Returns to Soybean Producers from Investments in Promotion and Research

Gary W. Williams, C. Richard Shumway, and H. Alan Love

U.S. soybean producers have been cooperatively investing in both production research and demand promotion for nearly four decades to enhance the profitability and international competitiveness of their industry. Have producers benefitted from their contributions to soybean checkoff program activities over the years? How has the return to investments in soybean production research compared to that of soybean demand promotion investments? The overall positive returns to producers over the study period resulted primarily from promotion activities. Production research contributed negatively to overall producer returns from soybean checkoff investments.

Key Words: benefit-cost analysis, checkoff program, promotion, research, soybeans

Over the last several decades, a large and growing number of programs have been established to promote cooperative investment by commodity producers in activities designed to enhance the profitability and competitiveness of the commodities they produce. Before 1990, producer contributions to many of these programs in most states were facilitated primarily by state legislation requiring producers to pay (or "check off") a small fraction of the value of each unit produced. National checkoff programs for four key commodities (beef, pork, corn, and soybeans) were mandated by the 1990 farm bill.[1] While virtually all commodity checkoff organizations invest in generic commodity promotion and related activities in an attempt to enhance demand, many also invest a considerable portion of checkoff funds in production research.

Analyses of the effectiveness of commodity checkoff programs have proliferated along with the programs themselves. Much of this research has focused on the benefits to producers from funded generic promotion activities (Williams and Nichols, 1998). Only a few studies have considered the returns to producers from checkoff investments in production research (e.g., Lim, Shumway, and Love, 2000). Likewise, producer returns across both demand promotion and production research activities and the implications of the allocation of checkoff funds between promotion and production research have received relatively little attention (e.g., Wolgenant, 1993; Chyc and Goddard, 1994).

This study considers the case of the soybean checkoff program to illustrate the potential joint and relative net returns to producers over time from the simultaneous investment of checkoff funds in both promotion and research activities. A brief review of the soybean checkoff program is followed by a consideration of relevant theoretical and measurement issues and a discussion of the methodology and data employed in the subsequent benefit-cost analysis of the program. The analytical results lead to conclusions and implications regarding the management of

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[1] Food, Agriculture, Conservation, and Trade Act of 1990, P.L. 101-624, 104 Stat. 3838-3928, Nov. 28, 1990, Title XIX.

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commodity checkoff investments and the allocations of funds between promotion and research activities.

The Soybean Checkoff Program

Since at least the mid-1950s, investments in U.S. soybean production research and demand promotion have been funded by a combination of private and public funds. For many years, the private funds consisted primarily of state-legislated checkoff contributions by producers of ½ to 2 cents per bushel sold. A national soybean checkoff program was launched in 1991 under the Soybean Promotion, Research, and Consumer Information Act of 1990.[2] Subsequently upheld in a required referendum, the program mandates soybean producer participation at the rate of 0.5% of the market price per bushel when the crop is first sold. The right to demand a refund was terminated in a second required referendum. Even so, the 1996 farm bill[3] requires a periodic evaluation of the effectiveness of the national soybean checkoff program and allows for periodic referenda to determine if soybean producers favor its continuance, suspension, or termination.

About half the funds collected under both the previous state-level programs and the current national mandatory program have remained in the states and been managed by state-level soybean-producer-controlled associations or boards. The state-level organizations have invested the largest portion of their checkoff funds in soybean production research (SPR) with only a minimal amount allocated to domestic demand promotion (DDP) programs. These groups have only rarely invested directly in foreign market development (FMD) activities.

The other half of the funds collected have been managed by a national soybean organization (the American Soybean Association prior to the national mandatory program and the United Soybean Board since that time) which has allocated most of its funds to support SPR and a large FMD program to promote U.S. soybean and soybean product export demand. The national organization has allocated only a small amount of funds to DDP programs. From 1978 to 1995, total soybean checkoff funds invested in SPR and FMD activities amounted to $163 million [Texas Agricultural Market Research Center (TAMRC), 1998a, b].

Soybean FMD checkoff investments have also been supported by private, in-country funds from third-party contributors and public funds through the U.S. Department of Agriculture's (USDA's) Foreign Agriculture Service (FAS) Cooperator Program, bringing total[4] checkoff investments to $350 million between 1978 and 1995 (TAMRC, 1998a). Public SPR investments have included research conducted by national organizations (such as the USDA's Agricultural Research Service) and by state agricultural experiment stations.

Despite rapid growth in total checkoff investments between 1978 and 1980, the annual rate of growth declined steadily thereafter through 1991, turning negative in most years after 1985. Implementation of the national soybean checkoff program in 1991 effectively reversed the downward trend and signaled a major shift in investment strategy. FMD consistently accounted for about 85% of the total soybean checkoff investment in the 1970s and 1980s. After 1990, an increasingly greater share of soybean checkoff dollars was allocated to SPR, reaching 43.5% by 1995. Over the entire 1978 to 1995 period, FMD and SPR accounted for 77% and 23% of total checkoff investments, respectively (TAMRC, 1998a, b).

Notwithstanding the millions of dollars spent on both SPR and FMD over the years, however, the investment intensity of the soybean checkoff program, i.e., the level of investment compared to farm sales, has been typically low. Between 1978 and 1995, total soybean checkoff investments amounted to only 0.08% to 0.20% of total soybean farm cash receipts each year (TAMRC, 1998a, b).

Theoretical and Measurement Issues

A primary objective of the soybean or any other commodity checkoff program is to foster the growth and profitability of the production of that commodity. The producers contributing to a checkoff program expect the funds will be spent in such a way that they are better off than they would have been without the program. Investments in research offer the potential for increased producer profits through technological advances that reduce production costs and/or boost yields (i.e., output per unit of input).

[2] 7 U.S.C. 6301-6311; 56 F.R. 31048-31068, codified in C.F.R. pt. 1220.

[3] Federal Agriculture Improvement and Reform Act of 1996, P.L. 104-727, 7 U.S.C. 7201 *et seq.*, Title V.

[4] References to "total" soybean checkoff investments include not only grower checkoff funds invested in SPR and FMD activities, but also the related FMD funds contributed by the USDA/Foreign Agriculture Service and third-party contributors in the countries of investment. Not included are the minimal amounts of state and national checkoff funds expended on domestic promotion programs because of the poor quality of the data on those programs.

Investments in demand-promoting activities, on the other hand, are intended to increase producer profits by shifting out demand, and thereby increase the market price on a higher volume of sales over time. Estimating the benefits that may accrue to producers from either type of investment, however, necessitates consideration of a number of theoretical and measurement issues.

Investments in Research

Major contributions to both the theory and measurement of the returns to producers from investments in agricultural production technology development and implementation have been made by a variety of researchers (e.g., Schultz, 1953; Griliches, 1958; Evenson, 1967; Peterson, 1967; Fox, 1985; Pardey and Craig, 1989; and Chavas and Cox, 1992). Norton and Davis (1981) document some of the basic approaches used to measure the returns to research. In this literature, estimates of the rate of return to agricultural research have been remarkably high, with nearly all exceeding 25% and some surpassing 100% (see Tweeten, 1970; Evenson, Waggoner, and Ruttan, 1979; Fuglie et al., 1996).

A growing literature has addressed possible errors in earlier methods and questioned the assumptions made in measuring research benefits. This latter literature generally concludes that the measured returns to producers from research can be either positive or negative depending on specific assumptions made on functional form, type of supply curve shift, and elasticities of supply and demand. Linder and Jarrett (1978); Rose (1980); Miller, Rosenblatt, and Hushak (1988); Voon and Edwards (1991); Elbasha (1997); Edwards and Voon (1997); and others have shown the effect of research on producer welfare is ambiguous and depends critically on at least three factors: (*a*) the effect of the research on the supply curve, (*b*) the relative slopes at equilibrium of the supply and demand curves, and (*c*) the form of the supply curve.

In general, this literature demonstrates that a parallel or convergent research-induced shift in supply will unambiguously lead to an increase in producer welfare. A divergent (pivotal or proportional) shift in supply, however, can decrease producer welfare if the absolute value of the slope of the demand curve is less than the slope of the supply curve.[5] The latter case is of interest because the demand for agricultural products is most often represented as price inelastic.[6]

Furthermore, because commodity supply curves are more likely to take a constant elasticity rather than a constant slope form, and because "the use of a nonlinear, constant elasticity specification of the supply curve and a pivot shift due to research is usually preferred to use of a linear supply curve with a pivotal shift" (Voon and Edwards, 1991, p. 419), measured producer welfare could quite plausibly decline as a result of investments in research.

Whether positive or negative, the effects of investments in research on producer welfare are often not immediate and may not be directly measurable. Because the lag between a research investment and the commercialization and adoption of new related technology can be lengthy, the full market impacts, and any benefits to producers, may not be realized for some time following the research investment (Wohlgenant, 1993). This is particularly the case for investments in basic research.

At the same time, investments in production research may not always have measurable market effects. For example, basic or applied research that provides knowledge about what does *not* work in increasing yields or reducing costs may have economic value but is not measurable in terms of market impacts. Also, applied research often is related to or depends on previous investments in basic research. Basic research, often characterized by public investments, may have only indirect market effects as investments in related but more applied research like that funded by many checkoff programs leads to the development of new technologies and processes for adoption by producers. Consequently, the measurement of the benefits to producers from public and private investments in research within a given time period may underestimate the total impact of those investments.

The research benefits to producers of various commodities have been analyzed, including corn

[5] For a proportional linear shift, the reduction in slope must be sufficiently large compared to the reduction in the intercept in order for producer welfare to decline (see Miller, Rosenblatt, and Hushak, 1988).

[6] Some researchers (e.g., Schuh, 1984) have argued that while the domestic market demand for agricultural products tends to be fairly price inelastic, export demand tends to be quite price elastic. Consequently, total demand (domestic plus export demand) for agricultural products could well be elastic. Many other researchers (e.g., Schmitz, 1988; Bredahl, Meyers, and Collins, 1979), however, contend the increasing prevalence of protectionism in world markets, including import quotas and nontariff barriers of all types, state trading, and other institutional arrangements "make the excess [export] demand curve facing the U.S. relatively price inelastic" (Schmitz, 1988, p. 300). If the export demand for an agricultural product is indeed price inelastic, then the total demand for that product is likely price inelastic. Therefore, a research-induced outward shift in supply could well result in a loss in producer welfare.

(Griliches, 1958), poultry (Peterson, 1967), cotton (Ayer and Schuh, 1972), rice (Akino and Hayami, 1975; Flores-Moya, Evenson, and Hayami, 1978), rapeseed (Nagy and Furtan, 1978), wheat (Zentner and Peterson, 1984), wool (Mullen, Alston, and Wohlgenant, 1989; Scobie, Mullen, and Alston, 1991), and soybeans (Lim, Shumway, and Love, 2000).

Investments in Demand Promotion

Measuring the returns to producers from demand promotion is complicated by a number of well-documented characteristics of the response of sales to advertising and promotion, including, for example, a lagged effect of promotion expenditures on sales, the tendency for promotion effects to carry over from one period to another, and both the decay of promotion effects and the wearout of a promotion program over time (Williams and Nichols, 1998). The consensus across a broad range of empirical research over a large number of agricultural and food products is that the promotion response of sales is normally quite small but the increase in sales revenues is generally larger than the costs of the related promotion, i.e., promotion pays (Williams and Nichols, 1998).

The most studied commodities over the years have been milk and milk products in the United States and Canada. Among the other, more salient studies of the returns to producers from advertising and promotion are those focusing on meat, fats and oils, citrus juices, apples, wool, avocados, catfish, and cotton.

Measuring the producer returns from investments in the promotion of demand is further complicated by the supply response over time to promotion-induced price changes. A promotion program that successfully raises price may also stimulate a supply response over time which could moderate the extent of the price increase and any producer gain. Therefore, the producer returns from a promotion-induced demand increase depend on the long-run price elasticity of supply. Given the intensity of competition in world soybean markets, the long-run world soybean supply curve is likely elastic. Thus, soybean checkoff-supported FMD investments might be expected to benefit producers, but with only a small positive long-run effect on price.

The problem of advertising response in an industry without supply controls was first discussed in a classic article by Nerlove and Waugh (1961). A number of empirical studies have reported that the supply response to producer-funded promotion programs can effectively prevent a long-term rise in producer price. In a study of the effectiveness of the soybean FMD program of the 1970s and early 1980s, Williams (1985) concluded that although the program was effective in expanding export demand and generated a high benefit-cost ratio, the farm price of soybeans was not much affected as the result of supply expansion. Kinnucan, Nelson, and Xiao (1995) determined that supply response completely eliminated returns to catfish advertising over time. Carman and Green (1993) found that while avocado producers benefitted from generic advertising during the initial years of the program (1960s through mid-1970s), supply expansion from continued advertising eventually led to negative producer returns.

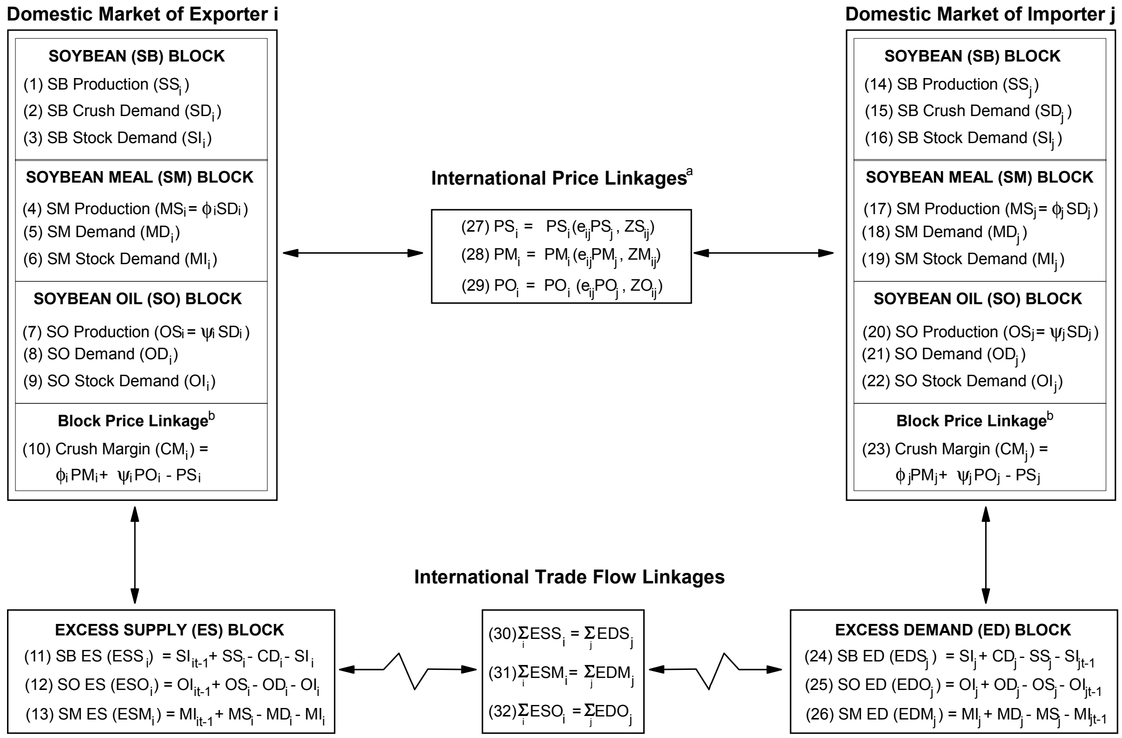
Methodology and Data

To measure and compare the returns to soybean checkoff program investments in research and demand promotion, the first step was to isolate the effects of those investments in domestic and foreign soybean and soybean product markets from those of other events which may have affected those markets over the years. For this purpose, soybean checkoff research and foreign demand promotion stock variables were constructed and incorporated into a world model of soybeans and soybean products. The model was then simulated over the 1978 to 1994 period under alternative assumptions regarding soybean checkoff research and demand promotion investment levels and the results used to calculate benefit-cost ratios for both types of investments.

The World Soybean and Soybean Products Model (*SOYMOD*)

The analysis of the returns to producers from the soybean checkoff program in this study utilizes a 186-equation, annual econometric, nonspatial, price equilibrium simulation model of world soybean and soybean product markets (SOYMOD) (for further details, the reader is referred to Williams, 1985; Williams et al., 1998; and Williams, 1999). Because they all have their roots in the early work of Houck, Ryan, and Subotnik (1972), SOYMOD is similar in form and specification to the world oilseed models utilized by Meilke and Griffith (1983), and more recently by Meilke, Wensley, and Cluff (2001).

SOYMOD allows for the simultaneous determination of the supplies, demands, prices, and trade of



Note: i = any exporter {i = 1, ..., n}; j = any importer {j = 1, ..., k}.
[a] The Z_{ij} represent all border instruments such as tariffs, taxes, subsidies, and transport costs that force a wedge between the internal prices of countries i and j. The e_{ij} are the exchange rates.
[b] N and ψ are meal and oil extraction rates; PS, PO, and PM are soybean, soyoil, and soymeal prices.

Figure 1. World soybean market model (SOYMOD) structure

soybeans, soymeal, and soyoil in six major world trading regions: the United States, Brazil, Argentina, the European Union, Japan, and a Rest-of-the-World (ROW) region. The domestic market of each region in the model is divided into four simultaneous blocks of equations: a soybean block, a soybean meal block, a soybean oil block, and an excess supply or excess demand block (figure 1). For each region, the first three blocks contain behavioral relationships specifying the manner in which soybean supply (acreage planted, acreage harvested, soybean yields, and production), soybean domestic demand (crush and stocks), and the supply, consumption, and stocks of soybean meal and soybean oil behave in response to changes in variables like prices of soybeans and products, prices of various competing commodities, technology, income, livestock production and prices, government policy, etc., as appropriate.

For the United States, regional rather than national acreage planted, acreage harvested, yield, and production equations represent the soybean supply relationship in the soybean block [equation (1) in figure 1] for seven production regions (Atlantic, Corn Belt, Delta, Lakes, Plains, South, and Other) to account for interregional competition within the United States:

(1) $AS_{kt} = AS_{kt}(PS^e_{kt}, RS_{kt}, \alpha_{kt}),$

(2) $HS_{kt} = HS_{kt}(AS_{kt}),$

(3) $YS_{kt} = YS_{kt}(RS_{kt}, \theta_{kt}),$

(4) $SS_{kt} = YS_{kt} (HS_{kt},$

where k = production region {1, ..., 7}; t = time period; AS = soybean acreage planted; HS = soybean acreage harvested; YS = soybean yield; SS = soybean production; RS = soybean research stock variable; PS^e = expected soybean farm price defined as the maximum of the loan rate and the lagged farm price (PS_{t-1}) in region k; and α and θ are appropriate shift variables.

The soybean research stock variables (RS_k) used in equations (1) and (3) were developed by Lim, Shumway, and Love (2000). Because the benefits of research investments in a given year may not be realized for a number of years, the RS_k are formed as weighted averages of historical investments measured in constant dollars to account for the time lag in the impact of research investments. Thus for any region k:

$$(5)\quad RS_t = \sum_{r=1}^{s} \lambda_r IS^*_{t-r}, \quad \sum_{r=1}^{s} \lambda_r = 1,$$

where $IS_t^* = IS_t/p_t$ is the constant dollar research investment in year t, IS_t is the nominal dollar research investment in year t, p_t is the corresponding research price index, λ_r is the weight on the constant dollar research investment lagged r years, and s is the lag length over which research investments are expected to impact farm decisions. Thus, the RS_k are proxies for the quantity of effective research.

To determine which of several alternative lag structures on research investment is preferred for purposes of defining research stock variables, Lim, Shumway, and Love (2000) conduct a series of model specification tests for two classes of research variables (stocks of soybean public research and soybean checkoff-funded research). For the public research stock variable, they select a Gamma distribution lag structure consistent with Chavas and Cox (1992), and for soybean checkoff-funded research a trapezoidal lag structure following the work of Huffman and Evenson (1989).

As recommended by Voon and Edwards (1991), the U.S. soybean regional acreage equations in the U.S. soybean block of SOYMOD are specified as nonlinear with constant elasticity (double-log). Consequently, the change in the level of soybean research investments in the soybean acreage and yield equations in the subsequent analysis of the return to those investments is manifest as a pivotal shift of the U.S. soybean supply curve.

Because applied research often depends on previous investments in basic research, returns to basic research investments are often transmitted through applied research to the development of new technologies and processes for adoption by producers. Given the interrelationship of public and soybean checkoff investments in production research (as discussed earlier), the public and soybean checkoff research stock variables are added together and treated as a single argument in each regional soybean acreage and yield equation.

The specification of the domestic demands (D) in the soybean, soybean meal, and soybean oil blocks of SOYMOD [corresponding to equations (2), (5), and (8) for any exporting region i, and equations (15), (18), and (21) for any importing region j in figure 1] includes promotion stock variables, often referred to as "goodwill" variables (G), to capture the effects of soybean checkoff-funded promotion activities in each region where such activities have been conducted:

$$(6)\quad D_{ist} = D_{ist}(P_{ist}, G_{ist}, \beta_{ist}),$$

where i = world region {1, ..., 6}; s = commodity (soybeans, soybean meal, and soybean oil); t = time period; P = domestic market price; and β represents appropriate shift variables.

The G_{ij} (promotion stock variables) used as regressors in the appropriate SOYMOD demand equations were constructed by Williams (1999) as weighted averages of the respective investments in promotion activities in each region. To account for the time lag in the impact of the promotion investments on the soybean, soybean meal, and soybean oil demands in each region, Williams used a second-order polynomial inverse lag (PIL) formulation based on Mitchell and Speaker (1986) because it does not require specifying the lag length, is conceptually an infinite lag, and, based on Monte Carlo work, outperforms the polynomial distributed lag (PDL) and several other popular distributed lag models.

Simultaneous interaction of soybean and soybean product markets within each region in SOYMOD is ensured through the endogenous soybean crush margin [equations (10) and (23) in figure 1] which is used as the own-price variable in the crush demand equations [equations (2) and (15) in figure 1]. The fourth block in each domestic market [equations (11)–(13) and (24)–(26) in figure 1] of SOYMOD includes net excess supply relationships for exporting regions and net excess demand relationships for importing regions specified for each region as the residual differences between their respective domestic supply and demand schedules.

Because of the important simultaneous interaction between the U.S. soybean and corn markets, SOYMOD also includes a model of the U.S. corn market. The specification of the U.S. supply and demand blocks of the corn model is similar to that for soybeans. The U.S. corn market model, however, is closed with a world corn import demand equation.

The soybean and soybean product markets of the trading countries in the model are linked through international price and trade flow relationships. The prices of soybeans, soymeal, and soyoil in exporting and importing regions are linked through price transmission equations [equations (27)–(29) in figure 1], following Bredahl, Meyers, and Collins (1979), which account for the effects of exchange rates as well as tariffs, export subsidies, border taxes, transportation costs, etc., and other factors (the Z_{ij}) that drive a wedge between prices in each world region. International market-clearing conditions [equations (30)–(32) in figure 1] require equality of the world excess supply and demand for soybeans, soymeal, and soyoil in each time period.

Data

The data for most of the endogenous and exogenous variables in SOYMOD (supply, demand, trade, price, policy, etc. by country and commodity over time) were taken from numerous public sources (TAMRC, 1997). To construct the soybean research stock variables (*RS*) used in this study, Lim, Shumway, and Love (2000) obtained publicly funded soybean production research investment data from the USDA's *Inventory of Agricultural Research* (1971–1995), and from Huffman and Evenson (1989). For checkoff-funded soybean production research investments, Lim, Shumway, and Love utilized data from records kept by the American Soybean Association (TAMRC, 1998b).

The data for soybean and soybean product demand promotion investments by product and country used by Williams (1999) to construct the promotion stock variables (*G*) employed in this study were compiled from various sources, primarily the American Soybean Association, the United Soybean Board, and FAS (TAMRC, 1998a). Because demand promotion activities in the United States have accounted for only a small proportion of all soybean checkoff expenditures, and because the available data on those expenditures are fragmentary, highly inconsistent in quality, type, time period, and level of aggregation, Williams (1999) was unable to construct soybean, soybean meal, and soybean oil demand promotion stock variables for the U.S. domestic market. Consequently, demand promotion stock variables are arguments of the demands for soybeans, soybean meal, and soybean oil only for those non-U.S. regions in SOYMOD where soybean checkoff-funded promotion expenditures occurred over the years.

Model Parameter Estimation and Validation

The parameters of the U.S. soybean supply and corn blocks of the model were estimated using the Nonlinear Iterative Seemingly Unrelated Regression (ITSUR) estimator with annual data for 1975 through 1994. Normalization by an exogenous input price index maintained linear homogeneity in prices. In their model of U.S. regional soybean supply, Lim, Shumway, and Love (2000) also maintained symmetry among cross-price parameters. Negative estimated own-price elasticities of supply in their model, however, led them to square the own-price parameters to force upward slopes on supply. The consequence was own-price elasticities that were extremely close to zero in most cases and not statistically significant in all but one U.S. soybean production region and two corn production regions. In addition, tests for nonjoint production in each region of the Lim, Shumway, and Love model led to the "surprising" conclusion that soybeans are not jointly produced with corn or any other commodity in any region.

Given the questionable and counterintuitive econometric results of Lim, Shumway, and Love, the specification of the equations in the U.S. soybean and corn supply blocks of SOYMOD was simplified, including relaxing the symmetry condition. The estimated parameters of the behavioral equations in all production regions in both blocks are unconstrained, consistent with a priori expectations in sign and magnitude, and statistically significant. All Durbin-*h* and Durbin-Watson statistics indicate no evidence of autocorrelation. As expected, the responsiveness of soybean acreage and yield to changes in both the soybean farm price and the soybean research stock is generally higher outside the Corn Belt in the less traditional and more marginal regions of soybean production (table 1).

The remaining parameters of the model were estimated by means of a truncated two-stage least squares (2SLS) procedure based on principal components using data for 1969 to 1995.[7] The model regression statistics indicate an excellent fit of the data and no evidence of autocorrelation. Also, the signs and sizes of all estimated parameters in each model equation are consistent with a priori expectations. Although the details of the full model, estimated parameters, regression statistics, and ex post model simulation validation statistics are available in Williams et al. (1998), the estimated direct price and foreign demand promotion stock elasticities are provided in table 2. In each case, the promotion stock elasticities are quite small and consistent in

[7] The 2SLS principal components estimator used here, and first proposed by Kloek and Mennes (1960), is consistent since it may be reduced to an instrumental variables estimator (Brundy and Jorgenson, 1971).

Table 1. SOYMOD Estimated U.S. Soybean Acreage and Yield Elasticities

	U.S. Planted Acreage				U.S. Yield
	Soybean Farm Price		Research Stock		
U.S. Production Region	Short Run	Long Run	Short Run	Long Run	Soybean Research Stock
Atlantic	0.5022***	1.8132***	0.0398***	0.0938***	0.2084***
Corn Belt	0.2758***	0.8469***	0.0604***	0.1916***	0.1643***
Delta	0.4092***	5.3186***	0.0485***	0.5266***	0.1589**
Lakes	0.5419***	1.8629***	0.0874**	0.3003**	0.1809***
Other	0.8114***	7.5329***	0.0771**	0.7154**	0.3477***
Plains	0.3575***	3.5143***	0.0872	0.8571	0.2438***
South	0.8979***	9.3128***	0.7315***	0.7587***	0.2153***

Notes: ** and *** denote statistical significance at the 5% and 1% levels, respectively. Yield and demand elasticities are evaluated at the means of the data. A constant elasticity assumption was used in estimation of the parameters of the acreage equations.

Table 2. SOYMOD Estimated Domestic Price and Promotion Stock Elasticities of Foreign Demand

	Domestic Price			Promotion Stock		
Region	Soybeans [a]	Soymeal [b]	Soyoil [b]	Soybeans	Soymeal	Soyoil
EU-15	0.03***	!0.36***	!0.19**	0.023**	0.045***	0.045***
Japan	0.09***	!0.19***	!0.17***	0.037***	0.073***	0.032***
Rest of the World (ROW)	!1.00	!0.80	!0.80	0.068***	0.052***	0.016**

Notes: ** and *** denote statistical significance at the 5% and 1% levels, respectively. All elasticities are long run except for the domestic price of soybeans for the EU-15, and all are evaluated at the means of the data. Import demand price elasticities for the ROW are constrained.

[a] Elasticities of domestic demand with respect to the gross soybean crushing margin for the EU-15 and Japan, and elasticity of import demand with respect to soybean price for the ROW.

[b] Direct price elasticities of domestic demand for the EU-15 and Japan, and direct import demand elasticities for the ROW.

both magnitude and sign with the findings of other studies (see, e.g., Williams and Nichols, 1998). Most of the estimated promotion stock elasticities are statistically significant at the 1% or 5% level.

Validation of the structural model included both a check of the dynamic, within-sample (ex post) simulation statistics for the fully simultaneous structural model and a sensitivity analysis to check the stability of the model. The common time period across all data types defined 1978–1994 as the period for the simulation analysis of the effectiveness of the soybean checkoff program. Dynamic simulation statistics (e.g., the root mean squared error, Theil inequality coefficients, and the Theil error decomposition proportions) were calculated from simulating the full model over the 1978–1994 sample, i.e., the baseline historical simulation. Those statistics indicated a highly satisfactory fit of the historical, dynamic simulation solution values to observed data (Williams et al., 1998). The Theil U coefficients were small, with none over about 0.7. The Theil bias error proportion indicated no systematic deviation of simulated and actual data values for any of the endogenous variables.

To check the stability of the model, a test of the sensitivity of the model to a one-period shock in checkoff investments was conducted. First, nominal checkoff investments both in U.S. soybean production research and in demand promotion across all importing regions and all commodities were increased by 10% in 1978 (the first year of the checkoff data). The respective investment stock variables were then re-generated and the model was re-simulated over the 17-year period of 1978–1994. Following the initial period shock, all endogenous variables returned to equilibrium within a reasonable time period (most within five years), indicating the model is highly stable to changes in checkoff investments over time (Williams et al., 1998).

Benefit-Cost Analysis of the Soybean Checkoff Program

The first step in evaluating the benefit of the soybean checkoff program to those who pay for the program was to isolate the effects of soybean checkoff investments on U.S. and world soybean markets from those of all other events that may have affected those markets over the years. This was accomplished by simulating the world soybean and soybean products model over the 1978–1994 period *with* and *without* checkoff investments and then comparing the results. The baseline simulation used to validate the model represents the "with checkoff investments" scenario.

For the "without soybean checkoff investment" scenario, the level of soybean checkoff investments was first set to zero in the model in each year from 1978 through 1994. The model was then simulated over the historical period to generate changes in the levels of U.S. and world soybean and product production, consumption, trade, and prices which would have existed over time in the absence of any checkoff expenditures. The simulated differences between the values of the endogenous variables in the baseline solution ("with checkoff investments") and in the zero investment scenario ("without checkoff investments") provide direct measures of the historical effects of the soybean checkoff investments on U.S. and world soybean and product markets.

Following this process, three "without checkoff investment" scenarios were simulated: (*a*) without FMD investments, (*b*) without SPR investments, and (*c*) without both FMD and SPR investments. A summary comparison of the three "without checkoff investment" scenario results ("without investments") to the baseline simulation ("with investments") is provided in table 3. For each of the three scenarios, the market effects are first discussed and then the respective benefit-cost ratios (BCRs) and effectiveness of the soybean checkoff program are examined.

Benefit-Cost Analysis of FMD Investments

The simulation analysis indicates the soybean checkoff FMD program had a modest average annual impact on U.S. soybean production, crush, and prices between 1978 and 1994 (table 3). A negative effect on the U.S. soyoil price was the result of an FMD investment strategy during much of the period to emphasize soybean meal over either soybeans or soyoil as the primary foreign market promotion objective. This strategy resulted in a higher relative demand and price for soymeal, and therefore a larger domestic surplus and lower price of soyoil than would have been the case in the absence of the FMD program.

The simulation results also suggest the FMD program boosted U.S. exports of both soybeans and soybean products as well as the U.S. share of the world soybean market (table 3). The slightly higher U.S. world soybean market share (1.3 percentage points) resulted from a higher average annual level of U.S. exports [1.1 million metric tons (mt)] and a lower level of both Brazilian and Argentine exports (70,500 mt and 68,800 mt, respectively). In the case of soymeal and soyoil, the soybean checkoff FMD program raised the average annual levels of U.S. exports as well as those of Brazil and Argentina. U.S. exports of both soymeal and soyoil benefitted to a greater extent, however, raising the U.S. share slightly (1.1 percentage points) and lowering those of both Brazil and Argentina in each year on average.

Not surprisingly, the impacts of the FMD program on U.S. production, price, and exports of soybeans and products over time, although positive, have been modest in magnitude. Given the low level of checkoff investments in FMD compared to size of the U.S. soybean market as measured by farm sales, the magnitude of any effects of the program on market variables could not be expected to be large despite the statistically significant effects of the investments on foreign demand. For soybean producers, policy makers, and others in the U.S. soybean industry, the important consideration is whether the effects of the investments on the market have been large enough to outweigh the costs of the program.

A standard method to determine if promotion pays is to calculate a benefit-cost ratio (BCR) in terms of additional industry profit (i.e., the increase in industry sales net of additional production costs) generated per promotion dollar. Many studies of the returns to advertising and promotion report a *static* BCR calculated assuming that little (including prices) except demand changes when promotion expenditures change. The benefit of the promotion program is taken to be the regression coefficient for promotion expenditures in the demand equation valued at the mean of the data.

Following the work of Williams (1985); Sellen, Goodard, and Duff (1997); Schmit and Kaiser (1998); and others, a *dynamic* BCR for soybean checkoff investments is calculated in this study as the simulated increase in U.S. soybean industry revenues generated as a consequence of those

Table 3. Simulated Effects of Total Soybean Checkoff Investments on U.S. Soybean Supply, Crush, and Prices, and World Exports and Export Market Shares, 1978–1994

	Foreign Market Develop.		Production Research		Total Investments	
Average Annual Change[a] in:	Units	%	Units	%	Units	%
U.S. Soybean Planted Acres (1,000 acres)	2,052.8	3.4	−207.5	−0.3	1,845.3	3.0
U.S. Soybean Production (mil. bu.)	56.8	3.0	10.0	0.5	66.8	3.5
U.S. Soybean Crush (mil. bu.)	16.4	1.5	5.3	0.5	21.7	1.9
U.S. Exports (1,000 mt):						
Soybeans	1,059.9	5.6	121.3	0.6	1,181.2	6.3
Soymeal	487.7	9.3	94.5	1.7	582.2	11.3
Soyoil	43.2	5.8	20.6	2.7	58.5	8.0
Brazilian Exports (1,000 mt):						
Soybeans	−70.5	−3.0	−23.6	−1.0	−94.1	−3.9
Soymeal	326.1	4.1	−84.3	−1.0	241.8	3.0
Soyoil	40.2	5.3	−20.5	−2.5	19.7	2.5
Argentine Exports (1,000 mt):						
Soybeans	−68.8	−2.7	0.4	0.0	−68.3	−2.7
Soymeal	113.7	3.1	−32.0	−0.8	81.8	2.2
Soyoil	23.0	3.1	−6.8	−0.9	16.2	2.2
U.S. World Market Share (percentage):						
Soybeans	1.3	1.6	0.2	0.2	1.5	2.0
Soymeal	1.1	3.3	0.5	1.6	1.6	5.1
Soyoil	0.9	2.3	0.7	1.8	1.3	3.7
U.S. Prices:						
Soybeans ($/bu.)	0.08	1.3	−0.05	−0.8	0.03	0.5
Soymeal ($/ton)	8.70	5.0	−0.88	−0.5	7.82	4.4
Soyoil (¢/lb.)	−0.56	−2.4	−0.06	−0.3	−0.62	−2.6
Crush Margin ($/bu.)	0.06	8.6	0.02	2.8	0.09	11.9

[a] Change from the simulated levels of the indicated variables when all soybean checkoff investments are set to zero to the baseline simulation values of those variables.

investments over the 1978–1994 period divided by the level of those investments after deducting the additional U.S. production costs required to produce the additional soybean output generated. Thus, the additional soybean industry profit (VS) (in million dollars) generated by the soybean checkoff investment being analyzed in any given year (t) is calculated as:

$$(7)\quad VS_t = \left(PS_t^s \times SS_t^s - CS_t^s \times AS_t^s\right) - \left(PS_t^b \times SS_t^b - CS_t^b \times AS_t^b\right),$$

where all variables are as defined earlier, CS is the per acre soybean production cost, and s and b indicate scenario and baseline simulation value, respectively. Then the soybean checkoff *net soybean industry profit* BCR is calculated as:

$$(8)\quad NBCR = \sum_{t=1}^{T} \frac{VS_t}{IS_t} - 1,$$

where the cost of the checkoff program in each year (IS_t) has been netted out of the additional industry profit generated (VS_t) in those years (i.e., $VS_t - IS_t$). Accounting for the time value of money, the *discounted net soybean industry profit* BCR is calculated as:

$$(9)\quad DBCR = \sum_{t=1}^{T} \frac{(VS_t - IS_t)/(1+i)^t}{IS_t},$$

where i is the interest rate chosen to discount the additional profit flows to present value. The value of the DBCR depends on the discount rate chosen. In this study, the DBCR was calculated using the 30-day Treasury bill interest rates (IMF) for 1978–1994. Sellen, Goddard, and Duff (1997) arbitrarily fixed the annual discount rate at 5%. The Treasury bill rate was selected for this study simply because it represents a realistic alternative investment rate for the 1978–1994 period.

In terms of the additional soybean industry profit generated, the FMD program far exceeded the investment costs of the program over that period (table 4). The calculated NBCR for the soybean checkoff FMD program over time was high at $10.3, but is lower than the range of about $14 to $60 reported by other studies of the returns to

Table 4. Soybean Checkoff Investments: Producer Benefit-Cost Analysis, 1978–1994

Investment	1978–1989	1990–1994	1978–1994
Foreign Market Development (FMD):			
Added Soybean Cash Receipts ($ mil.)	6,542.5	1,813.7	8,356.1
Cost of Added Soybean Production ($ mil.)	4,047.8	1,466.2	5,514.0
Added Receipts Net of Added Production Costs ($ mil.)	2,494.7	347.5	12,842.1
Soybean Checkoff FMD Investments ($ mil.)	184.9	66.0	251.0
Producer Benefit-Cost Ratios:			
Net Profit BCR (NBCR)	12.5	4.3	10.3
Discounted Net Profit BCR (DBCR)	7.9	1.7	6.3
Production Research (SPR):			
Added Soybean Cash Receipts ($ mil.)	!415.6	!240.8	!656.4
Cost of Added Soybean Production ($ mil.)	!342.7	!303.6	!646.3
Added Receipts Net of Added Production Costs ($ mil.)	!72.9	62.8	!10.1
Soybean Checkoff SPR Investments ($ mil.)	35.2	20.8	56.0
Producer Benefit-Cost Ratios:			
Net Profit BCR (NBCR)	!3.1	2.0	!1.2
Discounted Net Profit BCR (DBCR)	!1.8	1.0	!0.8
Total Investments (FMD and SPR):			
Added Soybean Cash Receipts ($ mil.)	6,149.0	1,586.4	7,735.5
Cost of Added Soybean Production ($ mil.)	3,705.1	1,162.6	1,623.9
Added Receipts Net of Added Production Costs ($ mil.)	2,444.0	423.8	2,867.8
Soybean Checkoff Total Investments ($ mil.)	220.1	86.8	306.9
Producer Benefit-Cost Ratios:			
Net Profit BCR (NBCR)	10.1	3.9	8.3
Discounted Net Profit BCR (DBCR)	6.4	1.6	5.0

foreign market promotion programs (Williams and Nichols, 1998). When discounted to present value, the ratio of benefits to costs (i.e., the DBCR) falls to 6.3 to 1.

Interestingly, the calculated NBCR for the soybean FMD program was substantially higher in the period *before* the implementation of the national soybean checkoff program (1978–1989) than in the period *after* implementation (1990–1994) (table 4). The lower NBCR for the 1990–1994 period is the result of FMD funding problems over a number of years (1985 to 1991) prior to implementation of the national soybean checkoff program. A sharp deterioration of FMD funds from soybean grower checkoff and third-party (in-country) sources after 1985 was arrested beginning in 1992 with the implementation of the national soybean checkoff program. Because demand promotion efforts have carryover effects, the impact of the deterioration in FMD funding persisted for several years after the hemorrhage in funding was stopped.

By the same token, the effect of the new national soybean checkoff program FMD funding in the initial years was primarily to keep foreign demand from eroding any further from the levels achieved under the program in the 1970s and early 1980s. The full effects of the implementation of the national checkoff program in 1992–1994 were not fully felt in the market for several years beyond the data period for this study, and thus are not fully reflected in the results.

Benefit-Cost Analysis of SPR Investments

The simulation results indicate the soybean checkoff investments in SPR also boosted U.S. soybean yields and production modestly on average over the 1978–1994 period (table 4). Based on our results, U.S. soybean output averaged about 10 million bushels higher (0.5%) in each year than would have been the case in the absence of the SPR investments. The additional production, however, also led to a somewhat lower soybean farm price in each year on average ($0.05/bushel or 0.8%). The SPR-induced lower prices and higher yields, however, combined to reduce the acres planted to soybeans by an annual average of 207,500 acres over the same period.

In essence, the SPR investments over time forced a tradeoff between yield and acreage planted. The increased output from the yield-boosting effects of the research investments meant fewer acres needed to be planted to soybeans in order to meet the demand for soybeans in each year. The net effect on production over the 1978–1994 period, however, was slightly positive because the somewhat lower soybean price generated a small increase in the quantity of soybeans demanded in both domestic and foreign markets on average in each year. Of the 10 million bushels higher annual average soybean output between 1978 and 1994 as a result of SPR checkoff investments, about 5.3 million bushels were crushed domestically, 4.5 million bushels were exported, and about 0.2 million bushels were added to stocks.

Like the FMD investments, the SPR investments also tended to boost the level and market share of U.S. soybean and product exports (table 3). Unlike the FMD investments, however, the SPR investments between 1978 and 1994 had an unambiguous negative effect on both the level and market share of the soybean and soybean product exports of the two major U.S. export competitors (Brazil and Argentina). Although the absolute levels of the U.S. export and export share effects of the SPR investments were smaller than was the case for the FMD investments, recall that FMD checkoff investments averaged about three times more than SPR investments over the study period.

Despite positive impacts on the production and exports of U.S. soybeans and soybean product exports, the simulation results suggest the cost of the SPR checkoff investments over the 1978–1994 period outweighed the benefits to U.S. soybean growers. In fact, given the relatively price inelastic demand for soybeans and soybean products generally faced by U.S. soybean producers, the SPR-induced pivotal shift of the soybean market supply curve led to not only a lower soybean farm price but also lower soybean cash receipts (revenues) in each year on average between 1978 and 1994 (table 4).

Even though the lower planted acreage also led to lower total production costs, the net change in soybean producer profits (i.e., added revenues minus added costs) as a result of the SPR investments was slightly negative. Consequently, the calculated NBCR from SPR investments over the 1978–1994 period was also negative at about !1.2 to 1 (!0.8 to 1 on a discounted basis) (table 4).

Decomposing the 1978–1994 period into the pre- and post-national soybean checkoff program periods (1978–1989 and 1990–1994) provides some insight on the return to SPR investments. Just as soybean and product FMD investments experienced a sharp decline between about 1987 and 1991, SPR investments experienced a sharp increase beginning in about 1988 through 1994, both in absolute terms and as a percentage of total investments.

The share of total soybean investments accounted for by SPR declined from about 21% in 1981 to only 13% in 1987. By 1994, however, the SPR share had jumped dramatically to nearly 44%. Accordingly, the net producer return to SPR turned positive from !3.1 to 1 in the 1978–1989 period to 2.0 to 1 during the 1990–1994 period (table 4). Because of the normally lengthy lag between research investments and any associated market impacts, the slightly positive NBCR for the 1990–1994 period likely understates the actual return to the increasingly larger investments in research made between 1990 and 1994.

Total Soybean Checkoff Investments

Considered together, soybean checkoff investments in SPR and FMD promotion effectively increased U.S. soybean production, crush, exports, world market share, and producer profits. Given the larger size and share of the total investments accounted for by FMD than by SPR over much of the 1978–1994 period, the effects of FMD investments tend to dominate the measured impacts of the total soybean checkoff program during that period.

The effects of the two investment strategies together had a larger positive effect on soybean production (3.5%), soybean crush (1.9%), the soybean crush margin (11.9%), and soybean, soybean meal, and soyoil exports (6.3%, 11.3%, and 8%, respectively) and export shares (1.5, 1.6, and 1.3 percentage points, respectively) than either investment strategy alone over the 1978–1994 period (table 3). At the same time, total soybean checkoff investments resulted in lower soybean and soybean meal export shares by both Brazil and Argentina than either type of investment alone. On the other hand, the per bushel price received by soybean producers was somewhat lower with the two investment strategies over that period than with only FMD investments primarily because of the negative price effects of the research-induced expansion in production (table 3).

Despite the negative NBCR for SPR investments, the NBCR of 8.3 for the total soybean checkoff program suggests the benefits of the program more than exceeded the investment costs over the 1978–1994 period (table 4). The DBCR for the total program over that period was somewhat lower at 5.0 to 1 (table 4).

As was the case for the FMD investments, the calculated NBCR and DBCR for the total soybean checkoff program were higher in the 1978–1989 period than in the subsequent 1990–1994 period.

Again, the 40% decline in total FMD funding between the mid-1980s and early 1990s, combined with the lengthy carryover effects of those investments, led to a lengthy deterioration in the growth of U.S. soybean and soybean product exports despite some subsequent recovery of FMD investments. The differences between the 1978–1989 and 1990–1994 NBCRs and DBCRs for the total soybean checkoff program are smaller, however, than is the case for the FMD program alone, primarily because the sharp increase in SPR investments that began in 1988 switched the returns to SPR from negative to positive between those two periods.

Conclusions and Implications

Overall, soybean checkoff program investments since the early 1970s have benefitted the U.S. soybean industry as returns to the total program have been much in excess of the cost. The program has tended to increase the size of the U.S. soybean industry and reduce the competitive threat of the South American soybean industry. In general, the program has tended to increase the production and sales of U.S. soybeans and products but has had only a small positive impact on the U.S. farm price of soybeans over time.

The high per dollar return to overall soybean checkoff investments implies producers could realize large additional benefits from a substantial increase in those investments. As the level of investment increases, the BCR would be expected to drop to some extent. Because the current level of investment is relatively low (less than 0.2% of annual soybean farm cash receipts), however, even an extraordinary expansion of investments from their current level would likely have only a small negative effect on the net returns to soybean producers per dollar invested.

Perhaps the key finding of this study is that investments in soybean production research have tended to reduce rather than enhance the overall returns to the soybean checkoff program. Production research not only failed to recover its investment, it actually had a negative impact on farmer net returns over the 1978–1994 period of analysis. The benefits from the soybean program over the years have resulted primarily from investments in activities intended to shift out foreign demand for soybeans and products.

The obvious implication is that an increase in returns to soybean producers from their checkoff investments could be achieved even without an increase in funding by reallocating existing funds from production research to foreign demand promotion, a conclusion which conflicts with the findings of Wohlgenant (1993). He asserts that producers tend to benefit more from financing research to shift the supply curve than from financing promotion to shift the demand curve, implying a reallocation of producer funds from demand promotion to production research would tend to maximize returns to producers. Wohlgenant, however, analyzed a special case of equal shifts in demand and supply from a producer-financed research and promotion program. The historical data for the soybean checkoff program clearly show soybean producers have not invested equally in demand promotion and research activities. Moreover, by assuming a parallel shift of a linear supply curve from research, Wohlgenant guaranteed positive returns to research. A more plausible pivot of a nonlinear, constant elasticity supply curve from research would necessarily have led Wohlgenant to more ambiguous conclusions, as can clearly be seen from the work of Voon and Edwards (1991).

Nevertheless, the conclusion that soybean producers would be better off if soybean checkoff investments were transferred from production research to foreign market promotion should be interpreted cautiously for at least two reasons. First, if an objective of the soybean checkoff program is to maximize the U.S. share of world soybean and soybean product markets, or at least to reduce the competitive threat of foreign soybean producers, then production research may appear to be a more attractive investment choice. The findings of this study suggest production research unambiguously increases U.S. exports and reduces Brazilian exports of soybeans and soybean products as well as Argentine exports of soybean products.

Curtailing U.S. investments in new, high-yielding, and cost-efficient soybean production technologies and techniques could allow the comparative advantage in the production and export of soybeans and soybean products to shift slowly over the long run to U.S. export competitors like Brazil and Argentina that operate aggressive soybean production research programs of their own. In this sense, a low or even negative BCR for SPR investments could be considered to be the cost to U.S. soybean producers of staying competitive in world markets. In any case, there may be a tradeoff between the costs of production research investments from potentially lower overall returns to producers and the possible loss of competitiveness in world markets from curtailing such investments.

A second concern in considering a reduction in the checkoff funds allocated to production research is that the tendency for low producer returns from such research may well be the result of investments in yield-enhancing research, as suggested by Lim, Shumway, and Love (2000). In that case, their results imply a reallocation of checkoff production research investment funds from yield-enhancing to cost-reducing research could substantially increase the producer returns to production research investments and attenuate the advantage of investments in foreign market promotion. Clearly, additional research is needed to determine the optimal allocation of soybean checkoff funds in production research and foreign market promotion as a guide to future soybean checkoff allocation decisions.

The findings of this study also lead to at least two other conclusions. First, a failure to maintain and enhance the growth of commodity checkoff investments can have serious negative impacts on returns to producers over a number of years. For example, the large drop in soybean FMD funding between 1986 and 1992 led to a lower overall net return to soybean producers during the early 1990s (1990–1994) of $4 per dollar invested compared to the nearly $13 per dollar invested earned between 1978 and 1989.

Also, the way in which promotion investments are allocated among soybeans and soybean products and across countries can have important implications for the return to those investments and for U.S. competitiveness in each respective market. As total soybean and product FMD investments declined between 1986 and 1992, the share allocated to promote foreign demand for soybeans and soymeal increased from about 8% and 49% to 15% and 71%, respectively, while the FMD soyoil share declined from about 43% to only 14%. This reallocation of checkoff investments generated a larger increase in the U.S. share of those world markets in the early 1990s (1990 to 1994) compared to the pre-1990 period (1978 to 1989) with no reduction in the increase in the U.S. share of world soyoil markets despite the overall decline in FMD investments. At the same time, the decline in total FMD funding and the drop in the return to FMD investments corresponded to a shift in funding emphasis away from the traditional markets of Japan and Western Europe to Asia, Latin America, and other newer markets. Again, additional research is needed to determine the optimal or highest yielding regional and commodity allocation of soybean checkoff FMD investments.

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