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Export Demand Elasticity: Measurement and Implications for U.S. Exports

S. Devadoss, William H. Meyers, and Michael Helmar*

I. Introduction

Elasticity of export demand is the percentage change in the quantity of exports brought about by one percentage change in the export prices, given that the other shift variables remain unchanged. The value of this elasticity is computed along the excess demand schedule facing the United States, which embodies the net effect of all supply and demand adjustments of both importing and other exporting countries. Thus the coefficient describing the price responsiveness of export demand summarizes the reactions of importing and exporting countries to a price change by the Unites States.

It has been widely believed among agricultural economists and policy makers in the United States that the magnitude of the export demand elasticity is one of the most important parameters used in farm policy decisions. This is because policy makers would like to know how much the demand for U.S. exports of a commodity will change for a specific change in the U. S. price of that commodity. For example, in the Food Security Act of 1985 the loan rates for wheat, feed grains, soybean, cotton and rice were reduced with the assumption that lower loan rates, leading to a decline in export prices, would regain export market share of these commodities. The premise underlying the above policy was that the export demand elasticities for these commodities were greater than unity. Export earnings increase with lower prices if the export demand elasticity is greater than unity. Thus the magnitude of the export demand response, whether elastic or inelastic, is considered to be crucial not only for trade policy decisions and export marketing strategies but also for determining certain domestic policy parameters such as price supports and acreage reduction programs. However, despite its importance there is no professional consensus on the value of this parameter. For example, past empirical studies show that the long run U.S. export demand elasticity ranges from -0.23 to -6.72 for wheat, -0.86 to -10.18 for coarse grains, and -0.47 to -2.80 for soybeans (Gardiner and Dixit).

One reason for this wide range of empirical estimates may be that export demand elasticities vary over time due to the continuous changes in numerous factors which influence their values. As Gardiner and Dixit enumerated, these factors include the overall change in world trade volume and in U.S. share of trade; changes in foreign countries' populations, income, employment, inflation, tastes, and weather conditions; changes in other countries' government policies such as price supports, tariffs, quotas, subsidies, exchange rates, and transportation costs. As a result of the changes in these factors the export demand schedule facing the United States will shift and/or rotate, and the elasticity of export demand

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will depend on the new equilibrium level of the export price and quantity and the shape and position of the excess demand schedule. In view of this continuous variation in the value of the export demand elasticity, some agricultural economists have emphasized that it is important to view the elasticity of export demand as a variable rather than a parameter.

Our focus in this study is on the effect of volume of U.S. exports, and foreign countries' government policies. The specific objectives of this study are a) to show empirically how values of U.S. elasticities of export demand for major commodities vary over time because of the change in the volume of U.S. exports of these commodities and b) to examine how the trade barriers in the world wheat market affect the elasticity of wheat exports.

In the next section, following the approach used by Bredahl, Meyers, and Collins (BMC), elasticities of U.S. export demand for major commodities are computed for three different years -- 1969, 1979, and 1985, and the reasons for the variation in the magnitudes of the elasticities in these years are discussed. The computation of export demand elasticity in a trade model using an exogenous yield shock analysis is explained in Section 3. In Section 4, using a world wheat trade model the elasticity of export demand for U.S. wheat is computed for each year from 1988/87 to 1992/93 under a restricted trade scenario and a free trade scenario. The empirical results show that trade liberalization will increase the U.S. wheat export demand elasticity substantially. The conclusion and policy implications are summarized in the final section.

2. Variation in the Elasticity of Export Demand

Methods often used in the literature to estimate the export demand elasticity are direct estimation, computation, simulation, and synthetic methods (see Gardiner and Dixit for the details of these methods). In this section, following the earlier work of BMC, we employ the computation method to calculate the elasticities of export demand for major commodities in 1969, 1979, and 1985.

The net export of the U.S. (QX) is equal to the total quantity demanded (D_f) minus the total quantity supplied (S_f) by all other importing and exporting countries:

1) $QX = D_f - S_f$

From this equation, the expression for computing the elasticity of export demand can be derived as:

2) $E_X = E_{df}\, E_{pf}\, (D_f/QX) - E_{sf}\, E_{pf}\, (S_f/QX)$

where

E_X is the elasticity of U.S. export demand
E_{df} is domestic demand elasticity of rest of the world (ROW)
E_{sf} is domestic supply elasticity of ROW
$E_{pf} = (\partial p_f/\partial p)(p/p_f)$ = is price transmission elasticity; p and p_f are prices in the U.S. and in the ROW.

Since the 1979 article by BMC, the above expression for export demand elasticity incorporating price transmission elasticity has been commonly used. The salient contribution of BMC study is that trade restrictions and domestic price insulation policies, by constraining the values of price transmission elasticities to be less than one, reduce the elasticity of export demand.

First, we show how the elasticities of export demand for major commodities vary over time and depend on the level of aggregation. To illustrate this point the U.S. export demand elasticities are computed using expression (2), for rice, cotton, wheat, coarse grains, corn, all grains, and soybeans in three different years - 1969, 1979, and 1985. In computing the values of export demand elasticities, we assumed the ROW domestic demand and supply elasticities of these commodities (refer to table 1). These elasticities are very much in line with those used by Johnson and BMC, but more aggregate commodities are assumed to be more inelastic in supply and demand. The top half of table 1 presents export demand elasticities that are computed by assuming price transmission elasticities of one. The key point to note is that the export demand elasticity of a given commodity is not the same in these three years, even though the ROW domestic demand and supply elasticities and the price transmission elasticities are assumed to be constant over these periods. The variation in export demand elasticities is mainly due to the changes in the quantity of U.S. exports in relation to the rest of the world demand (D_f) and supply (S_f). From the equation (2) it should be evident that the larger the ratios D_f/QX and S_f/QX the higher the export demand elasticities. Stated differently, if U.S. exports of a commodity are small in relation to ROW demand and supply in a particular year, then the magnitude of the export demand elasticity will be larger in that year. On the other hand, if U.S. exports of a commodity are large in relation to ROW demand and supply, then the value of the export demand elasticity will be smaller. Therefore, in any given year the export demand elasticity depends on the volume of U.S. trade in relation to the total demand and supply in the ROW. Thus, a continuous change in the ratios (D_f/QX) and (S_f/QX) will make the elasticity of export demand a variable rather than a parameter.

The elasticity also depends on the level of aggregation of commodities. The reason that the coarse grains export demand elasticity is larger than that for corn is that the U.S. has a smaller share of total trade in coarse grains as a whole. The elasticity of export demand for all grains is lower than any of the individual grains because the underlying supply and demand elasticities are assumed to be so much smaller.

The bottom half of the table 1 presents export demand elasticities that are computed using price transmission elasticities of less than one, which entail that foreign nations insulate their domestic markets from international price movements. After incorporating price transmission elasticities of less than one, to take into account of the trade barriers, the values of export demand elasticities for all commodities decrease significantly. The elasticity estimates in this case may be the closest approximation of the real world. It is important to realize that price transmission elasticities play a key role in determining the values of the export demand elasticities. These results illustrate the conclusion derived by BMC.

Furthermore, these results indicate that the elasticity of export demand would increase if agricultural trade restrictions inhibiting the transmission of world market price variability to domestic market are removed. Currently, countries like the European Community and Japan, to a

Table 1. Export demand elasticities with changing market shares and alternate price transmission elasticities[a]

Commodities	Demand Elasticity in the ROW E_{df}	Supply Elasticity in the ROW E_{sf}	Price Transmission Elasticity E_{pf}	Export Demand Elasticities E_x		
				1969	1979	1985
Rice	-0.2	0.3	1.0	-56.8	-48.8	-97.4
Cotton	-0.5	0.3	1.0	-18.0	-6.5	-43.0
Wheat	-0.4	0.3	1.0	-15.7	-8.6	-16.1
Coarse grains	-0.4	0.2	1.0	-14.7	-4.9	-11.1
Corn	-0.5	0.3	1.0	-8.5	-3.5	-8.1
All grains	-0.1	0.1	1.0	-5.5	-2.3	-5.1
Soybeans	-0.5	0.3	1.0	-1.8	-1.7	-2.5
Rice	-0.2	0.3	0.1	-11.4	-9.8	-19.5
Cotton	-0.5	0.3	0.2	-1.8	-0.7	-4.3
Wheat	-0.4	0.3	0.1	-1.6	-0.9	-1.6
Coarse grains	-0.4	0.2	0.2	-1.5	-0.5	-1.1
Corn	-0.5	0.3	0.1	-1.7	-0.7	-1.6
All grains	-0.1	0.1	0.1	-0.6	-0.2	-0.5
Soybeans	-0.5	0.3	0.8	-1.5	-1.4	-2.0

[a]We would like to caution the readers that they should not use the export demand elasticities reported in this table as datum in their research work. Rather, it is merely an exercise to show how the export demand elasticities vary over time because of the changing U.S. market share and price transmission elasticities. Changes in the assumed values of domestic demand and supply elasticities in the ROW will influence the value of export demand elasticities greatly.

large extent, insulate their domestic markets from the price movements in the world market and thereby constrain their price transmission elasticities to be significantly less than one. If U.S. proposals in the GATT negotiations of moving towards free trade are implemented, it is very likely that U.S. export demand elasticities for important commodities will increase since the price transmission elasticities of exporting and importing countries will be closer to one. The impact of free trade on the values of export demand elasticities is the subject of section 4.

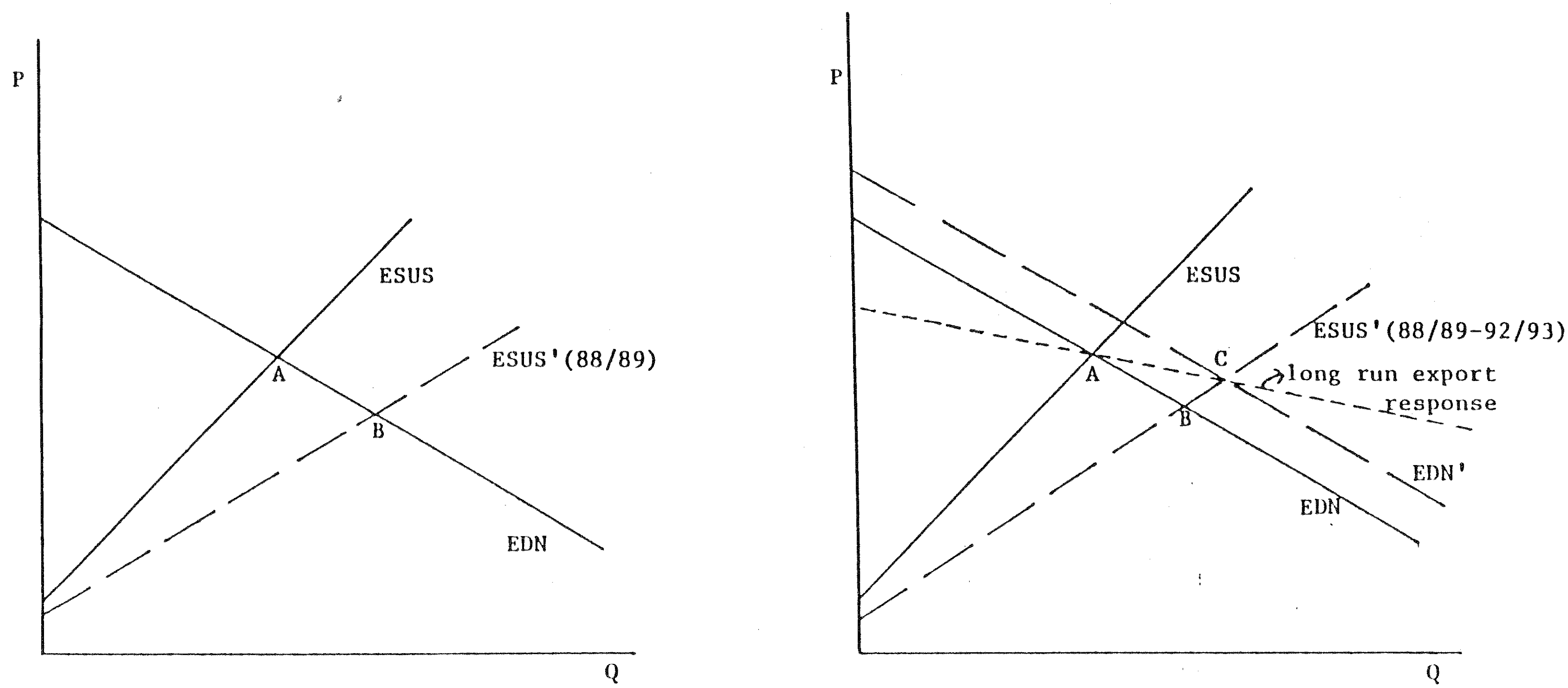
3. Analytical Framework

In this section, we explain the measurement of the elasticity of export demand by employing the simulation method. In particular, using the FAPRI wheat trade model, the elasticity of export demand was measured by exogenously shocking U.S. wheat yields (see Meyers, Devadoss, and Helmar for the details on the yield shock and export demand elasticity). Suppose that in Figure 1 ESUS represents the U.S. wheat export supply and EDN the wheat export demand curve facing the U.S. A yield shock such as increasing the wheat yield in the U.S. by a certain percent will proportionally shift the domestic wheat supply to the right, which will rotate the U.S. excess supply curve down (from ESUS to ESUS') along the export demand curve, and thus enabling one to measure the elasticity of the excess demand curve.

A multi-period yield shock was used to compute the long run export demand elasticity, and can be also used to deduce the short run elasticity. In this study, the multi-period yield shock was conducted by increasing the yield by 5 percent each year for five years, from 1988/89 to 1992/93. In Figure 1, panel I represents the short run impact and panel II the long run impacts. In panel I the short run impact of the first year shock traces the export responses along the fixed export demand schedule. The short run elasticity of export demand is computed as a ratio of percent change in quantity of exports to percent change in prices from point A to B. In panel II the first year impact is the same. But the continuous yield increases lower the long-run average prices and the export demand schedule shifts to the right as foreign production has more time to respond to the lower price levels. The long-run export response (dashed line) is expected to be larger for a given price change.

4. Impact of trade liberalization on the U.S. wheat export demand elasticity

Before going into the details of elasticity computation, a brief discussion of the structure of the FAPRI world wheat trade model is in order. By depicting the basic elements of supply and demand components of the wheat trade model, Figure 2 illustrates how the wheat excess demand schedule facing the United States is derived. The U.S. export supply curve (ESUS) is the difference between the domestic supply (SUS) and demand (DUS) in the U.S. and represents quantity supplied in the world market at various price levels. Other exporters' supply and demand schedules are given in the lower panel. The curve ESO is the combined excess supply of all competing exporters, which is derived as the difference between the supply and demand of all the exporters. The import demand schedule (EDT) of all importers is their total demand minus the total supply. Other competitors' export supply and importers' import demand are represented in the middle



Panel I - one-year shock

Panel II - five-year shock

Figure 1. Measurement of export demand elasticity using exogenous yield shock.

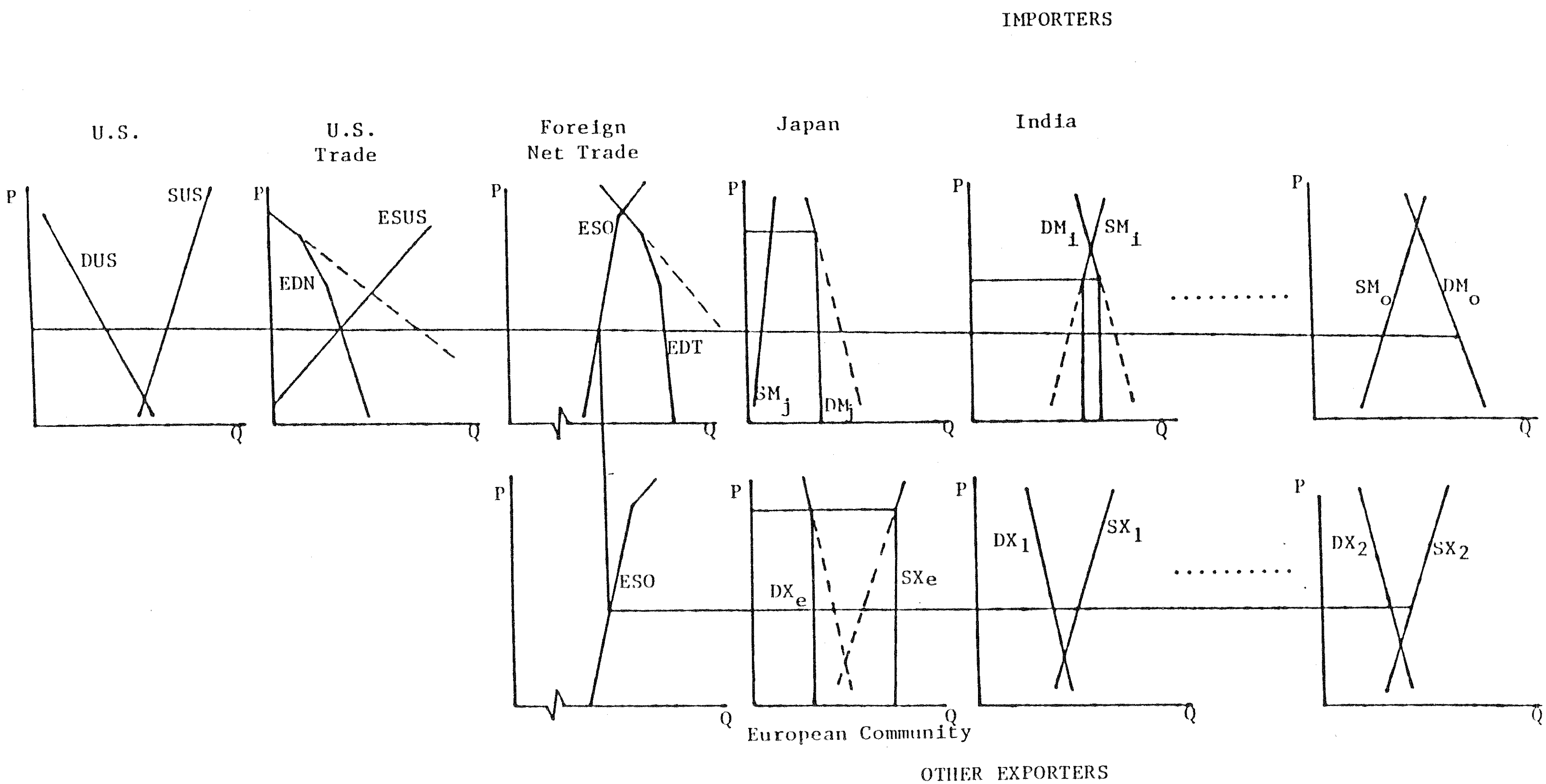


Figure 2. Illustration of wheat world trade model

diagram of the top panel. The export demand schedule (EDN) facing the United States is the difference between the import demand of all importers and the export supply of competitors. The kinked nature of the EDN is due to the restricted trade policies pursued by some foreign countries, which insulate domestic prices from world price variability (see below for the details). As illustrated in Figure 2, trade equilibrium is allowed by the clearing of excess demands and supplies generated within each region. The model is a nonspatial partial equilibrium model: nonspatial because it does not identify trade flows between specific regions, and partial equilibrium because only one commodity is modeled. The countries or regions included are Australia, Argentina, Canada, China, the European Community (EC -12), India, Japan, U.S., USSR, Eastern Europe, Africa and Middle East, Other Asia, High Income East Asia, and Other Western Europe[1].

We computed the export demand elasticity under two scenarios -- restricted trade and free trade. The restricted trade scenario entails a world wheat market with some countries pursuing trade policies that would insulate their domestic prices from world price movements and thereby reducing the price transmission elasticities to significantly less than one (refer to Table 2).

As explained in the previous section we conducted a simulation analysis by exogenously shocking U.S wheat yields to measure the wheat export demand elasticities for the period 1988/89 to 1992/93. Since the elasticities are calculated for the future period, the model was simulated to project the endogenous variables using forecast values of the exogenous variables.

Figure 3, a replica of the U.S. trade diagram of figure 2, illustrates the short run response of export demand by means of a yield shock. Point A represents the original equilibrium. The new equilibrium after the yield shock is at point B. The elasticity of export demand is the percentage change in the quantity of exports divided by the percentage change in prices from point A to point B.

Table 3 presents the impacts of the exogenous yield shock on exports and gulf port prices. An increase in the U.S. wheat yield lowers world wheat prices leading to higher U.S. exports. In the first year of the analysis, the exports rise by 2.88 percent and gulf port prices decline by 5.25 percent, which imply a short-run response elasticity of -0.55. The longer-term adjustments can be seen by examining the responses from the later years. By the last year of the analysis, an export increase of 6 percent is associated with a price decrease of 3.05 percent leading to an export demand elasticity of -1.96 percent. As discussed earlier (refer to Figure 1) the long-run export response to price changes is larger than the short-run response.

Before examining the values of export demand elasticities under free trade, we would like to briefly explain the existing trade restriction policies in the world wheat market and the procedure used in liberalizing the trade.

The countries that pursue trade policies, which inhibit the transmission of world wheat price variability to domestic markets include

Table 2. Price transmission elasticities of wheat prices of selected foreign countries with respect to U.S. wheat gulf port prices[a]

Countries	Restricted Trade	Free Trade
European Community - 12		
Wheat intervention prices	0.02	0.98
Japan		
Wheat resale prices	0.28	0.99
India		
Wheat farm prices	0.29	1.00

[a]Elasticities are evaluated at mean values.

Table 3. Impacts of a 5 percent increase in U.S. wheat yields from 1988/89 to 1992/932 and U.S. wheat export demand elasticity

	1988/89	1989/90	1990/91	1991/92	1992/93
Restricted trade scenario					
U.S. wheat exports					
Base (million bu)	1460	1417	1449	1491	1535
Percent change	2.88	5.79	6.27	6.84	6.00
Wheat gulf port price					
Base ($/mt)	128.91	134.47	136.61	138.40	137.97
Percent change	-5.25	-8.20	-6.38	-5.25	-3.05
Implied export demand elasticity	-0.55	-0.71	-0.98	-1.30	-1.96
Free trade scenario					
U.S. wheat exports					
Base (million bu)	1513	1456	1495	1537	1581
Percent change	3.31	6.39	7.16	7.22	6.14
Wheat gulf port price					
Base ($/mt)	147.63	152.78	152.86	156.86	159.05
Percent change	-2.87	-4.73	-3.91	-3.23	-1.81
Implied export demand elasticity	-1.15	-1.35	-1.83	-2.24	-3.39

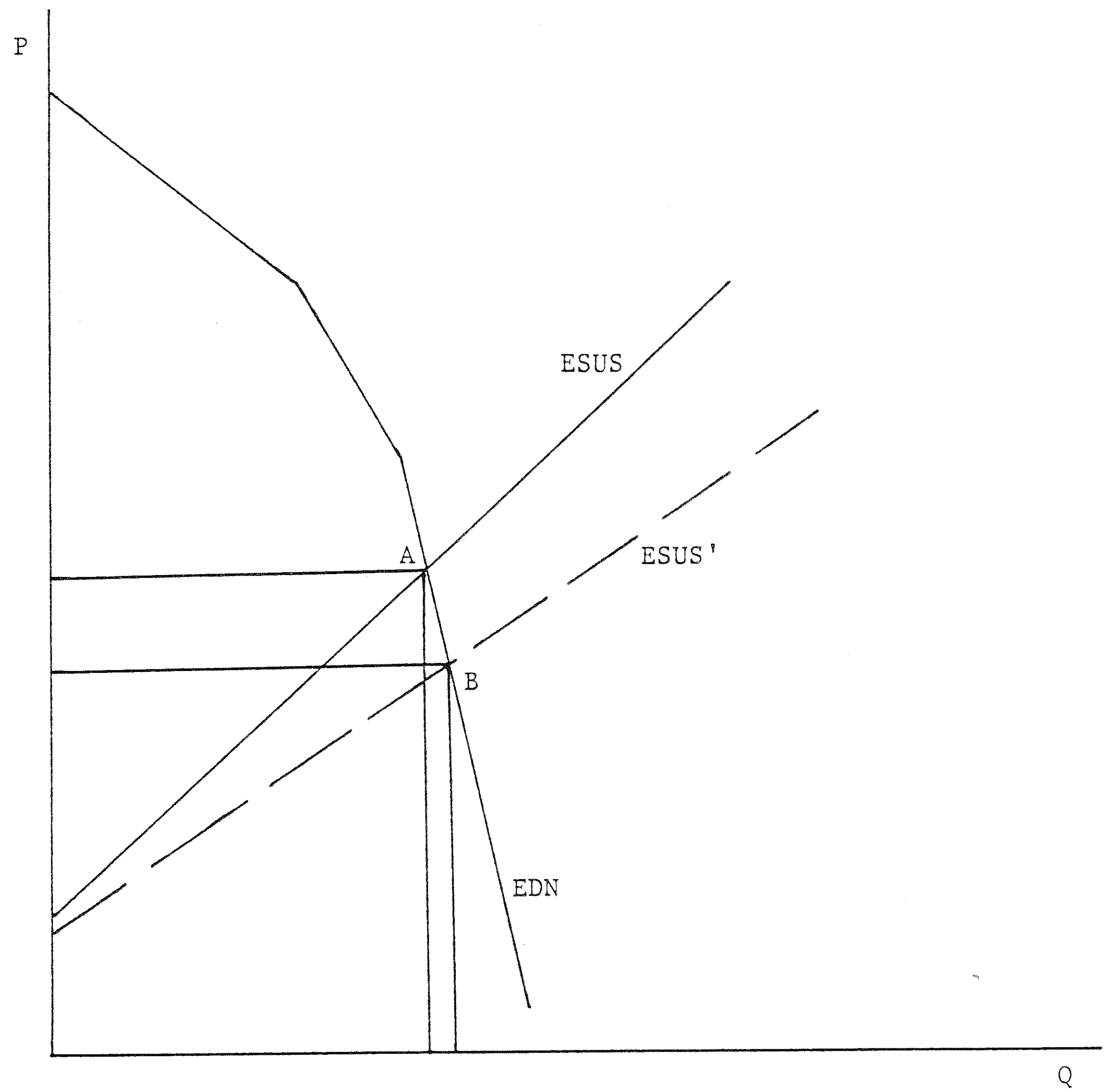


Figure 3. Short run elasticity of export demand under restricted trade scenario

the EC, India, Japan, Soviet Union, China, and Eastern Europe. It is assumed in this study that Centrally Planned Economies would not alter their domestic price insulation policies. So, the policies of only the EC, Japan, and India are considered for the trade liberalization. The EC maintains its domestic support prices well above the world prices, which creates perfectly inelastic excess supply for EC wheat below its support prices. This inelastic excess supply of EC wheat makes the aggregate export supply (ESO) of all competing exporters kinked and less elastic (see figure 2). Japan and India also maintain their domestic prices above the world prices and thereby generate inelastic excess demand curves below their respective domestic prices, resulting in an aggregate world import demand curve (EDT) that is kinked and less elastic. As a result of restricted trade policies in these countries, the export demand curve facing the United States is kinked and less elastic as it is derived from the kinked and less elastic import demand curve (EDT) of all importers and export supply curve (ESO) of all other exporters.

In the trade liberalization scenario, the trade barriers and domestic price insulation policies of these three countries are eliminated. For the EC, the Rotterdam prices of wheat and corn are used as border prices to replace the respective threshold prices. In addition, since the intervention prices are well above the world prices, the Rotterdam prices of wheat are also used to reflect the intervention prices of wheat. For Japan and India, wheat border prices are constructed by adding transport cost to the Gulf port prices of wheat. A similar procedure is followed in generating sorghum border prices for India. For all three countries, these changes led to lower internal prices. Removal of trade restrictions makes the export demand curve facing the U.S. in Figure 2 more elastic. Furthermore, these policy changes of moving toward free trade imply that the price transmission elasticities of these countries are close to one (refer to Table 2).

After eliminating the price insulation policies a baseline simulation was run to obtain the reference values. Then the impact analysis of a 5 percent increase in U.S. wheat yields was repeated to estimate the values of export demand elasticities under free trade. Figure 4, which is the same as Figure 3 but with the more elastic export demand curve included, illustrates the computation of export demand elasticities. The short run elasticity of export demand is computed as the ratio between the percent change in the quantity of exports to the percent change in the wheat gulf port prices from point A' to B'.

The results of the analysis are given in table 3. The short run response elasticity of exports relative to price is -1.15 and the long run implied elasticity is -3.39. Comparison of elasticities under restricted trade and free trade scenarios indicate that the elasticity of export demand would increase if agricultural trade moved toward free trade. The short run elasticity under restricted trade policies is inelastic at -0.55, but under free trade it is elastic at -1.15. These results also exemplify the importance of the price transmission elasticities in calculating the elasticity of export demand, i.e., as the price transmission elasticities approach one the elasticity of export demand increases. The long run export demand elasticity is -1.96 under restricted trade and -3.39 under free trade, which indicate that in the long run, as in the case of the

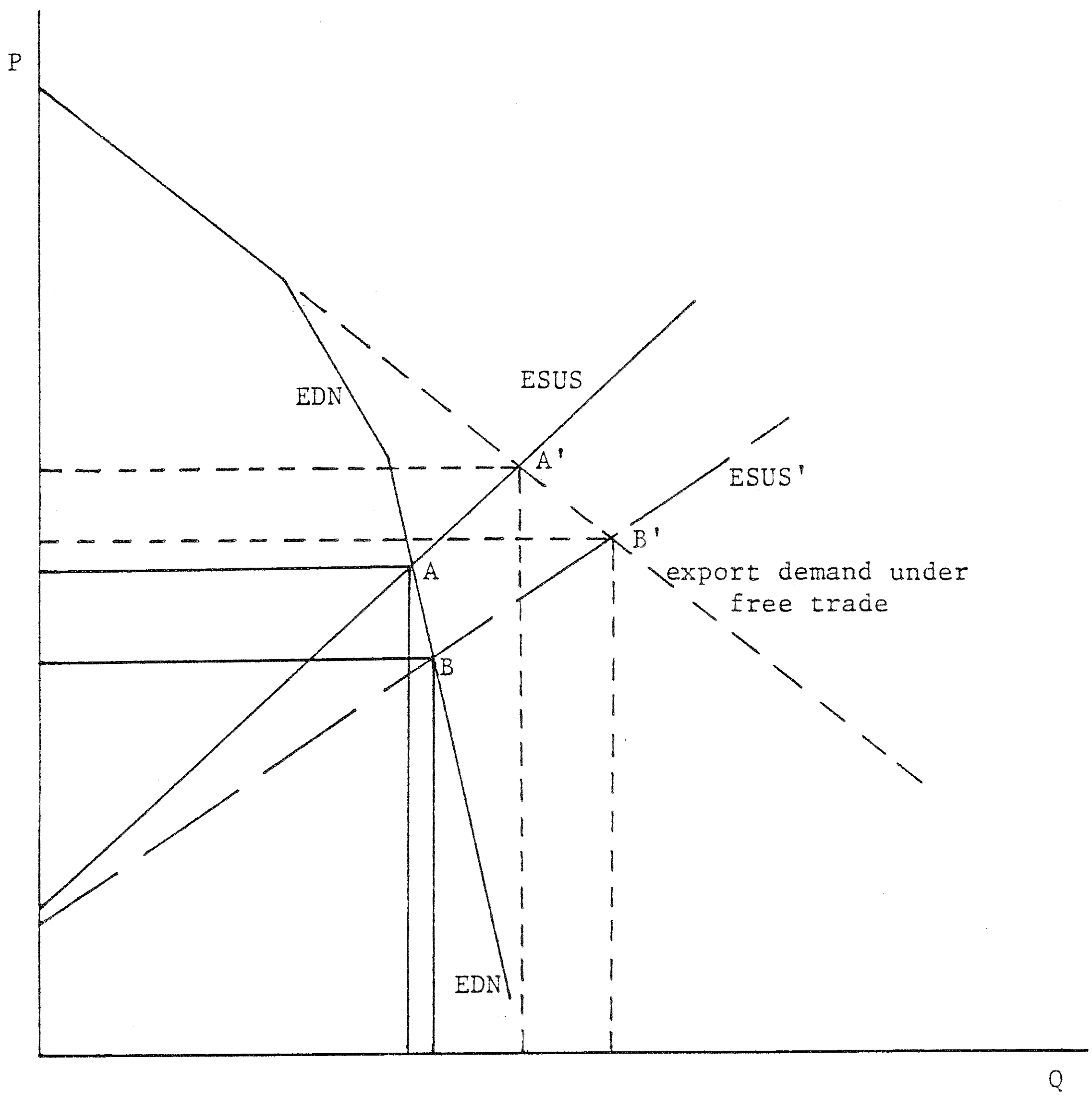


Figure 4. Short run elasticity of export demand under restricted and free trade scenarios

short run, the elasticity of export demand is higher (more elastic) under free trade than under trade restriction.

The magnitude of the elasticities estimated by the model depends on specification, regional disaggregation, period of analysis, and other factors. The important point to note is that the removal of trade barriers would increase the elasticity of U.S. export demand.

5. Conclusions and Implications

In this study, we focused on some of the factors that influence the magnitude of U.S. export demand elasticities. These factors include the quantity of U.S. trade in relation to the ROW quantity demanded and supplied, price transmission elasticities, and trade barriers. The empirical results show that if the ratios ROW demand/ U.S. exports and ROW supply/U.S. exports decline, the value U.S. export demand elasticity will also decline. Furthermore, the results indicate that trade barriers of foreign countries aimed at insulating domestic markets from international price movements thereby reducing the price transmission elasticities will lower the export demand elasticity. Conversely, free trade in agriculture will increase the elasticity of U.S. export demand.

The U.S. has proposed in the GATT negotiations to phase out all domestic and trade policies that affect agricultural trade over a ten-year period. The results of this study indicate that such trade liberalization will increase the magnitude of U.S. export demand elasticities substantially. The most important consequence of this change may be the extent to which the more elastic behavior of exports reduces price variability in world markets.

Footnotes

[1]Readers interested in the structure of the FAPRI wheat trade model can refer to Devadoss S., M.D. Helmar, W.H. Meyers (1987).

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