EFFECTIVENESS OF THE SOYBEAN CHECKOFF PROGRAM

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Texas Agricultural Market Research Center (TAMRC) Commodity Market Research Report No. CM-2-98, May 1998 by Dr. Gary W. Williams, Dr. C. Richard Shumway, Dr. H. Alan Love, and Mr. Jim Bob Ward.

Abstract: The 1996 farm bill requires an independent evaluation of the effectiveness of all commodity promotion programs not less than every 5 years. In compliance with that legislation, the United Soybean Board commissioned this study of the effectiveness of the soybean checkoff program. This report provides historical background on soybean checkoff investments, reviews pertinent literature on the measurement of returns to generic promotion and research investment activities, discusses the methodology used, presents the analytical results, and ends with a summary of the major conclusions and a discussion of the implications for the management of soybean checkoff investments.

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The **Texas Agricultural Market Research Center (TAMRC)** *has been providing timely, unique, and professional research on a wide range of issues relating to agricultural markets and commodities of importance to Texas and the nation for nearly thirty years.* **TAMRC** *is a market research service of the Texas Agricultural Experiment Station and the Texas Agricultural Extension Service. The main* **TAMRC** *objective is to conduct research leading to expanded and more efficient markets for Texas and U.S. agricultural products. Major* **TAMRC** *research divisions include International Market Research, Consumer and Product Market Research, Commodity Market Research, Information Systems Research, and Contemporary Market Issues Research.*

EFFECTIVENESS OF THE SOYBEAN CHECKOFF PROGRAM

Executive Summary

The 1996 farm bill requires an independent evaluation of the effectiveness of all commodity promotion programs not less than every 5 years. In compliance with that legislation, the United Soybean Board (USB) commissioned this study of the effectiveness of the soybean checkoff program. The primary objective of this study was to measure the overall return to soybean checkoff and related investments since the mid-1970s. In general, the study concludes that investments of soybean checkoff funds in foreign market development (FMD) and production research since the early 1970s have been highly effective in augmenting U.S. soybean producers' bottom lines.

From 1978 through 1995, farmers invested approximately $163.0 million of checkoff funds in soybean production research and in FMD activities to promote U.S. exports of soybeans, soybean meal, and soybean oil. In addition, the FMD checkoff investments generated in-country funds from third party contributors ($88.1 million) and from the USDA Foreign Agriculture Service (FAS) through the Cooperator Program ($98.9 million) bringing total investments in soybean production research and FMD to $350.0 million.

Although no previous work has been done to measure the returns to investments in soybean research, studies have shown high returns to research investment for other commodities. Most of those studies, however, ignore the price depressing effects of research-induced supply expansion over the years which could turn positive gains from such research into losses. For generic demand promotion programs, the consensus across a broad range of studies is that advertising and commodity promotion not only increase sales but they generally increase sales by more than enough to cover the costs of promotion. The Benefit-Cost Ratios (BCRs) calculated by most studies for domestic generic advertising and promotion programs fall in the range of about $2 to $12 earned per promotion dollar spent. For foreign market promotion programs, the reported BCRs are generally higher from $14 to $60 per dollar spent.

The basic tool of analysis used in this study is a 186-equation, annual econometric simulation model of world soybean and product markets, referred to as SOYMOD, that allows for the simultaneous determination of the supplies, demands, prices, and trade of soybeans, soybean meal, and soybean oil in six major world trading regions: the United States, Brazil, Argentina, the European Union, Japan, and a Rest-of-the-World region. Data for three types of soybean checkoff and related investments were needed for the analysis using the model: (1) soybean production research investments by state and national soybean producer organizations and the public sector, (2) domestic soybean and product market promotion investments by state and national soybean producer organizations, and (3) foreign soybean and product market demand promotion investments by state and national soybean producer organizations, the Foreign Agriculture Service (FAS) of USDA, and third party contributors. Unfortunately, although all state and national soybean producer organizations were surveyed to obtain data for domestic soybean utilization research and promotion investments, the data collected are fragmentary, highly inconsistent in quality, type, time period, and

level of aggregation, and, therefore, not useful for analytical purposes. Consequently, domestic utilization research and promotion programs could not be included in this study.

All investment data were converted to a constant dollar basis and then used to form research and FMD stock variables to account for the time lag in the market impact of the investments. Model specification tests were conducted to determine appropriate lag structures for calculating the stock variables. The research stock variables enter the model (SOYMOD) as arguments of the regional soybean acreage and yield functions. The foreign soybean, soybean meal, and soybean oil demand promotion investment stock variables enter SOYMOD as arguments of the respective demand functions of the importing regions in which the investments were made.

The parameters of SOYMOD were estimated using standard econometric procedures. Validation of the model through dynamic, within-sample simulation indicated a highly satisfactory fit of the historical, dynamic simulation solution values to observed data. A sensitivity test indicated that the model is highly stable to changes in checkoff investments over time.

To evaluate the effectiveness of the soybean checkoff program, two sets of simulations were conducted with SOYMOD to answer two general questions: (1) Have soybean producers benefitted from the soybean checkoff program and, if so, by how much? (2) Would soybean producers have been better off if the funds they have contributed to the checkoff program instead had been invested in other financial opportunities? The first set of simulations provides the basis for a benefit-cost analysis of the soybean checkoff program. The second set of simulations allows an alternative investment analysis of the soybean checkoff program.

To answer the first question, SOYMOD was simulated over 1978 to 1994 *with* and *without* checkoff investments. Three "without checkoff investment" scenarios were simulated and compared to the "with checkoff investment" simulation results: (1) without FMD investments, (2) without soybean production research investments, and (3) without either FMD or soybean production research investments. For each of these three scenarios, the effectiveness of the soybean checkoff program is summarized in a BCR calculation to determine the average rate of return in each case.

For the FMD program, the simulation results indicate clearly that checkoff investments were effective in increasing U.S. soybean production, crush, exports, price, world market share, and producer profits. Also, the benefits in terms of the additional soybean industry profits generated by the FMD program far exceeded the investment costs of the program over that period at $10.3 in profits earned on average by U.S. soybean farmers for every dollar invested which compares quite favorably to the BCRs reported by similar studies for other commodities.

For investments in soybean production research, the conclusions on the effectiveness of soybean checkoff investments are quite different. Without question, the checkoff investments in soybean production research have boosted U.S. soybean yields and production. On average in each year over the 1978 to 1994 period, U.S. soybean output was about 10 million bu. higher than would have been the case in the absence of the program. The additional production, however, also led to a somewhat lower farm price of soybeans in each year on average. Any benefits accruing to checkoff investments in soybean production research are most obvious in the effects they have had on U.S. exports and U.S. export share. Between 1978 and 1994, research investments not only boosted both the level of soybean, soymeal, and soyoil exports and the U.S. export share of each but also reduced both the level of exports and the export share of each commodity from Brazil and Argentina. Unfortunately, the costs of the soybean checkoff investments in production research over the 1978 to 1994 period just slightly outweighed the benefits in terms of the additional profits generated for U.S. soybean growers. Given a somewhat lower level of industry profit as a result of the research investments, the calculated BCR over the entire 1978 to 1994 period was slightly negative at about -1.2 to 1. For the 1990 to 1994 period, however, the BCR was much higher at 2.0 to 1 as a result of a sharp increase in investments in production research that began in about 1988.

Together, production research and FMD investments have been highly effective in increasing U.S. soybean production, crush, exports, world market share, and producer profits. The BCR for the total soybean checkoff program was quite high over the 1978 to 1994 period at $8.3 in profits earned on average by U.S. soybean farmers for every dollar invested.

Has the soybean checkoff program been successful as an investment alternative for soybean producers? That is, would soybean producers have been better off if the funds they have contributed to the checkoff program instead had been invested in other financial opportunities? To answer this question, the level of checkoff investments in one year (1978) in the model was increased by 10% and the simulated effects of the change tracked over the 17 year period of 1978 through 1994. The results were used to calculate the stream of benefits that have accrued to soybean producers from the total soybean checkoff program over time as an alternative investment opportunity. The analysis compares the internal rate of return to an investment in the soybean checkoff program to the rate that would have been realized over the same 17 year period if those same funds had instead been invested in other financial opportunities. The results indicate that the soybean checkoff program was a superior investment choice for soybean checkoff dollars. If the additional profits generated by the 1978 soybean checkoff investments each year from 1978 to 1994 had been invested by producers at a rate comparable to the interest they paid on farm debt, they would have realized an 18.3% rate of return on that investment over 17 years. Alternatively, if farmers had opted individually to invest the same initial amount of funds in buying down farm debt in 1978 instead of investing those funds first in the soybean checkoff program, the rate of return would have been much lower at 8.9%. In other words, investing jointly in the soybean checkoff program allowed larger profits than otherwise would have been available to farmers to pay off debt or invest elsewhere over time.

Among the major findings of this study are the following:

1. The BCR of the soybean checkoff investments has been reasonably high at $8 in additional profit earned by U.S. soybean farmers for every dollar invested.
2. Not only has the soybean checkoff program BCR been high, the soybean checkoff program has also been a superior investment choice for U.S. soybean farmers.
3. Overall, FMD and production research investments have grown the U.S. soybean industry and reduced the competitive threat of the South American soybean industry.

4. FMD investments alone have been profitable and have effectively pushed out world demand for U.S. soybeans and products.
5. Soybean checkoff investments in production research have boosted U.S. soybean output and crush and increased the U.S. share of world soybean and soybean product exports.
6. The BCR to soybean production research investments alone has been low but increased dramatically after 1990 following a shift in soybean checkoff investment strategy.

These conclusions suggest a number of implications for program management purposes. First, the U.S. soybean industry has been underinvesting in FMD and production research. The high BCR to checkoff investments given the relatively low current level of those investments suggests that large additional benefits can be realized from a substantial increase in those investments.

Second, a failure to maintain the growth in soybean checkoff investments can have serious negative impacts on soybean producer profitability over a number of years. For example, a 42% drop in total FMD investments between 1986 and 1992 resulted in a lower overall return to soybean farmers during the early 1990s of 5 to 1 compared to the 13 to 1 return earned between 1978 and 1989.

Third, the allocation of funding between production research and FMD can have important consequences for the effectiveness of the soybean checkoff program. During the late 1980s and into the 1990s as total soybean checkoff funding dwindled, a strategic shift in funding emphasis from FMD to production research boosted the return to investments in production research but reduced the overall return to soybean checkoff investments.

Fourth, related to the previous point, despite the low BCR for investments in soybean production research over the 1978 to 1994 period, any proposal to curtail future checkoff investments in production research should be carefully studied before being implemented. Soybean growers must weigh carefully the tradeoff between the cost of investments in production research from a lower overall return to checkoff investments and the possible loss of competitiveness in world markets from curtailing investments in production research.

Fifth, the way in which FMD 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. Research is needed to determine the optimal or highest yielding regional and commodity allocation of FMD investments.

Finally, a harmonized, systematic procedure for collecting, classifying, maintaining, and reporting data on soybean checkoff expenditures by state and national soybean groups is critically needed for future program evaluation and management purposes and must be a high priority for the USB and associated state and federal organizations and contractors.

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EFFECTIVENESS OF THE SOYBEAN CHECKOFF PROGRAM

Since at least the early 1950s, U.S. soybean producers have been cooperatively investing in production research and demand promotion in an effort to enhance the profitability and the international competitiveness of their industry. Before 1990, producer contributions to this effort were facilitated in most of the major soybean-producing states by state legislation requiring producers to pay (or "check off") from ½ to 2 cents per bushel sold. Such contributions, however, were considered to be voluntary because any producer could receive a full refund upon request. About 50% of the checkoff funds collected in each state during this period was allocated to and managed by that state's soybean association. The other half was controlled by the national organization, the American Soybean Association in St. Louis, Missouri.

The 1990 farm bill[1] authorized a national program of mandatory soybean producer checkoff contributions to fund promotion and research activities. Implemented in the Soybean Promotion, Research, & Consumer Information Act of 1990[2], the national soybean checkoff program was implemented in 1991 and upheld by soybean producers in a subsequent referendum required by the legislation. Every soybean producer is required to participate in the checkoff at the rate of 0.5% of the market price per bushel when the crop is first sold. The right of soybean producers to demand a refund of the mandatory checkoff assessment was terminated in a second referendum also required by the legislation. As before, half of the checkoff funds collected under the national soybean checkoff program remains in the states and half is allocated to a national organization. The legislation required the establishment of new state producer-controlled checkoff boards (Qualified State Soybean Boards or QSSBs) and a new national producer-controlled checkoff board (the United Soybean Board (USB) in St. Louis, Missouri) to manage the funds allocated to them.

The QSSBs invest the largest portion of their checkoff dollars in soybean production research with a small amount allocated to funding domestic utilization research and promotion programs. The USB also allocates a major portion of its funds to support soybean production research with some funding for utilization research and domestic promotion programs. As was the case with the American Soybean Association before the establishment of national checkoff program, however, the United Soybean Board also manages a large international foreign market development program designed to promote U.S. exports of soybeans and soybean products[3]. The state organizations have rarely invested directly in foreign market development activities.

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

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

[3] The American Soybean Association now serves as the primary contractor to the United Soybean Board for managing the foreign market development program.

Title V of the 1996 farm bill[4] requires an independent evaluation of the effectiveness of all new and existing promotion programs, not less than every 5 years, to assist Congress and the Secretary of Agriculture in ensuring that the objectives of the programs are met. In compliance with that legislation, the United Soybean Board commissioned this study of the effectiveness of the soybean checkoff and related investments in production research and promotion over the last two decades. The primary objective of the study was to measure the overall return to soybean checkoff and related investments since the mid-1970s in three areas: (1) soybean supply-oriented research; (2) domestic soybean and product market development; and (3) foreign soybean and product market development, including primarily the cooperator program activities. After providing some background on soybean checkoff investments since the mid-1970s, this report then reviews pertinent literature on the measurement of returns to generic promotion and research investment activities like the soybean checkoff program. The methodology used in this study to measure the effectiveness of the soybean checkoff program is then outlined which is followed by a discussion of the analytical results. Finally, the major conclusions of the study and implications for the management of soybean checkoff investments are considered.

Background on Soybean Checkoff Investments

Public and private investments to enhance agricultural output and revenue can be classified as either supply- or demand-oriented. Supply-oriented investments have concentrated on research to improve agricultural productivity. Demand-oriented investments, on the other hand, have attempted to shift demand schedules for agricultural commodities through market development activities, thereby enhancing price and stimulating output and producer revenues. Although soybean producers have been investing in both supply- and demand-oriented activities since the mid-1950s, consistent data and documentation of those investments are available only since the early to mid-1970s. This section first provides a brief overview of soybean checkoff investment activities over the last two decades. Then, the expected market effects of those investments are considered.

Historical Soybean Checkoff Investments in Production Research and Promotion[5]

From 1978 through 1995, farmers invested approximately $163.0 million of checkoff funds in soybean production research and in foreign market development (FMD) activities to promote U.S. exports of soybeans, soybean meal, and soybean oil (TAMRCb and TAMRCc). In addition, the FMD checkoff investments have generated in-country funds from third party contributors ($88.1 million) and from the USDA Foreign Agriculture Service (FAS) through the Cooperator Program

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

[5] Unless otherwise indicated, all investment expenditures presented in this section and in corresponding tables and figures are in nominal U.S. dollars. As discussed later, however, all expenditures are deflated and foreign market development expenditures are also corrected for changes in exchange rates for the empirical analysis of the effectiveness of these investments.

($98.9 million) bringing total investments in soybean production research and foreign market development to $350.0 million between 1978 and 1995 (Figure 1). Although both state and national checkoff funds have also been invested in domestic utilization research and promotion programs, records on such activities at both the state and national levels are quite sketchy, inconsistent, and have not been well maintained over time (TAMRCa).

Total soybean checkoff investments[6] grew by nearly 160% between 1978 and 1995 from $10.91 million to $28.24 million (Figure 1). Nevertheless, the annual rate of growth of those investments declined steadily from 1980 through 1991, turning negative in most years after 1985 (Figure 2). The establishment of the national soybean checkoff program in 1991 effectively arrested the decline of farmer investments in soybean production research and foreign market development, boosting soybean checkoff investments dramatically by 10.5% in 1992, 25.3% in 1993, and 28.4% in 1994. Total soybean checkoff investments in 1995, however, increased by only 1.1%.

The establishment of the national soybean checkoff program also signaled an apparent major shift in investment strategy. Whereas foreign market development consistently accounted for 80-87% of the total soybean checkoff investment in the 1970s and 1980s, an increasingly greater share of soybean checkoff dollars were allocated to production research after 1990 reducing the FMD share to 56.5% and increasing the production research share to 43.5% by 1995 (Figure 3).

Even though soybean farmers have invested millions of checkoff dollars in production research and foreign market development since the 1970s, the total funds invested have been quite meager compared to the revenues (cash receipts) earned by soybean farmers each year (Figure 4). Between 1978 and 1995, total soybean checkoff investments have amounted to only 0.08% to 0.20% of total soybean farm cash receipts each year. With such a low checkoff investment intensity, i.e., the level of investment compared to the size of the soybean market as measured by farm sales, the overall impact of the program could hardly be expected to be highly significant in a practical sense in its effects on U.S. production, prices, exports, and world market shares even if the impact could be said to be statistically significant.

Foreign Market Development Investments

Through the American Soybean Association (ASA) before the national soybean checkoff program and subsequently through the United Soybean Board (USB), U.S. soybean farmers have participated in the USDA Foreign Agriculture Service (FAS) Cooperator Program since its inception in 1954. Under the Cooperator program, commodity groups obtain federal funds to assist in developing foreign markets for U.S.-produced agricultural commodities by submitting marketing plans to FAS

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[6] References to "total" soybean checkoff investments in this report include not only soybean checkoff funds invested in soybean production research and foreign market development but also the foreign market development funds contributed by the USDA Foreign Agriculture Service and 3rd Party contributors in the countries of investment. Not included are state and national expenditures of checkoff funds on domestic promotion programs because of the poor quality of the data on those programs. See the discussion of data in the methodology section of this report for more details.

Figure 1: Soybean Research and Foreign Market Development Investments, 1978-95

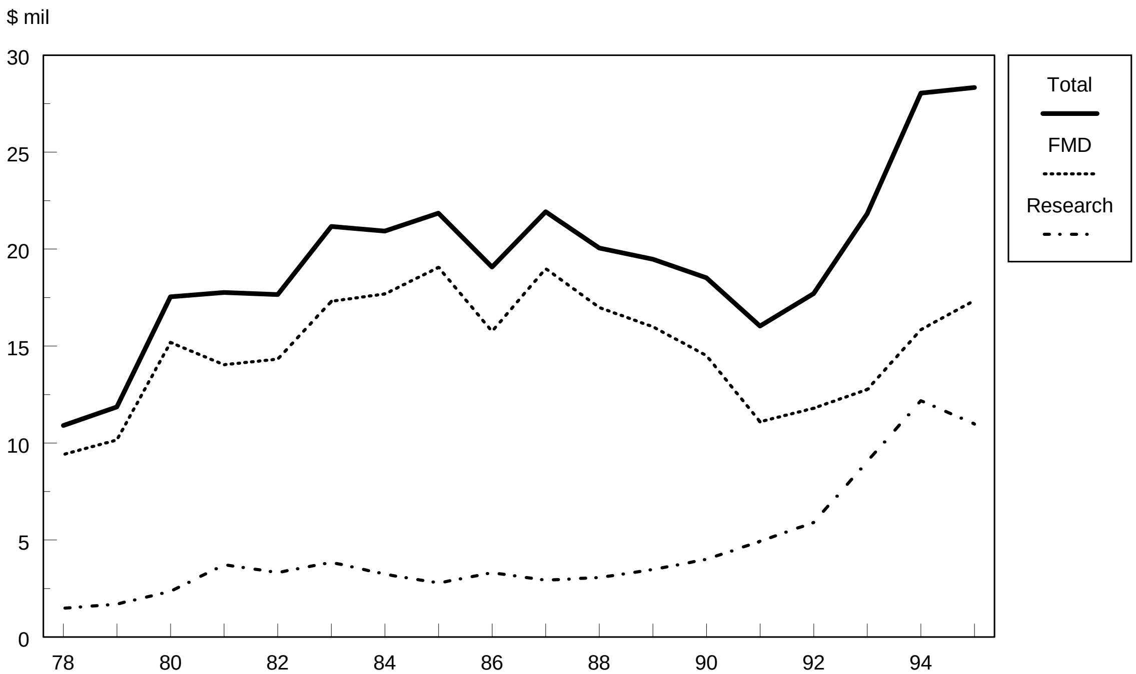


Figure 2: Annual Growth Rate in Soybean Research and Foreign Market Development Investments, 1978-95

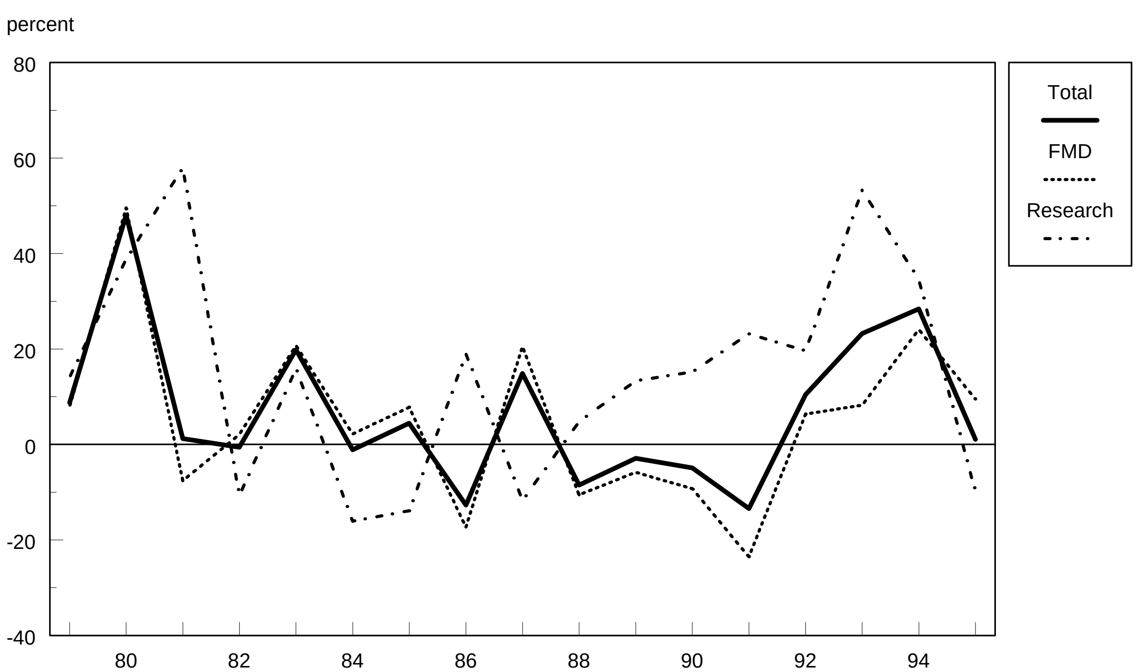


Figure 3: Soybean Research and Foreign Market Development Shares of Total Investments, 1978-95

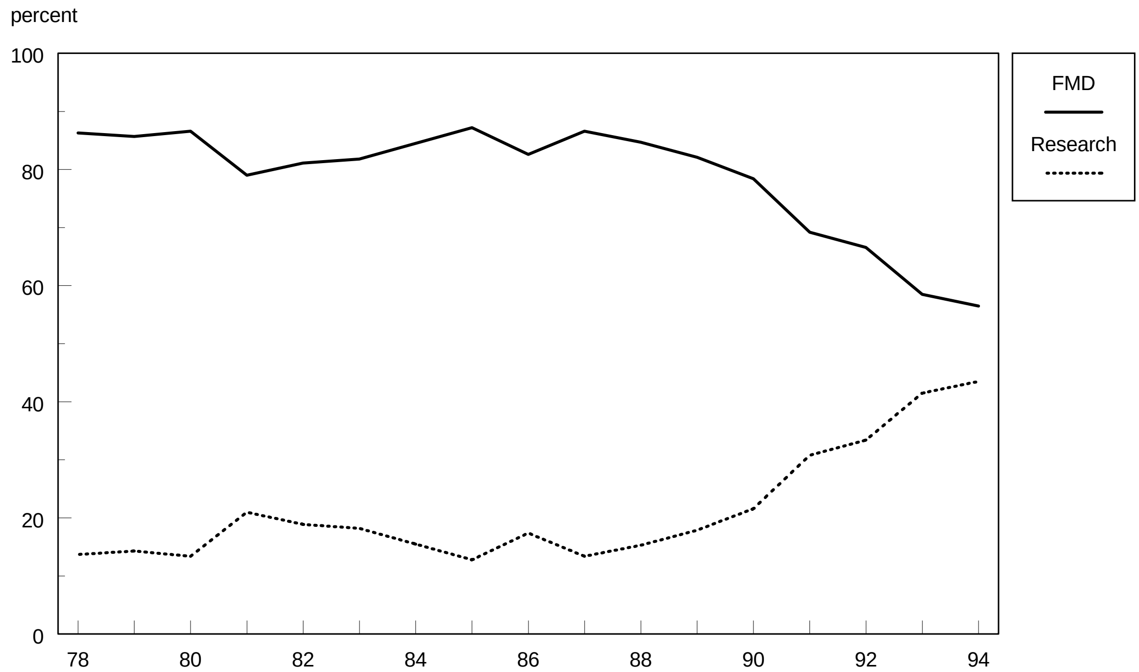
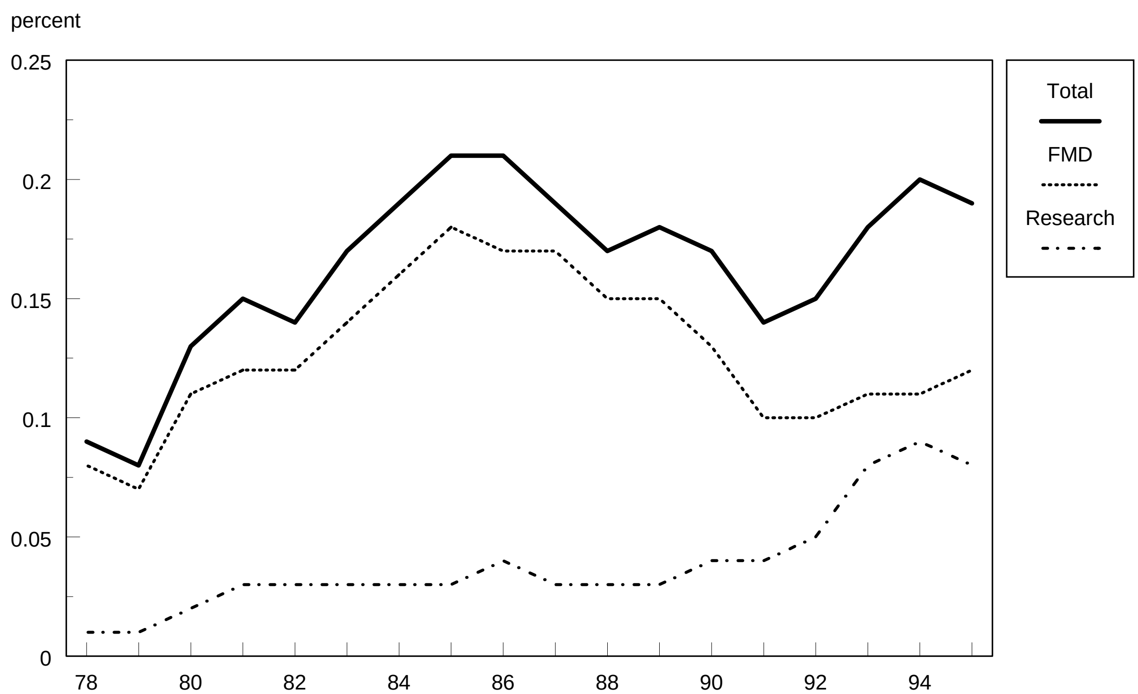


Figure 4: Soybean Research and Foreign Market Development Investments as a Percent of Soybean Cash Receipts, 1978-95



detailing how they intend to spend the requested funds. If FAS approves the marketing plan, the commodity cooperator is expected to share in the cost of implementing the plan for which, under the Soybean Cooperator Program, a large portion of soybean checkoff funds have been used over the years. In implementing the plan, the FAS and soybean checkoff funds are combined with funds raised from third party contributors (3rd Party) in each country where market development activities are undertaken in an effort to multiply the effect of the checkoff funds. The total FMD funds (FAS, ASA/USB, and 3rd Party) are used to support three types of soybean and product market development activities: (1) trade servicing, (2) technical assistance, and (3) consumer promotion (Kinnucan and Williams).

Trade servicing includes those activities specifically intended to facilitate or expand U.S. exports of soybeans or soybean products. Such activities include sponsoring the travel of foreign study teams to the United States to demonstrate U.S. productive capacity and the reliability of the United States as a soybean and soybean product supplier; trade press announcements and conferences; advertising in foreign trade periodicals; distribution of promotional material to foreign food buyers; and other trade-related promotional activities.

Technical assistance encompasses a wide range of activities designed to create or expand the type, quality, and number of uses of soybeans and products in the countries of expenditure. Such activities include technical assistance to foreign soybean crushers and oil refiners to improve crush efficiency and the production, handling, and marketing of soybean products; feeding trials and demonstrations; animal nutrition seminars; soybean product development research; short courses by U.S. experts on feed technology as well as general nutrition seminars. By emphasizing how U.S. soybean and products can be effectively utilized in the production and/or selling activities of foreign buyers, technical assistance programs seek to stimulate growth in the long-term demand for U.S. soybean and product exports.

Consumer promotion includes generic or identified promotion activities specifically designed to promote the use of soybean products or manufactures and soybean-based commodities such as formulated feeds or margarine. Generic promotion is intended to foster the use of such commodities by manufacturers and consumers without specifically identifying them as soybean or soybean-based products. For example, generic promotion of soybeans may consist of margarine and tofu sales campaigns and consumer education seminars in Japan or meat consumption promotion campaigns in Asian markets in cooperation with the U.S. Meat Export Federation. Identified promotion activities, on the other hand, attempt to enhance the demand for soybeans and products in foreign markets by attempting to differentiate them from their competitors in the marketplace. For example, identified promotion activities might include baking and cooking seminars in Japan for institutional nutritionists, cooks, and food buyers to illustrate the quality and versatility of soybean oil, distribution of booklets featuring soyoil and soyfood consumer and institutional recipes, and sharing costs related to the marketing of soy-based salad oils, margarines, and other products with third party contributors in the program countries.

Contributor Share of Foreign Market Development Investments

Between 1978 and 1987, total investments by all contributors (ASA/USB, FAS, and 3rd Party) in the development of foreign soybean and product markets consistently grew but at a declining annual rate from $9.4 million to $19.0 million (Figures 1 and 2) (TAMRCb). The annual growth rate turned negative from 1988 through 1991, plunging total FMD investments to a 12-year record low of $11.1 million. The national soybean checkoff program, however, boosted FMD investments back to $17.4 million by 1995, the level previously reached in the mid-1980s.

During the pre-national-checkoff-program era, farmer soybean checkoff (ASA/USB) investments in foreign market development trended slowly upward from $3.4 million in 1978 to $5.6 million in 1987 only to plummet by 70% over the next 4 years to a low of $1.7 million in 1991 (Figure 5). Likewise, 3rd Party contributions to the soybean FMD program reached a peak in 1985 at $8.6 million and then dropped by 64% to $3.1 million in 1991. Over the same 1978 to 1991 period, however, FAS contributions showed little trend, varying generally between about $5.5 million and $7.5 million. Consequently, when the national checkoff program was put in place in 1991, the ASA/USB share of total FMD investments had been dropping steadily from a high of 36.2% in 1978 to 15.6% in 1991 (Figure 6). Because the 3rd Party share of total FMD investments also declined from a high of 46.2% in 1984 to 27.9% in 1991, the FAS share of total FMD investments grew sharply from a low of 29.1% in 1978 to 56.5% in 1991 despite no substantial changes in the level of FAS funding of the program.

The implementation of the national soybean checkoff program dramatically boosted the level and the share of soybean checkoff funding of foreign market development activities. From a low of $1.7 million in 1991, checkoff investments in foreign market development soared by nearly 440% to $9.3 million in 1995, more than tripling the checkoff share of total soybean foreign market development funding. Along with a 26.6% slip in FAS contributions to soybean and product foreign market development activities from $6.3 million in 1992 to $4.6 million in 1995, the surge in soybean checkoff funding cut the FAS share of total funding in half from 53.6% to 26.8% over the same period. Although helping to reverse the downward trend in the financial support for development of foreign markets for soybeans and products, the national soybean checkoff program has done little to generate additional funds from 3rd party contributors in the program countries. During the mid-1980s, 3rd party contributors accounted for the largest share of the total funds invested in foreign market development (35% to 45%). Since 1984, however, the share of total FMD funds contributed by third parties has dropped steadily from 46.2% to 19.7% in 1995.

Commodity Share of Foreign Market Development Investments

Since at least the 1970s, the evident foreign soybean market development investment strategy has increasingly been to emphasize soybean meal[7] over either soybeans or soybean oil as the primary

[7] For this study, expenditures to promote soyfood in target countries were added together with such expenditures for soybean meal into one category referred to here as "soybean meal."

Figure 5: Foreign Market Development Investments by Contributor, 1978-95

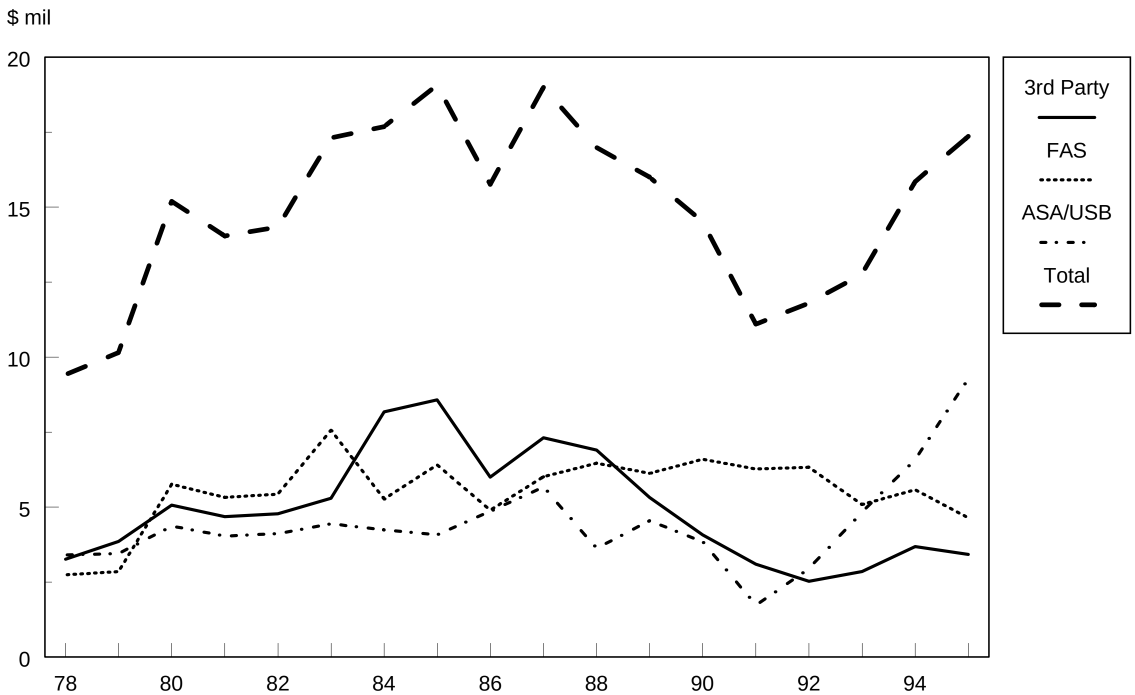
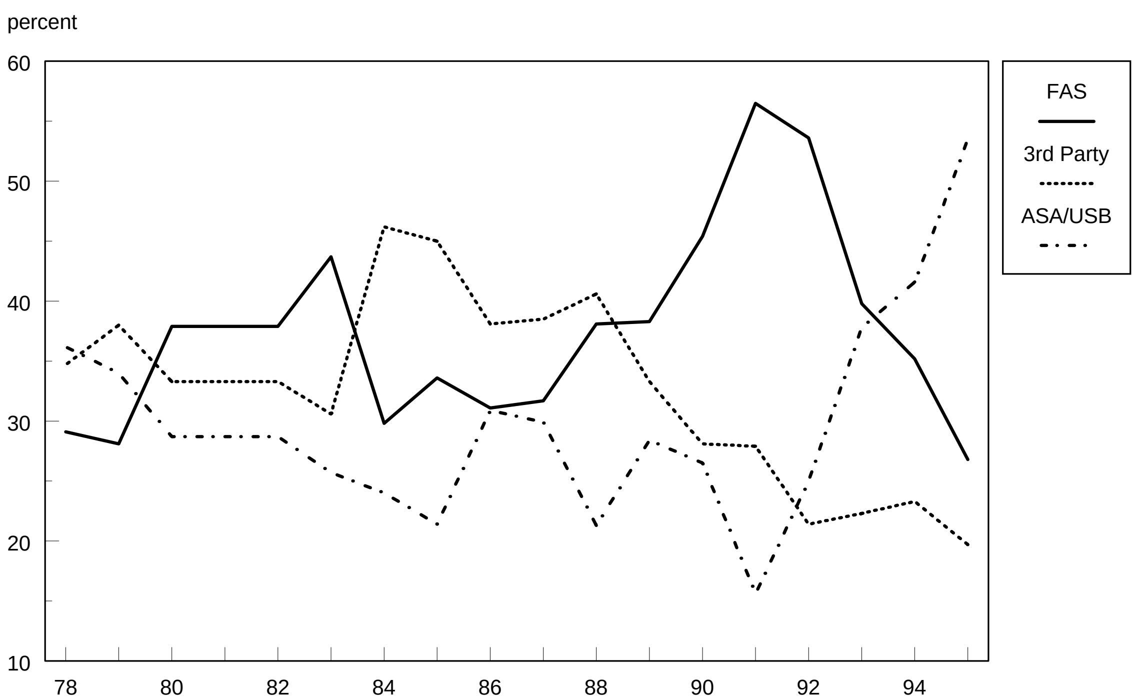


Figure 6: Contributor Share of Foreign Market Development Investments, 1978-95

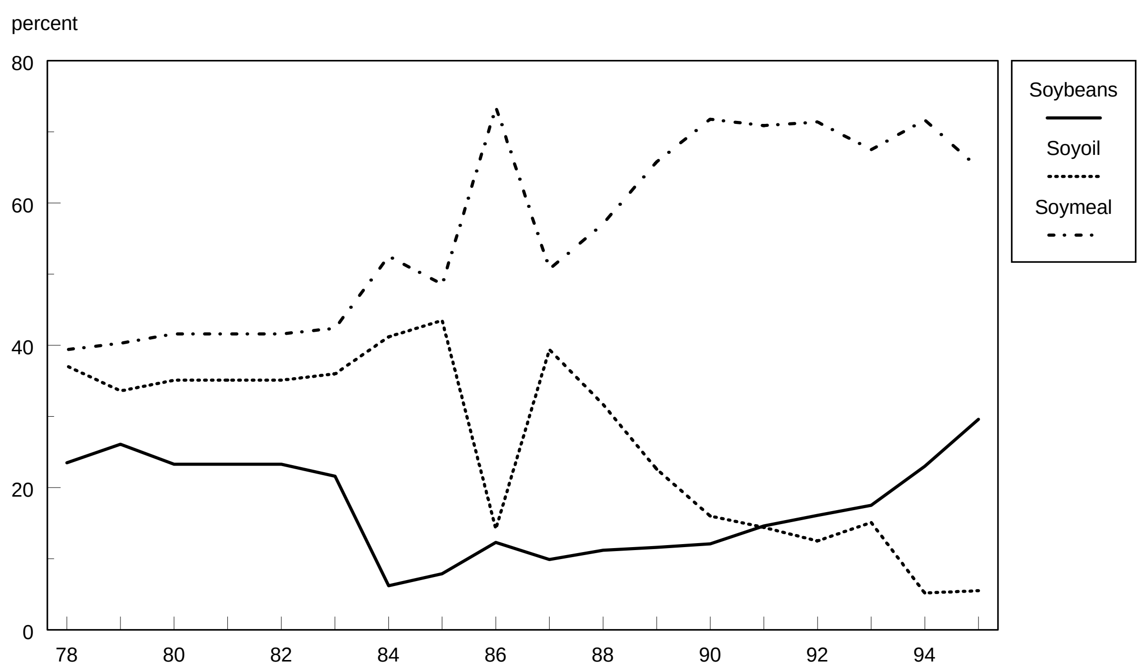


export promotion objective (TAMRCb). In 1978, soybean meal and soybean oil together accounted for about 60% of total investments with soybeans accounting for the remaining 40% (Figure 7). By 1984, the soybean product share had risen dramatically to about 94%. Although the soybean share rose once more to about 30% in 1995, the soybean oil share dropped steadily from a high of 43.5% in 1985 to only 5.5% over the same period. As a consequence, soymeal alone now accounts for as much as or more of total FMD investments (65% to 70%) than soybean meal and oil together accounted for two decades ago. The preference for funding soybean meal rather than soybean oil FMD activities was evident in 1986 when a sharp drop in FMD funds from both FAS (23.5%) and 3rd Party contributors (30%) was taken almost entirely out of soybean oil FMD activities in attempt to maintain the level of funding for soybean meal FMD activities. The result was an obvious upward spike in the soybean meal share of FMD funding from 48.6% in 1985 to 73.5% in 1986 and back down to 50.7% in 1987 with an almost equal downward spike in the soybean oil share from 43.5% to 14.2% and back to 39.4% over those same three years.

Regional Share of Foreign Market Development Investments

In the early 1970s, Japan and the European Community (6 members) accounted for 80% to 90% of all soybean and soybean product FMD investments (Williams 1985). Over time, the soybean and product FMD program expanded into a number of other countries, resulting in steadily declining shares of FMD investments being spent in Japan and the European Union (now with 15 members and referred to as the EU-15) (TAMRCb). By 1995, Japan and the EU-15 together accounted for

Figure 7: Commodity Share of Foreign Market Development Investments, 1978-95



only about 21% of total FMD investments (Figure 8). Despite the growth in the share of total FMD investments accounted for by other countries outside the EU-15 and Japan, the regional shares of those investments have not changed to any great extent. Asia accounted for 50-55% of FMD investments in countries other than the EU-15 and Japan in most years between 1978 and 1995 (Figure 9). Over the same time period, Latin America accounted for about 20% of FMD investments in other countries (excluding the EU-15 and Japan) until the implementation of the national soybean checkoff in 1992 after which the Latin American share dropped to about 10% by 1995. The implementation of the national soybean checkoff program signaled a change in the regional FMD investment strategy. Both Latin America and Africa have been de-emphasized in favor of the Former Soviet Union and Baltic States which grew from 6% of FMD expenditures in countries other than the EU-15 and Japan in 1991 to 13% in 1995. Some FMD funds were also diverted from Latin America to push Asia back to about 57% of FMD expenditures outside the EU-15 and Japan after reaching a low of 46% in 1990.

Soybean Production Research Investments

Between 1978 and 1995, soybean farmers invested over $82 million in checkoff funds in soybean production research projects (TAMRCc). Investments in soybean production research increased steadily from $1.5 million in 1978 and to $11.0 million in 1995 and commanded an increasing share of total investments (13.7% to 38.7%).

Production research projects have tended to fall in one of 5 general categories: (1) production systems research (tillage, cropping systems, management; water management; soil fertility; plant nutrients; nitrogen fixation; soybean seed quality; weed control; and extension education activities, (2) soybean breeding and germplasm screening, (3) soybean biotechnology and fundamental studies, (4) soybean disease and pest control (insect control, disease control, and nematode research), and other research (grain quality, research support, economic research, improving soybean composition, etc). In 1978, about 46% of the checkoff research funds went to production systems research, 23% to breeding research, 16% to disease and pest research, and nearly 10% to other production research (Figure 10). Only 5% of the research funds were allocated to biotechnology research in 1978. Until about 1987, a declining proportion of the funds was allocated to production systems research primarily in favor of soybean breeding research. After that, biotechnology research benefitted from the continuing decline in the share of funding being allocated to production systems research. By 1994, biotechnology research accounted for 28% of all soybean checkoff research funds with production systems, breeding, and other research accounting for 26%, 18%, and 11%, respectively.

Between 1978 and 1995, nearly 70% of all soybean production research was conducted by researchers in only eight states: (1) Illinois (12.5%), (2) Iowa (12.4%), (3) Arkansas (10.6%), (4) Minnesota (7.6%), (5) Louisiana (7.5%), (6) Mississippi (6.4%), (7) Montana (6.4%), and (8) Nebraska (4.8%) (Figure 11).

Figure 8: Regional Share of Foreign Market Development Investments, 1978-95

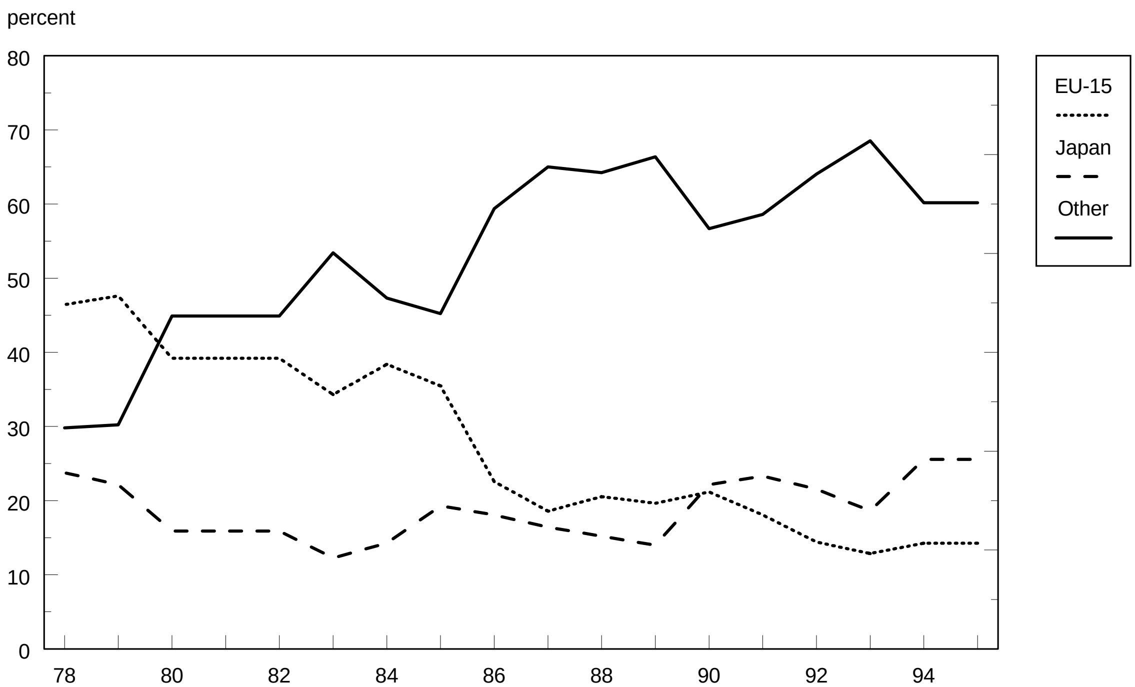


Figure 9: Regional Share of Other Foreign Market Development Investments (excludes Japan and the EU-15), 1978-95

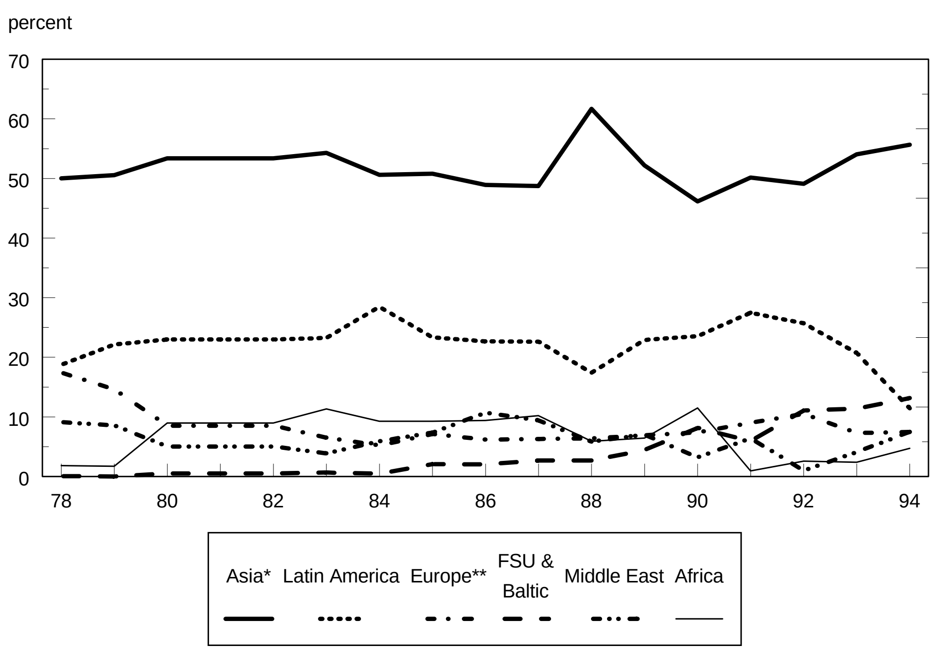


Figure 10: Share of State and National Soybean Research Investments by Type of Research, 1978-95

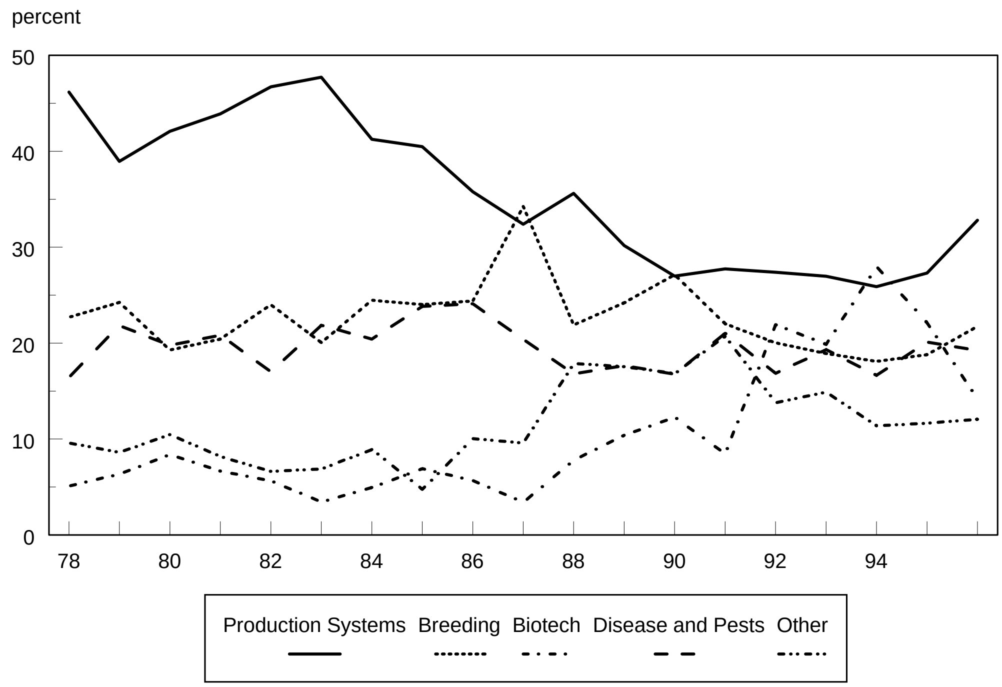
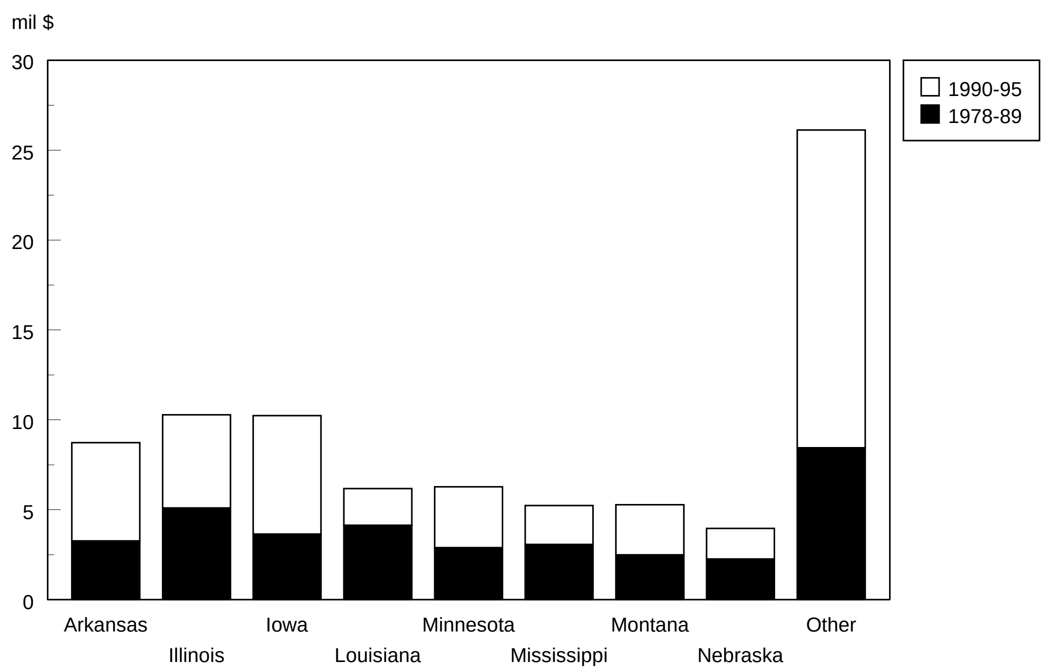


Figure 11: National and State Soybean Research Investments by State, 1978-95



Domestic Promotion and Utilization Research

Although checkoff funds have been invested by both state and national organizations in various efforts to promote domestic use of soybeans and soybean products, data on these investments have not been systematically gathered over time. Funds invested in soybean and soybean product utilization research were well maintained by both the American Soybean Association and the United Soybean Board over the years but not by individual state organizations. In contrast, neither state nor national soybean organizations before or after the establishment of the national soybean checkoff program have attempted to systematically compile data on domestic promotion campaigns.

Despite an attempt by the authors of this study to collect this data by survey from each organization, the data remain quite incomplete and unreliable, particularly for the period prior to the national checkoff program (TAMRCa). Unfortunately, a number of state organizations failed to respond to repeated requests for the information[8]. Also, even for those states that responded to the survey, the quality of the data provided was highly variable in terms of the time period of coverage, level of commodity and project aggregation, comprehensiveness, and other characteristics.

The quality of the data on domestic promotion expenditures available from the responding states and the national organization for the period after the establishment of the national checkoff program was much better than that available for preceding years. Nevertheless, the failure or inability of many states and even the national organization to systematically maintain detailed historical information in a consistent format across organizations on their annual funding of domestic promotion programs and utilization research renders even the most recent data virtually useless at least for program evaluation purposes[9]. Both the data that are available for domestic promotion programs (TAMRCa) and discussions with ASA and USB personnel indicate that until about 1992, domestic promotion accounted for an extremely small proportion of all soybean checkoff funds expended in those years. Even after 1992, however, domestic promotion expenditures continued to account for only a small proportion of total soybean checkoff investments.

Purchasing Power of Soybean Checkoff Investments

Despite a generally upward trend in the nominal dollar value of soybean checkoff investments between 1978 and 1995, inflation in the countries of expenditure and a general depreciation in the value of the U.S. dollar against foreign currencies have eroded the real purchasing power of those investments over time in all countries. Consequently, each U.S. dollar could purchase less

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[8] Refer to TAMRCa (Texas Agricultural Market Research Center Information Report No. IR 3-98) to see what was and was not provided by which states.

[9] Actually, the failure to systematically compile consistent quality checkoff expenditure data across state QSSBs and the USB is a serious problem for all types of expenditures except foreign market development. Fortunately, historical data on production research was faithfully compiled by a single ASA employee who has since retired. No effort is apparently being made currently by USB, the states, or any of their contractors to maintain and extend that production research funding database. As the USB contractor for the FMD program, the ASA appears to be maintaining adequate records of foreign market development investments by all contributors.

promotion and research in 1995 than was the case in 1978. In the U.S., inflation has had only a moderate effect on the real level of research purchased between 1978 and 1995 (Figure 12). In foreign markets, however, the combination of inflation and a depreciating U.S. dollar combined for a more serious effect on the purchasing power of foreign market development expenditures. In Japan, for example, the real purchasing power of soybean checkoff investments declined steadily between 1978 and 1995 despite an indeterminate overall trend in nominal expenditures (Figure 13). In the EU-15, however, the trends in soybean checkoff investments in nominal U.S. dollars and in real 1985 German Deutsche Marks (DM) were similar over that same period (Figure 14).

The Expected Effects of Research and Demand Promotion Investments

The primary objective of any commodity checkoff program is to foster the growth and profitability of the production of that commodity. Ultimately, however, the individual farmers contributing to the program expect that the funds will be spent in such a way that they are individually better off than they would have been without the checkoff program. What can be expected of a research and promotion program in terms of the market effects and the effects on producers? The section explores what could reasonably be expected - and what should not be expected - from a checkoff program.

Figure 12: Soybean Checkoff Research Investments, Nominal vs. Real (1978 $US), 1978-95

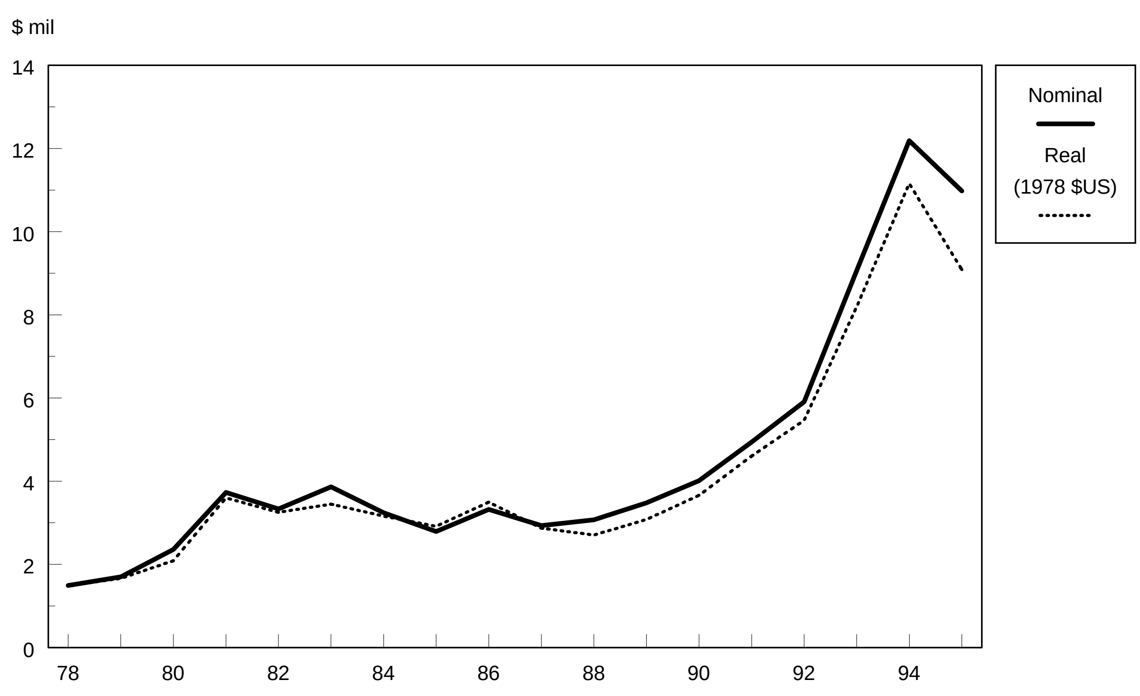


Figure 13: Japan Foreign Market Development Investments, Nominal (million $US) vs. Real (million 1985 yen), 1978-95

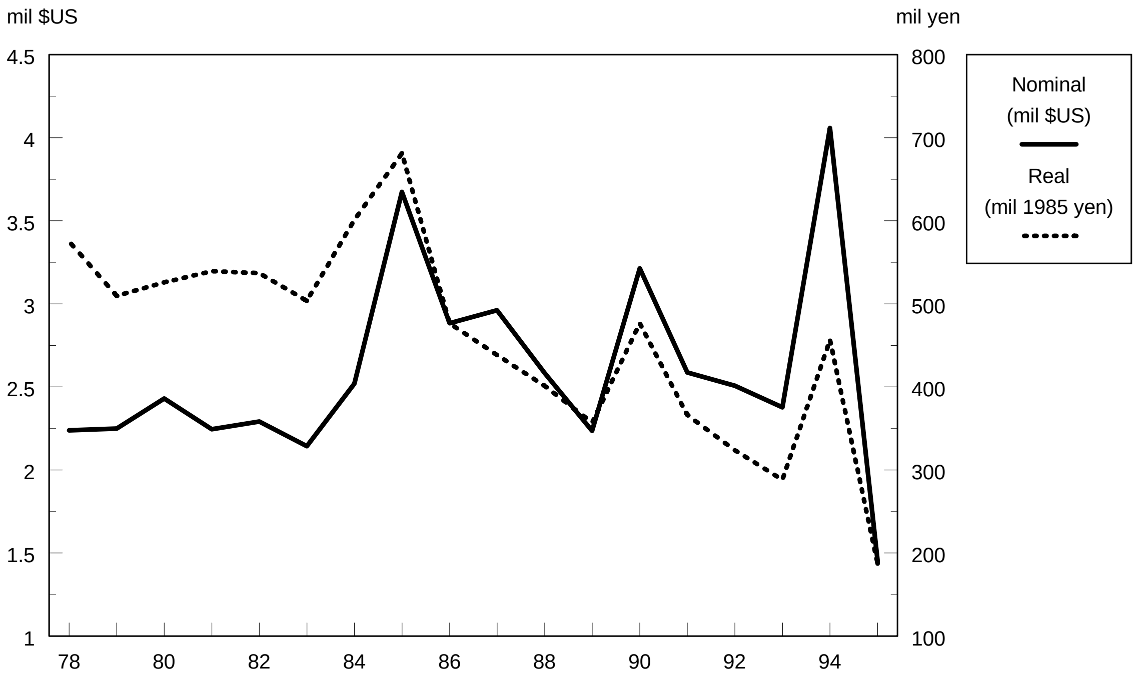
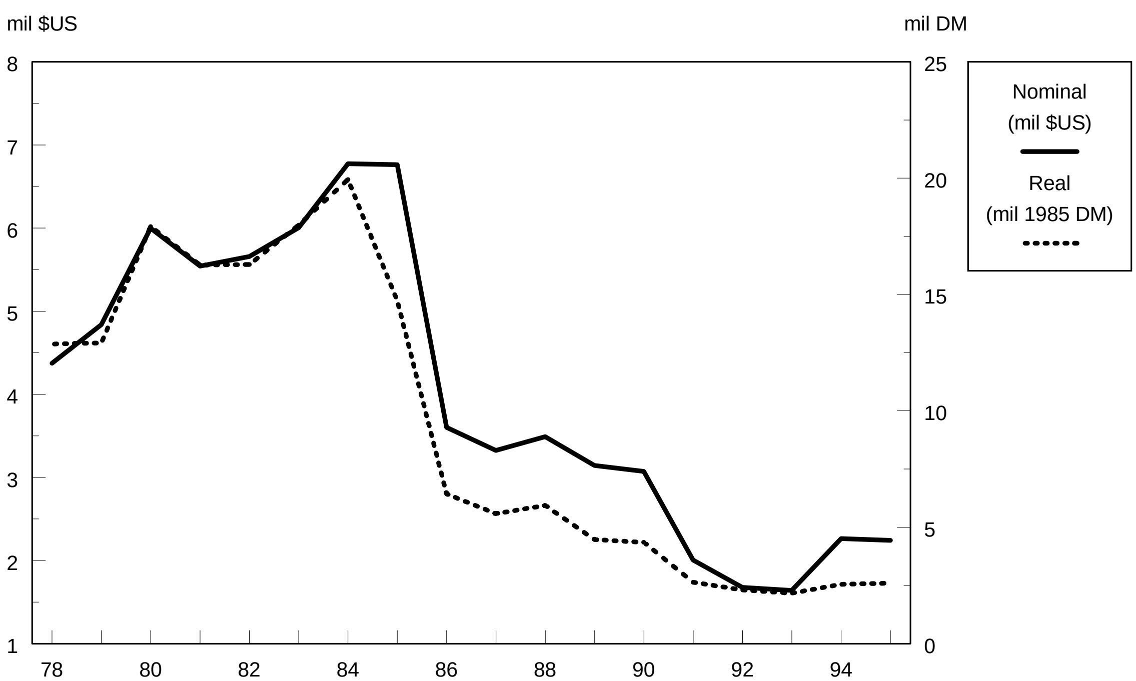


Figure 14: EU-15 Foreign Market Development Investments, Nominal (million $US) vs. Real (million 1985 DM), 1978-95



The Expected Effects of Investments in Research

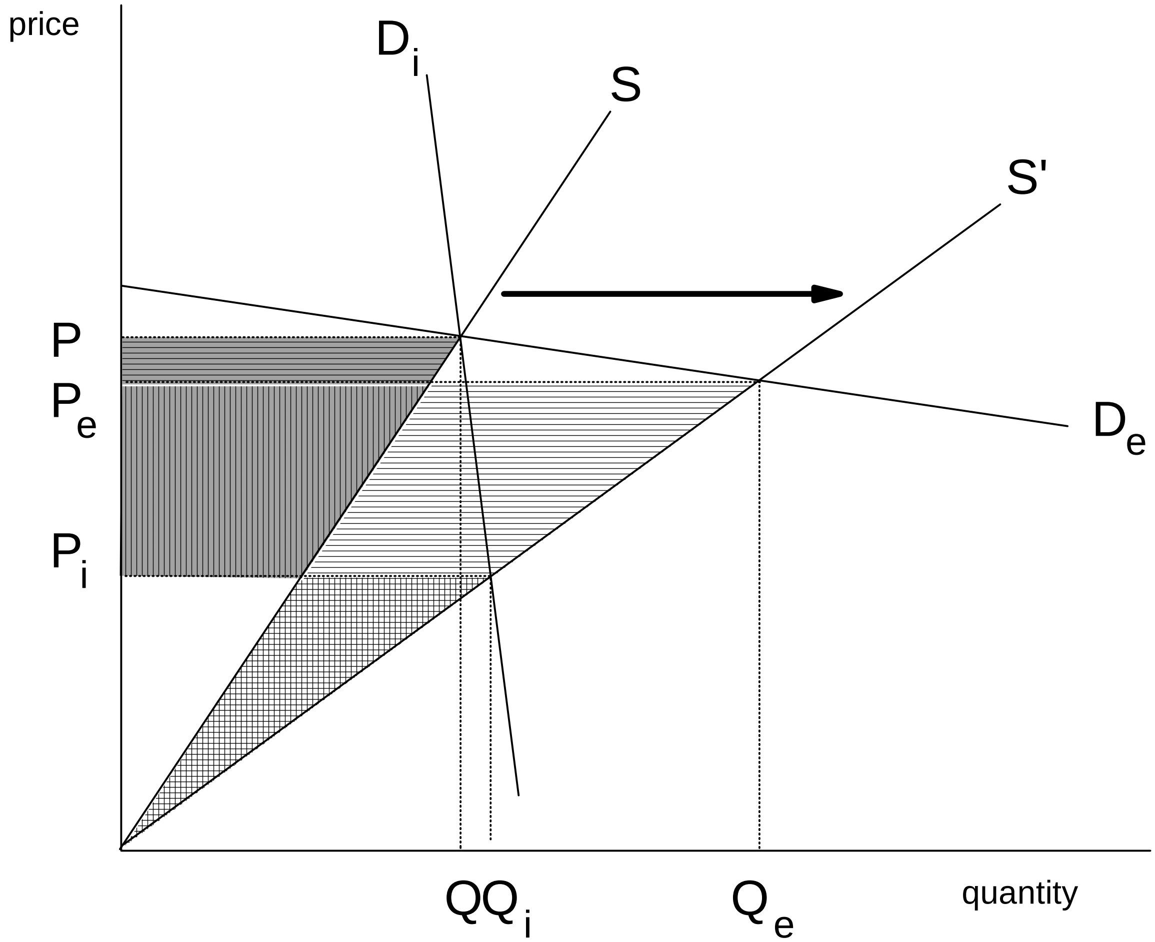
From the perspective of the individual producer, investments in research offer the potential for increased profits through technological advances that reduce their production costs and/or boost their yields (i.e., output per unit of input). From a market perspective, however, if such research-induced technological advances are successful at reducing costs and/or boosting yields of individual producers, the effect across all producers is an increase in the aggregate, market supply of the commodity and a potentially negative effect on each producer's profits from a lower market price. If the market price drop is large compared to the cost decline or supply increase of the individual producer, revenues and profits could decline. If not, then individual producers would likely benefit from the research investments. Whether a research-induced shift out of a given market supply curve will reduce or increase producer profits (welfare) depends critically on three factors: (1) the effect of the research on the supply curve, and (2) the revenue effect of the research-induced market supply increase, and (3) the cost effect of the supply increase.

The effects of investments in research on the market supply of a commodity are often not immediate, measurable, or direct. Checkoff dollars may fund either basic, long-term types of research or more applied, short-term types of research. Because the lag between research activities, particularly basic research, and the commercialization of new technologies available for adoption by soybean producers may be quite lengthy, the full market impacts and any benefits of checkoff-funded research to soybean producers may not be felt for a long time following the research investment. Also, research investments may not always result in measurable market impacts. For example, basic or applied research that provides knowledge about what does *not* work in increasing yields or reducing costs has value but is not measurable in terms of market impacts. At the same time, applied research often is related to or depends on previous investments in basic research. Consequently, investments in basic research may have only indirect market effects to the extent that the results of that research lead to more applied research to develop new technologies and processes for adoption by producers.

Even if funded research results in an increase in supply in a given period, the impact on producer profits (sales revenues minus production costs) depends critically on the responsiveness of demand to price changes. Assume, for example, that market demand is highly price responsive (i.e., price elastic) as represented by demand curve D_e in Figure 15. A research-induced shift out in the market supply curve from S to S' leads to an increase in the market sales of the commodity from Q to Q_e and a decline in the market price from P to P_e. In this case, total sales revenues (i.e., farm cash receipts) increase because the percentage increase in the quantity sold from Q to Q_e is greater than the percentage drop in market price from P to P_e. Although the total cost of production (represented by the area under the supply curve up to the point of production) may also increase, for a highly elastic demand curve, the revenue increase is likely to be greater than the cost increase resulting in a net increase in producer profits. The positive net effect on producer profits is represented in Figure 15 by the large, horizontally-lined triangular area minus the small, shaded, horizontally-lined trapezoidal area (i.e., the net change in producer surplus).

On the other hand, if market demand is highly unresponsive to price (i.e., price inelastic), as is the case with demand curve D_i in Figure 15, then the same research-induced shift in supply (S to S')

Figure 15: Research Investments: Market and Producer Welfare Effects



leads to a larger percentage drop in market price (P to P_i) than the percentage increase in the quantity sold in the market (Q to Q_i). As a consequence, farm cash receipts decline. Total production costs might also decline but, given a highly inelastic demand curve, the revenue drop could be greater than the cost decline resulting in a net loss to producers represented in Figure 15 by the small cross-hatched triangular area minus the larger total shaded area (vertically and horizontally lined). The more inelastic the demand, the more likely the cross-hatched area will be smaller than the shaded area resulting in a net loss to producers. That is, the more unresponsive demand is to price changes, the more likely it is that research investments will lead to a drop rather than an increase in farm profits. Some researchers (e.g., Schuh) have argued that while domestic market demand for agricultural products tends to be fairly unresponsive to price (i.e., price inelastic), export demand tends to be quite price responsive (i.e., price elastic). Consequently, total demand (domestic plus export demand) for agricultural products could well be elastic. Many other researchers (e.g., Schmitz and Bredahl, Meyers, and Collins), however, have argued that 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). If the export demand for an agricultural product is indeed price inelastic, then the total demand for that product is likely price inelastic so that a research-induced outward shift in supply could well result in a loss in producer profits.

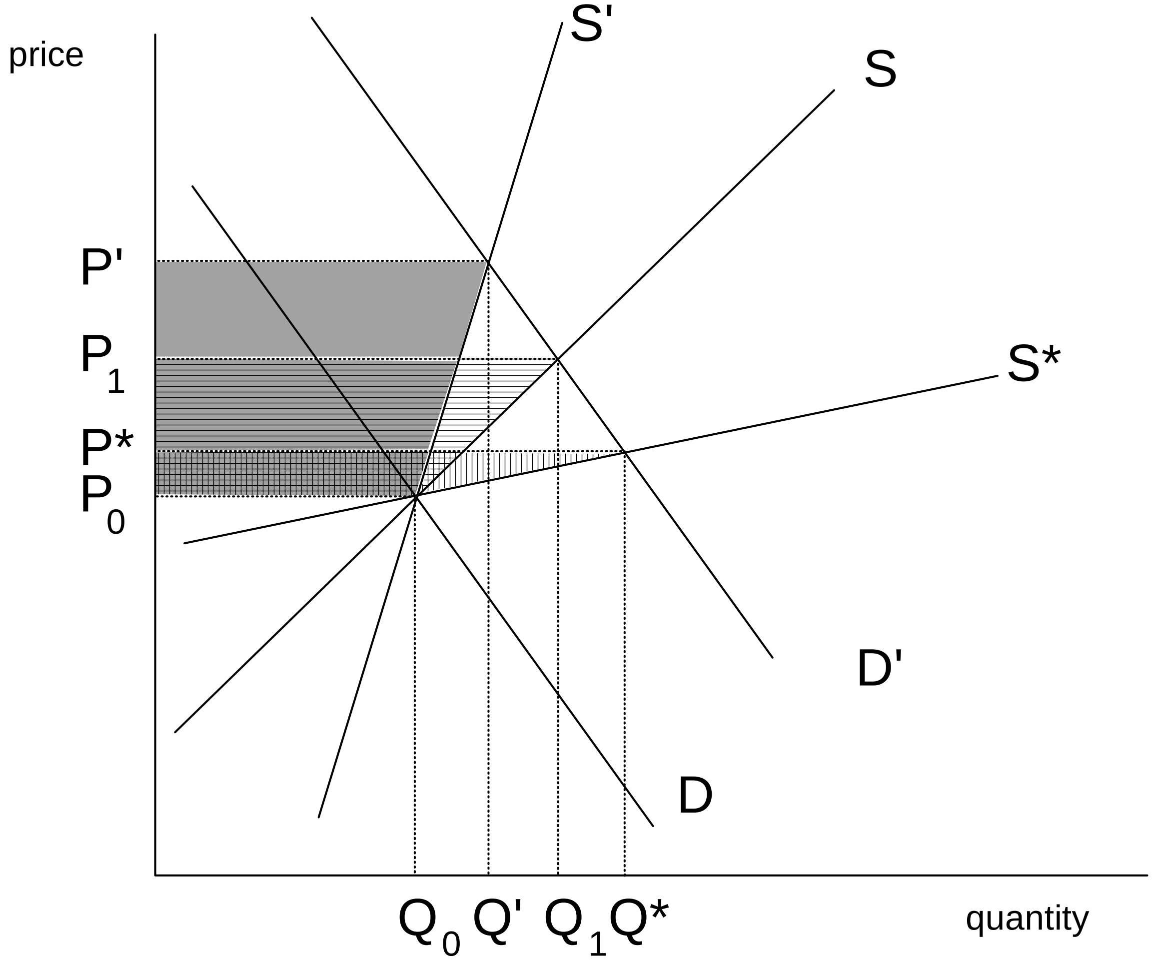
The Expected Effects of Demand Promotion

While ostensibly more straightforward than that of research investments, the relationship between investments in demand promotion and farm profits is not necessarily more direct nor less complex. Clearly, the objective of demand promotion is to shift out demand and, thereby, increase the market price on a higher volume of sales over time. Indeed, promotion programs that successfully move out the demand curve raise price. In raising the price, however, they also stimulate a greater level of production over time than would have occurred which moderates the extent of the price increase.

Assume, for example, that a particular demand promotion program shifts out the demand for soybeans in a given year from D to D' in Figure 16. Given a supply of soybeans for that year of S*, the demand shift would tend to raise the price from P_0 to P*. In this case, supply is so responsive to price changes (i.e., price elastic) that most of the adjustment to a successful promotion program is manifest as an increase in output and sales (Q_0 to Q*) rather than an increase in price. Even though the price increase from the promotion-induced demand shift is moderated by the vigorous supply response in this case, farm sales revenue increases by a greater percentage than the price increases over time because the quantity sold at the somewhat higher price also increases. Although the total cost of production also increases, the increase in revenue given a demand shift is greater than the cost increase so that the net effect on producer profits is positive, represented by the vertically-lined area in Figure 16. Thus, while it could appear to individual producers that the promotion program was not highly successful because the price did not increase much or as much as expected over time, in fact the program is quite successful in boosting farm revenues and even profits. A much less price-responsive supply (such as S' in Figure 16), however, would result in a higher price increase (P_0 to P') relative to the increase in sales (Q_0 to Q') as a result of the same demand increase (D to D') and, thus, a larger positive effect on farm profits (represented by the shaded area in Figure 16).

Thus, the extent to which farm profits increase from a promotion-induced increase in demand depends on the responsiveness of supply to price over time (i.e., the long-run price elasticity of supply). The stronger the competition from competing suppliers of a commodity, the more likely the long-run market supply curve will look like S* (price elastic) rather than S' (price inelastic) in Figure 16. For example, if a U.S. industry faces stiff competition in an international market relatively free of trade restrictions, a price rise induced by an increase in world demand will stimulate production not only in the U.S. but also in competing countries so that world supply increases by more than just the increase in the U.S. supply. Given the strong competition U.S. soybean producers face in the world market from South American producers, any increase in world demand for soybeans is likely to generate a substantial increase in world soybean supply to meet that demand which would moderate any price increase that might be expected. The important issue, then,

Figure 16: Demand Promotion: Market and Producer Welfare Effects



becomes the extent to which an increase in world soybean demand from checkoff supported promotion activities increases the U.S. share of increased world soybean sales compared to that of U.S. competitors in the world market. Given the intensity of competition in world soybean and soybean markets, the effects of a checkoff supported foreign market development program on both the level and world market share of U.S. exports of soybeans and products is a better indicator of the successfulness of the program than the changes in U.S. price.

A number of researchers have reported that the supply response can effectively prevent a long-term rise in producer price or even completely offset the effects of producer-funded commodity promotion programs. In a study of the effectiveness of the soybean cooperator foreign market development 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. As noted earlier, Kinnucan, *et al.* (1995) determined that supply response completely eliminated returns to advertising of catfish over time. Carman and Green found that while avocado producers benefitted from generic advertising during the initial years of the program (1960s through mid-1970s), supply expansion eventually led to negative returns to producers from continued advertising. They found that the avocado acreage response to the advertising-induced increase in the price of avocados was partially responsible for recent low returns in the avocado industry. While avocado producers existing at the time the advertising program was initiated benefitted, they conclude that "as acreage expanded, prices were forced down toward a level that would have existed for a smaller acreage without advertising. Now real returns per acre for avocados are similar to those that would have occurred without the advertising but the advertising has become a built-in cost." They question whether there are long-run benefits to advertising in an industry without supply control. The problem of advertising response in an industry without supply controls was first discussed in a now classic article by Nerlove and Waugh in 1961. Nevertheless, relatively few studies of the effects of advertising have considered the possibility of a supply response.

Besides the complications of a potential supply response to a promotion program, the linkage between investments in demand promotion and the anticipated market effects is further complicated by a number of well documented characteristics of the response of sales to advertising and promotion programs: (1) the magnitude of the sales response to promotion, (2) the minimum promotion threshold, (3) the delay or lagged effect of promotion, (4) the carryover effects of promotion, (5) the decay of promotion effects, and (6) advertising and promotion wearout.

The Magnitude of the Sales Response

Research has generally shown that the sales response to advertising is normally positive and statistically significant but fairly small in magnitude or elasticity (Williams and Nichols). Substantial investments may be necessary to achieve an acceptable sales response. In addition, the particular type of promotion activities undertaken may have differing levels of effectiveness and cost. Unfortunately, little research has been done to indicate the relative effectiveness of different types of promotion activities in expanding sales. Some commodity groups, like the beef, pork, and dairy producer associations, have focused intensely on the domestic market primarily through mass media advertising. Cost considerations have forced smaller commodity promotion groups to focus on the domestic market and to rely heavily on non-mass media forms of promotion. Soybean producers have tended to focus on promoting demand in foreign countries through trade servicing, technical servicing, and non-mass media consumer promotion activities. Whether that choice has led to a higher or lower effectiveness and return to each soybean checkoff promotion dollar spent than a more traditional direct mass media advertising to consumers in the domestic market approach might have yielded is not clear and may bear some analysis. The need for such an analysis may be particularly important since an increasing number of soybean checkoff dollars have been spent in domestic promotion programs since 1992 under the national soybean checkoff program. Unfortunately, as discussed earlier, the current state of the data on soybean checkoff investments in domestic promotion programs currently precludes such an analysis.

The Minimum Promotion Threshold

Some minimum level of promotion expenditures and messages may be required for the expenditures to begin having any effect. Below that level, promotion expenditures may be simply unable to generate sufficient recall or awareness to motivate consumers. Little research has been done to determine appropriate threshold levels. Most certainly, however, the threshold level is different for each commodity (soybeans, soybean oil, and soybean meal), situation, time period, and world location.

The Delay or Lagged Effect of Promotion

Even if investments in promotion activities well above the threshold level are made, the investments may still take time to yield results depending on the type and objective of the promotion program (Williams 1991). Mass media advertising is often intended to generate an immediate response of sales rather than to generate brand loyalty and repeat sales. Non-mass media promotion activities, however, are more often intended to generate streams of new revenues which may take some time in coming to fruition. Consequently, the response of sales to promotion activities, particularly the non-mass media type apparently favored by soybean producer groups, may not be apparent for some time after initiation of the promotion program. Several exposures to a promotion message over time may be required before an individual decides to buy (Lee, Brown, and Fairchild). Attempts to measure the effectiveness of the promotion effort in the early stages of the program, therefore, may yield disappointing results.

The Carryover Effects of Promotion

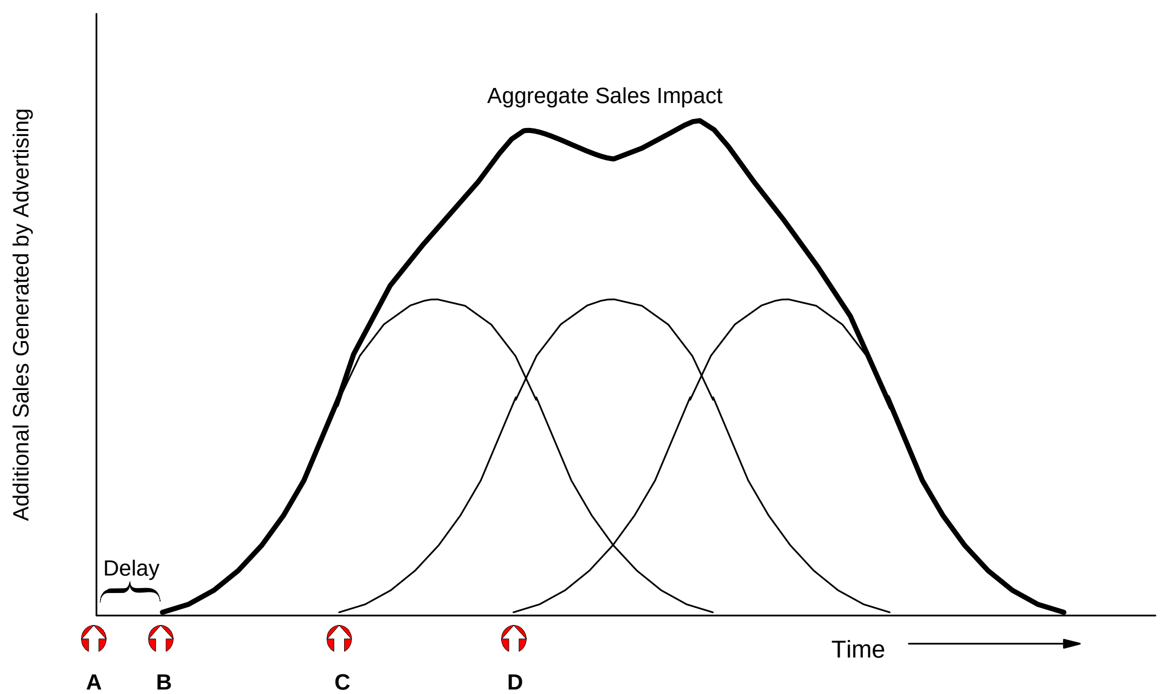
Current promotion expenditures often do not have their full impact in the current accounting period but continue to impact sales over an extended period of time. This "carryover effect" has been reported to last from 1 month up to 2 or more years depending on the commodity and the type of promotion activity (Jensen, *et al.*). Other programs are intended to have little or no carryover effects because they involve temporary specials or product attributes that will not continue (Forker and Ward). For that type of advertising, the objective is an immediate response without any intent to gain consumer loyalty to the product. Generic promotion activities, like those generally funded by soybean checkoff dollars in both the domestic and foreign markets, are generally directed toward longer-term responses and, therefore, have often been found to generate lengthy carryover effects (Forker and Ward).

The Decay of Promotion Effects

While the effects of promotion activities often persist beyond the period in which the expenditures are made, they do not last forever. A decay in those effects is expected after some period of time. Research has shown that the promotion message will be forgotten if the potential users are not continuously exposed to it (Zielske). Krugman concludes that continued investments in promotion are necessary because users filter messages and only respond when they are ready to make a purchase. When the user is interested, relatively few exposures to the promotion message are necessary for an effect. Also, without repeated exposure to the message, the number of recalls decreases.

Figure 17 illustrates a typical pattern of promotion effects on sales. Following the initial treatment or expenditure (point A), there is usually first some delay before the expenditures begin having an effect on sales (point B) assuming that the promotion expenditures are above some threshold level. The maximum impact of the initial treatment is eventually reached after which there is some decay in the sales effects. The decay from the initial treatment can be avoided and aggregate sales boosted if additional expenditures are made before the decay begins (point B). Continued investments in promotion (points C and D) can maintain the aggregate level of sales achieved with the first two treatments (dark line in Figure 17). Higher and higher expenditures, however, can push sales to higher levels while a drop off in the level of promotion expenditures results in a decay in the sales effects. If promotion activities are terminated altogether, the level of sales will taper off toward the pre-promotion program level over time. Some research suggests, however, that because promotion programs may achieve some permanent change in user behavior, sales will not drop all the way back to pre-program levels following a promotion campaign. Forker and Ward note that without the decay phenomenon, there would be no reason for continued investments in promotion activities after the initial effort.

Figure 17: Delay, Carryover, and Decay Effects of Demand Promotion



Note: A = Initial treatment B = First effects begin C = Second treatment D = Third treatment

Advertising Wearout

While continued expenditures can help stem the decay of the effects on sales of a given promotion program, it is possible that after long periods the promotion expenditures will begin to lose some of their original effects. This phenomenon, termed "advertising wearout," was initially discussed for generic advertising of agricultural products by Kinnucan, *et al.* (1993). Appel provides evidence that a particular promotion activity changes in effectiveness with the passage of time. Reberte, *et al.* found that two major generic milk advertising campaigns in New York City during the 1986 to 1992 period exhibited wearout. Relatively few studies have explored the question of generic commodity advertising wearout (Reberte, *et al.*). While most of those studies have considered the wearout phenomenon primarily in relation to media (television, radio, newspaper, etc.) advertising, the concept may have important applications for non-media promotions of the type characteristic of foreign market development activities. The effectiveness of feeding trials to demonstrate the improved performance of livestock on balanced rations as a means of promoting the use of soybean meal in a country, for example, will likely erode over time for many of the same reasons that a particular media advertising promotion program may suffer wearout. Unfortunately, the possibility of wearout for non-media promotion activities has not been considered in the literature.

Overview of Research on Effectiveness of Commodity Research and Promotion Programs

Early evaluation of the effectiveness and producer returns from commodity checkoff programs relied largely on anecdotal evidence and simple comparisons of gross investments against changes in prices, profitability, and utilization of soybeans and products. During the 1970s, when soybean markets and profits as well as producer investments in soybean research and market development were growing rapidly, this approach to evaluation yielded some persuasive stories and even more impressive upward-sloping graphical relationships between investments and market prices, demand, and profits. The problem with simply comparing market trends and profits with producer investments to measure program effectiveness, of course, is that many factors other than the producer investments affect the markets for soybeans and soybean products, including events in related markets, the costs of inputs, currency exchange rate fluctuations, the performance of U.S. and foreign macroeconomies, changes in consumer buying habits, and changes in government policies around the world to name just a few. This became rather apparent in the early 1980s with an unexpected downturn in commodity markets despite continued producer investments in both research and promotion. Such events, combined with concern over federal deficits and intense scrutiny of federal programs, underscored the need to devise better means of isolating and measuring the unique contribution of soybean producer investments in both research and demand promotion to the performance and profitability of the U.S. soybean sector.

Studies on the Returns to Investments in Research

Although research on the economic returns to agricultural research investments in general has been substantial, virtually nothing has been done to analyze the returns to soybean research investments.

The evaluation of the economic returns to investments in agricultural research builds on the seminal work of T.W. Schultz and Zvi Griliches in the 1950s. Major contributions to both the theory and empirical literature concerned with measuring the impact of investments in technology development and implementation have been made by a variety of researchers, including Evenson, Peterson, Huffman, Norton and Davis, Fox, Pardey and Craig, Chavas and Cox, and Yee. Although empirical estimates of the rate of return to agricultural research vary by commodity, location, and method of estimation, they have been remarkably high. Nearly all exceed 25% and some surpass 100%. For example, of more than 60 estimates reported in Evenson, Waggoner, and Ruttan's summary, all but 9 of them exceeded 25%. Of the 15 estimates reported by Tweeten, all exceeded 25% and three exceeded 100%. Recent work has addressed possible errors in earlier methods, including the failure to account for losses associated with tax collection to support public research (Fox, Yee). Nevertheless, estimates of the rate of return to public agricultural research are still above typical rates of return on private investments. Unfortunately, most of these studies have held prices exogenous to the models used. That is, the price-depressing effects of research-induced supply expansion over the years has not been generally accounted for in these studies. Because the demand for agricultural products is often inelastic, the negative price effects of research induced supply expansion over the years could turn positive measured welfare gains from such research into welfare losses.

Studies on the Return to Investments in Commodity Promotion

Most studies of the effects of investments in commodity advertising and promotion have focused on either or both of two related measures: (1) the responsiveness (i.e., elasticity) of sales or consumption of specific agricultural commodities to advertising campaigns and promotion programs and (2) the benefits to producers from investing in advertising and promotion. In either case, the major statistical challenge generally is to effectively isolate the effects of the promotion program from those of all other market forces. The most extensively studied advertising and promotion programs over the years have been those of milk and milk products not only in the U.S. but also in Canada and Japan. More recently, the effectiveness of the advertising funded by the beef and pork checkoff programs has been the focus of research. Among the other, more salient studies of the effectiveness of advertising and promotion are those focusing on poultry, fats and oils, potatoes, orange juice, eggs, avocados, cotton, wool, apples, alcoholic beverages, tobacco, and cigarettes.

Studies of the Responsiveness of Sales to Promotion

Many studies of the effectiveness of advertising and promotion are concerned primarily with the responsiveness of sales to changes in advertising and promotion expenditures. In these studies, the effectiveness of advertising and promotion is represented in the form of an "advertising elasticity" which is the estimated percentage change in sales from a 1% change in advertising after controlling for all other factors that could affect sales. Table 1 summarizes the findings of these studies.

One highly consistent finding across virtually all studies is that the advertising elasticities for both generic and brand advertising and promotion are quite small. For U.S. fluid milk sales, for example, estimated generic advertising elasticities have ranged from 0.0085 to 0.06 (Table 1). That is, a 1 % change in advertising has been estimated to have resulted in an increase in U.S. fluid milk sales of

Table 1: Effects of Generic and Brand Advertising on Commodity Sales/Consumption: Summary of Research

Commodity/Region	Promotion Period	Advertising Elasticities Generic	Advertising Elasticities Brand
		- % change in sales from a 1% change in advertising -	
Fluid Milk			
U.S. (USDAd)	1984-86	0.0097	
U.S. (Venkateswaran and Kinnucan)	1973-84	0.0445-0.06	
U.S. (Ward and McDonald)	1976-83	0.0085	
U.S. (Warman and Stief)	1978-89	0.017-0.0463	
U.S. (Kaiser and Liu)	1975-95	0.027-0.0324	0.026-0.0433
U.S. (Blisard, *et al.*)	1984-96	0.0458	
U.S. (Kaiser, 1997)	1984-96	0.039	
U.S. (Kaiser, 1998)	1984-97	0.030	
New York City (Kinnucan and Forker)	1971-81	0.051	
New York State (Liu, *et al.,* 1992)	1983-87	0.029 (long run)	
New York State (Lenz, *et al.*)	1986-95	0.0141-0.0886	
Texas (Capps and Schimtz)	1980-86	0.0075 (combined) 0.0021 (TV) 0.0071 (radio)	
Canada (Belleza)	1973-88	0.03	
Canada (Kaiser, *et al.,* 1994)	1973-88	0.03	
Japan (*Suzuki, et al.*)	1981-90	0.0058	
Cheese			
U.S. (Kaiser and Liu)	1975-95		0.004
U.S. (Blisard, *et al.*)	1984-96	0.015	0.0286
U.S. (Kaiser, 1997)	1984-96		0.010
U.S. (Kaiser, 1998)	1984-97		0.011
New York City (Kinnucan and Fearon)	1979-81	0.0348-0.088	0.182-0.205
New York City (Kinnucan and Forker)	1971-81	0.0593	
Canada (Belleza)	1973-88	0.09	
Canada (Kaiser, *et al.* 1994)	1973-88	0.00	
Beef			
U.S.(Kinnucan, *et al.* 1997)	1976-91	0.00113	
U.S.(Kinnucan, *et al.* 1997)	1976-93	-0.00026	
U.S. (Brester and Schroeder)	1970-93	0.006	0.007
U.S. (Cranfield and Goddard)	1971-91	0.0114	0.0898
Canada (Cranfield and Goddard)	1971-91	0.00001	0.00362
Australia (Alston, *et al.*)	1978-88	0.016-0.027	
Retail Meat Cuts			
U.S. (Capps)	1986-87		
Steak		0.0276	
Ground Beef		0.0331	
Roast Beef		0.0358	
Chicken		0.0350	
Pork Chops		0.0096	
Ham		0.0251	
Pork Loin		0.0129	

Table 1: Effects of Generic and Brand Advertising on Commodity Sales/Consumption: Summary of Research (continued)

Commodity/Region	Promotion Period	Advertising Elasticities: Generic	Advertising Elasticities: Brand
		- % change in sales from a 1% change in advertising -	
Pork			
U.S. (Brester and Schroeder)	1970-93	-0.0005	0.033
U.S.(Kinnucan, *et al.* 1997)	1976-91	0.00001	
U.S.(Kinnucan, *et al.* 1997)	1976-93	0.00006	
U.S. (Sellen, *et al.*)	1985-94	0.005	
Australia (Alston, *et al.*)	1978-88	0.00	
Canada (Sellen, *et al.*)	1985-94	0.027	
Canada (Duffy and Goddard)	1971-92		
Fresh		0.101	
Bacon		0.006	
Ham		0.048	
Sausage		0.08	
Other		0.047	
Poultry			
U.S. (Brester and Schroeder)	1970-93	0.047	
U.S. Exports (Rosson, *et al.*)	1972-81	0.15-0.25	
Fats and Oils			
U.S. (Chang and Kinnucan)	1973-76		
Butter		0.023	
Margarine		0.006	
Shortening		0.006	
Salad Oil		-0.074	
Canada (Goddard and Amuah)	1973-86		
Butter		0.01	
Margarine		0.04	
Shortening		0.03	
Vegetable Oils		0.07	
Food			
Canada (Chang and Green)	1980-84		
Meats		0.103	
Dairy		0.123	
Cereal		0.035	
Fruits and Vegetables		0.031	
All else		0.24	
Fibers			
U.S.			
Cotton (Capps, *et al.*)	1986-95	0.0367 (short-run) 0.0600 (long-run)	
Wool (Dewbre and Beare)	1974-85	0.07	

Table 1: Effects of Generic and Brand Advertising on Commodity Sales/Consumption: Summary of Research (continued)

Commodity/Region	Promotion Period	Advertising Elasticities: Generic	Advertising Elasticities: Brand
		- % change in sales from a 1% change in advertising -	
Miscellaneous			
U.S.			
Potatoes (Jones and Choi)	1970-87		
Fresh		0.0171	---
Frozen		0.0222	0.0157
Chips		---	0.0205
Dehydrated		---	0.069
Orange Juice (Ward 1988)	1978-88	0.027	0.031
Orange Juice (Lee and Brown)	1983-86	0.0098 (all O.J.)	0.0331 (3 major brands) 0.0389 (all other brands)
Cigarettes (Seldon and Doroodian)	1952-63	0.25	
	1979-84	0.09	
Tobacco Exports (Rosson, *et al.*)	1972-81	0.05	
Avocado (Carman and Green)	1961-90	0.15	
Alcoholic Beverages (Duffy)	1963-83		
Beer		0.055	
Spirits		0.096	
Wine		0.147	
Apple Exports (Rosson, *et al.*)	1972-81	0.51	
Apple Exports (Richards, *et al.*)			
Singapore	1986-93	0.055	
U.K.	1986-93	0.016	
Soybean & Product Exports			
(Williams 1985)	1969-79	Beans Meal Oil	
EC-9		0.029 0.061 0.042	
Japan		0.041 0.047 0.033	
Other Asia		-- -- 0.017	
Africa		-- -- 0.001	
Rest of World		0.045 0.037 0.080	
Eggs			
California (Schmit, *et al.*)	1985-95	0.13 (long run)	
U.S. (Reberte, *et al.*)	1990-95	0.02 (long run)	
Canada			
Eggs (Chyc and Goddard)	1974-88	0.007	
Apples (Goddard)	1966-88	0.008	

between 0.0085% and 0.06%. Thus, a doubling of advertising expenditures (100% increase) would be expected to increase U.S. fluid milk sales by only between about 0.85% and 6%.

For red meat, the estimated advertising elasticities are equally small, ranging from 0.00001 to 0.03 for beef and from -0.0005 to 0.08 for pork and pork products (Table 1). The negative advertising elasticity for pork reported by Brester and Schroeder (-0.0005) was also not statistically significant. They report, however, a strong, significant effect of pork brand advertising with an elasticity of 0.033 (Table 1). Another study (Capps) found that advertising elasticities for retail meat cuts are somewhat higher than those reported for the corresponding meat in general, ranging from about 0.01 for pork chops and pork loin to about 0.03 or higher for steak, ground beef, roast beef, ham, and chicken. The highest U.S. meat advertising elasticity was reported by Brester and Schroeder for poultry (0.047). Rosson, *et al.*, however, report quite high elasticities of poultry export demand to export promotion investments (0.12 to 0.25)

Only two major studies have focused on the generic advertising and promotion programs in fats and oils markets - one for the U.S. (Chang and Kinnucan) and the other for Canada (Goddard and Amuah). Both studies find that advertising elasticities for fats and oils are strikingly similar to those found for other products. For the U.S., the advertising elasticities range from a low of 0.006 for margarine and shortening to a high of 0.023 for butter. That study also failed to find a statistically significant effect of advertising on sales of salad oils. For Canada, the advertising elasticities were found to be somewhat lower for butter (0.01) but substantially higher for margarine (0.04), shortening (0.03), and vegetable oils (0.07).

Unfortunately, an analysis of the effectiveness of the domestic generic advertising programs of specific fats or oils has not yet been attempted. The only study that specifically focuses on soybeans and products considered only the foreign market promotion programs of the American Soybean Association for 1970 through 1980 (Williams 1985). Incidently, that study found that soybean oil advertising elasticities ranged from 0.001 in African countries to 0.033 in Japan, 0.017 in other Asian countries, 0.042 in the European Community, and 0.08 in the rest of the world. Note the remarkable similarity of those advertising elasticities to those estimated for most other products.

Two studies have evaluated the effects of generic promotion of fibers - one for cotton (Capps, *et al.*) the other for wool (Dewbre and Beare). The generic advertising elasticities estimated in the two studies are quite similar at 0.06 (long run) for cotton and 0.07 for wool.

For all other commodities, the generic advertising elasticities range from a low of 0.008 for apples in Canada (Goddard) to 0.15 for wine (Duffy) and for avocados (Carman and Green) in the U.S. The advertising elasticities for most of these other products, however, have been in the range of 0.01 to 0.02.

What research has been done on the effects of brand advertising on sales has been primarily for milk and cheese, meat, orange juice, and potatoes. In nearly all cases, the brand advertising elasticities are higher - and in many cases much higher - than the estimated elasticities for generic advertising. One recent study of beef promotion in North America (Cranfield and Goddard), for example, found that the effect of brand advertising on beef sales was about 9 times greater than that of generic advertising with a brand advertising elasticity of 0.09 and a generic advertising elasticity of 0.01. Kaiser and Liu, however, found that the relative effects of brand and generic milk advertising were not much different and depended on the specification of the milk demand model. For cheese, Kinnucan and Fearon found that the brand advertising elasticity ranged from 0.18 to 0.21 compared to the generic advertising elasticity in the range of only 0.035 to 0.09. On the other hand, Kaiser and Liu found that the generic advertising elasticity for cheese was greater that the brand advertising elasticity for cheese. For orange juice the results are mixed. A major study by Ward (1988) concluded that the effects of generic and brand advertising on sales of orange juice are about the same with advertising elasticities of about 0.03. Another major study (Lee and Brown), however, found brand advertising to be about 3 times more effective in boosting orange juice sales than generic advertising.

Thus, the consensus across a broad range of research is that advertising can effectively increase commodity sales. Although statistically significant, the response of sales to advertising for most commodities has been found to be small. The response of sales to brand advertising is also small but generally greater than that for generic advertising. Nevertheless, even a small response of sales to advertising can have potentially large effects on sales revenue and price when the supply of the commodity is not highly responsive to changes in price.

Studies of the Producer Benefits of Advertising and Promotion

Even though advertising and promotion have been found to be effective at increasing sales, the important question is whether the increase in sales and revenues has been sufficiently large to cover the costs of the related advertising and promotion programs. A standard method of determining if advertising and promotion pay has been to calculate the *average* return per dollar invested , i.e., a benefit-cost ratio (BCR), as the increase in *market sales revenue or cash receipts* (net of promotion costs) per dollar invested in advertising and promotion (i.e., a *revenue BCR*). Only a few studies have attempted to more appropriately calculate a BCR in terms of additional *industry profits* (i.e., the increase in industry sales or cash receipts net of additional production costs) or *producer surplus* (an economist's measure of producer welfare) generated per dollar invested in advertising and promotion (i.e., a *profit BCR* or *surplus BCR*).

In any case, the BCR reported in many studies is a static or *ceteris paribus* measure of the effectiveness of advertising and promotion. In other words, many reported BCRs are calculated assuming that nothing (including prices) but demand changes when advertising expenditures change.[10] A few studies have reported a more appropriate, dynamic BCR calculated as the sum of the returns to producers (in additional sales, profits, or economic surplus) over time divided by total advertising and promotion expenditures during that period allowing not just demand but also supply, prices, and other clearly endogenous variables to change in response to the advertising and promotion expenditures (e.g., Williams 1985; Reberte, *et al.*; Sellen, *et al.*; and Schmit, *et al.*). To

[10] In other words, the regression coefficient for advertising expenditures in the demand equation valued at the mean of historical demand.

account for the time value of money, such a dynamic BCR could be discounted to present value (i.e., a *discounted BCR*) by first discounting the calculated returns to producers over time before dividing by total advertising and promotion expenditures.

However calculated, an estimated BCR of greater than 1 is taken as an indication that the program is beneficial because sales, profits, or producer surplus have increased by more than one dollar for every dollar invested in advertising and promotion. On the other hand, a BCR of less than 1 is taken to mean that advertising and promotion do not pay since each dollar invested generates less than a dollar in additional sales, profits, or producer surplus.

Many studies report a "return on investment" (ROI) rather than a BCR as a measure of the effectiveness of advertising and promotion expenditures. Often referred to as the "marginal rate of return" (MRR), an ROI is usually calculated as the percentage increase in sales revenues (*revenue ROI*), profits (*profit ROI*), or economic surplus (*surplus ROI*) from a 1% increase in advertising and promotion expenditures. The estimated advertising elasticities discussed in the preceding section provide some notion of a static or *ceteris paribus* advertising or promotion ROI (i.e., the revenue, profit, or surplus ROI assuming that everything, including prices, except advertising expenditures remain constant). As with the BCR measure, an ROI would be more appropriately calculated as a dynamic concept, i.e., as the percentage increase in the returns to producers (in additional sales, profits, or economic surplus) over time from a 1% increase in advertising and promotion expenditures in some initial period when all supply, demand, prices, and other endogenous variables are allowed to change in response to the change in the advertising and promotion expenditures. A dynamic ROI can also be discounted to account for the time value of money and then compared to the rates of return from alternative investment opportunities to provide a measure of the successfulness of the commodity promotion investments in terms of the opportunity costs of the funds used for advertising and promotion. Unfortunately, no study has reported measuring the effectiveness of advertising and promotion using a dynamic ROI calculation.

Almost all studies have found that advertising and promotion increase sales revenues (gross or net of costs) by more than the cost of the advertising and promotion programs generating those revenues. In most cases, the calculated BCRs have been found to be much in excess of 1. For fluid milk, for example, depending on the market and time period, the estimated return ranges from $1.40 for New York City to as high as nearly $23 in Buffalo and $24 in Canada (Table 2). Note, however, that the estimated returns are highly variable. Ward and McDonald calculated the return to fluid milk advertising in a ten-region area of the U.S. to be $1.85 while Liu, *et al.* (1989) calculated the return to fluid milk advertising in the U.S. market to be more in the range of $7. Research on milk advertising has also indicated that the return to advertising of both fluid and manufactured milk is lower than the corresponding returns for fluid milk alone (Liu, *et al.*, 1989 and Kaiser, *et al.*). Liu, *et al.* (1989) concluded that the returns to advertising manufactured milk alone were virtually zero.

Table 2: Returns to Generic Commodity Promotion: Summary of Research

Commodity/Region	Return per $ Invested
	dollars
Milk	
Fluid	
U.S. (Liu, *et al.* 1989)	7.04
U.S. (Ward and McDonald)	1.85
U.S. (NYC) (Forker and Liu)	1.40
U.S. (NYC) (Kinnucan 1986)	6.00
U.S. (Buffalo) (Kinnucan 1983)	16.85-22.52
U.S. (Kaiser and Liu.)	1.53-1.65
U.S. (Blisard, *et al.*)	5.33
U.S. (Kaiser 1997)	5.27
U.S. (Kaiser 1998)	4.00
U.S. (NY State) (Lenz, *et al.*)	1.84
Canada (Goddard and Tielu)	8.00
Canada (Venkateswaran and Kinnucan)	10.00-24.00
Manufactured Only	
U.S. (Liu, *et al.*)	0.00
Fluid and Manufactured	
U.S. (Liu, *et al.* 1989)	4.77
U.S. (Kaiser, *et al.* 1992)	2.04
Milk and Cheese	
U.S. (Kinnucan and Forker)	11.29
Beef	
U.S. (Ward and Lambert)	5.74
Australia (Alston, *et al.*)	1.53 (short run) 1.2-1.5 (long run)
Red Meat	
Australia (Alston, *et al.*)	0.29 (short run) 1.3 (long run)
Pork	
Canada (Sellen, *et al.*)	2.37
Canada (Duffy and Goddard)	
All	11.83
Fresh	13.74
Ham	16.68
Bacon	1.18
Sausage & Wieners	3.73
U.S. (Sellen, *et al.*)	6.12
Eggs	
California (Schmit, *et al.*)	7.00
U.S. (Reberte, *et al.*)	6.00
Butter	
Canada (Goddard and Amuah)	1.11
Margarine	
Canada (Goddard and Amuah)	1.31
Soybeans & Products	
U.S. Exports (Williams 1985)	14.00
Orange Juice	
U.S. (Lee and Fairchild)	2.28
Grapefruit Juice	
U.S. (Lee)	10.44
Catfish	
U.S. (Kinnucan, *et al.* 1995)	0.57-1.30 (short run) 0.17-0.57 (long run)
Apples	
U.S. (Ward and Forker)	12.00
Canada (Goddard)	6.74
U.S. Exports (Rosson, *et al.*)	60.00
U.S. Exports (Richards, *et al.*)	
Singapore	27.84
U.K.	24.72
Australian Wool	
U.S. (Dewbre, Richardson, Beare)	1.94
Cotton	
U.S. (Capps, *et al.*)	1.57-3.49 (producers) 3.63-5.59 (importers)
Tobacco	
U.S. Exports (Rosson, *et al.*)	31.00

The estimated returns for meat have tended to be lower than those for milk (Table 2). For the U.S., Ward and Lambert calculated a beef advertising BCR of nearly $6. In contrast, Alston, *et al.* found that the BCR for beef advertising in Australia was much lower ($1.53 in the short run and $1.2 to $1.5 in the long-run). For pork advertising, Sellen, *et* al. calculated a BCR of $2.37 for Canada and $6.12 for the U.S. Duffy and Goddard found the returns to advertising all pork cuts except bacon to be quite high. A recent study by Kinnucan, *et al.* (1995) on catfish determined that while advertising pays in the short run, the profitability of promotion is undermined by increases in supply over the long run.

Only two studies have attempted to calculate the returns to advertising in fats and oils markets (Table 2). The first (Goddard and Amuah) found positive but relatively modest returns to butter and margarine advertising in Canada. The other study (Williams 1985) estimated that soybean producers realize a 14 to 1 increase in industry profits per dollar spent in foreign markets to promote sales of soybeans, soymeal, and soyoil.

Other studies focusing on such diverse commodities as orange juice (Lee and Fairchild), grapefruit juice (Lee), apples (Ward and Forker; Goddard; Rosson, *et al.*; Richards, *et al.*), and eggs (Schmit, *et al.*; Reberte, *et al.*) have likewise reported impressive returns from their respective advertising and promotion programs (Table 2). More modest returns were calculated for advertising Australian wool in the U.S. (Dewbre, Richardson, and Beare) and for U.S. cotton advertising and promotion programs (Capps, *et al.*). In the case of cotton, the returns to cotton importers was found to be higher than the returns to U.S. cotton producers.

Again, the consensus across a wide range of studies by many researchers covering a large number of commodities is that advertising pays. Advertising and promotion not only increase sales but they generally increase sales by more than enough to cover the costs of promotion. Although the estimated level of return per dollar spent in advertising varies widely across commodities, countries, and time periods, the BCRs calculated by most studies for domestic advertising and promotion programs fall in the range of about $2 to $12. For foreign market promotion programs, the reported BCRs are generally higher from $14 to $60. Unfortunately, most of these studies ignore cross-promotion effects, i.e, the effects of promoting one commodity on the sales of another. Thus, for example, expenditures that successfully promote the demand for pork likely shift some consumption from beef to pork, reducing beef consumption and offsetting the effects of beef promotion expenditures on the demand for beef.

Methodology and Data

This section lays out the methodology and the data used in the analysis of the effectiveness of the soybean checkoff program. After outlining the structural model used and the data required for the analysis, the econometric procedure and model validation process and results are discussed. Finally, the simulation process used for the analysis of the effectiveness of the soybean checkoff program is summarized.

The Structural Model

The basic tool of analysis is a 186-equation, annual econometric simulation model of world soybean and product markets, referred to as SOYMOD, that allows for the simultaneous determination of the supplies, demands, prices, and trade of soybeans, soybean meal, and soybean oil in six major world trading regions: the United States, Brazil, Argentina, the European Union, Japan, and a Rest-of-the-World region[11].

For each world exporting and importing region in SOYMOD, the domestic market is divided into four blocks: a soybean block, a soybean meal block, a soybean oil block, and an excess supply or excess demand block (Figure 18). The first three blocks in each region (equations (1)-(10) and (14)-(23) for exporting and importing regions, respectively, in Figure 18) contain behavioral relationships specifying the manner in which soybean supply (acreage planted, acreage harvested, and production), soybean crush and stocks, and the supply, consumption, and stocks of soymeal and soyoil 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. In the U.S., both soybean and corn production are divided into seven production regions (Atlantic, Cornbelt, Delta, Lakes, Plains, South, and Other) to account for interregional competition within the United States.

The last block in each domestic market includes net excess supply or export availability relationships (equations (11)-(13) in Figure 18) for exporting regions and net excess demand or import demand relationships (equations (24)-(26) in Figure 18) in importing regions. Excess supply and demand are specified in the model for each region as the residual differences between their respective domestic supply and demand schedules.

The markets of each region in the model are linked through international price and trade flow relationships. In equations (27)-(29) in Figure 18, the domestic prices of soybeans, soymeal, and soyoil in any exporting region i (P_i) and in any importing region j (P_j) are linked in the model in each time period as follows:

$$P_{jk} = Z_{1k} P_{ik} + Z_{2k}$$

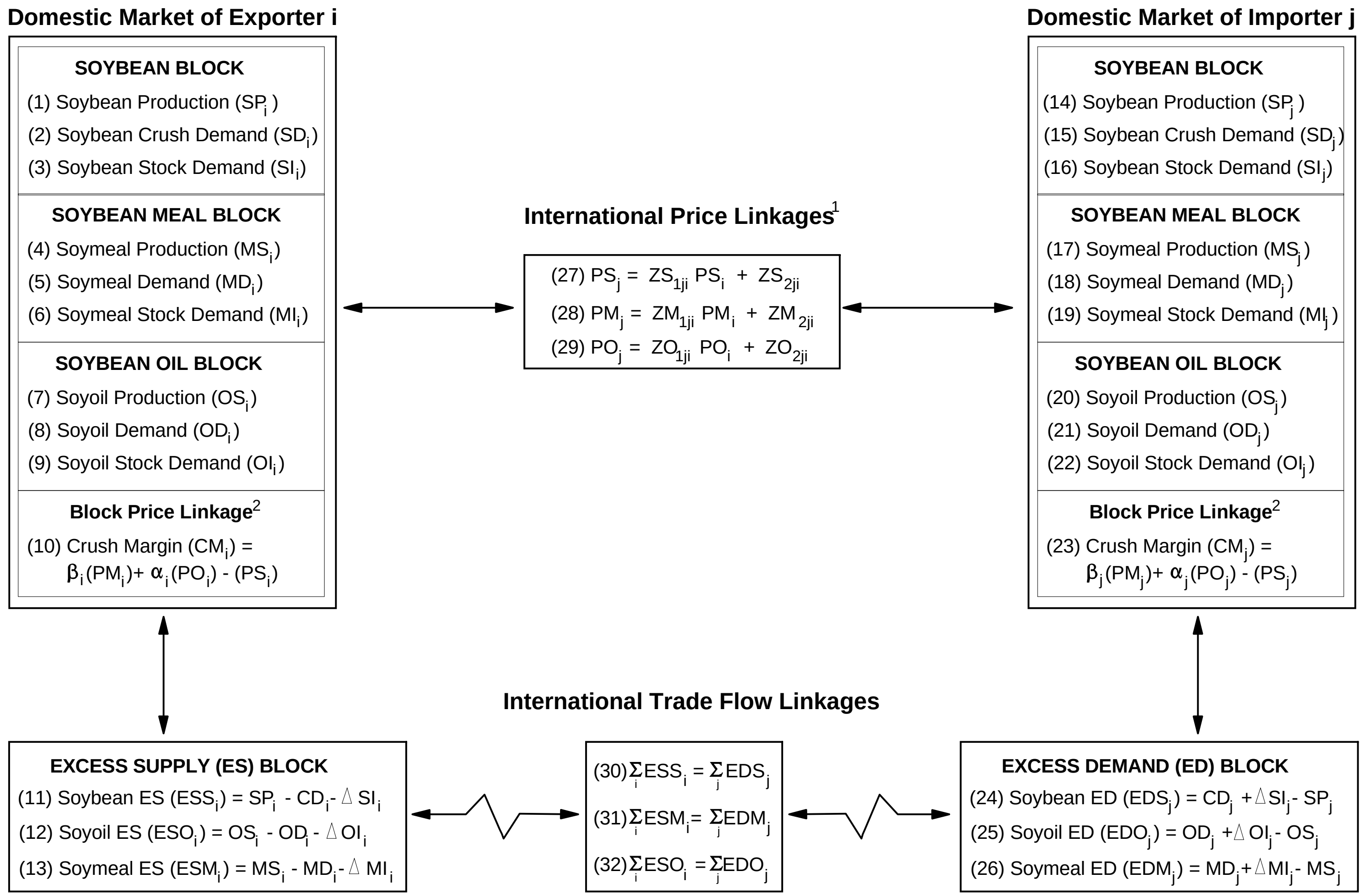
where k = soybeans, soymeal, and soyoil and Z_1 and Z_2 represent all factors that come between the prices of each commodity in exporting country i and importing country j:

$$Z_1 = E_{ji}(1-s_i)(1-s_j)(1+t_i)(1+t_j) \quad \text{and}$$

$$Z_2 = E_{ji}(T_i-S_i+C_{ji}) + T_j - S_j$$

[11] SOYMOD is an revised and enhanced version of the model initially developed and described in Williams (1981) and subsequently revised and used in Williams (1983), Williams and Thompson, Williams (1985), Williams (1994), Miller and Williams and numerous other publications.

Figure 18: World Soybean Market Model Structure



Note: i = any exporter i=1, ... , n; and j = any importer j=1, ... , k. Also Δ should be read "change in."

[1] The Z_1 and Z_2 include all multiplicative (e.g. exchange rates and *ad valorem* subsidies) and additive (transportation costs, specific tariffs, etc.) measures that come between prices of country i and j.

[2] β and α are meal and oil extraction rates; PS, PM, and PO are soybean, soyoil, soymeal prices.

where E_{ji} is the exchange rate in terms of country j currency per unit of country i currency; s_i and S_i are, respectively, *ad valorem* and specific export subsidies; s_j and S_j, are respectively, *ad valorem* and specific import subsidies; t_i and T_i are, respectively, *ad valorem* and specific export taxes; t_j and T_j are, respectively, *ad valorem* and specific import tariffs; and C_{ji} is transportation cost to country j from country i (in terms of the currency of country i). In this general specification, all exchange rates, policy variables, and transportation costs are treated as exogenous variables within each year. Where data on these variables are not available, price transmission equations following Bredahl, Meyers, and Collins are used to link prices between regions. The trade flow linkages (equations (30)-(32) in Figure 18) are international market clearing conditions requiring equality of world excess supply and demand for each commodity in each time period.

Data

Two types of data were needed for the analysis: (1) data to support SOYMOD (e.g., supply, demand, trade, price, policy, etc. data by country and commodity over time) and (2) soybean checkoff and related investments over time. The common time period across all data types defined 1978 to 1994 as the period for analysis of the effectiveness of the soybean checkoff program.

The first set of data (i.e., data to support SOYMOD) was taken from numerous public sources, including USDA oil crops situation and outlook reports (USDAb) and oilseed world markets and trade reports (USDAc), among many others, for the 1960 to 1997 period (see TAMRCd).

Three types of soybean checkoff and related investments were needed: (1) soybean production research investments by ASA, state soybean boards, USB, QSSBs, and the public sector, (2) domestic soybean and product market promotion investments by ASA, state soybean boards, USB, and QSSBs, and (3) foreign soybean and product market demand promotion investments by ASA, USB, the Foreign Agriculture Service of USDA, and third party contributors. Publicly-funded soybean production research investment data for 1970 to 1994 were obtained from the USDA *Inventory of Agricultural Research* (USDAa). Public soybean research expenditure data for two additional years (1960 and 1965) were taken from Huffman and Evenson. Public expenditures for the years between 1960 and 1965 and between 1965 and 1970 were approximated by linear extrapolation. Soybean checkoff-funded production research investment data by type of investment for 1978 to 1995 were readily available from records kept by the American Soybean Association (TAMRCc). Soybean checkoff research expenditures for 1970-1977 were extrapolated by regressing the checkoff research expenditures on U.S. soybean cash receipts given that total checkoff amounts are directly related to the value of soybean sales. Before 1970, soybean checkoff research expenditures were assumed to be zero because checkoff expenditures were quite small and focused on foreign market development during that period.

Data on foreign soybean and product demand promotion investments by product, country, and contributor for 1970 to 1996 were compiled from various sources, primarily the American Soybean Association, the United Soybean Board, and the USDA Foreign Agriculture Service (TAMRCb). Although rather fragmentary at best, soybean foreign market development expenditure data prior to 1970 imply that the total program was quite small and that foreign market development activities occurred almost entirely in Japan. Consequently, soybean foreign market development expenditures were assumed to be zero for the pre-1970 period.

Unfortunately, however, no consistent set of data on domestic soybean and product market promotion investments was available from any source (TAMRCa). All state and national soybean producer organizations were asked to provide this information by survey. The data collected, however, were fragmentary, highly inconsistent in quality, type, time period, and level of aggregation, and, therefore, not useful for analytical purposes.

Research investments were converted to constant-dollar series by dividing the investments by the annual U.S. agricultural research price index. For 1960-1990, the research price index was taken from Huffman and Evenson. The research price index for the years 1991-1994 was extrapolated by regressing the research price index on time. Likewise, the foreign market development investment expenditures for each country and commodity were adjusted for changes in the value of the U.S. dollar and deflated by an appropriate index of inflation. The adjusted foreign market development investment data, thus, represented the real purchasing power of those investments for each commodity in each country. Because the benefits of research investments in a given year may not be realized for a number of years and because a promotion investment can be expected to have an impact on demand much beyond the year of investment, some form of lag structure was required to account for the time adjustment process in both cases.

To account for the time lag in impact of research investments, research stock variables were formed as a weighted average of historical investments measured in constant dollars. The research stock variables, thus, are proxies for the quantity of effective research and are included in the model as exogenous variables formed as follows:

$$r_{mt} = \sum_{r=1}^{s} \lambda_{mr} I^{*}_{m,t-r}, \quad \sum_{r=1}^{s} \lambda_{mr} = 1$$

where $I^*_{mt} = I_{mt}/p_{mt}$ is the constant-dollar research investment of type m in year t, I_{mt} is the nominal-dollar research investment of type m in year t, p_{mt} is the corresponding research price index, λ_{mt} is the weight on the constant dollar research investment of type m lagged r years, and s is the lag length over which research investments are expected to impact farm profits.

A number of alternative investment weighting schemes (i.e., lag weights represented by the λ_{mt}) with lags of varying lengths were considered for constructing a research stock variable from research investments, including the Almon polynomial distributed lag (PDL) as discussed in George, et al. (pp. 729-734), a trapezoidal lag (TL) structure following the work of Huffman and Evenson, a Gamma distribution lag (GDL) structure consistent with Chavas and Cox, and the unconstrained polynomial inverse lag (PIL) as presented by Mitchell and Speaker. Preliminary model specification tests led to the selection of the following seven alternative lag structures representing three very different families of lag structures for further analysis[12]:

(1) PDL - lag length of 15 years;
(2) PDL - lag length of 30 years truncated after 15th year;
(3) TL - first linearly increasing (7 years), constant (6 years), and then decreasing (17 years), truncated after 15th year;
(4) TL - first linearly increasing (5 years), constant (10 years), and then decreasing (15 years), truncated after 15th year;
(5) GDL - infinite lag, peak at 5th year, truncated after 15th year;
(6) GDL - infinite lag, peak at 10th year, truncated after 15th year; and
(7) GDL - infinite lag, peak at 15th year, truncated at 15th year.

Further model specification tests were conducted to determine which of the seven alternative lag structures on research investment is preferred for purposes of defining research stock variables. Three exogenous research variables were included (stocks of soybean public research and stocks of yield-enhancing and of cost-reducing checkoff research investments). A total of 49 alternative models were estimated to permit independence of the lag structure between public research and the research supported by the checkoff program. Lag structures were chosen based both on formal statistical tests based on the Likelihood Dominance Criterion and on heuristic criteria (number of significant parameters and number of expected signs on own-price supply response). From among the 49 alternatives, the gamma distribution lag structure (5) was chosen for public soybean research and the trapezoidal lag structure (3) was chosen for soybean checkoff funded research. The lag weight distributions for each are depicted in Figure 19.

The research investment stock variables thus constructed enter the model (SOYMOD) as arguments of the U.S. regional soybean acreage functions and the U.S. regional yield functions. As discussed earlier, however, applied research often depends on previous investments in basic research so that returns to investments in basic research are often manifest through applied research to develop new technologies and processes for adoption by producers. Because public soybean investments tend to be in more basic, long-term types of research while soybean checkoff funds are more often invested in more applied, short-term types of research, the two research stock variables (public and soybean checkoff) are added together and treated as a single argument in each regional soybean acreage and yield equation.

To account for the time lag in the impact of promotion investments on foreign demand, stock variables, often referred to as "goodwill" variables, were also created for investments in soybean, soybean meal, and soybean oil promotion in each importing region in the model as weighted averages of the respective real foreign market investments. Given the lack of adequate data on domestic promotion investments as discussed earlier, stock variables could only be created for

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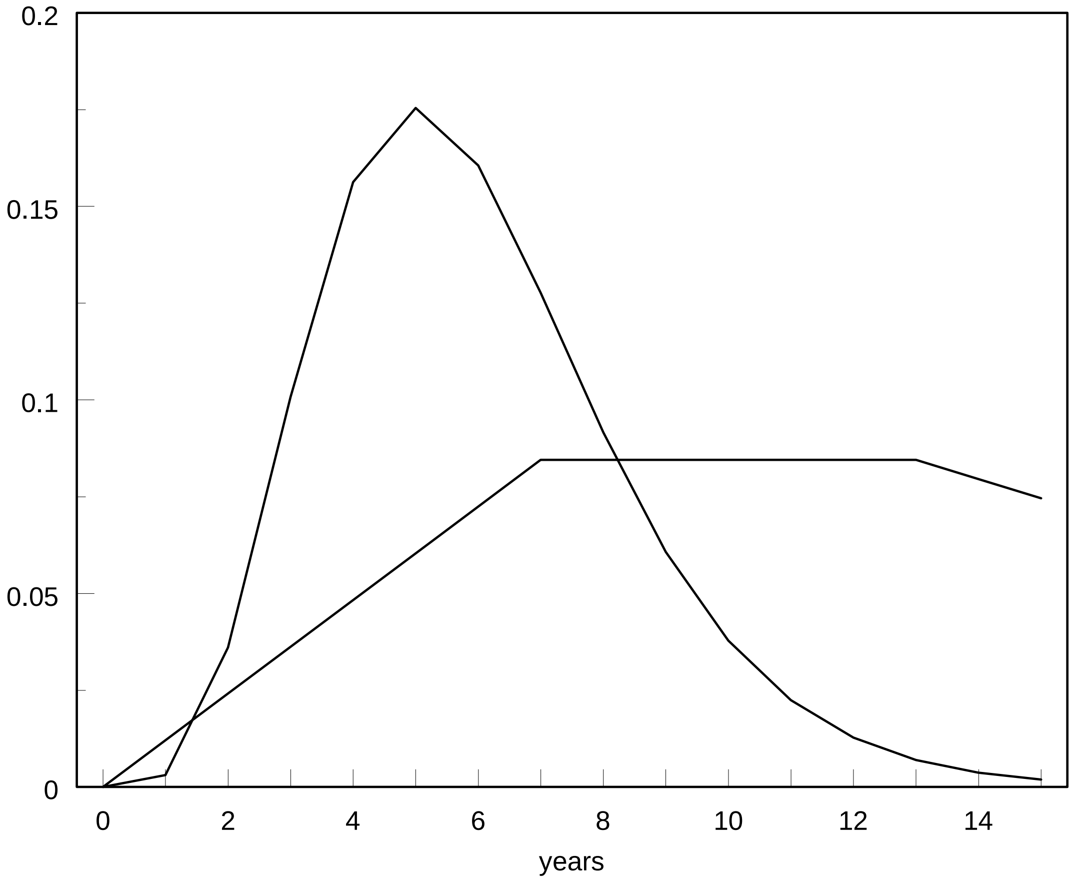
[12] Given the limited number of observations and the large number of parameters requiring estimation, no unconstrained lag structure, including the PIL, could be included in the lag structure choice set for further analysis.

Figure 19: Research Investment Lag Weight Distributions



foreign demand promotion investments. A lag formulation commonly used in the analysis of advertising effectiveness is the Almon polynomial distributed lag (PDL). Recent work by Capps, Seo, and Nichols and by Capps, *et al.* has employed a polynomial inverse lag (PIL) formulation based on Mitchell and Speaker because it does not require specifying the lag length, is conceptually an infinite lag, and, based on Monte Carlo work, outperforms the PDL and several other popular distributed lag models. The PIL is defined as follows:

$$Z_{jt} = \sum_{i=0}^{t-1} \frac{X_{t-i}}{(i+1)^j} \qquad j = 2, \ldots, n$$

with weights:

$$W_i = \sum_{j=2}^{n} \frac{\theta_j}{(i+1)^j} \qquad i = 0, \ldots, \infty.$$

The X_t represent the foreign market promotion investments and the θ_j represent the parameter vector associated with the jth order polynomial, j=2,...,n or Z_j variable. The PIL has a flexible shape, allowing both humped and monotonically declining lag weight distributions. The lag is similar in spirit to the PDL but is an infinite lag and does not require testing for or specifying a fixed lag length. The estimation involves a search for the polynomial degree using a series of nested OLS regressions for each commodity (soybeans, soybean meal, and soybean oil) in each importing region (the European Union (EU-15), Japan, and the Rest-of-the-World (ROW))[13]. In fact, such a search was done using both the PIL and PDL formulations for each commodity in each region. The appropriate lag formulation, lag length, and polynomial degree in each case were chosen based both on the composite criteria of the highest Akaike Information Criteria (AIC) statistic for selecting lag length and heuristic measures (i.e., the number of significant parameters and number of expected signs on own-price demand response)[14]. The heuristic aspect of the composite criteria may be viewed as *ad hoc* but is equivalent to restricting the class of models to be only those consistent with underlying theory. This procedure is commonly encountered in the literature, especially in analyses where equilibrium displacement models are used and only parameter values consistent with theory are utilized. Second, third, and fourth degree polynomials for PDL and PIL formulations were considered for each of the three commodities in each of the three importing regions. Using the composite criteria, a second order PIL was selected in each case to create the promotion investment stock variables for each commodity in each region. The lag weight distribution for the second order PIL is depicted in Figure 20. The foreign soybean, soybean meal, and soybean oil demand promotion investment stock variables thus constructed enter the model (SOYMOD) as arguments of the respective demand functions of the importing regions in which the investments were made.

Model Parameter Estimation and Validation

The parameters of the U.S. soybean supply block of SOYMOD were estimated using the Nonlinear Iterative Seemingly Unrelated Regression (ITSUR) estimator. Normalization by an exogenous input price index maintained linear homogeneity in prices. Symmetry among cross-price parameters by linear restrictions was initially attempted in a previous version of the supply model. Perverse econometric results led to the relaxing of the symmetry restriction in the final version of the model[15].

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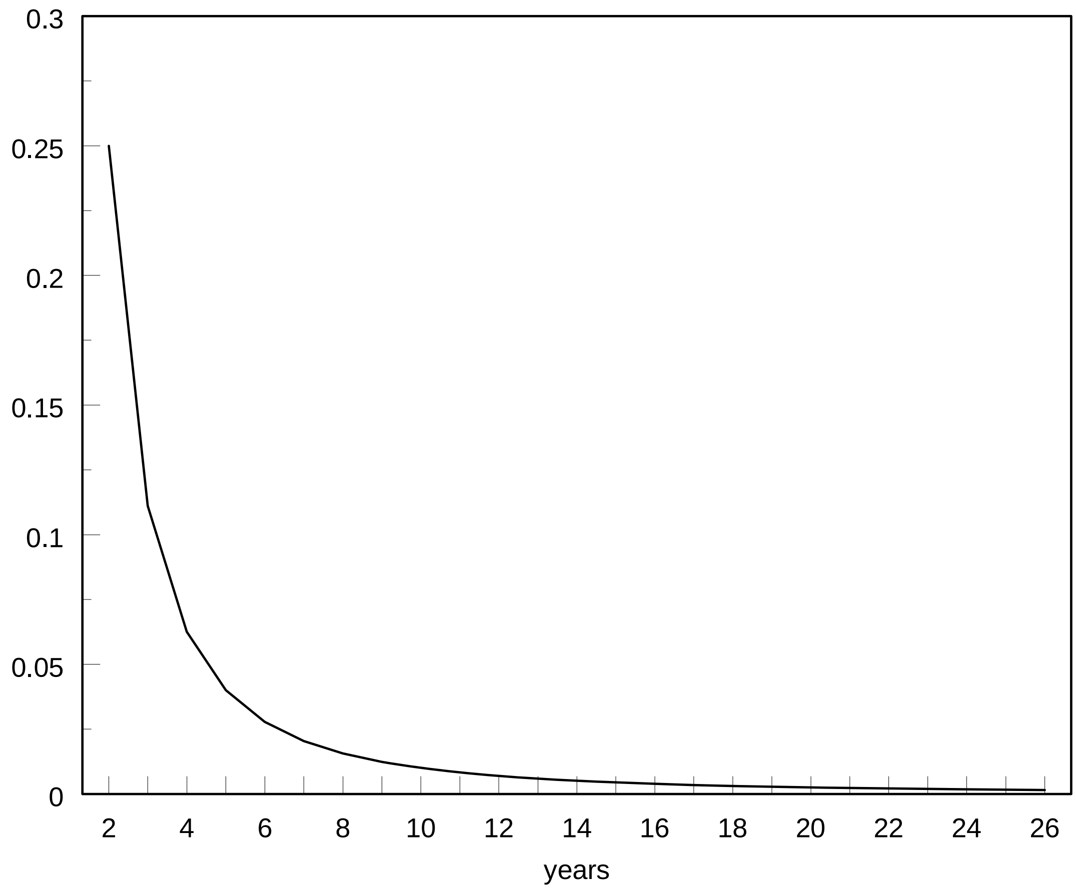
[13] Following Mitchell and Speaker, the remainder term is omitted from the regression equations in each case by dropping the first 8 observations (1970-1977) of the PIL.

[14] In the case of the PIL, because it allows for an infinite lag structure, the unrestricted lag specification search can be considered as helping to determine where to start the PIL or where the lag effects begin.

[15] In the initial model, negative own-price elasticities of supply led to squaring the own-price parameters to force upward slopes on supply. The consequence was own-price elasticities that were positive but extremely close to zero in all cases and not statistically significant in all but two U.S. soybean production regions and two corn production regions. Also, using the initial model with symmetry imposed, tests for nonjoint production in each region concluded that soybeans are not jointly produced with corn or any other commodity in any region. Given these counterintuitive results, the model was simplified, including relaxing the symmetry condition. In the final model, the estimated soybean and corn own-price and cross-price parameters of soybean and corn supply in all regions are unrestricted and consistent with *a priori* expectations in sign and magnitude and statistically significant.

Figure 20: Foreign Market Promotion Lag Weight Distribution



The remaining parameters of the model were estimated by means of a truncated two-stage least squares (2SLS) procedure based on principal components[16]. The model, estimated parameters, regression statistics, and *ex post* model simulation validation statistics are presented in the appendix.

The model regression statistics indicate an excellent fit of the data. Also, the signs and sizes of all estimated parameters in each model equation are consistent with *a priori* expectations. Table 3 provides the estimated research stock and foreign demand promotion elasticities which indicate the expected percentage increase in regional soybean acreage and yields and in foreign soybean, soymeal, and soyoil demand from a 1% increase in research investment stock or in foreign demand promotion investment stock, respectively, *ceteris paribus* (*i.e.*, assuming that everything, including prices, except advertising expenditures remain constant).

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

Table 3: Estimated Research and Foreign Demand Promotion Investment Stock Elasticities[a]

Variables/Regions	U.S. Soybean Research Stock		Foreign Demand Promotion Stock		
	Planted Acreage	Yields	Soybeans	Soymeal	Soyoil
	-------- % change in variable from a 1% change in investment stock --------				
U.S. Production Region					
Atlantic	0.0938	0.2084			
	(2.22)	*(2.54)*			
Corn Belt	0.1916	0.1643			
	(3.46)	*(2.28)*			
Delta	0.5266	0.1589			
	(2.33)	*(1.56)*			
Lakes	0.3003	0.1809			
	(1.93)	*(2.12)*			
Other	0.7154	0.3477			
	(1.59)	*(4.62)*			
Plains	0.8571	0.2438			
	(0.83)	*(2.24)*			
South	0.7587	0.2153			
	(2.29)	*(2.21)*			
European Union (15)			0.0234	0.0445	0.0446
			(1.51)	*(2.49)*	*(3.56)*
Japan			0.0367	0.0733	0.0323
			(2.43)	*(3.35)*	*(2.54)*
Rest-of-the-World			0.0680	0.0516	0.01557
			(5.04)	*(5.01)*	*(1.76)*

[a] All elasticities are long-run. 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. Italicized numbers in parentheses are t-values of the corresponding estimated coefficients.

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. 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 to 1994 sample period (referred to as the "baseline historical simulation"). Those statistics indicated a highly satisfactory fit of the historical, dynamic simulation solution values to observed data (see appendix for details). 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 foreign market demand promotion across all importing regions (EU-15, Japan, and rest-of-the-world) and across all commodities (soybeans, soymeal, and soyoil) and in soybean production research were increased by 10% in 1978 (the first year of the checkoff data). The respective investment stock variables were then re-generated following the process discussed earlier. Finally, the model was re-simulated over the 17-year sample period of 1978 to 1994.

Following the initial period shock, all endogenous variables in the model returned to equilibrium within a reasonable period of time (most within 5 years) indicating that the model is highly stable to changes in checkoff investments over time. The results of the sensitivity test are presented in Table 4 as dynamic simulation elasticities. The interim elasticities are calculated to represent the percent change in each model variable that occurs in each year between 1978 and 1994 from a 1% change in all checkoff investments in 1978. The long-run elasticity is a measure of the aggregate percentage impact on each model variable over the entire 17 year period. Thus, for example, a 1% increase in checkoff investments as allocated in 1978 would result in a 0.043% increase in U.S. soybean planted acreage over 17 years. In other words, a doubling of expenditures (a 100% increase) would boost planted acreage by 4.3% over 17 years with the majority of the change (3%) taking place within the first 5 years. At the same time, a doubling of checkoff investments as allocated in 1978 would boost U.S. soybean, soymeal, and soyoil exports over 17 years by 6.0%, 9.9%, and 9.5%, respectively, with most of the change again occurring in the first five years in each case. Similarly, the same doubling of checkoff expenditures would increase the U.S. share of world soybean, soymeal, and soyoil exports by 1.3 percentage points, 3.9 percentage points, and 4.9 percentage points, respectively, over a 17 year period.

Besides indicating the stability of the model, the sensitivity test results also suggest what can reasonably be expected of the checkoff program in terms of increased exports. For example, a primary objective in the current long-run strategic plan of the United Soybean Board is an increase in U.S. soybean exports from 1 billion bu. to 1.5 billion bu. by the year 2005 - a huge increase of 50% in U.S. soybean exports as a result of the checkoff program. The sensitivity tests suggest that such a huge increase in exports is much beyond what could reasonably be expected from checkoff investments alone. Given the 1978 expenditure allocation and that a doubling of investments in one year is required to achieve a 6% increase in soybean exports over 5 to 10 years, then checkoff investments would need to be boosted by 833% in one year to achieve a 50% increase in U.S. soybean exports over 5 to 10 years. Alternatively, investments would have to be doubled every year for 7 years to achieve a 50% increase (6% compounded annually for 7 years) in U.S. soybean exports after 10 to 15 years. In either case, such large increases in investments might be expected to have diminishing effects on exports over time so that reaching the 50% soybean export increase goal could well take even longer. The implication here is that if U.S. soybean exports reach the 1.5 billion bu. mark by the year 2005, the checkoff program will have contributed but other factors, such

Table 4. Dynamic Elasticities for Total Investments

as economic growth in key developing countries, with all its implications for income growth and shifts in consumer preferences towards meat, will have played the major role.

Scenario Simulation Process

The analysis of the returns to soybean growers from investments made in soybean production research and foreign demand promotion involved the historical simulation of SOYMOD under various scenarios over the 1978 to 1994 period of analysis. The first step in scenario simulation is to use the model to generate a baseline historical simulation of the endogenous variables in the model (e.g., production, demand, prices, trade in this study) that closely replicate the actual, historical values of those variables. As discussed earlier, the baseline historical simulation for this study was generated in the process of validating SOYMOD.

Next, the historic values of soybean production research and/or foreign market development promotion investments are changed for one or more years depending on the objective of the analysis and the model is simulated again over the period of analysis. Differences in the solution values of the endogenous variables in the model from their baseline simulation solution values are then taken as direct measures of the effects of the change in the respective checkoff investments. Because no other exogenous variable in the model is allowed to change (e.g., levels of inflation, exchange rates, income levels, agricultural and trade policies, etc.), this process effectively isolates the effects of the soybean checkoff program on the endogenous variables in the model.

Simulation Analysis of the Soybean Checkoff Program Effectiveness

To evaluate the effectiveness of the soybean checkoff program, two sets of simulations were conducted with SOYMOD to answer two general questions: (1) Have soybean producers benefitted from the soybean checkoff program and, if so, by how much? (2) Would soybean producers have been better off if the funds they have contributed to the checkoff program instead had been invested in other financial opportunities? The first set of simulations provides the basis for a benefit-cost analysis of the soybean checkoff program. The second set of simulations allows an alternative investment analysis of the soybean checkoff program.

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 comparing the results of simulating SOYMOD over the 1978 to 1994 period *with* and *without* checkoff investments. The baseline simulation represents the "with checkoff investments" scenario. For the "without soybean checkoff investment" scenario, the level of soybean checkoff investments were first set to zero in the model in each year from 1978 through 1994. Then SOYMOD was simulated over the historical period to generate changes in the levels of U.S. and world soybean and product production, consumption, trade, and prices that 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 (and only those investments) on the U.S. and world soybean and product markets. Following this process, three "without checkoff investment" scenarios were simulated: (1) without foreign market development investments, (2) without soybean production research investments, and (3) without either foreign market development or soybean production research investments. A summary comparison of each of the three "without" checkoff investment simulation scenario solutions to the baseline simulation solutions are provided in Tables 5, 6, and 7, respectively. For each of the three scenarios, the market effects are first discussed and then the effectiveness of the soybean checkoff program is summarized in the calculation of the benefit-cost ratio (BCR), i.e., the *average* rate of return to the program, as is commonly done in studies of the effectiveness of advertising and promotion programs. In this study, the *profit* benefit-cost ratio (BCR) formulation is used to calculate the average rate of return to the soybean checkoff program[17].

As usually calculated, the soybean grower *profit* BCR is the total soybean cash receipts added as a consequence of the investments over the 1978 to 1994 period as measured in each simulation divided by the level of investments made to generate those additional cash receipts after deducting the additional production costs required to produce the additional soybean output generated. Thus, if the additional industry profits (in million \$) generated by the checkoff investment being analyzed in any given year (t) is calculated as:

$$R_t = (p_t^s q_t^s - c_t^s A_t^s) - (p_t^b q_t^b - c_t^b A_t^b)$$

where p is the farm price of soybeans (\$/bu.); c is production cost (\$/acre); A is the area planted to soybeans (million acres); q is production of soybeans (million bu.); and s and b indicate scenario and baseline simulation value, respectively, then the grower profit BCR is calculated as:

$$BCR = \sum_{t=1}^{T} \frac{R_t}{I_t}$$

where I is the checkoff investment (\$ million) associated with the scenario being analyzed. If the cost of the checkoff program in each year (I_t) is first netted out of the additional profit generated (R_t) in those years (i.e., R_t - I_t) as is sometimes done, then the *net* grower profit BCR is calculated as:

$$NBCR = BCR - 1.$$

[17] See the overview of previous research section of this report for details.

Although not often done, if the time value of money is accounted for as in Sellen, *et al.*, then the discounted net grower profit BCR would be calculated as:

$$DBCR = \sum_{t=1}^{T} \frac{(R_t - I_t)/(1+i)^t}{I_t}$$

where i is the interest rate chosen to discount the additional profit flows to present value. The level of the DBCR, however, depends on the rate used to discount the benefits over time. In this study, the DBCR was calculated using the 30-day Treasury bill interest rates (IMF) for 1978 to 1994. Sellen, *et al.* made an arbitrary choice of an annual 5% fixed rate as the discount rate. Because the Treasury bill interest rate averaged 7.1% between 1978 and 1994, using a fixed 5% rate would generate a higher DBCR. The Treasury bill rate was selected simply because it represents a realistic alternative investment rate for the 1978 to 1994 period.

Benefit-Cost Analysis of Foreign Market Development Investments

The simulation results indicate clearly that the soybean foreign market development (FMD) program has been effective in increasing U.S. soybean production, crush, exports, price, world market share, and producer profits. On average between 1978 and 1994, soybean planted acreage was 3.4% higher in each year than would have been the case in the absence of the FMD program (Table 5a). Likewise, U.S. soybean production was higher by 1.5%, soybean farm price by 1.3%, soymeal wholesale price by 5.0%, and the crush margin by 8.6% on average in each year as a result of the FMD program. The wholesale price of soyoil, on the other hand, was 2.4% lower in each year on average as a result of investments to promote foreign demand for U.S. soybeans and products.

The negative result for the soyoil price is the result of a growing and continuing strategy to emphasize soybean meal over either soybeans or soyoil as the primary foreign market promotion objective[18]. The emphasis of the FMD program on soymeal that has boosted foreign demand for soymeal has also increased U.S. crush and generated additional U.S. soymeal production to meet that demand. At the same time, however, additional U.S. supplies of soyoil have also been produced which have tended to overhang the soyoil market and hold down the price of soyoil. In other words, the FMD program has been unbalanced in promoting one of the two joint products of soybeans over the other. The consequence has been a higher relative demand and price for one of the products (soymeal) and a larger domestic surplus and lower price of the other (soyoil) as a result of the program. The optimal allocation of funding among the two products and soybeans that would maximize benefits to U.S. soybean producers, however, is not clear. Should all funds be allocated to soymeal? If not, what is the optimal mix of investments between soymeal, soyoil, and soybeans? These and other critical questions relating to program management require further study.

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[18] See background section of this report for details.

Table 5a. Foreign Market Development Investment: Effets on U.S. Soybean Supply, Crush, and Prices, 1978-94*

The FMD program has tended to increase not only the level but also the U.S. share of world exports over the 1978 to 1994 period (Table 5b). Soybean, soymeal, and soyoil exports have averaged 5.6%, 9.3%, and 5.8% more in each year than they would have in the absence of the soybean FMD program. At the same time, the FMD program has lead to a higher U.S. share of world exports of soybeans, soymeal, and soyoil by 1.3, 1.1, and 0.9 percentage points, respectively, on average in each year between 1978 and 1994.

In the case of soybeans, the higher U.S. market share resulted from a higher average annual level of U.S. exports (1.6 million metric tons (mt)) and a lower level of Brazilian and Argentine exports (70,500 mt and 68,800 mt, respectively) as a direct consequence of the soybean FMD program (Table 5b). In other words, investments to promote U.S. soybean exports boosted both U.S. soybean exports and the U.S. share of world soybean exports while reducing both the level and share of world exports accounted for by Brazil and Argentina.

Although the FMD program raised the average annual level of soymeal exports of all three countries, U.S. exports benefitted to a greater extent thereby raising the U.S. share of world soymeal exports and reducing the shares of both Brazil and Argentina in each year on average (Table 5b). The story is the same for soyoil with two exceptions. First, the FMD program has benefitted Brazilian exports of soyoil almost as much as U.S. exports of soyoil. This result is likely due to the decreasing emphasis on promoting U.S. exports of soyoil. Thus, the additional U.S. exports of soyoil are more the result of a lower world price of soyoil than of a FMD-induced preference by foreign consumers for the U.S. as a source of soyoil. Second, the larger annual average U.S. and Brazilian shares of soyoil exports as a result of the FMD program over 1978 to 1994 came primarily at the expense of lower EU-15 exports of surplus soyoil.

While the FMD program had a measurably positive effect on U.S. production, price, and exports of U.S. soybeans and soybean products over the 1978 to 1994 period, was the impact large enough to justify the cost of the program? The answer is that the benefits in terms of the additional soybean industry profits generated by the FMD program far exceeded the investment costs of the program over that period (Table 5c). The net grower profit BCR, i.e., the average return to growers, for the soybean FMD program was quite attractive over that time period at $10.3 in profits earned on average by U.S. soybean farmers for every dollar invested. This BCR compares quite favorably to those found by similar studies for other commodities and by an earlier study of the soybean FMD program[19]. Even when the net grower benefits are discounted to present value (the DBCR), the ratio of benefits (net grower profits) to costs is still an impressive 6.3 to 1 (Table 5c). Because the Treasury bill interest rate averaged 7.1% between 1978 and 1994, using a fixed 5% rate as done by Sellen, *et al.* would have generated a higher DBCR of between 7 and 8. If a higher fixed rate of 10% had been used, the calculated DBCR would have been somewhat lower than 6.3 to 1.

Interestingly, the calculated BCR for the soybean FMD program was substantially higher in the 1978 to 1989 period than in the subsequent 1990 to 1994 period. Does that mean that the program was

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[19] See Table 2 and the associated discussion in an earlier section of this report.

Table 5b. Foreign Market Development Investment: Effects on World Trade and U.S. Market Share, 1978-94

Table 5c. Foreign Market Development Investment: Soybean Grower Benefit-Cost Analysis, 1978-94 more effective *before* the implementation of the national soybean checkoff program than *after*? Not necessarily. In fact, the lower BCR for the 1990-94 period is the result of FMD funding problems over a number of years (1985 to 1991) just *before* the national soybean checkoff program was implemented. Recall from the discussion in the background section of this report that FMD funding grew rapidly until 1985. In 1986, total funds for FMD investment were cut by over 17%. Although recovering back to the previous year's level in 1987, total FMD funding began a steep decline in 1988 that lasted until 1991 - a 40% drop over that period. The source of the decline was a reduction in funds made available for FMD investments from the soybean grower checkoff and from third party, in-country sources. Soybean FMD funds made available by the Foreign Agriculture Service remained relatively steady throughout that period. The rapid deterioration of the soybean FMD program was arrested beginning in 1992 with the implementation of the national soybean checkoff program which brought a much needed infusion of funds into the program. Because foreign market promotion efforts have carryover effects[20], however, the full impact of the increase in the level of FMD investments in 1992 through 1994 as a result of the implementation of the national soybean checkoff program was not felt immediately but rather over a number of years.

Thus, the deterioration in soybean checkoff and third party funding support for foreign market development between 1985 and 1991 brought with it a growing retreat in foreign demand for U.S. soybeans and products from the levels previously attained under the program which had its major impacts in the early 1990s and which persisted for many years after the hemorrhage in funding was stopped. By the same token, the effect of the new FMD funding made available through the national soybean checkoff program 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 soybean checkoff program in 1992 through 1994 were not likely felt in the market for several years - a period beyond the data set available for this study - and, thus, are not reflected in the results of this study.

Benefit-Cost Analysis of Soybean Production Research Investments

The conclusions on the effectiveness of the checkoff investments in soybean production research are quite different from those for the FMD program. Without question, the checkoff investments in soybean production research have boosted U.S. soybean yields and production (Table 6a). On average in each year over the 1978 to 1994 period, U.S. soybean output was about 10 million bu. higher than would have been the case in the absence of the program. The additional production, however, also led to a somewhat lower farm price of soybeans in each year on average ($0.05/bu.).

One consequence of the higher yields and the lower price as a result of the investments in production research over the 1978 to 1994 period was that fewer soybeans were planted by about 297,500 acres in each year on average. Nevertheless, while reducing the total number of U.S. acres planted to soybeans, the checkoff investments in soybean production research also induced a shift of soybean acreage from states in the Delta, South, Lakes, and Atlantic regions to those in the Corn Belt and the

[20] See background section on expected effects of demand promotion investments for more details.

Table 6a: Soybean Production Research Investment: Effects on U.S. Soybean Supply, Crush, and Prices, 1978-94

Plains regions[21]. Consequently, most of the production increase as a result of the production research investments came from States in the Cornbelt and Plains regions. Despite a lower total area planted to soybeans, however, production was higher in most regions because of higher yields induced by the research investments.

In essence, production research investments over time forced a trade-off between yield and acreage planted. The increased output from the yield-boosting effects of the research meant that 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 to 1994 period was slightly positive because the slightly lower soybean price generated a slightly higher quantity of soybeans demanded (in both domestic and foreign markets) on average in each year. Of the average 10 million bu. higher level of soybean production in each year between 1978 and 1994 as a result of the checkoff investments in production research, about 5.3 million bu. were crushed domestically, 4.5 million bu.were exported, and about 0.2 million bu. were added to stocks.

Any benefits accruing to checkoff investments in soybean production research are most obvious in the effects they have had on U.S. exports and U.S. export share (Table 6b). Between 1978 and 1994, the research investments not only boosted both the level of soybean, soymeal, and soyoil exports and the U.S. export share of each but also reduced both the level of exports and the export share of each commodity from Brazil and Argentina. Thus, while the FMD program tended to boost exports of soybean meal and oil from Brazil and Argentina as well as from the U.S. (although the U.S. share increased) over time, the production research investments had unambiguous negative effects on the exports of the two major U.S. export competitors. The absolute level of the effects on U.S. exports and export share were smaller as a result of the production research investments than was the case for the FMD investments. Recall, however, that the level of investments in the FMD program between 1978 and 1994 was about 4.5 times greater than that of production research investments.

Unfortunately, the cost of the soybean checkoff investments in production research over the 1978 to 1994 period just slightly outweighed the benefits in terms of the additional profits generated for U.S. soybean growers (Table 6c). Given the relatively price unresponsive (inelastic) demand for soybeans and soybean products generally faced by U.S. soybean producers, the increased national production of soybeans as a result of the research investments 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. The lower planted acreage also led to lower total production costs so that the net change in soybean industry profits (i.e., added receipts minus added costs) as a result of the soybean research investments was quite small but negative. Consequently, given a somewhat lower level of industry profit as a result of the research investments, the calculated net BCR over the entire 1978 to 1994 period was slightly negative at about -1.2 to 1 (-0.8 to 1 on a discounted basis).

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[21] States in each region are: (1) Cornbelt - Illinois, Indiana, Iowa, Missouri, Ohio; (2) Delta - Arkansas, Louisiana, Mississippi; (3) South - Alabama, Florida, Georgia, Kentucky, Oklahoma, Tennessee, Texas; (4) Plains - Kansas, Nebraska, North Dakota, South Dakota; (5) Lakes - Michigan, Minnesota, Wisconsin; (6) Atlantic - Delaware, Maryland, North Carolina, South Carolina, Virginia; and (7) Other - New York, New Jersey, Pennsylvania, West Virginia.

Table 6b: Soybean Production Research Investment: Effects on World Trade and U.S. Market Share, 1978-94

Table 6c: Soybean Production Research Investment: Soybean Grower Benefit-Cost Analysis, 1978-94

Does the slightly negative BCR mean that the funding of production research with soybean checkoff funds has been a poor investment? Not necessarily for two important reasons. First, given the strong competition in international soybean markets, investments in soybean production research may be necessary for the U.S. soybean industry to stay competitive in world soybean markets despite the possibility of negative returns. That is, a negative BCR may suggest that, *when considered alone and without consideration of what U.S. export competitors may have been doing to stay competitive in world soybean markets*, soybean checkoff investments in production research are not a source of profit but, rather, represent a cost to U.S. soybean producers. That cost, however, should be considered the price to U.S. soybean producers of staying competitive in world markets. Brazil and Argentina, in particular, have invested heavily and continue to invest in research to boost soybean yields, reduce soybean production costs, and, thereby, increase their competitiveness in world soybean markets. *Thus, even though the returns to production research investments may have been negative for the 1978 to 1994 period when considered alone, the change in the profitability of the U.S. soybean industry might have been even more negative from a loss of world market share if the U.S. soybean sector had failed to keep output growing through investments in production research.* Investments to promote foreign demand for soybeans and soybean products, then, should be seen as a companion strategy to raise price, boost producer profits, and otherwise offset the costs of the war to maintain and boost the international competitiveness of the U.S. soybean sector through investments in production research. Consequently, investments of both types (i.e., production research and foreign market development) should be considered to be important aspects of a full, well-balanced soybean checkoff investment program. The critical issue in this regard is the optimal mix of production research and foreign market development investments. Additional research is needed to provide insight on this important problem.

The second reason that funding production research should not necessarily be considered to be a poor investment of checkoff funds can be seen by decomposing the 1978 to 1994 period into two shorter periods - 1978-89 and 1990-94. Just as investments to develop foreign soybean and soybean product markets experienced a sharp decline between about 1987 and 1991 as previously discussed, investments in soybean production research experienced a sharp increase beginning in about 1988 through 1994 both in absolute terms and as a percentage of total investments (see Figures 1 and 3 and related discussion). The share of total soybean investment accounted for by production research declined from about 21% in 1981 to only 13% in 1987. By 1994, however, the production research share had jumped dramatically to nearly 44%. As a consequence, the BCR to production research turned positive from -3.1 to 1 in the 1978 through 1989 period to 2.0 to 1 during the 1990 to 1994 period (Table 6c). Because of the lag between investment in production research and the market impact of such investments (see Figure 19), the slightly positive BCR for the 1990-94 period likely understates the actual return to the increasingly larger investments in research made between 1990 and 1994.

Total Soybean Checkoff Investments

If checkoff investments in foreign market demand promotion and in production research are not separate programs but, indeed, companion strategies that support and strengthen each other, then perhaps any measure of their separate effects is not particularly meaningful. A more appropriate approach would be to consider their joint effects on U.S. and world soybean and product markets and on soybean grower profits.

Considered together, soybean checkoff investments in both production research and foreign market promotion have been highly effective in increasing 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 the FMD program over much of the 1978 to 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 percentage points, 1.6 percentage points, and 1.3 percentage points, respectively) than either investment strategy alone over the 1978-94 period (Tables 7a and 7b). At the same time, total soybean checkoff investments (production research and foreign market development) resulted in lower exports and lower export shares by both Brazil and Argentina than either type of investment alone (Table 7b). 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 7a).

Despite the slightly negative BCR calculated for soybean research investments as discussed earlier, the benefits of the total soybean checkoff program clearly exceeded the investment costs over the 1978 to 1994 period (Table 7c). The net grower profit BCR for the soybean checkoff program was quite high over that period at \$8.3 in profits earned on average by U.S. soybean farmers for every dollar invested. The net BCR for the total checkoff program approximates a weighted average of the net BCRs of the two component investment strategies (production research and foreign market development). The calculated net soybean grower BCR for the total soybean checkoff program still compares quite favorably to those found by similar studies for other commodities and by an earlier study of the soybean FMD program (refer to Table 2 and related discussion). Even when the benefits are discounted to present value, the BCR (i.e., the DBCR) for the 1978 to 1994 period is still an impressive 5.0 to 1 (Table 7c).

As was the case for the FMD investments, the calculated BCR for the total soybean checkoff program was higher in the 1978 to 1989 period than in the subsequent 1990 to 1994 period. Again, the reason is the steep 40% decline in total FMD funding that occurred between 1988 and 1991 as the result of a sharp deterioration of soybean checkoff and third party, in-country financial support for foreign market development during that period. The lengthy carryover effects of investments in foreign market development led to a lengthy deterioration in the growth of U.S. soybean and soybean product exports previously achieved through the program despite some recovery of FMD investment levels by the end of the 1978 to 1994 period. The divergence of the 1978-89 and 1990-94 BCRs for the total soybean checkoff program is smaller, however, than is the case for the FMD program primarily because the sharp increase in soybean production research investments that began in 1988 changed the returns to production research from negative to positive between those two periods.

Table 7a: Total Investments: Effects on U.S. Soybean Supply, Crush, and Prices, 1978-94

Table 7b: Total Investments: Effects on World Trade and U.S. Market Share, 1978-94

Table 7c: Total Investments: Soybean Grower Benefit-Cost Analysis, 1978-94

Alternative Investment Analysis of the Soybean Checkoff Program

The foregoing benefit-cost analysis suggests that the ratio of benefit to cost has been high for the soybean checkoff program compared to that of other commodity promotion programs as reported in previous studies. But has the return been high enough? Has the soybean checkoff program been successful as an investment alternative for soybean producers? That is, would soybean producers have been better off if the funds they have contributed to the checkoff program instead had been invested in other financial opportunities? If so, then it may make little difference if the returns from the investments made with checkoff funds have been "high" if soybean producers could have invested those same checkoff funds in other common investment opportunities and realized a higher return. To answer this question, the level of checkoff investments in one year (1978) in the model was increased by 10% (i.e., a one-period, 10% shock in 1978) and the effects of the change tracked over the 17 year period of 1978 through 1994. The results from this simulation were used to calculate the stream of benefits that have accrued to soybean producers from the soybean checkoff program over time as an alternative investment opportunity.

This analysis compares the rate of return to an investment in the soybean checkoff program as allocated to the various research and foreign market development activities in 1978 over the 17 year period of 1978 to 1994 with the rates of return that could have been realized over the same 17 year period if those same funds had instead been invested in other financial opportunities. The result is a dynamic grower profit return on investment (ROI) calculation for the total soybean checkoff program (soybean production research and foreign market development) that is compared with the ROIs from investing the same checkoff funds in 1978 in alternative investments. This allows a standard business comparison of ROIs to determine the highest yielding investment opportunity. To calculate the soybean checkoff ROI, the standard modified internal rate of return (MIRR) procedure is utilized as defined in Barry, *et al.* The procedure requires three steps. First, the present value (PV) of the initial 1978 soybean checkoff investment and any negative cash flows (i.e., negative soybean grower profits) in any year between 1978 and 1994 as a result of the 1978 investment is calculated as:

$$PV = -I_{1978} + \sum_{n=0}^{17} \frac{-P_n}{(1+i)^n}$$

where I_{1978} is the initial 1978 soybean checkoff investment, i.e., the 10% increase in checkoff funds as invested in soybean production research and foreign market development in 1978; $-P_n$ is a net negative cash flow in year *n* attributable to the investment in the initial year (i.e., the loss generated in year *n* as a result of the 10% increase in the 1978 soybean checkoff investment); and i is the discount rate.

Second, the future value (FV) of all positive or zero cash flows in any year as a result of the 1978 investment is calculated as:

$$FV = \sum_{n=0}^{17} P_n(1+i)^{17-n}$$

where P_n is the net positive cash flow (additional profit generated) in year *n* attributable to the investment in the initial year.

Finally, the MIRR that equates the PV to the FV is solved for according to:

$$PV = \frac{FV}{(1+MIRR)^{17}} \ .$$

Again, the choice of the discount rate to calculate the PV and FV is crucial. For this analysis, two different rates are used to calculate the MIRR to the soybean checkoff program: (1) the 30-day Treasury bill rate and (2) the average interest rate paid on farm debt. As with the calculation of the discounted BCR, instead of choosing an arbitrary fixed rate, the Treasury bill rate was selected to discount the cash flows in the MIRR calculations simply because it represents a realistic alternative investment rate for the 1978 to 1994 period. While Treasury bills represent a reasonable opportunity for investment of any additional profits generated from the checkoff program during the 1978 to 1994 period, soybean producers with farm debt would likely have opted to use those additional profits to pay down that debt or, at least, would have invested the profits in financial instruments with interests rate of no less than what they pay on farm debt. Thus, an alternative MIRR for the soybean checkoff program is also calculated using the average rate on farm real estate loans outstanding (NASS) over the 1978 to 1994 period.

The results indicate that, indeed, the soybean checkoff program was a superior investment choice for soybean checkoff dollars (Table 8). The internal rate of return (MIRR) to the 1978 soybean checkoff investment was 14.8% at the Treasury bill rate and 18.3% at the interest rate paid on farm debt. That is, if the additional profits generated by the 1978 soybean checkoff investments each year from 1978 to 1994 had been invested by producers in Treasury bills, they would have realized an 14.8% rate of return on that investment over 17 years. If, instead, soybean farmers had invested those additional profits in buying down farm debt, they would have realized an 18.3% rate of return on that investment over the 17 years.

Alternatively, if farmers could have opted individually to invest the same initial amount of funds in Treasury bills or to buy down farm debt in 1978 instead of investing those funds first in the soybean checkoff program, the rate of return would have been much lower at 7.5% and 8.9% for Treasury bills and farm debt repayment, respectively (Table 8). In other words, investing jointly in the soybean checkoff program allowed larger profits than otherwise would have been available to farmers to pay off debt or invest elsewhere over time. If producers had invested the funds directly in paying off debt or in other financial opportunities, producers would have realized a positive but much smaller return than could have been realized by first investing the funds in the soybean

Table 8: Internal Rate of Return to Soybean Checkoff Investments, 1978-94

checkoff program and then reinvesting the additional earnings generated by that program in paying off debt or in other investment opportunities.

The calculated MIRR to the foreign market development program alone is somewhat higher than for the total soybean checkoff program (16.2% and 19.8% for Treasury bills and farm debt repayment, respectively) just as the BCR for the FMD program was higher than that for the total soybean checkoff program (Table 8). As indicated earlier in the benefit-cost analysis, this result does not necessarily imply that investments of checkoff funds should be made only in developing foreign markets. Rather, investments in foreign market development and in production research should more appropriately considered to be companion strategies to boost producer profits and enhance the international competitiveness of the U.S. soybean sector.

A word of caution is in order. The MIRR calculation depends not only on the discount rate used but also on the year of analysis because the shares of funds allocated to the various activities are not constant over time. The share of total funds allocated to research and foreign market development have changed substantially over the years as well as how the funds in each investment type are allocated among alternative competing activities. Also, the regional distribution of production research and the country and commodity allocation of foreign market development investments have all changed considerably over time. Thus, a different MIRR could be calculated for each year and compared to determine the year in which the funding allocation achieved the highest return. For program management purposes, the MIRR to various relevant checkoff funding options (e.g., a shift in funding from soybean oil to meal, from Japan and the EU-15 to other countries, etc.) could be calculated and then compared to determine the options that yield the highest potential return. Although outside the scope of this project, such research in support of program management decisions is recommended.

Conclusions and Implications for Program Management

The main conclusion of this study is that investments of soybean checkoff funds in foreign market development and production research since the early 1970s have been highly effective in augmenting U.S. soybean producers' bottom lines. Among the major findings of this study are the following:

- *The Benefit -Cost Ratio (BCR) of the soybean checkoff investments has been reasonably high at $8 in additional profit earned by U.S. soybean farmers for every dollar invested.*

  For every checkoff dollar spent to promote foreign demand for soybeans and soybean products and to improve the international competitiveness of U.S. soybean production through soybean production research between 1978 and 1994, U.S. soybean farmers earned an additional $8 in profits (cash receipts minus production costs). This benefit-cost ratio compares favorably to those found by similar studies for other commodities and by an earlier study of the soybean checkoff program. Even when the benefits are discounted to present value to account for the time value of money, the benefit-cost ratio for the 1978 to 1994 period is still an impressive 5.0 to 1.

- *Not only has the soybean checkoff program BCR been high, the soybean checkoff program has also been a superior investment choice for U.S. soybean farmers.*

  The soybean checkoff program has performed outstandingly as an investment alternative for soybean farmers. That is, soybean producers have been better off contributing to the soybean checkoff program than they would have been if the funds they contributed to the program instead had been invested in other common financial opportunities. For example, if the additional profits generated by the 1978 soybean checkoff investments each year from 1978 to 1994 had been re-invested by producers at a rate comparable to what they pay on farm debt, they would have realized an 18.3% rate of return on that investment over 17 years. However, if soybean farmers had invested the same initial amount of funds in 1978 at a rate comparable to what they pay on farm debt instead of investing those funds first in the soybean checkoff program, the rate of return would have been much lower at 8.9% over the same 17 year period. By investing funds directly in other common financial opportunities, producers would have realized a positive but much smaller return than could have been realized by first investing the funds in the soybean checkoff program and then re-investing the additional earnings generated by that program in other investment opportunities.

- *Overall, foreign market development and production research investments have increased the size of the U.S. soybean industry and reduced the competitive threat of the South American soybean industry.*

  On average in each year between 1978 and 1994, as a result of the checkoff investments in foreign demand expansion for soybeans and products and in soybean production research:

  1. U.S. soybean production and crush averaged 3.5% higher and U.S. soybean crush 2% higher than would have been the case without the investments;
  2. The price farmers received for their soybeans averaged about 1% higher than would have been the case without the investments;
  3. The price margin to soybean crushers averaged 12% higher than would have been the case without the investments;
  4. U.S. exports of soybeans averaged over 6% more and those of Brazil and Argentina averaged 4% and 3%, respectively, less than would have been the case without the investments; and
  5. The U.S. share of world soybean, soybean meal, and soybean oil exports were each about 1 to 2 percentage points higher than would have been the case without the investments.

- *Foreign market development investments alone have been profitable and have effectively pushed out world demand for U.S. soybeans and products.*

In each year on average between 1978 and 1994, foreign market development investments alone generated $10 in net grower profits for every dollar invested, shifted world imports of U.S. soybeans, soybean meal, and soybean oil up by 6%, 9%, and 6%, respectively, and expanded the U.S. share of each of the three commodities by about 1 percentage point over what would have occurred without the investments.

- *Soybean checkoff investments in production research have boosted U.S. soybean output and crush and increased the U.S. share of world soybean and soybean product exports.*

  Between 1978 and 1994, U.S. soybean production and crush averaged 10 million bu. and 5 million bu. more, respectively, in each year on average as a result of the checkoff investments in soybean production research than would have occurred without those investments. Even so, production research investments over time have forced a trade-off between yield and acreage planted. The increased output from the yield-boosting effects of the research has meant that fewer soybean planted acres have been needed in order to meet the demand for soybeans in each year. The net effect on U.S. soybean production over the 1978 to 1994 period, however, was positive. At the same time, the investments have captured world market share for U.S. soybeans and products, pushing the U.S. share up by nearly 1 percentage point over what it would have been in each year between 1978 and 1994.

- *The Benefit-Cost Ratio to soybean production research investments alone has been low but increased dramatically after 1990 following a shift in soybean checkoff investment strategy.*

  Just as investments in foreign market development experienced a sharp decline between about 1987 and 1991, investments in soybean production research experienced a sharp increase, boosting the share of total soybean investment accounted for by production research from about 13% in 1987 to about 44% in 1994. This change in investment strategy towards a greater emphasis on soybean production research turned the BCR to production research from negative (-3 to 1) in 1978-89 to positive (2 to 1) in 1990-94. Given the lag between investment in production research and the market impact of the investment, however, the small but positive BCR for the 1990-94 period likely understates the actual return to investments in production research made between 1990 and 1994.

These conclusions suggest a number of implications for program management purposes. First and foremost is that the U.S. soybean industry has been underinvesting in foreign market development and production research. The high benefit-cost ratio to checkoff investments given the relatively low current level of those investments suggests that large additional benefits in terms of net grower profits can be realized from a substantial increase in those investments. As the level of investment increases, the benefit-cost ratio would be expected to drop to some extent. But because the current level of investment is relatively low, amounting to less than 0.2% of soybean farm cash receipts and less than 0.5% of the value of U.S. soybean and soybean product exports in each year, even an extraordinary expansion in the current level of investments would likely have only a small negative effect on the benefit-cost ratio.

Second, a failure to maintain and enhance the growth in soybean checkoff investments can have serious negative impacts on soybean producer profitability over a number of years. For example, foreign market development expenditures are investments intended to create a stream of new revenues over time. Thus, the full effects of such investments made in any given year are not realized immediately but rather over a number of years. Capricious, on-again-off-again foreign market development funding, therefore, can seriously erode the effectiveness of the program in boosting exports and raising producer profits over a long period of time. Indeed, a 42% drop in total foreign market development investments between 1986 and 1992 from $19.1 million to $11.1 million resulted in a lower overall return to soybean farmers during the early 1990s (1990-94) of $5 per dollar invested compared to the $13 per dollar invested earned between 1978 and 1989.

Third, the allocation of funding between production research and foreign market development can have important consequences for the effectiveness of the soybean checkoff program. During the late 1980s and into the 1990s as total soybean checkoff funding dwindled, a strategic shift in funding emphasis from foreign market development to production research boosted the return to investments in production research but reduced the overall return to soybean checkoff investments. Research is needed to determine the optimal rate of tradeoff between production research and foreign market development investments in terms of producer industry profits as a guide to checkoff fund allocation decisions. One possibility would be to calculate and compare the internal rates of return to alternative allocations of checkoff funding between production research and foreign market development.

Fourth, related to the previous point, despite the low BCR for investments in soybean production research over the 1978 to 1994 period, any proposal to curtail future checkoff investments in production research should be carefully studied before being implemented. The problem is that Brazil, Argentina, and other U.S. competitors in world soybean markets have invested heavily and continue to invest in research to boost soybean yields, reduce soybean production costs, and, thereby, increase their competitive edge in world soybean markets. While seemingly a sensible decision in the short run, curtailing U.S. investments in new, high yielding, and cost efficient soybean production technologies and techniques may allow the comparative advantage in the production and export of soybeans and soybean products to shift slowly over the long run to countries like Brazil and Argentina that continue to invest in production research. In this sense, a low or even negative BCR for soybean production research could be considered to be the cost to U.S. soybean producers of staying competitive in world markets. On the other hand, if soybean growers stopped financing soybean production research, much of this research might be done by the federal government or private soybean breeding companies anyway[22]. Unfortunately, however, federal research funds have been cut drastically and are expected to continue to decline over the foreseeable future. At the same time, private soybean breeders invest more in applied types of research rather than in more basic types of research because of the difficulty of capturing the returns to such research. Thus, there may be an important role for soybean growers to play in helping maintain the international competitiveness of U.S. soybean production. In any case, soybean

[22] This possibility was suggested by Harry Kaiser, Cornell University.

growers must weigh carefully the tradeoff between the cost of investments in production research from a lower overall return to checkoff investments and the possible loss of competitiveness in world markets from curtailing investments in production research.

Fifth, the way in which FMD 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 investments in the development of foreign markets for soybeans and products dropped between 1986 and 1992, the share allocated to promote foreign demand for soybeans and soybean meal increased from about 8% and 49% to 15% and 71%, respectively. Over the same period, the share allocated to soybean oil declined from about 43% to only 14%. The reallocation of investment funds from soybean oil to soybean meal and soybeans 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 soybean oil markets despite the overall decline in foreign market development investments. Also, the reallocation of investments to soybean meal prevented a significant erosion in the average annual soymeal price gain from the 1978-89 period ($8/ton) to the 1990-94 period ($7/ton). 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. Research is needed to determine the optimal or highest yielding regional and commodity allocation of FMD investments. One possible approach would be to calculate and compare the internal rates of return to alternative schemes of allocating foreign market development funding across regions and commodities. Whatever procedures are used, the market allocation rules discussed by Kinnucan and Christian and by Ding and Kinnucan would likely be useful.

Finally, a harmonized, systematic procedure for collecting, classifying, maintaining, and reporting data on soybean checkoff expenditures by state and national soybean groups is critically needed for future program evaluation and management purposes. Even though some groups like the American Soybean Association, the Foreign Agriculture Service, and the United Soybean Board have developed data systems for their internal purposes, they are not all compatible because they are based on different computer programs, use different classification schemes, and maintain different levels of detail on funded program activities. Few state organizations have attempted to develop a system to track their expenditure activities. Those state organizations that attempt to track their expenditure history have yet to work together to establish a common set of guidelines for collection, classification, maintenance, and reporting requirements. Historical, state-level data on program expenditures are critically needed to evaluate program performance over time but are currently quite sketchy in most cases. Developing an industry-wide, cooperative system for tracking such expenditures by activity and other relevant characteristics must be a high priority for the United Soybean Board and associated state and federal organizations and contractors.

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Appendix

This appendix provides details on SOYMOD, the model used in the evaluation of the soybean checkoff program, including the model structure, parameter estimates, and regression statistics as well as the historical model simulation validation statistics.

The 186 econometric, structural equations that make up SOYMOD are presented in Appendix Table 1. The definitions of variables are provided in Appendix Table 2. Note that the equations are organized by world region (U.S., EU-15, Japan, Brazil, Argentina, and Rest-of-the-World). Within each region, the equations are organized by commodity block (soybeans, soymeal, soyoil, and corn (U.S. only)). Within each commodity block, the supply equations are first presented and then those for demand followed by the market clearing identities. Those equations which were re-normalized on price for simulation purposes are marked with an asterisk (*) after the dependent variable of the equation. The public and checkoff research and foreign demand promotion investment stock variables are highlighted in bold type to assist the reader in locating them in the model.

The estimated parameters are those presented below each equation with the t-value in parentheses. The adjusted R^2 and the Durbin-Watson statistic for serial correlation are provided for each equation. For equations that include a lagged dependent variable, the Durbin-h statistic is provided as a check for serial correlation. All Durbin-Watson and Durbin-h statistics indicate the absence of serial correlation at the 5% level or the 2.5% level for those marked with an asterisk (*). The parameters of the soybean and corn production block were estimated using Nonlinear Iterative Seemingly Unrelated Least Squares (ITSUR) in SAS (Statistical Analysis System) with data for 1975/76 through 1994/95. The remaining model parameters were estimated with a truncated two stage least squares (2SLS) procedure based on principal components in SAS using data for 1969/70 to 1995/6.

All equations were estimated in linear or log-linear form. The log-linear form was used for acreage planted and a few demand equations where a rapid rate of annual growth over the sample period was evident. For simulation purposes, any lagged endogenous variables in the foreign soybean, soybean meal, and soybean oil equations were exogenized to avoid a compounding of the effects of the foreign market development program (FMD) over time. This procedure tends to bias the calculation of the benefit to cost ratio (BCR) of the FMD program downward. In this sense, the calculated BCRs represent a lower bound on the benefits of the FMD program.

Appendix Table 3 provides the Theil relative change forecast error (i.e., the relative change Mean Squared Error (MSE) Decomposition Proportions Inequality Coefficients) simulation validation statistics from simulating SOYMOD over the 1978 to 1994 sample period (*ex post* simulation). Those statistics indicate a highly satisfactory fit of the historical, dynamic simulation solution values to observed data. The Theil U coefficients were small with none over about 0.7. The Theil bias error proportions (UM) indicate no systematic deviation of simulated and actual data values for any of the endogenous variables. The variance proportions (US) are also remarkably low for such a large, highly simultaneous, and complex model.

Appendix Table 1: SOYMOD Structure and Regression Results

United States

Soybean Supply

Regional and Total U.S. Acreage Planted

LN(ASOYSAC)=ASOYSAC0+ASOYSAC1*LN(ASOYPCC/UFPI67)+ASOYSAC2*LN(ACORPPC/UFPI67)
+ASOYSAC3*LN(LAG(ASOYSAC))+ASOYSAC4*LN(**PUBRES**+**CHKRES**)+ASOYSAC5*DWA

ASOYSAC1: 0.50219(10.1)	ASOYSAC0: 2.65(6.35)	ASOYSAC2: -0.25426(-5.22)
ASOYSAC3: 0.57556(14.2)	ASOYSAC4: 0.039828(2.22)	ASOYSAC5: 0.19678(9.1)

Adj R^2= 0.9506 Dh=-1.411

LN(CSOYSAC)=CSOYSAC0+CSOYSAC1*LN(CSOYPCC/UFPI67)+CSOYSAC2*LN(CCORPPC/UFPI67)
+CSOYSAC3*LN(LAG(CSOYSAC))+CSOYSAC4*LN(**PUBRES**+**CHKRES**)+CSOYSAC5*DWC

CSOYSAC1: 0.27577(7.06)	CSOYSAC0: 2.4958(2.82)	CSOYSAC2: -0.30401(-7.33)
CSOYSAC3: 0.67438(7.57)	CSOYSAC4: 0.06039(3.46)	CSOYSAC5: -0.073327(-5.49)

Adj R^2=0.9203 Dh=0.232

LN(DSOYSAC)=DSOYSAC0+DSOYSAC1*LN(DSOYPCC/UFPI67)+DSOYSAC2*LN(LAG(DSOYSAC))
+DSOYSAC3*LN(**PUBRES**+**CHKRES**)+DSOYSAC4*DWD1+DSOYSAC5*DWD2

DSOYSAC1: 0.49016(12.9)	DSOYSAC0: -0.14882(-0.378)	DSOYSAC2: 0.90784(42)
DSOYSAC3: 0.048535(2.33)	DSOYSAC4: 0.13172(7.89)	DSOYSAC5: -0.096669(11.6)

Adj R^2=0.9962 Dh=-0.908

LN(LSOYSAC)=LSOYSAC0+LSOYSAC1*LN(LSOYPCC/UFPI67)+LSOYSAC2*LN(LCORPPC/UFPI67)
+LSOYSAC3*LN(LBARPPC/UFPI67)+LSOYSAC4*LN(LAG(LSOYSAC))
+LSOYSAC5*LN(**PUBRES**+**CHKRES**)

LSOYSAC1: 0.54192(7.64)	LSOYSAC0: 1.1252(1.63)	LSOYSAC2: -0.18808(-2.07)
LSOYSAC3: -0.37495(-3.97)	LSOYSAC4: 0.7091(7.16)	LSOYSAC5: 0.087371(1.93)

Adj R^2=0.9676 Dh=-1.968*

LN(OSOYSAC)=OSOYSAC0+OSOYSAC1*LN(OSOYPCC/UFPI67)+OSOYSAC2*LN(OCORPPC/UFPI67)
+OSOYSAC3*LN(LAG(OSOYSAC))+OSOYSAC4*LN(**PUBRES**+**CHKRES**)+OSOYSAC5*DWO

OSOYSAC1: 0.81137(7.23)	OSOYSAC0: -0.80013(-1.25)	OSOYSAC2: -0.72535(-5.22)
OSOYSAC3: 0.89229(10.8)	OSOYSAC4: 0.077052(1.59)	OSOYSAC5: -0.2405(-4.98)

Adj R^2=0.9597 Dh=-1.278

LN(PSOYSAC)=PSOYSAC0+PSOYSAC1*LN(PSOYPCC/UFPI67)+PSOYSAC2*LN(PCORPPC/UFPI67)
+PSOYSAC3*LN(LAG(PSOYSAC))+PSOYSAC4*LN(**PUBRES**+**CHKRES**)+PSOYSAC5*DWP

PSOYSAC1: 0.35747(5.54)	PSOYSAC0: -0.28918(-0.894)	PSOYSAC2: -0.42432(-6.12)
PSOYSAC3: 0.89828(7.85)	PSOYSAC4: 0.087185(0.828)	PSOYSAC5: -0.13627(-7.73)

Adj R^2=0.9934 Dh=-1.145

LN(SSOYSAC)=SSOYSAC0+SSOYSAC1*LN(SSOYPCC/UFPI67)+SSOYSAC2*LN(SCORPPC/UFPI67)

+SSOYSAC3*LN(LAG(SSOYSAC))+SSOYSAC4*LN**(PUBRES**+**CHKRES**)+SSOYSAC5*DWS

SSOYSAC1: 0.89785(17)   SSOYSAC0: -0.75248(-1.72)   SSOYSAC2: -0.22656(-3.47)
SSOYSAC3: 0.90359(52.7)   SSOYSAC4: 0.073146(2.29)   SSOYSAC5: -0.17317(-8.79)

Adj R^2=0.9962   Dh=-0.742

USOYSAC=(CSOYSAC+LSOYSAC+PSOYSAC+ASOYSAC+SSOYSAC+DSOYSAC+OSOYSAC)/1000

Regional and Total U.S. Acreage Harvested
ASOYSHC=ASOYSHC0+ASOYSHC1*ASOYSAC

ASOYSHC1: 1.0172(96.5)   ASOYSHC0: -230.78(-6.12)

Adj R^2=0.9963   DW=1.725

CSOYSHC=CSOYSHC0+CSOYSHC1*CSOYSAC

CSOYSHC1: 0.98604(171)   CSOYSHC0: 70.98(0.459)

Adj R^2=0.9988   DW=2.472

DSOYSHC=DSOYSHC0+DSOYSHC1*DSOYSAC

DSOYSHC1: 0.97663(130)   DSOYSHC0: -34.271(-0.543)

Adj R^2=0.9979   DW=2.021

LSOYSHC=LSOYSHC0+LSOYSHC1*LSOYSAC

LSOYSHC1: 0.97061(169)   LSOYSHC0: 59.527(1.89)

Adj R^2=0.9988   DW=2.111

OSOYSHC=OSOYSHC0+OSOYSHC1*OSOYSAC

OSOYSHC1: 0.99117(177)   OSOYSHC0: -4.3942(-2.65)

Adj R^2=0.9992   DW=2.061

PSOYSHC=PSOYSHC0+PSOYSHC1*PSOYSAC

PSOYSHC1: 0.9751(311)   PSOYSHC0: 2.5012(0.168)

Adj R^2=0.9996   DW=2.437

SSOYSHC=SSOYSHC0+SSOYSHC1*SSOYSAC

SSOYSHC1: 0.97178(160)   SSOYSHC0: -128.02(-3.74)

Adj R^2=0.9986   DW=1.781

USOYSHC=(CSOYSHC+LSOYSHC+PSOYSHC+ASOYSHC+SSOYSHC+DSOYSHC+OSOYSHC)/1000

Regional Soybean Yields

ASOYSYC=ASOYSYC0+ASOYSYC1*(**PUBRES**+**CHKRES**)

ASOYSYC1: 0.00011579(2.54) ASOYSYC0: 19.22(9.13)

Adj R^2=0.2223 DW=2.156

CSOYSYC=CSOYSYC0+CSOYSYC1*(**PUBRES**+**CHKRES**)

CSOYSYC1: 0.00013523(2.28) CSOYSYC0: 30.043(11)

Adj R^2=0.1810 DW=1.672

DSOYSYC=DSOYSYC0+DSOYSYC1*(**PUBRES**+**CHKRES**)

DSOYSYC1: 0.000088435(1.56) DSOYSYC0: 20.453(7.84)

Adj R^2=0.706 DW=1.914

LSOYSYC=LSOYSYC0+LSOYSYC1*(**PUBRES**+**CHKRES**)

LSOYSYC1: 0.00013547(2.12) LSOYSYC0: 26.807(9.12)

Adj R^2=0.1560 DW=2.193

OSOYSYC=OSOYSYC0+OSOYSYC1*(**PUBRES**+**CHKRES**)

OSOYSYC1: 0.00024822(4.62) OSOYSYC0: 20.347(8.21)

Adj R^2=0.5169 DW=1.931

PSOYSYC=PSOYSYC0+PSOYSYC1*(**PUBRES**+**CHKRES**)

PSOYSYC1: 0.00016154(2.24) PSOYSYC0: 21.889(6.58)

Adj R^2=0.1742 DW=2.111

SSOYSYC=SSOYSYC0+SSOYSYC1*(**PUBRES**+**CHKRES**)

SSOYSYC1: 0.00012628(2.21) SSOYSYC0: 20.114(7.62)

Adj R^2=0.1690 DW=1.719

Regional and Total U.S. Production

ASOYSPC=ASOYSYC*ASOYSHC
CSOYSPC=CSOYSYC*CSOYSHC
DSOYSPC=DSOYSYC*DSOYSHC
LSOYSPC=LSOYSYC*LSOYSHC
OSOYSPC=OSOYSYC*OSOYSHC
PSOYSPC=PSOYSYC*PSOYSHC
SSOYSPC=SSOYSYC*SSOYSHC
USOYSPC=(CSOYSPC+LSOYSPC+PSOYSPC+ASOYSPC+SSOYSPC+DSOYSPC+OSOYSPC)/1000

Soybean Regional Loan Rates
ASOYPLC=ASOYPLC0+ASOYPLC1*USOYPLC+ASOYPLC2*D90

ASOYPLC1: 1.018(186) ASOYPLC0: -0.043673(-2.12) ASOYPLC2: -0.36416(-7.35)

Adj R^2=0.9990 DW=1.079

CSOYPLC=CSOYPLC0+CSOYPLC1*USOYPLC

CSOYPLC1: 1.0082(364) CSOYPLC0: -0.0079919(-0.764)

Adj R^2=0.9997 DW=1.939

DSOYPLC=DSOYPLC0+DSOYPLC1*USOYPLC

DSOYPLC1: 1.0193(212) DSOYPLC0: -0.024852(-1.37)

Adj R^2=0.9992 DW=1.550

LSOYPLC=LSOYPLC0+LSOYPLC1*USOYPLC

LSOYPLC1: 0.98(271) LSOYPLC0: -0.0044409(-0.325)

Adj R^2=0.9995 DW=1.062

OSOYPLC=OSOYPLC0+OSOYPLC1*USOYPLC

OSOYPLC1: 1.0113(188) OSOYPLC0: -0.057554(-2.84)

Adj R^2=0.9990 DW=1.748

PSOYPLC=PSOYPLC0+PSOYPLC1*USOYPLC

PSOYPLC1: 0.96529(76.1) PSOYPLC0: -0.0058714(-0.123)

Adj R^2=0.9940 DW=1.922

SSOYPLC=SSOYPLC0+SSOYPLC1*USOYPLC

SSOYPLC1: 1.0162(153) SSOYPLC0: -0.048919(-1.96)

Adj R^2=0.9985 DW=1.792

Regional Market Price (Farm Level)
ASOYPFC=ASOYPFC0+ASOYPFC1*USOYPFC

ASOYPFC1: 1.0201(92.6) ASOYPFC0: -0.087672(-1.54)

Adj R^2=0.9959 DW=2.170

CSOYPFC=CSOYPFC0+CSOYPFC1*USOYPFC

CSOYPFC1: 1.0081(88.2) CSOYPFC0: -0.021269(-0.36)

Adj R^2=0.9955 DW=2.942

DSOYPFC=DSOYPFC0+DSOYPFC1*USOYPFC

DSOYPFC1: 1.0255(90) DSOYPFC0: -0.063911(-1.08)

Adj R^2=0.9957 DW=2.135

LSOYPFC=LSOYPFC0+LSOYPFC1*USOYPFC+LSOYPFC2*D76

LSOYPFC1: 0.9582(81.6) LSOYPFC0: 0.10452(1.74) LSOYPFC2: 1.0597(8.27)

Adj R^2=0.9952 DW=1.740

OSOYPFC=OSOYPFC0+OSOYPFC1*USOYPFC

OSOYPFC1: 1.0138(61.2) OSOYPFC0: -0.14404(-1.68)

Adj R^2=0.9907 DW=2.505

PSOYPFC=PSOYPFC0+PSOYPFC1*USOYPFC+PSOYPFC2*D76

PSOYPFC1: 0.97322(115) PSOYPFC0: -0.063058(-1.45) PSOYPFC2: 0.89951(9.72)

Adj R^2=0.9975 DW=2.431

SSOYPFC=SSOYPFC0+SSOYPFC1*USOYPFC

SSOYPFC1: 1.0236(86.4) SSOYPFC0: -0.13506(-2.2)

Adj R^2=0.9953 DW=2.184

Regional Expected Farm Price
ASOYPCC=MAX(LAG(ASOYPFC),ASOYPLC)
CSOYPCC=MAX(LAG(CSOYPFC),CSOYPLC)
DSOYPCC=MAX(LAG(DSOYPFC),DSOYPLC)
LSOYPCC=MAX(LAG(LSOYPFC),LSOYPLC)
OSOYPCC=MAX(LAG(OSOYPFC),OSOYPLC)
PSOYPCC=MAX(LAG(PSOYPFC),PSOYPLC)
SSOYPCC=MAX(LAG(SSOYPFC),SSOYPLC)

Soybean Demand and Market Clearing Condition

USOYDCC=USOYDCC0+USOYDCC1*USOMPWC+USOYDCC2*USOOPWC+USOYDCC3*USOYPWC
+USOYDCC4*UOISCPC+USOYDCC5*(LAG(USOYHTC)+USOYSPC)+USOYDCC6*D6985

USOYDCC1: 1.8123(2.67) USOYDCC0: 232.45(5.58) USOYDCC2: 10.788(3.54)
USOYDCC3: -90.164(-2.9) USOYDCC4: 0.31615(3) USOYDCC5: 0.21263(4.41)
USOYDCC6: -102.33(-4.11)

Adj R^2=0.9862 DW=1.233

*USOYHEC=USOYHEC0+USOYHEC1*USOYPFC+USOYHEC2*UCORPPC+USOYHEC3*USOYSPC

+USOYHEC4*USOYHGC+USOYHEC5*LAG(USOYHEC)+USOYHEC6*D6990

USOYHEC0: -170.56(-5.15) USOYHEC1: -27.701(-4.38) USOYHEC2: 60.096(3.92)
USOYHEC3: 0.1752(8) USOYHEC4: -0.2864(-2.7) USOYHEC5: 0.28204(3.91)
USOYHEC6: 66.284(3.21)

Adj R^2=0.9494 Dh=1.029

USOYPWC=USOYPWC0+USOYPWC1*USOYPFC+USOYPWC2*D72+USOYPWC3*D74+USOYPWC4*D87

USOYPWC1: 1.0169(79.6) USOYPWC0: 0.16656(2.54) USOYPWC2: 1.5995(11.7)
USOYPWC3: -0.59897(-4.32) USOYPWC4: 0.61389(4.47)

Adj R^2=0.9948 DW=1.850

USOYGCC=USOMQ*USOMPWC/1000+USOOQ*USOOPWC/100-USOYPFC
USOYHEC=USOYHTC-USOYHGC
USOYHTC=LAG(USOYHTC)+USOYSPC+USOYMMC-USOYDCC-USOYMEC-USOYDZC

Soybean Meal Supply, Demand, and Market Clearing Condition

USOMSPC=USOMQ*USOYDCC

*UHPMDDC=UHPMDDC0+UHPMDDC1*UHPMPWC+UHPMDDC2*UFIMPWA+UHPMDDC3*UYDA
+UHPMDDC4*USLSPFC+UHPMDDC5*UCORDFC+UHPMDDC6*D6982

UHPMDDC0: 6977.2(6.53) UHPMDDC1: -18.386(-3.98) UHPMDDC2: 6.6275(2.87)
UHPMDDC3: 2.5953(13) UHPMDDC4: 40.162(2.74) UHPMDDC5: 0.9275(2.66)
UHPMDDC6: 1438.3(4.31)

Adj R^2=0.9888 DW=1.944

LN(UCOMDPC)=UCOMDPC0+UCOMDPC1*LN((USOMDPC+UPEMDPC)*UCOMPWC/(USOMDPC
*USOMPWC+UPEMDPC*UPEMPWC))+UCOMDPC2*LN(.8103*UCOMSPC/(USOMSPC
+ .8103*UCOMSPC+1.124*UPEMSPC))+UCOMDPC3*LN(LAG(UCOMDPC))+UCOMDPC4*D80

UCOMDPC1: -0.31234(-3.8) UCOMDPC0: 0.084539(3.2) UCOMDPC2: 0.8409(31.3)
UCOMDPC3: 0.16904(5.35) UCOMDPC5: -0.76907(-19.7)

Adj R^2=0.9965 Dh=0.408

USOMDPC=1-UCOMDPC-UPEMDPC
UHPMDDC=USOMDDC/USOMDPC
USOMPWC=(UHPMPWC-UCOMDPC*UCOMPWC-UPEMDPC*UPEMPWC)/USOMDPC

USOMHEC=USOMHEC0+USOMHEC1*USOMPWC+USOMHEC2*LAG(USOMHEC)
+USOMHEC3*LAG(EMBARGO)+USOMHEC4*D6970+USOMHEC5*D8489

USOMHEC1: -0.52901(-2.49) USOMHEC0: 229.67(4.78) USOMHEC2: 0.34795(4.64)
USOMHEC3: 291.07(7.96) USOMHEC4: -105.15(-3.45) USOMHEC5: 127.49(4.78)

Adj R^2=0.8834 Dh=-0.497

USOMDDC=LAG(USOMHEC)+USOMMMC+USOMSPC-USOMDZC-USOMHEC-USOMMEC

Soybean Oil Supply, Demand, and Market Clearing Condition

USOOSPC=USOOQ*USOYDCC

UOLODDC/UPOPA=UOLODDC0+UOLODDC1*UOLOPWC/UWPI67+UOLODDC2*ULAOPWC/UWPI67
+UOLODDC3*UYDA/UCPI67/UPOPA+UOLODDC4*LAG(UOLODDC)/LAG(UPOPA)

UOLODDC1: -0.69015(-4.64) UOLODDC0: 2.4571(1.08) UOLODDC2: 0.38777(4)
UOLODDC3: 4.9632(2.77) UOLODDC4: 0.57717(4.32)

Adj R^2=0.9888 Dh=-1.982*

LN(UCOODPC)=UCOODPC0+UCOODPC1*LN((USOODPC+UPEODPC)*UCOOPWC/(USOODPC
*USOOPWC+UPEODPC*UPEOPWC))+UCOODPC2*LN(UCOOSPC/(USOOSPC+UPEOSPC))
+UCOODPC3*LN(LAG(UCOODPC))+UCOODPC4*D80

UCOODPC1: -0.35494(-1.63) UCOODPC0: -0.093007(-1.1) UCOODPC2: 0.28663(4.21)
UCOODPC3: 0.70148(9.71) UCOODPC4: -0.23832(-2.5)

Adj R^2=0.9748 Dh=0.188

USOODPC=1-UCOODPC-UPEODPC
USOODDC=UOLODDC*USOODPC
UOLOPWC=UCOODPC*UCOOPWC+UPEODPC*UPEOPWC+USOOPWC*USOODPC

*USOOHEC=USOOPWC0+USOOPWC1*USOOPWC+USOOPWC2*USOOSPC+USOOPWC3*USOOHGC
+USOOPWC4*USOOMGC+USOOPWC5*LAG(USOOHEC)+USOOPWC6*LAG2(USOOHEC)
+USOOPWC7*DSOOH2

USOOPWC0: 132.42(0.856) USOOPWC1: -40.068(-6.01) USOOPWC2: 0.16429(10.1)
USOOPWC3: 1.4439(1.09) USOOPWC4: -1.247(-3.59) USOOPWC5: 0.6637(7.06)
USOOPWC6: -0.34789(-3.58) USOOPWC7: 491.67(6.15)

Adj R^2=0.8950 Dh=-0.524

USOOMEC=USOOMTC-2.20462*USOOMGC
USOOHEC=USOOHTC-USOOHGC
USOOHTC=LAG(USOOHTC)+USOOSPC+USOOMMC-USOODZC-USOOMTC-UOLODDC*USOODPC

Corn Supply

Regional and Total U.S. Acreage Planted
ACORSAC=ACORSA0+ACORSA1*ACORPPC/UFPI67+ACORSA2*((ASOYPCC/UFPI67)*(D6881
+NORFLEX/100))+ACORSA3*LAG(ACORSAC)+ACORSA4*UCORPDC/UFPI67+ACORSA5*DPIK
+ACORSA6*D8795

ACORSA1: 306.72(1.46) ACORSA0: 1763.6(3.85) ACORSA2: -20.098(-0.62)
ACORSA3: 0.5079(6.48) ACORSA4: -54.737(-4.17) ACORSA5: -641.72(-3.39)

ACORSA6: -696.22(-5.25)

Adj R^2=0.9302   Dh=-0.301

CCORSAC=CCORSA0+CCORSA1*CCORPPC/UFPI67+CCORSA2*((CSOYPCC/UFPI67)*(D6881 +NORFLEX/100))+CCORSA3*LAG(CCORSAC)+CCORSA4*UCORPDC/UFPI67+CCORSA5*DPIK +CCORSA6*UCORARP

CCORSA1: 8059.7(3.98)   CCORSA0: 16563(4.25)   CCORSA2: -715.28(-3.95)
CCORSA3: 0.37312(4.96)   CCORSA4: -741.12(-8.59)   CCORSA5: -10705(-8.78)
CCORSA6: -175.95(-5.75)

Adj R^2=0.8855   Dh=0.518

DCORSAC=DCORSAC0+DCORSAC1*DCORPPC/UFPI67+DCORSAC2*((DSOYPCC/UFPI67)*(D6881 +NORFLEX/100)) +DCORSAC3*LAG(DCORSAC)+DCORSAC4*UCORPDC/UFPI67 +DCORSAC5*DPIK+DCORSAC6*UCORARP

DCORSAC1: 157.61(2.22)   DCORSAC0: -36.868(-0.425)   DCORSAC2: -42.034(-3.99)
DCORSAC3: 0.86572(29.1)   DCORSAC4: -15.364(-2.62)   DCORSAC5: -125.77(-1.81)
DCORSAC6: -2.0876(-1.41)

Adj R^2=0.9689   Dh=0.375

LCORSAC=LCORSAC0+LCORSAC1*LCORPPC/UFPI67+LCORSAC2*((LSOYPCC/UFPI67)*(D6881 +NORFLEX/100))+LCORSAC3*LBARPPC/UFPI67+LCORSAC4*LAG(LCORSAC) +LCORSAC5*UCORPDC/UFPI67+LCORSAC6*DPIK+LCORSAC7*UCORARP

LCORSAC1: 3868.1(3.43)   LCORSAC0: 6498.7(4.86)   LCORSAC2: -190.45(-2.15)
LCORSAC3: -2882.2(-3.48)   LCORSAC4: 0.52605(6.86)   LCORSAC5: -334.25(-7.42)
LCORSAC6: -3801.8(-7.26)   LCORSAC7: -129.11(-8.23)

Adj R^2=0.9250   Dh=0.512

OCORSAC=OCORSAC0+OCORSAC1*OCORPPC/UFPI67+OCORSAC2*((OSOYPCC/UFPI67)*(D6881 +NORFLEX/100))+OCORSAC3*LAG(OCORSAC)+OCORSAC4*UCORPDC/UFPI67 +OCORSAC5*DPIK+OCORSAC6*UCORARP+OCORSAC7*OWHEPPC/UFPI67

OCORSAC1: 613.27(3.71)   OCORSAC0: 81.197(0.312)   OCORSAC2: -10.907(-0.547)
OCORSAC3: 0.91459(19.1)   OCORSAC4: -22.551(-2.73)   OCORSAC5: -419.42(-3.83)
OCORSAC6: -9.2901(-3.34)   OCORSAC7: -297.21(-3.21)

Adj R^2=0.9574   Dh=1.161

PCORSAC=PCORSA0+PCORSA1*PCORPPC/UFPI67+PCORSA2*((PSOYPCC/UFPI67)*(D6881 +NORFLEX/100))+PCORSA3*LBARPPC/UFPI67+PCORSA4*LAG(PCORSAC) +PCORSA5*UCORPDC/UFPI67+PCORSA6*DPIK+PCORSA7*UCORARP

PCORSA1: 721.03(0.8)   PCORSA0: 11365(7.9)   PCORSA2: -264.41(-3.65)
PCORSA3: -2685.3(-3.77)   PCORSA4: 0.39819(5.15) PCORSA5: -263.03(-6.44)
PCORSA6: -3814.2(-8.04)   PCORSA7: -115.31(-7.84)

Adj R^2=0.9176   Dh=0.591

SCORSAC=SCORSAC0+SCORSAC1*SCORPPC/UFPI67+SCORSAC2*SSOYPCC/UFPI67
+SCORSAC3*LAG(SCORSAC)+SCORSAC4*UCORPDC/UFPI67+SCORSAC5*DPIK
+SCORSAC6*UCORARP+SCORSAC7*NORFLEX

SCORSAC1: 1790.3(5.39) SCORSAC0: 1892.4(3.37) SCORSAC2: -583.61(-3.74)
SCORSAC3: 0.64364(16) SCORSAC4: -85.741(-4.1) SCORSAC5: -1244.2(-4.78)
SCORSAC6: -32.807(-5.1) SCORSAC7: -15.258(-1.35)

Adj R^2=0.9500 Dh=-0.402

TCORSAC=TCORSAC0+TCORSAC1*TCORPPC/UFPI67+TCORSAC2*((OSOYPCC/UFPI67)*(D6881
+NORFLEX/100))+TCORSAC3*LAG(TCORSAC)+TCORSAC4*DPIK
+TCORSAC5*UCORPDC/UFPI67+TCORSAC6*UCORARP+TCORSAC7*OWHEPPC/UFPI67

TCORSAC1: 285.18(1.71) TCORSAC0: 649.07(2.19) TCORSAC2: -23.335(-1.13)
TCORSAC3: 0.88331(14.8) TCORSAC4: -413.96(-3.29) TCORSAC5: -24.224(-2.53)
TCORSAC6: -8.4422(-2.41) TCORSAC7: -387.61(-3.57)

Adj R^2=0.9502 Dh=0.097

UCORSAC=(ACORSAC+CCORSAC+DCORSAC+LCORSAC+OCORSAC+PCORSAC+SCORSAC
+TCORSAC)/1000

Regional and Total U.S. Acreage Harvested

ACORSHC=ACORSHC0+ACORSHC1*ACORSAC

ACORSHC1: 0.89957(36.6) ACORSHC0: -197.47(-2.27)

Adj R^2=0.9746 DW=1.850

CCORSHC=CCORSHC0+CCORSHC1*CCORSAC

CCORSHC1: 0.98137(42.6) CCORSHC0: -910.97(-1.14)

Adj R^2=0.9811 DW=1.308

DCORSHC=DCORSHC0+DCORSHC1*DCORSAC+DCORSHC2*D6982

DCORSHC1: 0.97259(131) DCORSHC0: -50.922(-8.69) DCORSHC2: -36.572(-6.44)

Adj R^2=0.9980 DW=1.397

LCORSHC=LCORSHC0+LCORSHC1*LCORSAC+LCORSHC2*D6985

LCORSHC1: 1.0018(41.3) LCORSHC0: -1691.3(-5.36) LCORSHC2: -675.45(-7.01)

Adj R^2=0.9819 DW=1.276

OCORSHC=OCORSHC0+OCORSHC1*OCORSAC+OCORSHC3*D72

OCORSHC1: 0.79998(30) OCORSHC0: -534.62(-7.1) OCORSHC3: -240.32(-3.28)

Adj R^2=0.9653 DW=1.509

PCORSHC=PCORSHC0+PCORSHC1*PCORSAC+PCORSHC2*D6982

PCORSHC1: 1.0145(28.2) PCORSHC0: -1597.9(-3.3) PCORSHC2: -805.06(-6.91)

Adj R^2=0.9732 DW=2.124

SCORSHC=SCORSHC0+SCORSHC1*SCORSAC+SCORSHC2*D77+SCORSHC3*D6990

SCORSHC1: 0.91698(54.3) SCORSHC0: -137.51(-1.41) SCORSHC2: -1601.4(-15.1)
SCORSHC3: -154.88(-3.1)

Adj R^2=0.9891 DW=2.047

TCORSHC=TCORSHC0+TCORSHC1*TCORSAC+TCORSHC2*D6980

TCORSHC1: 0.60626(31.2) TCORSHC0: -61.112(-1.23) TCORSHC2: -192.81(-8.06)

Adj R^2=0.9839 DW=1.391

UCORSHC=(ACORSHC+CCORSHC+DCORSHC+LCORSHC+OCORSHC+PCORSHC+SCORSHC
+TCORSHC)/1000

Regional and U.S. Production

ACORSPC=ACORSYC*ACORSHC
CCORSPC=CCORSYC*CCORSHC
DCORSPC=DCORSYC*DCORSHC
LCORSPC=LCORSYC*LCORSHC
OCORSPC=OCORSYC*OCORSHC
PCORSPC=PCORSYC*PCORSHC
SCORSPC=SCORSYC*SCORSHC
TCORSPC=TCORSYC*TCORSHC
UCORSPC=(ACORSPC+CCORSPC+DCORSPC+LCORSPC+OCORSPC+PCORSPC+SCORSPC+TCORSPC)/1000

Regional Market Price (Farm Level)

ACORPFC=ACORPFC0+ACORPFC1*UCORPFC

ACORPFC1: 1.0723(39) ACORPFC0: 0.033944(0.587)

Adj R^2=0.9775 DW=1.763

CCORPFC=CCORPFC0+CCORPFC1*UCORPFC

CCORPFC1: 1.0112(148) CCORPFC0: -0.024838(-1.72)

Adj R^2=0.9984 DW=1.781

DCORPFC=DCORPFC0+DCORPFC1*UCORPFC+DCORPFC2*D85

DCORPFC1: 1.0783(33.2) DCORPFC0: 0.05388(0.807) DCORPFC2: 0.75721(5.74)

Adj R^2=0.9718 DW=2.009

LCORPFC=LCORPFC0+LCORPFC1*UCORPFC

LCORPFC1: 0.97324(85.3) LCORPFC0: -0.017633(-0.734)

Adj R^2=0.9952 DW=1.693

OCORPFC=OCORPFC0+OCORPFC1*UCORPFC+OCORPFC2*D6985

OCORPFC1: 1.0851(60.9) OCORPFC0: 0.19849(4.29) OCORPFC2: -0.11583(-4.27)

Adj R^2=0.9924 DW=1.794

PCORPFC=PCORPFC0+PCORPFC1*UCORPFC

PCORPFC1: 0.9892(71.1) PCORPFC0: -0.014436(-0.493)

Adj R^2=0.9931 DW=1.713

SCORPFC=SCORPFC0+SCORPFC1*UCORPFC

SCORPFC1: 1.058(63.2) SCORPFC0: 0.055366(1.57)

Adj R^2=0.9913 DW=1.241

TCORPFC=TCORPFC0+TCORPFC1*UCORPFC

TCORPFC1: 1.0488(61.6) TCORPFC0: 0.12764(3.56)

Adj R^2=0.9908 DW=1.417

Regional Expected Price

ACORPPC=(MAX(LAG(ACORPFC),UCORPLC*(1-UCORARP/100)))*D6983+(MAX(LAG(ACORPFC), UCORPTC*(1-UCORARP/100)))*D8490+(MAX(LAG(ACORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100*LAG(ACORPFC))))*D9195+(MAX(LAG(ACORPFC), UCORPLC))*D9605

CCORPPC=(MAX(LAG(CCORPFC),UCORPLC*(1-UCORARP/100)))*D6883+(MAX(LAG(CCORPFC), UCORPTC*(1-UCORARP/100)))*D8490+(MAX(LAG(CCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100*LAG(CCORPFC))))*D9195+(MAX(LAG(CCORPFC), UCORPLC))*D9605

DCORPPC=(MAX(LAG(DCORPFC),UCORPLC*(1-UCORARP/100)))*D6883+(MAX(LAG(DCORPFC), UCORPTC*(1-UCORARP/100)))*D8490+(MAX(LAG(DCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100*LAG(DCORPFC))))*D9195+(MAX(LAG(DCORPFC), UCORPLC))*D9605

LCORPPC=(MAX(LAG(LCORPFC),UCORPLC*(1-UCORARP/100)))*D6883+(MAX(LAG(LCORPFC), UCORPTC*(1-UCORARP/100)))*D8490+(MAX(LAG(LCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100*LAG(LCORPFC))))*D9195+(MAX(LAG(LCORPFC), UCORPLC))*D9605

OCORPPC=(MAX(LAG(OCORPFC),UCORPLC*(1-UCORARP/100)))*D6883+(MAX(LAG(OCORPFC),

UCORPTC*(1-UCORARP/100)))*D8490+(MAX(LAG(OCORPFC),UCORPTC*(1-UCORARP/100
-NORFLEX/100)+(NRFLEX/100*LAG(OCORPFC))))*D9195+(MAX(LAG(OCORPFC),
UCORPLC))*D9605

PCORPPC=(MAX(LAG(PCORPFC),UCORPLC*(1-UCORARP/100)))*D6883+(MAX(LAG(PCORPFC),
UCORPTC*(1-UCORARP/100)))*D8490+(MAX(LAG(PCORPFC),UCORPTC*(1-UCORARP/100
-NORFLEX/100)+(NORFLEX/100*LAG(PCORPFC))))*D9195+(MAX(LAG(PCORPFC),
UCORPLC))*D9605

SCORPPC=(MAX(LAG(SCORPFC),UCORPLC*(1-UCORARP/100)))*D6883+(MAX(LAG(SCORPFC),
UCORPTC*(1-UCORARP/100)))*D8490+(MAX(LAG(SCORPFC),UCORPTC*(1-UCORARP/100
-NORFLEX/100)+(NORFLEX/100*LAG(SCORPFC))))*D9195+(MAX(LAG(SCORPFC),
UCORPLC))*D9605

TCORPPC=(MAX(LAG(TCORPFC),UCORPLC*(1-UCORARP/100)))*D6883+(MAX(LAG(TCORPFC),
UCORPTC*(1-UCORARP/100)))*D8490+(MAX(LAG(TCORPFC),UCORPTC*(1-UCORARP/100
-NORFLEX/100)+(NORFLEX/100*LAG(TCORPFC))))*D9195+(MAX(LAG(TCORPFC),
UCORPLC))*D9605

UCORPPC=(CCORSPC*CCORPPC+LCORSPC*LCORPPC+ACORSPC*ACORPPC+DCORSPC*DCORPPC
+SCORSPC*SCORPPC+PCORSPC*PCORPPC+TCORSPC*TCORPPC+OCORSPC*OCORPPC)
/(UCORSPC*1000)

Corn Demand and Market Clearing Condition

UCORDFC=UCORDFC0+UCORDFC1*UCORPWC+UCORDFC2*UGCAUA+UCORDFC3*UHOGPFC
+UCORDFC4*USLSPFC+UCORDFC5*DCORF

UCORDFC1: -365.29(-6.12) UCORDFC0: -6325.1(-6.96) UCORDFC2: 121.58(9.95)
UCORDFC3: 22.328(4.2) UCORDFC4: 14.975(4.75) UCORDFC5: 504.33(6.38)

Adj. R^2=0.9502 DW=2.197

UCORDOC=UCORDOC0+UCORDOC1*UCORPWC/UWPI67+UCORDOC2*UYDA/UCPI67
+UCORDOC3*UWHEPFC/UFPI67+UCORDOC4*LAG(UCORDOC)+UCORDOC5*D6981

UCORDOC1: -108.46(-3.58) UCORDOC0: 90.756(1.8) UCORDOC2: 0.37572(4.78)
UCORDOC3: 60.517(2.78) UCORDOC4: 0.66629(12.9) UCORDOC5: -125.15(-5.69)

Adj. R^2=0.9969 Dh=0.763

UCORMEC=UCORMEC0+UCORMEC1*(ECORPIA*XECUSA)+UCORMEC2*RCORMEC
+UCORMEC3*LAG(UCORMEC)+UCORMEC4*(JGCAUA/1000+EGCAUA)+UCORMEC5*D6970

UCORMEC1: -1.0094(-2) UCORMEC0: -731.52(-1.01) UCORMEC2: -1.2366(-6.46)
UCORMEC3: 0.78558(8.55) UCORMEC4: 18.993(2.92) UCORMEC5: -354.39(-2.75)

Adj. R^2=0.9401 Dh=-1.316

*UCORHOC=UCORHOC0+UCORHOC1*UCORPWC+UCORHOC2*UCORSPC+UCORHOC3*UCORHCC
+UCORHOC4*LAG(UCORHCC)+UCORHOC5*LAG(UCORHOC)+UCORHOC6*D6988

UCORHOC0: -1757.4(-7.95) UCORHOC1: -342.2(-5.86) UCORHOC2: 0.40929(14)
UCORHOC3: 0.12379(0.853) UCORHOC4: 0.52179(3.58) UCORHOC5: 0.33723(5.29)
UCORHOC6: 737.93(7.26)

Adj. R^2=0.9487 Dh=1.166

UCORPFC=UCORPFC0+UCORPFC1*UCORPWC+UCORPFC2*D95

UCORPFC1: 0.95805(90) UCORPFC0: -0.094548(-3.95) UCORPFC2: -0.55513(-11.2)

Adj. R^2=0.9961 DW=2.011

ECORPIA=ECORPIA0+ECORPIA1*UCORPWC+ECORPIA2*XECUSA+ECORPIA3*D73+ECORPIA4*D79

ECORPIA1: 34.752(13.9) ECORPIA0: 60.236(5.87) ECORPIA2: -11.735(-5.69)
ECORPIA3: 20.869(2.63) ECORPIA4: 18.637(2.36)

Adj. R^2=0.9579 DW=2.109

UCORHOC=UCORHTC-UCORHCC

UCORHTC=LAG(UCORHTC)+UCORSPC+UCORMMC-UCORDFC-UCORDOC-UCORMEC-UCORDZC

European Union (15)

Soybean Demand and Market Clearing Condition

ESOYDCC=ESOYDCC0+ESOYDCC1*((ESOMQ*ESOMPIA+ESOOQ*ESOOPXA-ESOYPIA)*XECUSA)
+ESOYDCC2*LESOYDC+ESOYDCC3***EBXIL2R**+ESOYDCC4*D72+ESOYDCC5*D88

ESOYDCC1: 26.554(3.85) ESOYDCC0: 893.97(1.42) ESOYDCC2: 0.91009(20)
ESOYDCC3: 85.836(1.51) ESOYDCC4: -2174(-9.95) ESOYDCC5: -1223.1(-7.61)

Adj. R^2=0.9674 Dh=-0.013

ESOYPIA=ESOYPIA0+ESOYPIA1*USOYPWC*36.7437+ESOYPIA2*D7274+ESOYPIA3*D8283

ESOYPIA1: 1.014(18.1) ESOYPIA0: 22.856(1.82) ESOYPIA2: 37.549(3.91)
ESOYPIA3: 32.916(3.37)

Adj. R^2=0.9288 DW=2.121

ESOYMIC=ESOYDCC+ESOYDZC+ESOYHEC-LAG(ESOYHEC)-ESOYSPC

Soybean Meal Supply, Demand, and Market Clearing Condition

ESOMSPC=ESOMQ*ESOYDCC

ESOMDDC=ESOMDDC0+ESOMDDC1*(ESOMPIA*XECUSA/ECWPI2)+ESOMDDC2*LESOMDD
+ESOMDDC3***EMXIL2R**+ESOMDDC4*D8788+ESOMDDC5*D94

ESOMDDC1: -1.7274(-3.24) ESOMDDC0: 5915.4(5.29) ESOMDDC2: 0.71821(14.7)
ESOMDDC3: 170.49(2.49) ESOMDDC4: -1556.5(-5.16) ESOMDDC5: 2308(6.06)

Adj. R^2=0.9803 Dh=1.424

ESOMPIA=ESOMPIA0+ESOMPIA1*USOMPWC*1.01231+ESOMPIA2*D72

ESOMPIA1: 0.97999(16.3) ESOMPIA0: 32.096(3.1) ESOMPIA2: 42.734(3.24)

Adj. R^2=0.9331 DW=1.275

ESOMMIC=ESOMDDC+ESOMDZC+ESOMHEC-LAG(ESOMHEC)-ESOMSPC

Soybean Oil Supply, Demand, and Market Clearing Condition

ESOOSPC=ESOOQ*ESOYDCC

ESOODDC=ESOODDC0+ESOODDC1*ESOOPXA*XECUSA/ECWPI2+ESOODDC2*EPAOPIA/ECWPI2
+ESOODDC3*LESOODD+ESOODDC4***EOXIL2R**+ESOODDC5*D72

ESOODDC1:-.091997(-1.53) ESOODDC0: 478(5.16) ESOODDC2: 0.23347(5.48)
ESOODDC3: 0.68215(14) ESOODDC4: 10.659(3.56) ESOODDC5: 330.32(8.55)

Adj. R^2=0.9357 Dh=-0.889

ESOOMXC=LAG(ESOOHEC)+ESOOSPC-ESOODDC-ESOODZC-ESOOHEC;

ESOOPXA=ESOOPXA0+ESOOPXA1*USOOPWC*22.04622+ESOOPXA2*D73+ESOOPXA3*D74

ESOOPXA1: 1.0323(21.2) ESOOPXA0: -8.4596(-0.299) ESOOPXA2: 86.367(2.87)
ESOOPXA3: -163.42(-5.49)

Adj. R^2=0.9622 DW=2.244

Japan

Soybean Demand and Market Clearing Condition

JSOYDCC=JSOYDCC0+JSOYDDC1*((JSOMQ*JSOMPUA+JSOOQ*JSOOPUA-JSOYPUA)*XJAUSA/JWPI85)
+JSOYDCC2*LJSOYDC+JSOYDCC3***JBXIL2R**+JSOYDCC4*DJEMBGO+JSOYDCC5*D6987
+JSOYDCC6*D8890

JSOYDCC1: 0 .00319(1.96) JSOYDCC0: 241.56(1.33) JSOYDCC2: 0.94793(19.1)
JSOYDCC3: 0.58677(2.43) JSOYDCC4: -201.72(-2.74) JSOYDCC5: -184.56(-2.58)
JSOYDCC6: -383.5(-5.79)

Adj. R^2=0.9592 Dh=-0.250

JSOYPUA=JSOYPUA0+JSOYPUA1*USOYPWC*36.7437+JSOYPUA2*D6987+JSOYPUA3*D72

JSOYPUA1: 1.1265(23.9) JSOYPUA0: 24.86(2.12) JSOYPUA2: -13.147(-2.66)
JSOYPUA3: -56.483(-4.8)

Adj. R^2=0.9610 DW=1.680

JSOYMIC=JSOYDCC+JSOYDZC+JSOYHEC-LAG(JSOYHEC)-JSOYSPC

Soybean Meal Supply, Demand, and Market Clearing Condition

JSOMSPC=JSOMQ*JSOYDCC

JSOMDDC=JSOMDDC0+JSOMDDC1*(JSOMPUA*XJAUSA/JWPI85)+JSOMDDC2*LJSOMDD
+ JSOMDDC3***JMXIL2R**+JSOMDDC4*D82

JSOMDDC1: -0.00966(-4.38) JSOMDDC0: 1942.5(22.2) JSOMDDC2: 0.44185(8.5)
JSOMDDC3: 0.75927(3.35) JSOMDDC4: 238.86(2.88)

Adj. R^2=0.9807 Dh=2.024*

JSOMPUA=JSOMPUA0+JSOMPUA1*USOMPWC*1.01231+JSOMPUA2*D6986+JSOMPUA3*D72
+JSOMPUA4*D8788

JSOMPUA1: 1.3061(19.2) JSOMPUA0: -7.1458(-0.522) JSOMPUA2: 19.453(3.34)
JSOMPUA3: -82.914(-6.37) JSOMPUA4: -32.399(-3.38)

Adj. R^2=0.9527 DW=1.958

JSOMMIC=JSOMDDC+JSOMDZC+JSOMHEC-LAG(JSOMHEC)-JSOMSPC

Soybean Oil Supply, Demand, and Market Clearing Condition

JSOOSPC=JSOOQ*JSOYDCC

JSOODDC=JSOODDC0+JSOODDC1*JSOOPUA*XJAUSA/JWPI85+JSOODDC2*LJSOODD
+ JSOODDC3*EPAOPIA*XJAUSA/JWPI85+JSOODDC4***JOXIL2R**+JSOODDC5*D85
+ JSOODDC6*D8890

JSOODDC1:-.00062(-3.92) JSOODDC0: 173.03(3.87) JSOODDC2: 0.80389(13.5)
JSOODDC3: 0.00032365(2.74) JSOODDC4: 0.08948(2.54) JSOODDC5: 112.59(4.82)
JSOODDC6: -54.956(-3.8)

Adj. R^2=0.9504 Dh=-1.705

JSOOPUA=JSOOPUA0+JSOOPUA1*USOOPWC*22.04622+JSOOPUA2*D6990

JSOOPUA1: 1.0754(9.84) JSOOPUA0: 347.28(5.11) JSOOPUA2: -311.35(-8.45)

Adj. R^2=0.9553 DW=1.997

JSOOMIC=JSOODDC+JSOODZC+JSOOHEC-LAG(JSOOHEC)-JSOOSPC

Rest-of-the-World

Soybean Demand and Market Clearing Condition

LN(RSOYMIN)=RSOYMIN0+RSOYMIN1*LN(USOYPWC)+RSOYMIN2*LN(LRSOYMI)
+RSOYMIN3*LN(RGDP85)+RSOYMIN4*LN(**OBXIL2R**)+RSOYMIN5*D70
+ RSOYMIN6*D71+RSOYMIN7*D74

RSOYMIN1:-1.0(c) RSOYMIN0: 9.1698(11.3) RSOYMIN2: 0.13072(1.34)
RSOYMIN3: 0.94017(4.81) RSOYMIN4: 0.067995(5.04) RSOYMIN5: -1.3126(-7.09)

RSOYMIN6: -1.8918(-10.2)   RSOYMIN7: -0.87962(-4.88)   Note: c=constrained

Adj. R^2=0.9179 Dh=1.640

Soybean Meal Supply, Demand, and Market Clearing Condition

RSOMSPN=.795*RSOYMIN*.8

LN(RSOMDDN)=RSOMDDN0+RSOMDDN1*LN(USOMPWC)+RSOMDDN2*LN(RGDP85)
+RSOMDDN3*LN(LRSOMDD)+RSOMDDN4*LN(**OMXIL2R**)+RSOMDDN5*D70
+RSOMDDN6*D71

RSOMDDN1: -0.8(c)   RSOMDDN0: 11.793(15.6)   RSOMDDN2: 1.3533(7.78)
RSOMDDN3: 0.15201(1.77)   RSOMDDN4: 0.051639(5.01)   RSOMDDN5: -0.89054(-7.08)
RSOMDDN6: -1.4839(-11.7)   Note: c=constrained

Adj. R^2=0.9688 Dh=-0.110

RSOMMIN=RSOMDDN-RSOMSPN

Soybean Oil Supply, Demand, and Market Clearing Condition

RSOOSPN=.179*RSOYMIN*.8

LN(RSOODDN)=RSOODDN0+RSOODDN1*LN(USOOPWC)+RSOODDN2*LN(RGDP85)
+RSOODDN3*LN(LRSOODD)+RSOODDN4*LN(**OOXIL2R**)+RSOODDN5*D71

RSOODDN1: -0.8(c)   RSOODDN0: 4.3172(5.25)   RSOODDN2: 0.25734(1.45)
RSOODDN3: 0.78254(7.51)   RSOODDN4: 0.01557(1.76)   RSOODDN5: -0.92379(-7.55)
Note: c=constrained

Adj. R^2=0.9568 Dh=0.034

RSOOMIN=RSOODDN-RSOOSPN

Brazil

Soybean Supply, Demand, and Market Clearing Condition

LN(BSOYSHC)=BSOYSHC0+BSOYSHC1*LAG(LN(BSOYPXC*XBZUSA/BWPI85))
+ BSOYSHC2*LAG(LN(BSOYSHC))+BSOYSHC3*LTIME+ BSOYSHC4*D8587

BSOYSHC1: 0.39882(8.84)   BSOYSHC0: -529.12(-9.09)   BSOYSHC2: 0.51536(11.1)
BSOYSHC3: 71.038(9.13)   BSOYSHC4: -956.78(-4.6)

Adj. R^2=0.9954 Dh=0.977

BSOYSPC=BSOYSYC*BSOYSHC

BSOYDCC=BSOYDCC0+BSOYDCC1*BSOMPXC*XBZUSA/BWPI85+BSOYDCC2*BSOOPXC
*XBZUSA/BWPI85+BSOYDCC3*BSOYPXC*XBZUSA/BWPI85+BSOYDCC4*(LAG(BSOYHEC)
+BSOYSPC)+BSOYDCC5*LAG(BSOYDCC)+BSOYDCC6*LTIME+BSOYDCC7*D7594

BSOYDCC1: 5.6422(1.64) BSOYDCC0: 1860638(2.95) BSOYDCC2: 0.46977(0.97)
BSOYDCC3: -6.1744(-1.57) BSOYDCC4: 0.52993(12.2) BSOYDCC5: 0.51435(9.93)
BSOYDCC6: -245333(-2.95) BSOYDCC7: -1327.6(-3.64)

Adj. R^2=0.9951 Dh=1.753*

BSOYPXC=BSOYPXC0+BSOYPXC1*ESOYPIA+BSOYPXC2*D6987

BSOYPXC1: 1.0448(90.3) BSOYPXC0: -38.125(-11.3) BSOYPXC2: 16.602(8.47)

Adj. R^2=0.9964 DW=1.884

BSOYMXC=LAG(BSOYHEC)+BSOYSPC-BSOYDCC-BSOYDZC-BSOYHEC

Soybean Meal Supply, Demand, and Market Clearing Condition

BSOMSPC=BSOMQ*BSOYDCC

BSOMDDC=BSOMDDC0+BSOMDDC1*BSOMPXC*XBZUSA/BWPI85+BSOMDDC2*LAG(BSOMDDC)
+BSOMDDC3*BGDP85+BSOMDDC4*D72+BSOMDDC5*D79

BSOMDDC1: -2.0996(-5.41) BSOMDDC0: 329.64(1.33) BSOMDDC2: 0.65085(8.76)
BSOMDDC3: 1.0313(4.41) BSOMDDC4: 1632.2(6.16) BSOMDDC5: 695.12(4.21)

Adj. R^2=0.9899 Dh=-1.769*

BSOMPXC=BSOMPXC0+BSOMPXC1*ESOMPIA+BSOMPXC2*D7379

BSOMPXC1: 0.96238(69.2) BSOMPXC0: -9.8674(-3.79) BSOMPXC2: -18.912(-6.19)

Adj. R^2=0.9929 DW=1.615

BSOMMEC=LAG(BSOMHEC)+BSOMSPC-BSOMDDC-BSOMDZC-BSOMHEC

Soybean Oil Supply, Demand, and Market Clearing Condition

BSOOSPC=BSOOQ*BSOYDCC

BSOODDC=BSOODDC0+BSOODDC1*BSOOPXC*XBZUSA/BWPI85+BSOODDC2*LAG(BSOODDC)
+BSOODDC3*BGDP85+BSOODDC4*LTIME+BSOODDC6*D73

BSOODDC1: -0.543(-1.55) BSOODDC0: 733494(2.23) BSOODDC2: 0.32581(2.64)
BSOODDC3: 2.1968(5.53) BSOODDC4: -96780(-2.23) BSOODDC5: 889.95(4.87)

Adj. R^2=0.9632 Dh=1.923*

BSOOPXC=BSOOPXC0+BSOOPXC1*ESOOPXA+BSOOPXC2*D8081

BSOOPXC1: 1.121(62.8) BSOOPXC0: -102.69(-12.5) BSOOPXC2: 45.861(4.32)

Adj. R^2=0.9916 DW=1.588

BSOOMXC=LAG(BSOOHEC)+BSOOSPC-BSOODDC-BSOODZC-BSOOHEC

Argentina

Soybean Supply, Demand, and Market Clearing Condition

LN(GSOYSHC)=GSOYSHC0+GSOYSHC1*LN(LAG(GSOYPXC*XARUSA/GWPI85
+GSOYSHC2*LN(LAG(GSOYSHC))+GSOYSHC3*LTIME+GSOYSHC4*D8889

GSOYSHC1: 0.26194(6.02) GSOYSHC0: -446.33(-5.72) GSOYSHC2: 0.6573(11.8)
GSOYSHC3: 58.827(5.71) GSOYSHC4: 496.88(4.96)

Adj. R^2=0.9955 Dh=-0.719

GSOYSPC=GSOYSYC*GSOYSHC

GSOYDCC=GSOYDCC0+GSOYDCC1*(GSOMQ*GSOMPXC+GSOOQ*GSOOPXC)*XARUSA/GWPI85
+GSOYDCC2*GSOYPXC*XARUSA/GWPI85+GSOYDCC3*(LAG(GSOYHEC)+GSOYSPC)
+GSOYDCC4*LAG(GSOYDCC)+GSOYDCC5*D72+GSOYDCC6*D73

GSOYDCC1: 0.14571(5.08) GSOYDCC0: -1703.9(-3.58) GSOYDCC2: -0.0462(c)
GSOYDCC3: 0.30348(5.81) GSOYDCC4: 0.72147(11.3) GSOYDCC5: 2104.1(6.24)
GSOYDCC6: 1147.5(3.05) Note: c=constrained

Adj. R^2=0.9938 Dh=1.383

GSOYPXC=GSOYPXC0+GSOYPXC1*ESOYPIA+GSOYPXC2*D72+GSOYPXC3*D75

GSOYPXC1: 0.80232(36.4) GSOYPXC0: 24.582(5.14) GSOYPXC2: 541.94(57.3)
GSOYPXC3: 87.081(9.38)

Adj. R^2=0.9941 DW=2.425

GSOYMXC=LAG(GSOYHEC)+GSOYSPC-GSOYDCC-GSOYDZC-GSOYHEC

Soybean Meal Supply, Demand, and Market Clearing Condition

GSOMSPC=GSOMQ*GSOYDCC

GSOMDDC=GSOMDDC0+GSOMDDC1*GSOMPXC*XARUSA/GWPI85+GSOMDDC2*GGDP85
+GSOMDDC3*TIME+GSOMDDC4*D84+GSOMDDC5*D86

GSOMDDC1: -6678(-2.24) GSOMDDC0: 12700(4.08) GSOMDDC2: 0.14409(8.41)
GSOMDDC3: -6.7035(-4.16) GSOMDDC4: 193.89(5.68) GSOMDDC5: 172.78(5.32)

Adj. R^2=0.9355 DW=1.297

GSOMPXC=GSOMPXC0+GSOMPXC1*ESOMPIA+GSOMPXC2*D72+GSOMPXC3*D73

GSOMPXC1: 0.81431(31.9) GSOMPXC0: 16.954(3.78) GSOMPXC2: -129.88(-14)
GSOMPXC3: -42.788(-4.97)

Adj. R^2=0.9724 DW=2.704

GSOMMXC=LAG(GSOMHEC)+GSOMSPC-GSOMDDC-GSOMDZC-GSOMHEC

Soybean Oil Supply, Demand, and Market Clearing Condition

GSOOSPC=GSOOQ*GSOYDCC

GSOODDC=GSOODDC0+GSOODDC1*GSOOPXC*XARUSA/GWPI85+GSOODDC2*LAG(GSOODDC)
+GSOODDC3*LTIME+GSOODDC4*D7480

GSOODDC1: -587.11(-1.55) GSOODDC0: -23970(-2.42) GSOODDC2: 0.50875(4.12)
GSOODDC3: 3163.1(2.42) GSOODDC4: 57.132(5.94)

Adj. R^2=0.9036 Dh=1.142*

GSOOPXC=GSOOPXC0+GSOOPXC1*ESOOPXA+GSOOPXC2*D7173

GSOOPXC1: 0.9278(33) GSOOPXC0: 6.5469(0.503) GSOOPXC2: 273.37(17.1)

Adj. R^2=0.9706 DW=2.316

GSOOMXC=LAG(GSOOHEC)+GSOOSPC-GSOODDC-GSOODZC-GSOOHEC

World Market Clearing Conditions

USOYMEC=(RSOYMIN-BSOYMXC-GSOYMXC+ESOYMIC+JSOYMIC)/27.21555

USOMMEC=(RSOMMIN-BSOMMEC-GSOMMXC+ESOMMIC+JSOMMIC)/0.907185

USOOMTC=(RSOOMIN-BSOOMXC-GSOOMXC-ESOOMXC+JSOOMIC)/0.4535925

Appendix Table 2: SOYMOD Variable Definitions

ENDOGENOUS VARIABLES

U.S. Regional Soybean Variables

Region	Acres Planted (1,000 acres)	Acres Harvested (1,000 acres)	Yield[1] (bu/acre)	Production (1,000 bu)	Loan Rate ($/bu)	Market Price[2] ($/bu)	Expected Price[3] ($/bu)
Atlantic	ASOYSAC	ASOYSHC	ASOYSYC	ASOYSPC	ASOYPLC	ASOYPFC	ASOYPCC
Cornbelt	CSOYSAC	CSOYSHC	CSOYSYC	CSOYSPC	CSOYPLC	CSOYPFC	CSOYPCC
Delta	DSOYSAC	DSOYSHC	DSOYSYC	DSOYSPC	DSOYPLC	DSOYPFC	DSOYPCC
Lakes	LSOYSAC	LSOYSHC	LSOYSYC	LSOYSPC	LSOYPLC	LSOYPFC	LSOYPCC
Other	OSOYSAC	OSOYSHC	OSOYSYC	OSOYSPC	OSOYPLC	OSOYPFC	OSOYPCC
Plains	PSOYSAC	PSOYSHC	PSOYSYC	PSOYSPC	PSOYPLC	PSOYPFC	PSOYPCC
South	SSOYSAC	SSOYSHC	SSOYSYC	SSOYSPC	SSOYPLC	SSOYPFC	SSOYPCC

[1] Weighted average regional yields with weights equal to the share of regional production accounted for by each state in the region.
[2] Average farm price over all states in the respective regions weighted by production in each state in the region.
[3] Expected price at the farm calcualted as given in the model.

U.S. National Soybean and Product Market Variables

UCOMDPC	U.S. cottonseed meal share of high protein meal use (soymeal equivalents), marketing year
UCOODPC	U.S. cottonseed oil share of oleic/linoleic oil use, marketing year
UHPMDDC	U.S. high protein meal use, 1,000 tons, marketing year (calculated as in model)
UHPMPWC	U.S. high proteinmeal price, $/ton, marketing year, wtd ave. (calculated as in model)
UOLODDC	U.S. oleic/linoleic oil use, mil lb., marketing year (calculated as in model)
UOLOPWC	U.S. oleic/linoleic oil price, ¢/lb, marketing year, wtd ave. (calculated as in model)
USOMDDC	U.S. soymeal use, 1,000 tons, marketing year
USOMDPC	U.S. cottonseed meal share of high protein meal use, marketing year
USOMHEC	U.S. soymeal ending stocks, 1,000 tons, September 30
USOMMEC	U.S. soymeal exports, 1,000 tons, marketing year
USOMPWC	U.S. wholesale price of soymeal, $/ton, marketing year
USOMSPC	U.S. soymeal production, 1,000 tons, marketing year
USOODDC	U.S. soyoil use, mil lb., marketing year
USOODPC	U.S. soyoil share of oleic/linoleic oil use, marketing year
USOOHEC	U.S. soyoil ending stocks, mil lb., September 30
USOOHTC	U.S. soyoil total ending stocks, mil lb., September 30
USOOMEC	U.S. soyoil commercial exports, mil lb., marketing year
USOOMTC	U.S. soyoil total exports, mil lb., marketing year
USOOPWC	U.S. wholesale price of soyoil, ¢/lb, marketing year
USOOSPC	U.S. soyoil production, mil lb., marketing year
USOYDCC	U.S. soybean crush, million bu., crop year
USOYGCC	U.S. soybean crush margin, $/bu, crop year (calculated as in model)
USOYHEC	U.S. soybean private ending stocks, million bu., August 31
USOYHTC	U.S. soybean total ending stocks, million bu., August 31
USOYMEC	U.S. soybean exports, mil bu., crop year
USOYPFC	U.S. farm price of soybeans, $/bu, crop year
USOYPWC	U.S. wholesale price of soybeans, $/bu, crop year
USOYSAC	Total U.S. soybean acreage planted, million acres, crop year
USOYSHC	Total U.S. soybean acreage harvested, million acres, crop year
USOYSPC	Total U.S. soybean production acreage harvested, million bu., crop year

U.S. Regional Corn Variables

Region	Acres Planted (1,000 acres)	Acres Harvested (1,000 acres)	Production (1,000 bu)	Market Price[1] ($/bu)	Expected Price[2] ($/bu)
Atlantic	ACORSAC	ACORSHC	ACORSPC	ACORPFC	ACORPPC
Cornbelt	CCORSAC	CCORSHC	CCORSPC	CCORPFC	CCORPPC
Delta	DCORSAC	DCORSHC	DCORSPC	DCORPFC	DCORPPC
Lakes	LCORSAC	LCORSHC	LCORSPC	LCORPFC	LCORPPC
Other	OCORSAC	OCORSHC	OCORSPC	OCORPFC	OCORPPC
Plains	PCORSAC	PCORSHC	PCORSPC	PCORPFC	PCORPPC
South	SCORSAC	SCORSHC	SCORSPC	SCORPFC	SCORPPC
Residual	TCORSAC	TCORSHC	TCORSPC	TCORSPC	TCORPPC

[1] Average farm price over all states in the respective regions weighted by production in each state in the region.
[2] Expected price at the farm calcualted as given in the model.

U.S. National Corn Market Variables

UCORDFC	U.S. feed demand for corn, million bu., marketing year
UCORDOC	U.S. food demand for corn, million bu.,marketing year
UCORHOC	U.S. corn private ending stocks, million bu., September 30
UCORHTC	U.S. corn total ending stocks, million bu., September 30
UCORMEC	U.S. corn exports, million bu.,marketing year
UCORPFC	U.S. farm price of corn, $/bu, marketing year
UCORPPC	U.S. expected price of corn at the farm level, $/bu, marketing year (calculated as in model)
UCORPWC	U.S. wholesale price of corn, $/bu, marketing year
UCORSAC	Total U.S. corn acreage planted, million acres, crop year
UCORSHC	Total U.S. corn acreage planted, million acres, crop year
UCORSPC	Total U.S. corn production,million bu, crop year

European Union (15) National Soybean and Product Market Variables

ECORPIA	EU import price of U.S. corn, cif Rotterdam, $/mt, annual
ESOMDDC	EU soymeal use, 1,000 mt, marketing year
ESOMMIC	EU net imports of soymeal (imports-exports), 1,000 mt, marketing year
ESOMPIA	EU import price of soymeal, cif Rotterdam, $/mt, annual
ESOMSPC	EU production of soymeal, 1,000 mt, marketing year
ESOODDC	EU soyoil use, 1,000 mt, marketing year
ESOOMXC	EU net exports of soyoil (exports-imports), 1,000 mt, marketing year
ESOOPXA	EU export price of soyoil, fob Rotterdam, $/mt, annual
ESOOSPC	EU production of soyoil, 1,000 mt, marketing year
ESOYDCC	EU soybean crush, 1,000 mt, marketing year
ESOYMIC	EU net imports of soybeans (imports-exports), 1,000 mt, marketing year
ESOYPIA	EU import price of soybeans, cif Rotterdam, $/mt, annual

Japan National Soybean and Product Market Variables

JSOMDDC	Japan soymeal use, 1,000 mt, marketing year
JSOMMIC	Japan net imports of soymeal (imports-exports), 1,000 mt, marketing year
JSOMPUA	Japan unit import price of soymeal, $/mt, annual
JSOMSPC	Japan production of soymeal, 1,000 mt, marketing year
JSOODDC	Japan soyoil use, 1,000 mt, marketing year
JSOOMIC	Japan net imports of soyoil (imports-exports), 1,000 mt, marketing year
JSOOPUA	Japan unit import price of soyoil, $/mt, annual
JSOOSPC	Japan production of soyoil, 1,000 mt, marketing year
JSOYDCC	Japan soybean crush, 1,000 mt, marketing year
JSOYMIC	Japan net imports of soybeans (imports-exports), 1,000 mt, marketing year
JSOYPUA	Japan unit import price of soybeans, $/mt, annual

Rest-of-the-World (ROW)[1] National Soybean and Product Market Variables

RSOMDDN	ROW soymeal use, 1,000 mt (calculated as in model)
RSOMMIN	ROW net imports of soymeal (imports-exports), 1,000 mt (residual calculated as in model)
RSOMSPN	ROW soymeal production, 1,000 mt (calculated as in model)
RSOODDN	ROW soyoil use, 1,000 mt (calculated as in model)
RSOOMIN	ROW net imports of soyoil (imports-exports), 1,000 mt (residual calculated as in model)
RSOOSPN	ROW soyoil production, 1,000 mt (calculated as in model)
RSOYMIN	ROW net imports of soybeans (imports-exports), 1,000 mt (residual calculated as in model)

[1] Defined as all countries except the EU-15, Japan, Argentina, Brazil, and the U.S.

Brazil National Soybean and Product Market Variables

BSOMDDC	Brazil soymeal use, 1,000 mt, marketing year
BSOMMEC	Brazil exports of soymeal, 1,000 mt, marketing year
BSOMPXC	Brazil export price of soymeal, $/mt, marketing year
BSOMSPC	Brazil soymeal production, 1,000 mt, marketing year
BSOODDC	Brazil soyoil use, 1,000 mt, marketing year
BSOOMXC	Brazil net exports of soyoil (exports-imports), 1,000 mt, marketing year
BSOOPXC	Brazil export price of soyoil, $/mt, marketing year
BSOOSPC	Brazil soyoil production, 1,000 mt, marketing year
BSOYDCC	Brazil soybean crush, 1,000 mt, marketing year
BSOYMXC	Brazil net exports of soybeans (exports-imports), 1,000 mt, marketing year
BSOYPXC	Brazil export price of soybeans, $/mt, marketing year
BSOYSHC	Brazil soybean acreage harvested, 1,000 ha, crop year
BSOYSPC	Brazil soybean production, 1,000 mt, marketing year

Argentina National Soybean and Product Market Variables

GSOMDDC	Argentina soymeal use, 1,000 mt, marketing year
GSOMMXC	Argentina net exports of soymeal (exports-imports), 1,000 mt, marketing year
GSOMPXC	Argentina export price of soymeal, $/mt, marketing year
GSOMSPC	Argentina soymeal production, 1,000 mt, marketing year
GSOODDC	Argentina soyoil use, 1,000 mt, marketing year
GSOOMXC	Argentina net exports of soyoil (exports-imports), 1,000 mt, marketing year
GSOOPXC	Argentina export price of soyoil, $/mt, marketing year
GSOOSPC	Argentina soyoil production, 1,000 mt, marketing year
GSOYDCC	Argentina soybean crush, 1,000 mt, marketing year
GSOYMXC	Argentina net exports of soybeans (exports-imports), 1,000 mt, marketing year
GSOYPXC	Argentina export price of soybeans, $/mt, marketing year
GSOYSHC	Argentina soybean acreage harvested, 1,000 ha, crop year
GSOYSPC	Argentina soybean production, 1,000 mt, marketing year

EXOGENOUS VARIABLES

General

Dn	Intercept shift dummy variable for year n such that n=1 and and all over years=0
Dnm	Intercept shift dummy variable for years n through m such that years n through m =1 and and all over years=0
LTIME	Time trend, natural log (years=78 ... 95)
TIME	Time trend (years=78...95)

United States

ACORSYC	Atlantic region wtd average corn yield, bu/acre, crop year
CHKRES	U.S. stock of soybean checkoff research expenditures, $1,000, annual
CCORSYC	Cornbelt region wtd average corn yield, bu/acre, crop year

DCORF Dummy variable for corn feed demand, 1977=-1 and 1982=1, all other years = 0.

DCORSYC	Delta region wtd average corn yield, bu/acre, crop year
DPIK	Dummy variable for the 1982 U.S. payment-in-kind (PIK) program, 1982 =1, all other years =0
DSOOH2	Dummy variable for speculative increase in oil stocks, 1987=1, 1992=1, all other years= 0
DWA	Atlantic region weather dummy, 1982=1, all other years=0
DWC	Cornbelt region weather dummy, 1988=1, 1989=1, 1990=1, all other years=0
DWD1	Delta region weather dummy, 1993=1, all other years=0
DWD2	Delta region weather dummy, 1983=1, 1984=1, 1985=1, 1986=1, all other years=0
DWO	Other region weather dummy, 1976=-1, 1981=1, all other years=0
DWP	Plains region weather dummy, 1976=1, 1984=-1, 1985=1, 1989=1, all other years=0
DWS	South region weather dummy, 1985=1, 1991=1, all other years=0
EMBARGO	Dummy variable for the 1972 U.S. embargo of U.S. soybean and product exports
LBARPPC	Lakes region expected farm price for barley (calculated using same formula as for regional corn expected farm prices (see model for formula)
LCORSYC	Lakes region wtd average corn yield, bu/acre, crop year
NORFLEX	Percent of acres required in the normal flex program under the 1990 farm bill, %
OCORSYC	Other region wtd average corn yield, bu/acre, crop year
OWHEPPC	Other region expected farm price for wheat (calculated using same formula as for regional corn expected farm prices (see model for formula)
PCORSYC	Plains region wtd average corn yield, bu/acre, crop year
PUBRES	U.S. Stock of public soybean research expenditures, $1,000, annual
RCORMEC	Corn exports by non-U.S. corn exporting countries, mil bu., crop year
SCORSYC	South region wtd average corn yield, bu/acre, crop year
TCORSYC	Residual other region wtd average corn yield, bu/acre, crop year
UCOMPWC	U.S. wholesale price of cottonseed meal, $/ton, marketing year
UCOMSPC	U.S. production of cottonseed meal, 1,000 tons, marketing year
UCOODPC	U.S. cottonseed oil share of oleic/linoleic oils use, marketing year
UCOOPWC	U.S. wholesale price of cottonseed oil, ¢/lb, marketing year
UCOOSPC	U.S. production of cottonseed oil, mil lb, marketing year
UCORARP	Corn acreage reduction program requirement, %
UCORDZC	U.S. seed, feed, and other use of corn, mil bu, marketing year
UCORHCC	U.S. government stocks of corn (CCC+FOR), mil bu., crop year
UCORMMC	U.S. imports of corn, mil bu., crop year
UCORPDC	Corn acreage diversion payments, $/bu, crop year
UCORPLC	U.S. average corn loan rate, $/bu, crop year
UCORPTC	U.S. corn target price, $/bu, crop year
UCPI67	U.S. consumer price index, 1967=100, annual
UFIMPWA	U.S. price of fish meal, $/ton, annual
UFPI67	U.S. farm input price index (1967=100), September-August
UGCAUA	U.S. grain consuming animal units, million head, marketing year
UHOGPFC	U.S. farm price of hogs (barrow/guilt), $/cwt, marketing year
ULAOPWC	U.S. lauric oils price (wtd average of coconut and palm kernel oils), ¢/lb, marketing year
UOISCPC	U.S. soybean processing capacity, mil bu, marketing year
UPEMDPC	U.S. peanut meal share of high protein meal use, marketing year
UPEMSPC	U.S. production of peanut meal, 1,000 tons, marketing year
UPEMPWC	U.S. wholesale price of peanut meal, $/ton, marketing year
UPEODPC	U.S. peanut oil share of oleic/linoleic oils use, marketing year
UPEOPWC	U.S. wholesale price of peanut oil, ¢/lb, marketing year
UPEOSPC	U.S. production of peanut oil, mil lb, marketing year
UPOPA	U.S. population, millions, annual
USLSPFC	U.S. price of slaughter steers, $/cwt, marketing year
USOMDZC	U.S. other use (statistical discrepancy) of soymeal, 1,000 tons, marketing year
USOMMMC	U.S. imports of soymeal, 1,000 tons, marketing year

USOMQ U.S. soymeal extraction rate, 1,000 tons/mil bu
USOODZC U.S. other use (statistical discrepancy) of soyoil, 1,000 tons, marketing year
USOOHGC U.S. government stocks of soyoil, mil lb, marketing year
USOOMGC U.S. government PL480 exports of soyoil, mil lb, marketing year
USOOMMC U.S. imports of soyoil, mil lb, marketing year
USOOQ U.S. soyoil extraction rate, lbs/ bu
USOYDZC U.S. seed, feed, and other use of soybeans, mil bu, marketing year
USOYHGC U.S. government stocks of soybeans, mil bu, marketing year
USOYMMC U.S. imports of soybeans, mil bu, marketing year
USOYPLC U.S. average soybean loan rate, $/bu, crop year
UWHEPFC U.S. farm price of wheat, $/bu, crop year
UWPI67 U.S. wholesale price index, 1967=100, annual
UYDA U.S. personal disposable income, bil $US, annual

European Union (15)
EBXIL2R EU-15 stock of foreign market development expenditures for soybeans, million real deflated DM
ECWPI2 EU-15 wtd average wholesale price index, 1985=100, annual
EGCAUA EU-15 grain consuming animal units, million head, January 1
EMXIL2R EU-15 stock of foreign market development expenditures for soymeal, million real deflated DM
EOXIL2R EU-15 stock of foreign market development expenditures for soyoil, million real deflated DM
EPAOPIA EU-15 palm oil price, cif NW Europe, $/mt, annual
ESOMDZC EU-15 other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
ESOMHEC EU-15 ending stocks of soymeal, end of marketing year
ESOMQ EU-15 soymeal extraction rate, mt of soymeal/mt of soybeans
ESOODZC EU-15 other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year
ESOOHEC EU-15 ending stocks of soyoil, end of marketing year
ESOOQ EU-15 soyoil extraction rate, mt of soyoil/mt of soybeans
ESOYDZC EU-15 seed, feed, and other use of soybeans, 1,000 mt, marketing year
ESOYHEC EU-15 ending stocks of soybeans, end of marketing year
ESOYSPC EU-15 production of soybeans, marketing year
LESOMDD EU-15 exogenized lagged soymeal use, 1,000 mt, marketing year
LESOODD EU-15 exogenized lagged soyoil use, 1,000 mt, marketing year
LESOYDC EU-15 exogenized lagged soybean crush, 1,000 mt, marketing year
XECUSA Exchange rate, German DM/$US, annual

Japan
DJEMBGO Dummy variable for impact of U.S. soybean export embargo on Japanese soybean market, 1972=1, 1973=1, 1974=1, all other years =0
JBXIL2R Japan stock of foreign market development expenditures for soybeans, million real deflated Yen
JGCAUA Japan grain consuming animal units, million head, February 1
JMXIL2R Japan stock of foreign market development expenditures for soymeal, million real deflated Yen
JOXIL2R Japan stock of foreign market development expenditures for soyoil, million real deflated Yen
JSOMDZC Japan other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
JSOMHEC Japan ending stocks of soymeal, 1,000 mt, end of marketing year
JSOMQ Japan soymeal extraction rate, mt of soymeal/mt of soybeans
JSOODZC Japan other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year
JSOOHEC Japan ending stocks of soyoil, 1,000 mt, end of marketing year
JSOOQ Japan soyoil extraction rate, mt of soyoil/mt of soybeans
JSOYDZC Japan seed, feed, and other use of soybeans, 1,000 mt, marketing year
JSOYHEC Japan ending stocks of soybeans, 1,000 mt, end of marketing year
JWPI85 Japan wholesale price index, 1985=100, annual
LJSOMDD Japan exogenized lagged soymeal use, 1,000 mt, marketing year
LJSOODD Japan exogenized lagged soyoil use, 1,000 mt, marketing year

LJSOYDC	Japan exogenized lagged soybean crush, 1,000 mt, marketing year
XJAUSA	Exchange rate, Japanese Yen/$US, annual

Rest-of-the-World

LRSOYMI	ROW exogenized lagged soybean use, 1,000 mt, marketing year
OBXIL2R	ROW stock of foreign market development expenditures for soybeans, million real deflated DM
OMXIL2R	ROW stock of foreign market development expenditures for soymeal, million real deflated DM
OOXIL2R	ROW stock of foreign market development expenditures for soyoil, million real deflated DM
RGDP85	ROW real GDP index, real 1985 prices, annual

Brazil

BGDP85	Brazil real gross domestic product, 1985 prices, annual
BSOMDZC	Brazil other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
BSOMHEC	Brazil soymeal ending stocks, 1,000 mt, end of marketing year
BSOMQ	Brazil soymeal extraction rate, mt of soymeal/mt of soybeans
BSOODZC	Brazil other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year
BSOOHEC	Brazil soyoil ending stocks, 1,000 mt, end of marketing year
BSOOQ	Brazil soyoil extraction rate, mt of soyoil/mt of soybeans
BSOYDZC	Brazil seed, feed, and other use of soybeans, 1,000 mt, marketing year
BSOYHEC	Brazil soybean ending stocks, 1,000 mt, end of marketing year
BSOYSYC	Brazil soybean yield, mt/hectare, crop year
BWPI85	Brazil whole sale price index, 1985=1, annual
XBZUSA	Exchange rate, Trillion Brazilian Reais/$US, annual

Argentina

GGDP85	Argentina real gross domestic product, 1985 prices, annual
GSOMDZC	Argentina other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
GSOMHEC	Argentina soymeal ending stocks, 1,000 mt, end of marketing year
GSOMQ	Argentina soymeal extraction rate, mt of soymeal/mt of soybeans
GSOODZC	Argentina other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year
GSOOHEC	Argentina soymeal ending stocks, 1,000 mt, end of marketing year
GSOOQ	Argentina soyoil extraction rate, mt of soyoil/mt of soybeans
GSOYDZC	Argentina seed, feed, and other use of soybeans, 1,000 mt, marketing year
GSOYHEC	Argentina soybean ending stocks, 1,000 mt, end of marketing year
GSOYSYC	Argentina soybean yield, mt/hectare, marketing year
GWPI85	Argentina wholesale price index, 1985=1, annual
XARUSA	Exchange rate, million Argentina Austral/$US, annual

Appendix Table 3: SOYMOD Ex Post Simulation Validation Statistics, Theil Relative Change Forecast Error Statistics, 1978 to 1994

Relative Change MSE Decomposition Proportions Inequality Coefficients							
Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U1	Theil U
ASOYPCC	0.013	0.255	0.732	0.070	0.917	0.5970	0.2753
CSOYPCC	0.017	0.221	0.762	0.058	0.925	0.5540	0.2582
DSOYPCC	0.007	0.309	0.684	0.099	0.894	0.6382	0.2891
LSOYPCC	0.008	0.144	0.848	0.022	0.971	0.5064	0.2432
OSOYPCC	0.013	0.192	0.794	0.038	0.949	0.5624	0.2652
PSOYPCC	0.010	0.167	0.824	0.029	0.962	0.5335	0.2541
SSOYPCC	0.012	0.298	0.690	0.092	0.896	0.6342	0.2879
ASOYPLC	0.000	0.074	0.926	0.048	0.952	0.1080	0.0534
CSOYPLC	0.001	0.001	0.998	0.000	0.999	0.0570	0.0285
DSOYPLC	0.005	0.063	0.932	0.041	0.954	0.0957	0.0475
LSOYPLC	0.000	0.220	0.780	0.250	0.749	0.0749	0.0381
OSOYPLC	0.004	0.193	0.803	0.156	0.840	0.1039	0.0509
PSOYPLC	0.004	0.042	0.954	0.109	0.886	0.2448	0.1276
SSOYPLC	0.015	0.495	0.490	0.427	0.558	0.1899	0.0894
ASOYSHC	0.274	0.359	0.367	0.128	0.599	1.1364	0.4540
CSOYSHC	0.175	0.447	0.377	0.181	0.643	1.0691	0.4412
DSOYSHC	0.199	0.164	0.637	0.026	0.775	0.6791	0.3272
LSOYSHC	0.002	0.020	0.979	0.018	0.981	0.4733	0.2446
OSOYSHC	0.214	0.274	0.512	0.036	0.750	0.9899	0.4685
PSOYSHC	0.568	0.199	0.233	0.097	0.335	0.8614	0.4159
SSOYSHC	0.024	0.188	0.788	0.026	0.951	0.6292	0.3004
USOYSHC	0.163	0.329	0.508	0.127	0.710	0.7659	0.3394
ASOYSPC	0.262	0.128	0.610	0.039	0.699	0.4931	0.2377
CSOYSPC	0.177	0.028	0.795	0.001	0.822	0.3372	0.1706
DSOYSPC	0.168	0.012	0.820	0.000	0.832	0.2516	0.1247
LSOYSPC	0.009	0.024	0.967	0.058	0.934	0.1639	0.0837
OSOYSPC	0.189	0.132	0.679	0.016	0.795	0.5904	0.2946
PSOYSPC	0.563	0.047	0.390	0.022	0.415	0.3147	0.1602
SSOYSPC	0.012	0.007	0.981	0.011	0.977	0.3679	0.1870
USOYSPC	0.184	0.024	0.792	0.001	0.815	0.3011	0.1522
ASOYPFC	0.005	0.369	0.627	0.108	0.888	0.7919	0.3501
CSOYPFC	0.006	0.361	0.632	0.106	0.888	0.7785	0.3453
DSOYPFC	0.001	0.430	0.569	0.147	0.852	0.8462	0.3639
LSOYPFC	0.002	0.278	0.720	0.053	0.945	0.7348	0.3387
OSOYPFC	0.004	0.312	0.684	0.070	0.926	0.7647	0.3470
PSOYPFC	0.003	0.293	0.705	0.058	0.939	0.7547	0.3458
SSOYPFC	0.003	0.411	0.587	0.135	0.862	0.8277	0.3590
ASOYSAC	0.260	0.462	0.279	0.219	0.521	1.3046	0.4756
CSOYSAC	0.207	0.457	0.336	0.203	0.590	1.1204	0.4507
DSOYSAC	0.189	0.214	0.597	0.073	0.738	0.5822	0.2756
LSOYSAC	0.001	0.047	0.952	0.002	0.998	0.4634	0.2342
OSOYSAC	0.265	0.248	0.487	0.049	0.686	0.9197	0.4287
PSOYSAC	0.599	0.230	0.171	0.140	0.261	0.9245	0.4300

Appendix Table 3 (continued)

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U1	Theil U
SSOYSAC	0.020	0.246	0.734	0.066	0.915	0.5943	0.2778
USOYSAC	0.179	0.354	0.467	0.158	0.663	0.7651	0.3342
ACORPPC	0.058	0.538	0.404	0.259	0.683	0.9838	0.3884
CCORPPC	0.088	0.664	0.248	0.406	0.506	1.2641	0.4419
LCORPPC	0.096	0.660	0.244	0.411	0.492	1.2461	0.4360
OCORPPC	0.049	0.591	0.360	0.316	0.635	1.0221	0.3925
PCORPPC	0.084	0.642	0.275	0.374	0.542	1.2135	0.4342
SCORPPC	0.051	0.644	0.305	0.365	0.584	1.1476	0.4214
DCORPPC	0.058	0.673	0.269	0.440	0.502	1.0678	0.3904
TCORPPC	0.067	0.645	0.288	0.379	0.554	1.1574	0.4207
UCORPPC	0.084	0.661	0.255	0.404	0.512	1.2313	0.4345
ACORSAC	0.127	0.002	0.871	0.048	0.825	0.3713	0.1887
CCORSAC	0.041	0.024	0.935	0.000	0.959	0.2831	0.1409
DCORSAC	0.197	0.528	0.275	0.264	0.539	1.2873	0.4560
LCORSAC	0.224	0.154	0.622	0.065	0.711	0.4270	0.1998
OCORSAC	0.380	0.237	0.383	0.024	0.595	1.3334	0.5585
PCORSAC	0.057	0.059	0.884	0.119	0.825	0.2244	0.1171
SCORSAC	0.391	0.110	0.499	0.030	0.579	0.5970	0.2807
TCORSAC	0.174	0.120	0.706	0.000	0.826	0.8280	0.4025
UCORSAC	0.150	0.027	0.823	0.002	0.848	0.2869	0.1419
ACORSHC	0.075	0.070	0.855	0.201	0.724	0.4066	0.2193
CCORSHC	0.001	0.001	0.998	0.009	0.990	0.2456	0.1242
DCORSHC	0.223	0.540	0.237	0.274	0.504	1.4480	0.4880
LCORSHC	0.199	0.100	0.701	0.037	0.764	0.3419	0.1632
OCORSHC	0.285	0.178	0.537	0.004	0.711	1.0753	0.4867
PCORSHC	0.076	0.002	0.922	0.039	0.884	0.3149	0.1639
SCORSHC	0.368	0.092	0.540	0.025	0.607	0.5125	0.2437
TCORSHC	0.049	0.119	0.831	0.000	0.951	0.7326	0.3607
UCORSHC	0.064	0.005	0.931	0.002	0.933	0.2454	0.1230
ACORSPC	0.157	0.145	0.697	0.187	0.656	0.1436	0.0743
CCORSPC	0.000	0.000	1.000	0.001	0.998	0.0876	0.0439
DCORSPC	0.189	0.438	0.372	0.185	0.626	1.0183	0.3935
LCORSPC	0.181	0.032	0.787	0.014	0.804	0.1431	0.0703
OCORSPC	0.247	0.066	0.688	0.012	0.742	0.4108	0.1961
PCORSPC	0.121	0.103	0.776	0.149	0.730	0.1586	0.0824
SCORSPC	0.370	0.092	0.538	0.056	0.574	0.2422	0.1162
TCORSPC	0.050	0.082	0.868	0.000	0.950	0.5687	0.2776
UCORSPC	0.030	0.000	0.970	0.001	0.969	0.1019	0.0509
ACORPFC	0.008	0.593	0.399	0.254	0.739	1.1292	0.4405
CCORPFC	0.007	0.629	0.364	0.263	0.730	1.2575	0.4765
DCORPFC	0.003	0.697	0.300	0.414	0.583	1.1322	0.4153
LCORPFC	0.007	0.630	0.363	0.253	0.740	1.2909	0.4884
OCORPFC	0.003	0.597	0.400	0.241	0.756	1.1663	0.4545
PCORPFC	0.011	0.638	0.351	0.271	0.718	1.2923	0.4847
SCORPFC	0.014	0.691	0.295	0.356	0.630	1.3342	0.4778
TCORPFC	0.008	0.681	0.311	0.334	0.658	1.3241	0.4800
UCORHTC	0.054	0.030	0.916	0.003	0.943	0.2474	0.1219
UCORDFC	0.015	0.025	0.961	0.000	0.985	0.3012	0.1497

Appendix Table 3 (continued)

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U1	Theil U
UCORDOC	0.229	0.039	0.732	0.225	0.546	0.3566	0.2016
UCORMEC	0.013	0.048	0.939	0.002	0.986	0.5062	0.2541
USOYDCC	0.000	0.284	0.716	0.107	0.893	0.4917	0.2291
USOYMEC	0.249	0.144	0.607	0.039	0.712	0.5578	0.2669
USOYPWC	0.007	0.471	0.522	0.182	0.811	0.8790	0.3698
USOYPFC	0.004	0.397	0.599	0.131	0.865	0.7982	0.3484
USOYHEC	0.003	0.090	0.908	0.010	0.987	0.3961	0.1938
USOYHTC	0.003	0.090	0.908	0.010	0.987	0.3961	0.1938
USOYGCC	0.045	0.715	0.240	0.609	0.346	0.5335	0.2203
USOMSPC	0.000	0.234	0.766	0.087	0.913	0.4323	0.2041
UCOMDPC	0.062	0.015	0.922	0.001	0.937	0.3232	0.1623
USOMDPC	0.058	0.021	0.920	0.000	0.942	0.3130	0.1574
UHPMDDC	0.086	0.069	0.845	0.000	0.914	0.4831	0.2477
USOMDDC	0.087	0.090	0.823	0.001	0.912	0.5190	0.2658
UHPMPWC	0.136	0.232	0.632	0.053	0.811	0.7226	0.3282
USOMPWC	0.136	0.253	0.611	0.057	0.807	0.7738	0.3479
USOMHEC	0.000	0.000	1.000	0.019	0.981	0.2301	0.1169
USOMMEC	0.072	0.320	0.608	0.114	0.814	0.6778	0.2989
USOOSPC	0.000	0.265	0.735	0.097	0.902	0.4735	0.2219
UCOODPC	0.084	0.277	0.639	0.013	0.903	1.0101	0.4628
USOODPC	0.069	0.208	0.722	0.010	0.921	0.8380	0.4000
UOLODDC	0.012	0.189	0.798	0.009	0.979	0.5921	0.2947
USOODDC	0.038	0.199	0.763	0.017	0.945	0.5976	0.2977
UOLOPWC	0.001	0.171	0.828	0.047	0.953	0.4505	0.2147
USOOPWC	0.001	0.202	0.797	0.058	0.941	0.4935	0.2328
USOOHEC	0.006	0.341	0.652	0.133	0.861	0.6114	0.2744
USOOHTC	0.006	0.341	0.652	0.133	0.861	0.6114	0.2744
USOOMEC	0.004	0.484	0.512	0.143	0.853	1.0017	0.4205
USOOMTC	0.000	0.343	0.657	0.034	0.966	0.9541	0.4397
UCORHOC	0.070	0.072	0.858	0.020	0.909	0.2744	0.1332
UCORPWC	0.009	0.632	0.359	0.270	0.721	1.2584	0.4752
UCORPFC	0.006	0.635	0.359	0.275	0.719	1.2529	0.4726
ECORPIA	0.019	0.384	0.596	0.052	0.929	1.0291	0.4638
ESOYDCC	0.325	0.381	0.294	0.163	0.513	1.2401	0.4821
ESOYMIC	0.329	0.331	0.340	0.146	0.524	1.0005	0.4147
ESOMSPC	0.325	0.385	0.290	0.162	0.513	1.2684	0.4903
ESOMDDC	0.097	0.061	0.841	0.001	0.902	0.4595	0.2333
ESOMMIC	0.076	0.721	0.203	0.280	0.644	1.8571	0.5975
ESOOSPC	0.327	0.407	0.266	0.179	0.494	1.3483	0.5076
ESOODDC	0.049	0.282	0.668	0.136	0.815	0.4636	0.2145
ESOOMXC	0.249	0.525	0.226	0.231	0.520	1.6429	0.5785
ESOYPIA	0.016	0.446	0.538	0.131	0.853	0.9689	0.4111
ESOMPIA	0.108	0.325	0.567	0.054	0.838	0.9934	0.4385
ESOOPXA	0.000	0.364	0.636	0.130	0.870	0.6953	0.3091
JSOYDCC	0.230	0.052	0.718	0.002	0.769	0.4819	0.2436
JSOYMIC	0.224	0.033	0.743	0.003	0.773	0.3201	0.1611
JSOMSPC	0.229	0.059	0.712	0.004	0.767	0.4730	0.2376
JSOMDDC	0.215	0.260	0.525	0.048	0.736	0.8328	0.4039

Appendix Table 3 (continued)

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U1	Theil U
JSOMMIC	0.001	0.680	0.320	0.485	0.514	0.7250	0.2917
JSOOSPC	0.230	0.066	0.704	0.003	0.767	0.5158	0.2588
JSOODDC	0.003	0.082	0.915	0.002	0.995	0.6140	0.3127
JSOOMIC	NA	NA	NA	NA	NA	NA	NA
JSOYPUA	0.010	0.493	0.497	0.176	0.813	0.9773	0.4044
JSOMPUA	0.151	0.302	0.547	0.072	0.777	0.9002	0.3921
JSOOPUA	0.000	0.001	0.999	0.027	0.973	0.3553	0.1828
RSOYMIN	0.005	0.003	0.992	0.128	0.867	0.5359	0.2968
RSOMSPN	0.005	0.003	0.992	0.128	0.867	0.5359	0.2968
RSOMDDN	0.088	0.083	0.829	0.002	0.910	0.5218	0.2629
RSOMMIN	0.092	0.269	0.639	0.070	0.838	0.6819	0.3197
RSOOSPN	0.005	0.003	0.992	0.128	0.867	0.5359	0.2968
RSOODDN	0.161	0.013	0.825	0.016	0.822	0.5084	0.2705
RSOOMIN	0.168	0.135	0.697	0.007	0.825	0.6640	0.3352
BSOYDCC	0.000	0.155	0.844	0.001	0.999	0.7515	0.3787
BSOYMXC	0.061	0.548	0.390	0.322	0.616	0.8211	0.3320
BSOMSPC	0.000	0.173	0.827	0.000	1.000	0.7655	0.3838
BSOMDDC	0.013	0.015	0.972	0.014	0.973	0.3988	0.2059
BSOMMEC	0.001	0.314	0.685	0.009	0.990	0.9620	0.4589
BSOOSPC	0.000	0.117	0.883	0.006	0.994	0.7196	0.3683
BSOODDC	0.088	0.399	0.513	0.073	0.839	0.9700	0.4519
BSOOMXC	0.057	0.300	0.643	0.126	0.817	0.5402	0.2429
BSOYSHC	0.037	0.322	0.641	0.051	0.912	0.8415	0.3759
BSOYSPC	0.023	0.048	0.929	0.000	0.977	0.4189	0.2071
BSOYPXC	0.018	0.485	0.496	0.200	0.782	0.8937	0.3720
BSOMPXC	0.087	0.342	0.571	0.067	0.845	0.9603	0.4214
BSOOPXC	0.003	0.455	0.542	0.190	0.806	0.7897	0.3376
GSOYDCC	0.012	0.220	0.768	0.007	0.981	0.8001	0.4223
GSOYMEC	0.000	0.041	0.959	0.004	0.995	0.2681	0.1331
GSOMSPC	0.012	0.206	0.782	0.009	0.979	0.7875	0.4174
GSOMDDC	0.022	0.006	0.973	0.026	0.953	0.4289	0.2241
GSOMMEC	0.000	0.173	0.827	0.022	0.978	0.8306	0.4357
GSOOSPC	0.011	0.265	0.725	0.002	0.987	0.8180	0.4262
GSOODDC	0.063	0.043	0.894	0.017	0.920	0.1634	0.0814
GSOOMEC	0.000	0.412	0.587	0.062	0.938	0.9134	0.4140
GSOYSHC	0.212	0.037	0.751	0.195	0.593	0.5103	0.3027
GSOYSPC	0.227	0.028	0.745	0.107	0.666	0.3636	0.1999
GSOYPXA	0.021	0.396	0.583	0.160	0.819	0.7205	0.3139
GSOMPXA	0.098	0.120	0.782	0.000	0.902	0.7627	0.3741
GSOOPXA	0.004	0.321	0.675	0.099	0.897	0.6753	0.3047

NA= Percent error statistics for 1 variables were set to missing values because the actual value was too close to zero to compute the percent error.