximations for the USA and Brazil, the two leading soyabean exporters for 1972-85. Space constraints do not allow presentation of all the estimators and *t*-values from equations where US and Brazilian elasticities were estimated directly, but the price and income elasticities are presented, weighted, and totalled in Table 3.

The weighted elasticities were summed two ways: first by totalling all that had the expected sign and then adding the wrong-sign estimates. Adding the wrong-sign estimates to the expected-sign totals changed the price and income elasticity approximations but did not change them from elastic to inelastic or vice versa. The market-share approach and the direct estimation approach produced similar aggregate elasticity approximations: US soyabean exports were inelastic with respect to price, while Brazil's were elastic. Exports from both countries were elastic with respect to income.

Implications

Results of this study contain implications for researchers who estimate elasticities by various methods and for policy makers who are confronted by numerous elasticity estimates that are not always consistent.

For Researchers

Elasticity estimates from Sirhan and Johnson's market-share approach (Table 2) and from direct estimation (Table 3) are so similar that they appear fairly robust across these two methods.

Table 1—Estimation Results for Soyabean Import Equations, 1972–85†

	a_{ii}	X_{i1}	X_{i2}	X_{i3}	X_{i4}	X_{i5}	X_{i6}	R^2	D-W	F
EC-9:										
Total	7.235	-0.2524	0.3140	1.663	--	-0.4269	-0.0093	0.91	2.273	405**
	(11.72)**	(-3.03)**	(3.97)**	(7.39)**		(-7.38)**	(-0.72)			
USA	0.8057	-0.2040	0.1340	0.2905	--	-0.3153	-0.0364	-0.16	0.921	8.40**
	(0.72)	(1.14)	(0.82)	(0.70)		(-3.27)**	(-0.63)			
Brazil	-31.12	1.400	-0.7445	-12.46	--	2.878	0.4885	0.16	1.213	20**
	(-3.25)	(0.92)	(-0.52)	(-3.48)		(3.84)	(1.00)			
Japan:										
Total	3.083	0.1527	-0.2927	0.0985	0.8218	0.0154	--	0.74	1.927	126**
	(1.61)	(0.66)	(-1.39)	(0.36)	(4.33)**	(0.14)				
USA	1.274	-0.1276	0.0164	0.1722	--	-0.1569	-0.0329	0.70	2.210	93**
	(5.97)**	(-2.39)**	(0.33)	(4.99)**		(-6.69)	(-1.89)			
Brazil	-57.40	28.86	-19.71	-13.93	--	1.643	-1.050	0.58	2.201	60**
	(-3.01)	(4.67)	(-3.38)	(-3.73)		(0.84)	(-0.52)			
Spain:										
Total	-1.858	0.3505	0.5926	-1.536	0.4085	0.0279	--	0.38	1.204	39**
	(-0.48)	(0.35)	(0.66)	(-0.95)	(1.25)	(0.20)				
USA	-1.708	-0.3836	0.4126	-1.388	--	-0.0084	0.0389	-0.07	1.690	11**
	(-0.64)	(-0.60)	(0.76)	(-1.19)		(-0.10)	(0.22)			
Brazil	14.03	1.276	-2.417	6.818	--	-0.4764	1.338	-0.36	1.959	4.13**
	(0.94)	(0.30)	(-0.64)	(1.07)		(-0.86)	(1.09)			
China:										
Total	4.165	-0.1600	-0.1695	1.406	-0.2256	-0.0335	--	0.80	1.953	170**
	(2.21)*	(-0.32)	(-0.37)	(5.36)**	(-0.78)	(-0.09)				
Mexico:										
Total	-10.78	3.419	-1.064	1.378	1.852	0.0509	--	0.37	2.189	39**
	(-0.85)	(0.93)	(-0.31)	(0.63)	(1.79)*	(0.06)				
USA	-5.774	0.2627	-0.1105	-1.755	--	0.0719	0.7569	0.62	2.336	68**
	(-3.92)**	(0.45)	(-0.20)	(-6.65)		(0.67)	(4.23)			
Brazil	47.15	5.176	-8.215	14.79	--	0.8278	-6.797	0.07	1.998	16**
	(1.73)*	(0.51)	(-0.87)	(2.91)**		(0.42)	(-2.16)			
USSR:										
Total	312.02	5.316	-10.05	26.33	-14.30	2.061	--	0.14	2.073	23**
	(4.93)**	(0.75)	(-1.50)	(2.58)**	(-3.94)	(1.05)				
USA	386.01	-18.22	11.13	59.52	--	-13.10	0.4341	0.30	2.245	28**
	(5.88)**	(-2.17)*	(1.39)	(6.07)**		(-7.34)**	(0.16)			
Brazil	297.19	3.799	-1.497	53.37	--	-17.86	2.290	0.16	1.558	20**
	(2.10)*	(0.39)	(-0.16)	(2.43)**		(-4.30)**	(0.72)			
South Korea:										
Total	11.45	-1.508	0.9246	3.436	0.4929	-1.017	0.3648	0.95	2.579	705**
	(3.37)**	(-1.99)*	(1.29)	(5.65)**	(1.98)*	(-2.96)**	(1.66)			
Portugal:										
Total	4.129	0.2256	-0.0239	3.901	2.691	0.2256	--	0.67	1.646	95**
	(0.43)	(0.34)	(-0.01)	(2.57)**	(3.45)**	(0.34)				
USA	-4.775	0.5797	-0.3310	-0.7759	--	0.3635	-0.1368	-0.40	2.657	3.38**
	(-1.37)	(0.64)	(-0.41)	(-1.34)		(1.29)	(-0.48)			
Brazil	34.95	-2.722	0.7739	4.378	--	-4.437	1.123	-0.54	2.499	1.19
	(0.62)	(-0.21)	(0.07)	(0.47)		(-0.93)	(0.26)			
Rest of the world:‡										
Total	8.418	0.4698	-0.6899	-0.1044	--	-2.521	--	0.77	1.993	156**
	(6.74)**	(0.79)	(-1.23)	(-0.66)		(-4.02)**				
USA	0.7318	0.2470	-0.3555	0.0693	--	0.069	0.0758	-0.02	1.712	12**
	(1.71)*	(1.20)	(-1.85)	(0.23)		(0.23)	(1.00)			
Brazil	-15.61	3.358	0.0430	1.609	--	13.00	-0.2989	0.36	1.550	33**
	(-2.39)**	(1.18)	(0.02)	(1.31)		(2.33)	(-0.25)			

†For explanation of variables, see text; D-W = Durbin-Watson statistic; F = test of significance of the model (see Chow, 1983, pp. 58–60); t-values in parentheses (significance levels for one-tail test: * = 5 percent and ** = 1 percent); and -- = insufficient data for estimation or variable not used.

‡Excludes the USA, Brazil, and Argentina, which are major soyabean exporters, not major soyabean importers.

The multiple-equation weighted-market-share approach substantially reduces the aggregated data problems, including the spectre of simultaneous equation bias intrinsic to a single rest-of-the-world equation.

The multiple-equation approach requires more data but has the advantage of providing market-specific elasticity estimates that can be evaluated individually. Questionable equations or estimators can be identified and isolated. Results from the equations for the USSR and Spain, plus some of the share equations, illustrate this point with their poor fits. Researchers can then re-estimate weak equations or use market-specific elasticities judged more appropriate.

Table 2—Price and Income Elasticities, US and Brazilian Soyabean Exports, 1972-85: Market-Share Method†

	Elasticities				Market Share		Weighted Elasticities			
	Price		Income				Price		Income	
	US	Brazil	US	Brazil	US	Brazil	US	Brazil	US	Brazil
EC-9	-0.456	-0.430	1.95	-10.80	0.427	0.507	-0.195	-0.218	0.834	-5.474
	(-3.03)**	(-0.52)	(7.39)**	(-3.48)						
Japan	0.025	-20.00	0.271	-13.83	0.213	0.031	0.005	-0.620	0.058	-0.429
	(0.66)	(-3.38)**	(4.99)**	(-3.73)						
Spain	-0.033	-1.82	-2.92	5.28	0.092	0.198	-0.003	-0.361	-0.269	1.046
	(-0.60)	(-0.64)	(-0.95)	(1.07)						
China	-0.160	-0.170	1.41	1.41	0.054	0.005	-0.009	-0.001	0.076	0.076
	(-0.32)	(-0.37)	(5.36)**	(5.36)**						
Mexico	3.68	-9.28	-0.377	16.17	0.027	0.030	0.099	-0.278	-0.010	0.485
	(0.93)	(-0.87)	(-6.65)	(2.91)**						
USSR	-12.90	-11.55	85.85	79.70	0.025	0.142	-0.323	-1.640	2.146	11.32
	(-2.17)*	(-1.50)	(6.07)**	(2.43)**						
South Korea	-1.51	0.92	3.44	3.44	0.020	0.004	-0.030	0.004	0.069	0.014
	(-1.99)*	(1.29)	(5.65)**	(5.65)**						
Portugal	0.805	0.750	3.13	8.28	0.013	0.023	0.010	0.017	0.041	0.190
	(0.64)	(0.07)	(2.57)**	(0.47)						
Rest of the world‡	0.717	-0.647	-0.035	1.50	0.127	0.060	0.091	-0.039	-0.004	0.090
	(0.79)	(-1.23)	(-0.66)	(1.31)						
World total					0.998	1.000				
Right sign							-0.56	-3.16	3.22	13.22
All							-0.35	-3.14	2.94	7.32

†Market shares are averages for 1972-85; weighted elasticities are elasticities times the market shares, computed from unrounded data; *t*-values in parentheses, from the largest of the two estimators (Table 1) totaled to obtain these estimates; and significance levels (one-tail test), * = 5 percent and ** = 1 percent.
‡Excludes the USA, Brazil, and Argentina.

Table 3—Price and Income Elasticities, US and Brazilian Soyabean Exports, 1972-85: Direct Estimation†

	Elasticities				Market Share		Weighted Elasticities			
	Price		Income				Price		Income	
	US	Brazil	US	Brazil	US	Brazil	US	Brazil	US	Brazil
EC-9	-0.478	-0.519	2.69	-14.01	0.427	0.507	-0.204*	-0.263	1.148**	-7.101
	(-2.00)*	(-0.35)	(4.71)**	(-2.50)						
Japan	0.104	-20.37	0.149	-22.15	0.213	0.031	0.022	-0.631**	0.032	-0.687
	(0.46)	(-3.51)**	(0.78)	(-2.55)						
Spain	-0.457	5.97	-1.53	3.69	0.092	0.198	-0.042	1.182	-0.140	0.731
	(-0.44)	(0.96)	(-2.07)	(0.27)						
China	-0.309	--	1.27	--	0.054	0.005	-0.017	--	0.069**	--
	(-0.64)		(5.89)**							
Mexico	3.78	-8.00	-3.10	52.80	0.027	0.030	0.102	-0.240	-0.084	1.584**
	(1.06)	(-0.81)	(-1.76)	(4.86)**						
USSR	-13.18	-12.90	86.58	74.69	0.025	0.142	-0.330	-1.832	2.165**	10.607**
	(-1.64)	(-1.36)	(7.67)**	(3.27)**						
South Korea	-1.51	--	4.79	--	0.020	0.004	-0.030*	--	0.096**	--
	(-1.91)*		(7.17)**							
Portugal	-0.566	12.84	3.22	38.79	0.013	0.023	-0.007	0.295	0.042	0.892**
	(-0.22)	(1.09)	(1.65)	(3.27)**						
Rest of the world‡	0.565	-0.751	-0.259	2.44	0.127	0.060	0.072	-0.045	-0.033	0.146**
	(0.79)	(-0.31)	(-1.34)	(2.84)**						
World total					0.998	1.000				
Right sign							-0.63	-3.01	3.55	13.98
All							-0.43	-1.53	3.30	6.17

†Market shares are averages for 1972-85; weighted elasticities are elasticities times the market shares, computed from unrounded data; *t*-values in parentheses; significance levels (one-tail test), * = 5 percent and ** = 1 percent; and -- = insufficient data for estimation.
‡Excludes the USA, Brazil, and Argentina.

For Policy Makers

This multiple-equation approach provides information, including price and income elasticity estimates, that could help policy makers tailor export marketing strategies to fit specific markets. This approach, with elasticities weighted by market shares, also allows export programme planners to adjust for changes in customer elasticities and shares of the US and Brazilian soyabean market, whereas elasticity estimates from the single-equation approach must presume that individual customer elasticities and market shares will remain unchanged from the estimation period.

The inelastic price elasticity estimates for US soyabean exports indicate that revenues would be decreased in the short run by lowering US export prices, while the elastic estimates for Brazilian soyabean exports indicate that revenues could be increased in the short run by lowering prices. The elastic income elasticity estimates suggest that increased income in the importing countries would increase US and Brazilian export revenues.

Note

[1]Economic Research Service, US Department of Agriculture.

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DISCUSSION OPENING—*Jack E. Houston* (University of Georgia)

Alfred North Whitehead was quoted as saying, "A theory is an unguarded statement of a partial truth.... Criticism of a theory does not start from the question, True or False? It consists in noting its scope of useful application, and its failure beyond that scope." In an extension of a Sirhan and Johnson approach, Davison and Arnade have presented a "new" disaggregated weighted-market-share approach for estimating soyabean export and import elasticities. The intended users of these elasticity estimates are policy makers in the major exporting countries, the USA and Brazil.

Disaggregation of the total, US, and Brazilian exports by importing countries appears to offer potentially valuable information not available in more aggregated world trade models.

Variables included in the theoretically and historically based model clearly affected importing countries differently, but, in many cases, insignificantly. Brazilian soyabean prices were significant only in EC total import elasticity estimates. Several factors discussed later may have some bearing on this finding, but US Gulf port prices, which are closely linked to world commodity futures trading markets in the USA were little better in price elasticity measures. Other structural and supply-related variables not considered in this approach may also be responsible within this particular 1972-85 time period, not least of which may be Brazil's changes in export policies from beans and products to soyabean meal only.

Perhaps due to the brevity of the paper, several aspects of the estimation procedure were not discussed. The shortness of the time series (14 annual observations) and the number of parameters being estimated may not be entirely overcome by employing the seemingly unrelated regressions technique. Multicolinearity was not explicitly addressed and likely influenced the incidence of theoretically incorrect signs and/or insignificance of some variables and thus their elasticities. This was particularly evident in estimates of the market shares, which were assumed to have constant elasticities in the log-log specification. Weather and politically motivated soyabean supply volatility during the period estimated subverted any meaningful relationship between the US and Brazilian market shares and variables included in the model.

Serial correlation problems in many of the country-specific elasticity and market-share equations diminish confidence in the efficiency of the estimated parameters and their significance, but could have been overcome in a Parks two-step procedure. Market-share weights used multiplicatively with price elasticity estimates, however, were simple averages over the 1972-85 period. Combined with Brazil's entry into the world soyabean export market and early circumstance-specific gains in share, these multipliers are only examples of information potentially available from a more completely developed model of weighted-market-share elasticities.

The exploratory use of the disaggregated weighted-market-share approach was referred to in the authors' concluding remarks, including suggestions for further analysis. While raising the possibility of country-specific market policy information, effects of admittedly "questionable estimates, for individual markets, on the estimate of aggregate elasticities" remain in this approach. Whether the approach has the potential to overcome soyabean supply volatility, structural change, and export market structure factors not presently included in the approach remains to be seen. Credible implications depend on satisfying these and other remaining questions.

GENERAL DISCUSSION—*Manuel Cabanes, Rapporteur* (Escuela Superior de Técnica Empresarial Agrícola, Universidad de Córdoba)

Questions were asked about the fact that soyabeans are not a single product, but several products (e.g., meal and oil), and how this could affect the authors' analysis. In reply, Arnade stated that as far as exports were concerned, only soyabeans were considered. With respect to the possibility that different importing countries may use the product derived from soyabeans in different proportions, he answered that perhaps the different set of equations formulated for each market would take care of that.

One participant commented that the consumption of pigmeat was included as an explanatory variable but not consumption of chicken or milk. Arnade explained that pigmeat consumption was the only data available for all the markets considered and for the whole period of time. He added that perhaps in the future the quality of the model could be improved.

Participants in the general discussion included C. Alves, G. Corazza, G.T. Jones, E. Soliman, and H. von Witzke.