"From the fields of producers… to the plates of consumers."

IMPACTS OF THE INVESTMENTS MADE IN RESEARCH, PROMOTION, AND INFORMATION ON PRODUCTION AND END USES OF SORGHUM

Research Report to the United Sorghum Checkoff Program (USCP) Board of Directors

Submitted to Florentino Lopez, Executive Director, USCP

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REPORT TO THE AGRICULTURAL MARKETING SERVICE, USDA

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EXECUTIVE SUMMARY

This research deals with the evaluation of the performance of the United Sorghum Checkoff Program (USCP) compliant with the criteria established by the U.S. Department of Agriculture (USDA) for reporting the return-on-investment in market development and promotion, information, and research programs. This requirement is set by the USDA to be concluded every five years under the provisions of the 1996 Farm Bill (FAIR Act).

Specific missions of the USCP are to increase yields through investment in research programs and to increase the demand for sorghum through a set of marketing and promotion programs, thereby providing U.S. producers with expanding markets for their commodity. The rightward shift in demand may occur through expansion of sorghum in the ethanol industry, the use of sorghum as a feedstock for advanced biofuels, the development of new uses for sorghum, and expansion of sorghum in international markets. The overriding goal of all USCP activities is to maximize return on grower investment.

The USCP was only recently established in 2008 with the promise of investing producer dollars to increase profitability for the sorghum industry. The overall objective of this project is to enable the USCP Board of Directors to obtain meaningful and reliable evaluations of the impacts of its activities on the sorghum industry over time. Consequently, we evaluate the programmatic activities of the USCP that satisfy the sorghum industry needs and legislative requirements as well as meet academic standards for such evaluations. To accomplish this overall objective, we undertake the following activities:

(1) Determine the impacts of USCP sorghum-oriented programs implemented since 2008, as related to promotion, research, and information, on the industry;

(2) Evaluate the effectiveness of the "Crop Improvement Program" in relation to changes in yields, planted and harvested acreage, and hence production;

(3) Evaluate the effectiveness of the "High-Value Program" in relation to the demand for sorghum in export markets and to the demand for sorghum in domestic markets associated with uses in the food industry, in the livestock industry, and in other industries;

(4) Evaluate the effectiveness of the "Renewables Program" in relation to potential benefits associated with the demand for sorghum in industrial use;

(5) Assess the availability and adequacy of current data currently in place to support the required evaluation of the impacts of USCP activities over time; the intent is to establish key tracking mechanisms that can be analyzed, documented, reviewed and communicated concerning the effectiveness of the checkoff program.

The aforementioned evaluations are dependent on the measurement, via the use of statistical procedures, of the effects of the programmatic activities of the USCP for various domestic markets of U.S. sorghum and export markets for sorghum as well as for the sorghum production. This analysis provides the basis for determining if the programmatic activities of the USCP Board lead to rightward shifts in demand for in domestic and export markets as well as for calculating the benefit-

cost ratio (BCR) metrics to stakeholders related to their investments in market development and promotion, information, and research programs. The return-on-investment metrics help to improve the efficiency and effectiveness of the investments in marketing activities and to provide needed feedback to stakeholders.

With this evaluation, we are in position to answer the most relevant question to sorghum growers, namely, where would sorghum use and prices paid to growers be without the programmatic efforts of the USCP Board? In this report, the key findings to this evaluation include;

- Revenue from assessments ranged from $6.6 million in 2009/2010 to $8.8 million in 2010/2011. Total expenses ranged from $6.2 million in 2009/2010 to $6.7 million in 2010/2011.

- Compared to the farm value of sorghum, on the order of $1.08 billion to $1.47 billion from 2008/2009 to 2011/2012, the amount of funds collected from the checkoff is extremely small. The ratio of revenue from assessments to farm value of production often referred to as the investment-intensity ratio, was on average 0.62 percent.

- The share of research expenses to total expenses was in the interval of 21 percent to 26 percent over the period 2008/2009 to 2011/2012. The share of information, communication, and education activities in relation to total expenditures was on the order of 9 percent to 17 percent. The share of market development expenses to total expenses varied from 10 percent to 18 percent.

- The share of administration expenses in relation to total expenses was in the interval of 7 percent to 10 percent. The share of total expenses for USDA oversight varied from 2.1 percent to 3.6 percent.

- From marketing years 1960 to 2012, a notable decline in acres planted of sorghum, acres harvested of sorghum, and sorghum production was evident. Over the same period, sorghum yields rose modestly from roughly 56 bushels per acre to 64 bushels per acre.

- From marketing years 1975 to 2012, feed use of sorghum and exports of sorghum were on the decline; but, food and industrial applications of sorghum were on the rise.

- Funds committed to crop improvement activities made by the USCP were positively and contemporaneously related to acres planted of sorghum. A one percent change in funds committed to crop improvement activities translated into a 0.026 percent change on average in the number of acres planted of sorghum. Put another way, as a result of the checkoff program, planted acreage rose 2.18 percent to 2.96 percent and harvested acreage rose 2.04 percent to 3.07 percent over the 2008/2009 to 2011/2012 period. However, despite the gains in planted and harvested acreage attributed to the USCP, these gains were not statistically different from zero.

- Funds committed by the USCP to crop improvement activities enhanced sorghum yields. A one percent change in funds committed resulted in a 0.012 percent to 0.016 percent change in sorghum yields. However, similar to the situation for acreage, this gain in yields was not significantly different from zero in statistical parlance.

- Due to the fact that sorghum production is the product of harvested acreage and yield, the efforts of the USCP led to increases in production of 3.19 percent to 4.55 percent. Consequently, funds committed by the USCP to crop improvement activities generated increases in sorghum production of roughly 9.7 million to 19.8 million bushels over marketing years 2008/2009 to 2011/2012.

- A one percent change in expenditures geared to crop improvement activities generated a 2.0 percent to 2.8 percent change in sorghum farm prices in the opposite direction. As a result of the effort made by USCP in crop improvement activities, sorghum farm prices dropped 7 cents per bushel to 16 cents per bushel over the marketing years 2008/2009 to 2011/2012. Importantly, this change in sorghum farm prices also was not statistically different from zero.

- Funds committed by the USCP to crop improvement activities generated a 1.50 percent increase in farm revenue on average. This figure rests on the changes in harvested acres and yields (and hence production) as well as the changes in farm prices attributed to the checkoff. All of these aforementioned changes however were not significantly different from zero.

- Bottom line, efforts made by the USCP in committing funds to crop improvement activities were positive in enhancing overall farm revenue; but efforts in this regard need to be continued going forward in order to bring about statistically significant increases in farm revenue. Hence, over a period of five years since its existence, the USCP is on the right track in its efforts to expand farm revenue through its investment in crop improvement activities.

- Funds committed to high-value markets made by the USCP were not able to stem the decline in domestic feed use of sorghum. Put another way, the efforts of the USCP were not successful in abating the downward trend in sorghum feed use domestically.

- Funds committed to renewables and high-value markets were positively linked to sorghum for food and industrial uses. This impact was not felt at one time but instead this impact was distributed over a period of two years. The cumulative impact of a one percent change in USCP funds to renewables and to high-value markets generated a 0.046 percent to 0.048 percent increase in the use of sorghum for food and industrial purposes over the period 2008/2009 to 2011/2012. This investment of $4.7 million in funds committed by the USCP in renewables and high-value markets generated a farm value of $40.1 million, a benefit-cost ratio or return-on-investment of 8.48 to 1.

- Efforts by the USCP to increase sorghum exports in total, to Mexico, and to Japan were not successful. That is, increases in funds committed to exports were ineffective in stemming the decline in exports. The only exception was for exports to the rest of the world, but this result was not significantly different from zero.

- The general non-significance of the impact of USCP funding on exports may be due to several factors. First, the USCP has existed only for four years. Second, the level of funding used in the econometric analysis may be understated. Third, other factors such as the worldwide substitution of corn over sorghum are not easily overturned by export promotion. Fourth, sorghum production is growing faster than sorghum consumption in Mexico, the largest U.S. export market. Finally, the United States is facing strong competition for sorghum in global markets, particularly from Australia (higher quality) and Argentina (lower prices).

Recommendations

Going forward, to continue to evaluate the effectiveness of the sorghum checkoff program, several recommendations are made:

- It is imperative for the USCP to maintain quality records in funds committed to various activities. A substantial amount of time in this project was devoted to insuring an accurate depiction of the amounts of expenditures committed to various activities, namely crop improvement, high-value markets, renewables, and exports. In particular, record keeping in each of these activities needs to appropriately document the amount of funds committed to feed use, food use, pet use, exports by destination, ethanol production, etc. Without this discipline, efforts to effectively evaluate the performance of the USCP are greatly hampered.

- In the same vein, it is necessary to capture efforts made by state programs as well as to retrieve historical data prior to the existence of the sorghum checkoff program. Efforts were made to retrieve data from state programs before and after the existence of the USCP. However, in most instances, we were not successful in obtaining these data. Consequently, it is likely that we have understated to a degree the funds committed to the sorghum checkoff.

- With limited resources, funds are to be allocated on the basis of the highest and best uses for sorghum. To that end, we recommend increases in funds committed to enhancing the demand for sorghum in food and industrial uses (essentially high-value markets and renewables). Opportunities not only exist in the use of sorghum for ethanol production but also for gluten-free products, pet foods, and renewable chemicals. These uses unequivocally are growth areas in the near to intermediate future. Further, efforts should focus on the visibility of sorghum not only as a healthy choice for cooking and baking but also as a gluten-free nutritious grain.

- We recommend as well increases in funds committed to crop improvement activities. In particular, we recommend a focus on research activities aimed at increasing sorghum yields. In order to compete with corn, sorghum needs higher yields, additional nutrient value, and/or lower costs of production (Informa Economics, 2013). Water demands of sorghum

also are less than those of corn, cotton, and rice. Attention should be centered on sorghum as a naturally drought-tolerant, input-efficient crop.

- We recommend funds committed to domestic feed use to focus on improvement in the quality of sorghum as a feed grain so as to better compete with corn. In addition, we recommend the promotion of non-genetically modified (non-GMO) sorghum for livestock feeding. The substitution of corn for sorghum for feed use indeed is a difficult obstacle at present.

- We recommend the commitment of funds in export markets to focus on two priorities: (1) maintaining market share and export volume in Mexico; and (2) recapturing market share in Japan. Differentiating U.S. sorghum from other competitive coarse grains and from sorghum supplies from other regions is critical to building long-term demand for U.S. sorghum. The USCP should undertake opportunities to differentiate U.S. sorghum from other origins, notably Argentina.

- With no change in the budget of the USCP, we recommend reallocation of funds away from domestic feed use and in export markets toward food and industrial uses and crop improvement activities.

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INTRODUCTION

Sorghum, also known as milo, is a grain, forage, or sugar crop, among the most efficient crops in conversion of solar energy and use of water. Simply put, sorghum is a high-energy, drought tolerant crop produced largely in several states, notably Kansas, Texas, Nebraska, Oklahoma, Colorado, South Dakota and Louisiana. Sorghum is used as a livestock feed in the poultry, beef, and pork industries; use for this crop also occurs in the production of ethanol. A notable amount of U.S. sorghum also is exported to international markets, principally Mexico, Japan, Morocco, and Saudi Arabia. Additionally, sorghum appears in U.S. food products because of its use in gluten-free products as it is an excellent substitute for wheat. Finally, sorghum is used for building material, fencing, floral arrangements, pet food, and brooms. Simply put, sorghum has a variety of uses including food for human consumption, feed grain for livestock, and industrial applications, particularly ethanol production and use of renewable chemicals (Stroade and Boland, 2003).

In 2008, the Sorghum Promotion, Research, and Information Order, commonly known as the Sorghum Checkoff Program,was established under the Commodity Promotion, Research, and Information Act of 1996. The Order became effective on May 7, 2008. The USCP is designed to increase the profitability of U.S. sorghum producers, advance sorghum into the ethanol market, develop foreign markets for sorghum, and in general to enhance the sorghum industry. In compliance with the Act of 1996, the United Sorghum Checkoff Program (USCP) Board of Directors, comprised of 13 sorghum producers, has commissioned a study of the effectiveness of this checkoff program. The directive states that "the Board shall authorize and fund an independent evaluation of the effectiveness of the Order and other programs conducted by the Board pursuant to the Act."

The USCP is funded by an assessment of 0.6 percent of the net market value of grain sorghum and 0.35 percent of the net market value of sorghum forage, silage, hay, and billets. The collection of assessments began on July 1, 2008. All producers must pay the assessment. Imports of sorghum products also are assessed, but imports are very limited presently. The Secretary of Agriculture is authorized, under the Act, to collect assessments. The Order provides that between 15 and 25 percent of the total assessments collected annually be returned to qualified state programs for promotion and research activities. Currently, various state-level checkoff programs exist for sorghum. The source of this information is the website for the USCP, http://www.sorghumcheckoff.com. Prior to the establishment of the mandatory USCP, voluntary tax collections occurred in several states from 1977 to 2008. For example, the Kansas commission collected a half cent a bushel tax on sorghum sold.

The USCP conducts market research and development projects, promotion, and related activities under the supervision of the Agricultural Marketing Service (AMS). Specific missions of the USCP are to increase yields through investment in research programs and to increase the demand for sorghum through a set of marketing and promotion programs, thereby providing U.S. producers with expanding markets for their commodity. The rightward shift in demand may occur through expansion of sorghum in the ethanol industry, the use of sorghum as a feedstock for advanced

biofuels, the development of new uses for sorghum, and expansion of sorghum in international markets. The overriding goal of all USCP activities is to maximize return on grower investment.

OBJECTIVES

Given that the USCP was only recently established in 2008, the overall objective of this project is to enable the USCP Board of Directors to obtain meaningful and reliable evaluations of the impacts of its activities on the sorghum industry over time. Consequently, this project seeks to evaluate the programmatic activities of the USCP that satisfy the sorghum industry needs and legislative requirements as well as meet academic standards. To accomplish this overall objective, we undertake the following activities: (1) determine the impact of USCP sorghum-oriented programs implemented over the past four years, as related to promotion, research, and information on the industry; (2) evaluate the effectiveness of the "Crop Improvement Program" in relation to changes in yields and production; (3) evaluate the effectiveness of the "High-Value Program" in relation to the demand for sorghum in export markets and to the demand for sorghum in domestic markets associated with uses in the food industry, in the livestock industry and in other industries; (4) evaluate the effectiveness of the "Renewables Program" in relation to potential benefits associated with the demand for sorghum in industrial use; and (5) assess the availability and adequacy of current data currently in place to support the required evaluation of the impacts of USCP activities over time; the intent is to establish key tracking mechanisms that can be analyzed, documented, reviewed and communicated concerning the effectiveness of the checkoff program.

The aforementioned evaluations are dependent on the measurement, via the use of statistical procedures, of the effects of the programmatic activities of the USCP for various domestic markets of U.S. sorghum and export markets for sorghum as well as for the sorghum production. This analysis will provide the basis for determining if the programmatic activities of the USCP Board lead to rightward shifts in demand for in domestic and export markets as well as for calculating the benefit-cost ratio (BCR) metrics to stakeholders related to their investments in market development and promotion, information, and research programs. The return-on-investment metrics help to improve the efficiency and effectiveness of the investments in marketing activities and to provide needed feedback to stakeholders.

In essence, the "metrics" part of program evaluation is an after-the-fact assessment of whether the checkoff program has been "doing things right," that is, whether the program has effectively met its goals after the funds have been committed and expended. A properly functioning evaluation process provides checkoff program managers the critically needed information to: (1) improve the efficiency and effectiveness of the program; (2) design and adjust the program's long-run strategic plan; (3) serve the information needs of contributors, industry, and other stakeholders; and (4) provide the information and program impact analysis required by the legislation establishing the program. Our work will provide recommendations for any adjustments in plans and processes that will facilitate the collection of the needed data and ultimately the required analyses of the impacts of USCP funded activities over time.

SCOPE AND ORGANIZATION

The scope of the project covers data from several periods. Data concerning acres planted, acres harvested, yields and production of sorghum range from 1960 to 2012. Data concerning end use of

sorghum range from 1975 to 2012. Funds committed by the USCP cover the period 2008 to 2012. The frequency of data is annual, that is, on a year-by-year basis.

The organization this report is as follows. Initially, we discuss data indigenous to the evaluation of checkoff programs. Next, we provide details associated with the programmatic activities of the USCP as well as details on the funds committed (expenditures) made by the USCP. Subsequently, we center attention on trends associated with acres planted, acres harvested, yield and production of sorghum. Further, we focus on trends dealing with end uses of sorghum, namely seed use; food and industry use; feed use; and exports. In addition, we develop the specifications of econometric models for planted acres and yields to determine the impact of the checkoff program on sorghum production. In similar fashion, we also develop econometric models for food and industry use of sorghum, feed use of sorghum, and sorghum exports to assess the effectiveness of the checkoff program on key end uses of the commodity. Finally, to end the report, we provide concluding remarks and recommendations to the USCP based on this work.

DATA INDIGENOUS TO EVALUATION OF CHECKOFF PROGRAMS

Evaluations of programmatic activities associated with any checkoff program face a number of challenges, the most important of which is the extensive set of data covering an extended period of time that is required for such analyses. Because the impacts of checkoff programs in a given year can be spread over a long period of time, several years of program experience and data gathering after a new checkoff program is established may be required before a quantitative evaluation of the impact of the overall program can be attempted. Other types of evaluation of program impacts, including the effects of research expenditures in increasing sorghum yields, the effects of market development and promotion expenditures in expansion of export markets, domestic use of sorghum for feed in various livestock industries, domestic use of sorghum as additives in selected food industries and domestic use of sorghum in ethanol production are data intensive.

In general, three sets of data must be collected on a continuing basis from the outset of a checkoff program: (1) benchmark data, (2) market factor data, and (3) checkoff program expenditure data.

Benchmark Data: Data for production, sales, inventories, trade, prices and related information over time are needed to provide benchmarks against which the checkoff program performance can be measured. The impact of the program on exports or domestic uses, for example, would be impossible to measure without detailed data over a sufficiently long period of time.

Market Factor Data: A second but related set of data that must be consistently collected over time relates to the various factors that have an influence on the markets of the checkoff commodity, such as weather, competing commodity prices, supply, and demand, government domestic and trade policies, etc. In measuring the impact of the checkoff program, the specific effects of the program must be isolated from those of all other important factors that can influence the market. Without data on these other factors, controlling for their impacts on the market and then isolating the specific effects of the checkoff program is an impossible task.

Checkoff Program Expenditure Data: The third set of data that must be systematically and consistently collected over time includes the types, levels, and other details of checkoff program expenditures. These data are the record of the type and level of expenditures approved and made by

the checkoff organization over time. Without these data, no assessment of program performance is possible. There are various forms and formats for archiving these important data. However the data are maintained, it is critical that the projects, activities, and related expenditures be related directly to the strategic plan. Because the strategic plan usually identifies more than one program objective, expenditures made to achieve the separate objectives of the program over time must be able to be identified and separated. In this way, the effectiveness of the program in achieving multiple objectives can be assessed using only the relevant program expenditure data. The expenditure data should include funds expended both by the USCP and any state sorghum organizations or third party groups as well, particularly if the national checkoff funds are shared in any way with such groups. In addition, collection of historical data is necessary for voluntary programs that were in place prior to the establishment of the mandatory checkoff program in 2008.

Revenues and Expenses Associated with the Sorghum Checkoff Program

The Sorghum Promotion, Research, and Information Program, commonly known as the Sorghum Checkoff Program, was established in 2008 under the Commodity Promotion, Research, and Information Act of 1996. The Act authorizes generic promotion, research, and information activities aimed at advancing the demand for agricultural commodities to benefit U.S. producers. Under the auspices of the Agricultural Marketing Service (AMS), the Sorghum Promotion, Research, and Information Order became effective on May 7, 2008. The collection of assessments began on July 1, 2008. The USCP is funded by an assessment of 0.6 percent of the net market value of grain sorghum and 0.35 percent of the net market value of sorghum forage, silage, hay, haylage, and billets.

The set of sorghum checkoff program revenues and expenditures over the period 2008/2009 to 2011/2012 is exhibited in Table 1. The revenue from assessments and total revenues ranged from roughly $6.6 million in 2009/2010 to $8.8 million in 2010/2011. Total expenses ranged from $6.2 million in 2009/2010 to $6.7 million in 2010/2011. Expenses accounted for roughly 76 percent to 93 percent of total revenues over the period 2008/2009 to 2011/2012.

Funds allocated to research activities varied from $1.4 million in 2009/2010 to $1.7 million in 2008/2009; the share of research expenses to total expenses was in the interval 21 percent and 26 percent. Funds allocated to market development activities ranged from $0.7 million in 2008/2009 to $1.1 million in 2010/2011. The share of market development expenses to total expenses varied from 10 percent to 18 percent.

Table 1. Sorghum Checkoff Program Revenues and Expenses, 2008/2009 to 2011/2012

	2008/2009	2009/2010	2010/2011	2011/2012
Revenues				
Revenues from Assessments	$7,470,074	$6,582,472	$8,801,109	$6,995,053
Revenues from Investments	$14,404	$27,261	$24,029	$36,372
Total Revenues[1]	$7,448,213	$6,604,438	$8,764,830	$7,167,847
Expenses				
Research	$1,726,321	$1,358,274	$1,409,065	$1,588,428
Market Development	$680,718	$955,147	$1,137,621	$1,117,897
Information, Communication, and Education	$1,102,641	$927,631	$599,234	$936,888
Passback Reserve[2]	$1,281,613	$1,490,010	$2,325,327	$2,014,346
Administration	$643,224	$469,556	$522,308	$477,532
USDA Oversight and Fees	$237,295	$150,000	$222,833	$133,650
Total Expenses[3]	$6,618,819	$6,158,866	$6,666,388	$6,268,541

[1]Accounts for refunds on double assessments.
[2]The USCP sends funds back to states that have submitted paperwork to be qualified organizations. These states use funds for research, market development, and education in conjunction with the USCP to benefit producers.
[3]Exclusive of mandatory reserve, referendum reserve, and refund reserve categories

Source: http://sorghumcheckoff.com, various Annual Reports of the United Sorghum Checkoff Program

Funds allocated to information, communication, and education activities ranged from $0.6 million in 2010/2011 to $1.1 million in 2008/2009. The share of information, communication, and education activities in relation to total expenditures was on the order of 9 percent to 17 percent.

The USCP sends funds back to states that have submitted paperwork to be qualified organizations. These states use funds for research, market development, and education in conjunction with the USCP to benefit U.S. producers. Funds allocated to this passback reserve varied from $1.3 million in 2008/2009 to $2.3 million in 2010/2011. Passback reserve accounted for 17 percent to 28 percent of total revenues and 19 percent to 35 percent of total expenses.

Certified producer organizations and qualified state organizations include:

- Arkansas Corn and Grain Sorghum Board (http://www.corn-sorghum.com/)
- National Sorghum Producers (http://www.sorghumgrowers.com/)
- South Dakota Corn Growers Association (http://sdcorn.org/)
- Colorado Sorghum Producers
- Nebraska Grain Sorghum Association (http://sorghum.state.ne.us/)
- South Dakota Farmers Union (http://sdfu.org/)
- Kansas Grain Sorghum Commission (http://www.ksgrainsorghum.org/)
- Nebraska Farm Bureau (http://nefb.org/)
- Texas Farm Bureau (http://texasfarmbureau.org/)
- Kansas Grain Sorghum Producers Association (http://ksgrains.com/)
- New Mexico Sorghum Producers Association
- Texas Grain Sorghum Association (http://texassorghum.org/)
- Kentucky Small Grain Growers Association (http://kysmallgrains.org/)
- Oklahoma Sorghum Commission (http://oksorghum.com/)
- Texas Grain Sorghum Board
- Louisiana Soybean and Grain Research and Promotion Board
- Oklahoma Sorghum Producers Association
- U.S. Grains Council (http://www.grains.org/)

Funds for administration purposes ranged from $469,556 in 2009/2010 to $643,224 in 2008/2009. The share of administration expenses in relation to total expenses was in the interval of 7 percent to 10 percent. Finally, funds for USDA oversight fees ranged from $133,650 in 2011/2012 to $237,295 in 2008/2009. The share of total expenses for USDA oversight varied from 2.1 percent to 3.6 percent.

Bottom line, this checkoff program is modest in sized of expenditures (on the order of $6 million to $7 million) in comparison to other commodity groups. To illustrate, expenditures associated with the milk checkoff program are on the order of $400 million (Capps *et al*, 2013), with the cotton checkoff program, expenditures are on the order of $80 million (Williams *et al*, 2011), and expenditures associated with the soybean checkoff program are on the order of $100 million (Williams, Capps, and Bessler, 2009).

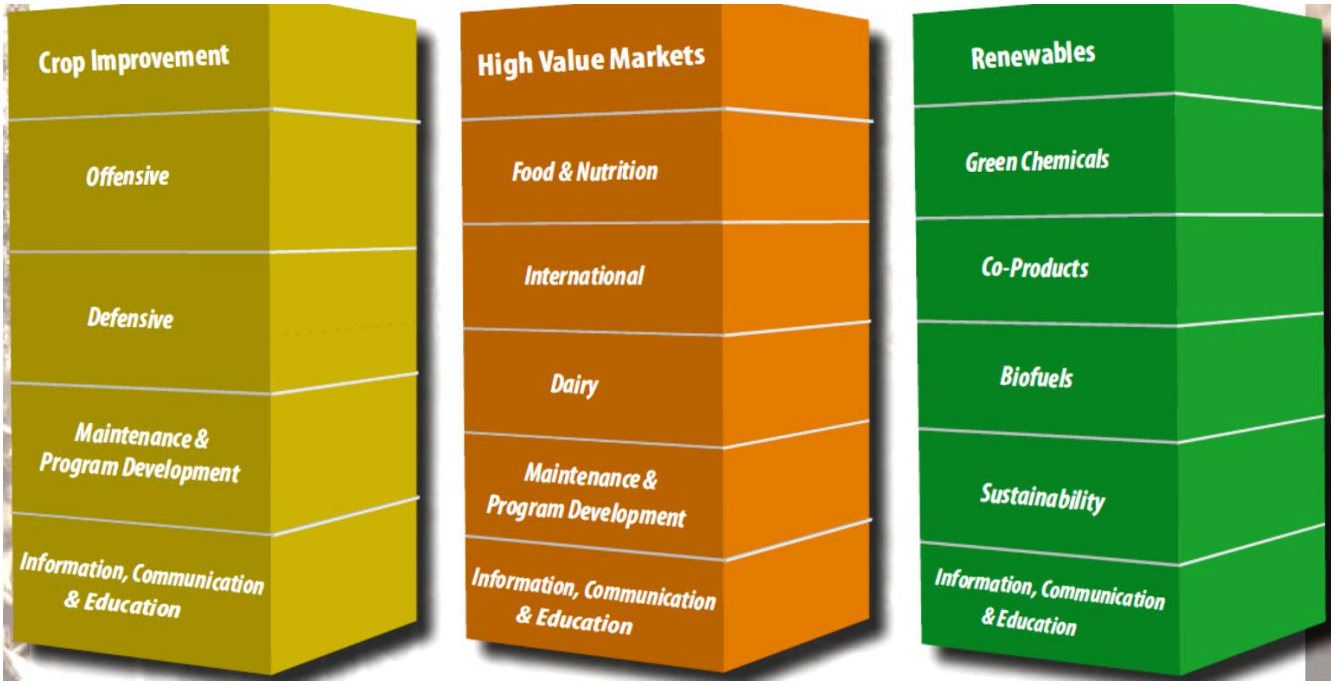
Compared to the farm value of sorghum, on the order of $1.08 billion to $1.47 billion from 2008/2009 to 2011/2012, the amount of funds collected from the checkoff is extremely small. The

ratio of revenue from assessments to farm vale of production (often referred to as the investment-intensity ratio), is, on average, 0.62 percent, ranging from a low of 0.47 percent to a high of 0.82 percent over the period 2008/2009 to 2011/2012. In other words, the amount of funds collected by the USCP has been on the order of one-half of one percent to four-fifths of one percent.

Increasing the profitability of sorghum producers is the primary goal of the sorghum checkoff. In 2011, the USCP Board of Directors and staff re-classified USCP projects in relation to identified program priorities that potentially would provide the most impetus to boosting producer profitability. Broadly speaking, these program priorities were: (1) crop improvement; (2) high-value markets; and (3) renewables.

A pictorial representation of this taxonomy is given in Figure 1. Crop improvement programmatic activities in large part are designed to improve sorghum yield and production and to improve producer profitability. High-value markets programmatic activities are geared toward food and nutrition and international (export) areas. Renewables programmatic activities deal with green chemical, co-products, biofuels, and sustainability.

Figure 1. A Pictorial Representation of Program Priorities of the USCP



Source: 2011, Annual Report, USCP

USCP funds research projects to improve yield, production, profitability, genetic improvement and herbicide tolerance. A listing of selected research projects funded by the USCP is presented in Table 2. In the livestock industry, USCP is developing educational material for dairies, cattle, feedlots, other livestock operations, and feed manufacturers to make them aware of the financial benefits of using sorghum. USCP marketing activities focus on the benefits of using sorghum as a feedstock. These benefits include improvements in efficiency due to less water requirements and other inputs compared to corn as well as the ability of sorghum to be produced on marginal land. Further, USCP supports educational efforts focusing on food and industrial uses. Food uses include gluten-free products and food additives that include high-antioxidant specialty sorghums. On the industrial side, checkoff dollars support research and education to make distillers dry grains (DDGs) more valuable by developing unique, renewable industrial products.

At present, a notable segment of the U.S. sorghum crop is used for biofuels production. Grain sorghum is an excellent crop for sustainable ethanol production because it produces the same amount of ethanol per bushel as comparable feed grains while using up to one-third less water in the plant growth process. From the standpoint of ethanol production, grain sorghum is equal to corn as an input. One bushel of grain sorghum or corn produces an equal amount of ethanol. With that in mind, ethanol producers can make grain sorghum part of successful feedstock procurement strategy, especially in areas where there is a ready supply of grain sorghum. Sweet sorghum, also drought-tolerant, grows very tall and the stalks contain a high volume of fermentable sugars. India and Asia are already using this crop to produce ethanol. Research is ongoing in the United States into infrastructure development needs to make sweet sorghum ethanol a mainstream reality. Forage and high tonnage biomass sorghums are under evaluation for their compositional makeup and production potential for use as a renewable feedstock for both the cellulosic and thermochemical process for conversion into biofuels. These annual feedstocks could become an important option for farmers looking to diversify their farming systems and to maintain rotation strategies on their farms.

USCP works in conjunction with the U.S. Grains Council (USGC) (http://www.grains.org/) to explore and develop overseas markets for sorghum. Checkoff dollars support general activities of the Council as well as a full-time USGC employee whose primary responsibility is to expand sorghum markets. In general, the sorghum checkoff helps to facilitate marketing relationships globally that ultimately benefit domestic sorghum producers.

Animal feeding is a key end use for U.S. sorghum production. Sorghum is utilized in the nutrition of dairy and beef cattle as well as swine and poultry. Importantly, besides the livestock industry, the pet food industry is utilizing sorghum in their products. This market is small in comparison to the livestock market at present.

The United Sorghum Checkoff Program is working to enhance the usability of sorghum in industries that reach beyond conventional markets. Domestically, checkoff funded research opportunities are looking at sorghum's potential to fight cancer, high cholesterol and obesity. Sorghum is high in antioxidants, and sorghum is gluten free. It is a versatile product for individuals diagnosed with Celiac disease, an intolerance to gluten found in products like wheat.

The pet food industry already uses sorghum because of its low glycemic index which helps it to control diabetes in companion animals. Sorghum is used in florals, birdseed, and deer feeders. Around the world, sorghum is already used for building materials like fencing, a plywood-like

product and as a binder is wallboard. The sorghum checkoff continues to fund projects which encourage new markets for this crop.

Finally, while there are currently no commercialized green chemical products made from sorghum on the market, research has demonstrated that sorghum has potential in meeting demand for environmentally-friendly products. By funding research and market development projects, the sorghum checkoff hopes to increase sorghum's use in green chemicals and consequently demand for U.S. sorghum.

As exhibited in Table 3, we provide the commitment of funds made by USCP in crop improvement, high-value markets, renewables, passbacks, and information, communication, and education (ICE). We assume that funds committed toward ICE are shared equally among the three key priority areas of crop improvement, high-value markets, and renewables. We make no assumptions as to the distribution of funds committed to passback in relation to crop improvement, high-value markets, and renewables. We have no prior information concerning this particular distribution of funds.

Consequently, exclusive of passbacks, funds committed to crop improvement ranged from $0.71 million to $1.31 million; for high-value markets, the range was $0.69 million to $0.99 million; and for renewables, the range was $0.16 million to $0.53 million. We present visual depictions of the commitment of funds for the various programmatic activities in Figure 2a – 2d. The total commitment of checkoff dollars for crop improvement, high-value markets, and renewables ranges from $1.5 million to $2.5 million over the period 2008/2009 to 2011/2012.

Table 2. A Listing of Selected Research Projects Funded by the USCP, 2008 to 2012

Research Project	Primary Researcher
Breeding sorghum for improved production and utilization	Tesso
Developing healthy foods from special sorghums	Rooney
Developing sorghum flouts with increased resistant starch content for health benefits	Shi
Developing and utilization of sorghum as feedstock for biofuel production	Wang
Development of forage sorghum tissue testing for efficient fertilization	Ottman
Development of sorghum germplasm with enhanced drought tolerance and higher grain yield	Perumal
Effect of starch content on functional quality of sorghum	Wilson, Bean
Evaluating advanced breeding lines and new sources for cold tolerance in sorghum	Aiken
Genetic analysis of drought tolerance in grain sorghum	Yu
Grain sorghum hybrid testing	Trostle
Great Plan Center for Sorghum Improvement and Utilization	Prasad/Staggenborg
Harvest and residue management of sorghum to facilitate double cropped wheat	Nelson
Identification of the prebiotic fraction of grain sorghum lipid extract	Wells
Identifying and developing new drought tolerant sorghum germplasm	Burke
IMP research for head worm in grain sorghum	Elliott
Increasing sorghum yield and profitability through efficient nitrogen use	Mengel
Interaction of grain sorghum planting date, hybrid maturity, row spacing, and seeding rate in KS environments	Roozeboom
Managing glyphosate-resistant kochia preplant and postplanting in no-till grain sorghum	Stahlman
Novel sorghum based food products for infant, young children, and adult nutrition	Alavi
Potential sources of Egot resistance	Magill
Protein adhesives from low-cost sorghum DDGs	Wang
Screening exotic sorghum germplasm to identify new sources of stalk rot resistance	Little
Screening sorghum genotypes for abiotic stress tolerance and biofuel production	Prasad
Sorghum conversion program to develop higher yielding sorghum	Miller
Sorghum flour processing and development of sorghum based gluten free baked products	Miller
Sorghum irrigation research	O'Shaughnessy
Study of genetic and physiological characteristics for improved nitrogen efficiency and drought tolerance	Tesso
Understanding needs for grain sorghum in human food products from consumers' perspectives	Vazqueez-Araujo
Updated growth, development, and nutrient uptake of sorghum	Roozeboom

Source: Informa Economics, *United Sorghum Checkoff Program: Strategy Development*, 2013.

Table 3. USCP Programmatic Activities and Commitment of Funds

2008-2009 Programs

	Crop Improvement	Funds Committed
R001-09	Texas AgriLife Extension	$ 21,857.00
R002-09	Oklahoma State University	$ 17,500.00
R003-09	Kansas State University	$ 15,000.00
R004-09	Kansas State University	$ 15,000.00
R005-09	Arkansas Farm Bureau	$ 18,000.00
R008-09	New Mexico State University	$ 17,500.00
R009-09	University of Florida	$ 5,000.00
R011-09	University of Illinois	$ 4,000.00
R012-09	U of Arizona - Ottman	$ 18,849.00
R013-09	Texas Agrilife - Isakelt	$ 13,800.00
R014-09	KSU - Roozeboom	$ 26,590.00
R015-09	USDA/ARS - Mahan	$ 42,504.00
R016-09	KSU - Al-Khatib	$ 41,400.00
R017-09	Texas AgriLife - Trostle	$ 28,104.00
R018-09	USDA-ARS - Gloria Burow	$ 84,000.00
R020-09	Purdue University - Gebisa Ejeta	$ 217,977.96
R021-09	USDA-ARS - Susan O'Shaughnessy	$ 13,500.00
R022-09	TAES - Brent Bean	$ 36,000.00
R023-09	TAMU - Bill Rooney	$ 35,347.00
R025-09	KSU - Dave Mengel	$ 10,000.00
R027-09	USDA - ARS - John Burke	$ 32,392.00
R028-09	U of Georgia - Andy Paterson	$ 48,180.00
R029-09	MMR Genetics - Fred Miller	$ 115,000.00
R033-09	University of Georgia	$ 32,500.00
R034-09	USDA/ARS - Zhanguo Xin	$ 52,200.00
R036-09	University of Arizona - Michael Ottman	$ 24,140.00
R035-09	KSU - Robert Gillen Hays Exp	$ 40,000.00
	1/3 ICE Shared Totals	$ 285,329.10
	Total	**$ 1,311,670.06**

High-Value Markets

S003-09	Whole Grains Council	$ 5,000.00
I002-09	Nebraska Grain Sorghum Board	$ 11,085.00
R030-09	NE - Curtis Weller	$ 51,213.00
R031-09	Texas A&M	$ 51,213.00
R032-09	KSU - Donghai Wang	$ 60.17
P002-09F	USGC	$ 156,000.00
P003-09F	USGC Staffing	$ 150,000.00
P004-09D	Broadhead	$ 104,990.00
P001-19D	Mackensie Associates	$ 90,000.00
	1/3 ICE Shared Totals	$ 285,329.10
	Total	**$ 904,890.27**

Renewables

S001-09	Renewable Fuels Association	$ 10,000.00
S005-09	PRX Geographics	$ 8,000.00
P006-09	Agri Energy	$ 30,000.00
	1/3 ICE Shared Totals	$ 285,329.10
	Total	**$ 333,329.10**

2008-2009 Programs

	Passback	Funds Committed
Q001-09	Oklahoma Sorghum Coomission	$ 23,021.00
Q002-09	Kansas Commission	$ 220,000.00
Q003-09	Nebraska Grain sorghum Board	$ 3,175.00
Q004-09	Louisiana Board	$ 48,514.00
Q005-09	Colorado Sorghum Producers	$ 14,750.00
Q006-09	Arkansas	$ 31,781.00
	Total	**$ 341,241.00**

ICE[1]

S002-09	NSP - One Issue Sorghum Grower Magazine	$ 5,400.00
I004-09	Texas Tech University	$ 30,000.00
I005-09	McCormick	$ 495,320.00
I001-09	Texas Grain Sorghum Board	$ 282,550.00
I003-09	Kansas GSP Association	$ 25,960.46
	Commodity Classic and Other Shows	$ 16,756.84
	Total	**$ 855,987.30**

Programs Total

Crop Improvement	$ 1,311,670.06
High-Value Markets	$ 904,890.27
Renewables	$ 333,329.10
2008-2009 Total	**$ 2,549,889.43**

Table 3. Continued

2009-2010 Programs CROP Improvement		Funds Committed
R0001-10	Paterson - University of Georgia	$ 33,475.00
R0002-10	Dwelkat - University of Nebraska	$ 39,000.00
R0003-10	Burke - USDA/ARS Lubbock	$ 32,392.00
R0004-10	Tesso - Kansas State University	$ 41,500.00
R0005-10	Miller - MMR Genetics	$ 117,000.00
R0006-10	Virginia PI&SU	$ 25,111.00
R0008-10	Elliott - USDA/ARS Stillwater	$ 28,000.00
R0009-10	Ottman - University of Arizona	$ 24,168.00
R0010-10	University of Illinois	$ 4,450.00
R0012-10	O'Shaughnessy - USDA/ARS Bushland	$ 11,000.00
R0015-10	Litie - Kansas State University	$ 20,000.00
R0016-10	Mengel - Kansas State University	$ 20,000.00
R0017-10	Roozeboom - Kansas State University	$ 25,000.00
R0018-10	Trosle - Texas AgriLife Extension Service/TAMU	$ 19,705.00
R0019-10	Foster - Texas AgriLife Extension Service/TAMU	$ 40,075.00
R0020-10	Magill - Texas AgriLife Extension Service/TAMU	$ 27,000.00
R0021-10	Oklahoma Sorghum Commission	$ 17,000.00
R0025-10	Paterson - University of Georgia	$ 48,100.00
R0029-10	S Dakota State University	$ 3,858.00
R0034-09.2	Xin-USDA/ARS	$ 54,700.00
	1/3 ICE Shared Totals	$ 80,000.00
	Total	**$ 711,534.00**

High-Value Markets		
R0013-10	Wang - Kansas State University	$ 31,578.00
R0023-10	Goodband - Kansas State University	$ 47,000.00
R0024-10*	Texas AgriLife Research	$ 56,100.00
R0026-10	AIB - Manhattan, KS	$ 33,000.00
R0027-10*	Univeristy of Nebraska	$ 45,000.00
R0028-10	Texas AgriLife Research	$ 43,950.00
R0032-10*	Haub - KSU	$ 45,000.00
P0002-10F	US Grains Council	$ 153,000.00
P0003-10F	US Grains Council	$ 75,000.00
P0007-10	Brouk - Kansas State University	$ 15,000.00
P0008-10	Tokach - Kansas State University	$ 15,000.00
P0009-10	Beyer - Kansas State University	$ 15,000.00
P0010-10	Lowe - Kansas State University	$ 63,400.00
P0011-10	Brouk - Kansas State University	$ 15,000.00
P0012-10	WKM Global Consulting	$ 17,500.00
P0013-10	JPZ Consulting Group	$ 38,500.00
I0005-10	McCormick	$ 13,000.00
	1/3 ICE Shared Totals	$ 80,000.00
	Total	**$ 802,028.00**

2009-2010 Programs Renewables		Funds Committed
R0007-10	Texas AgriLife Research	$ 20,644.00
R0011-10	Han - Louisiana State University	$ 29,890.00
R0014-10	Wang - Kansas State University	$ 42,810.00
R0030-10	Memphis Bioworks Foundation	$ 3,000.00
R0031-10	KSU	$ 20,000.00
P0005-10	Broadhead & Co	$ 19,893.75
P0006-10	Agri-Energy Solutions	$ 38,500.00
R0030-10	Memphis Bioworks Foundation	$ 10,000.00
P0015-10	Conestoga Energy Partners	$ 63,700.00
	1/3 ICE Shared Totals	$ 80,000.00
	Total	**$ 328,437.75**

Passback		
I0001-10	Texas Grain Sorghum Producers Board	$ 80,000.00
I0002-10	Nebraska Grain Sorghum Board	$ 40,000.00
I0003-10	Kansas Grain Sorghum Producers Assn	$ 60,000.00
I0004-10	Kansas Grain Sorghum Producers Assn	$ 20,000.00
I0006-10	Colorado Sorghum Prducers Association	$ 20,000.00
	Total	**$ 220,000.00**

ICE[1]		
R0022-10	Akers - TTU	$ 40,000.00
I0007-10	McCormick	$ 200,000.00
	Total	**$ 240,000.00**

Programs Total	
Crop Improvement	$ 711,534.00
High-Value Markets	$ 802,028.00
Renewables	$ 328,437.75
2009-2010 Total	**$ 1,841,999.75**

Table 3. Continued

2010-2011 Programs

	CROP Improvement	Funds Committed
R0001-11	Iowa State University	$ 45,000.00
R0003-11	Virginia Tech - Balota	$ 30,925.00
R0004-11	Oklahoma State University - Kochenower	$ 75,000.00
R0005-11	University of Kentucky - Murdock	$ 3,000.00
R0006-11	Kansas State University - Little	$ 27,195.00
R0007-11	Iowa State University - Fernandez	$ 32,765.00
R0010-11	USDA-ARS Lubbock- Burke	$ 200,000.00
R0011-11	University of Nebraska - Dweiket	$ 40,000.00
R0012-11	Kansas State University - Mengel	$ 100,000.00
R0013-11	Oklahoma State University - Arnall	$ 20,000.00
R0014-11	Oklahoma State University - Kochenower	$ 20,000.00
R0015-11	Texas A&M - McFarland	$ 40,000.00
R0016-11	University of Illinois - Ebelhar	$ 5,250.00
R0019-11	MMR Genetics - Miller	$ 119,000.00
R0020-11	University of California - Dahlberg	$ 17,075.00
R0021-11	Strategic Conservation Solutions, LLC	$ 26,000.00
R0022-11	KSU	$ 24,000.00
	1/3 ICE Shared Totals	$ 62,530.33
	Total	**$ 887,740.33**

High-Value Markets

R0002-11	Texas A&M - Turner	$ 199,982.00
R0008-11	Kansas State University - Alavi	$ 59,450.00
R0009-11	Kansas State University - Alavi	$ 59,725.00
R0017-11	South Dakota Sate University - Rickertsen	$ 6,515.00
P0002-11	US Grains Council	$ 150,000.00
P0001-11	US Grains Council	$ 156,000.00
P0001-11	US Grains Council	$ 94,000.00
P0004-11	William J cotter & Assoc - Odor Eval Summary	$ 10,000.00
P0005-11	Zim's Consulting LLC - Whole Grain Sorghum Bread	$ 70,000.00
P0006-11	McCormick - Operation Healthy Sorghum	$ 51,250.00
P0009-11	JPZ Consulting Group - Henley	$ 50,000.00
R0020-11	University of California - Dahlberg	$ 17,075.00
	1/3 ICE Shared Totals	$ 62,530.33
	Total	**$ 986,527.33**

Renewables

R0018-11	LSU Agricultural Center - Han	$ 30,353.00
P0003-11	Protec Fuel - Ethanol E85 Deliverables	$ 10,000.00
P0007-11	Memphis Bioworks Foundation - Powell	$ 46,900.00
P0008-11	LSU Agricultural Center - Reigh	$ 7,985.00
	1/3 ICE Shared Totals	$ 62,530.33
	Total	**$ 157,768.33**

2010-2011 Programs

	ICE[1]	Funds Committed
I0001-11	McCormick	$ 168,816.00
I0002-11	KLU Consulting	$ 5,000.00
I0004-11	Nebraska Grain Sorghum Producers	$ 13,775.00
	Total	**$ 187,591.00**

Programs Total

Crop Improvement	$ 887,740.33
High-Value Markets	$ 986,527.33
Renewables	$ 157,768.33
2010-2011 Total	**$ 2,032,036.00**

Table 3. Continued

2011-2012 Programs

	CROP Improvement	Funds Committed
CI001-12	Texas AgriLife Research - Rooney	$ 125,000.00
CI002-12	Chromatin, Inc. - Lambright	$ 100,000.00
CI003-12	Colorado State University - Johnson	$ 20,500.00
CI004-12	Virginia PI & State University - Balora	$ 35,999.00
CI005-12	USDA - ARS - Burke	$ 125,000.00
CI006-12	USDA - ARS - Burke	$ 145,585.00
CI008-12	Texas AgriLife Research - Peterson	$ 10,000.00
CI009-12	Kansas State University - Perumal	$ 20,000.00
CI010-12	Oklahoma State University - Kochenower	$ 20,000.00
CI011-12	Oklahoma State University - Arnall	$ 20,000.00
CI012-12	New Mexico State University - Marsalis	$ 20,000.00
CI013-12	Kansas State University - Mengel & Homan	$ 40,000.00
CI014-12	Texas A&M University - Bean & McFarland	$ 40,000.00
CI015-12	The State of Queensland - Jordan	$ 120,000.00
CI016-12	Stephen Kresovich - Consulting	$ 60,000.00
CI017-12	University of Arkansas - Espinoza	$ 20,000.00
CI018-12	MMR Genetics	$ 119,000.00
CI019-12	Kansas State University - Thompson	$ 21,000.00
CI020-12	Entira, Inc.	$ 60,000.00
	1/3 ICE Shared Totals	$ 75,333.33
	Total	**$ 1,197,417.33**

High-Value Markets

HVM001-12	US Grains Council - Doir	$ 156,000.00
HVM002-12	US Grains Council - Doir	$ 150,000.00
HVM003-12	US Grains Council - Roepke	$ 75,000.00
HVM005-12	Texas AgriLife Research - Miller	$ 60,000.00
HVM006-12	Texas AgriLife Research - Turner	$ 48,487.00
	Murphy Brown	$ 10,000.00
HVM007-12	Milex Corporation - Martin	$ 66,000.00
HVM008-12	JPZ	$ 15,950.00
HVM009-12	WKM	$ 29,800.00
	1/3 ICE Shared Totals	$ 75,333.33
	Total	**$ 686,570.33**

Renewables

RN001-12	BioDiminsions Delta - Powell	$ 45,200.00
RN002-12	USDA/ARS New Orleans - Eggleston	$ 17,500.00
RN003-12	Texas AgriLife Research - McDonald	$ 39,690.00
RN004-12	Oklahoma State University - Bellmer	$ 35,961.00
RN005-12	SGS North America - Ouiton	$ 220,700.00
RN006-12	Battelle Memorial Institute - McGraw	$ 75,000.00
RN007-12	Agri-Energy Solutions	$ 25,000.00
	1/3 ICE Shared Totals	$ 75,333.33
	Total	**$ 534,384.33**

2011-2012 Programs

	ICE[1]	Funds Committed
ICE01-12	McCormick	$ 100,000.00
ICE02-12	Hannah Lipps	$ 37,500.00
ICE03-12	Informa Economics	$ 88,500.00
	Total	**$ 226,000.00**

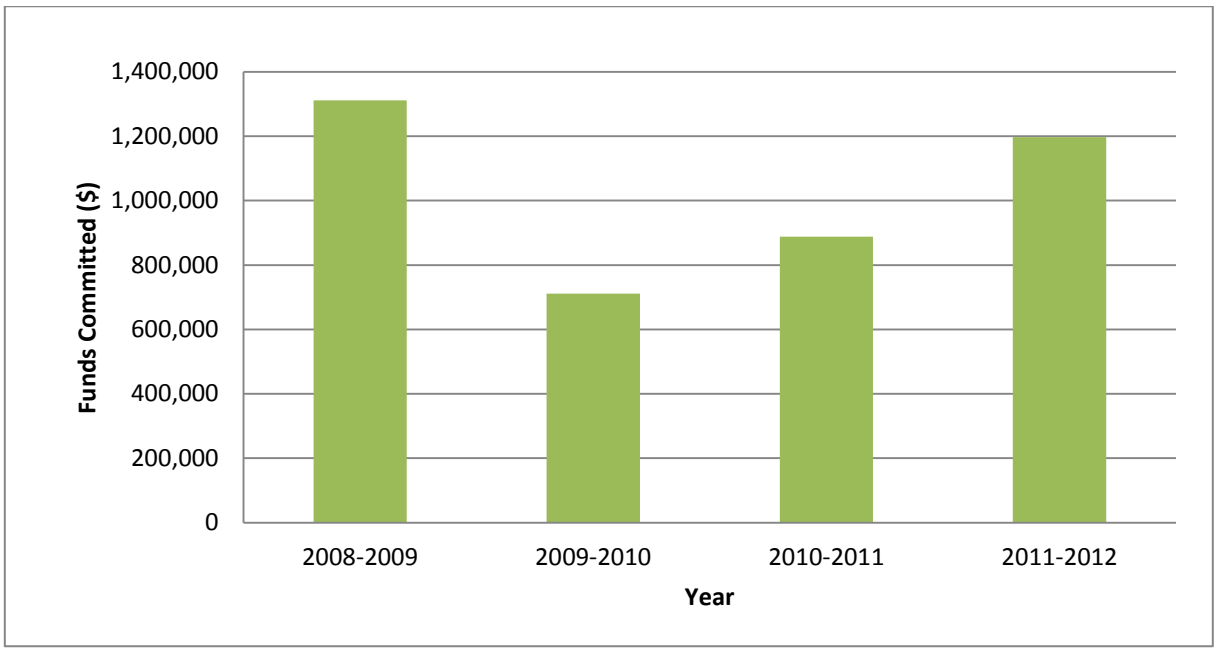
Programs Total

Crop Improvement	$ 1,197,417.33
High-Value Markets	$ 686,570.33
Renewables	$ 534,384.33
2011-2012 Total	**$ 2,418,372.00**

[1]Information, Communication, and Education

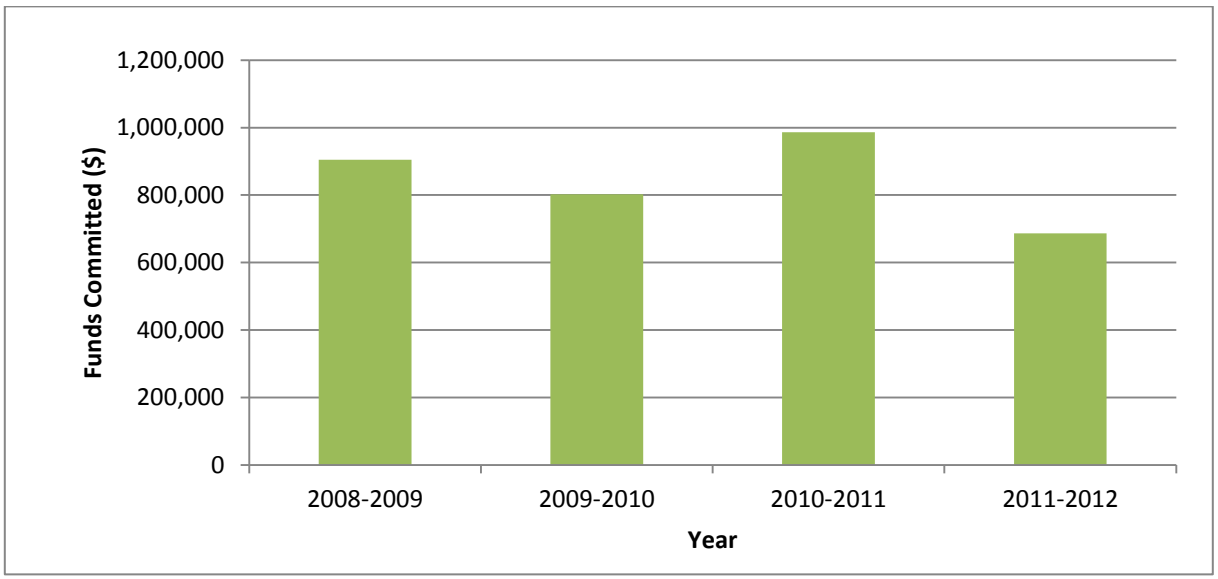
Source: United Sorghum Checkoff Program

Figure 2a. Commitment of Funds: Crop Improvement



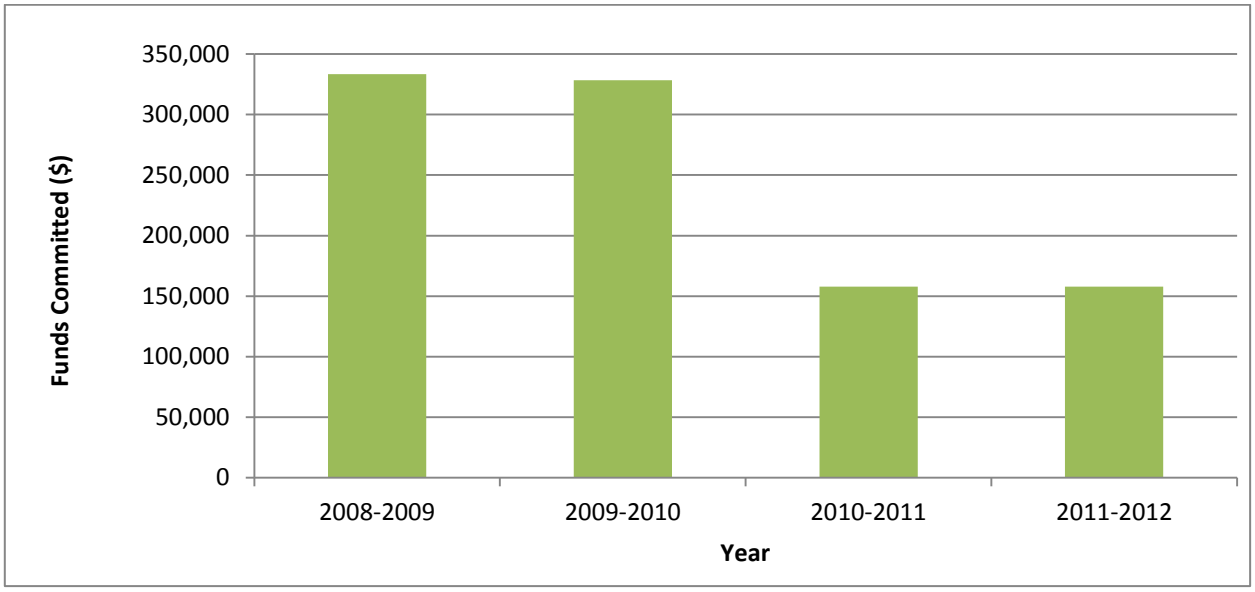
Source: United Sorghum Checkoff Program

Figure 2b. Commitment of Funds: High-Value Markets



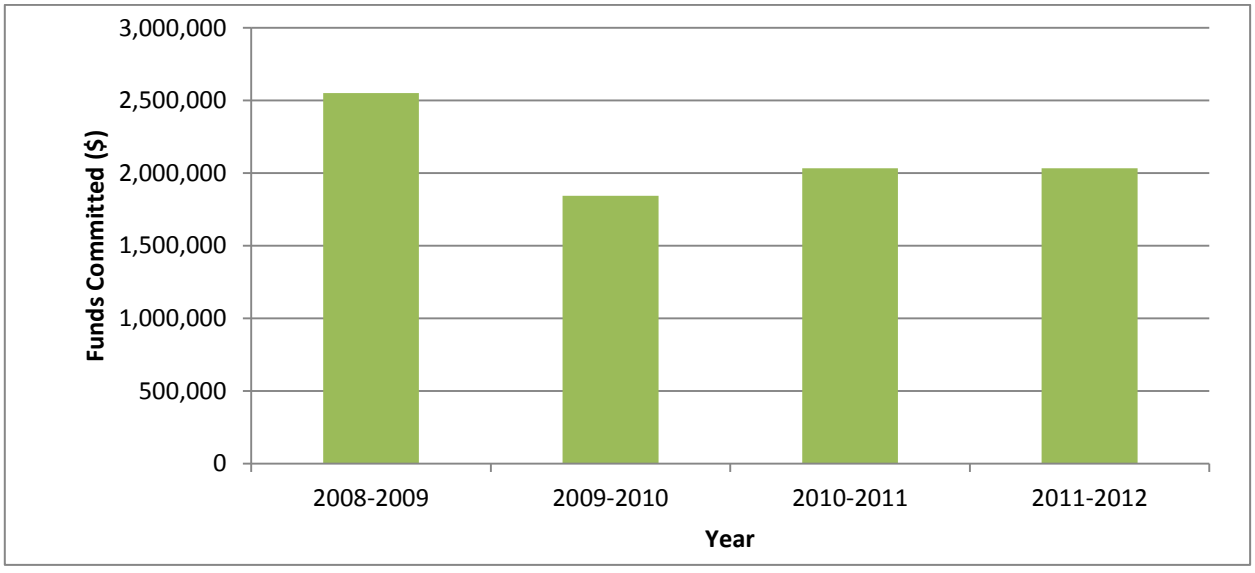
Source: United Sorghum Checkoff Program

Figure 2c. Commitment of Funds: Renewables



Source: United Sorghum Checkoff Program

Figure 2d. Total Commitment of Funds



Source: United Sorghum Checkoff Program

As presented in Table 4, we provide the commitment of funds made by USCP specifically for exports, food, livestock, biofuels, co-products, feed, industry use, and green chemicals. Funds committed to exports were $306,000 in 2008-2009, $228,000 in 2009-2010, $410,000 in 2010-2011, and $381,000 in 2011-2012. Funds committed to food and industry use were $178,685 in 2008-2009, $215,100 in 2009-2010, $439,157 in 2010-2011, and $220,237 in 2011-2012. Moreover, checkoff funds expended for livestock feed use was $214,350 in 2009-2010, $107,765 in 2010-2011, and $10,000 in 2011-2012. Finally, checkoff funds specifically geared to biofuels, co-products, and green chemicals were $280,015 in 2009-2010, $170,238 in 2010-2011, $163,351 in 2011-2012.

Table 4. USCP Programmatic Activities and Commitment of Funds Specifically for Exports, Food, Livestock, Biofuels, Co-Products, Feed, Industry Use, and Green Chemicals

2008-2009 Programs

	High-Value Markets - Export	**Funds Committed**
P002-09F	USGC	$ 156,000
P003-09F	USGC Staffing	$ 150,000
	Total	**$ 306,000**

High-Value Markets - Food

S003-09	Whole Grains Council	$ 5,000
I002-09	Nebraska Grain Sorghum Board	$ 11,085
R030-09	NE - Curtis Weller	$ 51,213
R031-09	Texas A&M	$ 51,213
R032-09	KSU - Donghai Wang	$ 60,174
	Total	**$ 178,685**

Table 4. Continued

2009-2010 Programs

	High-Value Markets - Export	Funds Committed
P0002-10F	US Grains Council	$ 153,000
P0003-10F	US Grains Council	$ 75,000
	Total	**$ 228,000**

High-Value Markets - Food

R0024-10*	Texas AgriLife Research	$ 56,100
R0027-10*	Univeristy of Nebraska	$ 45,000
R0032-10*	Haub - KSU	$ 45,000
P0012-10	WKM Global Consulting	$ 17,500
P0013-10	JPZ Consulting Group	$ 38,500
I0005-10	McCormick	$ 13,000
	Total	**$ 215,100**

High-Value Markets - Livestock

R0023-10	Goodband - Kansas State University	$ 47,000
R0028-10	Texas AgriLife Research	$ 43,950
P0007-10	Brouk - Kansas State University	$ 15,000
P0008-10	Tokach - Kansas State University	$ 15,000
P0009-10	Beyer - Kansas State University	$ 15,000
P0010-10	Lowe - Kansas State University	$ 63,400
P0011-10	Brouk - Kansas State University	$ 15,000
	Total	**$ 214,350**

Renewables - Biofuel

R0007-10	Texas AgriLife Research	$ 20,644
R0011-10	Han- Louisiana State University	$ 29,890
R0014-10	Wang - Kansas State University	$ 42,810
R0030-10	Memphis Bioworks Foundation	$ 3,000
P0005-10	Broadhead & Co	$ 19,893
P0006-10	Agri-Energy Solutions	$ 38,500
R0030-10	Memphis Bioworks Foundation	$ 10,000
	Total	**$ 164,737**

Renewables - Co Product

R0013-10	Wang - Kansas State University	$ 31,578
R0031-10	KSU	$ 20,000
P0015-10	Conestoga Energy Partners	$ 63,700
	Total	**$ 115,278**

Table 4. Continued

2010-2011 Programs

	High-Value Markets - Export	Funds Committed
P0002-11	US Grains Council	$ 150,000
P0001-11	US Grains Council	$ 156,000
P0001-11	US Grains Council	$ 94,000
P0004-11	William J cotter & Assoc - Odor Eval Summary	$ 10,000
	Total	**$ 410,000**

	High-Value Markets - Feed	
P0006-11	McCormick - Operation Healthy Sorghum	$ 51,250
	Total	**$ 51,250**

	High-Value Markets - Food	
R0002-11	Texas A&M - Turner	$ 199,982
R0008-11	Kansas State University - Alavi	$ 59,450
P0005-11	Zim's Consulting LLC - Whole Grain Sorghum Bread	$ 70,000
P0009-11	JPZ Consulting Group - Henley	$ 50,000
	Total	**$ 379,432**

	High-Value Markets - Industry	
R0009-11	Kansas State University - Alavi	$ 59,725
	Total	**$ 59,725**

	High-Value Markets - Livestock	
R0017-11	South Dakota State University - Rickertsen	$ 6,515
R0020-11	University of California - Dahlberg	$ 50,000
	Total	**$ 56,515**

	Renewables - Biofuels	
R0018-11	LSU Agricultural Center - Han	$ 30,353
P0003-11	Protec Fuel - Ethanol E85 Deliverables	$ 10,000
P0007-11	Memphis Bioworks Foundation - Powell	$ 46,900
P0008-11	LSU Agricultural Center - Reigh	$ 7,985
	Total	**$ 95,238**

	Renewables - Green Chemicals	
RN006-12	Battelle Memorial Institute - McGraw	$ 75,000
	Total	**$ 75,000**

Table 4. Continued

2011-2012 Programs

	High-Value Markets - Food	Funds Committed
HVM005-12	Texas AgriLife Research - Miller	$ 60,000
HVM006-12	Texas AgriLife Research - Turner	$ 48,487
HVM008-12	JPZ	$ 15,950
HVM009-12	WKM	$ 29,800
	Total	**$ 154,237**

High-Value Markets - Exports

HVM001-12	US Grains Council - Doir	$ 156,000
HVM002-12	US Grains Council - Doir	$ 150,000
HVM003-12	US Grains Council - Roepke	$ 75,000
	Total	**$ 381,000**

High-Value Markets - Livestock

	Murphy Brown	$ 10,000
	Total	**$ 10,000**

Renewables - Biofuel

RN001-12	BioDiminsions Delta - Powell	$ 45,200
RN002-12	USDA/ARS New Orleans - Eggleston	$ 17,500
RN003-12	Texas AgriLife Research - McDonald	$ 39,690
RN004-12	Oklahoma State University - Bellmer	$ 35,961
RN007-12	Agri-Energy Solutions	$ 25,000
	Total	**$ 163,351**

High-Value Markets - Industry

HVM007-12	Milex Corporation - Martin	$ 66,000
	Total	**$ 66,000**

TRENDS IN SORGHUM PRODUCTION, 1960 TO 2012

This section deals with planted and harvested acres of sorghum in the United Stations and regionally over the time period 1960 to 2012. As well, we present sorghum yields over this period. Sorghum production, defined as the product of sorghum yield and harvested acres, also is presented. This information is exhibited in Figures 3 – 9.

In 2012, U.S. grain sorghum production totaled roughly 246 million bushels, and the value of this crop was $1.63 billion. As exhibited in Figure 3, over the period 1960 to 2012, a downward trend in acres planed and acres harvested of sorghum is evident. On the other hand, as presented in Figure 4, sorghum yields have experienced a general upward trend, ranging from 40 bushels per acre to 70 bushels per acre. As exhibited in Figure 5, sorghum production since 1985 experienced a general decline, ranging from a low of 214 million bushels in 2011 to a high of 1,120 million bushels in 1985.

As given in Figures 6 – 9, we provide regional information dealing with planted and harvest acres, yields, and production. Generally speaking, sorghum is grown in 14 states. Historically, Kansas and Texas have been the top two sorghum-producing states. We delineate four regions: (1) South-Western (Texas, Arkansas, Louisiana, and Oklahoma); (2) South-Eastern (Alabama, Georgia, Kentucky, Mississippi, South Carolina, and Virginia); (3) Midwest (Illinois, Kansas, Missouri, Nebraska, and South Dakota); and (4) Western (Arizona, California, Colorado, and New Mexico).

Sorghum Grain by Region – Planted Acres and Harvested Acres

- The South-Western Region
    - The number of acres planted and harvested in Texas generally was on the decline from 1960 to 2012. The high was in the order of 8 million acres, and the low was roughly 2 million acres.
    - Similarly, acres planted and harvested in Oklahoma has been in decline.
    - Arkansas and Louisiana both consistently have planted and harvested under 500,000 acres each year since 1960, with exceptions in the mid-1980s.

- The South-Eastern Region
    - Alabama, Georgia, Kentucky, Mississippi, South Carolina and Virginia followed similar trends.
    - Mississippi was the leader of acres planted and harvested of sorghum in this region.
    - A spike was evident in acres planted and harvested for all states in this region in 1971-1973.
    - A notable spike was evident in acres planted and harvested for all states in this region except for Virginia in 1984-1985.

- The Midwest Region
    - Illinois, Kansas, Missouri, Nebraska, and South Dakota followed the same trend for the most part.
    - Unequivocally, the most planted and harvested acres in this region was attributed to Kansas with an average around 3.8 million.

- All the states in this region exhibited a decrease in the number of acres planted and harvested.

- The Western Region
  - Colorado and New Mexico followed the same trend for the most part.
  - Arizona and California followed the same trend for the most part.
  - The most planted and harvested acres of sorghum in this region were attributed to Colorado in this region.

Sorghum Grain by Region – Yield

- The South-West Region
  - Texas, Arkansas, and Oklahoma followed the same trend for the most part.
  - Yields in Louisiana and Arkansas were higher than yields in Texas and Oklahoma.
  - Increases in yields for all states in this region generally are evident.

- The South-East Region
  - Alabama, Georgia, Kentucky, Mississippi, and South Carolina followed similar trends in yields.
  - Yields were highest in Kentucky and Mississippi in the region.

- The Midwest Region
  - Illinois, Kansas, Missouri, Nebraska, and South Dakota followed the same upward trend, except for the period 2010-2012.
  - Yields were highest in Illinois, Nebraska, and Missouri in this region.

- The Western Region
  - Arizona, Colorado, and New Mexico followed the same trend.
  - Yields were highest in California and Arizona in this region when production occurs.

- General Observations
  - Yields varied greatly by state and by region.
  - States with the highest yields of sorghum were not the top-producing states.

Sorghum Grain by Region – Production

- The South-West Region
  - Production in Texas varied greatly from 1960 to 2012; generally speaking production levels diminished year over year over this period.
  - Texas is the dominant state in sorghum production in this region.

- The South-Eastern Region
  - Mississippi produced the most sorghum in this region.
  - A spike in production for all states in this region was evident during 1971-1973.
  - A definitive spike in production for all states in this region was evident, especially for Mississippi, in the mid-1980s.

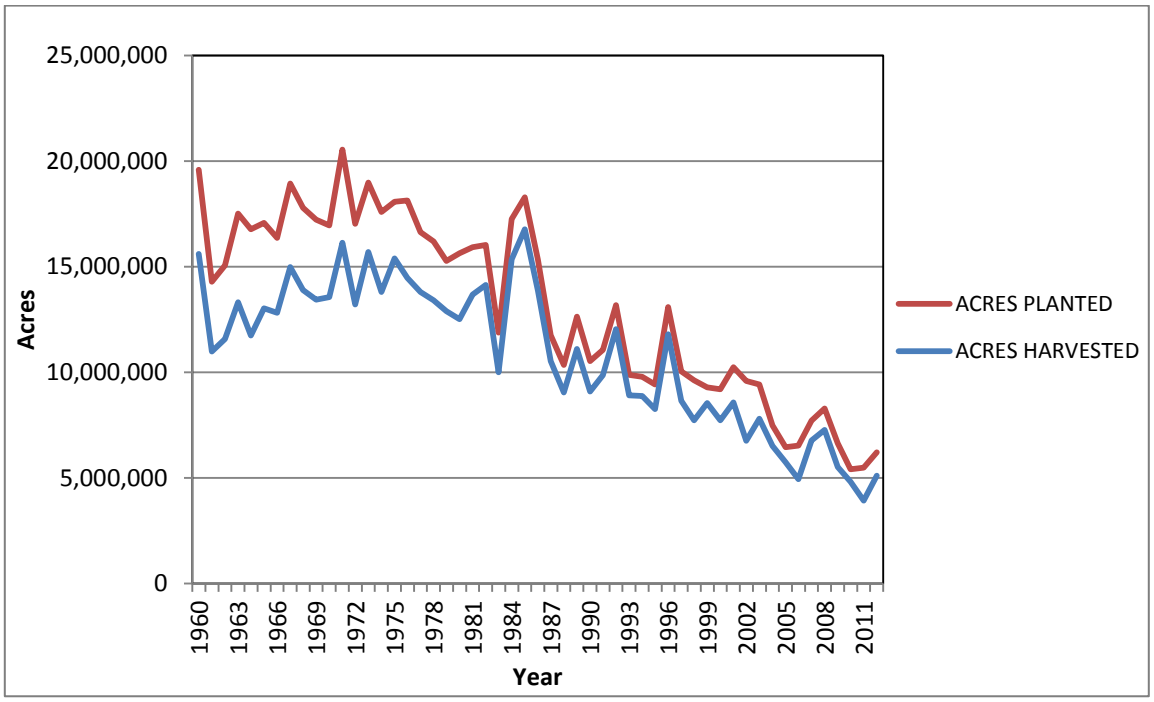
- The Midwest Region
  - Illinois, Kansas, Missouri, Nebraska, and South Dakota followed the same trend for the most part.

- Kansas, by far produced the most sorghum in this region followed by Nebraska and Missouri.

- The Western Region
  - Sorghum production was virtually nonexistent in California and Arizona since 1980.
  - Colorado and New Mexico were primarily the sorghum-producing states in this region.

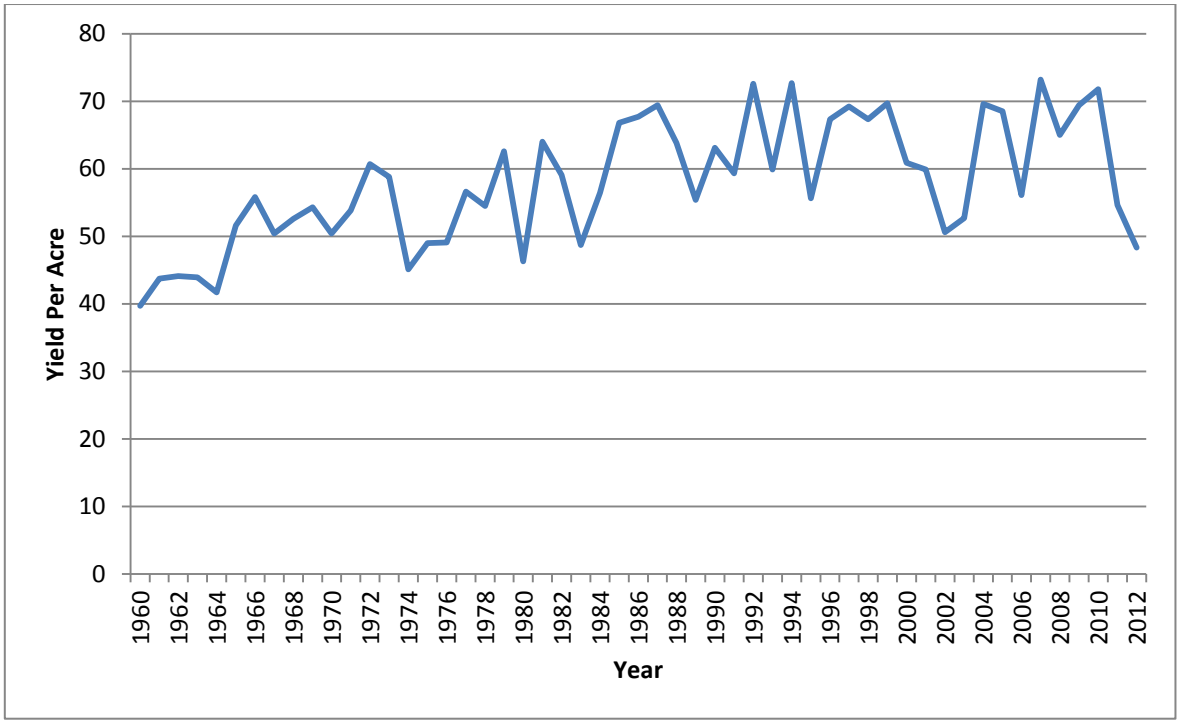
- General Observations
  - Clearly sorghum production was highest in Texas and Kansas
  - The South-Eastern region and the Western region were minor players in the production of sorghum.

Figure 3. Planted and Harvested Acres of Sorghum in the United States, 1960-2012



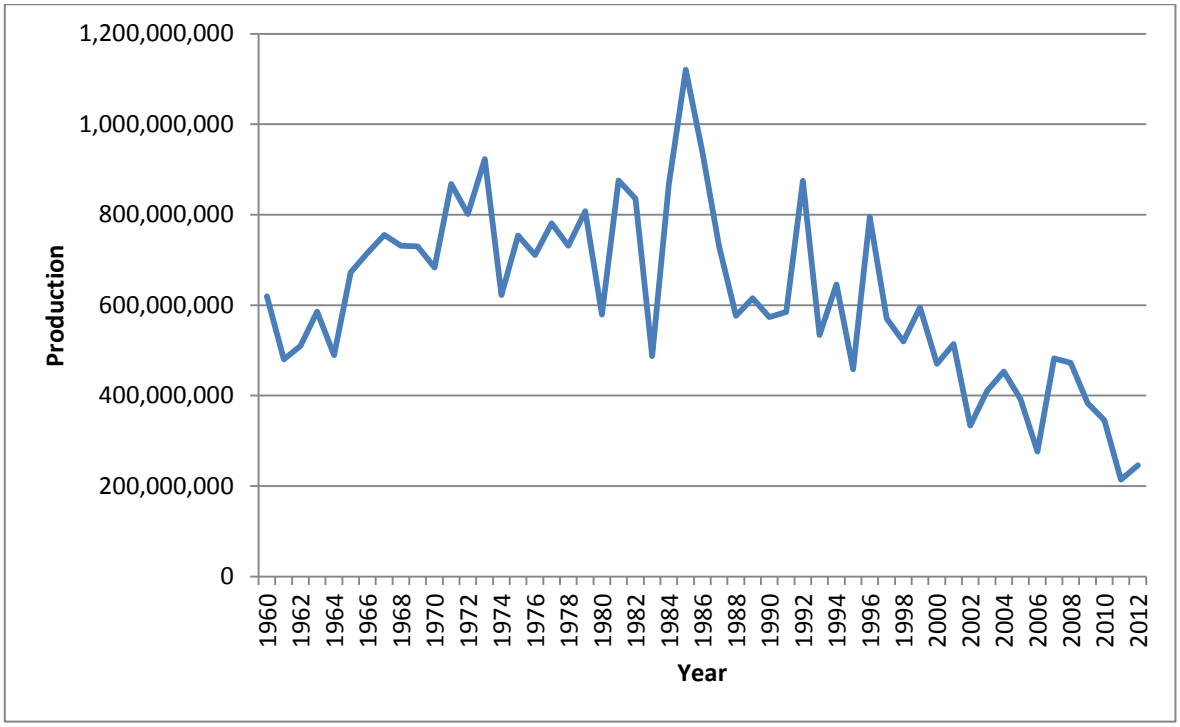
Source: Economic Research Service, U.S. Department of Agriculture

Figure 4. Sorghum Yield in the United States, 1960-2012, bushels per acre



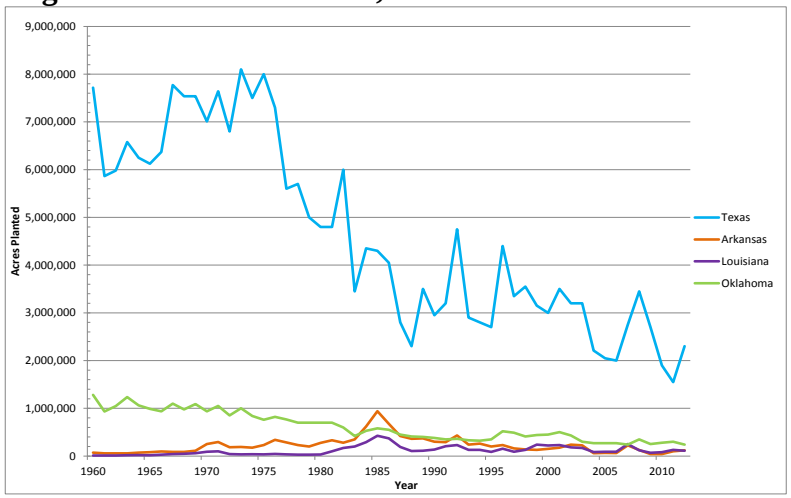
Source: Economic Research Service, U.S. Department of Agriculture

Figure 5. Sorghum Production in the United States, 1960-2012, bushels



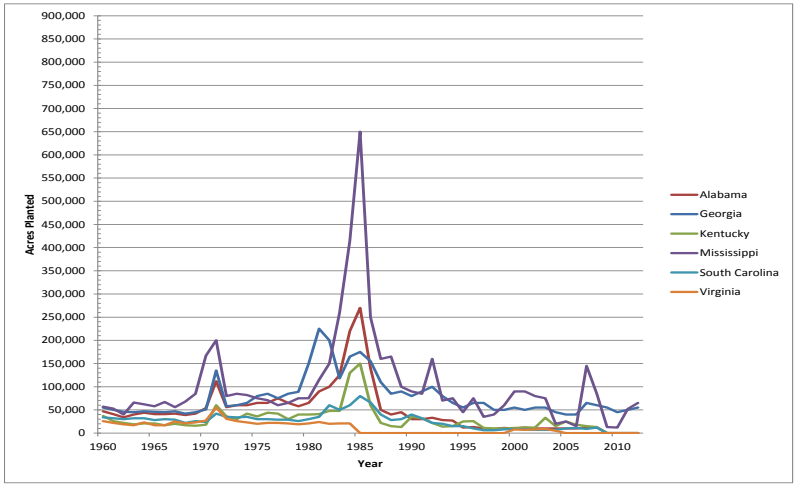
Source: Economic Research Service, U.S. Department of Agriculture

Figure 6a. Number of Acres Planted in the South-Western Region of the United States, 1960-2012



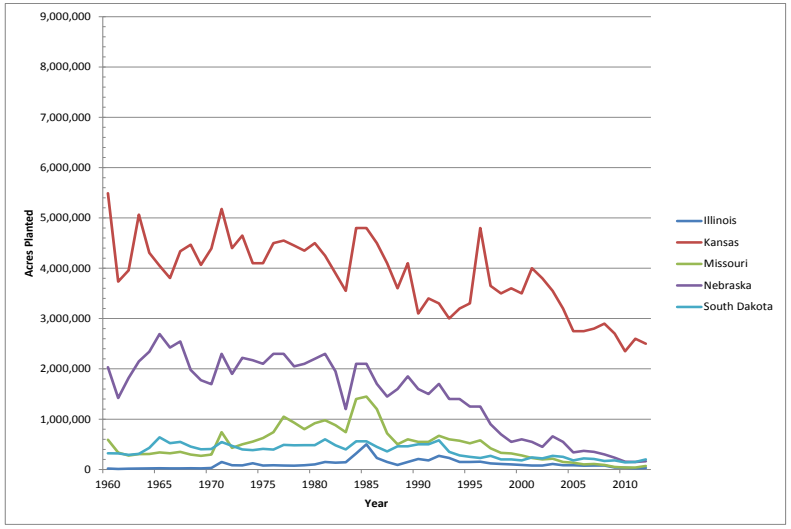
Source: Economic Research Service, U.S. Department of Agriculture

Figure 6b. Number of Acres Planted in the South-Eastern Region of the United States, 1960-2012



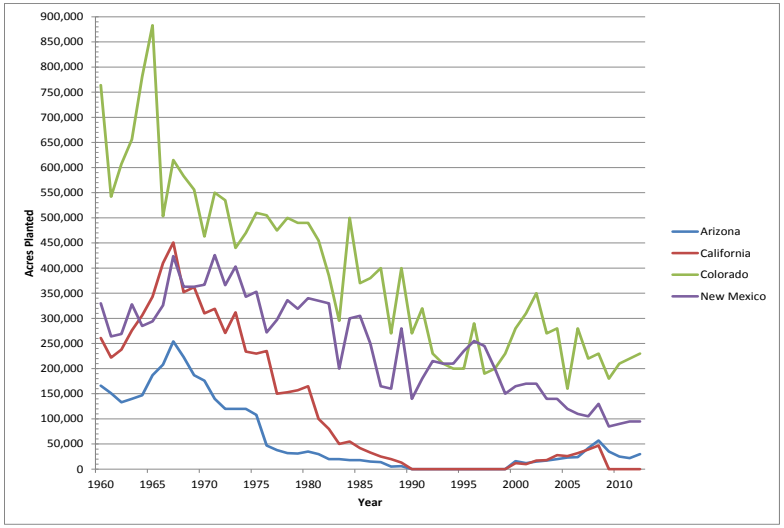
Source: Economic Research Service, U.S. Department of Agriculture

Figure 6c. Number of Acres Planted in the Midwest Region of the United States, 1960-2012



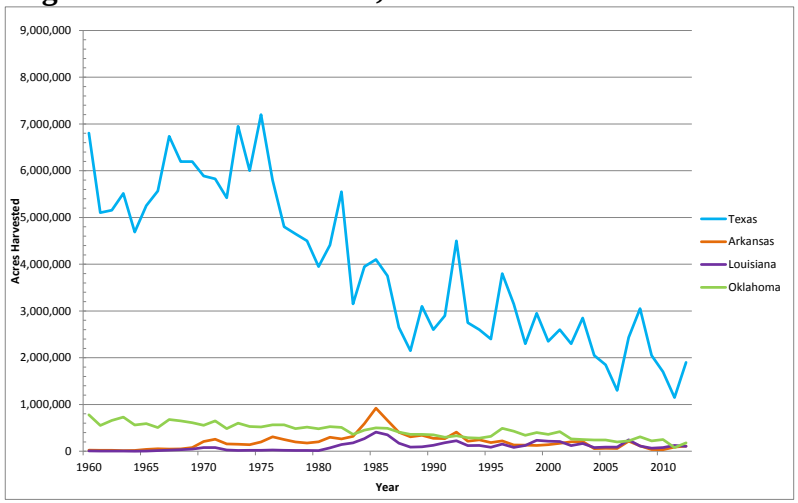
Source: Economic Research Service, U.S. Department of Agriculture

Figure 6d. Number of Acres Planted in the Western Region of the United States, 1960-2012



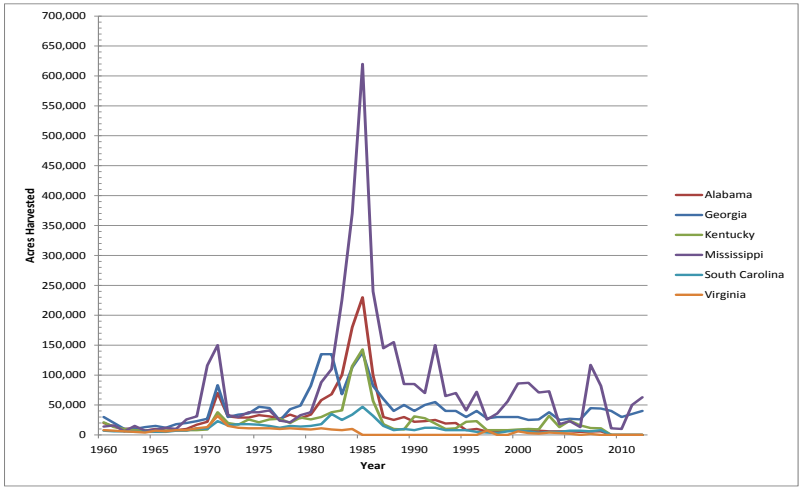
Source: Economic Research Service, U.S. Department of Agriculture

Figure 7a. Number of Acres Harvested in the South-Western Region of the United States, 1960-2012



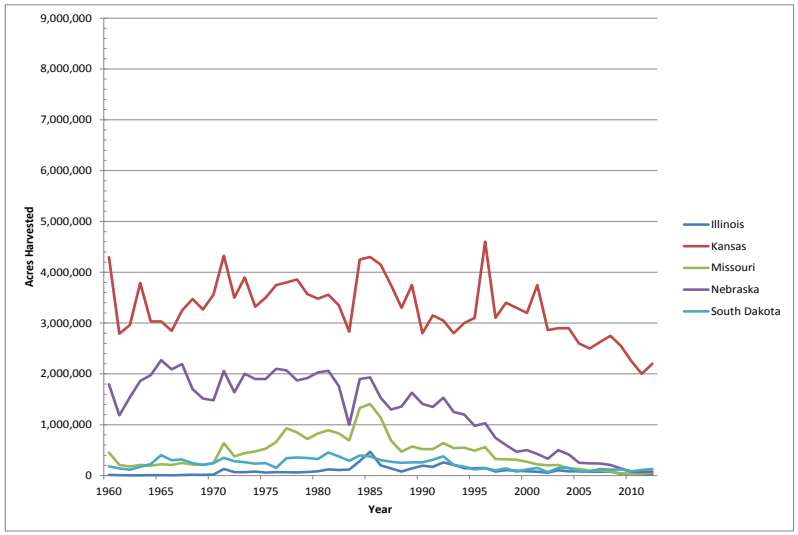
Source: Economic Research Service, U.S. Department of Agriculture

Figure 7b. Number of Acres Harvested in the South-Eastern Region of the United States, 1960-2012



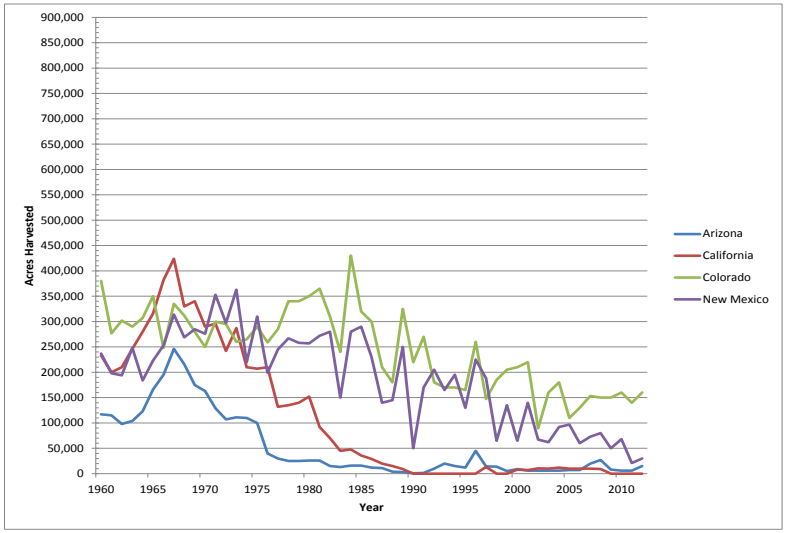
Source: Economic Research Service, U.S. Department of Agriculture

Figure 7c. Number of Acres Harvested in the Midwest Region of the United States, 1960-2012



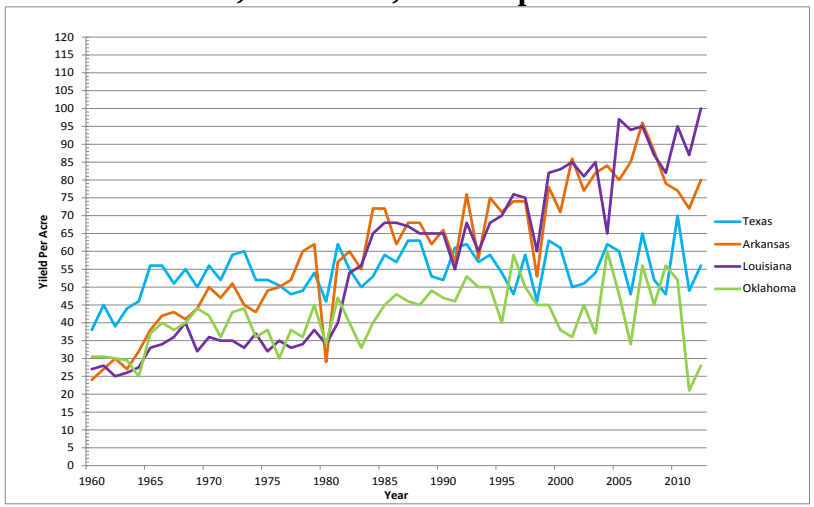
Source: Economic Research Service, U.S. Department of Agriculture

Figure 7d. Number of Acres Harvested in the Western Region of the United States, 1960-2012



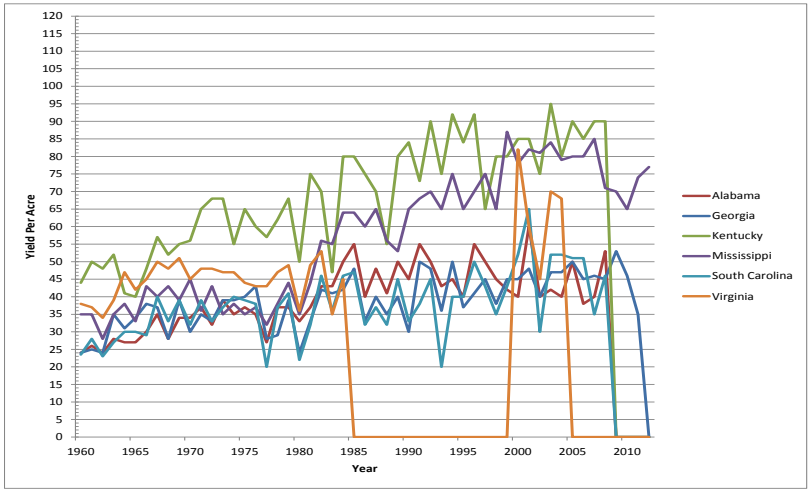
Source: Economic Research Service, U.S. Department of Agriculture

Figure 8a. Sorghum Yield in the South-Western Region of the United States, 1960-2012, bushels per acre



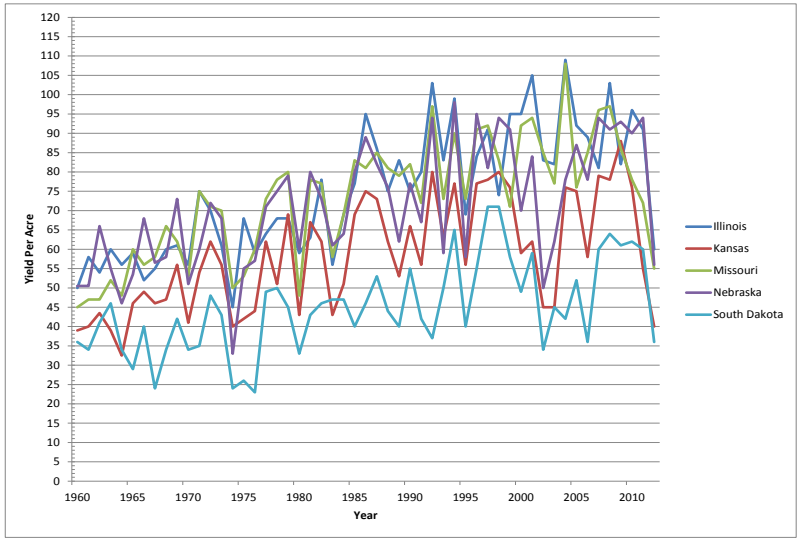
Source: Economic Research Service, U.S. Department of Agriculture

Figure 8b. Sorghum Yield in the South-Eastern Region of the United States, 1960-2012, bushels per acre



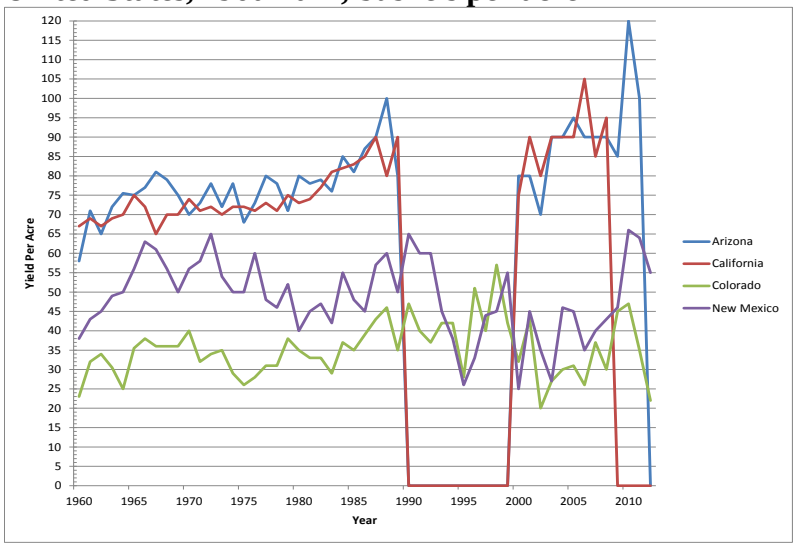
Source: Economic Research Service, U.S. Department of Agriculture

Figure 8c. Sorghum Yield in the Midwest Region of the United States, 1960-2012, bushels per acre



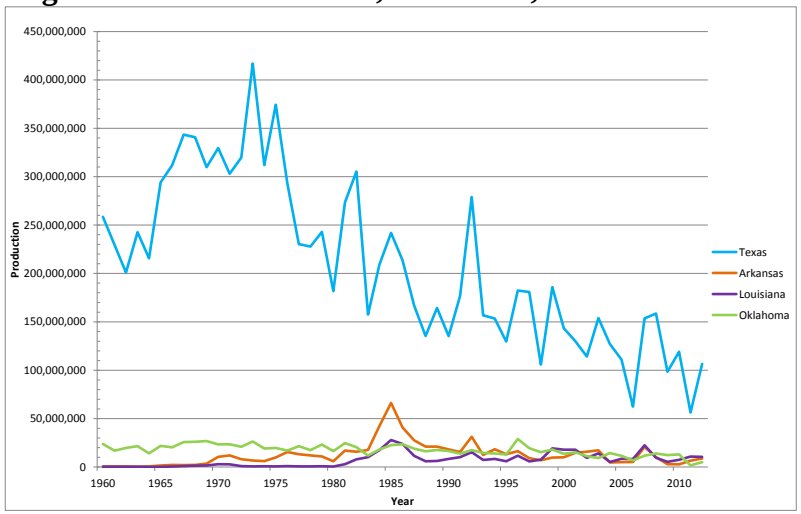
Source: Economic Research Service, U.S. Department of Agriculture

Figure 8d. Sorghum Yield in the Western Region of the United States, 1960-2012, bushels per acre



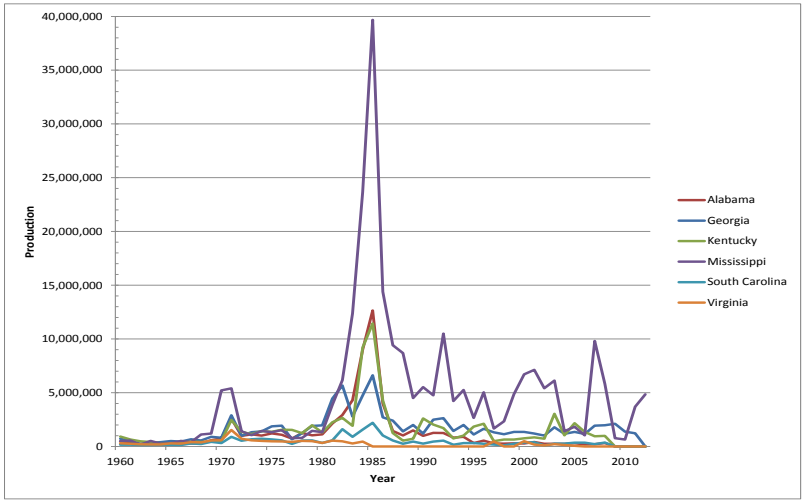
Source: Economic Research Service, U.S. Department of Agriculture

Figure 9a. Sorghum Production in the South-Western Region of the United States, 1960-2012, bushels



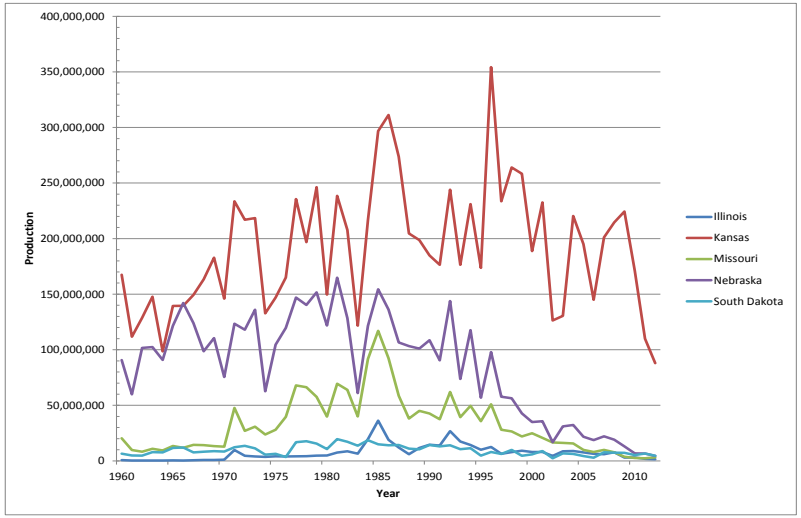
Source: Economic Research Service, U.S. Department of Agriculture

Figure 9b. Sorghum Production in the South-Eastern Region of the United States, 1960-2012, bushels



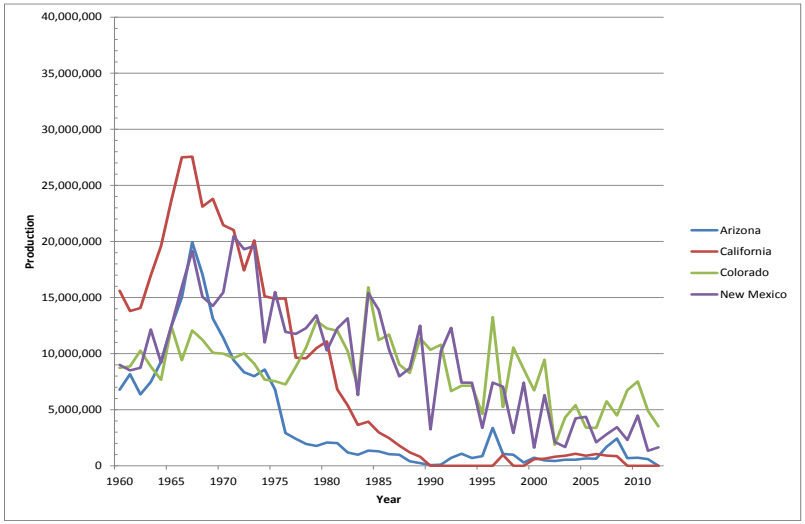
Source: Economic Research Service, U.S. Department of Agriculture

Figure 9c. Sorghum Production in the Midwest Region of the United States, 1960-2012, bushels



Source: Economic Research Service, U.S. Department of Agriculture

Figure 9d. Sorghum Production in the Western Region of the United States, 1960-2012, bushels per acre



Source: Economic Research Service, U.S. Department of Agriculture

As exhibited in Figures 10a and 10b, clearly the two principal states in terms of acres harvested and production of sorghum are Texas and Kansas. Over the period 1960-2012, the share of acres harvested in Texas and Kansas ranged from 20 percent to 50 percent. In 2012, this share was just under 40 percent for Texas and slightly more than 40 percent for Kansas. Consequently, those two states in 2012 accounted for roughly 80 percent of the acres harvested of sorghum. The share of sorghum production in Texas ranged from 20 percent to 50 percent, while the share of sorghum production in Kansas ranged from 20 percent to 60 percent over the period 1960 to 2012. In 2012, the share of sorghum production in Texas was slightly more than 40 percent, and the share of sorghum production in Kansas was slightly less than 40 percent. Hence, these two states in 2012 accounted for about 80 percent of the production of sorghum.

To provide additional perspective, we consider planted acreage, harvest acreage, yields, and production figures for feed grains, namely corn, sorghum, barley, and oats. As exhibited in Figure 11 – 14, over the period 1960 to 2012, unequivocally in all facets, corn is the major feed grain. Sorghum ranks second in terms of acres planted, acres harvested, and production. Yields of sorghum, barley, and oats are very similar over the period 1960 to 2012, ranging from about 40 bushels per acre to 70 bushels per acre. In contrast, corn yields varied from 60 bushels per acre to 160 bushels per acre over this period.

Figure 10a. Share of Acres Harvested and Total Production in Texas, 1960-2012

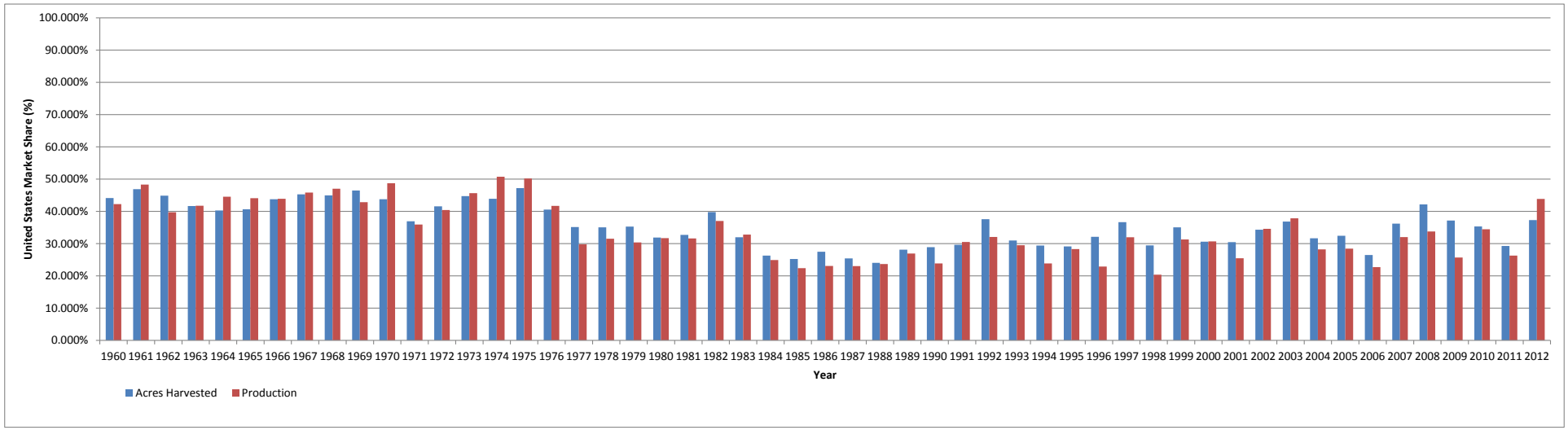
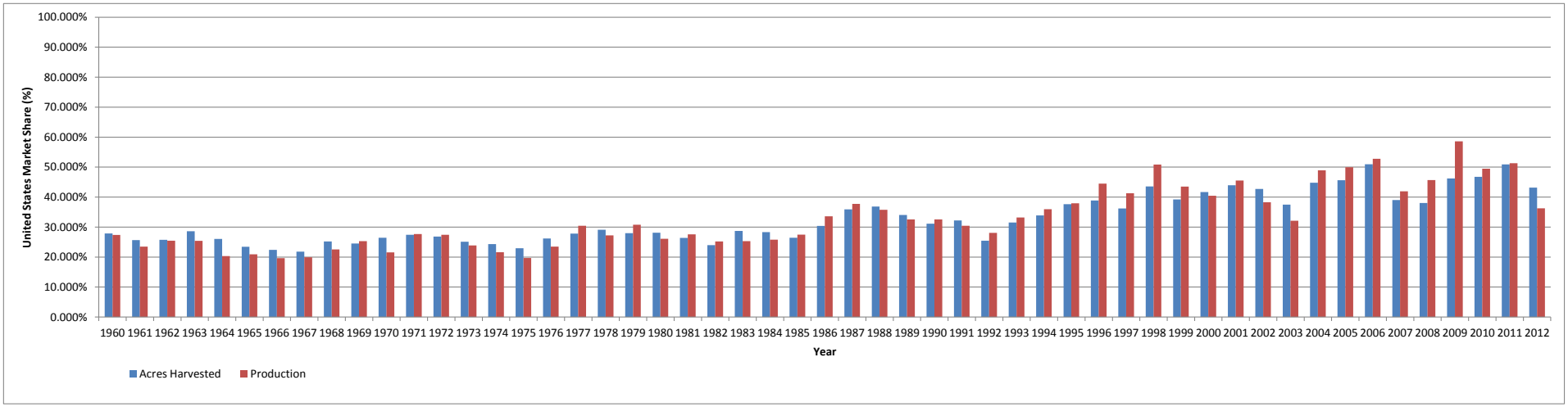
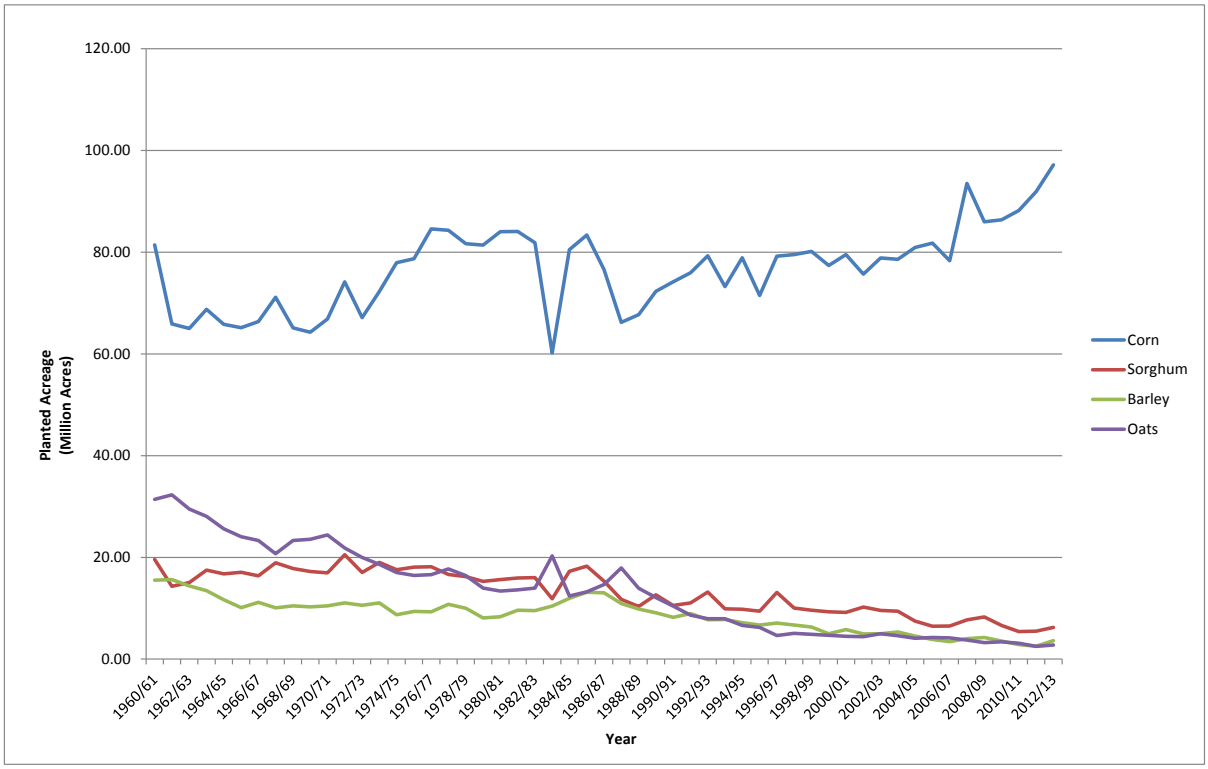


Figure 10b. Shares of Acres Harvested and Total Production in Kansas, 1960-2012



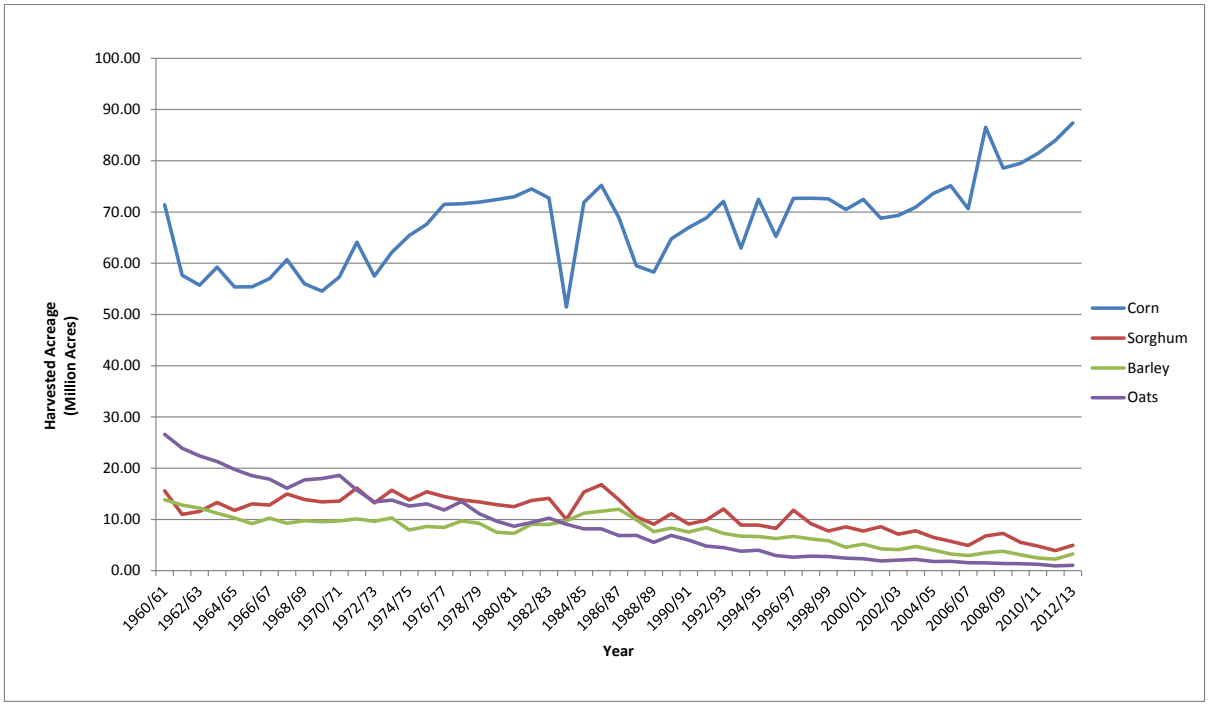
Source: Economic Research Service, U.S. Department of Agriculture and calculations by the authors.

Figure 11. Planted Acreage of Corn, Sorghum, Barley, and Oats, 1960-2012



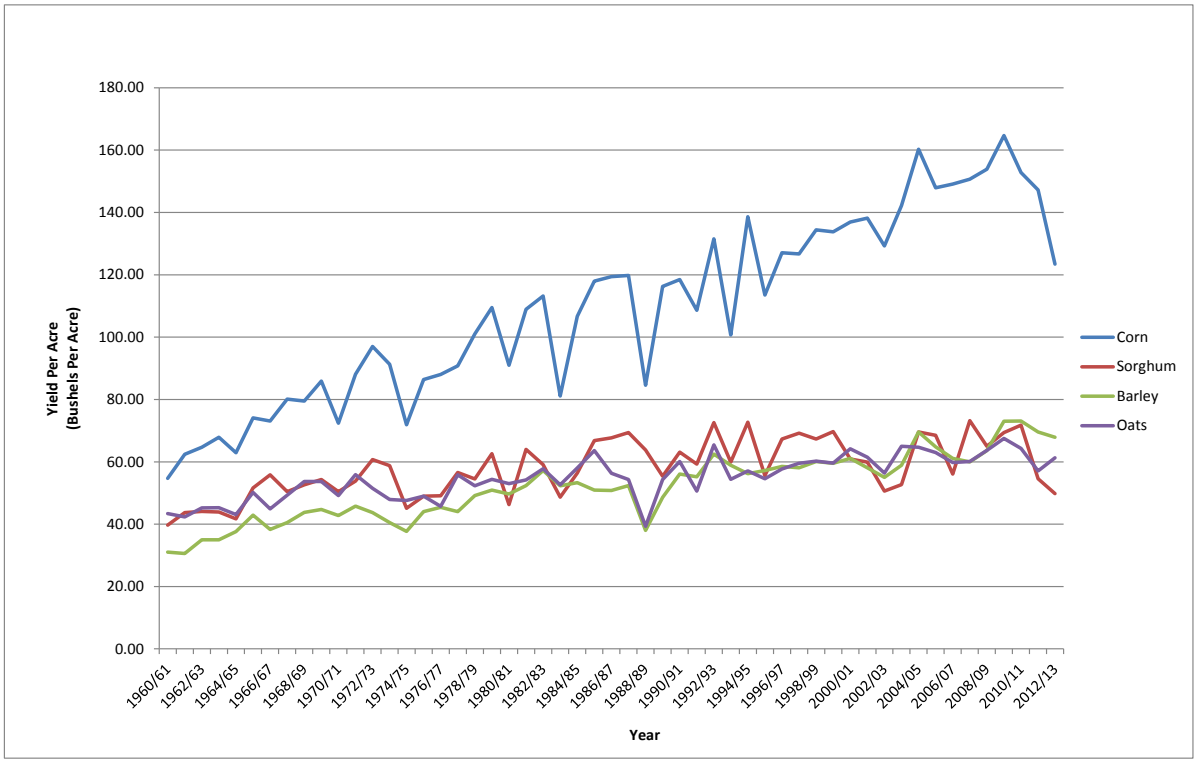
Source: Economic Research Service, U.S. Department of Agriculture

Figure 12. Harvested Acreage of Corn, Sorghum, Barley, and Oats, 1960-2012



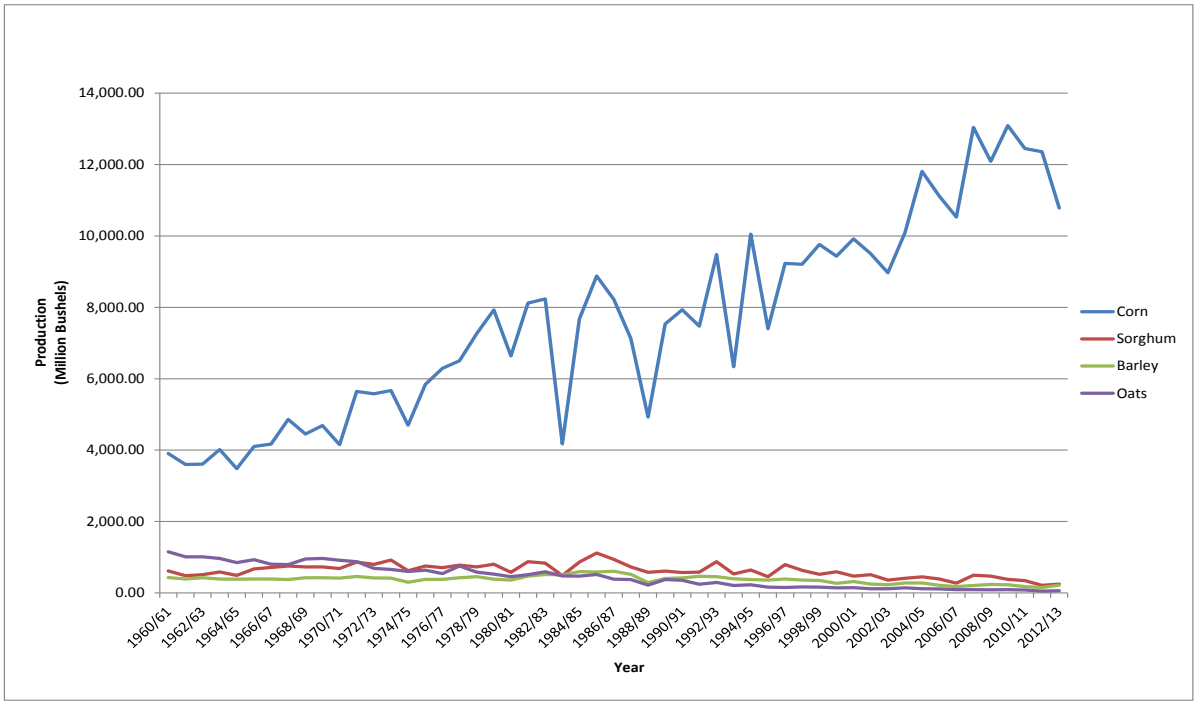
Source: Economic Research Service, U.S. Department of Agriculture

Figure 13. Yield Per Acre for Corn, Sorghum, Barley, and Oats, 1960-2012



Source: Economic Research Service, U.S. Department of Agriculture

Figure 14. Production of Corn, Sorghum, Barley, and Oats, 1960-2012

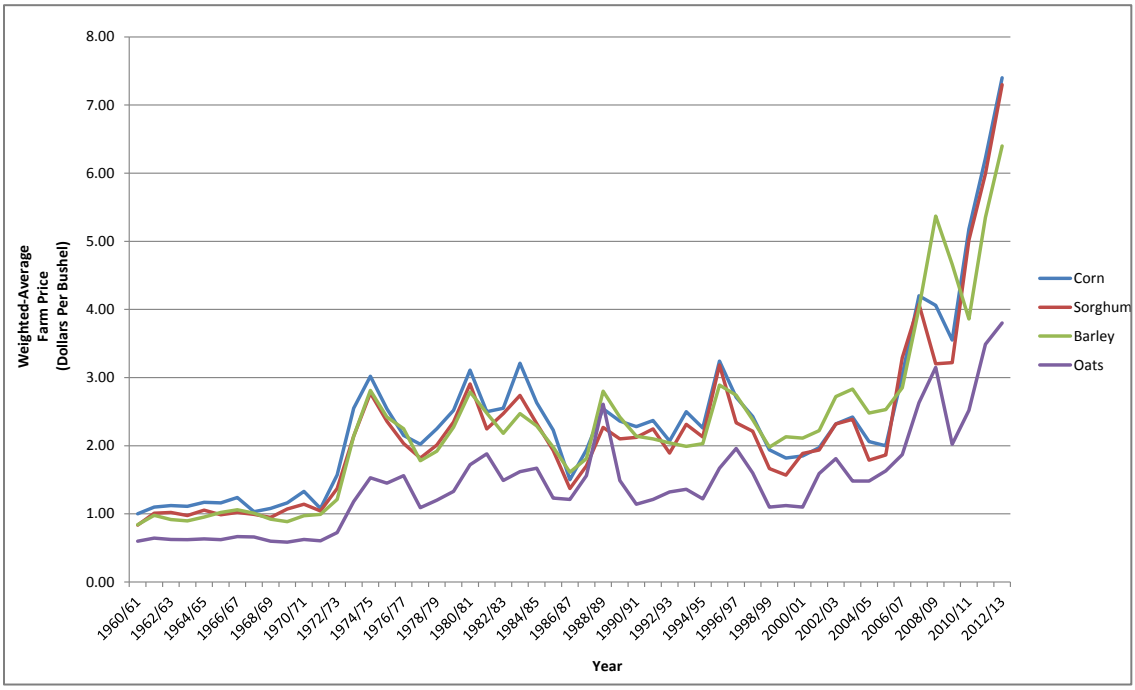


Source: Economic Research Service, U.S. Department of Agriculture

TRENDS IN PRICES RECEIVED BY PRODUCERS, 1960 TO 2012

Farm prices received by producers of feed grains over the period 1960 to 2012 are exhibited in Figure 15. Generally speaking, the respective farm prices move together. In particular, the correlation of sorghum prices and corn prices is 0.9921 over this period. In general, sorghum prices are roughly 97 percent to 98 percent of corn prices over this period.

Figure 15. Farm Prices Received by Producers, 1960-2012



Source: Economic Research Service, U.S. Department of Agriculture

SUPPLY AND DEMAND CHARACTERISTICS OF SORGHUM

Demand and supply characteristics for sorghum are exhibited in Table 5 for the period 1975 to 2012. Supply is equal to the sum of production, imports, and beginning stocks. Demand is equal to the sum of seed use, food and industry use, exports, and feed use. The difference between supply and demand is ending stocks. Domestic production by far is the major component of supply followed by beginning stocks. Imports of sorghum were negligible over the period 1975 to 2012. In 2012, imports of sorghum, predominantly from Argentina, were well above historical patterns, however.

The dominant demand or end use component of sorghum historically has been feed use, followed by exports, food and industry use, and seed use in that order (see Figure 16). We define industry use as any use of sorghum not related to seed use, feed use, food use, or exports. Historically much of the sorghum crop has been used as a component in livestock feed. Corn is the main substitute for sorghum in livestock feed.

Table 5. Demand and Supply Characteristics for Sorghum, 1975 to 2012, millions of bushels

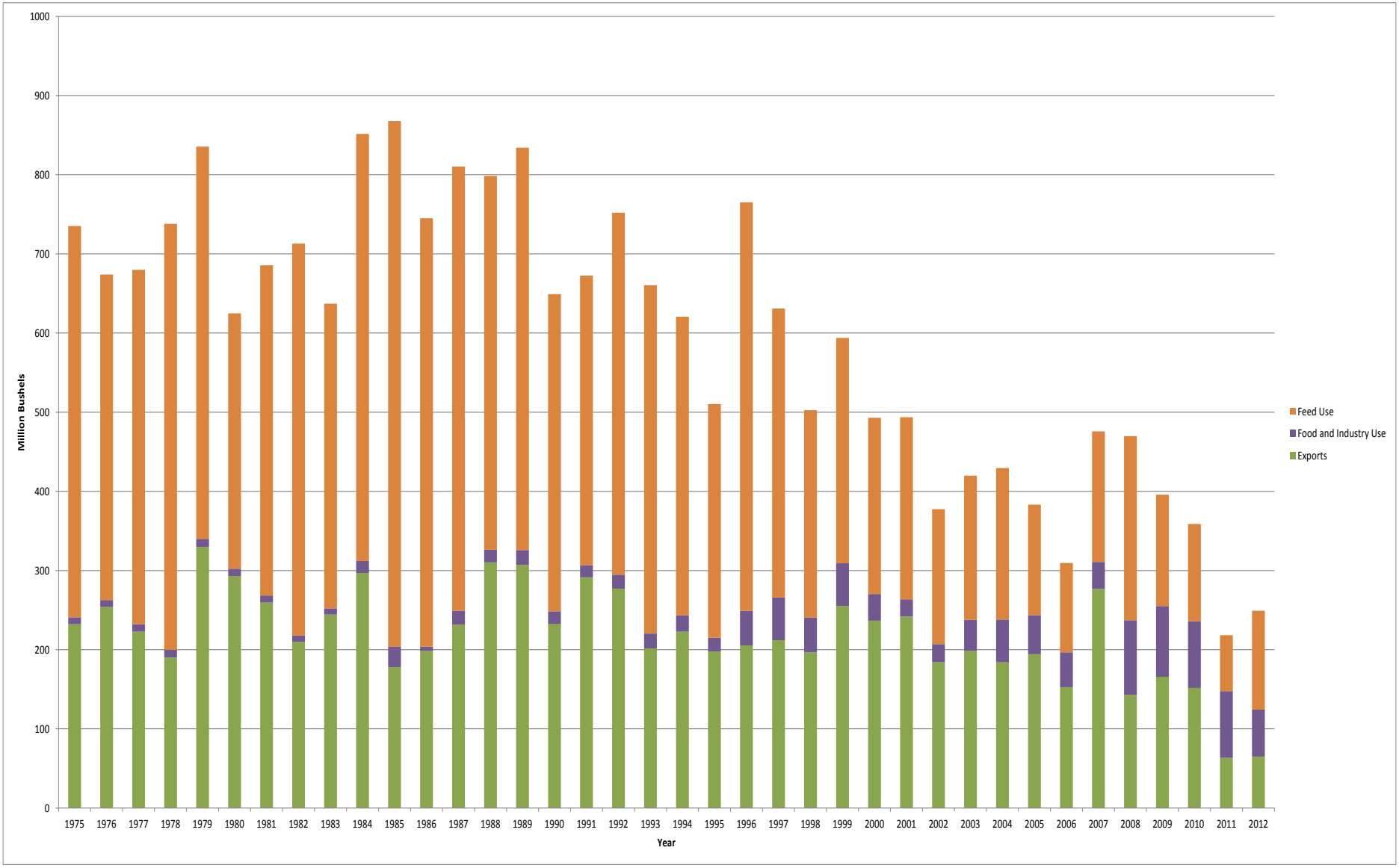
YEAR	PRODUCTION	BEGINNING STOCKS	ENDING STOCKS	SEED USE	SHARE[2] SEED USE	FOOD AND INDUSTRY USE	SHARE[2] FOOD AND INDUSTRY USE	EXPORTS	SHARE[2] EXPORTS	IMPORTS	FEED USE	SHARE[2] FEED USE
1975/76	754.354	65.000	82.300	2.300	0.28	8.800	1.07	232.161	28.32	0.001	494.094	60.28
1976/77	710.797	82.300	117.100	2.000	0.25	8.800	1.11	253.915	32.02	0.000	411.082	51.85
1977/78	780.944	117.100	216.000	2.000	0.22	9.400	1.05	222.842	24.82	0.022	447.624	49.85
1978/79	731.270	216.000	208.000	1.800	0.19	9.900	1.04	190.092	20.06	0.002	537.980	56.76
1979/80	807.422	208.000	178.000	2.000	0.20	10.400	1.02	329.672	32.47	0.002	495.352	48.78
1980/81	579.343	178.000	130.000	2.000	0.26	9.100	1.20	293.159	38.73	0.010	322.594	42.62
1981/82	875.835	130.000	319.000	2.000	0.20	8.800	0.87	259.613	25.79	0.017	417.139	41.44
1982/83	835.083	319.000	439.000	1.800	0.16	7.900	0.68	210.054	18.21	0.051	494.880	42.90
1983/84	487.521	439.000	288.000	2.300	0.25	7.700	0.83	244.479	26.36	0.142	384.884	41.50
1984/85	866.241	288.000	300.000	2.000	0.17	15.300	1.33	296.905	25.74	0.121	539.357	46.76
1985/86	1120.271	300.000	551.000	1.700	0.12	26.000	1.83	177.988	12.53	0.003	663.880	46.73
1986/87	938.869	551.000	743.000	1.600	0.11	5.336	0.36	198.327	13.31	0.007	541.286	36.34
1987/88	730.809	743.000	663.000	1.300	0.09	17.542	1.19	231.583	15.71	0.007	561.073	38.05
1988/89	576.686	663.000	440.000	1.500	0.12	16.238	1.31	310.185	25.02	0.019	471.921	38.06
1989/90	615.420	440.000	220.000	1.300	0.12	18.700	1.77	307.069	29.10	0.226	508.330	48.16
1990/91	573.303	220.000	143.000	1.399	0.18	15.600	1.97	232.803	29.34	0.068	400.743	50.50
1991/92	584.860	143.000	53.000	1.690	0.23	15.300	2.10	291.434	40.07	0.007	365.836	50.30
1992/93	875.022	53.000	175.000	1.300	0.14	17.600	1.90	277.100	29.85	0.012	457.212	49.26
1993/94	534.172	175.000	48.000	1.200	0.17	18.800	2.65	201.568	28.40	0.008	440.055	62.01
1994/95	645.741	48.000	72.000	1.200	0.17	20.800	3.00	222.688	32.10	0.007	377.017	54.35
1995/96	458.648	72.000	18.371	1.600	0.30	17.400	3.28	197.822	37.31	0.014	295.083	55.65
1996/97	795.274	18.371	47.461	1.200	0.15	43.700	5.37	205.374	25.24	0.034	515.944	63.41
1997/98	634.000	47.461	48.703	1.200	0.18	53.900	7.92	212.083	31.15	0.011	364.931	53.60
1998/99	519.933	48.703	64.863	1.200	0.21	43.900	7.72	196.690	34.60	0.013	261.896	46.06
1999/2000	595.166	64.863	65.375	1.149	0.17	53.900	8.16	255.261	38.66	0.003	284.647	43.11
2000/01	470.526	65.375	41.751	1.273	0.24	33.800	6.31	236.582	44.15	0.002	222.497	41.52
2001/02	514.040	41.751	60.873	1.192	0.21	21.800	3.92	241.815	43.52	0.000	230.011	41.39
2002/03	361.000	60.873	43.030	1.176	0.28	22.800	5.41	184.298	43.70	0.022	170.404	40.41
2003/04	411.219	43.030	33.549	0.915	0.20	39.000	8.59	198.773	43.76	0.001	182.013	40.07
2004/05	453.606	33.549	56.941	0.801	0.16	54.100	11.10	184.043	37.78	0.025	191.295	39.27
2005/06	392.739	56.941	65.663	0.806	0.18	49.218	10.95	194.315	43.21	0.002	139.680	31.06
2006/07	276.824	65.663	32.053	0.987	0.29	44.013	12.85	152.589	44.54	0.076	112.921	32.96
2007/08	497.000	32.053	52.750	1.055	0.20	34.100	6.44	276.740	52.26	0.039	164.892	31.14
2008/09	472.342	52.750	54.712	0.811	0.15	94.146	17.92	142.988	27.22	0.132	232.567	44.28
2009/10	382.983	54.712	41.240	0.743	0.17	89.257	20.39	165.792	37.88	0.005	140.668	32.14
2010/11	345.625	41.240	27.450	0.650	0.17	84.350	21.80	151.702	39.21	0.030	122.743	31.73
2011/12	214.443	27.450	23.000	0.700	0.29	84.300	34.83	63.397	26.19	0.105	70.649	29.19
2012/13[1]	246.021	23.000	22.000	0.700	0.25	79.000	28.04	80.000	28.40	12.000	100.000	35.50
				MEAN	0.20		6.56		31.76			44.45
				MEDIAN	0.18		2.82		30.50			43.00
				MIN	0.09		0.36		12.53			29.19
				MAX	0.30		34.83		52.26			63.41

[1]Projected.

[2]Share of Total Supply (Total Supply = Production + Beginning Stocks + Imports)

Source: Economic Research Service, U.S. Department of Agriculture and calculations by the authors.

Figure 16. Comparison of Feed, Exports, and Food and Industry Use, Activities of Sorghum in the United States, 1975 to 2012



Source: Economic Research Service, U.S. Department of Agriculture

DESCRIPTIVE ANALYSIS OF PRODUCTION METRICS AND END USES OF SORGHUM

To shed light on the assessment of the effectiveness of the sorghum checkoff program on production metrics and end uses of sorghum, we provide a descriptive analysis by selected periods of time. As exhibited in Table 6 and Figure 17 – 19, we provide averages of acres planted, acres harvested, yields, and production for: (1) 1960 to 1997; (2) 1998 to 2002; (3) 2003 to 2007; (4) 2008 to 2012 (the period of time during the implementation of the sorghum checkoff); and (5) 1960 to 2007 (the period of time prior to the implementation of the sorghum checkoff). From 1960 to 1997, the average number of acres planted (harvested) was 15.2 million (12.6 million); from 1998 to 2002, the average number of acres planted (harvested) was 9.6 million (7.9 million); from 2003 to 2007, these figures were 7.5 million on average for acres planted and 6.4 million for acres harvested respectively. Over the period of 2008 to 2012 during the existence of the checkoff program, on average acres planted was 6.4 million and acres harvested was 5.3 million. Even with the checkoff program in place, the downward trend in number of acres planted and number of acres harvested was not arrested.

Yields on average for sorghum were roughly 56 bushels over the period 1960 to 1997; yields rose to nearly 62 bushels on average over the period of 1998 to 2002. This upward trend in yields was evident over the 2003 to 2007 period, where yields on average were 64 bushels. Yields over the period of the checkoff program feel to roughly 62 bushels. Average yields prior to the checkoff program (57.6 bushels per acre) were lower in relation to average yields during the checkoff program (61.8 bushels per acre).

Because of the decline in harvested acres across the selected periods, a similar decline in sorghum production was evident. Average production levels were 703 million bushels from 1960 to 1997; 492 million bushels from 1998 to 2002; 406 million bushels from 2003 to 2007; and 332 million bushels from 2008 to 2012.

As exhibited in Table 7 and Figure 20, we also provide averages of feed use, seed use, food and industry use and exports for selected periods. Average levels of feed use were 457 million bushels over the period 1975 to 1997; 234 million bushels over the period 1998 to 2002; 158 million bushels from 2003 to 2007; and 138 million bushels from 2008 to 2012. A similar downward trend was evident for exports. Average levels of exports were 243 million bushels over the period 1975 to 1997; 223 million bushels from 1998 to 2002; 201 million bushels from 2003 to 2007; and 121 million bushels from 2008 to 2012. While small in terms of magnitude of use, a downward trend also was evident for seed use. However, in terms of food and industry use, average levels rose monotonically across the respective periods. Average levels of food and industry use were 17 million bushels from 1975 to 1997; 35 million bushels from 1998 to 2002; 44 million bushels from 2003 to 2007; and 86 million bushels from 2008 to 2012.

Table 6. Averages of Acres Planted, Acres Harvested, Yield, and Production of Sorghum by Selected Periods of Time

	1960-1997[1]	1998-2002	2003-2007	Prior to Mandatory USCP (1960-2007)	2008-2012
Acres Planted	15,216,605	9,589,200	7,518,800	13,828,563	6,402,400
Acres Harvested	12,587,149	7,865,465	6,357,567	11,445,767	5,326,200
Yield (Bushels Per Acre)	56.2	61.68	64.02	57.59	61.82
Production (Million Bushels)	703	492	406	650	332

[1]1960 to 1997 for acres planted, acres harvested, yield, and production

Source: Economic Research Service, U.S. Department of Agriculture

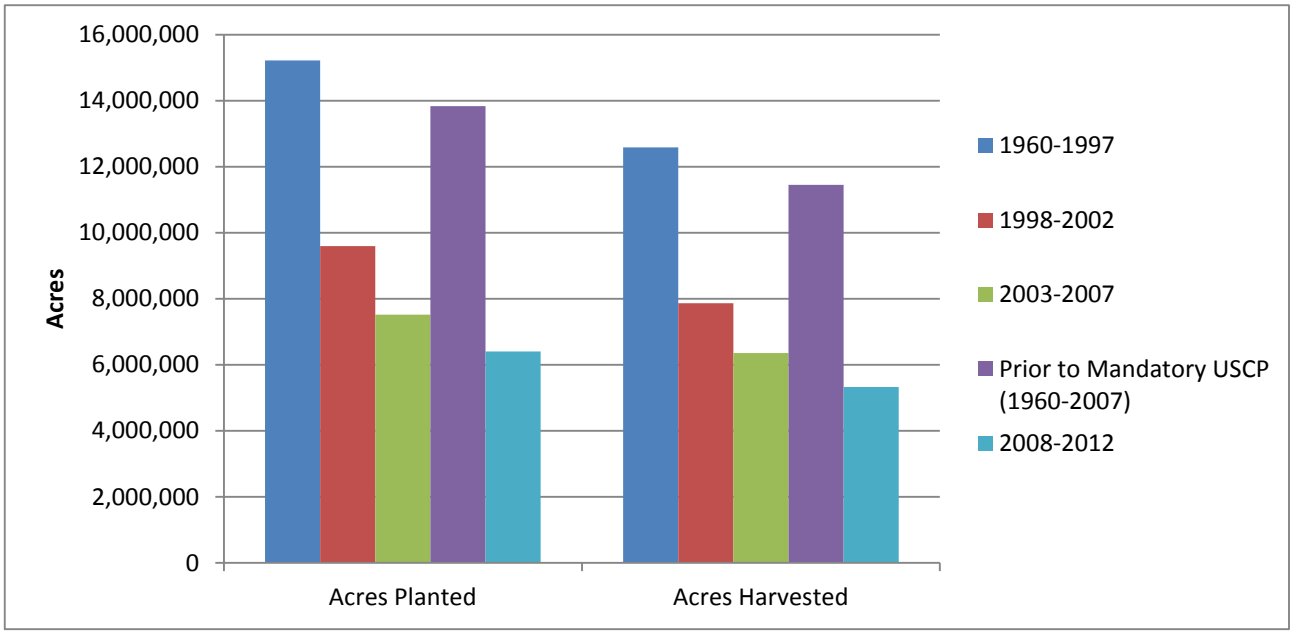
Table 7. Averages of End Uses of Sorghum by Selected Periods of Time, millions of bushels

	1975-1997[1]	1998-2002	2003-2007	Prior to Mandatory USCP (1975-2007)	2008-2012
Feed Use	456.88	233.89	158.16	377.83	138.33
Seed Use	1.67	1.20	0.91	1.48	0.72
Food and Industry Use	16.65	35.24	44.09	23.63	86.21
Exports	243.43	222.93	201.29	233.94	120.78

[1]1975 to 1997 for feed use; seed use; food and industry use; and exports.

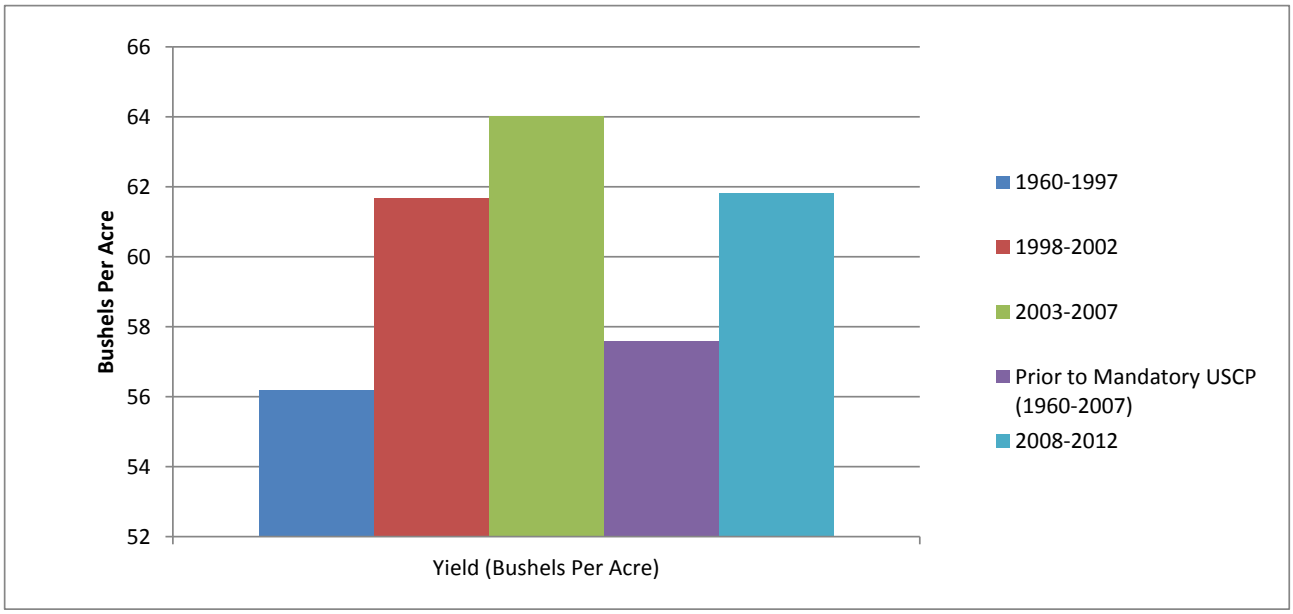
Source: Economic Research Service, U.S. Department of Agriculture

Figure 17. Acres Planted and Acres Harvested of Sorghum by Selected Periods of Time



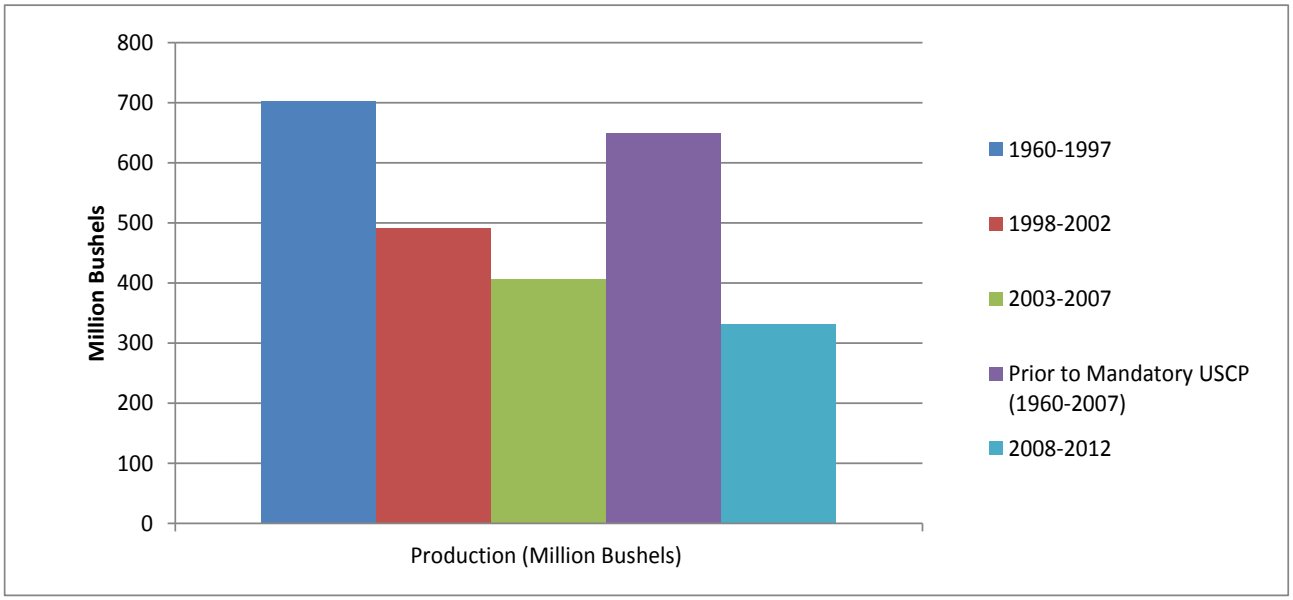
Source: Economic Research Service, U.S. Department of Agriculture

Figure 18. U.S. Sorghum Yield by Selected Periods of Time



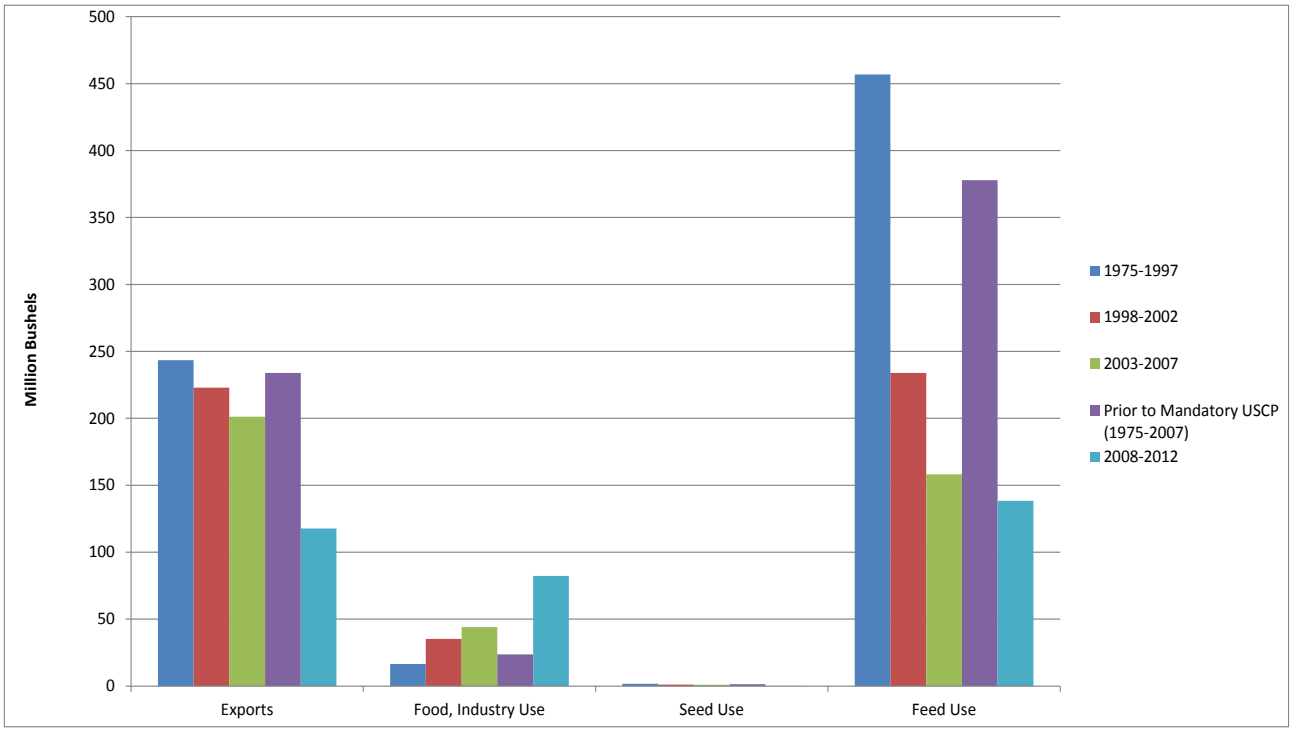
Source: Economic Research Service, U.S. Department of Agriculture

Figure 19. U.S. Production of Sorghum by Selected Periods of Time



Source: Economic Research Service, U.S. Department of Agriculture

Figure 20. End Uses of Sorghum by Selected Periods of Time



Source: Economic Research Service, U.S. Department of Agriculture

ANALYSES OF THE IMPACTS OF USCP ACTIVITIES ON THE SORGHUM INDUSTRY

Various analyses of the impacts of sorghum program expenditures (funds committed by USCP) can be done: (1) analyses of crop improvement (research) activities on acres planted, yields, and consequently production of sorghum; and (2) demand analyses associated with various uses of sorghum. The respective analyses conducted are designed to determine whether or not USCP program expenditures over the years effectively shift out the demand for sorghum and/or lead to increases in sorghum production. If the answer to that question is "yes," then the next question is whether or not the rightward shift in sorghum demand or the increase in sorghum production over time benefits those who have contributed to the program. Obviously, if the answer to the first question is "no," then the answer to the second question is "no" as well. However, if the answer to the first question is "yes," the answer to the second is not necessarily "yes" because any consequent increase in revenues to the contributors may or may not be sufficient to cover the cost to them of the USCP programmatic activities.

To measure the returns to USCP program expenditures, the first step is to isolate the effects of those investments in domestic and international markets from those of other events that may have affected those markets over the years. For this purpose, checkoff expenditures collected over time must be incorporated into appropriate structural models of domestic and international sorghum markets. These models then are simulated over the historical period under alternative assumptions regarding sorghum checkoff expenditure levels, and the results are used subsequently to calculate benefit-cost ratios. We pioneered this cutting edge evaluation procedure, and we have used this evaluation procedure in our previous analyses of the soybean, pork, cotton, and milk checkoff programs as well as the Florida Department of Citrus (FDOC) orange juice advertising program.

The use of the aforementioned structural or econometric models generates a baseline simulation of the various key endogenous or dependent variables (domestic sorghum production; domestic uses of sorghum; exports of sorghum to various foreign countries; and grower prices of sorghum). Because the programmatic expenditures made by the USCP are to be set to their actual or historical values, the baseline simulation represents the **"With Expenditures" scenario.** Subsequently, these expenditures are to be set to zero and the simulation is conducted again over the relevant time period to generate the **"Without Expenditures" scenario** results for the respective key variables in the structural models. These results then provide a measure of what the levels of production, prices, domestic uses, and exports would have been in the absence of the marketing activities of the USCP Board.

Differences in the solution values of the key variables in the "**Without Expenditures" or counterfactual scenario** from their baseline solution values, the **"With Expenditures" scenario",** consequently are direct measures of the effects of the programmatic activities of the USCP Board over time. Because no other exogenous or predetermined variables in the simulation model are allowed to change, this process effectively isolates the impacts of the marketing activities associated with the USCP Board on production, domestic uses, exports, and prices of sorghum. Therefore, our study indeed presents econometric evaluations of the impacts of USCP market development and promotion, information, and research activities that ultimately lead to the calculations of the returns to producer investments associated with the programmatic activities of the USCP.

All models are estimated using data made available from USCP records. Expenditures associated with programmatic activities of the USCP fall into program areas defined as research, market development and promotion, and information. Data pertaining to grower prices, production, yields, planted acreage and harvested acreage are publicly available from the U.S. Department of Agriculture, National Agricultural Statistics Service (USDA, NASS). Data on inflation, gross domestic incomes of foreign countries, and exchange rates are publicly available from various U.S. government agencies. Export data are published by the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture and gathered by the U.S. Department of Commerce.

Analyses of Research Activities on Planted Acreage, Yields, and Production of Sorghum

Agricultural research expenditures may affect planted acreage and yields. The product of acreage and yields results in a measure of production. Major contributions to both the theory and measurement of returns to producers from investments in agricultural research have been made by a variety of researchers. A number of commodities have been analyzed including corn, poultry, rice, rapeseed, wheat, wool, soybeans, and cotton. Because the benefits of research investments in any given year may not be realized for a number of years, it may not be possible to quantify accurately the effectiveness of agricultural research expenditures on the sorghum industry. We address these issues in our analysis of checkoff expenditures on agricultural research.

The economic relationship between sorghum checkoff-funded agricultural crop improvement or research expenditures and sorghum planted acreage and yield is measured with the use of econometric analysis. We implement, where necessary, a polynomial distributed lag (PDL) formulation to account for the potential carryover effects of agricultural research expenditures on planted acreage and on yields. Otherwise, funds committed by USCP are contemporaneously related to planted acreage and yields. In particular, we specify the logarithm of planted acreage in the current period to be a function of several variables: (1) the logarithm of the prices of sorghum and corn received by producers in the previous year; (2) a one-year lag of the logarithm of planted acreage; and (3) a PDL formulation or contemporaneous formulation of the funds committed to crop improvement activities by the USCP. Additionally, we use the logarithm of yield in the current period is specified to be a function of: (1) weather effects, with the use of El-Niño and La-Niña as proxy variables; (2) technological developments with the use of trend variables as proxies; and (3) a PDL formulation or contemporaneous formulation of crop improvement expenditures made by the USCP. Various lag lengths are considered with the optimal lag lengths chosen based on statistical criteria, namely the Schwarz Information Criterion (SIC), the Akaike Information Criterion (AIC), and the Hannan-Quinn Criterion (HQC).

Impacts of USCP Funds Committed to Crop Improvement

Checkoff expenditures in support of agricultural research (crop improvement) are intended to shift out supply of U.S. sorghum by increasing production efficiency and/or reduction production costs. Typically, agricultural research expenditures that reduce production costs would be expected to lead to an expansion in acreage dedicated to sorghum production. On the other hand, agricultural research expenditures that increase production efficiency would be expected to increase production yields, that is, the output per acre in production. Since production is the product of acreage and yield, successful agricultural research of either type would tend to increase output.

The effects of investments in research on the market supply of a commodity like sorghum however, are often not immediate, measureable, or direct. Research investments may fund either basic, long-term types of research or more applied, short-term types of research. Because the lag between research activities, particularly basic research, and the commercialization of new technologies available for adoption by sorghum producers may be quite lengthy, the full market impacts and any benefits of checkoff-funded research to sorghum producers may not be felt for a long time following the research investment.

Also, research investments may not always result in measurable market impacts. For example, basic or applied research that provides knowledge about what does *not* work in increasing yields or reducing costs has value but is not measurable in terms of market impacts. At the same time, applied research often is related to or depends on previous investments in basic research. Consequently, investments in basic research may have only indirect market effects to the extent that the results of that research lead to more applied research to develop new technologies and effectiveness of sorghum checkoff agricultural research expenditures over the years on sorghum production is difficult at best. An added complication is the difficulty of obtaining the necessary data over a sufficiently long enough period of time to be able to statistically identify the relations between research and production.

Major contributions to both the theory and measurement of the returns to producers from investments in agricultural research have been made by a variety of researchers (see, for example, Schultz (1953); Griliches (1958); Evenson (1967); Peterson (1967); Fox (1985); Pardey and Craig (1989); Chavas and Cox (1992); and Williams, Shumway, and Love (2002)). A number of commodities have been analyzed, including corn, cotton, poultry, rice, rapeseed, wheat, wool, and soybeans. The reality is that little research is available on the returns and supply effects of either public or private investments in sorghum research.

The economic relationships between sorghum checkoff-funded agricultural research expenditures and sorghum planted acreage and yield are measured using econometric analysis. Annual data on planted acreage and yield are available back to marketing years 1960/61. But data on USCP crop improvement activities are available only from 2008/09. We assume zero committed funds in crop improvement programs, prior to 2008/09, although we recognize that this assumption may not be tenable. Simply put, data on crop improvement activities prior to the establishment of the USCP (state-funded activities) were not available.

Separate single-equation models are specified corresponding to the planted acreage and the yields of sorghum. The data for this analysis are annual covering the marketing years 1960/61 to 2011/12. Agricultural research expenditures finance projects intended primarily to enhance sorghum yield and quality, improving sorghum's resistance to temperature extremes and to insects and diseases, advances in biotechnology, reduced dependence on pesticides, and profitable conservation tillage practices. Agricultural research expenditures that reduce production costs would be expected to give rise to expanding acreage dedicated to sorghum production.

The logarithm of planted acreage is specified to be a function of several variables: (1) the logarithm of the ratio of sorghum farm prices to corn prices in the previous year; (2) a one-year lag of the logarithm of harvested acreage; and (3) the square-root of USCP funds committed to crop improvement. Additionally, we capture other factors affecting yields through the use of a trend

variable and indicator variables representing qualitative events in 1961, 1983, 1984, 1985, and 1996. Further, we estimate the relationship between acres harvested and acres planted. This relationship is important in establishing the impact of changes in harvested acreage attributed to the USCP crop improvement activities.

For yield, the logarithm of yield in the current period is specified to be a function of: (1) weather effects, with the use of El-Niño and La-Niña as proxy variables; (2) the square-root of USCP funds committed to crop improvement; and (3) the use of trend variables and indicator variables representing qualitative events in 1980, 1983, and 2002.

Similar to Mitchell (2009), weather effects are proxied through the occurrences of the El-Niño/La-Niña phenomenon. El-Niño and La-Niña are two extreme phases of the El-Niño/Southern Oscillation (ENSO) climate cycle. El-Niño occurs when there is an irregular warming of subsurface temperatures from Peru to Ecuador to the Pacific. Over the period 1960 to 2012, major En-Niño occurrences were recorded in 1972/73, 1982/83, 1997/98, and 2009/10 (Stormfax, 2011).

The effects of El-Niño give rise to more rain across the Southern part of the United States. La-Niña were recorded in 1964/65, 1970/71, 1973/74, 1975/76, 1988/89, 1995/96, 1998/99, 2010/11, and 2011/12 (Stormfax, 2011). La-Niña leads to warmer conditions and less rain across the southern part of the United States. Consequently, for years in which La-Niña occurred, owing to more drought conditions, yields are expected to be lower. For years in which El-Niño occurred, yields are expected to be higher.

We may summarize the econometric specifications as follows:

(1) $\log(\text{Planted Acreage of Sorghum}_t) = f_1(\log((\text{sorghum farm price}_{t-1}) / (\text{corn farm price}_{t-1})), t^2, (\text{USCP\_crop\_improv})^{.5}, \text{D1961}, \text{D1983}, \text{D1984}, \text{D1985}, \text{D1996}) + v_1$

(2) $\text{Harvested Acres of Sorghum} = f_2(\text{Planted Acreage of Sorghum}) + v_2$

(3) $\log(\text{Sorghum Yield}_t) = f_3(\text{LA\_NINA}_t, \text{EL\_NINO}_t, t, t^2, (\text{USCP\_crop\_improv}_t)^{.5}, \text{D1980}, \text{D1983}, \text{D2002}) + v_3$

(4) $\text{Sorghum Production} = \text{Harvested Acres of Sorghum} * \text{Sorghum Yield}$

To close this system, we add a model specification for the farm price of sorghum:

(5) $\log(\text{sorghum farm price}) = f_4(\log(\text{corn farm price}_t), \log(\text{sorghum production}_t), \log(\text{price of no 2 sorghum at Kansas City}_t), (\text{USCP\_crop\_improv})^{.5}) + v_4$

Corn prices are hypothesized to positively affect sorghum prices; sorghum production is hypothesized to be inversely related to sorghum prices. The price of no 2 sorghum at Kansas City is hypothesized to be positively related to the farm price of sorghum. This relationship affects the price transmission process for farm prices to downstream prices in the marketing channel. Therefore, with this system of equations (1) through (5), we are in position to capture the impacts of funds committed to USCP crop improvement activities on planted acres, harvested acres, yields, production, and farm prices.

Empirical Results Associated with the Impacts of Funds Committed to Crop Improvement Activities

The empirical results of the econometric analyses associated with planted acres of sorghum, harvest acres of sorghum, and sorghum yields are exhibited in Tables 8-10. The measures of goodness-of-fit (R^2 or $\overline{R}^2$) are 0.94 (for R^2) and 0.93 ($\overline{R}^2$) which reflect that roughly over 90 percent of the variation in the number of acres planted is accounted for by the econometric model. From Table 8, the drivers of acres planted of sorghum in the United States are the ratio of the farm price of sorghum to the farm price of corn with a one-year lag, the number of acres planted in the previous year, qualitative factors occurring in various years (1961, 1983, 1984, 1985, and 1986), and a nonlinear (squared) trend. In particular, if the ratio of the farm price of sorghum to the farm price of corn in the previous year changes by one percent, then the number of acres planted of sorghum changes by 0.52 percent in the same direction. The significance of the number of acres of sorghum planted in the previous year is indicative of inertia on the part of growers.

Of note, funds committed to crop improvement activities made by the USCP are positively and contemporaneously related to acres planted of sorghum. The use of the square root transformation captures diminishing marginal returns in planted acres attributed to USCP expenditures over the marketing years 2008/09 to 2011/12; a one percent change in funds committed to USCP crop improvement activities translates into a 0.026 percent change on average in the number of acres planted of sorghum. As exhibited in Table 11, this sensitivity or elasticity of planted acreage and fund committed to crop improvement activities means that as a result of the checkoff program roughly an additional 130,000 to 250,000 acres of sorghum were planted. Based on the econometric results reported in Table 9, a one-unit change in number of acres planted leads to a 0.78 unit change in the number of acres harvested. Consequently, as given in Table 11, funds committed to crop improvement activities made by the USCP generated additional harvested acreage between 102,306 to 190,632 acres. Put another way, as a result of the checkoff program, planted acreage rose 2.18 percent to 2.96 percent and harvested acreage rose 2.04 percent to 3.07 percent (Table 11). However, despite the gains in planted and harvested acreage attributed to the USCP, these gains were not statistically different from zero.

As exhibited in Table 10, we present the econometric analysis of sorghum yields in the United States over the marketing years 1960/61 to 2011/12. The goodness-of-fit measure (R^2) for this analysis is 0.73, meaning that roughly then 73 percent of the variation in sorghum yields is explained by the model specification. Key determinants of yields as hypothesized, were weather effects, trends (proxies for technological charge), and qualitative events occurring in marketing years 1980, 1983, and 2002. The weather effects associated with La-Niña reduced yields by close to 6 percent, and the weather effects associated with El-Niño led to increases in yields by slightly more than 9 percent.

Funds committed by the USCP to crop improvement activities enhanced sorghum yields. A one percent change in funds committed resulted in a 0.012 percent to 0.016 percent change in sorghum yields. Again, a square-root transformation of dollar expenditures associated with crop improvement activities was used to reflect diminishing marginal returns. As presented in Table 11, the percent changes in yields translate into incremental yields of 1.18 percent to 1.60 percent bushels per acre. However, similar to the situation for acreage, this gain in yields was not significantly different from zero.

As exhibited in Table 11, due to the fact that sorghum production is the product of harvested acreage and yield, the efforts of the USCP led to increases in production of 3.19 percent to 4.55 percent. Put another way, funds committed by the USCP to crop improvement activities generated increases in sorghum production of roughly 9.7 million to 19.8 million bushels over marketing years 2008/09 to 2011/12.

To provide a measure of the impact of crop improvement activities on farm revenue, we develop a model specification for sorghum farm prices. As given in Table 12, the goodness-of-fit for this relationship is 0.9892. Hence, almost 99 percent of the variation in sorghum farm price is accounted for by this econometric analysis. Drivers of sorghum farm prices were corn farm prices, sorghum production, and sorghum prices at the terminal market in Kansas City. In particular, a one percent change in corn prices generated a 0.38 percent change in sorghum prices in the same direction; a one percent change in sorghum production, all other factors held constant, generated a 0.07 percent change in sorghum prices in the opposite direction; and a one percent change in downstream prices generated a 0.60 percent change in sorghum farm prices in the same direction.

Unlike the situation for planted acreage and yields, the impact of funds committed to crop improvement activities on farm prices was not felt all at once but instead, this impact was distributed over two years. A one percent change in expenditures geared to crop improvement activities generated a 2.0 percent to 2.8 percent change in sorghum farm prices in the opposite direction. As a result of the efforts made by USCP in crop improvement activities, as presented in Table 11, sorghum farm prices dropped 7 cents per bushel to 16 cents per bushel over the marketing years 2008/09 to 2011/12. Importantly, this change in sorghum farm prices also was not statistically different from zero.

Bottom line, as exhibited in Table 11, funds committed by the USCP to crop improvement activities generated $86.6 million of additional farm revenue or a 1.50 percent increase in farm revenue on acres. Owing that finds committed by the USCP was $4.1 million, the benefit-cost ratio for crop improvement activities was calculated to be 21 to 1. Consequently, for every dollar invested in crop improvement, a return of 21 dollars was evident. Realize however, that this set of calculations rests on the changes in harvested acres and yields (and hence production) as well as the changes in farm prices attributed to the checkoff. All of these changes however were not significantly different from zero.

Table 8. Econometric Analysis of Planted Acres of Sorghum in the United States, Marketing Year, 1960/61 to 2011/12

Dependent Variable: LOG(ACRES_PLANTED_US)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.61397	1.978703	5.364105	0.0000
LOG(SORGHUM_FARM_PRICE(-1)/CORN_FARM_PRICE(-1))	0.524019	0.260422	2.012193	0.0508
USCP_CROP_IMPROV^.5	5.17E-05	6.12E-05	0.843592	0.4038
@TREND^2	-0.000307	5.28E-05	-5.820582	0.0000
LOG(ACRES_PLANTED_US(-1))	0.368722	0.118494	3.111726	0.0034
D1961	-0.231854	0.099550	-2.329016	0.0249
D1983	-0.261415	0.098729	-2.647797	0.0114
D1984	0.302893	0.100569	3.011780	0.0044
D1985	0.221143	0.099290	2.227241	0.0315
D1996	0.258822	0.099121	2.611175	0.0125

R-squared	0.943409	Mean dependent var	16.33170
Adjusted R-squared	0.930987	S.D. dependent var	0.362104
S.E. of regression	0.095126	Akaike info criterion	-1.693329
Sum squared resid	0.371006	Schwarz criterion	-1.314540
Log likelihood	53.17989	Hannan-Quinn criter.	-1.548582
F-statistic	75.94470	Durbin-Watson stat	2.121684
Prob(F-statistic)	0.000000		

Source: Calculations by the authors using EVIEWS 7.1

Table 9. Relationship Between Acres Harvested and Acres Planted, Marketing Year 1960/61 to 2011/12

Dependent Variable: ACRES_HARVESTED_US

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	664199.2	322071.1	2.062275	0.0443
ACRES_PLANTED_US	0.777290	0.023303	33.35553	0.0000

R-squared	0.956170	Mean dependent var	10868449
Adjusted R-squared	0.955311	S.D. dependent var	3467890.
S.E. of regression	733105.9	Akaike info criterion	29.88497
Sum squared resid	2.74E+13	Schwarz criterion	29.95932
Log likelihood	-789.9518	Hannan-Quinn criter.	29.91357
F-statistic	1112.591	Durbin-Watson stat	0.822495
Prob(F-statistic)	0.000000		

Source: Calculations by the authors using EVIEWS 7.1

Table 10. Econometric Analysis of Sorghum Yields in the United States, Marketing Year 1960/61 to 2011/12

Dependent Variable: LOG(YIELD_US)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.767703	0.038469	97.94087	0.0000
LA_NINA	-0.059216	0.028245	-2.096475	0.0420
EL_NINO	0.092099	0.038575	2.387569	0.0214
@TREND	0.021912	0.003814	5.745505	0.0000
@TREND^2	-0.000294	7.91E-05	-3.715398	0.0006
USCP_CROP_IMPROV^.5	2.08E-05	6.73E-05	0.309655	0.7583
D1983	-0.322619	0.099468	-3.243429	0.0023
D1980	-0.253235	0.093740	-2.701467	0.0098
D2002	-0.245599	0.094518	-2.598440	0.0128

R-squared	0.733447	Mean dependent var	4.050904
Adjusted R-squared	0.683856	S.D. dependent var	0.161431
S.E. of regression	0.090768	Akaike info criterion	-1.804920
Sum squared resid	0.354266	Schwarz criterion	-1.467205
Log likelihood	55.92793	Hannan-Quinn criter.	-1.675448
F-statistic	14.78987	Durbin-Watson stat	2.292420
Prob(F-statistic)	0.000000		

Source: Calculations by the authors using EVIEWS 7.1

Table 11. Impact of the USCP on Planted Acres, Harvested Acres, Yields, Farm Prices, and Farm Revenue

IMPACT ON PLANTED ACRES AND HARVESTED ACRES

YEAR	ELASTICITY	PLANTED ACRES	INCREMENTAL PLANTED ACRES	% INCREASE PLANTED ACRES	HARVESTED ACRES	INCREMENTAL HARVESTED ACRES	% INCREASE HARVESTED ACRES
2008/09	0.029606	8,284,000	245,252	2.96	7,271,000	190,632	2.62
2009/10	0.021805	6,633,000	144,633	2.18	5,520,000	112,422	2.04
2010/11	0.024356	5,404,000	131,619	2.44	4,813,000	102,306	2.13
2011/12	0.028287	5,481,000	155,040	2.83	3,929,000	120,511	3.07

IMPACT ON YIELDS

YEAR	ELASTICITY	YIELD BUSHELS/ACRE	INCREMENTAL YIELD BUSHELS/ACRE	% INCREASE YIELD %
2008/09	0.016034	65.0	1.0	1.60
2009/10	0.011809	69.4	0.8	1.18
2010/11	0.013191	71.8	0.9	1.32
2011/12	0.015320	54.6	0.8	1.53

IMPACT ON PRODUCTION

YEAR		PRODUCTION BUSHELS	INCREMENTAL PRODUCTION BUSHELS	% INCREASE PRODUCTION %
2008/09		472,615,000	19,770,316	4.18
2009/10		383,088,000	12,233,841	3.19
2010/11		345,573,400	11,807,148	3.42
2011/12		214,523,400	9,765,588	4.55

Table 11. Continued

IMPACT OF SORGHUM FARM PRICES

YEAR	ELASTICITY	ACTUAL FARM PRICE $/BUSHEL	CHANGE IN FARM PRICE $/BUSHEL	% INCREASE FARM PRICE %	SIMULATED FARM PRICE WITHOUT USCP $/BUSHEL
2008/09	-0.027487	$3.20	-$0.09	-2.75	$3.29
2009/10	-0.020245	$3.22	-$0.07	-2.02	$3.29
2010/11	-0.022613	$5.09	-$0.12	-2.26	$5.21
2011/12	-0.026262	$5.99	-$0.16	-2.63	$6.15

YEAR	WITH USCP IN PLACE FARM REVENUE $	WITHOUT USCP IN PLACE FARM REVENUE $	CHANGE IN FARM REVENUE $	% INCREASE FARM REVENUE %	USCP CROP IMPROVEMENT $	BENEFIT-COST RATIO
2008/09	$1,512,368,000	$1,488,934,133	$23,433,867	1.55	$1,311,670	17.87
2009/10	$1,233,543,360	$1,218,325,483	$15,217,877	1.23	$711,534	21.39
2010/11	$1,758,968,606	$1,737,286,424	$21,682,182	1.23	$887,740	24.42
2011/12	$1,284,995,166	$1,258,710,081	$26,285,085	2.05	$1,197,417	21.95
OVERALL	$5,789,875,132	$5,703,256,120	$86,619,012	1.50	$4,108,362	21.08

YEAR	PRODUCTION WITH USCP IN PLACE BUSHELS	PRODUCTION WITHOUT USCP IN PLACE BUSHELS	INCREMENTAL PRODUCTION DUE TO USCP BUSHELS	% INCREASE PRODUCTION DUE TO USCP %	FARM REVENUE WITH USCP IN PLACE $	FARM REVENUE WITHOUT USCP IN PLACE $	INCREMENTAL FARM REVENUE DUE TO USCP $	% INCREASE FARM REVENUE DUE TO USCP %
2008/09	472,615,000	452,844,684	19,770,316	4.18	$1,512,368,000	$1,488,934,133	$23,433,867	1.55
2009/10	383,088,000	370,854,159	12,233,841	3.19	$1,233,543,360	$1,218,325,483	$15,217,877	1.23
2010/11	345,573,400	333,766,252	11,807,148	3.42	$1,758,968,606	$1,737,286,424	$21,682,182	1.23
2011/12	214,523,400	204,757,812	9,765,588	4.55	$1,284,995,166	$1,258,710,081	$26,285,085	2.05
OVERALL	1,415,799,800	1,362,222,907	53,576,893	3.78	$5,789,875,132	$5,703,256,120	$86,619,012	1.50

KEY POINT:
NO STATISTICALLY SIGNIFICANT CHANGE IN PLANTED ACREAGE/HARVESTED ACREAGE AND IN FARM PRICES HOWEVER

Source: Calculations by the authors.

Table 12. Econometric Analysis of Sorghum Farm Prices, Marketing Year 1960/61 to 2011/12

Dependent Variable: LOG(SORGHUM_FARM_PRICE)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.943036	0.422814	2.230379	0.0329
LOG(CORN_FARM_PRICE)	0.383036	0.087482	4.378469	0.0001
LOG(PRODUCTION_US)	-0.066918	0.019986	-3.348183	0.0021
LOG(SORG_PRICE_NO2_KC)	0.601717	0.080606	7.464871	0.0000
PDL01	-1.91E-05	1.39E-05	-1.370593	0.1800

R-squared	0.989210	Mean dependent var	0.851808
Adjusted R-squared	0.987862	S.D. dependent var	0.305554
S.E. of regression	0.033664	Akaike info criterion	-3.819687
Sum squared resid	0.036264	Schwarz criterion	-3.601995
Log likelihood	75.66421	Hannan-Quinn criter.	-3.742941
F-statistic	733.4598	Durbin-Watson stat	2.218211
Prob(F-statistic)	0.000000		

Lag Distribution of USCP_CROP_IMPROV^.5	i	Coefficient	Std. Error	t-Statistic
* .|	0	-1.4E-05	1.0E-05	-1.37059
* .|	1	-1.9E-05	1.4E-05	-1.37059
* .|	2	-1.4E-05	1.0E-05	-1.37059
	Sum of Lags	-4.8E-05	3.5E-05	-1.37059

Source: Calculations by the authors using EVIEWS 7.1

Demand Analyses Associated with Various Uses of Sorghum

To measure the extent to which USCP programs impact the actual demand for sorghum (either in domestic markets or in international markets), we implement a structural econometric model approach (essentially single-equation regression analysis). We examine specifically end uses for feed, exports, and food and industrial purposes. We do not center any attention on seed use owing to the relatively small size of this sector of the sorghum industry. Empirical findings from previous studies support the hypothesis that market development and promotion expenditures have carryover or lagged effects (Nerlove and Waugh, 1961; Lee and Brown, 1992; Ward and Dixon, 1989; Williams, Capps, and Palma, 2008; and Williams, Capps, and Dang, 2010). However, theory provides relatively little guidance as to the structure and length of these dynamic processes. Whatever the specification used, however, the point is that it may be necessary to account for the time lag between the market development and promotion expenditures and any changes in sorghum use that may occur.

The use of polynomial distributed lags (PDLs) is consistent with the quantitative evaluation of checkoff programs in general (Lee and Brown, 1992; Forker and Ward, 1993; Williams, Capps, and Palma, 2008; Williams, Capps, and Dang, 2010). With the lags in market development Williams, 1999; Williams and Nichols, 1998; Capps, Bessler, and Williams, 2004; Capps and Meyer, 2006; and promotion expenditures of the USCP, we are in position to capture short-run effects, long-run effects, and the average length of time before changes in expenditures made by the USCP affect the level of domestic uses or exports of sorghum.

Regardless of the approach taken, the analysis must measure the shift in the demand attributed the market development and promotion efforts of the USCP. To carry out this task and to avoid confounding of effects, the analysis must account and control for all possible drivers of the demand for sorghum. In this way, the effects of the market development and promotion activities separate from those of any other factor that affects the demand for sorghum can be isolated and measured.

Impacts of USCP Funds Committed to High-Value Markets and Renewables

To analyze the impacts of USCP funds committed to high-value markets and renewables, we focus on end uses of sorghum for feed and for food and industrial applications. In short, we develop separate single-equation econometric specifications for feed use and food and industrial use of sorghum.

Feed Use of Sorghum

The econometric model specification, in essence a derived demand function for feed use of sorghum, is given by equation (6):

$$(6) \quad \log(\text{feed use}_t) = g(\log(\text{sorghum price no2 at Kansas City}_t / \text{corn price no2 at Chicago}_t), \log(\text{number of grain consuming units}_t), \log(\text{feed use}_{t-1}), (\text{USCP\_high\_value\_markets}_t)^{.5}) + v_t$$

This specification is similar to the econometric model for feed use developed by Roy and Ireland (1975). The data associated with this analysis are annual covering market years 1975/76 to 2011/12.

As given in Table 13, the goodness-of-fit associated with the specification in equation (6) is 0.8240. Slightly more than 80 percent of the variability in feed use is accounted for by the model specification. Determinants of feed use were the ratio of sorghum prices (no2) at the Kansas City terminal market to corn prices (no2) at the Chicago terminal market, the number of grain-consuming animal units, and feed use in the previous year. A one percent rise in the ratio of downstream sorghum prices to corn prices led to decreases in feed use of sorghum by 1.32 percent. A one percent rise of grain consuming animal units led to decreases in feed use of sorghum by nearly 1.80 percent. Inertia was evident in feed use owing to the significance of the estimated coefficient of feed use in the previous year.

Funds committed to high-value markets made by the USCP resulted in a statistically significant decline of feed use from 12.7 percent to 15.2 percent, or about 14.6 percent on average over marketing years 2008/2009 to 2011/2012. We employ a square root transformation to account for diminishing marginal returns of USCP expenditures on feed use of sorghum. The use of sorghum for feed use was on the decline prior to the existence of the sorghum checkoff program. Over its limited existence, the efforts made by the USCP were not able to stem this decline in feed use.

Table 13. Derived Demand for Sorghum for Feed Use, 1975/76 to 2011/12

Dependent Variable: LOG(FEED_USE)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.89829	4.521534	2.410309	0.0221
LOG(SORG_PRICE_NO2_KC/CORN_PRICE_NO2_CHIC)	-1.317410	1.103577	-1.193763	0.2416
LOG(GRAIN_CONS_ANIMAL_UNITS)	-1.792013	0.872422	-2.054067	0.0485
USCP_HIGH_VALUE_MARKETS^.5	-0.000307	0.000174	-1.764626	0.0875
LOG(FEED_RESIDUAL_USE(-1))	0.592867	0.156556	3.786936	0.0007

R-squared	0.824023	Mean dependent var	5.726360
Adjusted R-squared	0.801317	S.D. dependent var	0.552135
S.E. of regression	0.246108	Akaike info criterion	0.162153
Sum squared resid	1.877642	Schwarz criterion	0.382086
Log likelihood	2.081249	Hannan-Quinn criter.	0.238915
F-statistic	36.28994	Durbin-Watson stat	2.140400
Prob(F-statistic)	0.000000		

Source: Calculations by the authors using EVIEWS 7.1

Food and Industrial Use of Sorghum

The econometric model specification, in essence a derived demand function for food and industrial use of sorghum is given by the equation:

(7) $\log(\text{food and industrial use}_t) = h(\log(\text{sorghum price in terminal market in Kansas City}_t), \log(\text{corn price in terminal market in Chicago}_t), \log(\text{industrial production index}_t), (\text{USCP\_renewables\_high\_value\_markets}_t)^{.5}) + e_t$

Ethanol can be made from grain sorghum within some technical limitations. Additionally, celiac and gluten intolerance is on the rise. The Center for Celiac Research estimates that approximately 6 percent of the U.S. population (roughly 18 million people) suffers from gluten sensitivity. In 2010, 12 percent of new products are claimed to be "gluten free," up from 1 percent in 2001 (Martinez, 2013). Sales of gluten-free foods have risen from $4.8 billion in 2009 to $6.1 billion in 2011 (SPINS, 2012). The largest increase in health and nutrition-related claims over the period 2001 to 2010 was for "no gluten" (Martinez, 2013). Moreover, sorghum is a viable replacement for corn in pet food. According to the 2011-12 National Pet Owners Survey conducted by the American Pet Products Manufacturers Association (APPMA), 62 percent of U.S. households own a pet. Given the steady historical growth trends in pet food sales, from $17 billion in 1994 to roughly $56 billion in 2013, strong growth in pet food sales is likely to continue (http://www.americanpetproducts.org, accessed June 2013). Finally, many chemicals can be produced from corn, sorghum, and other sugar sources. The global renewable chemicals industry has experienced notable growth over the last five years. This market is forecasted to reach $76 billion in 2015, up from $37 billion in 2009 (Informa Economics, 2013).

As exhibited in Table 14, this econometric relationship accounted for 93 percent of the variation in sorghum use for food and industrial purposes. Prices in downstream markets for sorghum and for corn prices were influential factors for food and industrial uses of sorghum. A one percent increase in sorghum prices (no2) at the Kansas City terminal market gave rise to a 3.37 percent decline in food and industrial use of sorghum. Similarly a one percent increase in corn prices (no2) Chicago terminal market leads to a 2.74 percent increase in food and industrial use of sorghum. Corn, as expected, is a notable substitute for sorghum in food and industrial uses. This result is mainly due to the use of sorghum and corn for ethanol production. The end use of sorghum for food and industrial purposes is very sensitive to changes in corn and sorghum prices at principal terminal markets.

As well, the demand for sorghum in food and industrial uses is quite sensitive to changes in industrial production. The base year for the industrial production index is 2007, and the source of this measure is the Federal Reserve Bank of St. Louis. A one percent rise in the industrial production index led to a 2.34 percent rise in sorghum for food and industrial use, all other factors invariant.

Table 14. Derived Demand for Sorghum in Food and Industrial Uses, 1975/76 to 2011/12

Dependent Variable: LOG(FOOD_IND_USE)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.525841	1.266061	-3.574741	0.0013
LOG(SORG_PRICE_NO2_KC)	-3.374986	1.087454	-3.103567	0.0045
LOG(CORN_PRICE_NO2_CHIC)	2.742816	1.102183	2.488530	0.0193
D1986	-1.306115	0.244411	-5.343927	0.0000
LOG(IND_PROD_INDEX)	2.337846	0.290581	8.045428	0.0000
PDL01	0.000508	0.000104	4.889322	0.0000
AR(1)	0.410644	0.201881	2.034084	0.0519

R-squared	0.931965	Mean dependent var	3.193161
Adjusted R-squared	0.916846	S.D. dependent var	0.782727
S.E. of regression	0.225711	Akaike info criterion	0.042116
Sum squared resid	1.375524	Schwarz criterion	0.356367
Log likelihood	6.284028	Hannan-Quinn criter.	0.149284
F-statistic	61.64224	Durbin-Watson stat	1.812907
Prob(F-statistic)	0.000000		

Inverted AR Roots	.41

Lag Distribution of USCP_RENEW_HIGH_VALUE^.5	i	Coefficient	Std. Error	t-Statistic
. * |	0	0.00038	7.8E-05	4.88932
. * |	1	0.00051	0.00010	4.88932
. * |	2	0.00038	7.8E-05	4.88932
	Sum of Lags	0.00127	0.00026	4.88932

Source: Calculations by the authors using EVIEWS 7.1

Importantly, USCP funds committed to renewables and high-value markets were positively linked to sorghum for food and industrial uses. This impact was not felt all at one time but instead this impact was distributed over a period of two years. The cumulative impact of a one percent increase in USCP funds to renewables and to high-value markets generated a 0.046 percent to 0.048 percent increase in the use of sorghum for food and industrial purposes over the period 2008/09 to 2011/12. This effect unequivocally was not only positive but also statistically significant.

As exhibited in Table 15, this increase in sorghum use translated into 3.88 million to 4.53 million more bushels over the 2008/09 to 2011/12 period. Given prices of sorghum at the Kansas City terminal, the incremental dollars over this period amounted to $76.9 million. The cumulative

amount of expenditures made by the USCP was $4.7 million. But given that the checkoff program is paid for by growers, we need to translate this notable benefit to the farm level.

To that end, as presented in Table 16, we relate the price spread (or marketing margin) relationship between sorghum prices at the terminal market of Kansas City and the farm price of sorghum. Mathematically, this relationship is depicted as follows:

$$(8) \qquad PSorghumKC_t - FarmPriceSorghum_t = s(PSorghumKC_t) + u_t$$

As exhibited in Table 16, this relationship accounted for almost 99 percent of the variation in the price spread. From this specification, we may derive the farm price transmission elasticity which represents the percentage change in sorghum farm prices due to a one percent change in sorghum downstream prices (the prices of sorghum (no2) at the terminal market of Kansas City). This elasticity of price transmission was calculated to be 0.97. So if the price of no2 sorghum at Kansas City increases by 1 percent, farm prices of sorghum increase by 0.97 percent.

This result suggests then to translate the benefits associated with investment in renewables and high-value markets to the farm level, we can implement the ratio of the farm price of sorghum to sorghum no2 prices at Kansas City. On average, this ratio was equal to 0.522, ranging from 0.455 to 0.572 over the time period 1975/76 to 2011/12. Thus, the $76.9 million in additional dollars associated with the investment in renewables and high-value markets is equivalent to a farm value of $40.1 million. Given the investment of slightly more than $4.7 million in funds committed by the USCP, the benefit-cost ratio (BCR) is calculated to be 8.48 to 1.

Table 15. Impact of the USCP on Food and Industrial Use of Sorghum

YEAR	ELASTICITY	FOOD AND INDUSTRIAL USE MILLION BUSHELS	INCREMENTAL FOOD AND INDUSTRIAL USE MILLION BUSHELS	SORGHUM PRICE NO2 KC $/CWT	SORGHUM PRICE NO2 KC $/BUSHEL	INCREMENTAL FOOD AND INDUSTRIAL USE DOLLARS	USCP RENEWABLES AND HIGH VALUE DOLLARS
2008/09	0.048156	94.146	4.534	$5.79	$3.24	$14,700,055	$1,238,219
2009/10	0.046099	89.257	4.115	$5.75	$3.22	$13,249,117	$1,130,466
2010/11	0.045995	84.350	3.880	$11.04	$6.18	$23,985,966	$1,144,296
2011/12	0.046787	84.300	3.944	$11.30	$6.33	$24,958,749	$1,220,955

AT TERMINAL MARKET	$76,893,887	$4,733,935	BCR
AT FARM LEVEL[1]	$40,141,938	$4,733,935	8.48

[1] Multiply the incremental value at the terminal market times the ratio of the farm price of sorghum to sorghum no2 prices at Kansas City.

Source: Calculations by the authors

Table 16. Price Spread Relationship Between Sorghum Prices at the Terminal Market of Kansas City and the Farm Price of Sorghum, 1975/76 to 2011/12

Dependent Variable: SORG_PRICE_NO2_KC-SORG_FARM_PRICE

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.066707	0.029101	-2.292264	0.0286
SORG_PRICE_NO2_KC	0.494771	0.005731	86.33378	0.0000
AR(1)	-0.623244	0.161851	-3.850739	0.0005
AR(2)	-0.651027	0.171663	-3.792469	0.0006

R-squared	0.987922	Mean dependent var	2.405000
Adjusted R-squared	0.986790	S.D. dependent var	1.148673
S.E. of regression	0.132025	Akaike info criterion	-1.107217
Sum squared resid	0.557776	Schwarz criterion	-0.931270
Log likelihood	23.92990	Hannan-Quinn criter.	-1.045807
F-statistic	872.4723	Durbin-Watson stat	1.610072
Prob(F-statistic)	0.000000		

Inverted AR Roots	-.31-.74i	-.31+.74i

Source: Calculations by the authors using EVIEWS 7.1

Exports

Export promotion efforts to expand U.S. sorghum exports have been performed by the U.S. Grains Council (USGC) and by the USCP. It was our understanding that all USCP export promotion activities were carried out by the USGC but not all USGC promotion expenditures came from the USCP. In our analysis, we only use funds committed to exports made by the USCP. Consequently, we acknowledge the possibility of underestimating export promotion expenditures in our analysis. We employ only USCP expenditures due to the lack of available data pertaining to USGC expenditures and the proper vetting of USGC expenditures.

As presented in Figure 21, peaks and valleys are evident in the level of U.S. exports of sorghum. An overwhelming majority of exported sorghum is used in the animal feed sector. In general, in recent years, the level of U.S. exports has been on the decline. Over the period 1975/76 to 2011/12, sorghum exports ranged from a low of 2.3 million metric tons to a high of 8.6 million metric tons. On average over this period, sorghum exports were slightly more than 5.5 million metric tons. Historically, total exports represented 40 percent of sorghum production and for several years this proportion was greater than 50 percent. A combination of factors may explain the recent decline in U.S. exports, including reductions in U.S. production, growth in domestic uses of sorghum, and loss of competitiveness in world markets.

As exhibited in Table 17, world sorghum imports have been shrinking in size over the period 1975/76 to 2011/12 from roughly 12 million metric tons to levels between 5 and 6 million metric

tons. In comparison, world corn imports have nearly doubled over this period. In essence, a substitution away from sorghum to corn has taken place in global markets.

Mexico, Japan, and more recently (although sporadically) the European Union (EU) represent the top destinations for U.S. sorghum exports. Overall, Mexico and Japan account for roughly 75 percent of U.S. exports, Mexico on average at 46 percent market share and Japan on average 28 percent market share over the period 1975/76 to 2011/12. The level of U.S. exports to Mexico from 1975/76 to 2011/12 on average was 2.5 million metric tons, with a low of 0.4 million metric tons to a high of 4.9 million metric tons. The level of U.S. exports to Japan from 1975/76 to 2011/12 on average was 1.6 million metric tons, with a low of 0.1 million metric tons to a high of 4.0 million metric tons. From the 1990s to present, U.S. exports to other countries were relatively small except in 2006/07.

In 2006/07, Mexico and Japan accounted for only 27 percent of U.S. exports; 70 percent of sorghum exports in that year went to the European market. The trends in level of U.S. exports to Mexico, Japan, and the rest of the world (ROW) are exhibited in Figures 22-24, and the corresponding market shares of U.S. exports to theses destinations are exhibited in Figures 25-27. The principal rivals to the United States in terms of sorghum exports are Argentina and Australia.

The United States is the primary sorghum supplier globally. Argentina ranks second behind the United States; however Argentina dominates the South American sorghum markets and competes with the United States in Asian markets (notably Japan) and in the EU. Further, Argentina possesses relatively lower production costs than the United States. Bottom line, Argentina presents the largest competitive threat to U.S. sorghum exports. Australia inconsistently displaces U.S. sorghum exports in Asian markets. Japan is the export destination of choice in years when production in Australia is high. Despite being one of the largest sorghum producers in the world, on-going conflict, lack of infrastructure and subsistence farming ensures that Sudan is not a competitive threat to U.S. exports. Finally Thailand and the Ukraine, while potential regional threats to the United States, are incapable of competing with the United States on a global scale (Bryant Christie, Inc., 2013).

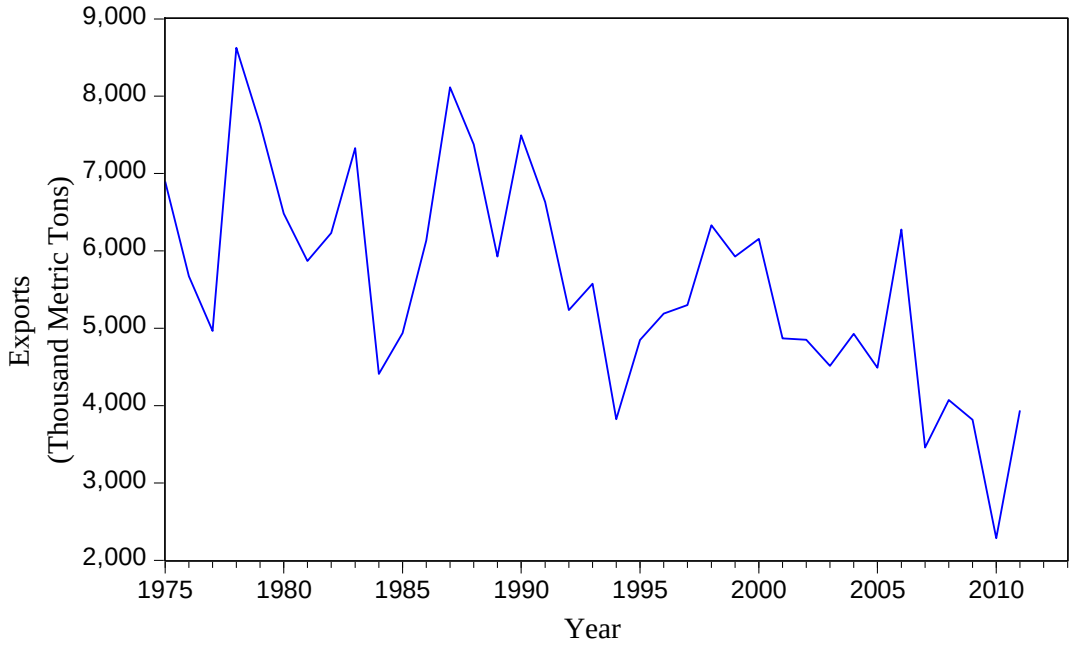
Any effort to expand U.S. sorghum exports should include separate analyses by markets. To that end, we provide econometric analyses for total U.S. exports, U.S. exports to Mexico, U.S. exports to Japan, and U.S. exports to ROW. Annual data from 1975/76 to 2011/12 were used in these respective analyses.

Table 17. Total World Corn and Sorghum Imports, 1975/76 to 2011/12 in Thousand Metric Tons

Marketing Year	World Corn Imports	World Sorghum Imports
1975/76	53,189	11,663
1976/77	56,426	11,375
1977/78	64,340	9,985
1978/79	71,716	11,418
1979/80	78,766	14,015
1980/81	64,951	13,808
1981/82	64,080	11,495
1982/83	61,006	12,393
1983/84	66,059	12,760
1984/85	53,481	8,716
1985/86	54,364	7,857
1986/87	57,009	8,342
1987/88	66,130	10,197
1988/89	77,968	9,397
1989/90	58,282	7,898
1990/91	61,888	9,278
1991/92	62,716	9,135
1992/93	56,757	6,709
1993/94	68,498	6,409
1994/95	66,139	6,686
1995/96	65,760	6,414
1996/97	62,901	6,980
1997/98	66,253	6,342
1998/99	71,764	8,521
1999/2000	75,100	7,342
2000/01	71,849	7,216
2001/02	75,946	5,715
2002/03	76,920	6,539
2003/04	76,175	5,403
2004/05	78,868	5,378
2005/06	90,340	5,464
2006/07	99,976	9,773
2007/08	82,405	6,112
2008/09	90,232	6,674
2009/10	91,052	6,752
2010/11	101,079	6,530
2011/12	96,120	6,477

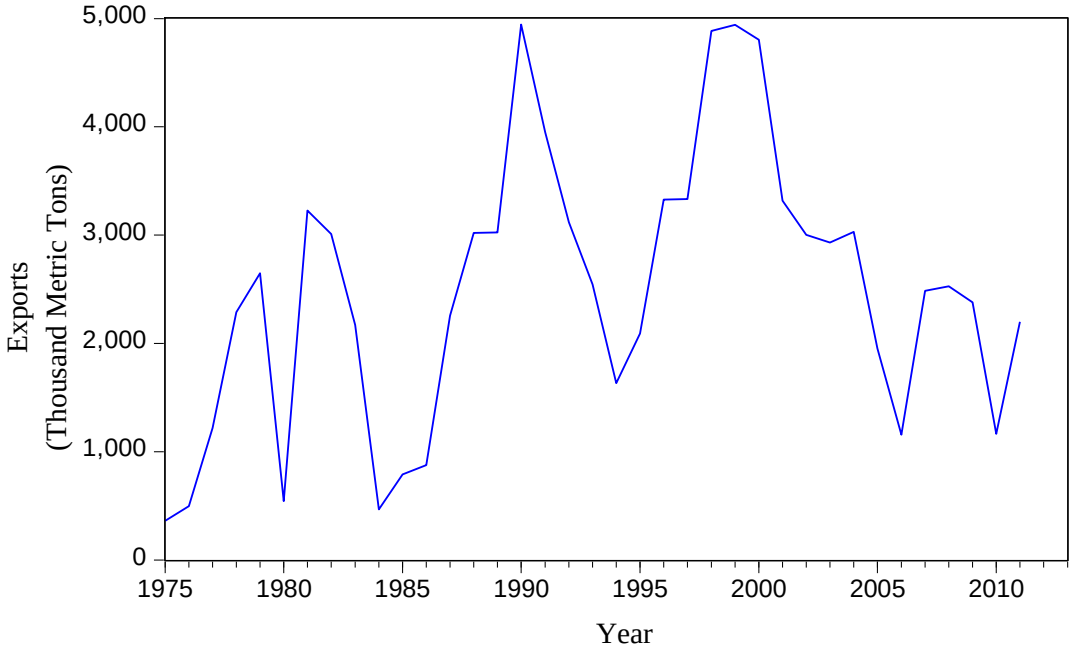
Source: U.S. Department of Agriculture

Figure 21. U.S. Exports of Sorghum, 1975/76 to 2011/12



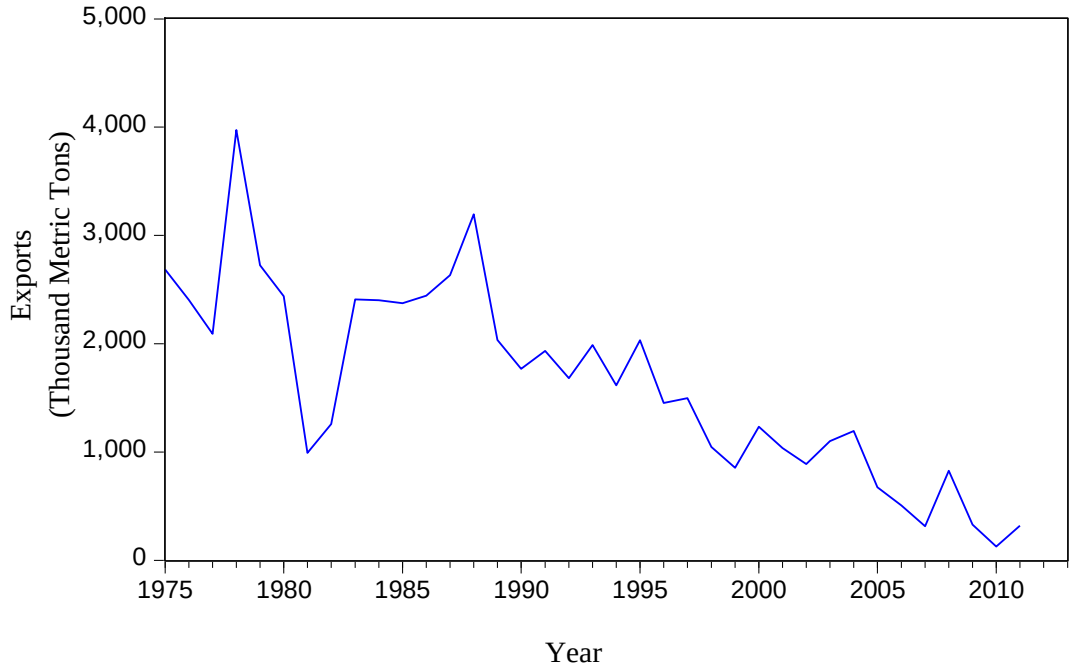
Source: U.S. Department of Agriculture

Figure 22. U.S. Exports of Sorghum to Mexico, 1975/76 to 2011/12



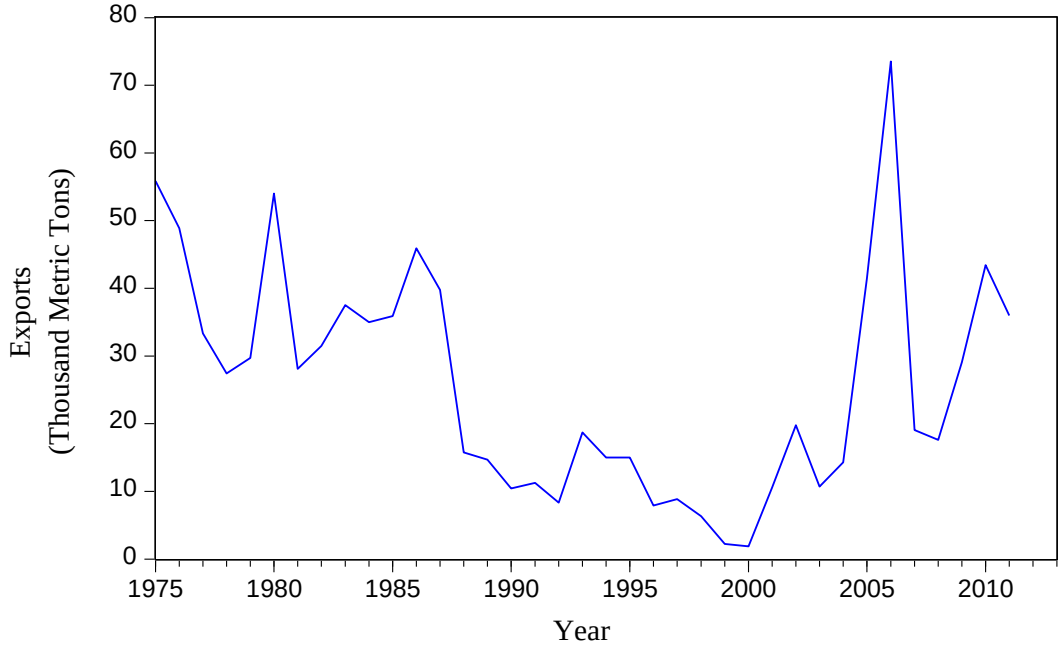
Source: U.S. Department of Agriculture

Figure 23. U.S. Exports of Sorghum to Japan, 1975/76 to 2011/12



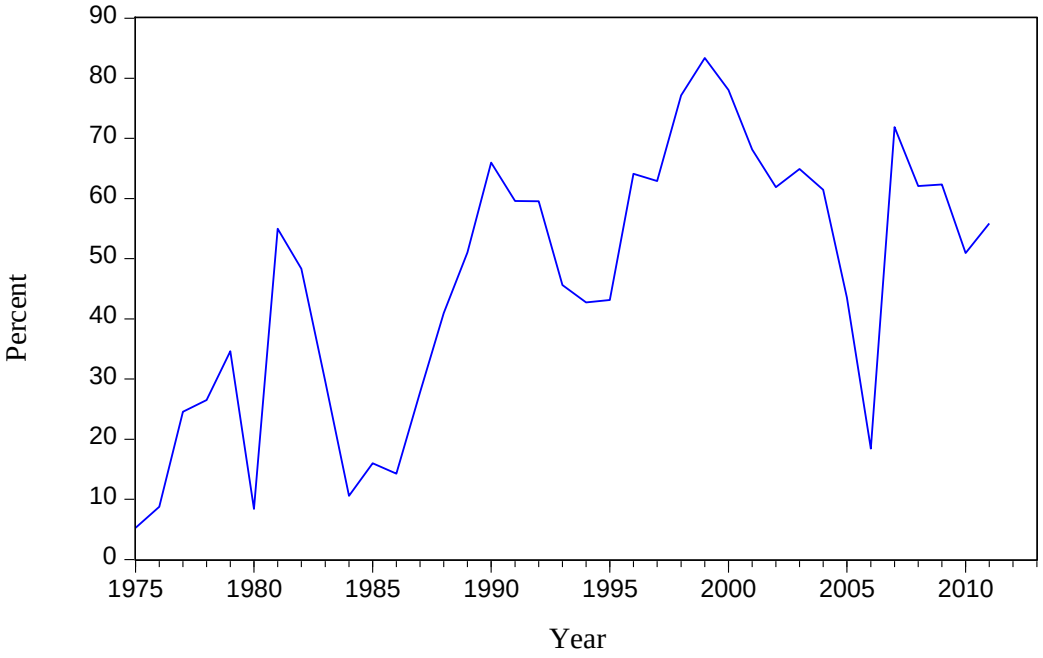
Source: U.S. Department of Agriculture

Figure 24. U.S. Exports of Sorghum to the Rest of the World, 1975/76 to 2011/12



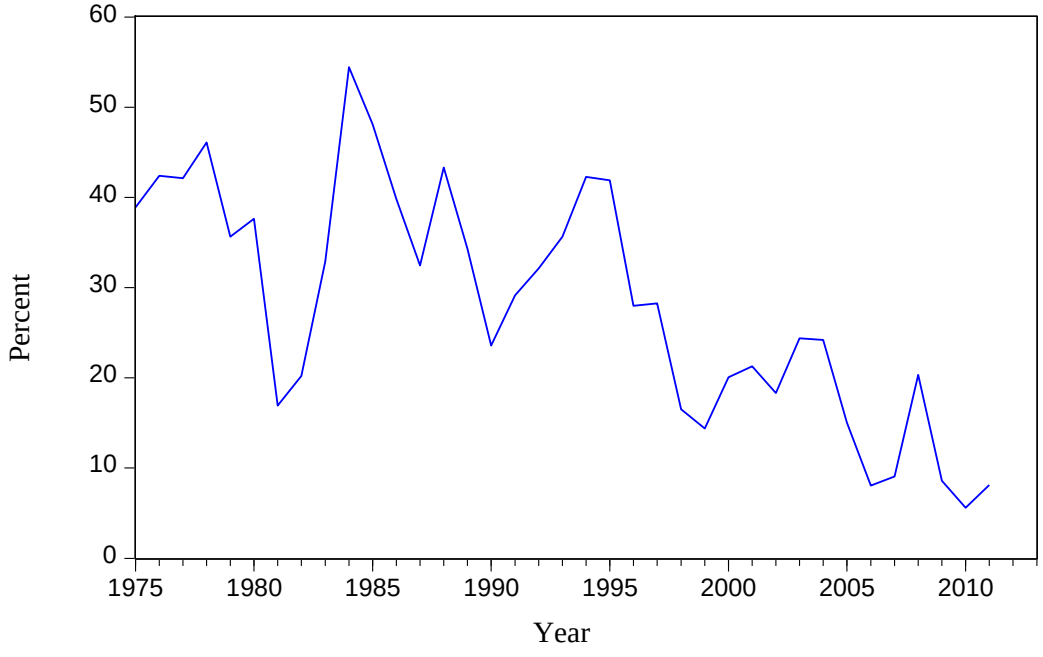
Source: U.S. Department of Agriculture

Figure 25. Share of U.S. Exports to Mexico, 1975/76 to 2011/12



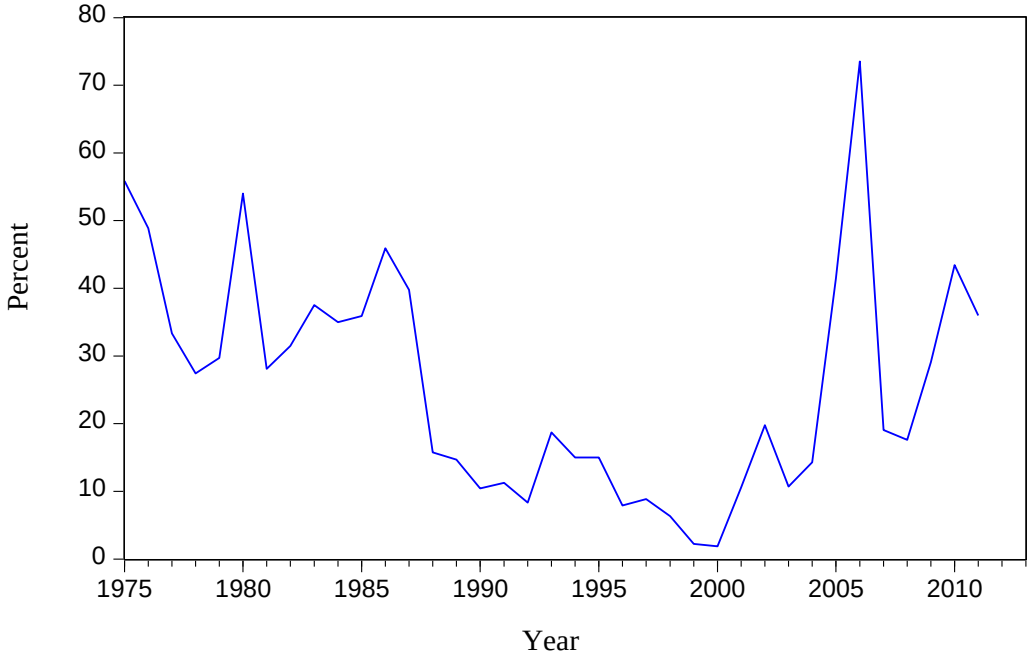
Source: Calculations by the authors.

Figure 26. Share of U.S. Exports to Japan, 1975/76 to 2011/12



Source: Calculations by the authors.

Figure 27. Share of U.S. Exports to the Rest of the World, 1975/76 to 2011/12



Source: Calculations by the authors.

Total U.S. Exports of Sorghum

The econometric specification for total U.S. exports includes as drivers the U.S. export price of sorghum relative to the export price of Argentina, non-U.S. world sorghum production in the previous year, total U.S. exports in the previous year and funds committed by USCP for exports. The level of funds committed by the USCP for exports ranged from $228,000 in 2009/10 to $410,000 in 2010/11. In essence, the levels of expenditures made by USCP are relatively small in comparison to investments made in crop improvement activities, high-value markets, and renewables.

As presented in Table 18, the econometric model accounts for roughly 77 percent of the variation in total U.S. exports of sorghum. A one percent change in the U.S. sorghum export price relative to the sorghum export price in Argentina gave rise to a modest 0.27 percent change in the level of exports in the opposite direction. Hence, price sensitivity is not a major issue in the aggregate of U.S. exports. A one percent change in non-U.S. world sorghum production in the previous year led to a 0.82 percent change in aggregate U.S. exports of sorghum in the opposite direction. Inertia also was present in total U.S. exports of sorghum as evident by the significance of the coefficient associated with level of U.S. exports of sorghum in the previous year.

Importantly, funds committed by the USCP to exports did not generate increases in aggregate U.S. exports. Holding other factors constant, a one percent increase in funding commitments to exports resulted in a 0.144 percent decline on average in U.S. exports. Over the period 2008/09 to 2011/12, this decline ranged from a low of 0.121 percent to a high of 0.162 percent. This result is due to the use of the square root transformation to depict declining marginal returns to USCP funding levels for exports. Importantly, this result is statistically significant.

Table 18. Econometric Analysis of Total U.S. Exports of Sorghum, 1975/76 to 2011/12

Dependent Variable: LOG(US_EXPORTS_TOTAL)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	14.93376	2.211869	6.751645	0.0000
LOG(US_SORG_EXPORT_PRICE/ARG_SORG_EXPORT_PRICE)	-0.265839	0.123329	-2.155536	0.0399
LOG(US_EXPORTS_TOTAL(-1))	0.293820	0.130458	2.252222	0.0323
USCP_EXPORTS^.5	-0.000505	0.000192	-2.629080	0.0137
D1978	0.507372	0.145981	3.475612	0.0017
D1994	-0.374113	0.143487	-2.607301	0.0145
LOG(NON_US_WORLD_SORG_PROD(-1))	-0.822209	0.167440	-4.910464	0.0000

R-squared	0.771101	Mean dependent var	8.596972
Adjusted R-squared	0.722051	S.D. dependent var	0.267507
S.E. of regression	0.141032	Akaike info criterion	-0.902807
Sum squared resid	0.556919	Schwarz criterion	-0.591737
Log likelihood	22.79912	Hannan-Quinn criter.	-0.795425
F-statistic	15.72080	Durbin-Watson stat	2.499515
Prob(F-statistic)	0.000000		

Source: Calculations by the authors using EVIEWS7.1

U.S. Exports of Sorghum to Mexico

Given the NAFTA connection and its proximity to the United States, Mexico is almost a captive market for U.S. sorghum exports. As well, Mexico is the major market of U.S. sorghum in part because its feeding industry is accustomed to sorghum and its corn imports have been limited by policies of the Mexican government (Hoffman et al, 2007). Previous studies on Mexican import demand for sorghum (Liu, 2010; Duch-Carvallo and Malaga, 2010) found that the demand for U.S. exports of sorghum to Mexico was related to the ratio of sorghum prices to corn prices in Mexico (termed the MX_Price_Ratio), as well as production associated with the poultry industry. Other factors may include the gross national income of Mexico (expressed in U.S. dollars to reflect exchange rates), NAFTA, and inertia of U.S. exports to Mexico.

As presented in Table 19, the econometric specification accounts for nearly 75 percent of the variation in U.S. exports of sorghum to Mexico. In disagreement with the aforementioned previous studies, no significance of poultry production in Mexico to U.S. exports to Mexico was found. As well, Mexican imports of sorghum from the United States were not found to be linked to the U.S. price of sorghum exports. Although the respective coefficients associated with NAFTA and the gross national income of Mexico (MX-RIDF) were positive as expected, no statistically significant relationships were evident. The principal factors affecting U.S. exports of sorghum to Mexico were exports made in the previous year and the ratio of sorghum prices to corn prices in Mexico. A one percent change in this ratio led to a one percent change in the level of U.S. exports to Mexico in the opposite direction.

Table 19. Econometric Analysis of U.S. Exports of Sorghum to Mexico, 1975/76 to 2011/12

Dependent Variable: LOG(US_EXPORTS_MX)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.026967	13.68178	-0.440510	0.6629
LOG(US_EXPORTS_MX(-1))	0.384523	0.121375	3.168049	0.0037
USCP_EXPORTS^.5	-0.000536	0.000459	-1.166281	0.2533
LOG(MX_PRICE_RATIO)	-1.001998	0.386475	-2.592659	0.0150
NAFTA	0.184015	0.226382	0.812854	0.4232
D1984	-1.654602	0.368031	-4.495826	0.0001
D1980	-1.672903	0.372705	-4.488547	0.0001
LOG(MX_PCIDF)	0.391619	0.529467	0.739647	0.4657

R-squared	0.747828	Mean dependent var	7.685641
Adjusted R-squared	0.684785	S.D. dependent var	0.634901
S.E. of regression	0.356459	Akaike info criterion	0.967933
Sum squared resid	3.557758	Schwarz criterion	1.319826
Log likelihood	-9.422796	Hannan-Quinn criter.	1.090753
F-statistic	11.86219	Durbin-Watson stat	1.959875
Prob(F-statistic)	0.000001		

Source: Calculations by the authors using EVIEWS7.1

The impact of funds committed to U.S. exports of sorghum was negative but not significantly different from zero. Because no breakdown of USCP export expenditures by country was available, the total amount of funds committed was used in the econometric analysis. A one percent increase in USCP funds for exports generated on average a 0.153 percent decrease in U.S. exports of Mexico. Over the period 2008/09 to 2011/12, this impact ranged from a decline of 0.128 percent to a decline of 0.172 percent. We capture this relationship through the use of the square root transformation associated with USCP export expenditures. Bottom line, the efforts made by the USCP were not sufficient to stem the decline in Mexican imports of sorghum. The substitution of sorghum to corn and advances in Mexican sorghum production provide major barriers in this export market.

U.S. Exports of Sorghum to Japan

Japan had been the top market for U.S. sorghum exports until 1981. In Japan, the arrival of new sorghum exporters, mainly Australia and Argentina, may make the re-establishment of Japan as a major U.S. export market difficult (Bryant Christie, Inc., 2013).

As exhibited in Table 20, the econometric model accounts for nearly 85 percent of the variation in U.S. exports of sorghum to Japan. Key determinants include inertia in exports to Japan, the gross national income of Japan, U.S. sorghum export prices relative to sorghum export prices in Australia, and non-U.S. world sorghum production in the previous year. A one percent increase in the gross national income of Japan led to a 1.44 percent decline in the level of U.S. exports to Japan. A one percent increase in the ratio of the U.S. sorghum export price relative to the sorghum export price in Australia led to a -0.55 percent decline in the level of U.S. exports of sorghum to Japan. Further, a one percent increase in non-U.S. world sorghum production in the previous year resulted in a 1.39 percent decrease in the level of U.S. sorghum exports to Japan.

Importantly, similar to the case of U.S. exports to Mexico, the impact of funds committed by the USCP to enhance exports to Japan was negative and not significantly different from zero. For Japan, however, the impact of USCP funds committed to exports was not felt all at once but instead distributed over a three-year time frame. Nevertheless, USCP funds committed to exports was not effective in stemming the decline of U.S. exports of sorghum to Japan. In fact, a one percent increase in USCP funding resulted in a decline of U.S. exports to Japan on the order of 0.33 percent. Over the period 2008/09 to 2011/12, this impact ranged from a decline of 0.28 percent to a decline of 0.37 percent.

Table 20. Econometric Analysis of U.S. Exports of Sorghum to Japan, 1975/76 to 2011/12

Dependent Variable: LOG(US_EXPORTS_JP)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	61.35986	13.23515	4.636127	0.0001
LOG(US_EXPORTS_JP(-1))	0.380477	0.152114	2.501272	0.0187
LOG(JP_PCIDF)	-1.447566	0.387403	-3.736585	0.0009
D1981	-0.810992	0.391164	-2.073283	0.0478
LOG(US_SORG_EXPORT_PRICE/AUS_SORG_EXPORT_PRICE)	-0.546223	0.330434	-1.653047	0.1099
LOG(NON_US_WORLD_SORG_PROD(-1))	-1.394508	0.484202	-2.880014	0.0077
PDL01	-0.000291	0.000186	-1.561915	0.1300

R-squared	0.837034	Mean dependent var	7.137258
Adjusted R-squared	0.800819	S.D. dependent var	0.764306
S.E. of regression	0.341107	Akaike info criterion	0.868003
Sum squared resid	3.141566	Schwarz criterion	1.182253
Log likelihood	-7.756043	Hannan-Quinn criter.	0.975171
F-statistic	23.11310	Durbin-Watson stat	1.976464
Prob(F-statistic)	0.000000		

Lag Distribution of USCP_EXPORTS^.5	i	Coefficient	Std. Error	t-Statistic
* . |	0	-0.00023	0.00015	-1.56191
* . |	1	-0.00035	0.00022	-1.56191
* . |	2	-0.00035	0.00022	-1.56191
* . |	3	-0.00023	0.00015	-1.56191
Sum of Lags		-0.00116	0.00075	-1.56191

Source: Calculations by the authors using EVIEWS 7.1

U.S. Exports of Sorghum to ROW

The rest of the world (ROW) market includes the European Union, Morocco, Saudi Arabia, and Sub-Saharan Africa. The European Union (EU) is the most erratic of the aforementioned markets. For certain years, namely 2006/07 and 2007/08, the EU absorbed 25 percent and 60 percent of U.S. exports of sorghum (Kustudija, 2012). For other years, the level of U.S. exports to the EU was almost negligible. U.S. sorghum exports to Morocco also have been erratic with notable shipments occurring only in 2009/10 and 2010/11; as well, notable shipments to Saudi Arabia occurred only in 2008/09 (Bryant Christie, Inc., 2013). These countries may have future potential but currently are facing infrastructural issues and policy issues which lead to difficulties for the expansion of U.S. exports of sorghum (Bryant Christie, Inc., 2013).

As presented in Table 21, key drivers of sorghum exports to the ROW include inertia in export levels, U.S. exports to Mexico, and non-U.S. world sorghum production in the previous year. The econometric model accounts for 75 percent of the variation in U.S. exports of sorghum to the ROW. In particular, a one percent rise in non-U.S. world production of sorghum in the previous year led to a 1.19 percent fall in the level of U.S. exports of sorghum to the ROW. Additionally, a one percent rise in U.S. exports of sorghum to Mexico led to a 0.37 percent fall in the level of U.S. exports of sorghum to the ROW.

Unlike the situation for Mexico and Japan, the impact of funds committed to exports was positive, but this result was not significantly different from zero for the ROW. On average, a one percent increase in USCP funding generated a 0.066 percent rise on average for U.S. exports to the ROW. This impact over the period 2008/09 to 2011/12 ranged from a 0.055 percent increase to a 0.074 percent increase in ROW exports.

Table 21. Econometric Analysis of U.S. Exports of Sorghum to ROW, 1975/76 to 2011/12

Dependent Variable: LOG(US_EXPORTS_ROW)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	18.60954	6.635822	2.804407	0.0089
LOG(US_EXPORTS_MX)	-0.369535	0.156545	-2.360571	0.0252
LOG(US_EXPORTS_ROW(-1))	0.569520	0.116965	4.869163	0.0000
LOG(NON_US_WORLD_SORG_PROD(-1))	-1.192860	0.582450	-2.048006	0.0497
D1999	-1.182262	0.492802	-2.399060	0.0231
D2007	-0.932135	0.547386	-1.702885	0.0993
USCP_EXPORTS^.5	0.000231	0.000450	0.513642	0.6114

R-squared	0.748318	Mean dependent var	6.935302
Adjusted R-squared	0.696245	S.D. dependent var	0.851359
S.E. of regression	0.469218	Akaike info criterion	1.497166
Sum squared resid	6.384792	Schwarz criterion	1.805072
Log likelihood	-19.94899	Hannan-Quinn criter.	1.604634
F-statistic	14.37076	Durbin-Watson stat	1.744544
Prob(F-statistic)	0.000000		

Source: Calculations by the authors using EVIEWS 7.1

CONCLUDING REMARKS

This report provides the independent evaluation of the effectiveness of the United Sorghum Checkoff Program (USCP). The USCP was only recently established in 2008, with the promise of investing producer dollars to increase profitability for the sorghum industry. Hence the overall objective is to enable the USCP Board of Directors to obtain meaningful and reliable evaluations of the impacts of its activities on the sorghum industry. In particular, the purpose of this report is to provide the USCP with information as to the actions/strategies needed to improve producer profitability via demand and productivity opportunities. The key findings in regard to this evaluation include:

- Revenue from assessments ranged from $6.6 million in 2009/2010 to $8.8 million in 2010/2011. Total expenses ranged from $6.2 million in 2009/2010 to $6.7 million in 2010/2011.

- Compared to the farm value of sorghum, on the order of $1.08 billion to $1.47 billion from 2008/2009 to 2011/2012, the amount of funds collected from the checkoff is extremely small. The ratio of revenue from assessments to farm value of production often referred to as the investment-intensity ratio, was on average 0.62 percent.

- The share of research expenses to total expenses was in the interval of 21 percent to 26 percent over the period 2008/2009 to 2011/2012. The share of information, communication, and education activities in relation to total expenditures was on the order of 9 percent to 17 percent. The share of market development expenses to total expenses varied from 10 percent to 18 percent.

- The share of administration expenses in relation to total expenses was in the interval of 7 percent to 10 percent. The share of total expenses for USDA oversight varied from 2.1 percent to 3.6 percent.

- From marketing years 1960 to 2012, a notable decline in acres planted of sorghum, acres harvested of sorghum, and sorghum production was evident. Over the same period, sorghum yields rose modestly from roughly 56 bushels per acre to 64 bushels per acre.

- From marketing years 1975 to 2012, feed use of sorghum and exports of sorghum were on the decline; but, food and industrial applications of sorghum were on the rise.

- Funds committed to crop improvement activities made by the USCP were positively and contemporaneously related to acres planted of sorghum. A one percent change in funds committed to crop improvement activities translated into a 0.026 percent change on average in the number of acres planted of sorghum. Put another way, as a result of the checkoff program, planted acreage rose 2.18 percent to 2.96 percent and harvested acreage rose 2.04 percent to 3.07 percent over the 2008/2009 to 2011/2012 period. However, despite the gains in planted and harvested acreage attributed to the USCP, these gains were not statistically different from zero.

- Funds committed by the USCP to crop improvement activities enhanced sorghum yields. A one percent change in funds committed resulted in a 0.012 percent to 0.016 percent change in sorghum yields. However, similar to the situation for acreage, this gain in yields was not significantly different from zero in statistical parlance.

- Due to the fact that sorghum production is the product of harvested acreage and yield, the efforts of the USCP led to increases in production of 3.19 percent to 4.55 percent. Consequently, funds committed by the USCP to crop improvement activities generated increases in sorghum production of roughly 9.7 million to 19.8 million bushels over marketing years 2008/2009 to 2011/2012.

- A one percent change in expenditures geared to crop improvement activities generated a 2.0 percent to 2.8 percent change in sorghum farm prices in the opposite direction. As a result of the effort made by USCP in crop improvement activities, sorghum farm prices dropped 7 cents per bushel to 16 cents per bushel over the marketing years 2008/2009 to 2011/2012. Importantly, this change in sorghum farm prices also was not statistically different from zero.

- Funds committed by the USCP to crop improvement activities generated a 1.50 percent increase in farm revenue on average. This figure rests on the changes in harvested acres and yields (and hence production) as well as the changes in farm prices attributed to the checkoff. All of these aforementioned changes however were not significantly different from zero.

- Bottom line, efforts made by the USCP in committing funds to crop improvement activities were positive in enhancing overall farm revenue; but efforts in this regard need to be continued going forward in order to bring about statistically significant increases in farm revenue. Hence, over a period of five years since its existence, the USCP is on the right track in its efforts to expand farm revenue through its investment in crop improvement activities.

- Funds committed to high-value markets made by the USCP were not able to stem the decline in domestic feed use of sorghum. Put another way, the efforts of the USCP were not successful in abating the downward trend in sorghum feed use domestically.

- Funds committed to renewables and high-value markets were positively linked to sorghum for food and industrial uses. This impact was not felt at one time but instead this impact was distributed over a period of two years. The cumulative impact of a one percent change in USCP funds to renewables and to high-value markets generated a 0.046 percent to 0.048 percent increase in the use of sorghum for food and industrial purposes over the period 2008/2009 to 2011/2012. This investment of $4.7 million in funds committed by the USCP in renewables and high-value markets generated a farm value of $40.1 million, a benefit-cost ratio or return-on-investment of 8.48 to 1.

- Efforts by the USCP to increase sorghum exports in total, to Mexico, and to Japan, were not successful. That is, increases in funds committed to exports were ineffective in stemming the decline in exports. The only exception was for exports to the rest of the world, but this result was not significantly different from zero.

- The general non-significance of the impact of USCP funding on exports may be due to several factors. First, the USCP has existed only for four years. Second, the level of funding used in the econometric analysis may be understated. Third, other factors such as the worldwide substitution of corn over sorghum are not easily overturned by export promotion. Fourth, sorghum production is growing faster than sorghum consumption in Mexico, the largest U.S. export market. Finally, the United States is facing strong competition for sorghum in global markets, particularly from Australia (higher quality) and Argentina (lower prices).

RECOMMENDATIONS

Going forward, to continue to evaluate the effectiveness of the sorghum checkoff program, several recommendations are made:

- It is imperative for the USCP to maintain quality records in funds committed to various activities. A substantial amount of time in this project was devoted to insuring an accurate depiction of the amounts of expenditures committed to various activities, namely crop improvement, high-value markets, renewables, and exports. In particular, record keeping in each of these activities needs to appropriately document the amount of funds committed to feed use, food use, pet use, exports by destination, ethanol production, etc. Without this discipline, efforts to effectively evaluate the performance of the USCP are greatly hampered.

- In the same vein, it is necessary to capture efforts made by state programs as well as to retrieve historical data prior to the existence of the sorghum checkoff program. Efforts were made to retrieve data from state programs before and after the existence of the USCP. However, in most instances, we were not successful in obtaining these data. Consequently, it is likely that we have understated to a degree the funds committed to the sorghum checkoff.

- With limited resources, funds are to be allocated on the basis of the highest and best uses for sorghum. To that end, we recommend increases in funds committed to enhancing the demand for sorghum in food and industrial uses (essentially high-value markets and renewables). Opportunities not only exist in the use of sorghum for ethanol production but also for gluten-free products, pet foods, and renewable chemicals. These uses unequivocally are growth areas in the near to intermediate future. Further, efforts should focus on the visibility of sorghum not only as a healthy choice for cooking and baking but also as a gluten-free nutritious grain.

- We recommend as well increases in funds committed to crop improvement activities. In particular, we recommend a focus on research activities aimed at increasing sorghum yields. In order to compete with corn, sorghum needs higher yields, additional nutrient value, and/or lower costs of production (Informa Economics, 2013). Water demands of sorghum also are less than those of corn, cotton, and rice. Attention should be centered on sorghum as a naturally drought-tolerant, input-efficient crop.

- We recommend funds committed to domestic feed use to focus on improvement in the quality of sorghum as a feed grain so as to better compete with corn. In addition, we recommend the promotion of non-genetically modified (non-GMO) sorghum for livestock feeding. The substitution of corn for sorghum for feed use indeed is a difficult obstacle at present.

- We recommend the commitment of funds in export markets to focus on two priorities: (1) maintaining market share and export volume in Mexico; and (2) recapturing market share in Japan. Differentiating U.S. sorghum from other competitive coarse grains and from sorghum supplies from other regions is critical to building long-term demand for U.S. sorghum. The USCP should undertake opportunities to differentiate U.S. sorghum from other origins, notably Argentina.

- With no change in the budget of the USCP, we recommend a reallocation of funds away from domestic feed use and in export markets toward food and industrial uses and crop improvement activities.

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