APPLICATION OF PRICE ELASTICITIES TO FARM POLICY ANALYSIS

W. Lanny Bateman and Earl A. Stennis

Much dialogue has been devoted to the "farm problem" by both the public and private sectors in recent months. Expressions of concern about chronic low farm income because of low prices received have again become common. Numerous proposals have been offered as solutions to the problem.

It is of concern to the authors that many of these proposals emphasize production control as means of maintaining adequate farm price levels. Economists routinely receive training in the concepts of demand and supply response which, although difficult to quantify, offer easily understood market principles. For example, elasticity of demand can be used to show U. S. farmers how actions taken to reduce domestic production could be less than beneficial to the producer. Perhaps economists have failed to apply some of these concepts in the evaluation of policy alternatives or have not clearly demonstrated the effects (particularly long-run) of unilateral actions taken by the United States.

The purpose of this article is to present an example of the use of demand elasticities in farm policy analysis. Two somewhat different approaches are used to demonstrate the importance of the world market to U. S. farmers with soybeans and cotton as examples.

ANALYTICAL PROCEDURE

The concept of elasticity offers a useful tool for economic analysis of certain policy alternatives. Certain limitations must be considered, but if demand elasticity coefficients are obtainable, published data are readily available to complete an initial evaluation of selected actions.

It has been well documented in economic literature [10, 13] that the elasticity of demand in a market for a product is the weighted sum of the elasticities from every submarket (weights are based on relative quantities sold in each market). Thus, if the total demand curve (or elasticity) is known, a selling country can analyze the impact of a supply change on the market. As an example, the market for U. S. soybeans is examined in terms of various elasticity estimates to demonstrate the problems incurred with policy alternatives requiring unilateral action by U. S. producers. First a total world market approach is used and then the demand for U. S. soybeans is separated into domestic and foreign markets to facilitate exposition.

In determining an appropriate agricultural policy, the United States cannot ignore the world market. Total U. S. production of soybeans is about 50 percent of world production, and about one half of the domestic production of soybeans is exported. As Tweeten [9] illustrates, a country will export as long as the domestic price in the absence of foreign trade is less than price in the foreign market minus transportation and handling costs. Thus, world prices less transportation costs tend to be an upper limit on prices paid by an exporter, and also the lower limit on price for selling in the world market. A change in relative price relationships—domestic prices rising above world price plus transportation costs—could reverse the flow of trade.

The possible effects of a 30 percent reduction in U. S. soybean production on world price levels and the net elasticity effect for the U. S. (base year = 1976) are illustrated in Table 1. (Net elasticity refers to the realized price response to the U. S. It is not equivalent to the world demand elasticity because the U. S. only has a portion of the market.) It should be emphasized that this scenario pertains to unilateral actions taken by U. S. producers. The 30 percent reduction is somewhat arbitrary; however, it is approximately the magnitude suggested by some proponents of production controls. Also, elasticities are generally considered appropriate only over a relatively small range. Although a change of the magnitude discussed here would certainly not be small, the authors believe such a large change would mean a more elastic response and this would not change the conclusions presented.

As the table indicates, the net elasticity in

W. Lanny Bateman and Earl A. Stennis are Associate Professor and Professor, respectively, Department of Agricultural Economics, Mississippi State University.

Mississippi Agricultural and Forestry Experiment Station Journal Series No. 4002.

the U. S. market is greater than that in the world market. This is generally the case for agricultural products unless the U. S. is the sole supplier. Even if the U. S. is the dominant or primary supplier, the price response to U. S. supply changes tends to be more elastic in the U. S. than in the world market. Further, if the elasticity of demand coefficient for the world market is equal to the proportion of the market supplied by an exporter (in decimal form), the net elasticity to that exporter is unitary. For example, with an elasticity of −.5 and a market share of .5 or 50 percent, the exporter will face a unitary response. For elasticities greater than the market share, the net response would be elastic meaning price changes would not be as great proportionally as quantity changes.

Because of the greater elasticity for the U. S. (Table 1), even in an inelastic world market the price benefits occurring from a unilateral action by the U. S. would accrue to the nation's competitors. This benefit would be due to two factors. First, with no change in their production levels the competitors would inherit a greater market share. Second, it is likely that other producers would increase production in response to the higher price, thus further increasing their market share and reducing the level of price change.

A second approach to estimating the demand response to supply changes offers some useful insight into the importance of selected components of the market [6, 9]. If the market for U. S. soybeans is separated into its foreign and domestic components, the level of demand for U. S. exports can be expressed as:

$$X = D_w - S_w \tag{1}$$

where X is the volume of exports, D_w is the demand component for the rest of the world, and S_w is the supply from the rest of the world. That is, the export demand for U. S. soybeans is the level at which foreign or world demand exceeds the rest of the world supply at a given price (i.e., the rest-of-world demand function below its intersection with the rest-of-world supply). Differentiating this function with respect to price and solving for the elasticity of demand for exports equation:

$$e_x = e_w \frac{D_w}{X} - e_s \frac{S_w}{X} \tag{2}$$

where e_x is the export elasticity, e_w is the demand elasticity in the rest of the world market, e_s is the supply elasticity in the rest of the world, and X, D_w, and S_w are base quantities as defined in equation 1.

Using Johnson's [6] estimates of −.04 elasticity of demand for soybeans at the world level and a world supply elasticity of .02, one can estimate the export elasticity for U. S. soybeans. Using 1976 as the base year [1], the weights D_w/X and S_w/X for equation 2 can be derived.

The supply weight is readily available from published statistics; however, D_w is not easily obtained. As estimate of demand weight can be derived from the relationship in equation 1. Because $X = D_w - S_w$, $D_w/X = S_w/X + 1$.

Given U. S. exports of 564.1 million bushels in 1976 and rest-of-world production of 1,275.2 million bushels, $S_w/X = 2.2608$ and $D_w/X = 3.2608$. Then:

$$e_x = (-.4)(3.2608) + (-.2)(2.2608) = -1.76 \tag{3}$$

or, export demand for U. S. soybeans is highly elastic.

Using the export elasticity with domestic elasticity, one can estimate the total elasticity of demand for U. S. soybeans as the weighted sum of domestic and export elasticities, or:

$$e_t = e_d W_1 + e_x W_2, \tag{4}$$

where e_t is total elasticity, e_d is domestic elasticity, and W_1 and W_2 are proportions of U. S. production utilized domestically and exported, respectively. Thus, using Johnson's estimate of domestic elasticities,

$$e_t = (-.35)(.554) + (-1.76)(.446) = -0.98. \tag{5}$$

This figure indicates that total elasticity for soybeans is close to unitary, or roughly comparable to the net effect of a −0.5 elasticity at the world level as presented in Table 1.

TABLE 1. ESTIMATED WORLD PRICE OF SOYBEANS DUE TO A 30 PERCENT REDUCTION IN UNITED STATES SOYBEAN PRODUCTION FOR VARIOUS ASSUMED WORLD ELASTICITIES[a]

World Demand Elasticity	-.35	-.4	-.5	-.75	-1.0	-1.2
Percent Price Change	42.7	37.4	30.0	19.9	15.0	12.0
Estimated Price dol./bu.	$11.28	$10.86	$10.27	$9.52	$9.09	$8.86
Net U. S. Elasticity	-.7	-.8	-1.00[b]	-1.51	-2.00	-2.51

[a]World price of $7.91 per bushel was calculated as the average of monthly Rotterdam prices from October, 1976 through September, 1977. U. S. production was 49.8 percent of world production [1], therefore, a 30 percent cut in U. S. production would result in a 14.9 percent reduction in world production.

[b]Rounded.

The following implications can be drawn from an analysis of the market components that are not intuitively obvious from Table 1. From equation 2, in order to have an inelastic export market, either the world demand must be extremely inelastic or exports from the U. S. must be high in relation to world demand or supply. Further, the supply elasticity for the rest of the world is an important variable. **There is some evidence that this coefficient may be greater than the 0.2 found in past studies (e.g., the recent rapid expansion in Brazilian production). In equation 3, a supply elasticity of 0.3 would mean an export elasticity of −2.0.**

This tendency for the world market to be elastic merits careful consideration in the formulation of farm policy. The reduction in export sales resulting from attempts to raise farm prices would reduce revenues from foreign sales. This in turn would worsen an already deficit balance of payments.

Production cuts will tend to move the U. S. toward the more inelastic portion of the demand curve, as is demonstrated in equation 4. As W_2 decreases, more weight is given the inelastic domestic market. Reduction of production in an inelastic market will increase total revenue in that component of the market; however, this effect would occur at considerably lower levels of production than are typical today. Whether farmers would benefit from higher prices at a loss of more than 40 percent of the market volume is questionable.

Looking specifically at cotton, one finds that many elasticities are reported and that a "typical" short run elasticity ranges from −.25 to −.40 [2, 3, 4, 7, 8, 11]. Thus superfically it appears that the producers would improve their lot by restricting production and enjoying higher prices and total revenues. In addition, the producers would be expected to save the variable costs associated with the diverted acreage. Given an elasticity of −.35, the **short run price flexibility for cotton would be** −2.86. A 2.86 percent increase in price would be associated with each 1 percent decrease in production. If one assumed 53 cents per pound as a starting point for the 1977 crop, a 33 percent decrease in production would imply a price increase of 94 percent or 50 cents, to a price of $1.03 per pound. Such a casual analysis may be the basis for the support of proposals for reducing domestic production.

It is unlikely that the foregoing scenario could materialize or hold for an extended period (unless inflation raises overall price levels). First, the available elasticities were developed over a relatively narrow range of data. They are not adequate for an extended extrapolation. Second, the available elasticity estimates are based on U. S. prices, consumption, and supplies. Realistically one cannot consider U. S. supply and demand in the absence of the world situation. Further, demand price elasticities may not fully account for substitute products and competition. U. S. prices are very dependent on world production and supply. In the recent past, annual production fluctuations for the U. S. and world have been similar in direction and proportion — these fluctuations essentially being a function of both prices and weather.

Even with comparable elasticities for the U. S. and the world, a unilateral acreage reduction by the U. S. would not have the same effect as for the market in isolation. Because the U. S. has averaged only 19 percent of world cotton production since 1970, it would follow that a 33 percent reduction in U. S. production would in fact cause a reduction in world production/supply of only 6.27 percent. If the price flexibility (−2.86) is applied to the 6.27 percent decrease in production, a price increase of 17.9 percent to 62.5 cents is indicated. Several points can be inferred from these figures. First, it is clearly not possible to restrict the benefits resulting from an acreage reduction to U. S. producers. Second, under the assumed conditions, total U. S. farm receipts from cotton will decrease; i.e., an acreage reduction may in fact reduce net farm income.

A 33 percent decrease in production may raise even more serious questions when viewed from the long run perspective. As with short run elasticity, estimates of long run elasticity vary [2, 3, 4, 7, 8, 11]. For the purposes of this analysis long run elasticity was assumed to be −1.5. A −1.5 demand elasticity yields a price flexibility of −.67; every 1 percent change in quantity would change price by .67 percent. This also means that in the long run, acreage restrictions would decrease farmers' income from cotton. In fact, if producers were to cut production by 33 percent, one would anticipate that in the long run prices would still be above the original level but that total revenue from cotton marketed would have decreased. With an assumed 1977 price of 53 cents, price would be expected to increase to 65 cents but the lowered gross income could mean less net income or profit, *even if* U. S. producers operated in an isolated market.

The logic applied to the short run situation can be applied to illustrate an even greater negative impact in the long run. Again, a reduction in U. S. production of 33 percent would mean a reduction in world production of only 6.27 percent. If the price flexibility (−.67) is applied to this 6.27 decrease in production, a

price increase of only 4.2 percent is indicated. Given the assumed 1977 price of 53 cents, a long run price of only 55.2 cents would be indicated. The implications drawn from this scenario are similar to those from the short run example — benefits of a domestic acreage reduction cannot be limited to the U. S. and total U. S. receipts from cotton will decrease. Even with an inelastic price in both world and domestic markets, the real effect of a unilateral reduction in production by one country is modified by its relationship to the world market.

To properly weigh possible short run benefits against long run costs of an acreage reduction program, one must have some idea of the time interval in which short run concepts would be applicable. At best, they would be applicable for one year and any benefits would diminish with each succeeding year.

LIMITATIONS AND CONCLUSIONS

Several factors limit the numerical accuracy of this analysis. As mentioned, elasticity coefficients generally hold over a small range and cross-elasticities were not considered; thus the elasticities used at any given level would tend to be conservative. There are a number of substitutes for the commodities used as examples that would tend to make demand response more elastic, at least over time. Without consideration of these points, the price response will tend to be overstated. Also, this article does not include analyses for output reductions of less than 30 percent; however, the conceptual argument is consistent for any level.

The analysis indicates that farm policies using supply control as a tool to maintain farm income will not succeed if pursued only in the U. S. — at least for cotton and probably for soybeans. The same conclusion can be inferred for other commodities unless their world market is almost perfectly inelastic and/or the U. S. is the only or dominant source of supply. This conclusion is readily recognized by most economists. But the number of proposed farm bills and requests for policies that call for acreage controls by some groups indicate that economists have not presented the information clearly.

The analysis used here illustrates an application of traditional economic theory that can be presented rather easily. The importance of the world market and competition from other producers is demonstrated explicitly, and can be summarized without resorting to economic jargon.

The authors are not suggesting that elasticities can be used alone in developing farm policy. However, elasticities can serve as useful reference points in determining the impact of certain decisions and can offer clues as to where acceptable alternatives can be found. One example would be the potential payoff from trade agreements with competing suppliers. Of course, an even more basic question is whether policy directed to maintaining price will provide adequate farm income given production uncertainties.

REFERENCES

[1] *Agricultural Statistics,* 1976, USDA. Washington, D.C.: U. S. Government Printing Office, 1976.

[2] **Donald, J. R., Frank Lowenstein, and S. Simon Martin.** ***The Demand for Textile Fibers in the United States,*** Technical Bulletin No. 1301, U. S. Department of Agriculture, 1965.

[3] Dudley, George E. *Demand for Textile Fibers in the United States: Estimation of Price Elasticities in Major End-Use Markets,* National Economics Analysis Division, Economic Research Service, 1965.

[4] Foote, Richard J. *Analytical Tools for Studying Demand and Price Structures,* Agriculture Handbook No. 146, U. S. Department of Agriculture, 1958.

[5] Hauck, J. P. and J. S. Mann. *An Analysis of Domestic and Foreign Demand for U. S. Soybeans and Soybean Products,* University of Minnesota Agriculture Experiment Station Technical Bulletin 256, 1968.

[6] Johnson, Paul R. "The Elasticity of Foreign Demand for U. S. Agricultural Products," *American Journal of Agricultural Economics,* Volume 59, 1977, pp. 735-736.

[7] Lowenstein, Frank. "Factors Affecting the Domestic Mill Consumption of Cotton," Agricultural Economic Research, W-2, U. S. Department of Agriculture, 1952.

[8] Stennis, Earl A. *Development of Quantitative Models for Use in the Projection of Domestic Mill Consumption of Cotton Fiber,* Department of Agricultural Economics, Mississippi Agricultural and Forestry Experiment Station AEC. Technical Publication No. 16, March 1977.

[9] Tweeten, Luther. "The Elasticity of Foreign Demand for U. S. Agricultural Products: Comment," *American Journal of Agricultural Economics,* Volume 59, 1977, pp. 737-738.

[10] Tweeten, Luther. *Foundations of Farm Policy,* Lincoln: University of Nebraska Press, 1970.
[11] Ward, Lionel and Gordon A. King. *Interfiber Competition with Emphasis on Cotton: Trends and Projections to 1980,* U. S. Department of Agriculture, Economic Research Service, Bulletin No. 1487, 1973.
[12] Waugh, Fredrick V. *Graphic Analysis: Applications in Agricultural Economics,* Agriculture Handbook No. 326, U. S. Department of Agriculture, 1966.
[13] Waugh, Frederick V. *Demand and Price Analysis,* Bulletin No. 1316, U. S. Department of Agriculture, 1964.