# IS THE SOYBEAN CHECKOFF PROGRAM WORKING?

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Texas Agribusiness Market Research Center (TAMRC) Commodity Market Research Report No. CM-01-09, April 2009, by Dr. Gary W. Williams, Dr. Oral Capps, Jr., and Dr. David A. Bessler, April 2009.

**Abstract:** The primary objective of this study is to answer two key questions regarding the U.S. soybean checkoff program over time: (1) What have been the effects of the soybean checkoff program on U.S. and world soybean and soybean product markets? (2) Has the soybean checkoff program benefited soybean producers? To answer the first key question, the effects of the soybean checkoff program on U.S. and foreign soybean, soybean meal, and soybean oil supplies, demands, prices, and trade over the 1980/81 through 2006/07 time period are measured. Those results are then used to answer the second question in a benefit-cost analysis of the soybean checkoff program to measure the overall return to producers from soybean checkoff and related expenditures over the years. In general, the study concludes that the expenditure of soybean checkoff funds to invest in production research and to promote the demand for soybeans and soybean products at home and abroad has been highly effective in enhancing the profitability, competiveness, and size of the U.S. soybean industry since at least 1980/81.

**Acknowledgements**: This study was conducted under contract with the United Soybean Board with the understanding that this work would be completely objective with no effort on the part of the researchers to bias the results either in favor of or against the United Soybean Board or the soybean checkoff program. Thanks are due to many individuals who provided assistance in the preparation of this report. Our thanks to Robin Hanselman for her excellent and detailed work in developing the expenditure database used in this study with some assistance provided by Rajorshi Sen Gupta and Kathryn Wright. Thanks are due also to John Becherer and the staff of the United Soybean Board for facilitating the data collection and other aspects of this study. We are grateful for the assistance of USB management contractors for sharing their expenditure data with us, including Miguel Escobar and the staff of the United Soybean Export Council (USSEC) (particularly Matt Rickard and Cheryl Huson), Don Gutgsell, Alan McIlroy, and others of Smith Bucklin Corporation, and Mike Orso, Theresa Lee, and others of Osborn & Barr Communications. A special thanks goes to Keith Smith of Keith Smith and Associates for providing the national and state production research expenditure data. We also owe a debt of gratitude to the leadership and staff of the many Qualified State Soybean Boards who responded to our requests for their expenditure data. Nevertheless, the results and conclusions of this study were not influenced or impacted in any way by anyone connected with the soybean checkoff program. The views and opinions expressed in this study are those of the authors and do not necessarily reflect those of the United Soybean Board, any of its subcontractors, QSSBs, or other groups associated with the checkoff, the Texas A&M University System, or the U.S. Department of Agriculture. All errors and omissions in this study are those of the authors alone.

*The **Texas Agribusiness Market Research Center (TAMRC**) has been providing timely unique and professional research on a wide range of issues relating to agricultural and agribusiness markets and products of importance to Texas and the nation for nearly forty years. **TAMRC** is a market research service of Texas AgriLife Research and Texas Extension Service of the Texas A&M University System. The mission of **TAMRC** is to provide high quality, objective, and timely market research to support strategic agribusiness decision-making at all levels along the supply chain from producers to processors, wholesalers, retailers, and consumers. Major **TAMRC** research divisions include International Market Research, Consumer and Product Market Research, Commodity Market Research, and Contemporary Market Issues Research.*

## IS THE SOYBEAN CHECKOFF PROGRAM WORKING?

### 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 is to answer two key questions regarding the U.S. soybean checkoff program over time: (1) What have been the effects of the soybean checkoff program on U.S. and world soybean and soybean product markets? and (2) Has the soybean checkoff program benefited soybean producers? In answering the first key question, the focus is on the effects of the soybean checkoff program on U.S. and foreign soybean, soybean meal, and soybean oil supplies, demands, prices, and trade over the 1980/81 through 2006/07 time period. The answer to the first question provides the basis for answering the second question in a farm-level benefit-cost analysis. For comparison purposes, the analysis decomposes the results into two time periods corresponding to the periods before and after implementation of the national soybean checkoff program. In general, the study concludes that the soybean checkoff program has been highly effective in enhancing the profitability, competiveness, and size of the U.S. soybean industry since at least 1980/81.

The study first provides a detailed look at how soybean checkoff funds have been spent over the years and why expenditure patterns are important for the effectiveness of the program. Then an analysis of how commodity checkoff programs affect markets is provided along with a review of pertinent literature and a comparison of the results of previous studies of the soybean and other commodity checkoff programs. The methodology used to measure the effectiveness of the soybean checkoff program is then outlined and 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.

Since 1970/71, soybean farmers have invested at least $724.1 million of checkoff funds in supply-oriented and demand-oriented activities to benefit U.S. soybean producers. When combined with the $213.8 million from the USDA cooperator and other programs and the $117.2 million in contributions from the private sector for joint promotional activities in foreign countries, the amount spent on soybean production research and promotion programs between 1970/71 and 2006/07 amounts to about $1.06 billion. The implementation of the national program in the early 1990s bumped annual expenditures from an average of about $20 million to currently well over $70 million. The national checkoff program also signaled major shifts in the checkoff fund expenditure strategy that have had important effects on the returns to producers from those expenditures. A review of expenditure trends over time reveals nine key characteristics of expenditure patterns that have impacted the returns to the soybean checkoff program:

1. Expenditures have tended to switch from international promotion activities to production research activities over time.

2. During most of the 1990s, expenditure allocations tended to favor domestic promotion as international marketing promotion expenditures declined.
3. The share of checkoff expenditures allocated to domestic promotion after 1999/00 was cut in half from 40% of total expenditures to only 20%.
4. In international promotion programs, the focus over time has switched from maintaining and building a few large, mature markets to opening and developing many new, smaller markets.
5. In international promotion programs, the commodity emphasis of expenditures since the early 1990s has shifted from value-added soybean products to soybeans.
6. The leveraging of international promotion program checkoff dollars with third party, in-country contributions declined in the 1990s and ceased completely in 1998/99.
7. Total checkoff expenditures are quite small compared to the value of soybean production.
8. Producer communications expenditures have no effect on the supply of or demand for soybeans and soybean products in U.S. or world markets.
9. Inflation in all countries and depreciations in the value of the U.S. dollar in foreign markets have seriously eroded the purchasing power of soybean checkoff expenditures.

The basic tool of analysis in this study is a 180-equation, fifth generation, annual econometric simulation model of world soybean and product markets, referred to as SOYMOD5, 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: (1) the United States, (2) Brazil, (3) Argentina, (4) the European Union 15/27, (5) Japan, and (6) a Rest-of-the-World region. Data for all types of soybean checkoff expenditures across all commodities, activities, and countries over a long period of time were needed for the analysis. Collection of these data was difficult, at best, since no harmonized expenditure data collection and reporting system has been established. The most problematic data to collect were state-level expenditures on domestic and international promotion. All expenditure data used in the study were converted to a constant dollar basis to remove the effects of inflation. Expenditures in foreign markets were also converted to the local currencies for the countries and regions of expenditure defined in the study. The data were then transformed into research and promotion stock variables to account for the time lag between expenditure and market impact for each commodity (soybeans, soymeal, and soyoil) in domestic and international markets. Model specification tests were conducted to determine appropriate lag structures for calculating the stock variables. The research stock variables enter the model (SOYMOD5) as arguments of the regional soybean acreage and yield functions. The domestic and international soybean, soybean meal, and soybean oil demand promotion expenditure stock variables enter SOYMOD5 as arguments of the respective demand functions in the U.S. or of the importing regions in which the expenditures were made. The parameters of SOYMOD5 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 expenditures over time.

To answer the two key questions that are the focus of this analysis, two scenarios were analyzed using SOYMOD5: (1) a *with* soybean checkoff expenditures scenario (the "*with* scenario") and (2) a *without* soybean checkoff expenditures scenario (the "*without* scenario"). The *with* scenario represents actual history over the 1980/81 to 2006/07 period of analysis, that is, the level of supply, demand, prices, trade, etc. in world soybean and soybean product markets that <u>include</u>

any effects on those markets from soybean checkoff expenditures in the U.S. and around the world. The *without* scenario analysis was conducted by setting the historic values of soybean checkoff production research and U.S. and international market promotion expenditures to zero in SOYMOD5 and then simulating the model once again over the same period to generate new values for U.S. and world soybean and product production, consumption, trade, prices, etc. Because the changes in the model variables in the *without* scenario were generated by changing only the levels of checkoff expenditures, they represent the levels of supply, demand, prices, trade, etc. that would have existed over time *in the absence of a soybean checkoff program*.

Because the differences in the simulated levels of the model variables in the *with* and *without* scenarios represent direct measures of the effects of the checkoff expenditures on U.S. and world markets, they also provide the basis for answering the first key question regarding the effects of the soybean checkoff program on world markets. A comparison of the results of the scenarios indicates clearly that the soybean checkoff program has been effective at increasing U.S. soybean production, crush, exports, price, world market share, and producer profits. The results indicate that, on average between 1980/81 and 2006/07, U.S. soybean production was higher by 4.2%, soybean farm price by 1.6%, and soymeal wholesale price by 2.1% on average in each year as a result of the checkoff program.

With the implementation of the national checkoff program in the early 1990s, the annual average impact on soybean production jumped from about 64 million bushels to about 170 million bushels by 2006/07. The sharp jump in annual production made increasing additional supplies of soybeans available for crushing and export but put downward pressure on the market prices of soybean and soybean products over that period. The U.S. soybean checkoff program successfully boosted U.S. soybean, soymeal, and soyoil exports and the U.S. export market share of all three products while reducing the export shares of both Brazil and Argentina. On average over the 1980/81-2006/07 period, U.S. soybean exports were higher each year by an average of 993,600 metric tons (mt) or nearly 5%. U.S. soymeal and soyoil exports were higher by an annual average of 15% and 24%, respectively.

The second key question, the more critical question, that must be answered about the U.S. checkoff program is whether the market effects generated by the program have increased producer profits by a sufficient amount to cover the cost of the program. Using the *with* and *without* soybean checkoff expenditure scenario results, the net profit benefit cost ratio (BCR) for the U.S. soybean program over the 1980/81 to 2006/07 period is calculated to be $6.4, indicating that the benefits in terms of the net additional soybean industry profits generated by the U.S. soybean checkoff program far exceeded the cost of the program expenditures over that period. This BCR compares quite favorably to those found by earlier studies of the soybean checkoff program and by studies of other checkoff commodity programs. Even when the net grower benefits are discounted to present value (the DBCR), the ratio of benefits (net grower profits) to costs is still respectable at $2.4.

The main conclusion of this study is that the U.S. soybean checkoff program has been highly effective over the years in enhancing the profitability, competitiveness, and size of the U.S. soybean industry. Among the major findings of this study are the following:

- *The Benefit -Cost Ratio (BCR) of the soybean checkoff program has been relatively high at $6.4 in additional profit earned by U.S. soybean farmers for every checkoff dollar spent.*
- *The soybean checkoff program has increased the size of the U.S. soybean industry.*
    1. U.S. soybean production and crush each averaged 4.2% higher each year;
    2. The soybean farm price averaged almost 2% higher;
    3. The soymeal price averaged more than 2% higher with little change in soyoil price; and
    4. U.S. soybean meal and oil use were both 2% higher.
- *The soybean checkoff program has reduced the competitive threat of the South American soybean industry.* U.S. soybean, soymeal, and soyoil exports averaged 5%, 15%, and 24%, respectively, more each year as a result of the program, substantially increasing their shares of world export markets, particularly for soybean meal and soybean oil.
- *The Benefit-Cost Ratio for the soybean checkoff program in the period following implementation of the national checkoff program was $2.8, substantially lower than the $14.1 BCR during the voluntary checkoff program years.*

These conclusions suggest a number of implications for program management purposes:

1. The U.S. soybean industry continues to underinvest in the soybean checkoff program despite the sharp increase in funding with the national checkoff program.
2. The current mix of checkoff expenditures appears to be reducing potential return. Several adjustments in the current funding allocation strategy are needed to increase in producer returns, including (1) more demand pull from domestic and international demand promotion relative to supply push from production research; (2) more international promotion relative to domestic demand promotion; (3) more promotion of value-added products relative to promotion of soybeans; and (4) a re-examination of the near abandonment of large, mature, developed country markets like the European Union and Japan in favor of smaller, less developed country markets for international promotion activities.
3. Care must be taken in determining the proper share of funds to allocate to production research. One the one hand, production research shifts out the supply curve and, therefore, tends to reduce prices suggesting that a low level of funding for production research may be most appropriate. On the other hand, failing to invest aggressively in research to develop new, high-yielding and cost efficient soybean production technologies and techniques could allow the comparative advantage in the production and export of soybeans and soybean products to shift slowly over the long run to Brazil and Argentina.
4. A failure to at least maintain the growth in soybean checkoff expenditures in any area in any time period has serious negative impacts on soybean producer profitability over many years.
5. A return to the practice of leveraging international market promotion funds with contributions from third party in-country contributors could substantially enhance the level of funds and effectiveness of the international promotion program.
6. The way in which funds for international and domestic demand promotion 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 foreign markets.
7. 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 continuing program evaluation and management purposes.

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## INSET BOXES

# IS THE SOYBEAN CHECKOFF PROGRAM WORKING?*

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 1991/92, producer contributions to this effort were facilitated in many soybean-producing states by state legislation requiring producers to pay (or "check off") from ½ to 2 cents per bushel sold. Such contributions 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 soybean producer organization, the American Soybean Association (ASA) 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. Half of the checkoff funds collected under the new mandatory national soybean checkoff program continues to remain in the states with the other half accruing to a new national producer-controlled checkoff board (the United Soybean Board (USB) in St. Louis, Missouri). To manage the half of the checkoff funds allocated to the states, the legislation required the establishment of new state-level, producer-controlled checkoff boards (Qualified State Soybean Boards or QSSBs).

The QSSBs invest the largest portion of their checkoff dollars in soybean production research with a normally small amount allocated to funding utilization research and domestic and foreign promotion programs. The USB also allocates a major portion of its funds to support soybean production research as well as domestic promotion programs. As was the case with the ASA before the establishment of the national checkoff program, the USB also manages a large international foreign market development program designed to promote U.S. exports of soybeans and soybean products[3].

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1 Food, Agric., Conservation & Trade Act of 1990, PL 101-624, 104 Stat. 3838-3928, Nov. 28, 1990, Title XIX.
2 7 U.S.C. 6301-6311; 56 F.R. 31048-31068, CFR. pt. 1220.

3 The American Soybean Association (ASA) initially served as the primary contractor to the United Soybean Board for managing the international market promotion program. Since 2005, the international market promotion program has been managed by the United States Soybean Export Council (USSEC).

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 and given that the last evaluation was conducted in 2003, USB commissioned this study to update the research on the effectiveness of the soybean checkoff and related investments in production research and promotion over the last two decades.

The primary objective of this study is to answer two key questions regarding the U.S. soybean checkoff program over time: (1) What have been the effects of the soybean checkoff program on U.S. and world soybean and soybean product markets? (2) Has the soybean checkoff program benefited soybean producers? In answering the first key question, the focus is on the effects of the soybean checkoff program on U.S. and foreign soybean, soybean meal, and soybean oil supplies, demands, prices, and trade. Once these market effects have been determined, they are then used to answer the second question in a benefit-cost analysis of the soybean checkoff program at the producer level. In the analysis, the producer benefit-cost ratio (BCR) of the soybean checkoff program is calculated as the additional net producer revenues generated by the checkoff program divided by the cost of the checkoff program. The analysis covers the period of 1980/81 through 2006/07 and then decomposes the results for comparison purposes into two time periods corresponding to the periods before and after implementation of the mandatory national soybean checkoff program.

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

The study first provides a detailed look at how soybean checkoff funds have been spent over the years and why expenditure patterns are important for the effectiveness of the program. Then an analysis of how commodity checkoff programs affect markets is provided along with a review of pertinent literature and a comparison of the results of previous studies of the soybean and other commodity checkoff programs. The methodology used in this study to measure the effectiveness of the soybean checkoff program is then outlined and 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 THE SOYBEAN CHECKOFF PROGRAM

Expenditures of U.S. soybean checkoff funds over the years to enhance the profitability of the U.S. soybean industry can be classified as either supply- or demand-oriented. Supply-oriented expenditures have concentrated on research to improve agricultural productivity and reduce production costs. Demand-oriented expenditures, on the other hand, have attempted to shift the demand schedules for soybeans and soybean products (soybean meal[5] and soybean oil) through market development and promotional activities, thereby attempting to enhance price and stimulate output and producer revenues. Although soybean producers have been investing in both supply- and demand-oriented activities since the mid-1950s, useable data and documentation of those investments are available only since

[5] Soybean checkoff funds have also been used to promote "soy-food" products. However, inasmuch as these products are manufactured from the meal portion of the soybean, they are treated as "soymeal" products in this study.

the 1970s with a few exceptions. This section begins with 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 Expenditures[6]

Since 1970/71, soybean farmers have invested at least $724.1 million of checkoff funds in supply-oriented and demand-oriented activities to benefit U.S. soybean producers (TAMRCa, TAMRCb, and TAMRCc)[7]. They have also invested in producer communications as a means of informing insuring that those who pay for the program are kept abreast of the activities and effectiveness of the checkoff program.

Over the same period, an additional $213.8 million in funds have been made available for foreign soybean and soybean product demand promotion activities through the cooperator and other programs of the Foreign Agriculture Service (FAS) of the U.S. Department of Agriculture. Also, until about 1998, the soybean checkoff and FAS funds invested in foreign demand promotion activities were leveraged in foreign markets to generate a total additional $117.2 million in contributions from the private sector for joint promotional activities referred to as third party contributions[8]. In total, the amount spent on supply-oriented and demand-oriented activities by the national soybean organization and its contractors between 1970/71 and 2005/06 has been about $1.06 billion[9].

In the years before the national mandatory program (pre-1992), annual soybean checkoff expenditure reached a high of a little more than $20 million (see Figure 1). With the implementation of the mandatory program in about 1992, annual soybean checkoff expenditures grew rapidly, more than tripling to almost $63.2 million by 1997/98 and subsequently growing to currently well over $70 million.

Not only did the establishment of the national soybean checkoff program dramatically increase the level of funds available for investment in supply-oriented and demand-oriented programs to increase industry profitability, it also signaled a major and program-defining shift in expenditure strategy away from foreign market promotion and toward domestic market promotion and research. In the 1970s and 1980s, international market promotion consistently accounted for 80-87% of the total soybean checkoff investment with production research expenditures accounting for most of the remainder (Figure 1). With the implementation of the national soybean checkoff pro-

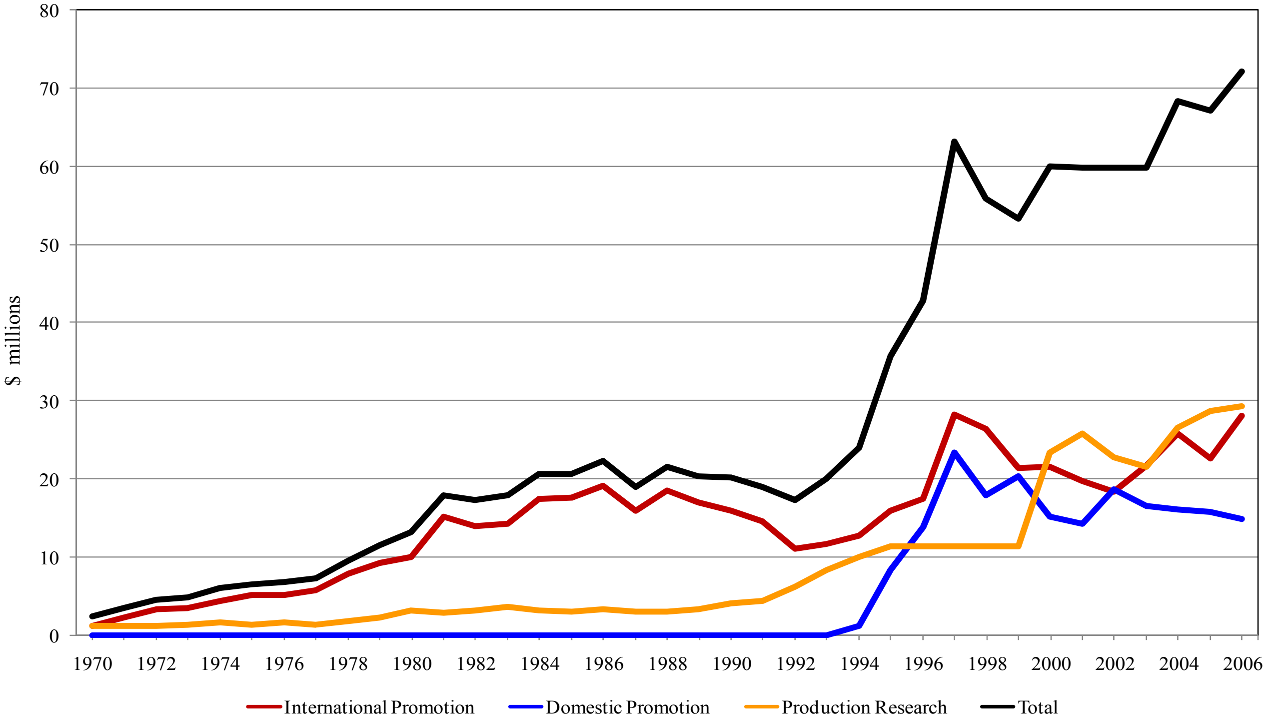
6 Unless otherwise indicated, all checkoff expenditure data presented in this section and in corresponding tables and figures are in nominal U.S. dollars. As discussed later, however, all research and domestic demand promotion expenditures were deflated and international marketing expenditures were also corrected for changes in exchange rates for the empirical analysis of the effectiveness of those expenditures.

7 This figure includes only funds collected from soybean producers and expended by either QSSBs or the national soybean organization (the American Soybean Association (ASA) before 1992 and the United Soybean Board since that time). Funds provided by the Foreign Agriculture Service (USDA) through the cooperator program are NOT included. Also, this figure does NOT include expenditures made by QSSBs for domestic or international programs over the years, data for which are quite sketchy and inconsistent and have not been well-maintained over the years (see TAMRCa).

8 Whether or not such leveraging of international market promotion funds in foreign markets was actually discontinued after 1998 is not clear. However, if such leveraging has continued, the funds contributed by third parties to foreign demand promotional activities have not amounted to much and have not been reported by in-country representatives since 1998 (Rickard 2008).

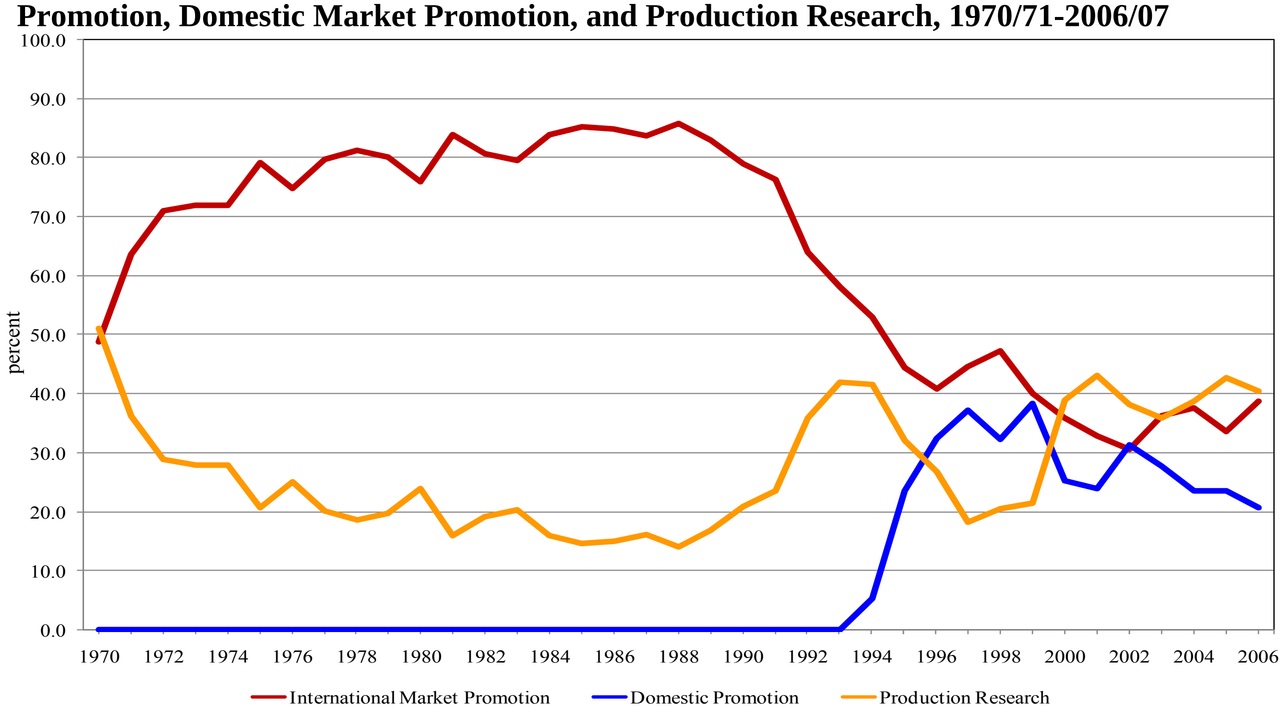
9 Unless otherwise specified, all subsequent references to "soybean checkoff expenditures/investments" in this report include not only producer-contributed soybean checkoff funds invested in soybean production research, domestic promotion, and international market promotion programs but also the foreign market promotion funds contributed by the USDA through the Foreign Agriculture Service and by 3rd Party contributors in the countries of investment. Not included are state 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: Total Soybean Checkoff Expenditures, 1970/71-2006/07




Source: Based on TAMRCa, TAMRCb, and TAMRCc.

## Figure 2: Share of Soybean Checkoff Expenditures Allocated to International Market Promotion, Domestic Market Promotion, and Production Research, 1970/71-2006/07




Source: Based on TAMRCa, TAMRCb, and TAMRCc.

gram in 1991/92, however, an increasingly larger share of checkoff funds were allocated to production research and domestic demand promotion. By 2002/03, the international market promotion share had declined to only 30% while the production research share nearly tripled from 15% in the mid-1980s to 43% in 2001/02 and domestic market promotion share increased from virtually nothing before 1992 to 38% in 1999/00 (Figure 2). Since 2000/01, domestic market promotion and production research together have accounted for 65% of annual expenditures with international market promotion accounting for only about 35%.

Another aspect of the checkoff expenditure strategy shift under the national program has been the remarkable increase in the importance of production research in the overall expenditure portfolio. Now accounting for the largest share of checkoff expenditures (40%), production research was a relatively small part of the overall expenditure strategy prior to the national program (15%-20%).

Even though soybean farmers have spent millions of checkoff dollars on production research and demand promotion since the 1970s, total expenditures have been quite meager when compared to the total industry revenues (cash receipts) earned by U.S. soybean farmers each year (Figure 3). Between 1970/71 and 2006/07, total soybean checkoff investments have amounted to only between 0.05% and 0.48% 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.

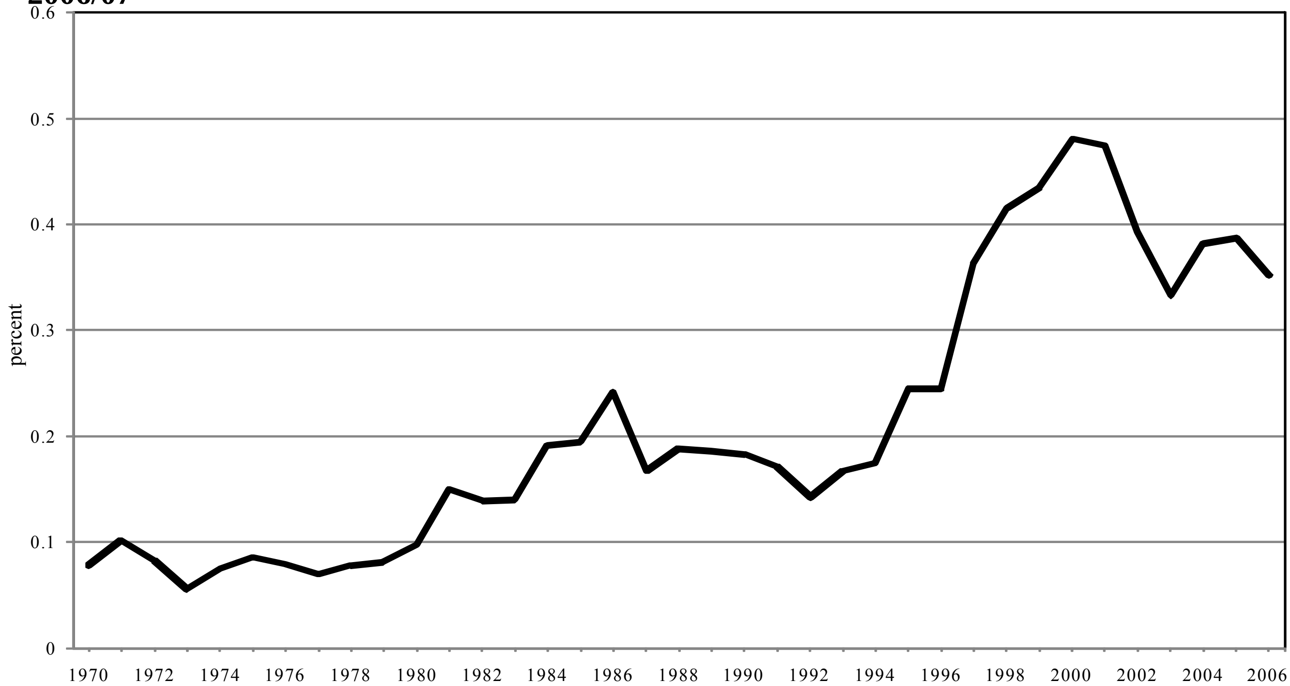
## *International Market Promotion Expenditures*

Between 1970/71 and 2006/07, $540.6 million were invested in promoting foreign consumption of U.S. soybeans and soybean products (TAMRCb). Of that total, 38.8% came directly from soybean checkoff revenues with another 39.6% from USDA through the Foreign Agriculture Service (FAS) Cooperator Program, and 21.7% from the private sector (third party contributions).

Under the USDA 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 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. Until 1998/99, the FAS and soybean checkoff funds were leveraged 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 (see inset box "International Market Promotion Activities" on a following page for more details).

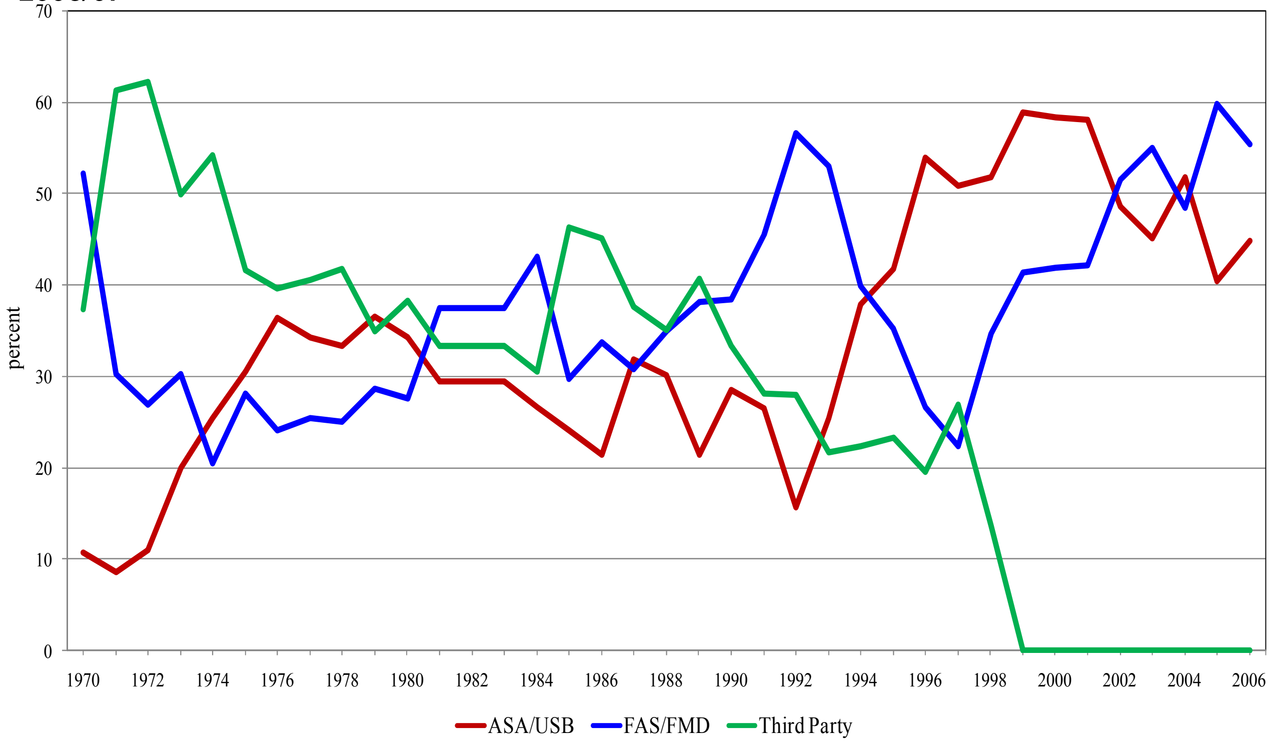
Between 1970/71 and 1986/87, total expenditures by all contributors (soybean farmers, FAS, and 3rd Party) in the development of foreign soybean and product markets consistently grew but at a declining annual rate from $1.2 million to $19.1 million (see Figure 1), accounting for an average of 85% of all expenditures during that period (see Figure 2). The annual growth rate turned negative in most years from 1988/89 through 1992/93 as funds were redirected to produc-

**Figure 3: Soybean Checkoff Expenditures as a Percent of Soybean Cash Receipts, 1970/71-2006/07**




Source: Based on TAMRCa, TAMRCb, TAMRCc, and TAMRCd.

**Figure 4: Contributor Shares of International Market Promotion Expenditures, 1970/71-2006/07**




Source: Based on data in TAMRCd.

## INTERNATIONAL MARKET PROMOTION ACTIVITIES

International market promotion includes: (1) trade servicing, (2) technical assistance, and (3) consumer promotion (Kinnucan and Williams 1988). *Trade servicing* attempts to expand U.S. soybean and product exports through foreign study teams to demonstrate U.S. productive capacity and reliability as a supplier; trade press announcements and conferences; advertising in foreign periodicals; promotional material for foreign food buyers; and other similar activities.

*Technical assistance* includes activities to expand the type, quality, and number of uses of soybeans and products in foreign markets such as technical assistance to foreign crushers and oil refiners to improve efficiency and the production, handling, and marketing of soy products; feeding trials and demonstrations; animal nutrition seminars; soy product development research; and feed technology short courses. 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 to promote the use of soybeans and soy-based commodities such as formulated feeds or margarine. Generic promotion fosters manufacturer and consumer use of these commodities without specifically identifying them as soy-based and may consist of margarine and tofu sales campaigns and consumer education seminars or meat consumption promotion campaigns in cooperation with the U.S. meat and poultry exporters. Identified promotion intends to enhance foreign demand by differentiating U.S. soy products from their competitors and might include baking/cooking seminars for institutional nutritionists, cooks, and food buyers to illustrate the quality and versatility of soybean oil; the distribution of booklets featuring soy products and institutional recipes; and sharing the costs of marketing of soy-based products with third party contributors in the program countries.

tion research, plunging international market expenditures to a 12-year record low of $11.1 million, accounting for only 64% of total expenditures (see Figure 2). With the implementation of the national soybean checkoff program, however, international market promotion expenditures jumped to an all-time high of $28.2 million in 1997/98. Nevertheless, the share of total expenditures allocated to international market promotion continued to slide to 45% in that same year as allocations to production research and domestic promotion grew even faster.

The growth rate in allocations to international market promotion turned negative once again over the following five years until 2002/03 as allocations to production research jumped dramatically over that period. From a low that year of about 30%, the share of total expenditures allocated to international promotion has edged upward slightly to just under 39% currently.

### Contributor Shares of International Market Development Expenditures

Interestingly, before the implementation of the national soybean checkoff program, the smallest share of international market promotion expenditures was contributed by soybean farmers through the voluntary checkoff program in effect at the time. Between 1970/71 and 1992/93, voluntary soybean checkoff funds accounted for an average of only 26% of international market promotion expenditures while funds through the USDA cooperator program and from third party contributors accounted for an average of 34% and 40%, respectively (Figure 4). This leveraging of checkoff funds greatly increased the level of international promotion dollars and magnified the potential impact of each checkoff dollar on foreign demand for U.S. soybeans and products during that period.

The implementation of the national soybean checkoff program in 1992/93, however, was accompanied by a dramatic shift in source of international market promotion funds. By 1999/2000, the checkoff share of international market expenditures had more than doubled from the 1970/71-1992/93 average to nearly 60% with funds through the cooperator program accounting for all the rest of the expenditures (Figure 4).

Although helping to reverse the downward trend in the financial support for development of international markets for U.S. soybeans and products, the implementation of the national soybean checkoff program did little to generate additional funds from Third Party contributors in the program countries. During the mid-1980s, Third Party contributors accounted for the largest share of the total funds invested in foreign market development (35% to 45%). Following the implementation of the national soybean checkoff, however, efforts to leverage checkoff funds in foreign markets apparently waned, perhaps due to the dramatic increase in availability of checkoff funds. By 1999/2000, contributions from Third Party contributors, once the largest contributor of international market promotion funds, had dried up completely (Figure 4).

### Commodity Shares of International Market Development Expenditures

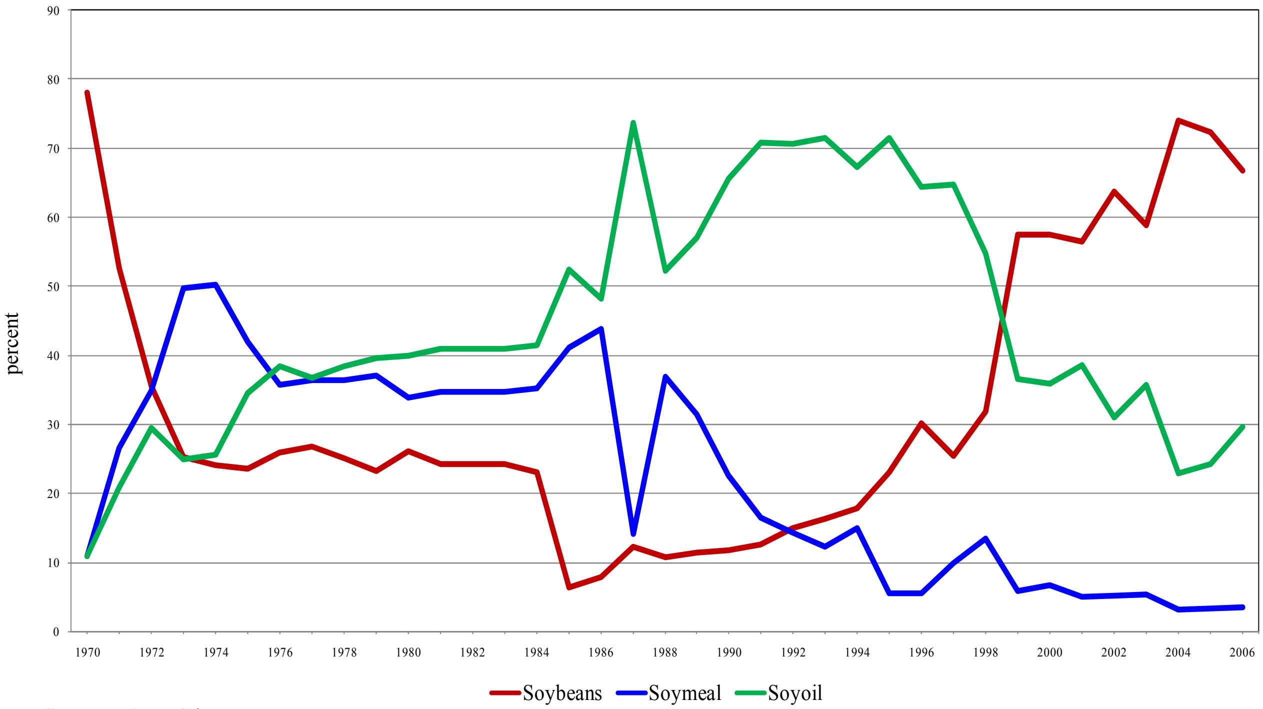
Before the implementation of the national soybean checkoff program, the evident strategy of the international market development program was to emphasize soybean products (soybean oil and soybean meal) rather than soybeans as the primary export promotion objective[10]. In the early 1970s, soybeans accounted for the largest share of international market development expenditures (Figure 5). Emphasis quickly shifted to soybean products in the mid- to late 1970s with soybean meal and soybean oil together accounting for about 60% of total expenditures. By 1985/86, the soybean product share had risen dramatically to about 94% with soybean oil commanding the largest share at 52%. By 1991/92, the year just before the implementation of the national checkoff, soybean oil had become the commodity of preference in international market promotion accounting for 70% of expenditures while the soybean meal share had slumped to only 17% (Figure 5).

The implementation of the national checkoff program brought renewed emphasis on soybeans as the preferred export promotion commodity. The soybean share rose dramatically from 12.5% in 1991/92 to a high of 74% in 2004/05. The growth in soybean promotion expenditures came at the expense primarily of expenditures to promote soybean oil. By 2004/05, soybean oil accounted for only 23% of expenditures with soybean meal a paltry 3%.

The motivation behind the switch from promoting the export of soybean products in the pre-national checkoff period to promoting soybean exports in recent years is unclear. Most likely, as suggested later, the change in emphasis was related to a shift in the regional focus of expenditures that occurred with the implementation of the national soybean checkoff program. As the regional emphasis of expenditures shifted from the EU and Japan to smaller, less developed countries over time, the commodity emphasis also shifted to soybeans rather than soybean products.

[10] 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: Commodity Shares of International Market Promotion Expenditures, 1970/71-2006/07**

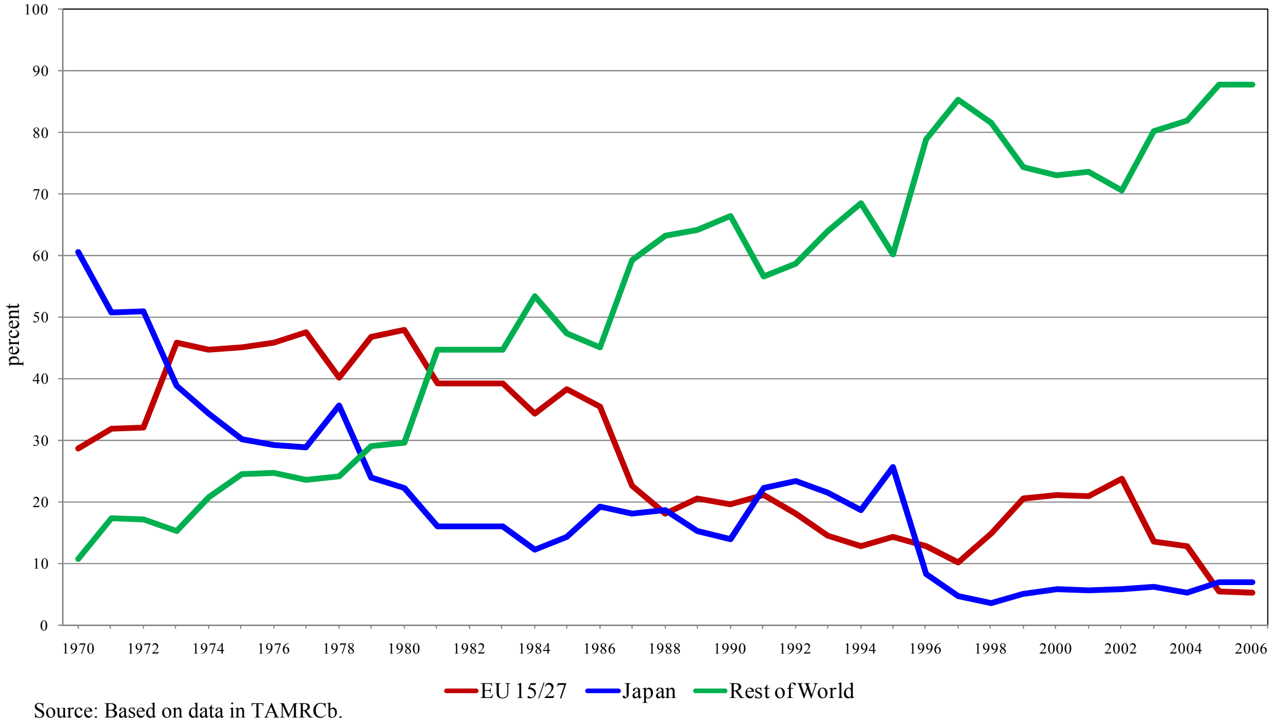



Source: TAMRCd.

Regional Share of International Market Development Expenditures

In the early 1970s, Japan and the European Community (6 members) accounted for 80%-90% of all international market development expenditures (Figure 6.) Over time, the international market development program expanded into a number of other countries, resulting in a steadily declining share of expenditures in Japan as well as in the European Union (EU) despite the growth in the number of EU member countries (TAMRCb). By 2006/07, Japan and the EU (which by then included 27 member countries) together accounted for only about 12% of total international market promotion expenditures (Figure 6). In contrast, the share of those expenditures going to smaller, less developed countries outside Japan and the EU-27 increased dramatically from around 10% in 1970/71 to nearly 90% by 2006/07. The shift in the allocation of expenditures away from developed countries towards smaller, emerging markets over time represents another key shift in the international market development strategy of the soybean checkoff program. This shift over time may help explain the concurrent shift in expenditures away from value-added products (soybean oil and meal) toward soybeans as noted in the previous section (also see Figure 5). Note that in the early years (1970s) of the international market development promotion effort, the focus of the program activities and expenditures was on soybeans, primarily in Japan and the EU. As those two markets matured, the emphasis in promotion activities began to switch to value added products. Then as the strategy for international market promotion broa-

**Figure 6: Regional Shares of International Market Promotion Expenditures, 1970/71-2006/07**




Source: Based on data in TAMRCb.

dened to include new, emerging markets across a broad number of less developed countries, the focus once again shifted to soybeans rather than value-added products.

This strategy makes sense, of course, because before growth in consumption of value-added products can occur in a new market, a supply of value-added products must be available. Working with importers, processors, and refiners in new markets to enhance efficiency and capacity, develop products suited to the needs of the consumers in that country, and improve the production, handling, and marketing process and infrastructure is an important first step to developing the needed supply of value-added soybean products in the market.

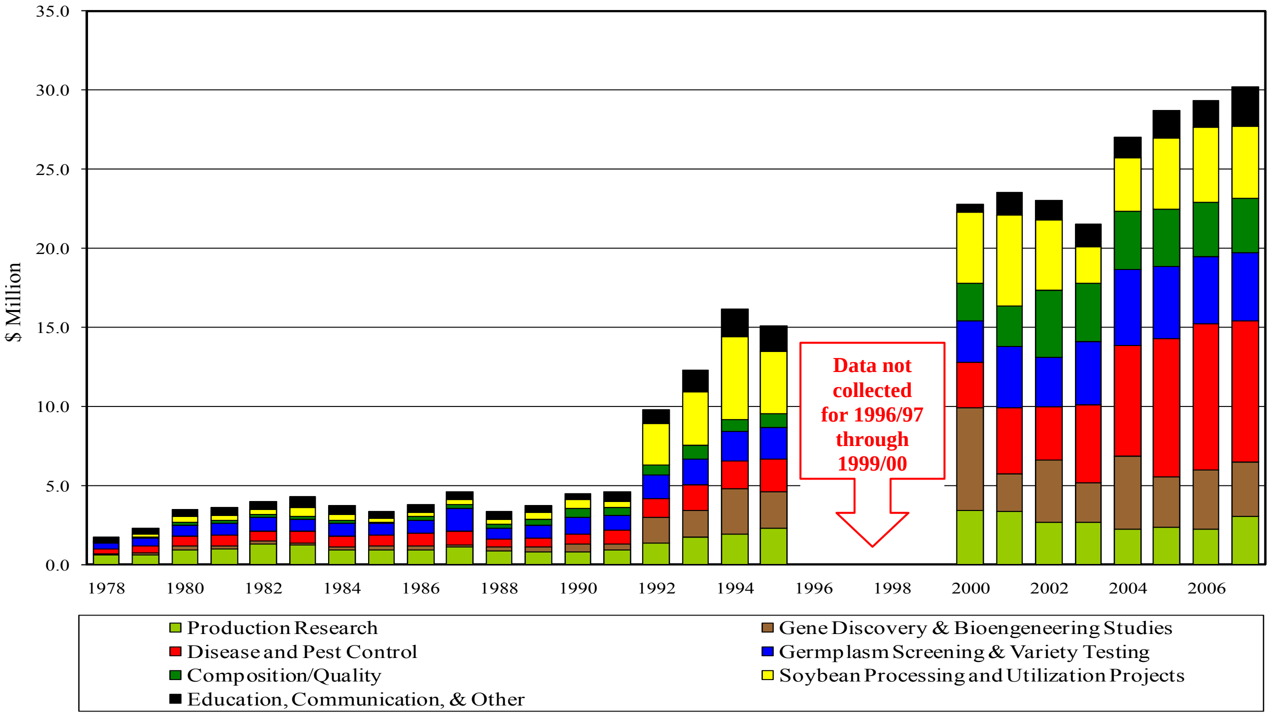
### *Soybean Production Research Expenditures*

Between 1970/71 and 2006/07, soybean farmers spent a total of over $317.2 million in checkoff funds on soybean production research projects (TAMRCc). From $1.3 million in 1970/71, the combined allocation of checkoff funds through both national and state-level organizations for soybean production research increased steadily to $29.3 million in 2006/07 (Figure 7)[11].

While soybean production research accounted for more than half of total checkoff expenditures in 1970/71, however, the prod-

[11] Note from Figure 7 that data on national and state-level expenditures for production research were not collected or maintained by project for four years beginning in 1996/97. In additional, the national-level expenditures data in all other years were broken out by project but not by state.

**Figure 7: Total Production Research Expenditures by Type of Research, 1978/79-2007/08**




Source: Based on data in TAMRCc.

duction research share of total expenditures declined steadily to an all-time low of 14.1% in 1988/89 (see Figure 2). Aided by the implementation of the mandatory checkoff program in the early 1990s, the production research share jumped once again to 43.2% in 2001/02, the highest level since 1970/71. The production research share was slightly lower at 40.6% in 2006/07.

Production research projects funded with soybean checkoff dollars over at least the last decade have tended to fall into one of eight broad categories: (1) production systems research; (2) gene discovery and bioengineering studies; (3) soybean disease and pest control; (4) soybean germplasm screening and variety testing and development; (5) soybean composition and quality research; (6) soybean processing and utilization research; (7) education and communication projects; and (8) various other research activities (see inset box "Domestic Production Research Expenditures" for more details).

In 1978/79, about 35% of checkoff research funds went to production systems research, 23% to germplasm screening and variety testing and development, 15% to disease and pest control research, 15% to the combination of education/communication and other projects, 5% to gene discovery and bioengineering studies, 3% to soybean processing and utilization projects, and 3% to soybean composition and quality research (Figure 7).

The largest component of funded production research projects has involved soybean disease and pest control, accounting for 30% of production research expenditures in 2007/08, double the level of 1978/79. Soybean processing and utilization studies also experienced increases in shares of production research funding by 2007/08 (15%) along

## DOMESTIC PRODUCTION RESEARCH ACTIVITIES

Production research projects have tended to fall into one of 8 broad categories: (1) production systems research; (2) gene discovery and bioengineering studies; (3) soybean disease and pest control; (4) soybean germplasm screening and variety testing and development; (5) soybean composition and quality research; (6) soybean processing and utilization research; (7) education and communication projects; and (8) various other research activities (TAMRCc 2009).

*Production systems research* has focused on production management, soil moisture and water management, soil fertility and nutrient management, and weed control.

*Gene discovery and bioengineering studies* have covered a broad range of biotechnology and basic research projects.

*Soybean disease and pest control research* has focused primarily on insect control (e.g., aphids), disease control (e.g., Asian rust, stem rot, leaf spot), nematodes, and fungicide evaluation).

*Soybean germplasm screening and variety testing and development* has included a wide range of activities from soybean breeding to soybean seed quality and germplasm screening.

*Soybean processing and utilization research* has examined the use of soybean oil and meal for food, industrial and animal purposes, human and animal nutrition, processing efficiency, by-product uses and value.

*Soybean composition and quality research* has included a wide variety of activities designed to understand the many factors affecting the composition and quality of soybeans.

*Education and communication projects* have included on-farm research demonstration projects and extension research and communication activities.

*Other projects* have ranged from marketing studies to studies in nitrogen fixation.

with gene discovery and bioengineering studies (12%), and soybean composition and quality research (11%). Those increases, however, have come primarily at the expense of production systems research (down to 10% in 2007/08), germplasm screening and variety testing and development (down to 14% in 2007/08), and education/ communication and other research (down to 8%).

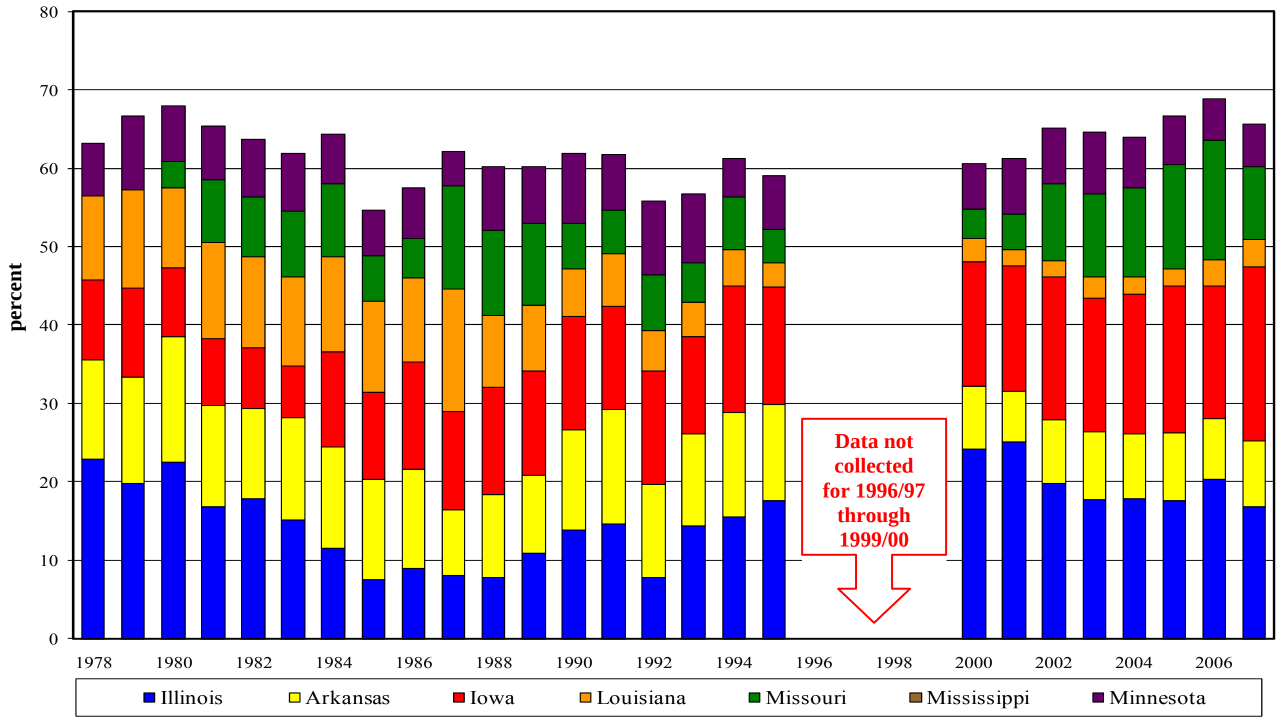
Between 1978/79 and 2007/08, 70% of soybean production research funded by the state soybean associations before the implementation of the national soybean checkoff and then the QSSBs there-after was conducted by researchers in only seven states: (1) Illinois (15.9%), (2) Iowa (13.8%), (3) Arkansas (11.1%), (4) Missouri (7.5%), (5) Louisiana (7.2%), (6) Minnesota (6.9%), and (7) Mississippi (5.9%) (Figure 8).

### *Domestic Promotion Program Expenditures*

Prior to the implementation of the national checkoff program, relatively few dollars were allocated at either the national or state level for activities designed to promote the domestic use of soybeans and soybean products. Nearly all checkoff funds during that period were used either to promote foreign use of soybeans and soybean products in an effort to enhance U.S. exports or to fund production research in an effort to boost productivity and reduce costs of production.

Few records exist to provide much insight on the objectives and amount of checkoff dollars used to fund domestic promotion activities prior to the early 1990s. The data available for that period (TAMRCa) and discussions with ASA and USB personnel both indicate that until after the implementation of the national soybean checkoff program, domestic promotion accounted for an extremely small proportion of all soybean checkoff funds expended in those years.

**Figure 8: Share of Production Research Expenditures by State, 1978/79-20070/08**



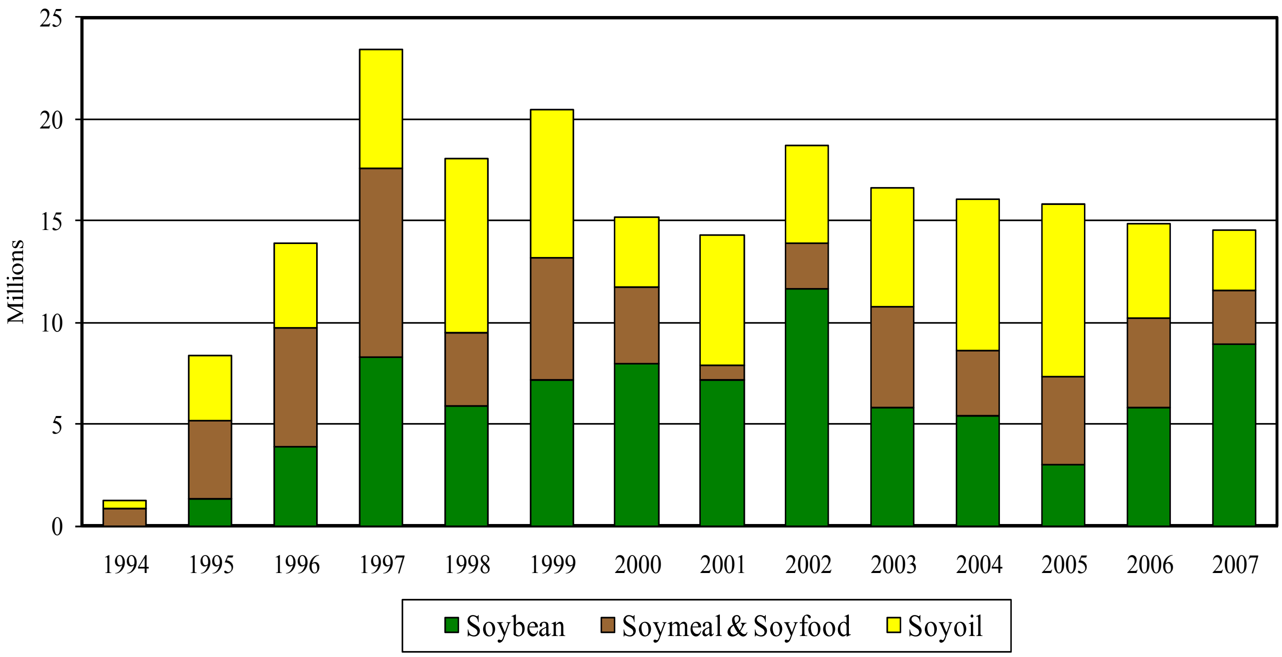

Source: TAMRCc.

With the implementation of the national soybean checkoff program, the strategy for checkoff expenditures was expanded to include a broad range of activities to promote the use of soybeans and soybean products in U.S. markets (see inset box "Domestic Promotion Program Activities" on a following page). At the national level between 1994/95 and 2007/08 (the period over which complete records are available), $211.9 million of soybean checkoff funds were spent on domestic promotion programs (TAMRCa). From $1.4 million in 1994/95 (5.3% of all checkoff promotion and research expenditures), national-level domestic promotion expenditures increased markedly to a high of $23.5 million in 1997/98 (37.1% of promotion and research expenditures) (Figure 9). Since then, annual expenditures on domestic promotion have backed off to $14.6 million in 2007/08 (less than 20% of promotion and research expenditures). Also since 1994/95, soybean promotion activities have represented about 39% of national-level promotion expenditures while soybean oil accounted for 35% and soybean meal and soyfood the remaining 26% (Figure 9).

Although checkoff funds have been invested by both state and national organizations in domestic promotion programs, data on state-level expenditures by QSSBs have not been systematically gathered over time. In an 1997/98 study of the effectiveness of the soybean checkoff program, the authors attempted to collect this data by survey from each state (QSSB) (Williams, Shumway, and Love 2002).

At that time, we reported that the state-level expenditure data generated by that survey were "quite incomplete and unreliable, par-

**Figure 9: National Level Expenditures on Domestic Promotion Programs, 1994/95-2007/08**




Source: TAMRCa.

ticularly for the period prior to the national checkoff program" (p. 13). A number of QSSBs failed to respond to repeated requests for the information. At the same time, the quality of the data provided by the responding QSSBs was highly variable in terms of the time period of coverage, level of commodity and project aggregation, comprehensiveness, and other characteristics[12].

Since that time, little has been done to consistently collect and report QSSB expenditures except for production research data which is collected from QSSBs by Keith Smith and Associates. Consequently, in an effort to develop as accurate and comprehensive expenditure database as possible, we once again attempted to collect the necessary data directly from the QSSBs.

The quality of the domestic promotion expenditure data provided by the responding QSSBs for recent years was obviously much better than that of data available for earlier years. Even so, the lack of a harmonized system to maintain detailed historical information on QSSB annual promotion and research expenditures in a consistent format continues to render even the most recent state-level expenditure data virtually useless, at least for program evaluation purposes[13].

[12] Refer to TAMRCa (Texas Agricultural Market Research Center Information Report No. IR 2-09) to see what was and was not provided by which states.

[13] The failure to systematically compile consistent quality checkoff expenditure data across state QSSBs and USB contractors is a serious problem for nearly all types of soybean checkoff expenditures. Fortunately, historical data on production research were faithfully compiled by a former ASA employee except for a four year period beginning in 1996/97.

## DOMESTIC PROMOTION PROGRAM ACTIVITIES

Domestic promotion programs are intended to boost domestic use of soybeans, soymeal and soyfood, and soyoil. These programs are similar to international promotion programs in that they are intended to shift out the demand curves for U.S. soybeans and soybean products. However, domestic and international promotion programs tend to compete in their market effects. If a domestic promotion program increases the domestic use of soybeans and products, for example, the result is less availability of these products for export and vice versa. To soybean producers, however, the result is the same – more demand for what they produce, the only difference being whether the increased demand comes from domestic or foreign consumers.

In contrast to most other checkoff commodities, relatively few soybean checkoff dollars are spent on media advertising. Most domestic soybean and product promotion has involved new use research and working directly with potential users to boost awareness and usage. Examples include the following (TAMRCc 2009):

*Domestic soybean promotion programs* range from many new use projects focused on soybean composition and quality to trade and consumer communication projects, and a wide variety of soybean chemistry, genetics, processing, and utilization projects.

*Domestic soymeal and soyfood promotion programs* have focused on financing partnerships with meat marketing organizations, seminars and research on the nutritional and health aspects of soyfoods, and many projects related to animal nutrition, feeding technology, high protein meal development, and soymeal use in aquaculture production, among many others.

*Soybean oil promotion programs*, particularly in recent years, have focused on developing industrial applications for soyoil (e.g., plastics, soyink, solvents) and the use of soyoil in biodiesel fuel production, among many others.

### *Producer Communications Expenditures*

From 1992/93 to 2007/08, anywhere from 4% (1995/96) to slightly more than 25% (1993/94) of national soybean checkoff program expenditures were allocated to producer communications for an average of 14.5% over the period. In 2007/08, producer communications accounted for 13.5% of total expenditures. Many other checkoff commodity organizations spend a similar amount on producer communications, from as low as 5% by the Beef Board and Pork Board to as high as 20% by the National Corn Grower's Association (Table 1). Most smaller checkoff organizations spend little on producer communications.

While comparisons with other checkoff groups are interesting, they provide little indication of the relative effectiveness of their producer communications programs. The lower percentage spent by the Beef and Pork Boards, for example, could mean they are more cost-effective in getting out their messages or simply that they under-investing in producer communications so that their stakeholders are relatively less well-informed and, as a result, less satisfied with the results of their checkoff program.

Checkoff expenditures for producer communications are neither expected nor intended to increase soybean productivity, reduce soybean production costs, or promote demand for soybeans or soybean products (see inset box "Producer Communications Program Activities for more details). Rather, the goals of producer communications are to (Osborn and Barr Communications):

- Strengthen producer awareness and knowledge of soybean checkoff activities and initiatives, which can impact the profitability and competitiveness of their operations;

**Table 1: Comparison of Selected Commodity Checkoff Board Expenditures on Producer Communications**

| Commodity Checkoff Boards | Producer Communications | Total Expenses | Percent of Total |
|---|---|---|---|
| Beef Board (2007)[1] | $2,274,092 | $49,562,847 | 4.6 |
| Pork Board (2007)[2] | $2.6 million | $50.8 million | 5.1 |
| Dairy (DMI) (2007)[3] | $19.0 million* | $175.2 million | 10.8 |
| American Lamb Board (2007)[4] | $251,772 | $2,331,671 | 10.8 |
| National Honey Board (2007)[5] | $467,712 | $4,443,442 | 10.5 |
| United Soybean Board (2007)[6] | $5,703,156 | $42,195,884 | 13.5 |
| American Egg Board[7] | na | $19,849,174 | na |
| National Corn Growers Assn (2008 budget)[8] | na | na | 20.0** |

na = not available. * = "Business and Integrated Communications." ** Share of expenses for communications from all revenue sources.
Sources: [1] http://www.beefboard.org/uDocs/2008cbbannrep-forwebposting.pdf
[2] http://www.pork.org/NewsAndInformation/News/docs/2007AnnualReport.pdf
[3] http://www.dairycheckoff.com/NR/rdonlyres/F924A8DE-7267-4E75-9079-9392284B7C20/0/2007_DMI_FINAL_LORES.pdf
[4] http://www.americanlambboard.org/userfiles/file/Final%20FS07(1).pdf
[5] http://www.honey.com/media/nucleus/Spring08.pdf
[6] http://www.unitedsoybean.org/about/usb_annual_reports.aspx
[7] http://www.aeb.org/pdfs/aboutAEB/annual_report/AEB%202007%20Report%20Book.pdf
[8] http://www.ncga.com/files/pdf/2008AnnualReport.pdf

- communicate the benefits of the check-off program to farm managers;
- build relationships among key influencers in agriculture and in agricultural media industries; and
- establish the soybean checkoff and the USB as resources for information pertaining to the soybean industry.

Given their highly different goals, the effectiveness of commodity checkoff producer communications expenditures cannot be measured using the same statistical procedures used to analyze the effectiveness of supply- and demand-oriented expenditures. Thus, studies of checkoff program effectiveness normally do not include producer communications expenditures as part of their analyses.

Measuring the effectiveness of producer communications requires a different type of approach, one that measures whether the specific goals of the expenditures have been met. Most efforts to measure the effectiveness of producer communications focus on the effect of the expenditures on enhancing producer awareness and the checkoff program, its activities, and benefits.

The most common method to determine the effectiveness of producer communications activities is to survey producers and measure their awareness of the checkoff program and their support, opposition, and beliefs regarding the program. The initial survey normally establishes a benchmark against which changes in level of awareness, support, and beliefs of producers regarding the program can be tracked over the years in subsequent surveys. This iss the approach taken by the Tarrance Group, Inc. In a report of their most recent producer survey results to assess the effectiveness of the soybean checkoff program's producer communications efforts, the Tarrance Group concludes, among other things, that on average over the period of 1997/98 to 2008/09:

- About 13% of producers are familiar with the program, 66% are somewhat familiar, and 20% are not at all familiar;
- Producer support for the program steadily increased from 65% to 75% while opposition decreased from 30% to 14%;
- Most producers believed the program to be effective, efficient, and farmer driven;
- The percentage of producers who believe that the program has helped to expand or develop new international markets for U.S. soybeans increased from 67% to 81%;
- The percentage of producers who believe that production research expenditures had helped develop any new advances or improvements in soybean production techniques increased from 63% to 76%;
- The percentage of producers who believed that the program had helped to develop any new uses for soybeans increased from 78% to 89%; and
- The percentage of producers who believe that the program is still a good investment for the industry increased from 63% to 71% (only measured over the 2004/05 to 2008/09 period.

### *Purchasing Power of Soybean Checkoff Investments*

Despite an upward trend in the nominal dollar value of soybean checkoff expenditures over the years, inflation in the U.S. and foreign countries and a general depreciation in the value of the U.S. dollar against foreign currencies have eroded the real purchasing power of those expenditures over time in all countries. In other words, each U.S. dollar could purchase less promotion and research in 2007/08 than was the case in 1970/71 which has eroded the impact of program expenditures over time.

## PRODUCER COMMUNICATIONS PROGRAM ACTIVITIES

Checkoff expenditures for producer communications are neither expected nor intended to increase soybean productivity, reduce soybean production costs, or promote demand for soybeans or soybean products. Rather, the goal of producer communications is generally to inform stakeholders of the activities funded by checkoff dollars and the benefits they receive. A number of strategies are followed to communicate the value of the checkoff program to producers and their ownership of it.

Checkoff messages are communicated to soybean producers through various industry trade shows and meetings. Some outreach is directed to farmers while others intend to educate media representatives or industry groups on checkoff priorities in order for them to carry the messages back to soybean farmers (Osborn and Barr Communications).

Providing regular and concise soybean-industry focused messages to media is a major component of producer communications. Communications with media is accomplished through outreach projects, such as a national media tour, by continually building relationships and responding to media requests and the development of a media primer CD. Many requests for soybean checkoff collateral material, background and support information as well as photographs and graphics are filled. The news media are also monitored to take advantage of emerging topics to leverage checkoff communications and provide support to other program areas.

The producer communications program maintains and updates a media database to better leverage resources when contacting the media, sending news releases, and conducting media tours and special events.

USB and state farmer-directors also work to establish themselves as “expert” resources for information and interviews on soybean checkoff and industry-related topics through a national media tour.

In the U.S., inflation has had an important effect on the real level of research and domestic promotion purchased particularly in recent years (Figure 10). As a result of inflation, research and domestic promotion dollars spent in 2007/08 purchased only about a third or less of what those dollars would have purchased in 1970/71. In other words, the nearly $30 million spent on research in 2007/08 purchased only about $10 million in research when the effects of inflation are removed. In the case of domestic promotion, despite an expenditure of about $12 million in 2007/08, the actual promotion purchased was worth only about 25% of that figure (about $4 million) when measured in 1970/71 dollars.

In foreign markets, the combination of inflation and a depreciating U.S. dollar combined for an even more serious impact on the purchasing power of checkoff dollars spent on international market promotion programs. In both the EU15/27 and Japan, for example, inflation and a declining value of the dollar reduced the purchasing power of soybean checkoff expenditures in those countries even more rapidly than the planned reduction in nominal dollars (Figures 11 and 12).
In less developed and other countries to which checkoff dollars have been increasingly shifted over the years, progressively rapid inflation, particularly since the mid-1980s, has seriously reduced the effectiveness of the market development activities in many of those countries (Figure 13). In essence, the rate of inflation in the cost of goods and services in many of those countries has far outpaced the annual rate of increase in checkoff dollars expended in those same countries. The consequence has been a serious erosion in the purchasing power of the budgets of the foreign soybean promotion offices (USSEC) which has hindered their ability to maintain levels of promotion much less expand activities in many cases.

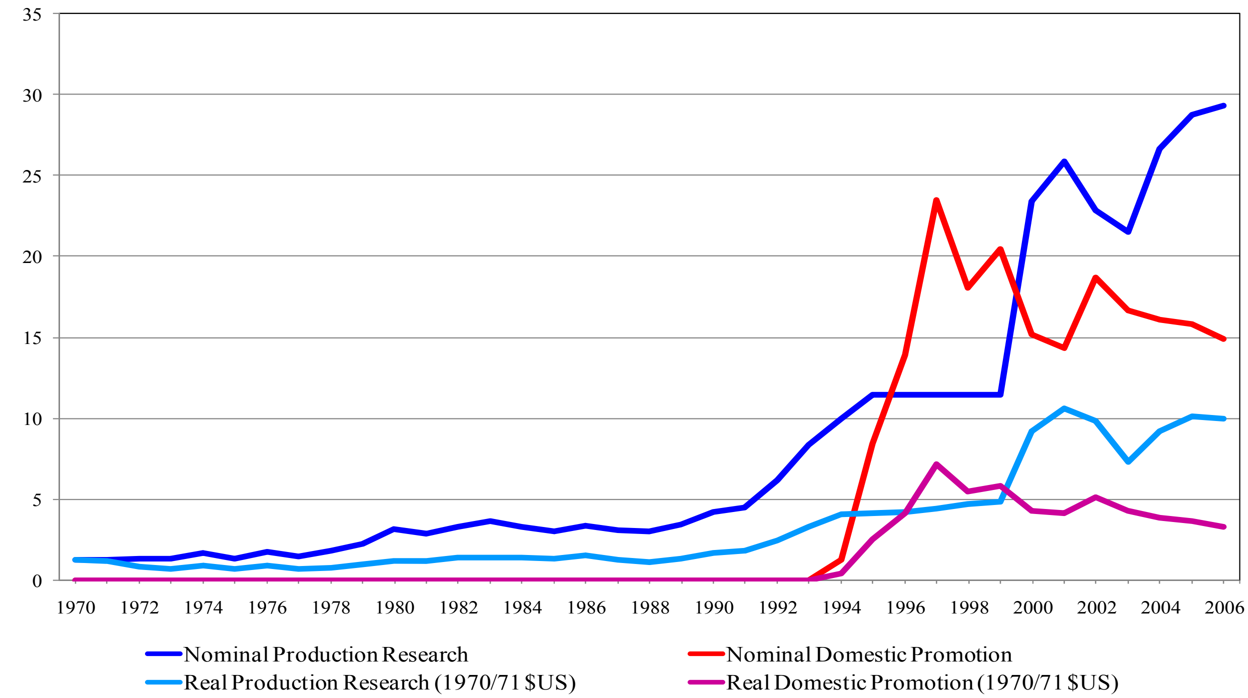
### *Summary of Key Characteristics of Soybean Checkoff Expenditures*

For any checkoff program, two main factors affect the estimate of its market effects and returns to producers: (1) the statistical relationship estimated between the checkoff expenditures and market demand and supply and (2) the expenditure strategy of the checkoff board as revealed by the commodity, region, and promotional activity patterns of expenditures over time. The methods and results of the statistical measurement of the relationship between checkoff expenditures and the market demand and supply of soybeans and soybean products are presented and discussed later in this report.

This section of the report summarizes the preceding review of checkoff expenditure patterns and highlights nine key important features of soybean checkoff expenditure patterns that will provide a strong basis for understanding the statistical results and related interpretation and conclusions presented later in this report. The following nine characteristics highlight changes in checkoff expenditure strategies with the implementation of the national checkoff program in the early 1990s:

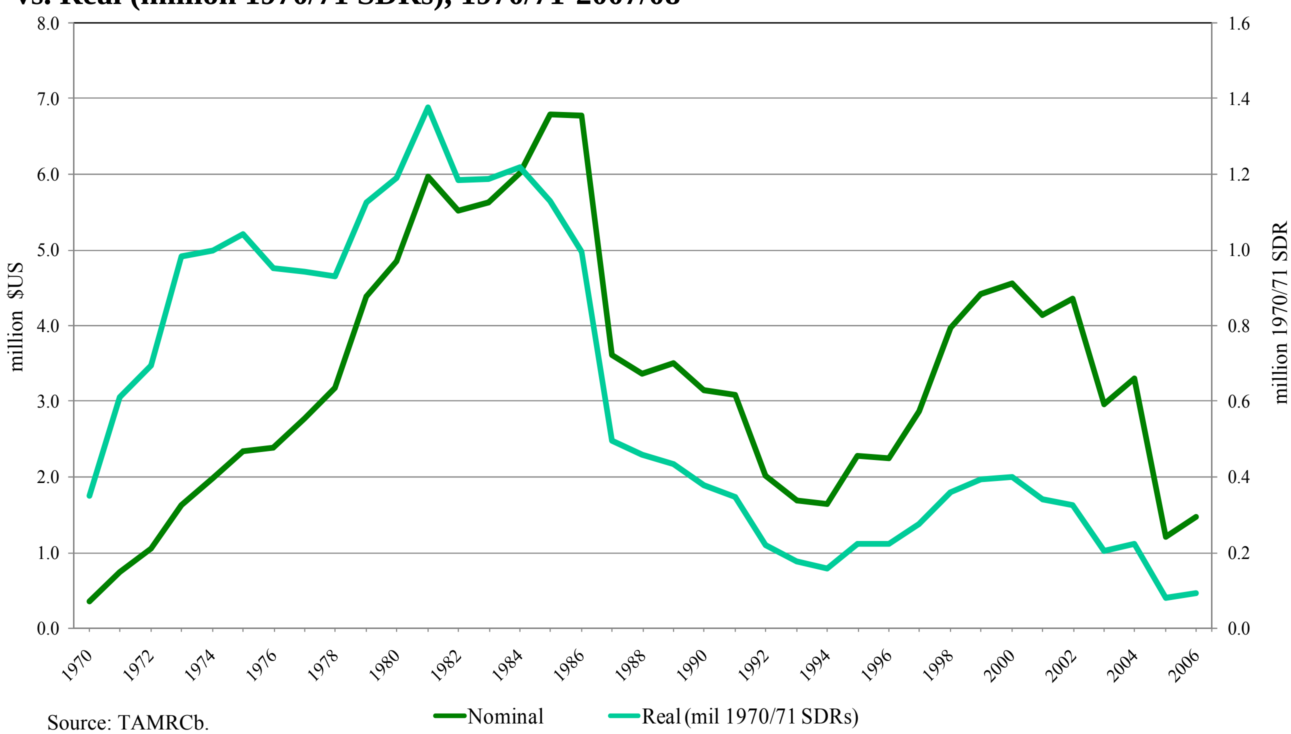
1. *Expenditures have tended to switch from international promotion to production research over time.* The share of checkoff expenditures allocated to international promotion dropped from 85% before the early 1990s to about 30% in recent years while the production research share jumped from 15% to 40% over the same period. The consequence has been less demand “pull” being generated in world markets by the checkoff program and more supply “push” leading to less support for soybean and product prices since implementation of the national soybean checkoff program.

**Figure 10: U.S. Production Research and Domestic Promotion Expenditures, Nominal vs. Real, Inflation Adjusted, (1970/71 $US), 1970/71-2007/08**



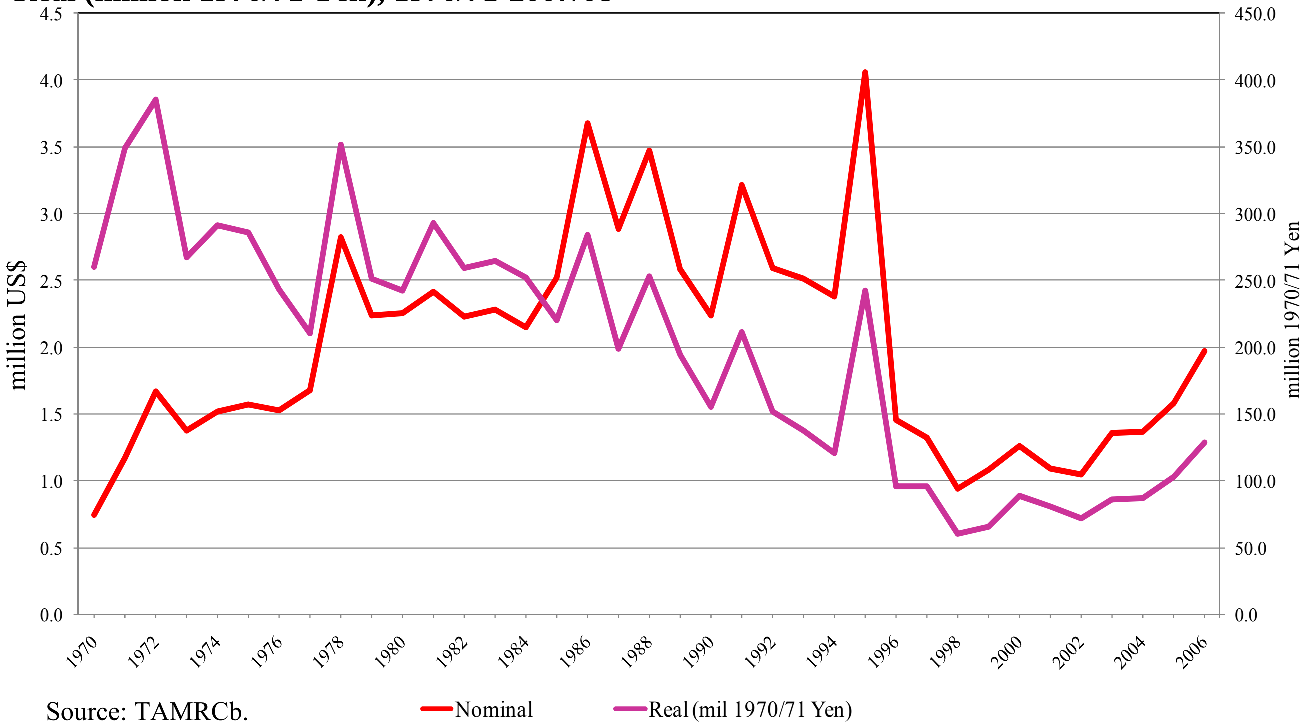

Source: TAMRCa and TAMRCc.

**Figure 11: EU15/27 International Market Promotion Expenditures, Nominal (million $US) vs. Real (million 1970/71 SDRs), 1970/71-2007/08**



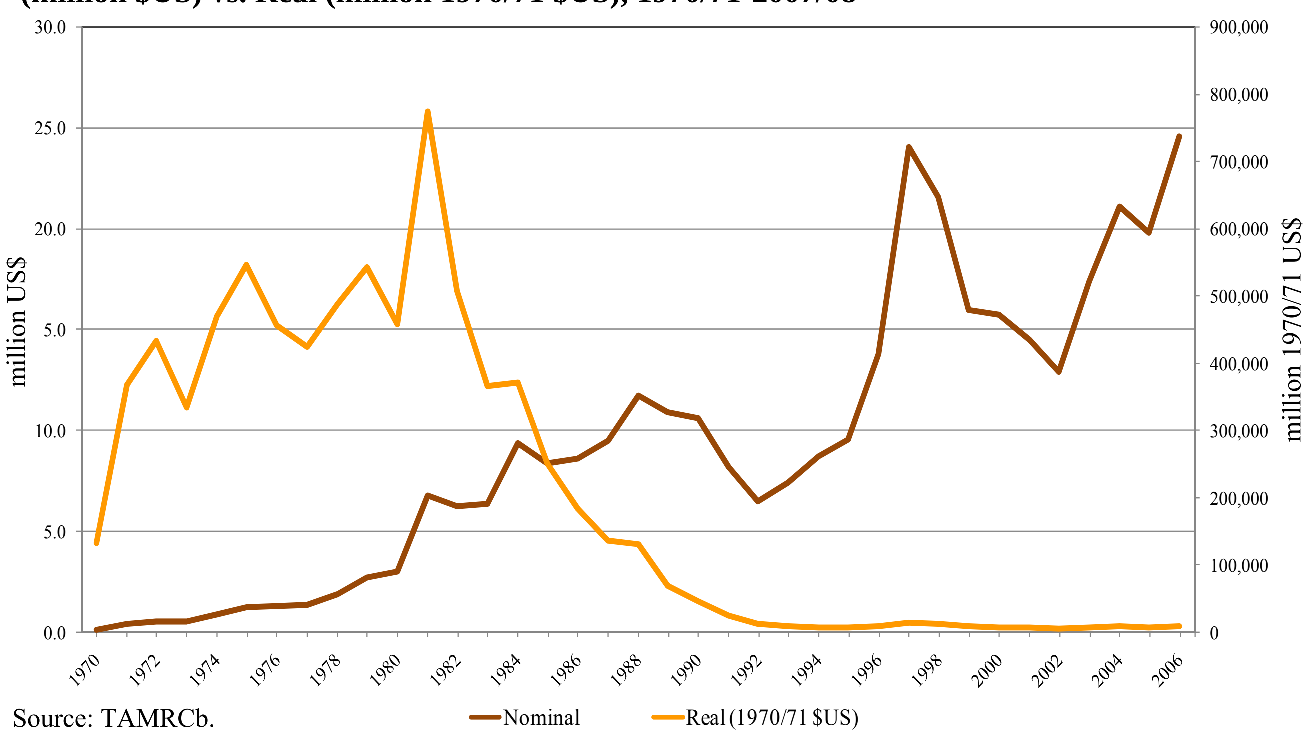

Source: TAMRCb.

**Figure 12: Japan International Market Promotion Expenditures, Nominal (million $US) vs. Real (million 1970/71 Yen), 1970/71-2007/08**




Source: TAMRCb.

**Figure 13: Rest of the World International Market Promotion Expenditures, Nominal (million $US) vs. Real (million 1970/71 $US), 1970/71-2007/08**




Source: TAMRCb.

2. *During most of the 1990s, expenditure allocations tended to favor domestic promotion as international marketing promotion expenditures declined.* From virtually nothing in the early 1990s, the share of expenditures allocated to domestic promotion programs spiked at 40% in 1999/00 while expenditure allocations to international marketing promotion were declining sharply. Because that was also when allocations to production research were also rising rapidly, the increasing allocations to both domestic promotion and production research pulled soybean checkoff programs decidedly away from traditional promotion activities in foreign markets toward activities focused on U.S. markets.

3. *The share of checkoff expenditures allocated to domestic promotion after 1999/00 was cut in half from 40% of total expenditures to only 20%.* Because the expenditure allocation to international promotion stabilized during that period at about 30%-40%, the result was even greater emphasis on production research to shift out the supply curve while emphasis on demand promotion waned. This change added even more supply "push" to soybean checkoff programs and less demand "pull."

4. *In international promotion programs, the focus over time has switched from maintaining and building a few large, mature markets to opening and developing many new, smaller markets.* The share of international market promotion expenditures going to the European Union and Japan, the two largest, single markets for U.S. soybeans and products, declined from 80%-90% in the 1970s to only 10%-15% in recent years. Nearly 90% of all international market promotion expenditures are now allocated to smaller, less developed countries and regions. The trade-off has pitted a philosophy of maintaining sales in large but stable markets against one of building sales in a large number of smaller, growing markets. The problem is that the redirection of international market promotion expenditures from mature to new markets must generate at least the same return to the checkoff dollars spent as might have been achieved without redirecting those expenditures to avoid revenue losses. As emphasized in the next section, it can take years of expenditures in new markets before substantial returns are generated but only a short period of no expenditures to lose any gains previously achieved.

5. *In international promotion programs, the commodity emphasis of expenditures since the early 1990s has shifted from value-added soybean products to soybeans.* Over time, checkoff dollars allocated to international market promotion have been increasingly used to promote foreign demand for U.S. soybeans rather than for soybean products. This shift may be the consequence of the growing emphasis on new, less developed markets rather than the larger, more mature markets in international market promotion strategy. Over time, as the newer markets mature, market demand and promotion expenditures might be expected to shift towards value-added products (soymeal, soyfood, and soyoil). In the meantime, lower returns may be generated by a relative increase in promotion-induced soybean exports relative to those of value-added products.

6. *The leveraging of international promotion program checkoff dollars with third party, in-country contributions declined in the 1990s and ceased completely in*

*1998/99.* Accounting for 1/3 or more of the funds used to promote foreign demand for soybeans and products during the voluntary checkoff program era, contributions from third party, in-country contributors apparently are no longer sought after as a means of magnifying the purchasing power of checkoff dollars in foreign markets. Efforts to leverage international market promotion dollars by partnering with in-country retailers, merchandisers, and manufacturers began to wane with the substantial increase in the availability of checkoff and FAS/USDA funds with the implementation of the national soybean checkoff program. The consequence has been a further weakening of the traditional, foreign market promotion program in favor of domestic promotion and production research programs than might be the case if third party leveraging was still an important component of the international market promotion strategy.

7. *Total checkoff expenditures are extremely small compared to the value of soybean production.* Although the $60-$70 million of annual checkoff expenditures is a great deal of money to most producers, that amount of money represents a drop in the bucket compared to the value of U.S. soybean production each year. Checkoff expenditures represent less than one-half of one percent (0.5%) of the value of production. Consequently, it would be unreasonable to expect that such a relatively small amount of money to have huge impacts on market supply, demand, and price. The effects are likely to be small but as long as the cost of bringing about small changes is even smaller, the returns to producers per dollar spent could be quite large.

8. *Producer communications expenditures have no effect on the supply of or demand for soybeans and soybean products in U.S. or world markets.* While necessary to maintain support among producers for the checkoff program, checkoff expenditures for producer communications are neither expected nor intended to increase soybean productivity, reduce soybean production costs, or promote demand for soybeans or soybean products. Thus, the effectiveness of producer communications expenditures cannot be measured using the same statistical procedures used to analyze the effectiveness of supply- and demand-oriented expenditures. Consequently, this study, like those of other commodity checkoff programs, does not include producer communications expenditures in the analysis of the effectiveness of the soybean checkoff program.

9. *Inflation in all countries and depreciations in the value of the U.S. dollar in foreign markets have seriously eroded the purchasing power of soybean checkoff expenditures.* In the U.S., checkoff dollars spent in 2007/08 purchased only about a third or less of what those dollars would have purchased in 1970/71. In foreign markets, depreciation in the dollar combined with rapid inflation have caused the cost of goods and services in many of those countries to far outpace the annual rate of increase in checkoff dollars expended in those same countries. Thus, despite growth in the *nominal* value of dollars spent at home and abroad, the real, effective purchasing power of those dollars has increased much less rapidly and even declined in many areas of the world.

## The Expected Effects of Research and Demand Promotion Expenditures

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 reasonably be expected of a research and promotion program in terms of the market effects and the effects on producers? The section explores what could be expected - and what should not be expected - from a checkoff program.

### *The Expected Effects of Investments in Research*

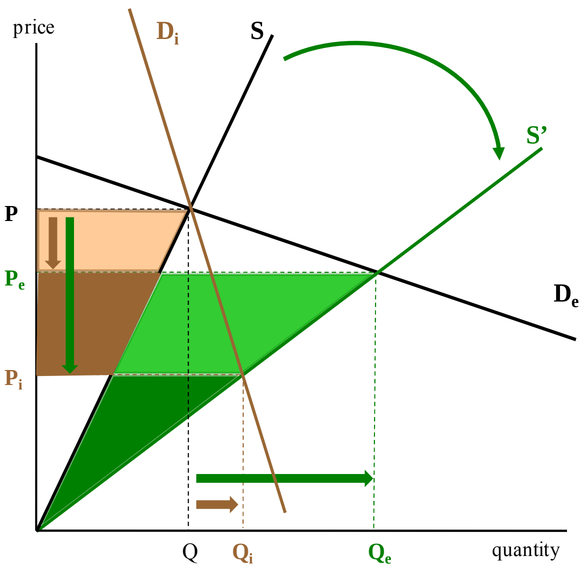
From the perspective of the individual producer, checkoff expenditures on production research offer the potential for increased profits through technological advances that reduce their production costs and/or boost their yields (i.e., output per unit of input). From a market perspective, however, if such research-induced technological advances are successful, 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 also decline. If not, then individual producers would likely benefit from the research expenditures. 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, (2) the revenue effect of the research-induced market supply increase, and (3) the cost effect of the supply increase.

The effects of expenditures on production 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 expenditures on research (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 expenditures.

Also, research expenditures 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. Also, applied research often is related to or depends on previous expenditures on basic research. Consequently, expenditures on 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 production 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 14. 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 $P_e$.

**Figure 14: Production Research Expen-di-tures: Market and Producer Welfare Effects**




In this case, total sales revenues (i.e., farm cash receipts) actually increase even though the price declines 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 14 by sum of the two greenish areas minus the light brown 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 14, then the same research-induced shift in supply (S to S') 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 in this second case as well 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 14 by the darker green area minus the darker brown area. The more inelastic the demand, the more likely the darker green area will be smaller than the darker brown area resulting in a net loss to producers. That is, the more unresponsive demand is to price changes, the more likely it is that checkoff expenditures on research will lead to a drop rather than an increase in farm profits.

Some researchers (e.g., Schuh 1984) 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 responsive to price changes (i.e., price elastic). Consequently, total demand (domestic plus export demand) for agricultural products could well be elastic. If that is the case, then checkoff-induced increases in supply would be expected to enhance farm profits.

Other researchers (e.g., Schmitz 1988 and Bredahl, Meyers, and Collins 1979), 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 demand curve facing the U.S. relatively price inelastic" (Schmitz). If the export demand for an agricultural product is indeed price inelastic, then 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.

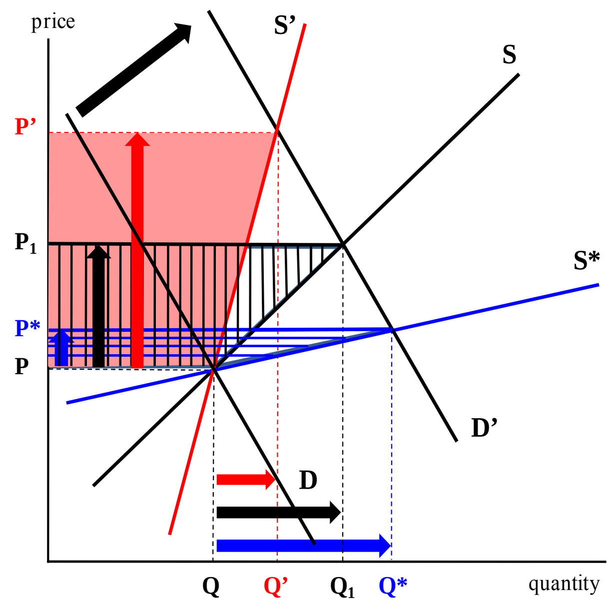
### *The Expected Effects of Demand Promotion*

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 15. Given a supply of soybeans for that year of S*, the demand shift would tend to raise the price from P 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 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 in this case, 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 small blue lined area in Figure 15. Thus, while it could appear to individual producers that the promotion program was not highly successful because the price did not increase

**Figure 15: Demand Promotion Expenditures: Market and Producer Welfare Effects**




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 15), however, would result in a higher price increase ($P_0$ to P') relative to the increase in sales (Q 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 light red area in Figure 15).

Thus, the extent of the increase in farm profits 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 15.

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, is 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 product markets, the effects of a checkoff-supported international market promotion program on both the level and world market share of U.S. exports of soybeans and products is perhaps a better indicator of the successfulness of the program than changes in U.S. soybean and product 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. Two separate studies of the effectiveness of the soybean checkoff program (Williams 1985 and Williams, Shumway, and Love 2002) concluded that although the program was effective in expanding demand and generated a high benefit-cost ratio, the farm price of soybeans was not much affected as the result of supply expansion.

Similar results have been found by other researchers for other checkoff commodities. 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. Kinnucan, Nelson, and Xiao (1995) determined that supply response completely eliminated returns to advertising of catfish over time.

Carman and Green (1993) found that while avocado producers benefitted from generic advertising during the initial years of the program (1960s and mid-1970s), supply expansion eventually led to negative returns to producers from continued advertising. 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.

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 shown that the sales response to advertising is normally positive and statistically significant but fairly small in magnitude or elasticity (Williams and Nichols 1998). Substantial advertising and promotion expenditures 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.

Most of the large commodity checkoff groups, like those for beef, pork, cotton, orange juice, and dairy, have focused intensely on domestic market promotion through mass media advertising. Cost considerations have forced most smaller commodity promotion groups to rely heavily on non-mass media forms of promotion. Because soybeans and soybean products are sold primarily in wholesale markets, little retail-level media advertising is done to promote their demand either in this country or abroad.

Unlike the cotton checkoff program, for example, which has adopted a strategy of promoting cotton directly to consumers as a preferred "ingredient" of clothes and other retail textile goods, the soybean checkoff program has historically opted to promote sales of soybeans and products through funding new use development, working directly with manufacturers and other industrial users, and other forms of non-media advertising[14]. Whether a media advertising or non-media promotion strategy is more effective in boosting sales and the return to checkoff promotion dollars has received little attention in the literature. A recent study for milk in New York state markets suggests that both advertising and non-advertising promotion activities are effective in enhancing demand although advertising was found to be the most effective promotion strategy (Zheng and Kaiser 2009).

## The Minimum Promotion Threshold

Some minimum level of promotion expenditures and messages are normally 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.

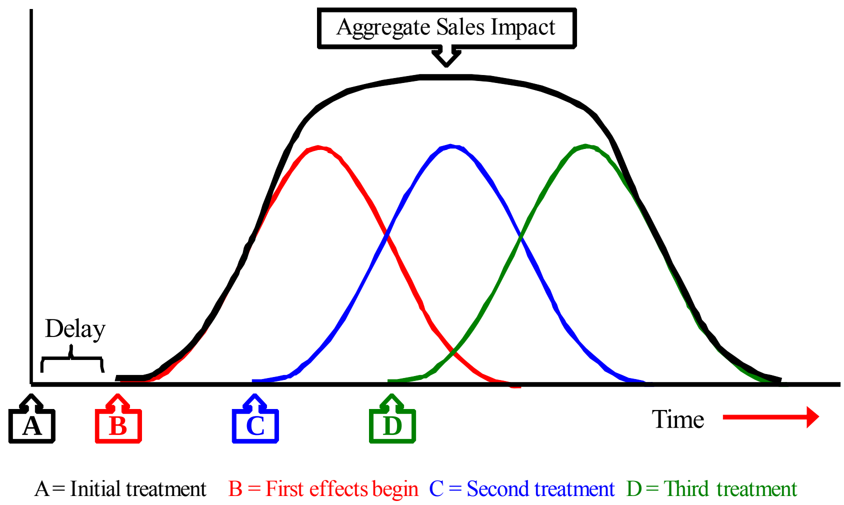
## The Delay or Lagged Effect of Promotion

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.

[14] The several inset boxes presented on preceding pages provide some detail on the types of research, promotion, and producer communications activities that are funded with soybean checkoff dollars.

Consequently, the response of sales to non-mass-media types of promotion programs apparently favored by the United Soybean Board may not be apparent for some time after initiation of the programs. Several exposures to a promotion message over time may be required before an individual decides to buy (Lee, Brown, and Fairchild 1989). Attempts to measure the effectiveness of the promotion effort in the early stages of the program, therefore, may yield disappointing results.

**Figure 16: Delay, Carryover, and Decay Effects of Demand Promotion**




## The Carryover Effects of Promotion

Promotion expenditures in the current period often do not have their full impact within 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. 1992).

Some promotion 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 1993). 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 1993).

## The Decay of Promotion Effects

While the effects of promotion activities often persist beyond the period when the expenditures are made, they do not last forever. A decay in those effects is expected after some period of time. Research shows that the promotion message will be forgotten if the potential users are not continuously exposed to it (Zielske 1959). Krugman (1972) concludes that continued expenditures on promotion are necessary because users filter messages and only respond when they are ready to make a purchase. If 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 16 illustrates a typical pattern of promotion effects on sales. Following the initial treatment (expenditure) at point A, there is usually some delay before the expenditures begin having an effect on sales at point B, assuming that the promotion expenditures are above some threshold level. The maximum impact of the initial treatment in Figure 16 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 promotion treatments (expenditures) (points C and D) can maintain the aggregate level of sales achieved with the first two treatments (dark black line in Figure 16). 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 ended altogether, the level of sales will taper off toward the pre-promotion program level over time.

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 after a promotion campaign. Forker and Ward (1993) note that without the decay phenomenon, there would be no reason for continued expenditures on promotion activities after the initial effort.

### 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, known as "advertising wearout," was initially discussed for generic advertising of agricultural products by Kinnucan, Chang, and Venkateswaran (1993). Appel (1971) provides evidence that a particular promotion activity changes in effectiveness with the passage of time. Reberte et al. (1996) found that two major generic milk advertising campaigns in New York City during the 1986 to 1992 period exhibited wearout.

Most studies of the wearout phenomenon have focused on media advertising rather than generic commodity promotion. Even so, the concept may have important applications for non-media promotions of the type characteristic of soybean checkoff demand promotion expenditures. 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.

The implication is that continued treatments over time are necessary to sustain the level of market sales impact achieved with the initial treatments. Conversely, allowing treatments to lapse (e.g., allowing a decline in expenditures to promote the use of soymeal in balanced livestock rations in one or more countries) will result in a decline in sales revenues. Achieving that same level of sales impact once again with increased funding will take time and additional potential revenues will be lost in the meantime.

## Overview of Research on Effectiveness of Commodity Research and Promotion Programs

Early evaluation of the effectiveness of and producer returns from commodity checkoff programs relied largely on anecdotal evidence and simple comparisons of gross promotion expenditures against changes in prices, profitability, and utilization of the commodities being promoted. During the

1970s, when commodity markets and producer profits as well as voluntary checkoff program expenditures on research and demand promotion for soybeans and a few other commodities were growing rapidly, this approach to evaluation yielded some persuasive stories and even more impressive upward-sloping graphical relationships between promotion expenditures and market prices, demand, and profits.

The problem with simply comparing market trends and profits with checkoff program expenditures to measure program effectiveness, of course, is that many factors other than the promotion expenditures affect the markets for agricultural commodities, 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 problem became rather apparent in the early 1980s for the voluntary checkoff programs in existence when commodity markets experienced a sharp, unexpected downturn despite continued expenditures by those checkoff programs for both research and demand 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 commodity checkoff programs to the performance and profitability of the U.S. soybean sector.

### *Studies on the Returns to Investments in Research*

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 returns to investments in the development and implementation of new technology subsequently have been made by a variety of researchers, including Evenson (1967), Peterson (1967), Huffman and Evenson (1993), Norton and Davis (1981), Fox (1985), Pardey and Craig (1989), Chavas and Cox (1992), and Yee (1995).

Although empirical estimates of the rate of return to agricultural research vary by commodity, location, and method of estimation, they have been remarkably high. 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 1985, Yee 1995). Nevertheless, estimates of the rate of return to public agricultural research are still above typical rates of return on private investments.

Unfortunately, most studies on the returns to production research 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 price-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.

Although research on the economic returns to agricultural research investments in general has been substantial, comparatively little attention has been paid to the returns to commodity checkoff program expenditures on production research. Two of the more prominent of these studies consider the returns to soybean producers from their investments in production research through the voluntary and mandatory soybean checkoff programs. Lim, Shumway, and Love (2002) conclude that checkoff-funded expenditures on production research over 1970-1994 returned $2.22 (present value) per dollar invested. They also found that returns to yield-enhancing research was negative but highly positive for cost-reducing research and conclude that “yield-enhancing research should be discontinued as one of the Soybean Board’s investments” (p. 145).

In a broader study of the soybean checkoff program, Williams, Shumway, and Love (2002) consider the returns to soybean checkoff expenditures on production research and demand promotion together over the period of 1978-1994. For production research expenditures, they find a negative return to producers and conclude that “production research not only failed to recover its investment, it actually had a negative impact on farmer net returns” (p. 109).

### *Studies on the Return to Commodity Promotion Expenditures*

Most studies of the effects of commodity advertising and promotion have focused on one 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/or (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 commodity checkoff promotion programs have been those funded by nationally mandated programs, including dairy products, beef, pork, cotton, and soybeans. Among other salient studies of the effectiveness of commodity checkoff advertising and promotion programs include those focusing on lamb, poultry, fats and oils, potatoes, orange juice, eggs, avocados, wool, apples, alcoholic beverages, tobacco, and cigarettes.

#### Sales Response to Promotion Studies

Most studies of the effectiveness of commodity checkoff advertising and promotion programs measure and report the responsiveness of the sales of the corresponding checkoff commodity to changes in checkoff advertising and promotion expenditures. The advertising and promotion responsiveness is usually represented in the form of an "advertising elasticity" which is the estimated percentage change in sales from a 1% change in advertising and promotion after controlling for all other factors that could affect sales. Kinnucan and Zheng (2009) provide an overview of some recent estimates of the checkoff advertising and promotion elasticities for dairy, beef, pork, and cotton. Williams and Nichols (1998) provide a historical summary of the advertising and promotion elasticities estimated across a broader range of commodities.

One highly consistent finding across virtually all studies and all checkoff commodities is that the checkoff advertising and promotion elasticities are quite small. For U.S. fluid milk sales, for example, the reported estimated generic advertising elasticities have ranged from as low as 0.0018 (Kinnucan et al. 2001) to as high as 0.150 (Schmit et al. 2002). That is, a 1% change in advertising has been estimated to have resulted in an increase in U.S. fluid milk sales of as low as 0.0018% and as high as 0.15%. Thus, a doubling of advertising expenditures (100% increase) would be expected to increase U.S. fluid milk sales by only between about 0.18% and 15%.

For red meat, the estimated advertising elasticities are equally small, ranging from a low of -0.00004 (Boetel and Liu 2003) to 0.028 (Ward 2001) for beef and from -0.0005 (Brester and Schroeder 1995) to 0.11 (Davis et al. 2001) for pork. For lamb, Capps and Williams (2008) estimate the checkoff promotion elasticity to be 0.044.

For cotton and orange juice, the results are similar. Estimated cotton checkoff advertising and promotion elasticities range from 0.023 (Murray, et al.) to 0.066 (Ding and Kinnucan 1996). A more recent and detailed study of the cotton checkoff program estimates the retail-level advertising elasticity to be 0.05 and 0.03 for non-agricultural production research. Williams, Capps, and Bessler (2004) estimated the orange juice checkoff program advertising and promotion elasticity at 0.127. In contrast, Ward (1988) found an orange juice advertising elasticity of 0.027 while Lee and Brown (1992) found an advertising elasticity of 0.01.

For the soybean checkoff program, three studies have provided estimates of the checkoff promotion advertising elasticity. Since the soybean checkoff program promotes both foreign and domestic demand for 3 separate products (soybeans, soybean oil, and soybean meal), the studies estimated elasticities for each product in the U.S. and the foreign countries or regions in which promotion programs are conducted. Williams (1985) estimated that the promotion elasticity of the foreign demand for soybeans ranged from 0.029 to 0.045 for the period of 1969 to 1979 depending on the country or region of promotion. For soymeal and soyoil, he estimated promotion elasticities of between 0.037 and 0.061 and between 0.001 and 0.08, respectively.

With updated data for the 1978-1994 period, Williams, Shumway, and Love (2002) estimated the promotion elasticity for foreign soybean, soymeal, and soyoil demand to range from 0.023 to 0.068, 0.045 to 0.073, and 0.016 to 0.045, respectively, depending on the country or region of promotion.

A 2003 study by World Perspectives, Inc. and AgriLogic, Inc. estimated a single promotion elasticity for the foreign export demand for each of the three products: 0.357 for soybeans, 0.819 for soymeal, and 1.46 for soyoil. Obviously, these estimated promotion elasticities are extremely high and well out of the range of those estimated for any other checkoff commodity.

While the estimates of the advertising and promotion elasticities have ranged widely even for the same commodity in different studies, the consensus across a broad range of research is that: (1) advertising can, but does not always, effectively increase commodity sales and (2) the response of sales to advertising (the advertising elasticity) for most commodities is small and usually in the range between close to zero and 0.1.

## Producer Benefits from Advertising and Promotion Studies

Even though advertising and promotion is now generally considered to be effective at increasing sales of most checkoff commodities, the important question for the producers and others who pay for the programs is whether the increase in sales and revenues generated are 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 spent on advertising and promotion, i.e., a benefit-cost ratio (BCR), as the increase in *market sales revenue or cash receipts* (net of promotion costs) per checkoff dollar

spent on advertising and promotion, referred to as a *revenue BCR* (RBCR).
When any additional production costs are first netted out of the additional revenue calculated to be generated by the program, the resulting BCR can be referred to as a *profit BCR* (PBCR). Sometimes economists use measures of the producer economic welfare, or producer surplus, generated by the program instead of revenue or profit to calculate a *surplus BCR* (SBCR).

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.[15] A few studies report 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, Schmit, and Kaiser 1996; Sellen, Goddard, and Duff 1997; Schmit et al. 2002; Williams, Shumway, and Love 2002; Williams, Capps, and Bessler 2004; Capps and Williams 2006). To account for the time value of money, a dynamic BCR can be discounted to present value (i.e., a *discounted BCR* or DBCR) 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 spent on 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 spent generates less than a dollar in additional sales, profits, or producer surplus.

Many studies report a "return on investment" (ROI) measure of the returns to producers from checkoff advertising/promotion expenditures. Often, those studies actually report a BCR rather than a true ROI. Often referred to as the "marginal rate of return" (MRR), an ROI is properly calculated as the percentage increase in sales revenues (*revenue ROI*), profits (*profit ROI*), or economic surplus (*surplus ROI*) from a 1% increase in advertising/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, that is, 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

[15] In other words, the BCR is calculated from the regression coefficient for advertising expenditures in the demand equation valued at the mean of historical demand.

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.

Most commodity checkoff program studies have found that advertising/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, the estimated return ranges from $1.85 to $7.04 (Table 2). A more recent study by Kaiser (2000) estimated the fluid return to advertising to be $4.3. Other studies focusing on diverse checkoff commodities such as beef, pork, lamb, orange juice, cotton, eggs, and rice have likewise reported impressive returns from their respective advertising and promotion programs (Table 2).

For the soybean checkoff program over the 1978-1994 period, Williams, Shumway, and Love (2002) estimated a producer profit ROI of $8 ($5 when discounted to present value over the life of the program). Using a model that the authors admit basically "mimicked" that of Williams, Shumway, and Love (2002), World Perspectives, Inc. and Agri-Logic, Inc. (2002) estimated a producer profit BCR for the soybean checkoff program of $6.75 for the 1995-2001 period.

The estimated BCRs for many other checkoff commodities are similar to those presented here in terms of both magnitude and range. The consensus across a wide range of studies by many researchers covering a large number of checkoff commodities seems to be that the return to producers from advertising and promotion by commodity checkoff organizations is positive. That is, in general, commodity checkoff program advertising and promotion have been found not only to increase sales but to increase sales by more than enough to cover the costs of the advertising and promotion activities.

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 $10. 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

To measure and compare the returns to soybean checkoff program investments in research and demand promotion, the first step was to isolate the effects of those investments in domestic and foreign soybean and soybean product markets from those of other events that may have affected those same markets over the years. For this purpose, soybean checkoff research, domestic promotion, and foreign demand promotion stock variables were constructed and incorporated into a world model of soybeans and soybean products. The model was then simulated over the 1980/81 to 2006/07 under alternative assumptions regarding soybean checkoff research and demand and international market promotion expenditure levels and the results used to calculate benefit-cost ratios for the soybean checkoff program.

**Table 2: Returns to Generic Commodity Promotion, Selected Studies**[a]

| Commodity/Study | Benefit-Cost Ratio (BCR) |
|---|---|
| | average $ earned per $ spent on advertising |
| Milk - Fluid | |
| Liu et al. (1989) | 7.04 |
| Ward and McDonald (1986) | 1.85 |
| Kaiser (2000) | 4.29 |
| Meat | |
| Beef: Ward (2001) | 5.70 |
| Pork: Davis et al. (2001) | 16.0 |
| Pork: Sellen, Goddard, and Duff (1997) | 6.12 |
| Lamb: Capps and Williams (2008) | 44.5 |
| Soybeans | |
| Williams, Shumway, and Love (2002) | 8.0 (5.0) |
| World Perspectives/AgriLogic (2003) | 6.75 |
| Orange Juice | |
| Lee and Fairchild (1988) | 2.28 |
| Capps, Williams, and Bessler (2004) | 6.1 (2.9) |
| Cotton | |
| Capps et al. (1996) | 3.23 to 3.49 |
| Murray et al. (2001) | 3.2 to 6.0 |
| Capps and Williams (2006) | 7.6 (5.7) |
| Eggs | |
| Schmit, Reberte, and Kaiser (1996) | 7.00 |
| Reberte, Schmit, and Kaiser (1996) | 6.00 |
| Rice Rusmevichientong and Kaiser (2009) | 6.21-14.48[b] |

[a] BCRs in parentheses are discounted to present value.
[b] Depending on the magnitude of the assumed prices elasticity of excess supply.

## The Structural Model

The analysis of the returns to producers from the soybean checkoff program in this study utilizes a fifth generation, 180-equation, annual econometric, non-spatial, price equilibrium simulation model of world soybean and soybean product markets (SOYMOD5) (see Williams 1981, Williams and Thompson 1984, Williams 1985, Williams 1994, Williams 1999, and Williams Shumway, and Love 2002 for more details on the model). Because they all have their roots in the early work of Houck, Ryan, and Subotnik (1972), SOYMOD5 is similar in form and specification to the world oilseed models utilized by Meilke and Griffith (1983) and more recently by Meilke, Wensley, and Cluff (2001).

SOYMOD5 allows for the simultaneous determination of the supplies, demands, prices, and trade of soybeans, soymeal, and soyoil in six major world trading regions: (1) the United States, (2) Brazil, (3) Argentina, (4) the European Union, (5) Japan, and (6) a Rest-of-the-World region which accounts for the effects of China and other new growth areas in world soybean markets. The domestic market of each region in the model is divided into four simultaneous blocks of equations: (1) a soybean block, (2) a soybean meal block, (3) a soybean oil block, and (4) an excess supply or excess demand block (Figure 17). For each region, the first three blocks contain behavioral relationships specifying the manner in which soybean supply (acreage planted, acreage harvested, soybean yields, and production), soybean domestic demand (crush and stocks), and the supply, consumption, and stocks of soybean meal and soybean oil behave in response to changes in variables like prices of soybeans and products, prices of various competing commodities, technology, income, livestock production and prices, government policy, etc. as appropriate.

For the U.S., the soybean block contains regional rather than national acreage planted, acreage harvested, yield, and production equations (equation (1) in Figure 17) for seven production regions (Atlantic, Cornbelt, Delta, Lakes, Plains, South, and Other) to represent the soybean supply relationship and account for interregional competition within the United States:

$$[1]\ AS_{kt} = AS_{kt}(PS^{e}_{kt}, RS_{kt}, \alpha_{kt}),$$

$$[2]\ HS_{kt} = HS_{kt}(AS_{kt}),$$

$$[3]\ YS_{kt} = YS_{kt}(RS_{kt}, \Theta_{kt}),$$

$$[4]\ SS_{kt} = YS_{kt} \bullet HS_{kt},$$

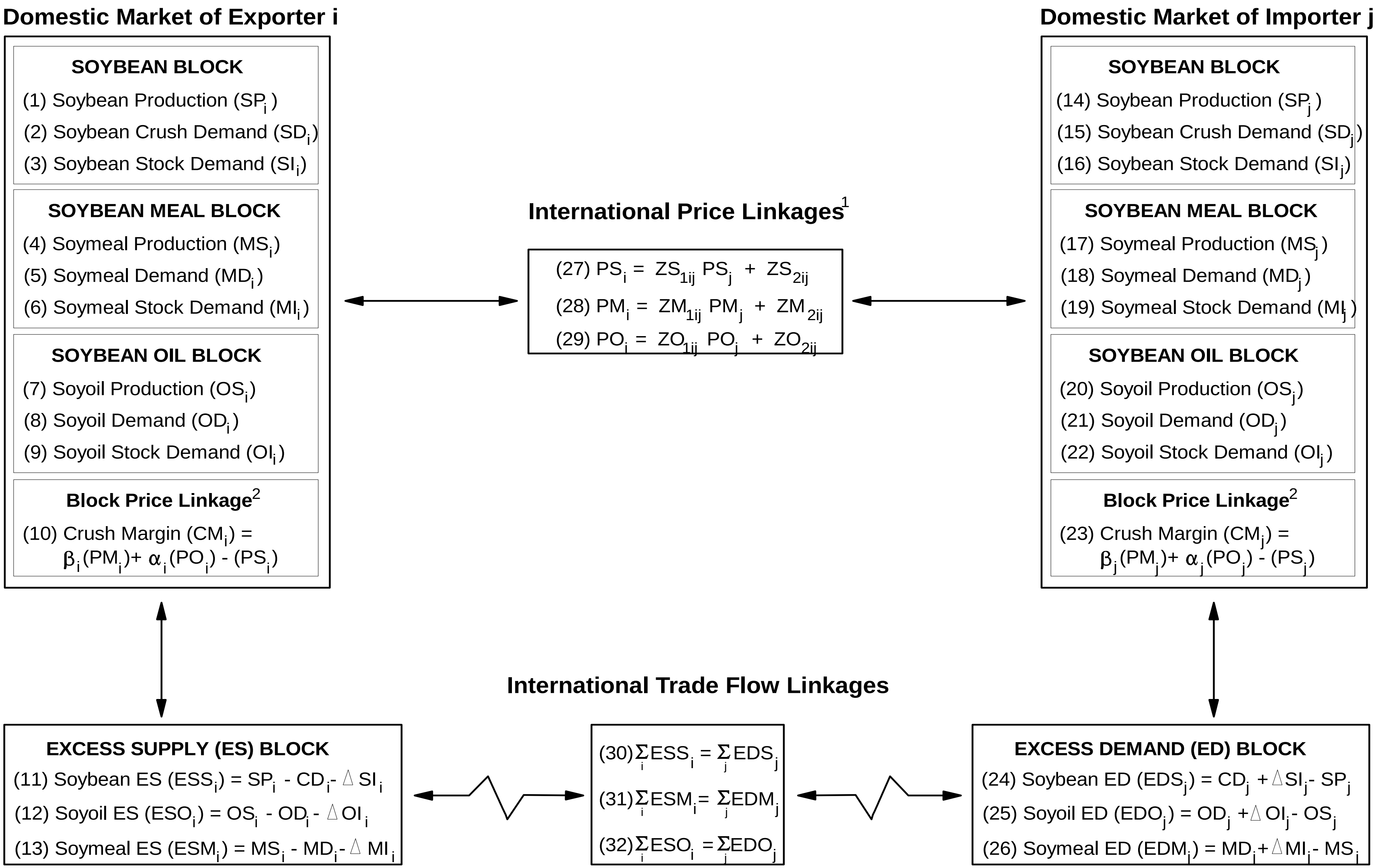
where k = production region 1,..., 7; t = time period; AS = soybean acreage planted; HS = soybean acreage harvested; YS= soybean yield; SS = soybean production; RS = soybean research stock variable; α and θ are appropriate shift variables and $PS^e$ = expected soybean farm price for each region:

$$[5]\ PS^{e} = MAX(PS_{t-1}, LS_{t}) \bullet D5901 + MAX(PS_{t-1}, 0.85 \bullet TS_{t} + 0.15 \bullet LS_{t}) \bullet D0207$$

where LS = the soybean loan rate; TS = soybean target price; D5901 = indicator variable which equals 1 for 1959/60 through 2001/02 and 0 otherwise; and D0207 = indicator variable which equals 1 for 2002/03 through 2007/08 and 0 otherwise.

The soybean research stock variables ($RS_k$) used in equations (1) and (3) were developed by Bessler (2009) based on two main results from previous research on the returns to research: (1) research benefits are not immediate so that a lag exists from the time the expenditures are made and possible real time adoption of results in the field and (2) research results from many years ago may still be yield benefits for a number of years into the future. Consequently, the $RS_k$ are formed as weighted averages of historical soybean checkoff expenditures on production research at the national and state level measured in constant dollars to account for the time lag in the impact of research expenditure. So, in general, for any region k:

**Figure 17: Structure of SOYMOD5**




Note: i = any exporter i=1, ... , n; and j = any importer j=1, ... , k. Also, $\Delta$ 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] $\beta$ and $\alpha$ are meal and oil extraction rates; PS, PO, and PM are soybean, soyoil, soymeal prices.

$$[6] \qquad RS_{ks} = \sum_{r=i} \lambda_r IS^*_{t-r} \quad \sum_{r=i} \lambda_t = 1,$$

where $IS^*_t = IS_t/p_t$ is the constant-dollar research investment in year t, $IS_t$ is the nominal-dollar research investment in year t, $p_t$ is the corresponding research price index, $\lambda_r$ is the weight on the constant dollar research expenditures lagged r years and i is the number of years before the first impact and s is the lag length over which research investments are expected to impact farm decisions. The $RS_k$ are proxies for the quantity of effective research.

To determine which of several alternative weighting schemes and lag structures on research investment is preferred for purposes of defining research stock variables, Bessler (2009) conducts a series of model specification tests, balancing fit and forecasts (or parsimony) in possible models. The metric used is that of Hannan and Quinn[16], given as:

$$[7] \; \Phi_k = \ln(\sigma_k^2) + [2k(\ln(\ln(T)))]/T,$$

which has two components: (1) $\ln(\sigma_k^2)$ which falls as more terms are added to the right hand side of the models tested where ln is the natural logarithm transformation and $\sigma_k^2$ is the residual error variance from fit versions of the model with k lags and (2) a penalty function which increases with more complex models.

The model specification that minimizes the Hannah and Quinn criterion (the sum of both terms) indicates a delay of four periods between actual expenditures of check-off production research dollars and new technology adoption and use in the field. Bessler selects (somewhat arbitrarily) an upper bound of ten lags since he could not search over more than 10 years due to degrees of freedom limitations. The resulting research stock ($RS_t$) measure developed by Bessler (2009) and used in equations [1] and [3] is a convex combination of research expenditures for the years t-4, t-5, t-6, t-7, t-8, t-9, t-10, with respective weights of .10, .20, .20, .20, .20, .05, and .05. Other weight patterns explored gave generally the same results[17].

The specification of the domestic demands (D) in the soybean, soybean meal, and soybean oil blocks of SOYMOD5 (corresponding to equations (2), (5), and (8) for any exporting region i and equations (15), (18), and (21) for any importing region j in Figure 17) include promotion stock variables, often referred to as "goodwill" variables (G), to capture the effects of soybean check-off funded promotion activities in each region where such activities have been conducted:

$$[8] \; D_{ist} = D_{ist}(P_{ist}, G_{ist}, \beta_{ist}),$$

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

The $G_{ij}$ (promotion stock variables) used as regressors in the appropriate SOYMOD5 demand equations were constructed following Williams (1999) and Williams, Shumway, and Love (2002) as weighted averages of the respective inflation- and exchange-adjusted expenditures on promotion activities in each region as appropriate. To capture diminishing marginal returns to domestic and foreign checkoff promotion expenditures, a square root transformation of the $G_{ij}$ was used. In most applications of evaluating

[16] For more discussion on this metric see Geweke and Meese (1981).

[17] See chapter 3 of Alston, Norton and Pardey (1998) for a general discussion of this issue.

the effectiveness of promotion campaigns, a logarithmic transformation of promotion expenditures is useful to capture diminishing marginal returns. However, because of the presence of zero promotion expenditures for some commodities in some years, a square root transformation was used instead.

To account for the time lag in the impact of the promotion investments on the soybean, soybean meal, and soybean oil demands in each region, Williams (1999) and Williams, Shumway, and Love (2002) used a second order polynomial inverse lag (PIL) formulation based on Mitchell and Speaker (1986). An alternative lag formulation commonly used in the analysis of advertising effectiveness is the Almon polynomial distributed lag (PDL). Other lag models have been employed in the literature on checkoff promotion programs, including moving averages and unrestricted lags of varying lengths.

The lag formulation and lag length used for each demand equation for each commodity (soybeans, soymeal, and soyoil) in each relevant region of the model (U.S., EU15/27, Japan, and the Rest-of-the-World) were selected using the process described earlier for production research expenditures. Although the PIL does not require specifying the lag length, it is conceptually an infinite lag. Thus, the use of the PIL lag formulation imposes the assumption on the model that advertising expenditures in one period have infinitely long impacts over time on consumption. Consequently, in testing for lag length, the PIL model was not included leaving the PDL formulation, moving averages, and simple lags of varying lengths as the potential lag formulations to be considered.
The search for the pattern and time period over which soybean checkoff promotion expenditures influence soybean and soybean product demand in each region in the model involved a series of nested OLS regressions. For each lag formulation considered, lags of up to 10 years were considered and for the PDL up to fourth degree polynomials with alternative choices of head and tail restrictions. Based on a composite set of criteria, including the Akaike Information Criterion (AIC), the Schwarz statistic, the Hannan-Quinn criterion, and heuristic measures[18] (i.e., the number of significant parameters and number of expected signs on own-price demand response), a second order PDL of two lags with head and tail restrictions was selected for U.S. soybeans, soymeal, and soyoil demand functions.

For foreign market demands, simple, one-year lags of the square root transformation of the respective $G_{ij}$ were selected using the same criteria. Before being transformed in this way, however, the $G_{ij}$ for the U.S. and foreign markets were first deflated by the wholesale price index in the respective regions and then the foreign $G_{ij}$ were converted from U.S. dollars to foreign currency with the respective exchange rates.

Simultaneous interaction of soybean and soybean product markets within each region in SOYMOD5 is insured through the endogenous soybean crush margin (equations (10) and (23) in Figure 17) which is the own price variable in the crush demand equations ((2) and (15) in Figure 17). The fourth block in each domestic market (equations (11)-(13) and (24)-(26) in Figure 17) of the model includes net excess supply relationships for exporting regions and net excess demand relationships for importing regions specified as the residual differences between their respective domestic supply and demand schedules.

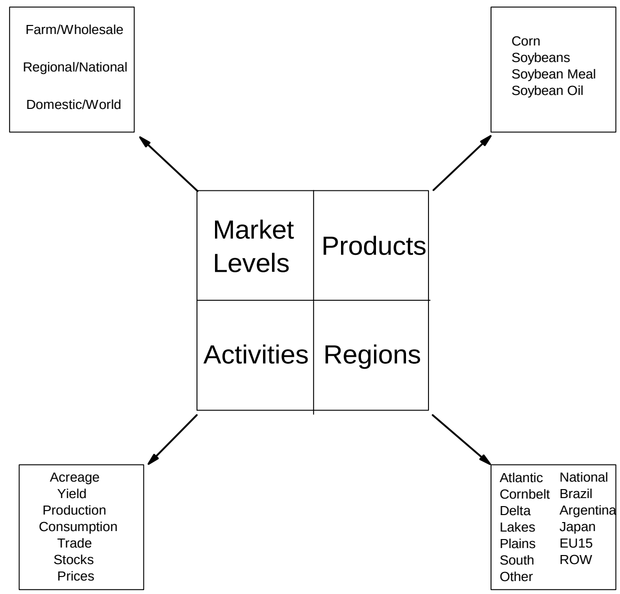
[18] The heuristic aspect of the composite criteria may be viewed as *ad hoc* but is equivalent to restricting the class of models to be only those consistent with underlying theory. This procedure is commonly encountered in the literature, especially in analyses where equilibrium displacement models are used and only parameter values consistent with theory are utilized.

Because of the important simultaneous interaction between the U.S. soybean and corn markets, SOYMOD5 also includes a model of the U.S. corn market. The specification of the U.S. supply and demand blocks of the corn model is similar to that for soybeans. The U.S. corn market model, however, is closed with a world corn import demand equation.

The soybean and soybean product markets of the trading countries in the model are linked through international price and trade flow relationships. The prices of soybeans, soymeal, and soyoil in exporting and importing regions are linked through price transmission equations (equations (27)-(29) in Figure 17) following Bredahl, Meyers, and Collins (1979) which account for the effects of exchange rates as well as tariffs, export subsidies, border taxes, transportation costs, etc. and other factors (the $Z_{ij}$) that drive a wedge between prices in each world region. International market clearing conditions (equations (30)-(32) in Figure 17) require equality of the world excess supply and demand for soybeans, soymeal, and soyoil in each time period.

Figure 18 summarizes the many dimensions of SOYMOD5. The model includes acreage, yield, production, consumption, inventory, price, and trade relationships and operates at both the farm and wholesale levels in all countries and regions for four products (corn, soybeans, soymeal, and soyoil). The U.S. model includes seven production regions and the full model includes six trading countries/regions.

**Figure 18: Dimensions of SOYMOD5**




## Data

SOYMOD5 includes 180 equations and endogenous variables and 409 exogenous variables. Two types of data were needed for the analysis of the soybean checkoff program: (1) data to support SOYMOD5 (e.g., supply, demand, trade, price, policy, etc. data by country and commodity over time) and (2) soybean checkoff and related expenditures over time.

The first set of data relate to most of the model endogenous and exogenous variables (supply, demand, trade, price, policy, etc. by country and commodity over time) and are taken from numerous public sources, including USDA (for example, USDA-ERS, USDA-FAS, and USDA-NASS) for 1959/60 through 2006/07 as available. The full data base is compiled, published, and available in TAMRCd (2009).

Three types of soybean checkoff and related expenditures were needed for the analysis: (1) national and state-level expenditures for soybean production research, (2) national and state-level expenditures to promote soybeans and products in the United States, and (3) national and state-level international market promotion expenditures. The national and state-level soybean research expenditure data for 1970/71 through 2006/07 were provided by Keith Smith and Associates. These data are compiled, published, and available in TAMRCc (2009). Unfortunately, the production research data for 1996/97 through 1999/00 were not collected and maintained and, thus, were interpolated following a random walk model (Bessler 2009).

National-level (USB) data on expenditures to promote the domestic demand of soybeans, soymeal, and soyoil were provided by Smith Bucklin Corp., a management contractor of the United Soybean Board. Unfortunately, data for state-level (QSSB) expenditures to promote domestic and international soybean and product demand have not been systematically collected and maintained. Both Williams, Shumway, and Love (2002) and World Perspectives, Inc./ Agri-Logic, Inc. (2003) reported the same problem with the QSSB promotion expenditure data in their studies of the soybean checkoff program. Williams, Shumway, and Love (2002) attempted to collect the needed data by survey but report that the data they collected "were fragmentary, highly inconsistent in quality, type, time period, and level of aggregation" and, therefore, not useful for analytical purposes (p. 103).

Undaunted, the authors of this study once again attempted to collect state-level domestic and international promotion expenditure data from the QSSBs for the period since the implementation of the national soybean checkoff program. Because many QSSBs had not changed their expenditure data collection and maintenance practices since the first attempt to collect that data by Williams, Shumway, and Love (2003) in the mid-1990s, many simply reported that the data were not available or reported a few years of sketchy data that had been kept. A few state QSSBs, notably those in Kansas, Maryland and Pennsylvania, Michigan, Minnesota, Nebraska, the Northeast Region, Ohio, Tennessee, and Texas, provided good records of expenditures for that time period. Several others provided what little they had. In the end, however, the result was the same as before in that the data in the aggregate were too full of holes and inconsistent in time period, coverage, and other details to be useful for analysis. Consequently, in the analysis of domestic and international promotion programs, only national-level data are used. All domestic promotion expenditure data collected, at both the national and state-level, are compiled, published, and available in TAMRCa (2009).

Data on national-level international demand promotion expenditures by product, country, and contributor for 1970/71 through 2006/07 were compiled from various sources, primarily the American Soybean Association (ASA), the U.S. Soybean Export Council (USSEC), the USDA Foreign Agriculture Service (FAS), and the United Soybean Board (USB). The data used are compiled, published, and available in TAMRCb (2009). Although fragmentary at best, available soybean international market promotion expenditure data prior to 1970/71 indicate that the international promotion program was quite small during that period and that promotion activities occurred almost entirely in Japan. Consequently, soybean and product international market promotion expenditures were assumed to be zero for the pre-1970/71 period.

## Model Parameter Estimation and Validation

The parameters of the U.S. soybean supply and corn blocks of the model were estimated using the Nonlinear Iterative Seemingly Unrelated Regression (ITSUR) estimator with annual data for 1970/71 through 2006/07. Normalization by an exogenous input price index maintained linear homogeneity in prices.

In their model of U.S. regional soybean supply, Lim, Shumway, and Love (2000) also maintained symmetry among cross-price parameters. Negative estimated own-price elasticities of supply in their model, however, led them to square the own-price parameters to force upward slopes on supply. The consequence was own-price elasticities that were extremely close to zero in most cases and not statistically significant in all but one U.S. soybean production region and two corn production regions. In addition, tests for nonjoint production in each region of the Lim, Shumway, and Love model led to the "surprising" conclusion that soybeans are not jointly produced with corn or any other commodity in any region.

Given the questionable and counterintuitive econometric results of Lim, Shumway, and Love, the specification of the equations in the U.S. soybean and corn supply blocks of SOYMOD was simplified, including relaxing the symmetry condition. The estimated parameters of the behavioral equations in all production regions in both blocks are unconstrained, consistent with *a priori* expectations in sign and magnitude, and statistically significant. All Durbin-h and Durbin Watson statistics indicate no evidence of autocorrelation.

As expected, the responsiveness of soybean acreage and yield to changes in both the soybean farm price and the soybean research stock, particularly over the long-run, is generally higher outside the Cornbelt in the less traditional and more marginal regions of soybean production (Table 3). Both price and research stock elasticities for planted acreage and yield are similar across regions and of the same order of magnitude and statistical significance as those estimated by Williams, Shumway, and Love (2002). The main exception is that the estimated relationships between the acreage planted in the Atlantic, Delta, and South regions and the respective research regional stock variables in this study were not found to be statistically significant. Consequently, in the simulation analysis of the effectiveness of the soybean checkoff program discussed later in this study, the coefficients of the research stock variables in those three regions were set to zero.

The remaining parameters of the model were estimated by means of a truncated two-stage least squares (2SLS) procedure based on principal components using data for 1969/70 to 2006/07[19] in most cases. The use of a systems estimator like three-sage least squares was deemed impractical since the common time period over the large dataset required to support the model was only about 27 years so that the cost in terms of lost degrees of freedom would be likely to be at least as large as any gain in efficiency that might be achieved.

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. Details of the full model, estimated parameters, and regression statistics, are provided in Appendix 1 with variable definitions in Appendix Table 2.

The estimated direct price and promotion stock elasticities of demand are provided in Table 4. In each case, the promotion stock elasticities are quite small and consistent in both magnitude and sign with the results of Williams, Shumway, and Love (2003) as

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

**Table 3. SOYMOD5 Estimated U.S. Soybean Acreage and Yield Elasticities[a]**

| U.S. Production Region | U.S. Planted Acreage | | | | U.S. Yield | |
|---|---|---|---|---|---|---|
| | Soybean Farm Price | | Research Stock[b] | | Research Stock | |
| | Short Run | Long Run | Short Run | Long Run | Short Run | Long Run |
| Atlantic | 0.6002* | 2.1308* | 0.0000 | 0.0000 | 0.0173* | 0.2168* |
| Corn Belt | 0.1834* | 0.5594* | 0.0228* | 0.0809* | 0.0514* | 0.1567* |
| Delta | 0.3898* | 1.8909* | 0.0000 | 0.0000 | 0.0606** | 0.2942** |
| Lakes | 0.2577* | 0.7736* | 0.0292* | 0.3644* | 0.0134* | 0.1669* |
| Other | 0.5383* | 1.7329* | 0.0449** | 0.4162** | 0.0005* | 0.0050* |
| Plains | 0.1786* | 0.6736* | 0.0514* | 0.5055* | 0.0176* | 0.2521* |
| South | 0.9514* | 4.1153* | 0.0000 | 0.0000 | 0.0253** | 0.2107* |

[a] Elasticities evaluated at the means of the data based on the coefficients used in the simulation model. * = coefficient significant at the 1% level. **= coefficient significant at the 5% level.

[b] Because the estimated coefficients of the research stock variables for planted acreage in the Atlantic, Delta, and South regions were not significantly different from zero at least at the 10% level , the coefficients of these variables in the simulation model were set to zero.

**Table 4. SOYMOD5 Estimated Domestic Price and Promotion Stock Elasticities of U.S. and Foreign Demand[a]**

| Region | Domestic Price | | | Promotion Stock | | |
|---|---|---|---|---|---|---|
| | Soybeans[b] | Soymeal[c] | Soyoil[c] | Soybeans | Soymeal | Soyoil |
| U.S. | 0.109** | -0.236* | -0.118* | 0.046* | 0.034* | 0.029* |
| EU-15/27 | 0.052* | -0.230* | -0.180* | 0.040*** | 0.059** | 0.031** |
| Japan | 0.020* | -0.316* | -0.219* | 0.029** | 0.043* | 0.020*** |
| ROW | -1.00[d] | -.80[d] | -.80[d] | 0.063** | 0.062 | 0.052** |

[a] All elasticities evaluated at the means of the data.. * = significant at the 1% level. **= significant at the 5% level, and ***=significant at the 10% level.
[b] Elasticities of domestic demand with to respect to the gross soybean crushing margin for the U.S., EU-15/27, and Japan and elasticity of import demand with respect to soybean price for the Rest-of-the-World (ROW).
[c] Direct price elasticities of domestic demand for U.S., EU-15/27 and Japan and direct import demand elasticities for ROW.
[d] For the ROW (Rest-of-the-World) region, price elasticities are constrained.

well as with studies of other checkoff commodities (see earlier section on "Studies on the Return to Commodity Promotion Expenditures" to compare these results to those of other Studies). Most estimated promotion stock elasticities are statistically significant at the 1% or 5% level.

Validation of the structural model included both a check of the dynamic, within-sample (*ex-post*) simulation statistics for the fully simultaneous structural model and a sensitivity analysis to check the stability of the model. The common time period across all data types defined 1980/81 to 2006/07 as the period for the simulation analysis of the effectiveness of the soybean checkoff program. Dynamic simulation statistics (e.g., the root mean squared error, Theil inequality coefficients, and the Theil error decomposition proportions) were calculated from simulating the full model over the 1980/81 to2006/07 sample period, i.e., the baseline historical simulation (see Appendix Table 3). Those statistics indicate a highly satisfactory fit of the historical, dynamic simulation solution values to observed data.
The Theil U coefficients were small with all less than 0.4. The Theil bias error proportion indicated no systematic deviation of simulated from actual data values for any of the endogenous variables. To check the stability of the model, a test of the sensitivity of the model to a one-period shock in checkoff investments was conducted. First, nominal checkoff investments both in U.S. soybean production research and in demand promotion in the U.S. and across all importing regions and all commodities were increased by 10% in 1980/81 (the first year of the simulation sample period). The respective investment stock variables were then re-generated and the model was re-simulated over the 27-year period of 1980/81 to 2006/07. Following the initial period shock, all endogenous variables returned to equilibrium within a reasonable time period (most within 5-10 years) indicating that the model is highly stable to changes in checkoff investments over time.

## ANALYSIS OF THE SOYBEAN CHECKOFF PROGRAM EFFECTIVENESS

Recall that the primary objective of this analysis of the effectiveness of the soybean checkoff program is to answer two key questions: 1) What have been the effects of the soybean checkoff program over time on U.S. and world soybean and soybean product markets (supplies, demands, prices, trade, etc.) and (2) Have soybean producers benefitted from the soybean checkoff program and, if so, by how much? To answer these questions, two scenarios were analyzed using SOYMOD5 (as developed and presented earlier in this report): (1) a *with* soybean checkoff expenditures scenario (referred to as the "*with* scenario") and (2) a *without* soybean checkoff expenditures scenario (referred to as the "*without* scenario").

The *with* scenario represents actual history, that is, the level of supply, demand, prices, trade, etc. in world soybean and soybean product markets that include any effects on those markets from soybean checkoff expenditures in the U.S. and around the world. The *with* scenario analysis was conducted through historical simulation of SOYMOD5 over the 1980/81 through 2006/07 period of analysis to generate a baseline scenario of the endogenous variables in the model (e.g., production, demand, prices, trade, etc.) that closely replicate the actual, historical values of those variables.

Because the baseline historical simulation for this study was generated in the process of validating SOYMOD5, the accuracy of the model in tracking the historical values of model values can be determined through inspection of the baseline simulation statistics discussed earlier and presented in Appendix Table 3. The statistics show that the model replicates the functioning of U.S. and world soybean markets extremely well and that the baseline simulation of the model variables fits the historical data equally as well.

The *without* scenario analysis was conducted by setting the historic values of soybean checkoff production research and U.S. and international market promotion expenditures to zero in SOYMOD5 and then simulating the model again over the 1980/81 to 2006/07 period of analysis to generate new values for U.S. and world soybean and product production, consumption, trade, prices, etc. Because the changes in the endogenous model variables in this *without* scenario were generated by changing only the levels of checkoff expenditures, they represent those that would have existed over time *if there had been no checkoff program.* Differences in the simulated levels of the model variables (world supplies, demand, prices, trade, etc.) in the *with* scenario from those in the *without* scenario are then taken as direct measures of the effects of the checkoff expenditures. Because no other exogenous variable in the model (e.g., levels of inflation, exchange rates, income levels, agricultural and trade policies, etc.) other than checkoff expenditures is allowed to change in either scenario, this process effectively isolates the effects of the soybean checkoff program on the U.S. and world soybean markets, prices, and trade. That is, the simulated differences between the values of the endogenous variables from the *with* checkoff expenditure scenarios and from the *without* checkoff expenditures scenario in which those expenditures are set to zero provide direct measures of the historical effects of the soybean checkoff expenditures (and only those expenditures) on the U.S. and world soybean and product markets.

The analysis of the effectiveness of the soybean checkoff program begins by considering the first question posed earlier through an examination of the simulated effects of the soybean checkoff program on U.S. and world soybean product markets, that is, the differences between the *with* and *without* scenario results. Then the second question is considered by using the scenario analysis results to conduct a benefit-cost analysis of the soybean checkoff program over the 1980/81-2006/07 period of analysis at the soybean grower level.

## Effects of the Soybean Checkoff Program on U.S. and World Soybean and Soybean Product Markets

A comparison of the *with* and *without* scenario analyses indicates clearly that the soybean checkoff program has been effective in increasing U.S. soybean production, crush, exports, price, world market share, and producer profits. The results indicate that, on average between 1980/81 and 2006/07, U.S. soybean planted acreage was 3.7% higher in each year than would have been the case in the absence of the soybean checkoff program (Table 5). Likewise, U.S. soybean production was higher by 4.2%, soybean farm price by 1.6%, and soymeal price by 2.1% on average in each year as a result of the checkoff program.

On the other hand, the net effects on the soyoil price and the crush margin were slightly negative over the full 1980/81-2006/07 period (Table 5). The negative result for the soyoil price is likely the result of at least two factors: (1) the declining share of expenditures allocated to soyoil in international market promotion in recent years and (2) the increasing relative importance of domestic promotion programs in which the soymeal allocation is relatively higher than has historically been the case for soymeal in international promotion programs. The small change in the crush margin simply reflects the offsetting effects of the higher soybean price against the higher soymeal price.

Note that the average annual levels of U.S. soybean crush and soymeal and soyoil consumption were also higher over the 1980/81-2006/07 period as a result of the soybean checkoff program by 4.2%, 1.6%, and 2.0%, respectively (Table 5). These average annual results for the full period, however, obscure the actual effectiveness of the domestic promotion programs since they have been in place only since the early 1990s.

Table 5 decomposes the effects of the soybean checkoff program into two time periods: (1) the 1980/81-1991/92 period prior to the implementation of the national soybean checkoff program (referred to as the "*voluntary* checkoff period") and (2) the 1992/93-2006/07 period since the national program was implemented (referred to as the "*national* checkoff period"). Note that over the *national* checkoff period, the average annual level of crush demand was 5.3% higher than would have been the case without the program while those of soymeal and soyoil consumption were 3.1% and 3.4% higher, respectively. Importantly, these effects are the <u>net</u> result of two forces: (1) the *direct* effects of U.S. domestic checkoff promotion programs and (2) the *indirect* effects of all soybean checkoff programs (U.S. and foreign) on prices which affects the quantities consumed of each commodity.

During the *national* checkoff program period, the relatively larger increase in soybean crush demand than in soymeal or soyoil demand implied an increase in supplies of soymeal and soyoil relative to their demands. The consequence was a lower price of soymeal and soyoil during that period as a result of the program than otherwise would have been the case. The *indirect* effect of lower prices led to higher quantities of soymeal and soyoil consumed adding to the *direct* effects of the promotion programs in shifting out the demands of the two products. In this case the *direct* and *indirect* effects worked together to produce greater effectiveness of the promotion programs for U.S. demand for soymeal and soyoil.

In the case of soybean crush, however, the *direct* and *indirect* effects work against each other producing a net effect on the level of soybean crush that is lower than would be the case without the indirect price effects. The lower average annual crush margin during the *national* checkoff period put downward pressure on the domestic soybean crush demand while the *direct* effects pushed the crush demand outward resulting in a net 5.2% increase in U.S. soybean crush demand.

The importance of the *direct* and the *indirect* effects of the checkoff program is particularly notable during the *voluntary* checkoff program period when there were no checkoff expenditures for domestic promotion programs. During that period, the large expenditures on international market promotion relative to those on production research resulted in an increase in foreign demand for soybeans, soymeal, and soyoil and an increase in the prices of soybeans, soymeal, and soyoil of 5%, 2.1%, and 2.4%, respectively. The *indirect* effects of those price increases put downward pressure on soymeal and soyoil use in U.S. markets during that period. Without domestic promotion programs to generate *direct* effects in shift-

**Table 5: Effect of Total Checkoff Expenditures on U.S. Soybean and Products Markets, 1980/81-2006/07**

| | 1980/81-91/92 | | 1992/93-2006/07 | | **1980/81-2006/07** | |
|---|---|---|---|---|---|---|
| **Annual Average Change In:** | 1,000 acres | % | 1,000 acres | % | **1,000 acres** | **%** |
| **U.S. Soybean Planted Acres** | | | | | | |
| Cornbelt | 700.6 | 2.3 | 1,096.3 | 3.3 | **920.4** | **2.9** |
| Delta | 243.9 | 2.8 | 184.8 | 3.1 | **211.1** | **3.0** |
| South | 338.0 | 5.3 | 206.1 | 6.1 | **264.7** | **5.6** |
| Plains | 256.8 | 4.4 | 714.0 | 6.4 | **510.8** | **5.8** |
| Lakes | 266.1 | 4.3 | 425.3 | 4.6 | **354.6** | **4.5** |
| Atlantic | 135.1 | 3.3 | 78.2 | 2.6 | **103.5** | **3.0** |
| Other | 17.9 | 5.6 | 35.0 | 6.4 | **27.4** | **6.1** |
| Total | 1,958.4 | 3.2 | 2,739.8 | 4.1 | **2,392.5** | **3.7** |
| | mil. bu. | % | mil. bu. | % | **mil. bu.** | **%** |
| **U.S. Soybean Production** | | | | | | |
| Cornbelt | 27.9 | 2.7 | 55.6 | 4.0 | **43.3** | **3.5** |
| Delta | 6.9 | 3.7 | 6.3 | 3.6 | **6.6** | **3.7** |
| South | 8.5 | 6.0 | 6.4 | 6.2 | **7.3** | **6.1** |
| Plains | 7.4 | 4.6 | 25.9 | 6.7 | **17.7** | **6.2** |
| Lakes | 9.1 | 4.4 | 16.7 | 4.8 | **13.3** | **4.7** |
| Atlantic | 3.4 | 3.7 | 2.4 | 2.8 | **2.8** | **3.2** |
| Other | 0.6 | 5.9 | 1.3 | 6.5 | **1.0** | **6.3** |
| Total | 63.8 | 3.5 | 114.5 | 4.6 | **92.0** | **4.2** |
| **U.S. Soybean Crush** | 24.6 | 2.3 | 77.5 | 5.3 | **54.0** | **4.2** |
| | 1,000 tons | % | 1,000 tons | % | **1,000 tons** | **%** |
| **U.S. Soybean Meal Consumpti** | -214.7 | -1.1 | 881.8 | 3.1 | **394.4** | **1.6** |
| | mil. lbs. | % | mil. lbs. | % | **mil. lbs.** | **%** |
| **U.S. Soybean Oil Consumptior** | -37.9 | -0.4 | 512.7 | 3.4 | **268.0** | **2.0** |
| | $/unit | % | $/unit | % | **$/unit** | **%** |
| **U.S. Wholesale Soybean and Product Prices** | | | | | | |
| Soybean ($/bu) | 0.15 | 2.4 | 0.06 | 1.0 | **0.10** | **1.6** |
| Soymeal ($/ton) | 9.38 | 5.0 | -0.31 | -0.2 | **3.99** | **2.1** |
| Soyoil (cents/lb) | 0.44 | 2.1 | -0.39 | -1.7 | **-0.02** | **-0.1** |
| Crush Margin ($/bu) | 0.13 | 14.6 | -0.11 | -7.7 | **-0.01** | **-0.4** |

ing out the demand curves of those two products to offset the negative *indirect* price effects, the final result during that period was lower annual average domestic use of soymeal and soyoil by 1.1% and 0.4%, respectively as a result of checkoff programs than otherwise would have been the case.

Figure 19 provides some insight on the changes in U.S. markets and prices over time brought about by the voluntary and national mandatory checkoff programs. In the *voluntary* checkoff period, the checkoff program was responsible for increasing soybean production annually by an average of about

64 million bushels (top left graph in Figure 19). The annual impact on production remained the same until about 1997/98 when growing soybean research expenditures during *national* checkoff period began to have an effect on production. While the average annual production impact of the checkoff program increased increased to 92 million bushels during the *national* checkoff period, the annual impact has continued to grow, hitting about 170 million bushels in 2006/07. The growth in the checkoff program's effect on production will likely continue growing in the future as past expenditures continue to have an impact into the future and additional expenditures are made. Recall from an earlier section that Bessler (2009) found that there is a four year lag between expenditures on production research and initial production effects and that the expenditures continue to have an effect for up to ten years.

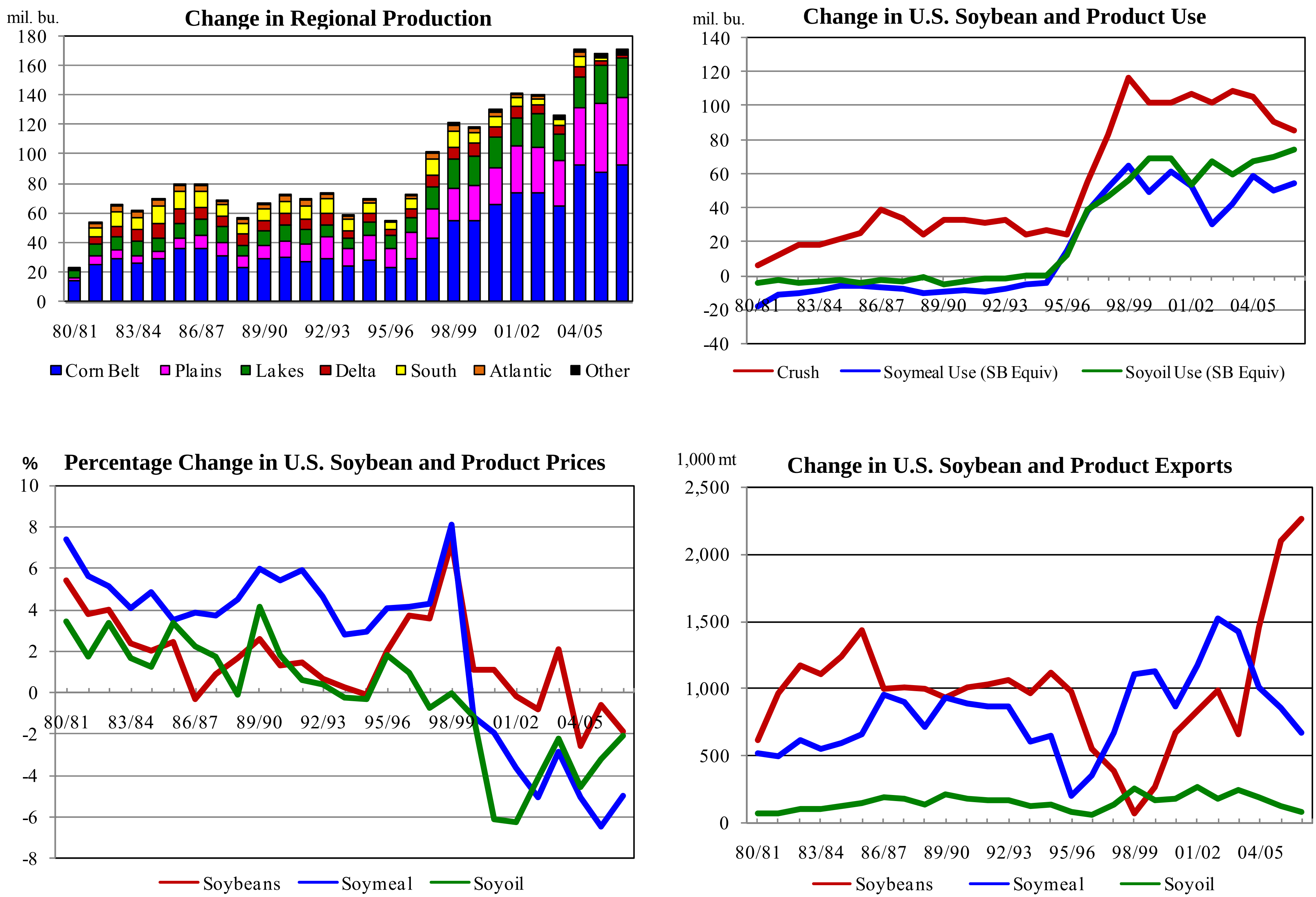
The larger annual increase in production during the *national* period made increasing additional supplies of soybeans available for crushing. As a result, the annual increase in soybean crush jumped from an average of about 25 million bushels during the *voluntary* period to a high of nearly 120 million bushels in 1998/99 following implementation of the national checkoff program (see top right graph of Figure 19). At the same time, the large increase in production meant that instead of supporting soybean and soybean product prices as it had during the voluntary period, the checkoff program actually pressured prices down to lower levels than otherwise would have existed during the national period (see bottom left graph in Figure 19).

The increased soybean production during *national* period as a result of the checkoff program together with a growing shift of international promotion funds to promoting soybeans rather than value-added soybean products also led to a sharp increase in soybean exports over that period to an average annual level of about 2.3 million metric tons (mt) increase in 2006/07. This checkoff-induced surge in U.S. soybean exports began during the late 1990s, when the impact of the checkoff program on U.S. soybean exports had all but disappeared (bottom right graph of Figure 19). In 1998/99, the annual impact of the checkoff program on soybean exports had dropped to only 70,000 mt compared to 1.1 million mt just four years earlier. The surge that followed pushed the annual impact on soybean exports up almost continually to nearly 2.3 million mt in 2006/07.

On average over the entire 1980/81-2006/07 period, the soybean checkoff program boosted soybean exports each year by an average of 993,600 mt or nearly 5% (Table 6). Although the program also raised the annual level of Brazilian soybean exports, the increase was less than a third of the increase experienced by U.S. soybean exports (295,900 mt). The U.S. soybean-checkoff-induced increase in Argentine soybean exports was only 123,600 mt on average each year over the same period.

For U.S. soymeal and soyoil, the checkoff program boosted exports by an annual average of 15% and 24%, respectively, over the full 1980/81-2006/07 period (Table 6). Although both Brazil and Argentina also experienced increases in their average annual exports of soymeal and soyoil due to the checkoff, the increases were insufficient to maintain their shares of world trade in the two products. Consequently, the U.S. share of world soymeal and soyoil exports increased by over 9 and 23 percentage points, respectively, while those of Brazil and Argentina declined. In other words, the U.S. soybean checkoff program boosted U.S.

**Figure 19: Effects of the Soybean Checkoff on U.S. Acreage Planted, Domestic Use, Prices, and Exports, 1980/81-2006/07**



soybean, soymeal, and soyoil exports and the U.S, export market share of all three products while reducing the export shares of both Brazil and Argentina.

By comparing the impact of the checkoff program on world soybean and product trade before and after the implementation of the national soybean checkoff program, the effects of the shift in international promotion strategy become more clear. The increasing share of international market promotion funds allocated to smaller, less developed countries and away from the EU and Japan resulted in a sharp decline in the annual average increase in imports of all three products by the latter two countries and a surge in imports by other countries (Table 6). The average annual increase in soybean imports by the EU and Japan dropped from just over 754,400 mt and 197,800 mt, respectively, during the *voluntary* period to only 444,900 mt and 100,900 mt, respectively, during the *national* period. In contrast, the average annual increase in soybean imports by the rest of the world as a result of the checkoff program jumped substantially from 340,300 mt to nearly 1.6 million mt. The story is the same for soymeal and soyoil imports. In the case of EU, the reduction in U.S. promotion of soyoil consumption in those countries over time led to lower soyoil demand by those countries and, thus, greater EU exports of soyoil in competition with U.S. exports.

## Benefit-Cost Analysis of the Soybean Checkoff Program

Clearly, based on a comparative analysis of the *with* and *without* checkoff expenditure scenarios as summarized in the previous section and illustrated in Tables 5 and 6 and Figure 19, the answer to the first key question regarding the U.S. soybean checkoff program posed earlier is that it has effectively increased the supply, demand, prices, trade, and export market shares of U.S. soybean and soybean products.

The second key question, the more critical question that must be answered about the U.S. checkoff program, is whether any gains in profit realized by soybean producers as a result of the program have been sufficient to more than pay for the cost of the program. That is, has the program run at a loss or a profit over time? Have the market effects induced by the checkoff program been substantial enough to generate sufficient additional profits to soybean producers over time to more than cover the cost of the checkoff program? If not, then the conclusion would be that the program should be discontinued because the program costs producers more than it returns to them. On the other hand, if the profits generated more than cover the costs, the program would be deemed a successful investment opportunity for soybean producers.

This section, then, provides a benefit-cost analysis of the soybean checkoff program to answer these questions based on the results of the scenario analyses discussed in the previous section. As usually calculated, the producer *profit* Benefit Cost Ratio (PBCR) is the additional industry profits (additional cash receipts net of additional production costs and checkoff assessments) earned by producers as a consequence of the checkoff expenditures (as measured through the scenario analyses) divided by the historical level of checkoff expenditures made to generate those additional profits. For the soybean checkoff program, the additional soybean industry profits (in $million) generated by the program in any given year (t) are calculated as:

$$[9]\quad R_t = (p_t^w q_t^w - c_t^w A_t^w) - (p_t^{wo} q_t^{wo} - c_t^{wo} A_t^{wo})$$

## Table 6: Soybean Checkoff Program Effects on World Soybean and Products Trade and U.S. Market Share, 1980/81-2006/07

| **Average Change In:** | 1980/81-1991/92 | | 1992/93-2006/07 | | 1980/81-2006/07 | |
|---|---|---|---|---|---|---|
| | 1,000 mt | % | 1,000 mt | % | 1,000 mt | % |
| **World Soybean Imports** | | | | | | |
| EU-15/27 | 754.4 | 5.9 | 444.9 | 3.0 | 582.4 | 4.2 |
| Japan | 107.8 | 2.4 | 100.9 | 2.2 | 104.0 | 2.3 |
| Rest of the world | 340.3 | 6.0 | 1,035.9 | 4.8 | 726.8 | 5.0 |
| Total | 1,202.5 | 5.3 | 1,581.7 | 3.8 | 1,413.2 | 4.3 |
| **World Soybean Exports** | | | | | | |
| United States | 1,040.0 | 5.6 | 956.6 | 4.0 | 993.6 | 4.6 |
| Brazil | 141.7 | 6.8 | 419.3 | 3.5 | 295.9 | 3.9 |
| Argentina | 20.8 | 0.9 | 205.8 | 4.0 | 123.6 | 3.2 |
| Total | 1,202.5 | 5.3 | 1,581.7 | 3.8 | 1,413.2 | 4.3 |
| **World Soymeal Imports** | | | | | | |
| EU-15/27 | 1,147.2 | 15.1 | 620.2 | 3.8 | 854.4 | 6.9 |
| Japan | 71.1 | 23.2 | 55.8 | 5.7 | 62.6 | 9.2 |
| Rest of the world | 14.0 | 0.2 | 794.4 | 5.5 | 447.6 | 3.9 |
| Total | 1,232.3 | 7.6 | 1,470.4 | 4.7 | 1,364.6 | 5.5 |
| **World Soymeal Exports** | | | | | | |
| United States | 727.2 | 14.8 | 873.8 | 15.3 | 808.6 | 15.1 |
| Brazil | 441.6 | 5.7 | 540.2 | 4.9 | 496.4 | 5.2 |
| Argentina | 63.5 | 1.8 | 56.4 | 0.4 | 59.5 | 0.6 |
| Total | 1,232.3 | 7.6 | 1,470.4 | 4.7 | 1,364.6 | 5.5 |
| **World Soyoil Imports** | | | | | | |
| Japan | 0.3 | 3.9 | -13.6 | -47.1 | -7.4 | -39.0 |
| Rest of the world | 241.7 | 9.3 | 283.8 | 4.7 | 265.1 | 5.9 |
| Total | 242.0 | 9.3 | 270.1 | 4.5 | 257.6 | 5.7 |
| **World Soyoil Exports (000 mt)** | | | | | | |
| United States | 138.4 | 23.9 | 158.8 | 24.1 | 149.8 | 24.0 |
| Brazil | 49.0 | 6.9 | 36.4 | 2.3 | 42.0 | 3.5 |
| Argentina | 13.5 | 2.1 | 12.7 | 0.4 | 13.0 | 0.6 |
| EU-15/27 | 41.0 | 6.1 | 62.2 | 13.6 | 52.8 | 9.6 |
| Total | 242.0 | 9.3 | 270.1 | 4.5 | 257.6 | 5.7 |
| **Exporter Share of Soybean Imports** | | | | | | |
| United States | 0.4 | 0.5 | 0.0 | 0.1 | 0.1 | 0.3 |
| Brazil | 0.1 | 1.1 | 0.0 | 0.2 | 0.1 | 0.6 |
| Argentina | -0.5 | -4.4 | 0.0 | 0.6 | -0.2 | -1.7 |
| **Exporter Share of Soymeal Imports** | | | | | | |
| United States | 2.0 | 7.1 | 1.8 | 11.3 | 1.9 | 9.4 |
| Brazil | -0.9 | -1.7 | 0.1 | 0.2 | -0.3 | -0.6 |
| Argentina | -1.2 | -4.6 | -1.8 | -4.2 | -1.5 | -4.4 |
| **Exporter Share of Soyoil Imports** | | | | | | |
| United States | 3.2 | 19.8 | 2.0 | 26.4 | 2.5 | 23.4 |
| Brazil | -0.4 | -0.3 | -0.5 | -1.8 | -0.5 | -1.2 |
| Argentina | -2.2 | -5.8 | -2.1 | -4.3 | -2.2 | -5.0 |
| EU-15/27 | -0.7 | -1.3 | 0.7 | 5.9 | 0.1 | 2.7 |

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 "wo" and "w" indicate the values from the *with* checkoff expenditure scenario (baseline simulation) and the *without* checkoff expenditures scenario (zero checkoff expenditures), respectively.

Then the grower profit BCR is calculated as:

$$[10]\ \ PBCR = \sum_{t=1}^{T} \frac{R_t}{E_t}$$

where E is total checkoff expenditures ($ million) across all programs (production research, domestic promotion, and international market promotion).

If the cost of the checkoff program in each year ($E_t$) is first netted out of the additional profit generated ($R_t$) in those years (i.e., $R_t$ - $E_t$) since the checkoff represents a cost to producers, then the *net* grower profit BCR is calculated as:

$$[11]\ \ NBCR = PBCR - 1\ .$$

If the time value of money is accounted for as various researchers have done in considering the soybean and other commodity checkoff programs, then the discounted net grower profit BCR would be calculated as:

$$[12]\ \ DBCR = \frac{\sum_{t=1}^{T} (R_t - E_t)/(1+i)^t}{\sum_{t=1}^{T} E_t}$$

where i is the interest rate chosen to discount the additional profit flows to present value. Obviously the level of the DBCR 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 1980/81 through 2006/07 as done by Williams (1999), Williams, Shumway, and Love (2002) and others. Sellen, Goddard, and Duff (1997) and Davis *et al.* (2001) made an arbitrary choice of an annual 5% fixed rate as the discount rate. The Treasury bill interest rate, which averaged 5.6% between 1980/81 and 2006/07, was selected simply because it represents a realistic alternative investment rate for the 1980/81 through 2006/07 period.

Recall that a BCR as calculated in equations [10], [11], and [12] that is greater than 1 is interpreted as meaning that the program has more than paid for itself. Otherwise, the program would be considered to be ineffective in increasing the profits of the soybean producers who pay for the program.

Using the *with* and *without* soybean checkoff expenditure scenario results and equations [9] – [12], the net profit BCR (NBCR) for the U.S. soybean program over the 1980/81 to 2006/07 period is calculated to be $6.4, indicating that the benefits in terms of the net additional soybean industry profits generated by the U.S. soybean checkoff program far exceeded the cost of the program expenditures over that period (Table 7). This NBCR compares quite favorably to those found by earlier studies of the soybean checkoff program and for other checkoff commodities[20]. Even when the net grower benefits are discounted to present value (the DBCR), the ratio of benefits (net grower profits) to costs is still respectable at $2.4 (Table 7).

Interestingly, the calculated NBCR for the soybean checkoff program was substantially

[20] See Table 1 and the associated discussion in an earlier section of this report.

**Table 7: U.S. Soybean Checkoff Program Benefit-Cost Analysis, 1980/81-2006/07**

| | 1980/81-1991/92 | 1992/93-2006/07 | **1980/81-2006/07** |
|---|---|---|---|
| **Added Soybean Cash Receipts ($ million)** | 7,700.2 | 11,833.4 | **19,533.7** |
| **Soybean Checkoff Investment[a] ($ million)** | 234.8 | 511.0 | **745.8** |
| **Revenue Benefit-Cost Ratio (RBCR) ($/$ spent))** | 32.8 | 23.2 | **26.2** |
| **Cost of Production ($/acre)** | | | |
| Total | 179.71 | 239.88 | **213.14** |
| Variable cash expenses | 60.44 | 79.48 | **71.02** |
| All other (capital, land, etc.) | 119.27 | 160.40 | **142.12** |
| **Cost of Production ($/bu)** | | | |
| Total | 5.87 | 6.25 | **6.08** |
| Variable cash expenses | 1.97 | 2.07 | **2.03** |
| All other (capital, land, etc.) | 3.90 | 4.18 | **4.06** |
| **Cost of Added Production ($ million)** | | | |
| Total | 4,148.8 | 9,901.3 | **14,050.1** |
| Variable cash expenses | 1,399.3 | 3,256.2 | **4,655.5** |
| All other (capital, land, etc.) | 2,749.5 | 6,645.0 | **9,394.6** |
| **Net Revenue[b] ($ million)** | 3,551.4 | 1,932.2 | **5,483.6** |
| **Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)** | 15.1 | 3.8 | **7.4** |
| **Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)** | 14.1 | 2.8 | **6.4** |
| **Discounted NBCR[c] (DBCR) ($/$ spent)** | 5.4 | 1.0 | **2.4** |

[a] Production Research (lagged 10 years to account for lag between expenditure and impact) + Domestic Promotion + International Market Development (ASA/USB, FAS, and Third Party contributions).
[b] Added cash receipts minus added production costs.
[c] The interest rate on the 30-day Treasury Bill used as the discount rate.

higher in the *voluntary* checkoff period of 1980/91 to 1991/92 ($14.1) than in the subsequent *national* checkoff period of 1992/93 to 2006/07 period ($2.8) (Table 7). Does that mean that the program was more effective *before* the implementation of the national soybean checkoff program than *after*? Not necessarily. In the first place, the level of soybean checkoff funding increased by nearly 300% from $17.3 million in 1992/93 to $63.2 in just 5 years. Research has shown that both the average and marginal rates of return from promotion and advertising tend to decline as the level of funding increases. In other words, the relationship between expenditures and returns is not linear. As expenditures increase, each additional dollar spent is less and less effective at moving out the demand curve. With such a huge increase in funding, the BCR would be expected to decline to some extent.

The increased size of the checkoff is not likely the whole reason for the drop in the BCR both because the decline is so large and because Williams, Shumway, and Love (2002) report finding a similar decline using data only through 1994/95. They found a much smaller decline between the period of 1978/79-1989/90 and 1990/91-1994/95 from $11.1 to $4.9. They conclude that the decline was the result of a shift in funding allocation strategy that funneled more funds to production research and less to international market promotion.

That change in strategy apparently was continued because the share of checkoff funds allocated to production research continued to surge after 1992/93 while the share allocated to international marketing was declining sharply (see Figure 2 and associated discussion). After 1999/2000, the continuing increase in the allocation of checkoff funds to production research came at the expense of the allocations to not only international market promotion but also domestic promotion. This shift in strategy as the national checkoff program was implemented added tremendous supply push to checkoff program funding while reducing the demand pull of the program. At the same time, the international promotion strategy was moving away from funding value-added product promotion activities and focusing less on the large mature markets of Europe and Japan and focusing more on smaller, less developed countries.

The net effect of these strategic changes in checkoff funding allocations was that the "supply push" of the production research program began to have a greater impact on U.S. and world soybean and product markets than the "demand pull" of the domestic and international demand promotion programs particularly since 2000/01. This was exactly opposite of what had occurred under the voluntary checkoff program. The consequence has been a small but growing decline in market prices as a direct result of the strategic re-allocation of checkoff funds since the implementation of the national soybean checkoff program and, therefore, a smaller positive effect on soybean producer profits than was the case in previous years. Note in Table 5 and in Figure 19 how the positive average annual increases in prices during the *voluntary* checkoff period turned negative with the implementation of the *national* checkoff program.

A final reason that the BCR in the more recent period is likely lower than in the earlier period is the long lag found between expenditures on production research and market impact and the lengthy period over which such expenditures were found to have an impact. Bessler (2009) found that the lag between expenditure and initial market impact was ten years and that the expenditures in a given year could have market impacts for up to 10 years (see "Methodology and Data" section). That means that the returns from much of the growing current level of production research expenditures may not be realized for years to come. Consequently, the BCR for the period since the implementation of the national checkoff likely underestimates the true BCR since the future returns from recent expenditures have yet to be realized.

## CONCLUSIONS AND IMPLICATIONS FOR PROGRAM MANAGEMENT

The main conclusion of this study is that the U.S. soybean checkoff program has been highly effective over the years in enhancing the profitability, competitiveness, and size of the U.S. soybean industry. Among the major findings of this study are the following:

- *The Benefit-Cost Ratio (BCR) of the soybean checkoff program has been relatively high at $6.4 in additional profit earned by U.S. soybean farmers for every checkoff dollar spent.*

  For every checkoff dollar spent to promote the demand for U.S. soybeans and soybean products at home and abroad and to improve the international competitiveness of U.S. soybean production through soybean production research between 1980//81 and 2006/07, U.S. soybean farmers earned an additional $6.4 in profits (cash receipts minus production costs and checkoff assessments). This BCR compares favorably to those found by similar studies for other commodities and by two earlier studies 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 1980/81 to 2006/07 period is still a reasonable $2.4.

- *The soybean checkoff program has increased the size of the U.S. soybean industry.*

  On average each year between 1980/81 and 2006/07, as a result of soybean checkoff program expenditures on production research and domestic and foreign demand promotion:

  1. U.S. soybean production and crush each averaged 4.2% higher than would have been the case without the checkoff program;
  2. The price farmers received for their soybeans averaged almost 2% higher than would have been the case without the program;
  3. The price of soymeal averaged more than 2% higher than would have been the case without the program with little change in the price of soyoil; and
  4. U.S. soybean meal and oil use were both 2% higher than would have been the case without the program.

- *The soybean checkoff program has reduced the competitive threat of the South American soybean industry.*

  U.S. soybean, soymeal, and soyoil exports averaged 5%, 15%, and 24%, respectively, more each year than would have been the case without the program. Also, the U.S. shares of world soybean, soybean meal, and soybean oil exports were respectively 0.3, 9, and 23 percentage points higher than would have been the case without the program.

- *The Benefit-Cost Ratio for the soybean checkoff program was substantially lower in the period following implementation of the national checkoff program than was the case during the voluntary checkoff program years.*

  While the BCR for the soybean checkoff program was estimated to be a respectable $2.8 since the implementation of the national checkoff program in the early 1990s, the BCR was calculated to be several times higher during the years when the checkoff program was voluntary. Economics, program funding strategy, and the nature of returns from production research likely account for the lower BCR in the more recent period. A well-established feature of the economics of commodity checkoff programs is that the returns per dollar spent tend to decline as the level of promotion and advertising expenditures increase. The rush of funds into the checkoff program coffers following the implementation of the national soybean checkoff program undoubtedly worked to reduce the returns to program expenditures. Also, a new funding strategy was adopted with the implementation of the national checkoff which favored production research over international market promotion and even over domestic promotion in recent years. The consequence was less price increase from the program, and thus, lower industry revenues and profits. Finally, the BCR is also likely lower because the returns from production research expenditures in recent years have not yet been fully realized and may not be for some time to come.

These conclusions suggest a number of implications for program management purposes. First and foremost is that the U.S. soybean industry continues to underinvest in the soybean checkoff program despite the sharp increase in funding with the national checkoff program. The high benefit-cost ratio to checkoff expenditures suggests that large additional benefits in terms of net grower profits can be realized from an additional increase in those expenditures. As the level of expenditure increases, the benefit-cost ratio would be expected to drop to some extent. But because the current level of expenditure is still relatively low, amounting to less than 0.5% of soybean farm cash receipts, even an extraordinary expansion in the current level of investments would likely have only a small negative effect on the benefit-cost ratio.

Second, the current mix of checkoff expenditures appears to be reducing potential return. A comparison of the market effects and returns to the checkoff program before and after the implementation of the national soybean checkoff program and an examination of the key characteristics of checkoff expenditures discussed earlier in the report suggest that the following adjustments in the current funding allocation strategy would likely lead to an increase in returns to soybean producers:

(1) more demand pull from domestic and international demand promotion relative to supply push from production research;
(2) more international promotion relative to domestic demand promotion;
(3) more promotion of value-added products (soymeal, soyoil, soyfood) relative to promotion of the raw product (soybeans); and
(4) some re-examination of the near abandonment of large, mature, developed country markets like the European Union and Japan in favor of smaller, less developed country markets for international promotion activities.

Third, care must be taken in determining the proper share funds to allocate to production research. One the one hand, production research shifts out the supply curve and, therefore, tends to reduce prices suggesting that a low level of funding for production research may be most appropriate. On the other hand, Brazil, Argentina, and other U.S. competitors in world soybean markets have invested heavily and continue to invest in research to boost their soybean yields, reduce their soybean production costs, and, thereby, increase their competitive edge in world soybean markets. The failure of the U.S. to invest aggressively in research to develop new, high-yielding and cost-efficient soybean production technologies and techniques could allow the comparative advantage in the production and export of soybeans and soybean products to shift slowly over the long run to countries like Brazil and Argentina that continue to invest in production research.

Finding the proper mix is a complicated problem and requires additional research much beyond the scope of this study. There is a possibility that if soybean growers stopped financing soybean production research, much of the needed research might be done by the federal government or private soybean breeding companies anyway[21]. Unfortunately, however, federal research funds 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 the soybean checkoff program to play in helping maintain the international competitiveness of U.S. soybean production. In any case, 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 such investments.

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

Fourth, a failure to maintain and enhance the growth in soybean checkoff expenditures in any area over any time period can have serious negative impacts on soybean producer profitability over many years. Checkoff expenditures are intended to create a stream of new revenues over time. Expenditures in any given year are not realized immediately but rather are distributed over a number of years. Consequently, any reduction in funding for even one year can seriously erode the effectiveness of the program in boosting exports and raising producer profits not just in that year but over a long period of time. By the same token, increasing funding levels again after some period of lapse usually requires years before the benefits are fully realized once again. In the mean time, the returns from the program drop. In essence, this is what occurred with the severe reduction in the share of funding allocated to international marketing that began in the early 1990s and likely explains much of the drop in the BCR to the soybean checkoff program since that time (see Figure 2 and associated discussion).

Fifth, a return to the practice of leveraging international market promotion funds with contributions from third party in-country contributors could substantially enhance the level of funds and the effectiveness of the international promotion program. The loss of third party contributions, which at one time accounted for a third of all funds used to promote soybeans and products in foreign markets, was an important contributing element in the decline of the share of total expenditures accounted for by the international market program beginning in the 1990s.

Sixth, the way in which funds for international and domestic demand promotion 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 foreign markets. For example, a shift in the commodity allocation of international promotion funds which pushed the soybean share from 8% in 1985/86 to over 70% by 2004/05 kept the soybean price from falling during that period despite the downward price pressure of the production-research-induced increase in soybean supplies. The prices of soymeal and soyoil during that period, however, were lower than they would have been because of the reduced emphasis on those products in international promotion in favor of soybeans. At the same time, international promotion funds were being redirected from the traditional markets of Japan and Western Europe to Asia, Latin America, and other newer, less developed country markets. Research is needed to determine the optimal or highest yielding regional and commodity allocation of international promotion programs.

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 Smith Bucklin, USSEC, and the Foreign Agriculture Service have developed database management systems for their internal purposes, those systems are different, use different classification schemes, and maintain different levels of detail on funded program activities. At the state level, only a few QSSBs attempt to systematically track their expenditure activities. However, the QSSBs have not worked together to establish a common set of guidelines for expenditure data collection, classification, maintenance, and reporting. The result is that every five years when an evaluation of the checkoff program must be conducted per USDA guidelines, researchers must spend a great deal of time and effort to collect the necessary data from many different groups using different data management systems, if indeed they even attempt to maintain the needed expenditure data over time. Because of the cost and time involved, the expenditure dataset that can be assembled every time an analysis is required in the amount time allowed will necessarily be of lower quality than desired for such studies. Because the results of these evaluations can be no better than the expenditure data available for the analysis, the study results may also be less accurate than could be possible with a more complete set of expenditure data. For this reason, developing an industry-wide, cooperative system for tracking checkoff expenditures by activity and other relevant characteristics across state- and national-level organizations over time 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 SOYMOD5, 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 180 econometric, structural equations that make up SOYMOD5 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-15/27, Japan, Brazil, Argentina, and Rest-of-the-World). Within each region in Appendix Table 1, 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 model equations that were renormalized on price for simulation purposes are marked with an asterisk (*) after the dependent variable of the equation. The soybean checkoff research and demand promotion expenditure stock variables are highlighted in bold type to assist the reader in locating them in the model. For more details on the model, the reader is referred to the "Methodology and Data" section of this report and to Williams 1981, Williams and Thompson 1984, Williams 1985, Williams 1994, Williams 1999, and Williams, Shumway, and Love 2002.

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 except for those few marked with an asterisk (*). The parameters of the soybean and corn production block were estimated using Nonlinear Iterative Seemingly Unrelated Least Squares (IT-SUR) in SAS (Statistical Analysis System) with data for 1970/71 through 2006/07. 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 2006/07 as data were available. All equations were estimated in linear form. The parameters for the price variables in the soybean, soymeal, and soyoil demand equations were constrained to insure elasticities of -1.0, -0.8, and -0.8, respectively.

Appendix Table 3 provides the Theil forecast error (i.e., the Mean Squared Error (MSE) Decomposition Proportions Inequality Coefficients) simulation validation statistics from simulating SOYMOD5 over the 1980/81 to 2006/07 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 all but one less than 0.2. The one variable with a higher Theil coefficient (0.4) was Japanese soyoil imports which historically has been extremely small and has fluctuated from a positive to a negative (net exports) number. 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: SOYMOD5 Structure and Regression Results

### United States

***U.S. Soybean Supply***

**Regional and Total U.S. Acreage Planted**

ASOYSAC=ASOYSAC0+ASOYSAC1*ASOYPCC/LAG(UFPI67)+ASOYSAC2*ACORPPC/LAG(UFPI67)
+ ASOYSAC3*AOATPPC/LAG(UFPI67)+ASOYSAC4*LAG(ASOYSAC)+ASOYSAC5*D82

| | | |
|---|---|---|
| ASOYSAC0: 194.86(0.65) | ASOYSAC1: 819.74(8.26) | ASOYSAC2: -605.84(-2.89) |
| ASOYSAC3: -909.15(14.2) | ASOYSAC4: 0.71833(18.51) | ASOYSAC5: 104.82(5.10) |

Adj $R^2$= 0.9473 Dh=0.3396

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

| | | |
|---|---|---|
| -CSOYSAC0: -278432(-4.82) | CSOYSAC1: 2055.66(5.71`) | CSOYSAC2: 3426.84(-3.34) |
| CSOYSAC3: 0.67221(12.98) | CSOYSAC4: 42.5956 (3.47) | CSOYSAC5: -4223.56(-5.46`) |

Adj $R^2$=0.9892 Dh=-0.1896

DSOYSAC=DSOYSAC0+DSOYSAC1*DSOYPCC/LAG(UFPI67)+DSOYSAC2*DRICPPC/LG(UFPI67)
+DSOYSAC3*DWHEPPC/LAG(UFPI67)+DSOYSAC4*LAG(DSOYSAC)+DSOYSAC5*DWD1
+DSOYSAC6*DWD2

| | | |
|---|---|---|
| DSOYSAC0: 348.3985(0.56) | DSOYSAC1: 1185.59(5.36) | DSOYSAC2: -387.43(-3.34) |
| DSOYSAC3: -405.28(-1.40) | DSOYSAC4: 0.7939(23.65) | DSOYSAC5: 1070.60(2.53) |
| DSOYSAC6: -1480.38(-3.31) | | |

Adj $R^2$=0.9672 Dh=-0.5323

LSOYSAC=LSOYSAC0+LSOYSAC1*LSOYPCC/LAG(UFPI67)+LSOYSAC2*LCORPPC/LAG(UFPI67)
+LSOYSAC3*LBARPPC/LAG(UFPI67)+LSOYSAC4*LAG(LSOYSAC)+LSOYSAC5***LCHKRES**
**+**LSOYSAC6*DFB96+LSOYSAC7*DWL

| | | |
|---|---|---|
| LSOYSAC0: -101010(-3.67) | LSOYSAC1: 668.53(4.77) | LSOYSAC2: -684.99(-1.30) |
| LSOYSAC3: -1447.83(-3.19) | LSOYSAC4: 0.6487(7.35) | LSOYSAC5: 69.9043(8.47) |

Adj $R^2$=0.9878 Dh=-0.6370

OSOYSAC=OSOYSAC0+OSOYSAC1*OSOYPCC/LAG((UFPI67)+OSOYSAC2*OCORPPC/LAG(UFPI67)
+OSOYSAC3*OWHEPPC/LAG(UFPI67)+OSOYSAC4*LAG(OSOYSAC)+OSOYSAC5*O**CHKRES**
+OSOYSAC6*DFB96+OSOYSAC7*DWO1+OSOYSAC8*DWO2

| | | |
|---|---|---|
| OSOYSAC0: -7643.17(-5.73) | OSOYSAC1: 71.7050(10.24) | OSOYSAC2: -139.053(-5.63) |
| OSOYSAC3: -48.9595(-3.32) | OSOYSAC4: 0.6894(15.71) | OSOYSAC5: 94.1924(13.23) |
| OSOYSAC6: 25.6541(3.11) | OSOYSAC7: -45.5361(-7.14) | OSOYSAC8: -31.9897(-4.16) |

Adj $R^2$=0.9966 Dh=-0.7602

PSOYSAC=PSOYSAC0+PSOYSAC1*PSOYPCC/LAG(UFPI67)+PSOYSAC2*PCORPPC/LAG(UFPI67)
+PSOYSAC3*OWHEPPC/LAG(UFPI67)+PSOYSAC4*LAG(PSOYSAC)+PSOYSAC5***PCHKRES**
+PSOYSAC6*DFB96+PSOYSAC7*DWP1+PSOYSAC8*DWP2

## Appendix Table 1 (continued)

PSOYSAC0: -125565(-4.47) PSOYSAC1: 462.0434(3.03) PSOYSAC2: -1610.84(-2.91)
PSOYSAC3: -268.61(-0.73) PSOYSAC4: 0.7348(14.41) PSOYSAC5: 110.971(10.121)
PSOYSAC6: 1217.648(5.38) PSOYSAC7: -1020.68(-6.56) PSOYSAC8: -722.838(-4.61)

Adj $R^2$=0.9959 Dh=-0.8625

SSOYSAC=SSOYSAC0+SSOYSAC1*SSOYPCC/LAG(UFPI67)+SSOYSAC2*SCORPPC/LAG(UFPI67)
+SSOYSAC3*LAG(SSOYSAC)+SSOYSAC4*D82

SSOYSAC0: -2127.09(-5.90) SSOYSAC1: 1796.638(9.58) SSOYSAC2: -1224.86(-3.42)
SSOYSAC3: 0.768812(30.27) SSOYSAC4: 1705.935(4.65)

Adj $R^2$=0.9813 Dh=1.3471

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

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

ASOYSHC0: -5446.8( -4.94) ASOYSHC1: 0.9995(104.40)

Adj $R^2$=0.9960 DW=1.8688

CSOYSHC=CSOYSHC0+CSOYSHC1*CSOYSAC

CSOYSHC0: -108.677( -0.89) CSOYSHC1: 0.993957( 237.97)

Adj $R^2$=0.9988 DW=2.472

DSOYSHC=DSOYSHC0+DSOYSHC1*DSOYSAC

DSOYSHC0: -38.2084(-0.72) DSOYSHC1: 0.9769(145.60)

Adj $R^2$=0.9978 DW=2.0915

LSOYSHC=LSOYSHC0+LSOYSHC1*LSOYSAC

LSOYSHC0: 3.9585(0.17) LSOYSHC1: 0.9823(294.77)

Adj $R^2$=0.9995 DW=1.9193

OSOYSHC=OSOYSHC0+OSOYSHC1*OSOYSAC

OSOYSHC0: -3.1365(-2.10) OSOYSHC1: 0.9856(273.90)

Adj $R^2$=0.9995 DW=2.1765

PSOYSHC=PSOYSHC0+PSOYSHC1*PSOYSAC

PSOYSHC0: -8.0199(-0.41) PSOYSHC1: 0.9786(388.23)

Adj $R^2$=0.9997 DW=2.3677

## Appendix Table 1 (continued)

SSOYSHC=SSOYSHC0+SSOYSHC1*SSOYSAC

SSOYSHC0: -116.123(-3.68) SSOYSHC1: 0.9704(160.96)

Adj $R^2$=0.9982 DW=1.6524

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

**Regional Soybean Yields**
ASOYSYC=ASOYSYC0+ASOYSYC1***ACHKRES**

ASOYSYC0: 16.4182(4.59) ASOYSYC1: 0.021(2.81)

Adj $R^2$=0.2718 DW=1.9861

CSOYSYC=CSOYSYC0+CSOYSYC1***CCHKRES**

CSOYSYC0: 35.1502(20.27) CSOYSYC1: 0.0116(3.66)

Adj $R^2$=0.2935 DW=1.5074

DSOYSYC=DSOYSYC0+DSOYSYC1***DCHKRES**

DSOYSYC0: 19.8267(3.80) DSOYSYC1: 0.016(1.66)

Adj $R^2$=0.0494 DW=0.8562*

LSOYSYC=LSOYSYC0+LSOYSYC1***LCHKRES**

LSOYSYC0: 32.4248(17.26) LSOYSYC1: 0.0112(2.51)

Adj $R^2$=0.1663 DW=1.8472

OSOYSYC=OSOYSYC0+OSOYSYC1***OCHKRES**

OSOYSYC0: 31.8161(21.24) OSOYSYC1: 0.0089(2.71)

Adj $R^2$=0.1792 DW=2.1592

PSOYSYC=PSOYSYC0+PSOYSYC1***PCHKRES**

PSOYSYC0: 28.4754(17.72) PSOYSYC1: 0.0133(4.30)

Adj $R^2$=0.3348 DW=1.6931

SSOYSYC=SSOYSYC0+SSOYSYC1***SCHKRES**

SSOYSYC0: 18.6529(2.50) SSOYSYC1: 0.022(1.45)

Adj $R^2$=0.0389 DW=0.9214*

**Regional and Total U.S. Production**
ASOYSPC=ASOYSYC*ASOYSHC

## Appendix Table 1 (continued)

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

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

ASOYPFC0 -0.0785(-1.32)    ASOYPFC1 1.0166(91.13)

Adj $R^2$=0.9945    DW=2.3577

CSOYPFC=CSOYPFC0+CSOYPFC1*USOYPFC

CSOYPFC0: -0.0335(-0.65)    CSOYPFC1: 1.0119(105.14)

Adj $R^2$=0.9959    DW=2.8091

DSOYPFC=DSOYPFC0+DSOYPFC1*USOYPFC

DSOYPFC0: -0.0032(-0.04)    DSOYPFC1: 1.016093(67.88)

Adj $R^2$=0.9901    DW=1.8287

LSOYPFC=LSOYPFC0+LSOYPFC1*USOYPFC+LSOYPFC2*D76

LSOYPFC0: 0.0880(1.63)    LSOYPFC1: 0.9629(94.37)    LSOYPFC2: 1.0444(8.76)

Adj $R^2$=0.9952    DW=1.6350

OSOYPFC=OSOYPFC0+OSOYPFC1*USOYPFC

OSOYPFC0: -0.1219(-1.33)    OSOYPFC1: 0.0089(58.63)

Adj $R^2$=0.9868    DW=2.5076

PSOYPFC=PSOYPFC0+PSOYPFC1*USOYPFC+PSOYPFC2*D76

PSOYPFC0: -0.0616(-1.62)    PSOYPFC1: 0.9727(135.39)    PSOYPFC2: 0.9017(10.75)

Adj $R^2$=0.9976    DW=2.438

SSOYPFC=SSOYPFC0+SSOYPFC1*USOYPFC

SSOYPFC0: -0.1069(-1.78)    SSOYPFC1: 1.0215(90.54)

Adj $R^2$=0.9944    DW=2.0808

**Regional Expected Farm Price**
ASOYPCC=MAX(LAG(ASOYPFC),ASOYPLC)*D59T01+MAX(LAG(ASOYPFC),0.85*USOYPTC

## Appendix Table 1 (continued)

**Regional Expected Farm Price**

+0.15*ASOYPLC)*D02T07
CSOYPCC=MAX(LAG(CSOYPFC),CSOYPLC)*D59T01+MAX(LAG(CSOYPFC),0.85*USOYPTC
+0.15*CSOYPLC)*D02T07
DSOYPCC=MAX(LAG(DSOYPFC),DSOYPLC)*D59T01+MAX(LAG(DSOYPFC),0.85*USOYPTC
+0.15*DSOYPLC)*D02T07
LSOYPCC=MAX(LAG(LSOYPFC),LSOYPLC)*D59T01+MAX(LAG(LSOYPFC),0.85*USOYPTC
+0.15*LSOYPLC)*D02T07
OSOYPCC=MAX(LAG(OSOYPFC),OSOYPLC)*D59T01+MAX(LAG(OSOYPFC),0.85*USOYPTC
+0.15*OSOYPLC)*D02T07
PSOYPCC=MAX(LAG(PSOYPFC),PSOYPLC)*D59T01+MAX(LAG(PSOYPFC),0.85*USOYPTC
+0.15*PSOYPLC)*D02T07
SSOYPCC=MAX(LAG(SSOYPFC),SSOYPLC)*D59T01+MAX(LAG(SSOYPFC),0.85*USOYPTC
+0.15*SSOYPLC)*D02T07

***Soybean Demand and Market Clearing Condition***

USOYDCC=USOYDCC0+USOYDCC1*USOMPWC+USOYDCC2*USOOPWC+USOYDCC3*USOYPWC
+USOYDCC4*UOISCPC+USOYDCC5*(LAG(USOYHTC)+USOYSPC)+USOYDCC6***PDLSEXP**
+USOYDCC7*DFB90+USOYDCC8*D97

| | | |
|---|---|---|
| USOYDCC0: 104.2572(5.31) | USOYDCC1: 1.9127(2.72) | USOYDCC2: 12.2678(3.43) |
| USOYDCC3: -98.0161(-3.89) | USOYDCC4: 0.3100(6.64) | USOYDCC5: 0.22311(8.30) |
| USOYDCC6: 0.5562(5.12) | USOYDCC7: 134.6680(7.78) | USOYDCC8: 86.1386(2.40) |

Adj $R^2$=0.9862 DW=1.233

where PDLSEXP = 0.045*LAG(SQRT(USOYEXPR) + 0.055*LAG2(SQRT(USOYEXPR)
+ 0.045*LAG3(SQRT(USOYEXPR)

*****USOYHEC=USOYHEC0+USOYHEC1*USOYPFC+USOYHEC2*UCORPPC+USOYHEC3*USOYSPC
+USOYHEC4*USOYHGC+USOYHEC5*LAG(USOYHEC)+USOYHEC6*D6994

| | | |
|---|---|---|
| USOYHEC0: -210.185(-5.02) | USOYHEC1: -24.730(-3.53) | USOYHEC2: 51.69361(2.66) |
| USOYHEC3: 0.1372(6.76) | USOYHEC4: -0.2592(-2.11) | USOYHEC5: 0.3511(4.97) |
| USOYHEC6: 139.8208(5.57) | | |

Adj $R^2$=0.9131 Dh=-0.096

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

| | | |
|---|---|---|
| USOYPWC0: 0.1137(1.48) | USOYPWC1: 1.0311(71.30) | USOYPWC2: 1.5905(9.53) |
| USOYPWC3: -0.6401(-3.80) | USOYPWC4: 0.5835(3.49) | |

Adj $R^2$=0.9913 DW=1.8528

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

## Appendix Table 1 (continued)

***Soybean Meal Supply, Demand, and Market Clearing Condition***

*UHPMDDC=UHPMDDC0+UHPMDDC1*UHPMPWC/UWPI67+UHPMDDC2*UYDA/UCPI67
+UHPMDDC3*UCORDFC+UHPMDDC4***PDLMEXP**+UHPMDDC5*D6982

| | | |
|---|---|---|
| UHPMDDC0: 7297.86(7.42) | UHPMDDC1: -82.5311(-4.18) | UHPMDDC2: 15.8876(13.21) |
| UHPMDDC3: 0.9589(2.21) | UHPMDDC4: 0.9670(2.47) | UHPMDDC5: 1525.479(5.14) |

Adj $R^2$=0.9899 DW=1.947
where PDLMEXP = 0.7253*LAG(SQRT(USOMEXPR) + 0.9670*LAG2(SQRT(USOMEXPR)
+ 0.7253*LAG3(SQRT(USOMEXPR)

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

| | | |
|---|---|---|
| UCOMDPC0: 0.0545(2.12) | UCOMDPC1: -0.30206(-4.34) | UCOMDPC2: 0.8369(32.94) |
| UCOMDPC3: 0.1689(6.25) | UCOMDPC4: -0.76973(-20.30) | |

Adj $R^2$=0.9978 Dh=0.8518

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

| | | |
|---|---|---|
| USOMHEC0: 240.1005(5.75) | USOMHEC1: -0.49406(-2.90) | USOMHEC2: 0.321543(4.48) |
| USOMHEC3: 287.3877(7.67) | USOMHEC4: -111.317(-4.17) | USOMHEC5: 123.3497(4.55) |

Adj $R^2$=0.8587 Dh=0.0772

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***PDLOEXP**+UOLODDC5*D92

| | | |
|---|---|---|
| UOLODDC0: 5.2939(2.23) | UOLODDC1: -0.73437(-5.24) | UOLODDC2: 0.3742(4.05) |
| UOLODDC3: 11.1454(21.26) | UOLODDC4: 0.3902(3.22) | UOLODDC5: -5.4690(-3.01) |

Adj $R^2$=0.9942 DW=1.9106

where PDLOEXP = 0.2926*LAG(SQRT(USOOEXPR) + 0.3902*LAG2(SQRT(USOOEXPR)
+ 0.2926*LAG3(SQRT(USOOEXPR)

## Appendix Table 1 (continued)

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

UCOODPC0: -0.08077(-1.28) UCOODPC1: -0.4315(-3.07) UCOODPC2: 0.1495(3.38)
UCOODPC3: 0.818625(15.80) UCOODPC4: -0.23503(-2.28)

Adj $R^2$=0.9719 Dh=-1.4106

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

*USOOHEC=USOOPWC0+USOOPWC1*USOOPWC+USOOPWC2*USOOSPC+USOOPWC3*USOOMGC
+USOOPWC4*USOOHGC+USOOPWC5*LAG(USOOHEC)+USOOPWC6*LAG2(USOOHEC)
+USOOPWC7*DSOOH3

USOOPWC0: -234.945(-1.42) USOOPWC1: -39.1529(-6.19) USOOPWC2: 0.1873(12.13)
USOOPWC3: -0.4764(-1.38) USOOPWC4: 2.4436(1.66) USOOPWC5: 0.6537(8.72)
USOOPWC6: -0.44088(-5.43) USOOPWC7: 477.6181(5.53)

Adj $R^2$=0.9237 Dh=0.1559

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

### *U.S. Corn Supply*

**Regional and Total U.S. Acreage Planted**

ACORSAC=ACORSA0+ACORSA1*ACORPPC/LAG(UFPI67)+ACORSA2*(ASOYPCC/LAG(UFPI67))
*(D69T81+NORFLEX/100+D96T06)+ACORSA3*LAG(ACORSAC)+ACORSA4*DPIK
+ACORSA5*UCORARP+ACORSA6*D8706

ACORSA0: 1508.128(4.34) ACORSA1: 494.2308(2.95) ACORSA2: -57.0043(-2.04)
ACORSA3: 0.5349(8.67) ACORSA4: -743.841(-4.09) ACORSA5: -17.5229(-4.82)
ACORSA6: -772.848(-6.38)

Adj $R^2$=0.9551 Dh=-0.8277

CCORSAC=CCORSA0+CCORSA1*CCORPPC/LAG(UFPI67)+CCORSA2*CSOYPCC/LAG(UFPI67)
*(D69T81+NORFLEX/100+D96T06)+CCORSA3*LAG(CCORSAC)+CCORSA4*DPIK
+CCORSA5*UCORARP+CCORSA6*D9395

CCORSA0: 17161.66(5.76) CCORSA1: 6683.483(5.28) CCORSA2: -625.021(-3.55)
CCORSA3: 0.3932(5.34) CCORSA4: -11019.4(-8.66) CCORSA5: -17.228(-6.77)
CCORSA6: -3153.88(-3.49)

Adj $R^2$=0.8438 Dh=0.7198

DCORSAC=DCORSAC0+DCORSAC1*DCORPPC/LAG(UFPI67)+DCORSAC2*DSOYPCC/LAG(UFPI67)
+DCORSAC3*LAG(DCORSAC)+DCORSAC4*D9699

## Appendix Table 1 (continued)

| | | |
|---|---|---|
| DCORSAC0: 143.9955(1.05) | DCORSAC1: 165.0028(1.55) | DCORSAC2: -92.0846(-1.60) |
| DCORSAC3: 0.7619(18.84) | DCORSAC4: 625.7426(8.41) | |

Adj $R^2$=0.9414 Dh=0.4713

LCORSAC=LCORSAC0+LCORSAC1*LCORPPC/LAG(UFPI67)+LCORSAC2*(LSOYPCC/LAG(UFPI67)) *(D69T81+NORFLEX/100+D96T06)+LCORSAC3*LBARPPC/LAG(UFPI67)+LCORSAC4 *LAG(LCORSAC)+LCORSAC5*UCORPDC/UFPI67+LCORSAC6*DPIK+LCORSAC7*UCORARP

| | | |
|---|---|---|
| LCORSAC0: 3545.477(3.04) | LCORSAC1: 5233.03(4.85) | LCORSAC2: -239.771(-2.58) |
| LCORSAC3: -2449.76(-2.94) | LCORSAC4: 0.580693(7.70) | LCORSAC5: -1304.93(-2.35) |
| LCORSAC6: -3486.53(-6.02) | LCORSAC7: -85.083(-6.12) | |

Adj $R^2$=0.9000 Dh=0.6507

OCORSAC=OCORSAC0+OCORSAC1*OCORPPC/LAG(UFPI67)+OCORSAC2*(OSOYPCC/LAG(UFPI67)) *(D69T81+NORFLEX/100+D96T06))+OCORSAC3*LAG(OCORSAC)+OCORSAC4*UCORPDC /UFPI67+OCORSAC5*DPIK+OCORSAC6*UCORARP+OCORSAC7*OWHEPPC/LAG(UFPI67)

| | | |
|---|---|---|
| OCORSAC0: -285.547(-1.89) | OCORSAC1: 568.5899(5.15) | OCORSAC2: -23.2854(-1.52) |
| OCORSAC3: 0.979957(24.04) | OCORSAC4: -282.134(-2.72) | OCORSAC5: -354.278(-3.45) |
| OCORSAC6: -3.71366(-1.69) | OCORSAC7: -154.373(-2.21) | |

Adj $R^2$=0.9577 Dh=0.3081

PCORSAC=PCORSA0+PCORSA1*PCORPPC/LAG(UFPI67)+PCORSA2*(PSOYPCC/LAG(UFPI67))*(D69T81 +NORFLEX/100)+D96T06)+PCORSA3*LBARPPC/LAG(UFPI67)+PCORSA4*LAG(PCORSAC) +PCORSA5*UCORPDC/UFPI67+PCORSA6*DPIK+PCORSA7*UCORARP

| | | |
|---|---|---|
| PCORSA0: 9177.879(5.43) | PCORSA1: 2236.906(1.97) | PCORSA2: -159.49(-1.74) |
| PCORSA3: -4080.62(-4.43) | PCORSA4: 0.547292(7.22) | PCORSA5: -745.761(-1.26) |
| PCORSA6: -3762.27(-5.59) | PCORSA7: -107.131(-5.39) | |

Adj $R^2$=0.9389 Dh=0.3358

SCORSAC=SCORSAC0+SCORSAC1*SCORPPC/LAG(UFPI67)+SCORSAC2*SSOYPCC/LAG(UFPI67) +SCORSAC3*LAG(SCORSAC)+SCORSAC4*DPIK+SCORSAC5*UCORARP +SCORSAC6*DFB02

| | | |
|---|---|---|
| SCORSAC0: 858.6548(2.19) | SCORSAC1: 1692.38(5.22) | SCORSAC2: -295.571(-1.94) |
| SCORSAC3: 0.6676(17.01) | SCORSAC4: -1097.28(-3.93) | SCORSAC5: -18.0948(-3.23) |
| SCORSAC6: -349.102(-2.33) | | |

Adj $R^2$=0.9392 Dh=-1.3381

TCORSAC=TCORSAC0+TCORSAC1*TCORPPC/LAG(UFPI67)+TCORSAC2*(OSOYPCC/LAG(UFPI67) *(D69T81+NORFLEX/00+D96T06)+TCORSAC3*LAG(TCORSAC)+TCORSAC4*OWHEPPC /LAG(UFPI67)+TCORSAC5*DPIK+TCORSAC6*UCORPDC/UFPI67+TCORSAC7*UCORARP

| | | |
|---|---|---|
| TCORSAC0: 418.0528(1.48) | TCORSAC1: 234.1463(1.80) | TCORSAC2: -3.9881(-0.23) |
| TCORSAC3: 0.915073(12.62) | TCORSAC4: -271.30(-2.99) | TCORSAC5: -358.255(-2.91) |
| TCORSAC6: -147.314(-1.22) | TCORSAC7: -4.9511(-1.21) | |

Adj $R^2$=0.9588  Dh=-0.2268

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

**Regional and Total U.S. Acreage Harvested**
ACORSHC=ACORSHC0+ACORSHC1*ACORSAC

ACORSHC0: -94.1786(-1.75)  ACORSHC1: 0.873611(53.49)

Adj $R^2$=0.9842  DW=1.6320

CCORSHC=CCORSHC0+CCORSHC1*CCORSAC+CORSHC2*TIME

CCORSHC0: -49233.5(-6.69)  CCORSHC1: 0.95904(53.3)  CCORSHC2: 24.83043

Adj $R^2$=0.9868  DW=1.9049

DCORSHC=DCORSHC0+DCORSHC1*DCORSAC+DCORSHC2*D6982

DCORSHC0: -43.4121(-4.14)  DCORSHC1: 0.973575(90.60)  DCORSHC2: -44.6373(-5.06)

Adj $R^2$=0.9947  DW=1.8288

LCORSHC=LCORSHC0+LCORSHC1*LCORSAC+LCORSHC2*D6985

LCORSHC0: -1564.45(-5.69)  LCORSHC1: 0.9937(47.35)  LCORSHC2: -697.241(-10.34)

Adj $R^2$=0.9844  DW=1.5523

OCORSHC=OCORSHC0+OCORSHC1*OCORSAC+OCORSHC3*D72

OCORSHC0: -509.887(-6.34)  OCORSHC1: 0.790966(27.36)  OCORSHC3: -241.398(-2.97)

Adj $R^2$=0.9459  DW=1.6475

PCORSHC=PCORSHC0+PCORSHC1*PCORSAC+PCORSHC2*D6982

PCORSHC0: -1443.75(-3.55)  PCORSHC1: 1.004653(37.15)  PCORSHC2: -841.099(-6.58)

Adj $R^2$=0.9850  DW=1.6988

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

SCORSHC0: -11727.2(-4.24)  SCORSHC1: 0.935159(53.08)  SCORSHC2: -1655.27(-17.49)
SCORSHC3: -607.905(-6.87)

Adj $R^2$=0.9916  DW=1.9115

TCORSHC=TCORSHC0+TCORSHC1*TCORSAC+TCORSHC2*D6980

TCORSHC0: -149.091(-2.83)  TCORSHC1: 0.648547(32.18)  TCORSHC2: -186.75(-8.06)
Adj $R^2$=0.9842  DW=1.0471

## Appendix Table 1 (continued)

TCORSHC=TCORSHC0+TCORSHC1*TCORSAC+TCORSHC2*D6980

TCORSHC0: -149.091(-2.83) TCORSHC1: 0.648547(32.18) TCORSHC2: -186.75(-8.06)

Adj $R^2$=0.9842 DW=1.0471

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+ACORPFC2*DFB96

ACORPFC0: 0.036572(0.630) ACORPFC1: 1.0710(39.12) ACORPFC2: 0.29211(3.65)

Adj $R^2$=0.9724 DW=1.7943

CCORPFC=CCORPFC0+CCORPFC1*UCORPFC

CCORPFC0: -0.02462(-1.95) CCORPFC1: 1.0120(172.01)

Adj $R^2$=0.9984 DW=1.781

DCORPFC=DCORPFC0+DCORPFC1*UCORPFC+DCORPFC2*D85

DCORPFC0: 0.0346(0.51) DCORPFC1: 1.0861(33.13) DCORPFC2: 0.7591(5.51)

Adj $R^2$=0.9629 DW=2.0504

LCORPFC=LCORPFC0+LCORPFC1*UCORPFC

LCORPFC0: -0.02077(-0.85) LCORPFC1: 0.9703(84.70)

Adj $R^2$=0.9936 DW=1.4124

OCORPFC=OCORPFC0+OCORPFC1*UCORPFC+OCORPFC2*D6985

OCORPFC0: 0.2123(4.33) OCORPFC1: 1.0804(53.48) OCORPFC2: -0.1212(-4.66)

Adj $R^2$=0.9875 DW=1.9399

## Appendix Table 1 (continued)

PCORPFC=PCORPFC0+PCORPFC1*UCORPFC

PCORPFC0: -0.0068(-0.38) PCORPFC1: 0.9791(115.83)

Adj $R^2$=0.9967 DW=1.4682

SCORPFC=SCORPFC0+SCORPFC1*UCORPFC+SCORPFC2*DFB96

SCORPFC0: 0.0547(1.52) SCORPFC1: 1.0584(61.96) SCORPFC2: 0.0921(3.49)

Adj $R^2$=0.9889 DW=1.8228

TCORPFC=TCORPFC0+TCORPFC1*UCORPFC

TCORPFC0: 0.1591(4.80) TCORPFC1: 1.028506(63.98)

Adj $R^2$=0.9900 DW=1.6475

**Regional Expected Price**

ACORPPC=(MAX(LAG(ACORPFC),UCORPLC*(1-UCORARP/100)))*D59T73+(MAX(LAG(ACORPFC), UCORPTC*(1-UCORARP/100)))*D74T90+(MAX(LAG(ACORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100)*UCORPLC))*D9T195+(MAX(LAG(ACORPFC), UCORPLC))*D96T01+(MAX(LAG(ACORPFC),UCORPTC*.85+UCORPLC*.15))*D02T07

CCORPPC=(MAX(LAG(CCORPFC),UCORPLC*(1-UCORARP/100)))*D59T73+(MAX(LAG(CCORPFC), UCORPTC*(1-UCORARP/100)))*D74T90+(MAX(LAG(CCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100)*UCORPLC))*D91T95+(MAX(LAG(CCORPFC), UCORPLC))*D96T01+(MAX(LAG(CCORPFC),UCORPTC*.85+UCORPLC*.15))*D02T07

DCORPPC=(MAX(LAG(DCORPFC),UCORPLC*(1-UCORARP/100)))*D59T73+(MAX(LAG(DCORPFC), UCORPTC*(1-UCORARP/100)))*D74T90+(MAX(LAG(DCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100)*UCORPLC))*D91T95+(MAX(LAG(DCORPFC), UCORPLC))*D96T01+(MAX(LAG(DCORPFC),UCORPTC*.85+UCORPLC*.15))*D02T07

LCORPPC=(MAX(LAG(LCORPFC),UCORPLC*(1-UCORARP/100)))*D59T73+(MAX(LAG(LCORPFC), UCORPTC*(1-UCORARP/100)))*D74T90+(MAX(LAG(LCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100)*UCORPLC))*D91T95+(MAX(LAG(LCORPFC), UCORPLC))*D96T01+(MAX(LAG(LCORPFC),UCORPTC*.85+UCORPLC*.15))*D02T07

OCORPPC=(MAX(LAG(OCORPFC),UCORPLC*(1-UCORARP/100)))*D59T73+(MAX(LAG(OCORPFC), UCORPTC*(1-UCORARP/100)))*D74T90+(MAX(LAG(OCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100)*UCORPLC))*D91T95+(MAX(LAG(OCORPFC), UCORPLC))*D96T01+(MAX(LAG(OCORPFC),UCORPTC*.85+UCORPLC*.15))*D02T07

PCORPPC=(MAX(LAG(PCORPFC),UCORPLC*(1-UCORARP/100)))*D59T73+(MAX(LAG(PCORPFC), UCORPTC*(1-UCORARP/100)))*D74T90+(MAX(LAG(PCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100)*UCORPLC))*D91T95+(MAX(LAG(PCORPFC), UCORPLC))*D96T01+(MAX(LAG(PCORPFC),UCORPTC*.85+UCORPLC*.15))*D02T07

SCORPPC=(MAX(LAG(SCORPFC),UCORPLC*(1-UCORARP/100)))*D59T73+(MAX(LAG(SCORPFC), UCORPTC*(1-UCORARP/100)))*D74T90+(MAX(LAG(SCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+(NORFLEX/100)*UCORPLC))*D91T95+(MAX(LAG(SCORPFC), UCORPLC))*D96T01+(MAX(LAG(SCORPFC),UCORPTC*.85+UCORPLC*.15))*D02T07

## Appendix Table 1 (continued)

TCORPPC=(MAX(LAG(TCORPFC),UCORPLC*(1-UCORARP/100)))*D59T73+(MAX(LAG(TCORPFC),
UCORPTC*(1-UCORARP/100)))*D74T90+(MAX(LAG(TCORPFC),UCORPTC*(1-UCORARP/100
-NORFLEX/100)+(NORFLEX/100)*UCORPLC))*D91T95+(MAX(LAG(TCORPFC),
UCORPLC))*D9T601+(MAX(LAG(TCORPFC),UCORPTC*.85+UCORPLC*.15))*D02T07

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

***U.S. Corn Demand and Market Clearing Condition***

UCORDFC=UCORDFC0+UCORDFC1*UCORPWC+UCORDFC2*UGCAUA+UCORDFC3*UHOGPFC
+UCORDFC4*USLSPFC+UCORDFC5*D2CORF

| | | |
|---|---|---|
| UCORDFC0: -6530.23(-11.12) | UCORDFC1: -350.676(-6.48) | UCORDFC2: 125.1447(15.69) |
| UCORDFC3: 22.7607(4.76) | UCORDFC4: 12.3111(4.07) | UCORDFC5: 493.3948(5.91) |

Adj. $R^2$=0.9709 DW=1.7587

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

| | | |
|---|---|---|
| UCORDOC0: -8.7012(-0.15) | UCORDOC1: -158.409(-4.17) | UCORDOC2: 0.3263(3.54) |
| UCORDOC3: 75.4202(2.84) | UCORDOC4: 0.8078(15.76) | UCORDOC5: 183.3124(7.26) |

Adj. $R^2$=0.9982 Dh=0.3203

UCORMEC=UCORMEC0+UCORMEC1*(ECORPIA*XECUSA)+UCORMEC2*RCORMEC
+UCORMEC3*(JGCAUA/1000+EGCAUA)+UCORMEC4*EGDP/ECWPI2
+UCORMEC5*LAG(UCORMEC) +UCORMEC6*D6970

| | | |
|---|---|---|
| UCORMEC0: -491.131(-1.40) | UCORMEC1: -3.87672(-2.12) | UCORMEC2: -1.1747(-10.39) |
| UCORMEC3: 11.1920(2.62) | UCORMEC4: 0.5509(4.85) | UCORMEC5: 0.7715(15.15) |
| UCORMEC6: -247.186(-2.98) | | |

Adj. $R^2$=0.9694 Dh=--0.0523

*UCORHOC=UCORHOC0+UCORHOC1*UCORPWC+UCORHOC2*UCORSPC+UCORHOC3
*LAG(UCORHCC)+UCORHOC4*LAG(UCORHOC)+UCORHOC5*D6988+UCORHOC6*DFB96

| | | |
|---|---|---|
| UCORHOC0: -1860.57(-8.98) | UCORHOC1: -325.141(-7.01) | UCORHOC2: 0.4018(18.42) |
| UCORHOC3: 0.3782(4.25) | UCORHOC4: 0.4173(11.85) | UCORHOC5: 852.8902(9.72) |
| UCORHOC6: 1061.9143(7.92) | | |

Adj. $R^2$=0.9610 Dh=-0.9459

UCORPFC=UCORPFC0+UCORPFC1*UCORPWC+UCORPFC2*D95

| | | |
|---|---|---|
| UCORPFC0: -0.09074(-3.66) | UCORPFC1: 0.9568(87.79) | UCORPFC2: -0.5562(-10.67) |

Adj. $R^2$=0.9948 DW=2.3118

## Appendix Table 1 (continued)

ECORPIA=ECORPIA0+ECORPIA1*UCORPWC+ECORPIA2*XECUSA+ECORPIA3*D73+ECORPIA4*D82

| | | |
|---|---|---|
| ECORPIA0: 54.1901(4.77) | ECORPIA1: 35.0363(20.53) | ECORPIA2: -44.9744(-4.38) |
| ECORPIA3: 18.5330(2.82) | ECORPIA4: 23.19357(3.41) | |

Adj. $R^2$=0.9555 DW=1.7875

UCORHOC=UCORHTC-UCORHCC

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

**European Union (15/27)**

***EU 15/27 Soybean Demand and Market Clearing Condition***

ESOYDCC=ESOYDCC0+ESOYDCC1*((ESOMQ*ESOMPIA+ESOOQ*ESOOPXA-ESOYPIA)*XECUSA)
+ESOYDCC2*LAG(ESOYDCC)+ESOYDCC3*LAG(SQRT(**ESOYEXPR)**)+ESOYDCC4*D9400

| | | |
|---|---|---|
| ESOYDCC0: 2372.727(8.80) | ESOYDCC1: 60.5232(3.98) | ESOYDCC2: 0.6774(6.13) |
| ESOYDCC3: 176.0174(1.71) | ESOYDCC4: -2174(-9.95) | ESOYDCC5: -2053.77(-4.57) |

Adj. $R^2$=0.9625 Dh=--1.1414

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

| | | |
|---|---|---|
| ESOYPIA0: 14.0640(2.25) | ESOYPIA0: 0.9404(31.05) | ESOYPIA2: 34.6090(3.73) |
| ESOYPIA3: 31.06224(3.33) | | |

Adj. $R^2$=0.9581 DW=2.2542

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*EGDP/ECWPI2
+ESOMDDC3*EGCAUA+ESOMDDC4*LAG(SQRT(**ESOMEXPR**))+ESOMDDC5*D8101

| | | |
|---|---|---|
| ESOMDDC0: -21917(-5.13) | ESOMDDC1: -560.682(-5.75) | ESOMDDC2: 11.0314(7.85) |
| ESOMDDC3: 268.7651(8.54) | ESOMDDC4: 480.0915(2.02) | ESOMDDC5: -2891.89(-4.78) |

Adj. $R^2$=0.9884 DW=2.1582

ESOMPIA=ESOMPIA0+ESOMPIA1*USOMPWC*1.01231+ESOMPIA2*D9402

| | | |
|---|---|---|
| ESOMPIA0: -2.1543(-0.48) | ESOMPIA1: 1.056715(40.72) | ESOMPIA2: 24.4446(4.94) |

Adj. $R^2$=0.9748 DW=2.1133

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

## Appendix Table 1 (continued)

***EU 15/27 Soybean Oil Supply, Demand, and Market Clearing Condition***

ESOOSPC=ESOOQ*ESOYDCC

ESOODDC=ESOODDC0+ESOODDC1*ESOOPXA*XECUSA/ECWPI2+ESOODDC2*EPAOPIA/ECWPI2
+ESOODDC3*EGDP/ECWPI2+ESOODDC4*LAG(ESOODDC)+ESOODDC5
*LAG(SQRT(**ESOOEXPR**))+ESOODDC6*D9202

ESOODDC0: -99.2496(-1.13) ESOODDC1: -15.8287(-6.29) ESOODDC2: 15.00(4.48)
ESOODDC3: 1.0696(7.04) ESOODDC4: 0.6952(10.44) ESOODDC5: 23.1041(2.38)
ESOODDC6: 389.3277(10.34)

Adj. $R^2$=0.9786 Dh=-0.4558

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

ESOOPXA=ESOOPXA0+ESOOPXA1*USOOPWC*22.04622+ESOOPXA2*D74+ESOOPXA3*D06

ESOOPXA0: -20.2861(-1.90) ESOOPXA1: 1.0276(42.97) ESOOPXA2: -200.782(-8.43)
ESOOPXA3: 117.2918(4.92)

Adj. $R^2$=0.9791 DW=1.5581

**Japan**

***Japan Soybean Demand and Market Clearing Condition***

JSOYDCC=JSOYDCC0+JSOYDDC1*((JSOMQ*JSOMPUA+JSOOQ*JSOOPUA-JSOYPUA)
*XJAUSA/JWPI85)+JSOYDCC2*LAG(JSOYDCC)+JSOYDCC3*LAG(SQRT(**JSOYEXPR**))
+JSOYDCC4*DJEMBGO+JSOYDCC5*DFB02

JSOYDCC0: 792.6693(5.24) JSOYDCC1: 0 .0040(2.06) JSOYDCC2: 0.7628(17.15)
JSOYDCC3: 0.3801(1.98) JSOYDCC4: -317.822(-3.43) JSOYDCC5: -417.272(-6.40)
Adj. $R^2$=0.9792 Dh=-1.4297

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

JSOYPUA0: 28.103(3.78) JSOYPUA1: 1.1497(38.44) JSOYPUA2: -22.5117(-5.49)
JSOYPUA3: -55.6456(-4.51)

Adj. $R^2$=0.9797 DW=1.5166

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

***Japan Soybean Meal Supply, Demand, and Market Clearing Condition***

JSOMSPC=JSOMQ*JSOYDCC

JSOMDDC=JSOMDDC0+JSOMDDC1*(JSOMPUA*XJAUSA/JWPI85)+JSOMDDC2*LAG(JSOMDDC)
+ JSOMDDC3*LAG(SQRT(**JSOMEXPR**))+JSOMDDC4*D82

JSOMDDC0: 1555.514(7.71) JSOMDDC1: -0.01214(-6.61) JSOMDDC2: 0.6247(13.32)
JSOMDDC3: 0.5736(3.18) JSOMDDC4: 232.6031(5.22)

Adj. $R^2$=0.9926 Dh=0.6541

## Appendix Table 1 (continued)

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

JSOMPUA0: 12.3561(2.03)    JSOMPUA1: 1.19587(32.14)    JSOMPUA2: -86.9739(-6.47)
JSOMPUA3: -48.815(-4.94)

Adj. $R^2$=0.9691   DW=1.7993

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

***Japan Soybean Oil Supply, Demand, and Market Clearing Condition***

JSOOSPC=JSOOQ*JSOYDCC

JSOODDC=JSOODDC0+JSOODDC1*JSOOPUA*XJAUSA/JWPI85+JSOODDC2*LAG(JSOODDC)
+ JSOODDC3*EPAOPIA*XJAUSA/JWPI85+JSOODDC4*LAG(SQRT(**JSOOEXPR**))

JSOODDC0: 116.603(3.05)    JSOODDC1:-.00055(-3.29)    JSOODDC2: 0.8662(17.98)
JSOODDC3: 0.00046(2.69)    JSOODDC4: 0.08716(1.84)

Adj. $R^2$=0.9599   Dh=1.4822

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

JSOOPUA0: 341.8325(9.10)    JSOOPUA1: 1.0251(15.39)    JSOOPUA2: -280.191(-12.71)

Adj. $R^2$=0.9538   DW=2.1074

JSOOMIC=JSOODDC+JSOODZC+JS1OHEC-LAG(JSOOHEC)-JSOOSPC

**Rest-of-the-World (ROW)**
***ROW Soybean Demand and Market Clearing Condition***

RSOYMIN=RSOYMIN0+RSOYMIN1*USOYPWC+RSOYMIN2*LAG(RSOYMIN)
+RSOYMIN3*LAG(SQRT(**RSOYEXPR**))+RSOYMIN4*D04+RSOYMIN6*D0506

RSOYMIN0:15568.22(34.08)    RSOYMIN1:-2344.94(c)   RSOYMIN2: 0.9990(19.79)
RSOYMIN3: 17.1762(2.37)    RSOYMIN4: 11677.09(13.27)    RSOYMIN5: -7391.12(-12.47)
Note: c=constrained

Adj. $R^2$=0.9959   Dh=-1.7049

***ROW Soybean Meal Supply, Demand, and Market Clearing Condition***

RSOMSPN=.795*RSOYMIN*.8

RSOMDDN=RSOMDDN0+RSOMDDN1*USOMPWC+RSOMDDN2*LAG(RSOMDDN)
+RSOMDDN3*LAG(SQRT(**RSOMEXPR)**)+RSOMDDN4*D98+RSOMDDN5*D9604

RSOMDDN0: 20451.23(22.57)    RSOMDDN1: -107.516(c)    RSOMDDN2: 0.9775(27.67)
RSOMDDN3: 17.9494(1.46)    RSOMDDN4: -15918.2(-16.40)    RSOMDDN5: 9767.63(21.94)

Adj. $R^2$=0.9956   Dh=-0.5072    Note: c=constrained

## Appendix Table 1 (continued)

RSOMMIN=RSOMDDN-RSOMSPN

***ROW Soybean Oil Supply, Demand, and Market Clearing Condition***

RSOOSPN=.179*RSOYMIN*.8

RSOODDN=RSOODDN0+RSOODDN1*USOOPWC+RSOODDN2*RGDP85+RSOODDN3*LAG(RSOODDN)
+RSOODDN4*LAG(SQRT(RSOOEXPR))+RSOODDN5*D7879+RSOODDN6*D0001

| | | |
|---|---|---|
| RSOODDN0: 4182.26(14.97) | RSOODDN1: -294.935(c) | RSOODDN2: 4688.371(24.94) |
| RSOODDN3: 0.7852(17.14) | RSOODDN4: 8.9780(2.04) | RSOODDN5: 2162.51(16.49) |
| RSOODDN6: 1458.658(16.55) | Note: c=constrained | |

Adj. $R^2$=0.9963 Dh=-1.3236

RSOOMIN=RSOODDN-RSOOSPN

**Brazil**

***Brazil Soybean Supply, Demand, and Market Clearing Condition***

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

| | | |
|---|---|---|
| BSOYSHC0: -460.067(-11.29) | BSOYSHC1: 0.3821(10.73) | BSOYSHC2: 0.6179(14.48) |
| BSOYSHC3: 61.7881(11.32) | BSOYSHC4: -1025.92(-3.30) | |

Adj. $R^2$=0.9951 Dh=-0.1187

BSOYSPC=BSOYSYC*BSOYSHC

BSOYDCC=BSOYDCC0+BSOYDCC1*BSOMPXC*XBZUSA/BWPI85/1000000000+BSOYDCC2*BSOOPXC
*XBZUSA/BWPI85/1000000000+BSOYDCC3*BSOYPXC*XBZUSA/BWPI85/1000000000
+BSOYDCC4*(LAG(BSOYHEC)+BSOYSPC)+BSOYDCC5*LAG(BSOYDCC)
+BSOYDCC6*D70T75+BSOYDCC7*D94

| | | |
|---|---|---|
| BSOYDCC0: 5208.466(5.83) | BSOYDCC1: 9.7225(2.43) | BSOYDCC2: 1.3752(2.30) |
| BSOYDCC3: -13.0338(-2.91) | BSOYDCC4: 0.2774(10.73) | BSOYDCC5: 0.3414(4.99) |
| BSOYDCC6: -2939.974(-5.82) | BSOYDCC7: -2936.974(4.22) | |

Adj. $R^2$=0.9952 Dh=0.2856

BSOYPXC=BSOYPXC0+BSOYPXC1*ESOYPIA+BSOYPXC2*D73

| | | |
|---|---|---|
| BSOYPXC0: -15.524(-3.77) | BSOYPXC1: 1.0944(53.08) | BSOYPXC2: -47.6133(-5.59) |

Adj. $R^2$=0.9848 DW=1.5553

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

***Soybean Meal Supply, Demand, and Market Clearing Condition***

BSOMSPC=BSOMQ*BSOYDCC

## Appendix Table 1 (continued)

BSOMDDC=BSOMDDC0+BSOMDDC1*BSOMPXC*XBZUSA/BWPI85/1000000000
+BSOMDDC2*LAG(BSOMDDC)+BSOMDDC3*D72

BSOMDDC0: 1136.062(3.17) BSOMDDC1: -2.43688(-3.20) BSOMDDC2: 0.968702(24.38)
BSOMDDC3: 522.0162(3.43)

Adj. $R^2$=0.9899 Dh=-0.7666

BSOMPXC=BSOMPXC0+BSOMPXC1*ESOMPIA+BSOMPXC2*DFB02

BSOMPXC0: 4.4261(0.76) BSOMPXC1: 0.9581(29.43) BSOMPXC2: -32.5853(-5.46)

Adj. $R^2$=0.9499 DW=1.5838

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

***Brazil Soybean Oil Supply, Demand, and Market Clearing Condition***

BSOOSPC=BSOOQ*BSOYDCC

BSOODDC=BSOODDC0+BSOODDC1*BSOOPXC*XBZUSA/BWPI85/1000000000
+BSOODDC2*LAG(BSOODDC)+BSOODDC3*BGDP85/100+BSOODDC4*D73+BSOODDC5*D0405

BSOODDC0: -177.705(-2.44) BSOODDC1: -0.24022(-3.93) BSOODDC2: 0.2977(3.07)
BSOODDC3: 0.194951(7.49) BSOODDC4: 426.5776(3.18) BSOODDC5: -225.151(-3.31)

Adj. $R^2$=0.9947 Dh=-1.0495

BSOOPXC=BSOOPXC0+BSOOPXC1*ESOOPXA+BSOOPXC2*D8706

BSOOPXC0: -63.4459(-4.17) BSOOPXC1: 1.0945(30.56) BSOOPXC2: 77.9649(5.54)

Adj. $R^2$=0.9620 DW=1.6406

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

**Argentina**

***Argentina Soybean Supply, Demand, and Market Clearing Condition***

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

## Appendix Table 1 (continued)

GSOYDCC=GSOYDCC0+GSOYDCC1*(GSOMQ*GSOMPXA+GSOOQ*GSOOPXA)*XARUSA/GWPI85 *1000000+GSOYDCC2*GSOYPXC*XARUSA/GWPI85*1000000+GSOYDCC3*(LAG(GSOYHEC) +GSOYSPC)+GSOYDCC4*LAG(GSOYDCC)+GSOYDCC5*D72+GSOYDCC6*D97

GSOYDCC0: -1754.05(-6.11) GSOYDCC1: 0.1731(2.95) GSOYDCC2: -0.0655(-1.41)
GSOYDCC3: 0.3347(12.68) GSOYDCC4: 0.6370(16.64) GSOYDCC5: 2626.212(1.91)
GSOYDCC6: 3737.815(11.20)

Adj. $R^2$=0.9990 Dh=-1.1688

GSOYPXA=GSOYPXA0+GSOYPXA1*ESOYPIA+GSOYPXA2*D72+GSOYPXA3*D75

GSOYPXA0: 24.4350(4.60) GSOYPXA1: 0.8836(34.36) GSOYPXA2: 540.0959(48.70)
GSOYPXA3: 81.2739(7.42)

Adj. $R^2$=0.9895 DW=2.3787

GSOYMEC=LAG(GSOYHEC)+GSOYMMC+GSOYSPC-GSOYDCC-GSOYDZC-GSOYHEC

***Argentina Soybean Meal Supply, Demand, and Market Clearing Condition***

GSOMSPC=GSOMQ*GSOYDCC

GSOMDDC=GSOMDDC0+GSOMDDC1*GSOMPXA*XARUSA/GWPI85+GSOMDDC2*GGDP85 +GSOMDDC3*D74+GSOMDDC4*D0123

GSOMDDC0: -165.624(-4.14) GSOMDDC1: -3442.59(-1.72) GSOMDDC2: 0.0019(15.63)
GSOMDDC3: 111.4525(4.12) GSOMDDC4: 170.8404(10.96)

Adj. $R^2$=0.9811 DW=1.1767

GSOMPXA=GSOMPXA0+GSOMPXA1*ESOMPIA+GSOMPXA2*D72+GSOMPXA3*DFB02

GSOMPXA0: 37.9752(8.83) GSOMPXA1: .6955(26.40) GSOMPXA2: -95.0186(-9.55)
GSOMPXA3: -25.3968(-5.58)

Adj. $R^2$=0.9620 DW=2.3617

GSOMMEC=LAG(GSOMHEC)+GSOMMMC+GSOMSPC-GSOMDDC-GSOMDZC-GSOMHEC

***Argentina Soybean Oil Supply, Demand, and Market Clearing Condition***

GSOOSPC=GSOOQ*GSOYDCC

GSOODDC= GSOODDC0+GSOODDC1*GSOOPXA*XARUSA/GWPI85+GSOODDC2*LAG(GSOODDC) +GSOODDC3*GGDP85+GSOODDC4*D78+GSOODDC5*D06

GSOODDC0: -22.9609(-0.92) GSOODDC1: -589.666(-1.98) GSOODDC2: 0.9518(25.07)
GSOODDC3: 0.0002(2.00) GSOODDC4: +54.8233(-4.31) GSOODDC5: 154.7835(10.23)

Adj. $R^2$=0.9921 Dh=0.1922

## Appendix Table 1 (continued)

GSOOPXA=GSOOPX0+GSOOPXA1*ESOOPXA+GSOOPXA2*D72+ GSOOPXA2*D73

GSOOPXA0: 24.4350(4.60) GSOOPXA1: 0.8836(34.36)
GSOOPXA3: 81.2739(7.42)

Adj. $R^2$=0.9895 DW=2.3787

GSOOMEC=LAG(GSOOHEC)+GSOOSPC-GSOODDC-GSOODZC-GSOOHEC;

**World Market Clearing Conditions**

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

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

USOOMTC=(RSOOMIN-BSOOMXC-GSOOMEC-ESOOMXC+JSOOMIC)/0.453592

## Appendix Table 2: SOYMOD5 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) | Market Price[2] ($/bu) | Expected Price[3] ($/bu) |
|---|---|---|---|---|---|---|
| Atlantic | ASOYSAC | ASOYSHC | ASOYSYC | ASOYSPC | ASOYPFC | ASOYPCC |
| Cornbelt | CSOYSAC | CSOYSHC | CSOYSYC | CSOYSPC | CSOYPFC | CSOYPCC |
| Delta | DSOYSAC | DSOYSHC | DSOYSYC | DSOYSPC | DSOYPFC | DSOYPCC |
| Lakes | LSOYSAC | LSOYSHC | LSOYSYC | LSOYSPC | LSOYPFC | LSOYPCC |
| Other | OSOYSAC | OSOYSHC | OSOYSYC | OSOYSPC | OSOYPFC | OSOYPCC |
| Plains | PSOYSAC | PSOYSHC | PSOYSYC | PSOYSPC | PSOYPFC | PSOYPCC |
| South | SSOYSAC | SSOYSHC | SSOYSYC | SSOYSPC | 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 calculated 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 protein meal 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 |
| USOYEHR | U.S. soybean stock to use ratio, 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 |

## Appendix Table 2 (continued)

### 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. weighted ave. expected farm price of corn, $/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 |

## Appendix Table 2 (continued)

| | |
|---|---|
| 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-15/27, 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 |
| GSOMMEC | Argentina exports of soymeal (exports-imports), 1,000 mt, marketing year |
| GSOMPXA | Argentina export price of soymeal, $/mt, calendar year |
| GSOMSPC | Argentina soymeal production, 1,000 mt, marketing year |
| GSOODDC | Argentina soyoil use, 1,000 mt, marketing year |
| GSOOMEC | Argentina exports of soyoil (exports-imports), 1,000 mt, marketing year |
| GSOOPXA | Argentina export price of soyoil, $/mt, calendar year |
| GSOOSPC | Argentina soyoil production, 1,000 mt, marketing year |
| GSOYDCC | Argentina soybean crush, 1,000 mt, marketing year |
| GSOYMEC | Argentina exports of soybeans (exports-imports), 1,000 mt, marketing year |
| GSOYPXA | Argentina export price of soybeans, $/mt, calendar year |
| GSOYSHC | Argentina soybean acreage harvested, 1,000 ha, crop year |
| GSOYSPC | Argentina soybean production, 1,000 mt, marketing year |

### EXOGENOUS VARIABLES

**General**

| | |
|---|---|
| Dn | Indicator variable for year n such that n=1 and all other years=0 |
| Dnm | Indicator variable for years n and m such that years n and m =1 and all other years=0 |
| DnTm | Indicator variable for years n through m such that years n through m =1 and all other years=0 |
| TIME | Time trend (years=1960...2006) |

## Appendix Table 2 (continued)

| | |
|---|---|
| **United States** | |
| ACHKRES | Atlantice region stock of soybean checkoff research expenditures, $1,000, crop year |
| ACORSYC | Atlantic region wtd average corn yield, bu/acre, crop year |
| AOATPPC | Atlantic region expected farm price for oats (same formula as for corn, see model for formula) |
| ASOYPLC | Atlantic region non-recourse soybean loan rate, $/bu, crop year |
| CCHKRES | Corn Belt region stock of soybean checkoff research expenditures, $1,000, cropyear |
| CCORSYC | Cornbelt region wtd average corn yield, bu/acre, crop year |
| CSOYPLC | Corn belt region non-recourse soybean loan rate, $/bu, crop year |
| DCHKRES | Delta region stock of soybean checkoff research expenditures, $1,000, annual |
| D2CORF | Indicator variable for corn feed demand, 1977=-1, 1973=1, 1982=1, and1994=1all other years = 0 |
| DCORSYC | Delta region wtd average corn yield, bu/acre, crop year |
| DETHANOL | Indicator variable for surge in demand for ethanol, 2004, 2005, 2006 = 1, all other years=0 |
| DFB90 | Indicator variable for the effects of the 1990 farm bill, 1990-1995=1, all other years =0 |
| DFB96 | Indicator variable for the effects of the 1996 farm bill, 1996-2001=1, all other years =0 |
| DFB02 | Indicator variable for the effects of the 1990 farm bill, 2002-2007=1, all other years =0 |
| DJEMBGO | Indicator variable for effects of U.S. 1972 soybean embargo, 1972-1973 = 1, all other years=0 |
| DPIK | Indicator variable for the 1982 U.S. payment-in-kind (PIK) program, 1982 =1, all other years =0 |
| DRICPPC | Delta region expected farm price for rice (same formula as corn,see model for formula) |
| DSOOH3 | Indicator variable for speculative increase in oil stocks, 1992=1, 2005=1, all other years= 0 |
| DSOYPLC | Delta region non-recourse soybean loan rate, $/bu, crop year |
| DWC | Cornbelt region weather indicator variable, 1973=1, 1978=1, 1979=1, all other years=0 |
| DWD1 | Delta region weather indicator variable, 1993=1, all other years=0 |
| DWD2 | Delta region weather indicator variable, 2001=1, all other years=0 |
| DWHEPPC | Delta region expected farm price for wheat (same formula as for corn, see model for formula) |
| DWL | Lakes region weather indicator variable,1991=1, 2003=1, all other years=0 |
| DWO2 | Other region weather indicator variable, 1979=-1, 1980=-1, 1981=1, all other years=0 |
| DWO2 | Other region weather indicator variable, 1996, 1999=1 and 1997, 1998=-1, all other years=0 |
| DWP1 | Plains region weather indicator variable, 2005=1 and 2006=-1, all other years=0 |
| DWP2 | Plains region weather indicator variable, 1993, 1996=1 and 1994=-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 (same formula as for corn, see model for formula) |
| LCHKRES | Lakes region stock of soybean checkoff research expenditures, $1,000, annual |
| LCORSYC | Lakes region wtd average corn yield, bu/acre, crop year |
| LSOYPLC | Lakes region non-recourse soybean loan rate, $/bu, crop year |
| NORFLEX | Percent of acres required in the normal flex program under the 1990 farm bill, % |
| OCHKRES | Other region stock of soybean checkoff research expenditures, $1,000, annual |
| OCORSYC | Other region wtd average corn yield, bu/acre, crop year |
| OSOYPLC | Other region non-recourse soybean loan rate, $/bu, crop year |
| OWHEPPC | Other region expected farm price for wheat (same formula as corn, see model for formula) |
| PCHKRES | Plains region stock of soybean checkoff research expenditures, $1,000, annual |
| PCORSYC | Plains region wtd average corn yield, bu/acre, crop year |
| PDLMEXP | U.S. Stock of soybean checkoff demand promotion expenditures for soymeal, $US, mktg year |
| PDLOEXP | U.S. Stock of soybean checkoff demand promotion expenditures for soyoil, $US, mktg year |
| PDLSEXP | U.S. Stock of soybean checkoff demand promotion expenditures for soybeans, $US, mktg year |
| PSOYPLC | Atlantic region non-recourse soybean loan rate, $/bu, crop year |
| RCORMEC | Corn exports by non-U.S. corn exporting countries, mil bu., crop year |
| SCHKRES | South region stock of soybean checkoff research expenditures, $1,000, annual |
| SCORSYC | South region wtd average corn yield, bu/acre, crop year |
| SSOYPLC | South region non-recourse soybean loan rate, $/bu, 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 |

## Appendix Table 2 (continued)

| | |
|---|---|
| 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 |
| 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 |
| USOYPTC | U.S. soybean target price, $/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 (15/27)** | |
| ECWPI2 | EU-15/27 wtd average wholesale price index, 1985=100, annual |
| EGCAUA | EU-15/27 grain consuming animal units, million head, January 1 |
| EGDP | EU-15/27 aggregate GDP, billions of SDRs |
| EPAOPIA | EU-15/27 palm oil price, cif NW Europe, $/mt, annual |
| ESOMDZC | EU-15/27 other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year |
| ESOMEXPR | EU-15/27 stock of international market promotion expenditures for soymeal, real deflated SDRs |
| ESOMHEC | EU-15/27 ending stocks of soymeal, end of marketing year |
| ESOMQ | EU-15/27 soymeal extraction rate, mt of soymeal/mt of soybeans |
| ESOODZC | EU-15/27 other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year |
| ESOOEXPR | EU-15/27 stock of international market promotion expenditures for soyoil, real deflated SDRs |
| ESOOHEC | EU-15/27 ending stocks of soyoil, end of marketing year |
| ESOOQ | EU-15/27 soyoil extraction rate, mt of soyoil/mt of soybeans |

## Appendix Table 2 (continued)

| | |
|---|---|
| ESOYDZC | EU-15/27 seed, feed, and other use of soybeans, 1,000 mt, marketing year |
| ESOYEXPR | EU-15/27 stock of international market promotion expenditures for soybeans, real deflated SDRs |
| ESOYHEC | EU-15/27 ending stocks of soybeans, end of marketing year |
| ESOYSPC | EU-15/27 production of soybeans, marketing year |
| XECUSA | Exchange rate, SDRs$US, annual |
| **Japan** | |
| DJEMBGO | Dummy variable for impact of U.S. soybean export embargo on Japanese soybean market, 1972=1, 1973=1, 1974=1, all other years =0 |
| JGCAUA | Japan grain consuming animal units, million head, February 1 |
| JSOMDZC | Japan other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year |
| JSOMEXPR | Japan stock of international market promotion expenditures for soymeal, real deflated Yen |
| JSOMHEC | Japan ending stocks of soymeal, 1,000 mt, end of marketing year |
| JSOMQ | Japan soymeal extraction rate, mt of soymeal/mt of soybeans |
| JSOODZC | Japan other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year |
| JSOOEXPR | Japan stock of international market promotion expenditures for soyoil, real deflated Yen |
| JSOOHEC | Japan ending stocks of soyoil, 1,000 mt, end of marketing year |
| JSOOQ | Japan soyoil extraction rate, mt of soyoil/mt of soybeans |
| JSOYDZC | Japan seed, feed, and other use of soybeans, 1,000 mt, marketing year |
| JSOYEXPR | Japan stock of international market promotion expenditures for soybeans, real deflated Yen |
| JSOYHEC | Japan ending stocks of soybeans, 1,000 mt, end of marketing year |
| JSOYSPC | Japan soybean production, 1,000 mt, Japan crop year |
| JWPI85 | Japan wholesale price index, 1985=100, annual |
| XJAUSA | Exchange rate, Japanese Yen/$US, annual |
| **Rest-of-the-World (ROW)** | |
| RGDP85 | ROW real GDP index, real 1985 prices, annual |
| RSOMEXPR | ROW stock of international market promotion expenditures for soymeal, real deflated $US |
| RSOOEXPR | ROW stock of international market promotion expenditures for soyoil, real deflated $US |
| RSOYEXPR | ROW stock of international market promotion expenditures for soybeans, real deflated $US |
| **Brazil** | |
| BGDP85 | Brazil real gross domestic product, 1985 prices, annual |
| BSOMDZC | Brazil other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year |
| BSOMHEC | Brazil soymeal ending stocks, 1,000 mt, end of marketing year |
| BSOMMMC | Brazil soymeal imports, 1,000 mt, marketing year |
| BSOMQ | Brazil soymeal extraction rate, mt of soymeal/mt of soybeans |
| BSOODZC | Brazil other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year |
| BSOOHEC | Brazil soyoil ending stocks, 1,000 mt, end of marketing year |
| BSOOQ | Brazil soyoil extraction rate, mt of soyoil/mt of soybeans |
| BSOYDZC | Brazil seed, feed, and other use of soybeans, 1,000 mt, marketing year |
| BSOYHEC | Brazil soybean ending stocks, 1,000 mt, end of marketing year |
| BSOYSYC | Brazil soybean yield, mt/hectare, crop year |
| BWPI85 | Brazil whole sale price index, 1985=1, annual |
| XBZUSA | Exchange rate, Trillion Brazilian Reais/$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 |
| GSOMMMC | Argentina soymeal imports, 1,000 mt, marketing year |
| GSOMQ | Argentina soymeal extraction rate, mt of soymeal/mt of soybeans |

## Appendix Table 2 (continued)

| | |
|---|---|
| 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: SOYMOD5 Ex-Post Simulation Validation Statistics, Theil Forecast Error Statistics, 1980/81 to 2006/07

| | MSE Decomposition Proportions | | | | | Inequality Coefficients | |
|---|---|---|---|---|---|---|---|
| Variable | Bias (UM) | Reg (UR) | Dist (UD) | Var (US) | Covar (UC) | Theil U1 | Theil U |
| ASOYPCC | 0.10 | 0.30 | 0.60 | 0.11 | 0.79 | 0.0819 | 0.0404 |
| CSOYPCC | 0.10 | 0.23 | 0.67 | 0.07 | 0.83 | 0.0785 | 0.0387 |
| DSOYPCC | 0.04 | 0.43 | 0.53 | 0.13 | 0.83 | 0.1068 | 0.0527 |
| LSOYPCC | 0.06 | 0.23 | 0.70 | 0.07 | 0.87 | 0.0768 | 0.0380 |
| OSOYPCC | 0.06 | 0.36 | 0.58 | 0.13 | 0.81 | 0.0834 | 0.0412 |
| PSOYPCC | 0.08 | 0.26 | 0.67 | 0.07 | 0.85 | 0.0844 | 0.0416 |
| SSOYPCC | 0.07 | 0.34 | 0.59 | 0.11 | 0.81 | 0.0902 | 0.0445 |
| ASOYSAC | 0.05 | 0.49 | 0.46 | 0.14 | 0.81 | 0.0430 | 0.0214 |
| CSOYSAC | 0.22 | 0.08 | 0.70 | 0.00 | 0.78 | 0.0234 | 0.0117 |
| DSOYSAC | 0.05 | 0.03 | 0.92 | 0.18 | 0.77 | 0.0603 | 0.0304 |
| LSOYSAC | 0.04 | 0.03 | 0.93 | 0.01 | 0.95 | 0.0134 | 0.0067 |
| OSOYSAC | 0.01 | 0.12 | 0.87 | 0.05 | 0.94 | 0.0416 | 0.0208 |
| PSOYSAC | 0.04 | 0.08 | 0.88 | 0.12 | 0.85 | 0.0191 | 0.0096 |
| SSOYSAC | 0.08 | 0.49 | 0.44 | 0.05 | 0.87 | 0.1140 | 0.0560 |
| USOYSAC | 0.06 | 0.33 | 0.61 | 0.18 | 0.77 | 0.0205 | 0.0103 |
| ASOYSHC | 0.04 | 0.44 | 0.52 | 0.15 | 0.81 | 0.0387 | 0.0193 |
| CSOYSHC | 0.32 | 0.07 | 0.61 | 0.00 | 0.68 | 0.0239 | 0.0120 |
| DSOYSHC | 0.04 | 0.01 | 0.95 | 0.15 | 0.81 | 0.0654 | 0.0329 |
| LSOYSHC | 0.00 | 0.02 | 0.98 | 0.00 | 1.00 | 0.0160 | 0.0080 |
| OSOYSHC | 0.01 | 0.13 | 0.87 | 0.06 | 0.93 | 0.0396 | 0.0198 |
| PSOYSHC | 0.09 | 0.07 | 0.85 | 0.09 | 0.82 | 0.0159 | 0.0080 |
| SSOYSHC | 0.07 | 0.50 | 0.43 | 0.09 | 0.84 | 0.1047 | 0.0516 |
| USOYSHC | 0.12 | 0.37 | 0.51 | 0.23 | 0.65 | 0.0200 | 0.0100 |
| ASOYSPC | 0.05 | 0.27 | 0.68 | 0.19 | 0.76 | 0.0403 | 0.0200 |
| CSOYSPC | 0.28 | 0.31 | 0.41 | 0.25 | 0.47 | 0.0232 | 0.0117 |
| DSOYSPC | 0.05 | 0.03 | 0.92 | 0.13 | 0.82 | 0.0579 | 0.0292 |
| LSOYSPC | 0.00 | 0.00 | 1.00 | 0.01 | 0.99 | 0.0149 | 0.0074 |
| OSOYSPC | 0.00 | 0.23 | 0.76 | 0.17 | 0.83 | 0.0408 | 0.0204 |
| PSOYSPC | 0.08 | 0.06 | 0.85 | 0.08 | 0.83 | 0.0159 | 0.0080 |
| SSOYSPC | 0.11 | 0.63 | 0.26 | 0.48 | 0.40 | 0.1187 | 0.0578 |
| USOYSPC | 0.11 | 0.50 | 0.39 | 0.44 | 0.45 | 0.0195 | 0.0098 |
| ACORPPC | 0.05 | 0.01 | 0.94 | 0.09 | 0.86 | 0.1128 | 0.0558 |
| CCORPPC | 0.06 | 0.00 | 0.94 | 0.06 | 0.88 | 0.0850 | 0.0421 |
| DCORPPC | 0.07 | 0.01 | 0.91 | 0.29 | 0.64 | 0.1229 | 0.0607 |
| LCORPPC | 0.08 | 0.00 | 0.92 | 0.06 | 0.87 | 0.0657 | 0.0326 |
| OCORPPC | 0.05 | 0.06 | 0.89 | 0.01 | 0.94 | 0.1089 | 0.0538 |
| PCORPPC | 0.07 | 0.00 | 0.93 | 0.07 | 0.86 | 0.0741 | 0.0367 |
| SCORPPC | 0.10 | 0.03 | 0.86 | 0.05 | 0.84 | 0.1129 | 0.0555 |
| TCORPPC | 0.09 | 0.05 | 0.86 | 0.03 | 0.88 | 0.1112 | 0.0548 |
| UCORPPC | 0.10 | 0.00 | 0.90 | 0.07 | 0.83 | 0.0875 | 0.0432 |
| ACORSAC | 0.04 | 0.33 | 0.63 | 0.03 | 0.94 | 0.0773 | 0.0384 |
| CCORSAC | 0.18 | 0.25 | 0.57 | 0.06 | 0.76 | 0.0295 | 0.0146 |
| DCORSAC | 0.09 | 0.01 | 0.90 | 0.01 | 0.90 | 0.1034 | 0.0526 |
| LCORSAC | 0.58 | 0.21 | 0.21 | 0.00 | 0.42 | 0.0614 | 0.0300 |
| OCORSAC | 0.41 | 0.00 | 0.59 | 0.21 | 0.38 | 0.0677 | 0.0332 |
| PCORSAC | 0.18 | 0.31 | 0.51 | 0.02 | 0.80 | 0.0530 | 0.0268 |
| SCORSAC | 0.29 | 0.16 | 0.55 | 0.00 | 0.71 | 0.0935 | 0.0456 |

**Appendix Table 3** (continued)

| Variable | Bias (UM) | Reg (UR) | Dist (UD) | Var (US) | Covar (UC) | Theil U1 | Theil U |
|---|---|---|---|---|---|---|---|
| TCORSAC | 0.61 | 0.12 | 0.28 | 0.00 | 0.39 | 0.0770 | 0.0397 |
| UCORSAC | 0.11 | 0.55 | 0.34 | 0.00 | 0.88 | 0.0326 | 0.0162 |
| ACORSHC | 0.00 | 0.45 | 0.55 | 0.05 | 0.95 | 0.0968 | 0.0484 |
| CCORSHC | 0.14 | 0.24 | 0.62 | 0.07 | 0.79 | 0.0300 | 0.0149 |
| DCORSHC | 0.10 | 0.11 | 0.79 | 0.00 | 0.90 | 0.1320 | 0.0673 |
| LCORSHC | 0.58 | 0.22 | 0.20 | 0.00 | 0.42 | 0.0663 | 0.0323 |
| OCORSHC | 0.29 | 0.03 | 0.68 | 0.22 | 0.49 | 0.0973 | 0.0475 |
| PCORSHC | 0.19 | 0.40 | 0.41 | 0.05 | 0.77 | 0.0630 | 0.0319 |
| SCORSHC | 0.28 | 0.35 | 0.37 | 0.03 | 0.69 | 0.1077 | 0.0523 |
| TCORSHC | 0.51 | 0.00 | 0.49 | 0.03 | 0.46 | 0.1057 | 0.0550 |
| UCORSHC | 0.07 | 0.52 | 0.41 | 0.03 | 0.90 | 0.0371 | 0.0185 |
| ACORSPC | 0.00 | 0.00 | 1.00 | 0.04 | 0.96 | 0.0967 | 0.0485 |
| CCORSPC | 0.12 | 0.02 | 0.86 | 0.08 | 0.80 | 0.0304 | 0.0151 |
| DCORSPC | 0.15 | 0.02 | 0.82 | 0.17 | 0.67 | 0.1307 | 0.0674 |
| LCORSPC | 0.60 | 0.04 | 0.35 | 0.01 | 0.39 | 0.0650 | 0.0317 |
| OCORSPC | 0.29 | 0.02 | 0.69 | 0.11 | 0.61 | 0.0879 | 0.0430 |
| PCORSPC | 0.19 | 0.02 | 0.78 | 0.02 | 0.79 | 0.0644 | 0.0327 |
| SCORSPC | 0.27 | 0.35 | 0.38 | 0.06 | 0.66 | 0.1103 | 0.0535 |
| TCORSPC | 0.50 | 0.01 | 0.49 | 0.03 | 0.48 | 0.1071 | 0.0557 |
| UCORSPC | 0.06 | 0.00 | 0.94 | 0.03 | 0.90 | 0.0363 | 0.0181 |
| ASOYPFC | 0.00 | 0.40 | 0.60 | 0.12 | 0.87 | 0.1481 | 0.0734 |
| CSOYPFC | 0.00 | 0.37 | 0.63 | 0.11 | 0.89 | 0.1410 | 0.0702 |
| DSOYPFC | 0.00 | 0.52 | 0.48 | 0.16 | 0.84 | 0.1738 | 0.0866 |
| LSOYPFC | 0.00 | 0.36 | 0.64 | 0.09 | 0.91 | 0.1444 | 0.0719 |
| OSOYPFC | 0.00 | 0.42 | 0.58 | 0.13 | 0.87 | 0.1519 | 0.0754 |
| PSOYPFC | 0.00 | 0.40 | 0.60 | 0.11 | 0.88 | 0.1511 | 0.0750 |
| SSOYPFC | 0.00 | 0.47 | 0.53 | 0.16 | 0.84 | 0.1563 | 0.0779 |
| ACORPFC | 0.01 | 0.53 | 0.47 | 0.12 | 0.87 | 0.1916 | 0.0944 |
| CCORPFC | 0.01 | 0.52 | 0.47 | 0.16 | 0.83 | 0.1844 | 0.0908 |
| DCORPFC | 0.01 | 0.45 | 0.54 | 0.05 | 0.93 | 0.2024 | 0.0996 |
| LCORPFC | 0.03 | 0.49 | 0.48 | 0.13 | 0.85 | 0.1972 | 0.0964 |
| OCORPFC | 0.01 | 0.53 | 0.46 | 0.15 | 0.84 | 0.1762 | 0.0869 |
| PCORPFC | 0.02 | 0.50 | 0.48 | 0.14 | 0.85 | 0.1927 | 0.0945 |
| SCORPFC | 0.01 | 0.53 | 0.46 | 0.14 | 0.85 | 0.1738 | 0.0857 |
| TCORPFC | 0.01 | 0.61 | 0.38 | 0.22 | 0.77 | 0.1743 | 0.0859 |
| USOYDCC | 0.01 | 0.30 | 0.69 | 0.15 | 0.84 | 0.0267 | 0.0134 |
| USOYMEC | 0.19 | 0.16 | 0.65 | 0.05 | 0.76 | 0.0503 | 0.0254 |
| USOYPWC | 0.00 | 0.28 | 0.72 | 0.06 | 0.94 | 0.1303 | 0.0650 |
| USOYHEC | 0.00 | 0.01 | 0.99 | 0.01 | 0.98 | 0.1657 | 0.0827 |
| USOYHTC | 0.00 | 0.01 | 0.99 | 0.01 | 0.98 | 0.1657 | 0.0827 |
| USOYEHR | 0.01 | 0.00 | 0.99 | 0.09 | 0.90 | 0.2015 | 0.1009 |
| USOYGCC | 0.02 | 0.29 | 0.69 | 0.02 | 0.95 | 0.3465 | 0.1702 |
| USOMSPC | 0.01 | 0.31 | 0.68 | 0.16 | 0.83 | 0.0268 | 0.0134 |
| LCOMDPC | 0.08 | 0.00 | 0.91 | 0.04 | 0.88 | 0.0141 | 0.0071 |
| UCOMDPC | 0.07 | 0.02 | 0.92 | 0.06 | 0.88 | 0.0467 | 0.0233 |
| USOMDPC | 0.07 | 0.01 | 0.92 | 0.04 | 0.89 | 0.0016 | 0.0008 |
| UHPMDDC | 0.00 | 0.65 | 0.34 | 0.57 | 0.43 | 0.0195 | 0.0098 |
| USOMDDC | 0.01 | 0.61 | 0.39 | 0.52 | 0.48 | 0.0195 | 0.0098 |
| USOMPWC | 0.04 | 0.06 | 0.90 | 0.00 | 0.96 | 0.0953 | 0.0472 |
| USOMHEC | 0.12 | 0.01 | 0.86 | 0.03 | 0.85 | 0.1485 | 0.0764 |

**Appendix Table 3** (continued)

| Variable | Bias (UM) | Reg (UR) | Dist (UD) | Var (US) | Covar (UC) | Theil U1 | Theil U |
|---|---|---|---|---|---|---|---|
| USOMMEC | 0.02 | 0.37 | 0.61 | 0.09 | 0.89 | 0.1276 | 0.0631 |
| USOOSPC | 0.01 | 0.26 | 0.74 | 0.13 | 0.86 | 0.0268 | 0.0134 |
| LCOODPC | 0.47 | 0.22 | 0.31 | 0.33 | 0.20 | 0.0395 | 0.0195 |
| UCOODPC | 0.46 | 0.32 | 0.23 | 0.41 | 0.13 | 0.1320 | 0.0695 |
| USOODPC | 0.46 | 0.26 | 0.28 | 0.38 | 0.16 | 0.0066 | 0.0033 |
| UOLODDC | 0.00 | 0.13 | 0.86 | 0.06 | 0.94 | 0.0193 | 0.0096 |
| UOLOPWC | 0.00 | 0.01 | 0.99 | 0.06 | 0.94 | 0.0636 | 0.0318 |
| USOODDC | 0.03 | 0.05 | 0.92 | 0.01 | 0.96 | 0.0196 | 0.0098 |
| USOOHEC | 0.00 | 0.33 | 0.67 | 0.54 | 0.46 | 0.1449 | 0.0735 |
| USOOHTC | 0.00 | 0.33 | 0.67 | 0.54 | 0.46 | 0.1449 | 0.0735 |
| USOOMEC | 0.00 | 0.50 | 0.50 | 0.22 | 0.78 | 0.2754 | 0.1339 |
| USOOMTC | 0.00 | 0.46 | 0.54 | 0.19 | 0.81 | 0.2573 | 0.1256 |
| UCORDFC | 0.04 | 0.34 | 0.62 | 0.16 | 0.80 | 0.0268 | 0.0134 |
| UCORDOC | 0.00 | 0.03 | 0.97 | 0.02 | 0.98 | 0.0097 | 0.0048 |
| UCORHOC | 0.02 | 0.04 | 0.94 | 0.02 | 0.96 | 0.1618 | 0.0801 |
| UCORMEC | 0.44 | 0.04 | 0.51 | 0.01 | 0.55 | 0.0963 | 0.0467 |
| UCORHTC | 0.02 | 0.04 | 0.94 | 0.02 | 0.96 | 0.1612 | 0.0799 |
| UCORPFC | 0.01 | 0.52 | 0.47 | 0.16 | 0.83 | 0.1852 | 0.0911 |
| ECORPIA | 0.05 | 0.34 | 0.61 | 0.11 | 0.84 | 0.1400 | 0.0686 |
| USOYPFC | 0.00 | 0.40 | 0.60 | 0.12 | 0.88 | 0.1455 | 0.0723 |
| UHPMPWC | 0.04 | 0.06 | 0.90 | 0.00 | 0.96 | 0.0924 | 0.0458 |
| USOOPWC | 0.00 | 0.01 | 0.99 | 0.06 | 0.94 | 0.0689 | 0.0345 |
| UCORPWC | 0.01 | 0.46 | 0.53 | 0.16 | 0.83 | 0.1699 | 0.0836 |
| ESOYDCC | 0.26 | 0.01 | 0.73 | 0.01 | 0.73 | 0.0385 | 0.0194 |
| ESOYMIC | 0.26 | 0.00 | 0.74 | 0.01 | 0.73 | 0.0378 | 0.0191 |
| ESOMSPC | 0.26 | 0.01 | 0.72 | 0.01 | 0.73 | 0.0384 | 0.0194 |
| ESOMDDC | 0.02 | 0.14 | 0.85 | 0.06 | 0.93 | 0.0358 | 0.0179 |
| ESOMMIC | 0.01 | 0.10 | 0.89 | 0.03 | 0.96 | 0.0633 | 0.0315 |
| ESOOSPC | 0.26 | 0.01 | 0.73 | 0.01 | 0.73 | 0.0385 | 0.0195 |
| ESOODDC | 0.00 | 0.00 | 1.00 | 0.02 | 0.98 | 0.0368 | 0.0184 |
| ESOOMXC | 0.36 | 0.02 | 0.62 | 0.03 | 0.60 | 0.1108 | 0.0609 |
| ESOYPIA | 0.01 | 0.24 | 0.75 | 0.06 | 0.93 | 0.1194 | 0.0592 |
| ESOMPIA | 0.04 | 0.15 | 0.81 | 0.02 | 0.94 | 0.0992 | 0.0491 |
| ESOOPXA | 0.08 | 0.00 | 0.92 | 0.01 | 0.91 | 0.0606 | 0.0305 |
| JSOYDCC | 0.00 | 0.15 | 0.85 | 0.07 | 0.93 | 0.0331 | 0.0165 |
| JSOYMIC | 0.00 | 0.12 | 0.88 | 0.04 | 0.96 | 0.0253 | 0.0126 |
| JSOMSPC | 0.00 | 0.16 | 0.84 | 0.07 | 0.93 | 0.0331 | 0.0165 |
| JSOMDDC | 0.01 | 0.09 | 0.91 | 0.00 | 0.99 | 0.0387 | 0.0194 |
| JSOMMIC | 0.00 | 0.41 | 0.59 | 0.24 | 0.75 | 0.1454 | 0.0722 |
| JSOOSPC | 0.00 | 0.18 | 0.82 | 0.08 | 0.92 | 0.0333 | 0.0166 |
| JSOODDC | 0.00 | 0.03 | 0.97 | 0.26 | 0.74 | 0.0468 | 0.0234 |
| ESOMPIA | 0.04 | 0.15 | 0.81 | 0.02 | 0.94 | 0.0992 | 0.0491 |
| ESOMPIA | 0.04 | 0.15 | 0.81 | 0.02 | 0.94 | 0.0992 | 0.0491 |
| ESOOPXA | 0.08 | 0.00 | 0.92 | 0.01 | 0.91 | 0.0606 | 0.0305 |
| JSOYDCC | 0.00 | 0.15 | 0.85 | 0.07 | 0.93 | 0.0331 | 0.0165 |
| JSOYMIC | 0.00 | 0.12 | 0.88 | 0.04 | 0.96 | 0.0253 | 0.0126 |
| JSOMSPC | 0.00 | 0.16 | 0.84 | 0.07 | 0.93 | 0.0331 | 0.0165 |
| JSOMDDC | 0.01 | 0.09 | 0.91 | 0.00 | 0.99 | 0.0387 | 0.0194 |
| JSOMMIC | 0.00 | 0.41 | 0.59 | 0.24 | 0.75 | 0.1454 | 0.0722 |
| JSOOSPC | 0.00 | 0.18 | 0.82 | 0.08 | 0.92 | 0.0333 | 0.0166 |

**Appendix Table 3** (continued)

| Variable | Bias (UM) | Reg (UR) | Dist (UD) | Var (US) | Covar (UC) | Theil U1 | Theil U |
|---|---|---|---|---|---|---|---|
| JSOODDC | 0.00 | 0.03 | 0.97 | 0.26 | 0.74 | 0.0468 | 0.0234 |
| JSOOMIC | 0.00 | 0.90 | 0.10 | 0.74 | 0.26 | 1.2834 | 0.4346 |
| JSOYPUA | 0.05 | 0.19 | 0.76 | 0.04 | 0.92 | 0.1090 | 0.0550 |
| JSOMPUA | 0.02 | 0.11 | 0.87 | 0.00 | 0.98 | 0.1084 | 0.0538 |
| JSOOPUA | 0.02 | 0.05 | 0.93 | 0.04 | 0.94 | 0.1196 | 0.0594 |
| RSOYMIN | 0.00 | 0.01 | 0.99 | 0.00 | 1.00 | 0.0601 | 0.0300 |
| RSOMSPN | 0.00 | 0.01 | 0.99 | 0.00 | 1.00 | 0.0601 | 0.0300 |
| RSOMDDN | 0.01 | 0.01 | 0.97 | 0.00 | 0.99 | 0.0547 | 0.0274 |
| RSOMMIN | 0.04 | 0.02 | 0.93 | 0.00 | 0.96 | 0.0675 | 0.0340 |
| RSOOSPN | 0.00 | 0.01 | 0.99 | 0.00 | 1.00 | 0.0601 | 0.0300 |
| RSOODDN | 0.01 | 0.10 | 0.90 | 0.06 | 0.93 | 0.0369 | 0.0185 |
| RSOOMIN | 0.03 | 0.19 | 0.78 | 0.13 | 0.83 | 0.0323 | 0.0162 |
| BSOYDCC | 0.02 | 0.04 | 0.93 | 0.01 | 0.97 | 0.0354 | 0.0177 |
| BSOYMXC | 0.04 | 0.00 | 0.96 | 0.04 | 0.92 | 0.1021 | 0.0508 |
| BSOMSPC | 0.02 | 0.04 | 0.94 | 0.01 | 0.97 | 0.0353 | 0.0176 |
| BSOMDDC | 0.38 | 0.19 | 0.43 | 0.13 | 0.48 | 0.0618 | 0.0303 |
| BSOMMEC | 0.07 | 0.00 | 0.93 | 0.04 | 0.89 | 0.0653 | 0.0330 |
| BSOOSPC | 0.02 | 0.04 | 0.93 | 0.01 | 0.97 | 0.0355 | 0.0177 |
| BSOODDC | 0.01 | 0.35 | 0.64 | 0.24 | 0.75 | 0.0236 | 0.0118 |
| BSOOMXC | 0.01 | 0.00 | 0.99 | 0.01 | 0.98 | 0.0905 | 0.0451 |
| BSOYSHC | 0.04 | 0.00 | 0.96 | 0.00 | 0.96 | 0.0549 | 0.0273 |
| BSOYSPC | 0.04 | 0.00 | 0.96 | 0.02 | 0.95 | 0.0529 | 0.0263 |
| BSOYPXC | 0.01 | 0.44 | 0.55 | 0.16 | 0.83 | 0.1428 | 0.0705 |
| BSOMPXC | 0.00 | 0.20 | 0.80 | 0.03 | 0.97 | 0.1168 | 0.0584 |
| BSOOPXC | 0.05 | 0.04 | 0.90 | 0.00 | 0.95 | 0.1060 | 0.0536 |
| LBSOYSH | 0.07 | 0.01 | 0.91 | 0.05 | 0.88 | 0.0051 | 0.0025 |
| GSOYDCC | 0.03 | 0.04 | 0.93 | 0.03 | 0.94 | 0.0178 | 0.0089 |
| GSOYMEC | 0.00 | 0.02 | 0.98 | 0.06 | 0.94 | 0.0999 | 0.0503 |
| GSOMSPC | 0.04 | 0.04 | 0.93 | 0.03 | 0.94 | 0.0178 | 0.0089 |
| GSOMDDC | 0.02 | 0.11 | 0.87 | 0.19 | 0.80 | 0.0477 | 0.0238 |
| GSOMMEC | 0.04 | 0.05 | 0.91 | 0.04 | 0.92 | 0.0179 | 0.0090 |
| GSOOSPC | 0.03 | 0.04 | 0.93 | 0.03 | 0.93 | 0.0177 | 0.0089 |
| GSOODDC | 0.00 | 0.00 | 0.99 | 0.00 | 1.00 | 0.0395 | 0.0198 |
| GSOOMEC | 0.03 | 0.04 | 0.93 | 0.03 | 0.94 | 0.0190 | 0.0095 |
| GSOYSHC | 0.01 | 0.18 | 0.81 | 0.20 | 0.78 | 0.0211 | 0.0106 |
| GSOYSPC | 0.03 | 0.13 | 0.84 | 0.15 | 0.82 | 0.0192 | 0.0096 |
| GSOYPXA | 0.01 | 0.20 | 0.80 | 0.03 | 0.96 | 0.1108 | 0.0551 |
| GSOMPXA | 0.05 | 0.13 | 0.82 | 0.02 | 0.92 | 0.0859 | 0.0425 |
| GSOOPXA | 0.00 | 0.00 | 1.00 | 0.07 | 0.93 | 0.0882 | 0.0442 |
| GSOYSHC | 0.00 | 0.24 | 0.75 | 0.28 | 0.72 | 0.0032 | 0.0016 |