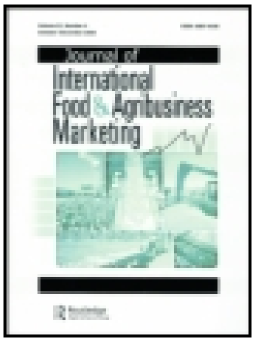

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Generic Promotion of Sorghum for Food and Industrial Uses

Gary W. Williams and Oral Capps, Jr.

Department of Agricultural Economics, Food and Consumer Economics Research Center, Texas A&M University, College Station, Texas, USA

ABSTRACT
Globally, over half of all sorghum is used for human consumption. Yet sorghum is largely unknown as a food in the United States and other developed countries. Recently, the U.S. demand for sorghum as a gluten-free, non-GMO input to food products has been growing. At the same time, the use of sorghum for food and industrial uses is being promoted by the producer-financed United Sorghum Checkoff Program (USCP). How much of that growth can be attributed to the USCP promotion? Has the investment been profitable for sorghum producers? This study finds that USCP promotion programs have resulted in a 4% increase in the sales value of sorghum for that purpose and a 1% increase in total sorghum farm revenue. The farm level benefit-cost ratio is estimated at between 5.8 and 7.1 in terms of producer profit per dollar spent on promotion.

KEYWORDS
Sorghum; generic advertising and promotion; food demand; checkoff program; benefit-cost analysis

Introduction

Known primarily as a feed grain for livestock in most developed counties, sorghum is an important staple food across much of Africa, Asia, and Latin America. Sorghum is an ingredient in a variety of foods in these regions of the world from tortillas to breads, cakes, biscuits, noodles and pasta, porridges, and a wide variety of breakfast and snack food items (Ratnavathi & Patil, 2013). Sorghum is also used in fermented and unfermented beverages and can be steamed, popped, flaked or consumed as a whole grain. Sorghum sirup, produced from the stalks of the sorghum plant, is used in many areas of the world as an alternative sweetener to produce whiskey and rum type products.

Globally, over half of all sorghum produced each year is used for human consumption (Beta & Isaak, 2016). In contrast, sorghum has been largely unknown as a food product in the United States and most other developed

CONTACT Gary W. Williams gwwilliams@tamu.edu Department of Agricultural Economics, Agribusiness, Food and Consumer Economics Research Center, Texas A&M University, 600 John Kimbrough Blvd, Suite 371, College Station, Texas 77843-2124, USA.
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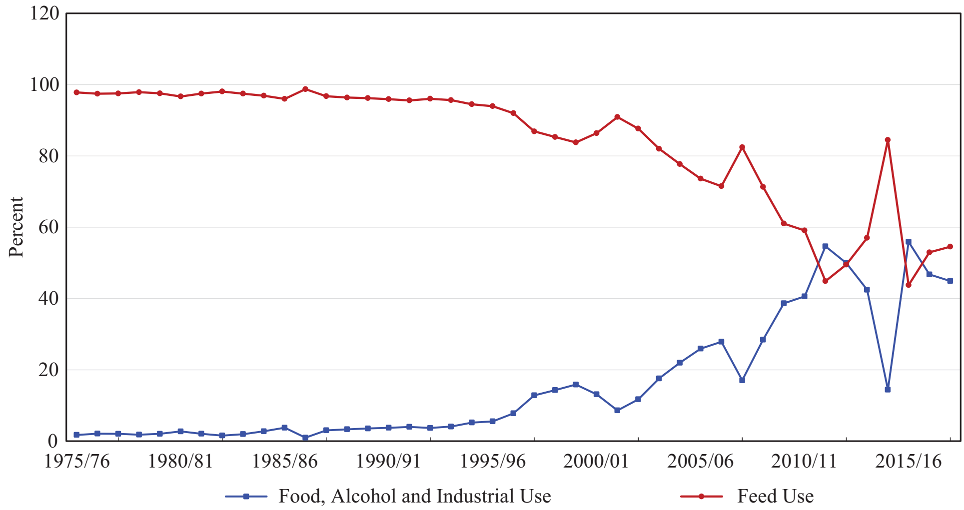

Figure 1. Shares of domestic use of sorghum by category of use, 2008/09–2015/16.

countries. In recent years, however, sorghum has been gaining ground in the United States as a gluten-free, non-GMO input to food products traditionally made with wheat and other grains. Sorghum is known to be an excellent source of energy with about 75% complex carbohydrates and a good source of iron, zinc, and B complex vitamins (USCP, 2018a). Sorghum was named the new "It" grain and number 5 on its list of the top 13 "food trends' for 2017 by the James Beard Foundation (JBF Editors, 2016). Sorghum is also used by U.S. agribusinesses as an input into the production of a variety of consumer goods including, ethanol, pet foods, insulation, cat litter, and more. Sorghum now can be found in more than 350 product lines in the United States (USCP, 2018b).

The utilization of sorghum as a food product or for other non-feed (industrial[1]) uses accounted for only one to two percent of the total U.S. domestic use of sorghum in the 1970s (Figure 1). Feed use accounted for 97–98% of U.S. domestic sorghum use in those years. Over time, however, the share of sorghum going into food and industrial products in the United States has grown steadily to 47% of domestic use in 2016/17 while feed use dropped to 53% over the same period.

Growth in the use of sorghum in the United States, including food use, has been promoted by the producer-financed United Sorghum Checkoff Program (USCP) since its establishment in 2008. How much of the growth of the food and industrial use of sorghum in the United States can be attributed to the generic promotional efforts of the USCP? Has the investment been profitable for sorghum producers? This article addresses these questions. Following a brief background discussion of sorghum promotion for food and industrial use in the United States, the methodology used in

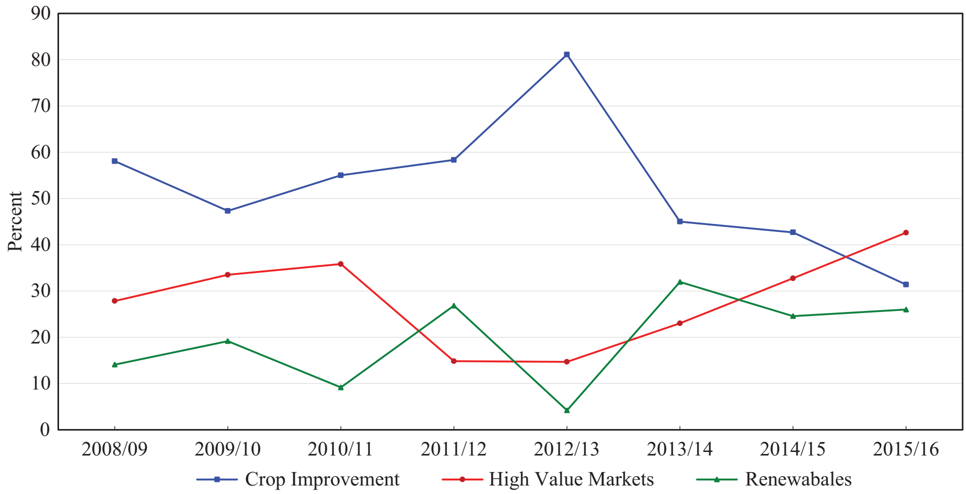

Figure 2. Shares of the USCP domestic promotion expenditures by category of expenditure, 2008/09–2015/16.

this study to determine the effectiveness of the USCP in promoting the food use of sorghum is discussed. The results of the analysis based on the methodology described are then examined followed by summary comments and conclusions.

Background

The USCP is a mandatory U.S. generic promotion program created in 2008 by the Sorghum Promotion, Research, and Information Order under authority of the Commodity Promotion, Research, and Information Act of 1996. The USCP is funded by assessments that all sorghum producers must pay on their sales of sorghum. The current assessment is 0.6% of the net market sales value of grain sorghum and 0.35% of the net market sales value of sorghum forage, silage, hay, haylage, and billets. All imports of such products also are assessed, although currently imports are very limited.

Sorghum food demand promotion

Like many such generic commodity promotion programs (see Williams, Capps, & Hanselka, 2018), the USCP promotes the demand for sorghum downstream in wholesale and retail markets under the assumption that sufficient benefits will migrate upstream to the producers who paid for the promotion to more than cover their collective investment in the generic promotion activities funded. Thus, the goal of the program is to maintain and expand U.S. sorghum markets to enhance the profitability of U.S.

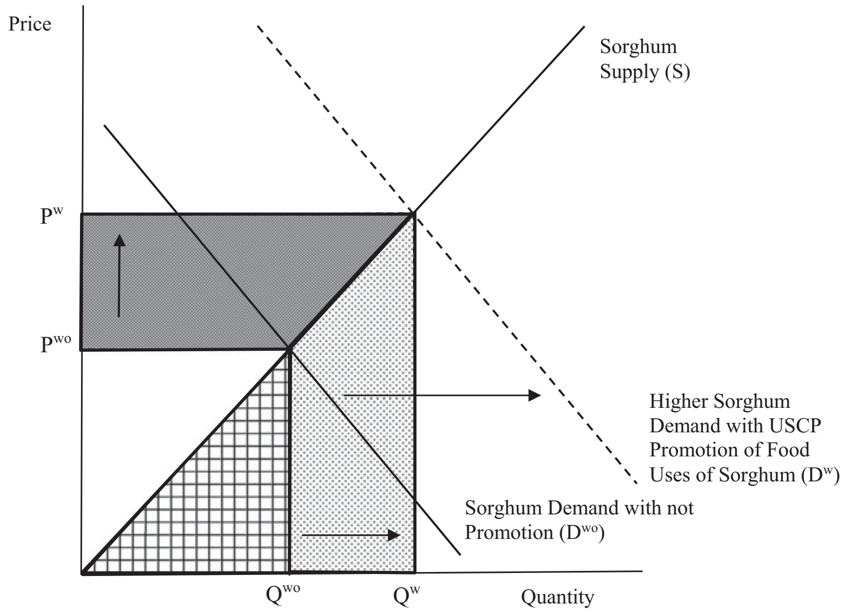

Figure 3. Effects of USCP promotion on the demand for sorghum for food and industrial uses.

sorghum producers. The USCP promotion programs began just as sorghum started to gain popularity in food products in the United States because of its gluten-free food and non-GMO properties. Sorghum is an excellent substitute for wheat, rye, and barley for those who cannot tolerate gluten.

Besides promoting the use of sorghum as a food product in the United States, USCP designs programs to advance sorghum into the ethanol market, develop foreign markets for sorghum, and, in general, enhance the U.S. sorghum industry. Prior to 2012/13, USCP spent the largest share of its funds (50–80%) for crop improvement research intended to increase sorghum yield and reduce production cost (Figure 2). The share devoted to the promotion of "high-value markets" (feed, food, and new product use), however, has increased steadily and now represents the largest share of sorghum checkoff funds spent in the domestic market (43%) compared to only 31% for crop improvement. USCP expenditures to promote "renewables" (ethanol and renewable chemicals) in the U.S. market amounted to about 26% of expenditures in 2015/16.

The economic effects of sorghum food and industrial demand promotion

USCP promotion expenditures are intended to increase the demand for sorghum in various uses, including food uses, and, thereby, increase the price on a higher volume of sales of sorghum over time. In raising the price, however, demand promotion also stimulates a greater level of production over time than otherwise would have occurred which in turn moderates the extent of the price increase. The importance of supply response to any price increase generated by promotion was first discussed in a now classic article by Nerlove and Waugh (1961). Subsequent researchers have concluded that when there are no supply controls, the supply response to promotion can limit a long-term rise in producer price and, thus, constrain or even completely offset the market effects of promotion programs (see, for example, Carman & Green, 1993; Kinnucan, Nelson, & Xiao, 1995; Williams, Capps, & Lee, 2014).

As depicted in Figure 3, an effective USCP sorghum for food and industrial use promotion campaign shifts the demand for sorghum to the right with a corresponding increase in the quantity and value of sorghum sales from D^{wo} to D^{w} (where the superscripts "*w*" and "*wo*" refer to "with" and "without" promotion, respectively). Given the U.S. supply of sorghum (S), the demand shift due to food and industrial demand promotion tends to raise the price for sorghum from P^{wo} to P^{w} and the sales volume from Q^{wo} to Q^{w} in Figure 3. The extent of the shift and the consequent price and quantity effects are indications of the effectiveness of the promotion program. The more effective the program the greater the rightward shift of the demand curve. Depending on the slope of the supply curve, the price increase relative to the quantity increase could be higher or lower than the situation depicted in Figure 3.

Revenue from the sales of sorghum for food and industrial uses before the promotion is $P^{wo} \cdot Q^{wo}$ in Figure 3 and is $P^{w} \cdot Q^{w}$ after the promotion. Thus, the increase in sorghum sales revenue resulting from the food and industrial use promotion can be calculated as $P^{w} \cdot Q^{w} - P^{wo} \cdot Q^{wo}$ which is the sum of the dark and light shaded areas in Figure 3. The promotion leads to not only greater revenues to sorghum producers, however, but also greater costs because the price increase prompts additional sorghum production over time which requires additional production costs. Consequently, the gain to producers from the promotion is the additional revenue earned less the additional costs. To account for those costs, we can calculate the "producer surplus" which is the difference between the amount that producers receive for their production and the minimum amount they would be willing to accept to just cover their costs of production. In Figure 3, the sorghum supply curve (S) indicates the prices that sorghum producers would be willing to accept for each additional unit of sales to just cover costs. Thus, the area under the sorghum supply curve (S) up to Q^{wo} where the original sorghum demand curve (D) crosses S (the cross-hatched triangle area in Figure 3) is a measure of the minimum total amount producers would be willing to accept for the level of sorghum demanded in the market at production level Q^{wo}.

Of course, however, producers do not sell each additional bushel of production at the price that would just cover their costs. Rather, they sell all their output at the market price (P^{wo}). Thus, their revenue for selling Q^{wo}

bushels is $P^{wo}{\cdot}Q^{wo}$ (the sum of the white triangle area above the supply curve and the cross-hatched area below supply curve up to Q^{wo}). Subtracting the costs (the cross-hatched area) from the total revenue ($P^{wo}{\cdot}Q^{wo}$) leaves the white triangle area above the supply curve. That area is the "producer surplus" from sorghum production up to level Q^{wo} of production. Although not precisely the same thing, "producer surplus" can be thought of as a measure of producers' profit from sorghum production.

When the promotion of sorghum for food and industrial uses shifts sorghum demand out to D^{w} in Figure 3, sales revenue increases by the amount represented by the sum of the dark and light shaded areas. The light shaded area represents the additional costs of that additional amount of production. Thus, the dark-shaded area represents the additional "producer surplus" or profit to producers for the additional sales of sorghum induced by the promotion of sorghum for food uses.

Methodology and data

Recall that the two central questions in this analysis are whether the USCP generic promotional activities have enhanced the food and industrial demand for sorghum and whether sorghum producers have benefitted as a result. Econometric techniques are used to measure the extent of any shift in the sorghum demand curve due to the promotion of food and industrial sales of sorghum. Econometric analysis requires a sufficiently large amount of not only historical data on the sales of the product and advertising and promotion expenditures over time but also data related to the many other relevant market forces that might have affected sales over the same period. The application of the statistical techniques to the data allows for the measurement of the unique contribution of each market force considered, including promotion, to the change in sorghum sales observed over the years. Thus, econometric analysis provides a measure of how much of the change in the demand for sorghum over time can be reliably attributed to the USCP promotion of sorghum for food purposes in the United States. To determine whether sorghum producers have benefitted from the promotion of sorghum as food product by the USCP, the econometric results are used in a simulation analysis to determine the benefits relative to the costs of the program

Measuring the effects of USCP promotion on sorghum food and industrial demand

The analysis of the impact of USCP promotion of sorghum for food and industrial uses relies on a structural econometric model approach (essentially single-equation regression analysis). The generalized model of the food and industrial demand for sorghum (*D*) specifies that demand as a function of the market price for sorghum (*PM*), a variable representing the USCP expenditures to promote sorghum for food and industrial uses (*G*), and other demand shift variables (*X*):

$$D_t = D_t(PM_t, G_t, X_t) \text{ where } t = \text{time period} \quad (1)$$

The variable G in Equation (1) (often referred to as a demand stock or "goodwill" variable) is a transformation of USCP expenditures to account for several key characteristics of the relationship between those expenditures and the food demand for sorghum: (1) the lag between the period of expenditure and the demand impact, (2) the diminishing marginal impact of promotion expenditures on demand, and (3) the effects of inflation on the purchasing power of the expenditures.

A large body of literature supports the hypothesis that generic advertising and promotion expenditures have carryover or lagged effects (Capps, Williams, & Hudson, 2016; Forker & Ward, 1993; Lee & Brown, 1992; Nerlove & Waugh, 1961; Ward & Dixon, 1989; Williams, Capps, & Dang, 2010; Williams, Capps, & Palma, 2008; Williams et al., 2014, among many others). That is, expenditures in one period have impacts on demand not only in the current period but over future periods as well. Unfortunately, economic theory provides relatively less guidance as to the structure and length of this dynamic process. We follow a common procedure in the extant literature of using the Almon polynomial distributed lag (PDL) formulation to account for the time lag in the impact of the USCP promotion investments on the U.S. food and industrial demand for sorghum. The search for the pattern, polynomial degree, and time period over which the promotion expenditures influence that demand involved a series of nested OLS regressions.

Conventionally, researchers, through the use of statistical criteria like the Akaike Information Criterion (AIC), the Schwarz Loss Criterion (SLC), or the Hannan-Quinn Criterion (HQC) allow the data to suggest the optimal number of lags to include in the specification. Previous research on a broad range of agricultural and food products suggests that the full impacts of promotion expenditures in 1 year occur within 1–2 and no more than 5 years. Hence, we consider lags of USCP expenditures up to 5 years and up to third-degree polynomials with alternative choices of head and tail restrictions. With the lags in export promotion expenditures, we can measure the short-run (immediate or contemporaneous) effects and long-run (cumulative) effects, as well as the average length of time (in years) before changes in USCP expenditures, begin to affect the U.S. food and industrial demand for sorghum.

After some period of exposure to a promotion campaign, additional promotion expenditures on the messages in that campaign normally have decreasing impacts on sales. This phenomenon, referred to as advertising wearout (for example, see Stewart & Kamins, 2002), is consistent with the law of diminishing marginal returns in economics. For example, the effectiveness of the promotion of a particular use of sorghum for food will likely erode over time as that particular use becomes adopted into the diets of consumers. To capture the effects of advertising wearout, we implement a logarithmic transformation of the USCP promotion expenditures as is commonly done in many studies of U.S. checkoff promotion programs. USCP expenditures are also divided by the U.S. consumer price index to account for the effects of inflation on the purchasing power of those expenditures over time on the U.S. food and industrial demand for sorghum.

Measuring the profitability of USCP promotion expenditures to producers

The statistical analysis discussed in the previous section is designed to determine whether or not USCP program expenditures over the years have effectively shifted out the food and industrial demand for sorghum. If the answer to those questions is "yes," then the next question is whether or not any increase in sorghum food and industrial demand achieved through USCP generic promotion activities generated benefits to sorghum producers who paid for those programs. Obviously, if the answer to the first question is "no" (USCP programs have had no effect food demand), then the answer to the second question is "no" as well (producers have not benefitted). However, if the answer to the first questions is "yes," then the answer to the second is not necessarily "yes" because any consequent increase in revenues to producers may or may not have been sufficient to cover the cost to them of USCP programmatic activities.

To determine whether sorghum producers have benefitted from USCP program expenditures to promote sorghum food and industrial demand, the econometrically estimated version of Equation (1) is used to simulate the level of U.S. sorghum food and industrial demand under two alternative assumptions regarding sorghum checkoff expenditure levels (the variable G in Equation (1)). In the first simulation scenario, the programmatic expenditures made by USCP to promote food and industrial demand (G) are set to their actual or historical values. This simulation is the baseline simulation and is referred to as the "*With Expenditures*" scenario. In the second simulation scenario, the expenditures (G) in Equation (1) are set to zero and the simulation is conducted again over the relevant time period to generate a "*Without Expenditures*" scenario. These results provide a measure of what sorghum food and industrial demand would have been in the absence of the marketing activities of the USCP Board.

Differences in the solution values of the food and industrial demand for sorghum in the "*Without Expenditures*" scenario (sometimes referred to as the "counterfactual" scenario) from the baseline solution values (the "*With Expenditures*" scenario) 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 checkoff program activities associated with the USCP board on sorghum food and industrial demand.

A standard method of addressing the question of producer returns from a commodity checkoff program is to calculate the average benefit-to-cost ratio (BCR) (i.e., the *average* return per dollar spent on the checkoff program) of the contributions by producers to the promotion program. In this case, the sorghum producer BCR from the promotion of sorghum food and industrial demand is calculated as the additional producer surplus or profits realized by producers as a result of the USCP expenditures on sorghum food and industrial demand promotion over time net of the checkoff expenditures divided by the level of checkoff expenditures made to generate those additional revenues.

For a given period (t), the additional producer surplus or profit generated by the promotion of sorghum for food and industrial uses at the market level (RS) as shown in Figure 3 is calculated as:

$$RS_t = \left(P_t^w - P_t^{wo}\right)Q_t^w - 1/2\left(Q_t^w - Q_t^{wo}\right)\left(P_t^w - P_t^{wo}\right), \tag{2}$$

where P is the market price of sorghum; Q is the market quantity demanded of sorghum for food and industrial uses; w and wo indicate "with" and "without" sorghum checkoff promotion expenditures, respectively, and t refers to a particular year.

Because the USCP promotion of sorghum food and industrial demand takes place downstream from producers, Equation (2) calculates the returns from the promotion at the downstream market level. The revenue transmitted upstream to farmers from the promotion of sorghum food and industrial demand (RF) is calculated from Equation (2) by estimating a price transmission equation that relates the price of sorghum at the market level (P) to the farm price of sorghum (PF):

$$PF_t = f(P_t) \tag{3}$$

The estimated coefficient of P in this equation (β) relates P to PF such that one dollar of sales at the market value is equal to β dollars at the farm level. The coefficient β can be used to transform the market value of sorghum food sales to a value of sales at the farm level. Thus, the estimated value of β can be used to transform Equation (2) into a calculation of the additional sorghum producer surplus or profit generated by the promotion of sorghum for food and industrial uses at the farm level (RF):

$$RF_t = \beta\left[\left(PM_t^w - PM_t^{wo}\right)QM_t^w - 1/2\left(QM_t^w - QM_t^{wo}\right)\left(PM_t^w - PM_t^{wo}\right)\right]. \tag{4}$$

Then, the BCR to sorghum producers can be calculated as:

$$\text{BCR} = \frac{\sum_{t-1}^{T} RF_t - E_t}{\sum_{t-1}^{T} E_t}, \tag{5}$$

where RF is from Equation (4); E is the USCP sorghum food and industrial demand promotion expenditures, t is a given time period, and T is the number of years over which the simulation analysis is conducted.

Data

The sorghum checkoff program expenditure data were provided by the United Sorghum Checkoff Program (2008–2017). Data for sorghum prices and quantities were taken from the U.S. Department of Agriculture (USDA, 2017). Other data required for the analysis such as inflation and U.S. gross domestic income were taken from various other U.S. government agencies such as the Federal Reserve Bank of St. Louis (2017).

Promotion impact and return analysis

The analysis is composed of two steps. First, the results of econometrically estimating the relationship between USCP promotion expenditures based on Equation (1) are reported. The results of that analysis than are used in a benefit–cost simulation analysis of the program based on Equations (2)–(5).

Econometric analysis

Following Equation (1), the econometric model specification for the demand for sorghum for food and industrial use is the following:

Table 1. Econometric analysis of the food and industrial demand for sorghum, 1975/76–2016/17.

Dependent variable: LOG (Sorghum Food and Industrial Use Demand)

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
Constant	−5.980411	0.517863	−11.54825	0.0000
LOG (Sorghum Price (no. 2))	−2.324525	0.640355	−3.630058	0.0012
LOG (Corn Price (no. 2))	1.933676	0.671401	2.880060	0.0079
LOG (Industrial Production Index)	2.472367	0.120106	20.58487	0.0000
D2014	−1.988088	0.176075	−11.29114	0.0000
D1985	0.662555	0.146188	4.532226	0.0001
D1986	−0.971084	0.157108	−6.181010	0.0000
D1996	0.501552	0.146753	3.417666	0.0021
D1997	0.502010	0.147650	3.399992	0.0022
D2001	−0.587324	0.153326	−3.830552	0.0007
D2002	−0.427107	0.155236	−2.751336	0.0107

R-squared	0.981099	Mean dependent var	3.200874
Adjusted *R*-squared	0.973102	S.D. dependent var	0.862114
S.E. of regression	0.141393	Akaike info criterion	−0.822465
Sum squared resid	0.519788	Schwarz criterion	−0.305332
Log likelihood	27.62683	Hannan-Quinn criter.	−0.638473
F-statistic	122.6869	Durbin-Watson stat	2.615015
Prob(*F*-statistic)	0.000000		

Lag Distribution of LOG(USCP Renewable and High Value Market Expenditures)	*i*	Coefficient	Std. Error	*t*-Statistic
. *|	0	0.03589	0.00406	8.83177
. *|	1	0.03589	0.00406	8.83177
	Sum of Lags	0.07178	0.00813	8.83177

$$\log\ (\text{food and industrialuse}_t) = f\big(\log\big(\text{sorghum price in terminal market in KansasCity}_t/\text{UCPI}_t\big), \log\big(\text{corn price in terminal market in Chicago}_t/\text{USCPI}_t\big), \log\ (\text{industrial production index}_t),\ \text{PDL}\ \log\ (\text{USCP renewables and high value markets expenditures}_t/\text{UCPI}_t),\ \text{D1985},\ \text{D1986},\ \text{D1996},\ \text{D1997},\ \text{D2001},\ \text{D2002},\ \text{D2014}) + e_t \tag{6}$$

Estimation of Equation (6) accounted for 98% of the variation in sorghum use for food and industrial purposes over the 1975/76–2016/17 period of analysis (Table 1). The econometric results indicate that the demand for sorghum for food and industrial uses is highly responsive to changes in downstream market prices for sorghum and for corn with price elasticities of −2.32 and 1.93, respectively. As indicated by its statistically significant positive sign, corn is a notable substitute for sorghum in food and industrial uses as expected.

As well, the results reveal that the demand for sorghum in food and industrial uses is quite sensitive to changes in industrial production, a proxy for trends in technological advance and other forces in industrial production. A one percent rise in the industrial production index leads to a 2.47% rise in sorghum for food and industrial uses, all other factors invariant.

For the promotion expenditure variable in Equation (6), USCP expenditures for "renewables and high-value markets" is used. USCP includes expenditures for food and industrial use in this aggregate category of promotion expenditures. More specific data that would include only expenditures for food and industrial uses are not available. Because the USCP only began promotion programs in 2008, expenditures in previous years over the 1975/76–2016/17 period of analysis were set to approximately zero. Note that the natural log of the generic promotion expenditures is used to account for diminishing marginal returns of those expenditures. In addition, the Almon polynomial distributed lag (PDL) formulation is applied to the expenditures to test and account for the time lag in the impact of the USCP investment in the promotion of the demand for sorghum in food and industrial uses.

The econometric results indicate that the link between USCP funds committed to renewables and high-value markets and sorghum food and industrial use demand is positive and statistically significant. This impact was not felt in 1 year but rather was distributed over the current and previous year. The results suggest that a one percent increase in USCP funds to renewables and high-value market promotion generated an increase of 0.036% in the demand for sorghum for food and industrial purposes in the year of expenditure and a 0.072% increase over 2 years on average over the 2008/09 to 2015/16 period of analysis. The estimated magnitude of the effect of USCP promotion on sorghum food and industrial use demand is just above the average across 23 checkoff programs as reported by Williams et al. (2018).

Finally, a number of indicator variables are included in the econometric model to account for structural changes in food and industrial use demand over the years, including 1985, 1986, 1997, 2001, 2002, and 2014.

Benefit–cost analysis

To determine the returns to sorghum producers from the USCP promotion of food and industrial use of sorghum, the econometric model in Equation (6) is used to conduct a counterfactual simulation analysis over the period of 2008/09 through 2015/16, the period over which USCP has promoted sorghum food and industrial demand. First, the levels of the market price and quantity demanded of sorghum for food and industrial use (P^w and Q^w as shown in Figure 3) are calculated using Equation (6) with USCP

Table 2. Econometric estimation of the linkage between sorghum prices at the terminal market in Kansas City and the farm price of sorghum, 1975/76–2015/16.

Dependent variable: sorghum farm price

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
C	0.082047	0.070254	1.167856	0.249955
Sorghum Price (no. 2 KC)	0.906873	0.022707	39.93716	0.0000
R-squared	0.976132	Mean dependent var		2.663961
Adjusted *R*-squared	0.976132	S.D. dependent var		1.125329
S.E. of regression	0.176071	Akaike info criterion		−0.610015
Sum squared resid	1.209032	Schwarz criterion		−0.527269
Log likelihood	14.81033	Hannan-Quinn criterion		−0.579686
F-statistic	1594.977	Durbin-Watson statistic		2.121921
Prob (*F*-statistic)	0.000000			

expenditures set at their historical levels. This is the "*With Expenditures*" scenario discussed in the methodology section. Then, the levels of the market price and quantity demanded of sorghum for food and industrial use are calculated in the same way but this time with USCP promotion expenditures are set at zero (the "W*ithout Expenditures*" simulation discussed in the methodology section).

As shown in Figure 3, however, the level of the market price and quantity that would have existed *without* USCP promotion expenditures for food and industrial uses (P^{wo} and Q^{wo}, respectively) depend on the price elasticity of the supply of sorghum. For this analysis, we use the sorghum supply elasticity at the sample means of 0.847371 as reported by Capps, Williams, & Welch (2017). To determine a plausible range of the resulting BCR estimate, we conduct the same simulation assuming supply elasticities one standard deviation above (1.109927) and one standard deviation below (0.584815) the mean value reported by Capps et al. (2017).

The BCRs at the three supply elasticities are calculated using Equations (3–5). First, Equation (3) is estimated to determine the value of β used in Equation (4):

$$\text{Sorghum Farm Price}_t = f\left(\text{Price of Sorghum at Kansas City (no.2)}\right)_t + u_t \quad (7)$$

The estimation of Equation (7) accounted for nearly 98% of the variation in the sorghum farm price (Table 2). The estimated coefficient of the sorghum market price is the price transmission factor (β) and indicates that a one dollar change in the sorghum downstream price (the price of no. 2 sorghum at the terminal market of Kansas City) results in a $0.907 change in the sorghum farm price. That value was then used in Equation (4) for β (the value transmission factor) to calculate the economic surplus or profit derived by farmers from USCP expenditures to promote sorghum food and industrial use over the life of the sorghum checkoff program (2008/09–2015/16). The calculated producer surplus or profit values calculated

Table 3. Farm level benefit-cost ratios (BCRs) for the USCP sorghum food and industrial use promotion, 2008/09–2015/16.

	Supply elasticities		
BCR calculation:	One standard deviation below (0.585)	Elasticity at the mean (0.847)	One standard deviation above (1.110)
Additional farm revenue from food and industrial sales	$115,877,465	$122,709,399	$128,527,863
- Percent increase in farm revenue from food and industrial sales	4.32%	4.58%	4.81%
- Percent addition to total farm sales	0.91%	0.96%	1.01%
Additional producer surplus (net of expenditures)	$66,000,842	$59,495,100	$54,023,895
USCP promotion investment for renewables and high value markets	$9,271,078	$9,271,078	$9,271,078
Net revenue BCR at the farm level ($ added/$ spent)	11.50	12.24	12.86
Producer surplus or profit BCR ($ added/$ spent)	7.12	6.42	5.83

from Equation (4) are then used in Equation (5) to calculate the farm level BCRs for the promotion of sorghum in food and industrial uses (Table 3).

The BCR calculation results indicate that the USCP promotion of sorghum demand for food and industrial uses added from $115.9 million (4.3%) to $128.5 million (4.8%) to the value of sorghum sales for food and industrial uses and from 0.9% to 1% to the value of total farm sales of sorghum between 2008/09 and 2015/16 depending on the elasticity of the supply of sorghum (Table 3). In addition, producer economic surplus or profit (net of promotion expenditures) increased from between $54.0 million to $66.0 million over the same period. Given that the total USCP investment in the promotion of sorghum for food and industrial uses amounted to almost $9.3 million over that period, the BCR to producers from their investment in the promotion of the demand for sorghum in food and industrial uses ranged from $11.5 to $12.9 in terms of additional farm revenues generated per dollar spent on promotion. In terms of the additional, economic surplus or profit generated for producers (net of expenditures) per dollar spent on promotion, the BCR ranged from $5.8 to $7.1.

Conclusions

Sorghum has largely been grown and marketed as an animal feed ingredient in the United States and other developed countries even though humans consume half of all sorghum produced in the world in a variety of food products. Until 2004/05, food and industrial uses of sorghum accounted for less than 10% of total sorghum consumption in the United States. By 2011/12, however, food and industrial uses accounted for nearly 40% of U.S. domestic sorghum consumption. In 2008, the United Sorghum Checkoff Program (USCP) was established with the objective of promoting the demand for sorghum, including the use of sorghum for food and industrial products. The establishment of the USCP closely corresponds to the jump in the use of sorghum in food and industrial uses. This study analyzes the extent to which the USCP contributed to that growth and the returns to sorghum growers from their investment in the promotion of the food and industrial use of sorghum.

The overall conclusion of this study is that the USCP played a statistically significant role in the growth of the food and industrial demand for sorghum in the United States. The study also finds that the return to growers from their investment in that promotion was positive. More specifically, the study concludes:

- USCP promotion programs have had a positive and statistically significant effect on U.S. food and industrial demand for sorghum. The effects of the promotion in any given year tend to persist over a 2-year period. On average since the establishment of the USCP in 2008, the 2-year cumulative effect of a one percent change in those promotion expenditures generated a 0.0718% increase in the use of sorghum for food and industrial purposes at a given price.
- The promotion program increased the farm revenue from the sales of sorghum for food and industrial purposes by 4.3% to 4.4% and added 0.9% to 1% to total sorghum revenues at the farm level annually on average since the inception of the USCP.
- Sorghum producers who has funded the USCP generic sorghum promotion programs since 2008 has realized a return of between $5.83 and $7.12 per dollar spent on promotion (the producer profit benefit-cost ratio) depending on the level of responsiveness of supply to price changes (supply elasticity).
- Opportunities for enhancing producer profitability appear to exist in the use of sorghum for the production of ethanol, gluten-free products, pet foods, aquaculture, and renewable chemicals. These uses appear to be growth areas in the near to intermediate future. Furthermore, efforts could also focus on the visibility of sorghum not only as a healthy choice for cooking and baking but also as a gluten-free nutritious grain.

Note

1. Industrial use includes any use of sorghum not related to seed use, feed use, food use, or exports.

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