An Economic Analysis of the Cattlemen's Beef Promotion and Research Board Demand-Enhancing Programs

Dr. Harry M. Kaiser, Cornell University

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EXECUTIVE SUMMARY

This research addresses two important questions regarding the Cattlemen's Beef Promotion and Research Board (CBB):

1. *What would U.S. beef demand be in domestic and foreign markets had there not been any CBB marketing programs?*
2. *Are the benefits of the CBB marketing programs larger than their costs?*

To address these two questions, econometric models of the domestic and international beef markets are constructed, which enables us to net out the impacts of other important factors besides CBB activities affecting beef demand such as beef and other meat prices, income, exchange rates, and economic conditions in importing countries.

The answer to the first question is a resounding yes. Had there not been any CBB marketing over the period 2006 through 2013, total domestic beef demand would have totaled 15.7 billion pounds (11.3%) less than it actually was. In terms of the nine individual CBB program areas, had there been no:

- Generic beef advertising, domestic beef demand would have been 0.7% lower over;
- Channels marketing, domestic beef demand would have been 0.6% lower;
- Industry information marketing, domestic beef demand would have been 0.2% lower;
- New product development, domestic beef demand would have been 1.2% lower;
- Public relations, domestic beef demand would have been 0.5% lower;
- Nutritional research, domestic beef demand would have been 3% lower;
- Beef safety research, domestic beef demand would have been 2.1% lower;
- Product enhancement research, domestic beef demand would have been 0.4% lower;
- CBB foreign market development, foreign beef demand would have been 6.4% lower.

While these results are important, the benefits of CBB's marketing programs to industry profitability relative its cost is a more important question to address. A benefit-cost ratio (BCR) or return on investment is computed, which measures the benefits to the industry in terms of additional profits from an extra dollar invested in each activity. Collectively, the overall BCR for all CBB activities is $11.20. In other words, an extra dollar invested in CBB activities over the period, 2006-13, returned $11.20 to beef industry producer profit.

An Economic Analysis of the Cattlemen's Beef Promotion and Research Board Demand-Enhancing Programs

The Cattlemen's Beef Promotion and Research Board, which is usually referred to as the Cattlemen's Beef Board or CBB, has a central mission to increase the demand for beef through implementing consumer advertising, marketing partnerships, public relations, educational programming, research, and new product development. The program is funded by a mandatory assessment of $1.00 per head on all cattle sold in the United States. In addition, the equivalent of $1.00 per head is assessed on imported cattle, beef, and beef products. In 2014, the CBB had a budget of $40.7 million to spend on these activities. Under existing agricultural legislation, the CBB is required to have an independent analysis of the economic effectiveness of the program conducted at least once every five years. Accordingly, the purpose of the research reported here is to conduct such an economic evaluation for the most recent period of performance for the CBB.

The purpose of the research is to independently evaluate the economic effectiveness and optimal allocation of the individual programs funded by the CBB. Specifically, this research addresses three objectives:

1. Quantify and measure the economic benefit to cattlemen of CBB-funded programs for the period 2006-2013 in terms of net return on investment.
2. Quantify and compute marginal rates of return on investment for alternative existing and potential checkoff-funded activities.
3. Estimate the optimal allocation of the CBB budget across the various program activities.

In this study, the impacts of all factors affecting domestic and export beef product demand for which data are available are measured statistically. In this way, the analysis nets out

the impacts of other important factors besides CBB activities affecting beef demand over time. In addition, the incremental sales generated by CBB activities are estimated for their various types of marketing programs and all activities combined. The benefits to beef producers are estimated using an "Equilibrium Displacement Model," which enables computation of a marginal benefit-cost ratio for each individual program and all programs combined.

This independent evaluation is carried out by Dr. Harry M. Kaiser, who is the Gellert Family Professor of Applied Economics and Management at Cornell University. Dr. Kaiser has extensive experience in conducting economic evaluation studies of domestic and international checkoff programs. Dr. Kaiser has written 128 refereed journal articles, five books, 17 book chapters, over 150 research bulletins, and received $8 million in research grants in the area of agricultural marketing with an emphasis on promotion programs. He has conducted over 120 economic evaluation studies of domestic and international checkoff programs in the United States, Canada, and Europe on such commodities as fluid milk, cheese, butter, salmon, red meat, pork, raisins, walnuts, blueberries, potatoes, beef, wheat, watermelons, high-valued-agricultural commodities, and bulk agricultural commodities. In 2005, Kaiser was the lead author of a book on all commodity checkoff programs in California.

Cattlemen's Beef Board Program Expenditures

The CBB was implemented in 1986 as part of the 1985 Farm Bill and is designed to increase the overall demand (both domestic and foreign) for U.S. beef products. The CBB is funded by a mandatory assessment of $1.00 per head on all cattle sold in the U.S. and a $1.00 per head

equivalent on all imported cattle, beef, and beef products. Collectively, this program raises approximately $40 million on an annual basis for national programs.

The CBB invests in a variety of activities to accomplish its overall objective of improving the demand for U.S. beef products. In this report, the marketing activities are divided into nine categories:

1. Generic beef advertising,
2. Public relations,
3. Beef safety research,
4. Channels marketing,
5. Industry information,
6. New product development,
7. Foreign market development,
8. Product enhancement research, and
9. Nutritional research

Figure 1 presents the total budget for these nine activities over the time period 2006-13. Because the budget is based on number of head of cattle, which has decreased since 2006, it has declined over this period. In 2006, these nine CBB activities totaled $40.7 million and by 2013 it totaled $30.5, which is a decline of 25%.

Figure 2 illustrates the percent of the 2013 CBB budget spent on each of these activities. In 2013, advertising expenditures was the largest category of the CBB budget, accounting for 27% of the spending. This was followed in importance by foreign market development activities (22%) and channels marketing (15%). CBB contributions to public relations activities represented 11% of the 2010 budget, while industry information comprised 9%. The remaining

Figure 1. Total CBB budget, 2006-13.

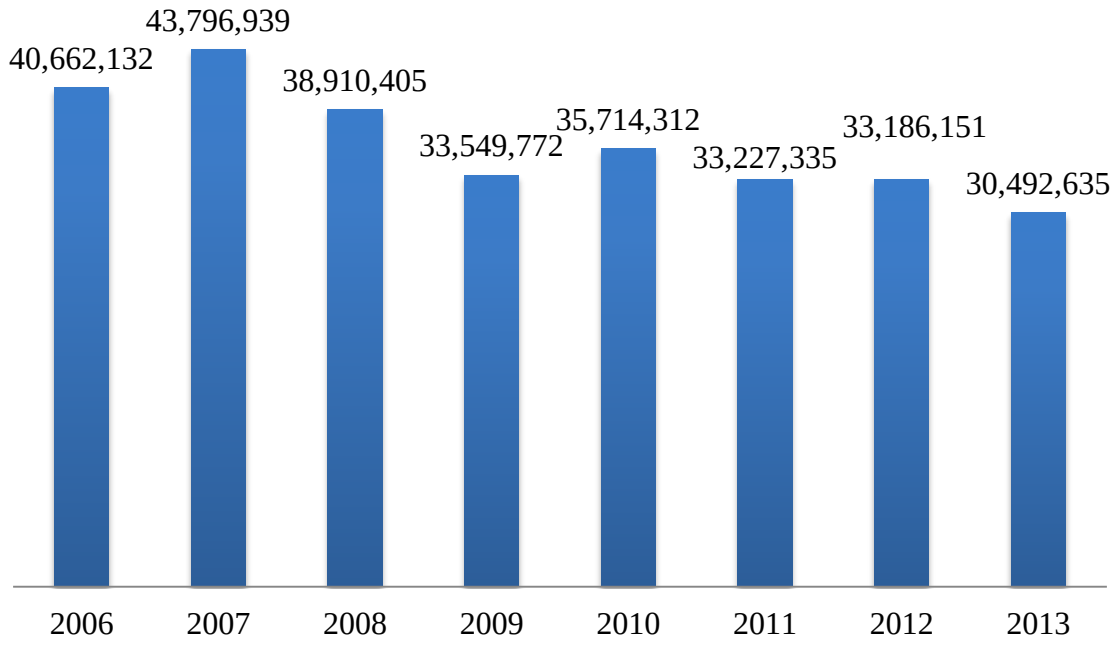
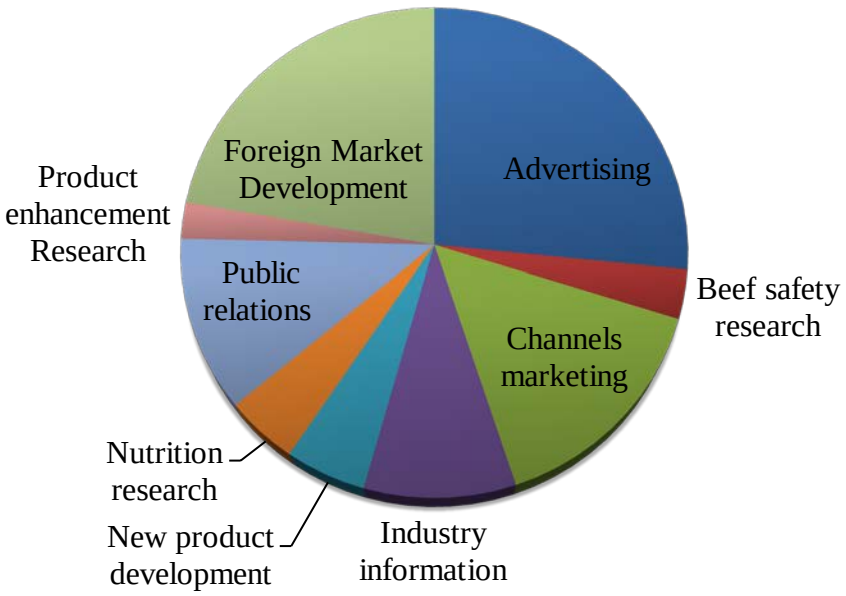


Figure 2. Percent of CBB Expenditures by Major Activity, 2013.



activities included new product development and nutritional research (each 5%), beef safety research (3%), and product enhancement research (2%). The relative magnitudes of these activities have varied over time.

Figure 3 displays annual generic beef advertising expenditures as a percentage of the total CBB budget from 2006 through 2013. These expenditures are devoted to all domestic media advertising such as radio, print, outdoor, and web advertising. Since 2006, there has been a slight downward trend in advertising as a share of the total budget. For instance, in 2006, advertising comprised 37.2% while in 2013 it comprised 29.8% of the budget. Hence, while advertising is still the most important activity by the CBB, it has declined somewhat.

Figure 4 presents CBB contributions to foreign market development programs as a percent of the total budget from 2006-13 in seven countries: Japan, Mexico, Russia, European Union (EU), Taiwan, China and Hong Kong, and South Korea (note that while this is the majority of funds expended, there are also funds going to other countries as well that are not included in these numbers). These expenditures by the CBB are used along with funds by the U.S. Meat Export Federation (USMEF) and matching dollars from the U.S. Department of Agriculture (USDA)/Foreign Agricultural Service (FAS) in export marketing programs designed to stimulate export demand in important international markets for U.S. beef products. These activities include promotion, trade service, technical assistances, and other promotional strategies. The export market for the U.S. beef industry is very important to the vitality of the industry. For instance, in 2012, the U.S. exported about 2.5 billion pounds of beef (commercial carcass weight) valued at $5.1 billion, or about 6% of the retail value of U.S. beef. There has been a steady positive trend over this period in this category of activities. In 2006, the CBB invested 4.3% of its budget into this activity, and by 2013 it comprised 12.8% of the CBB

budget.

Figure 3. Beef advertising as a percent of CBB budget, 2006-13.

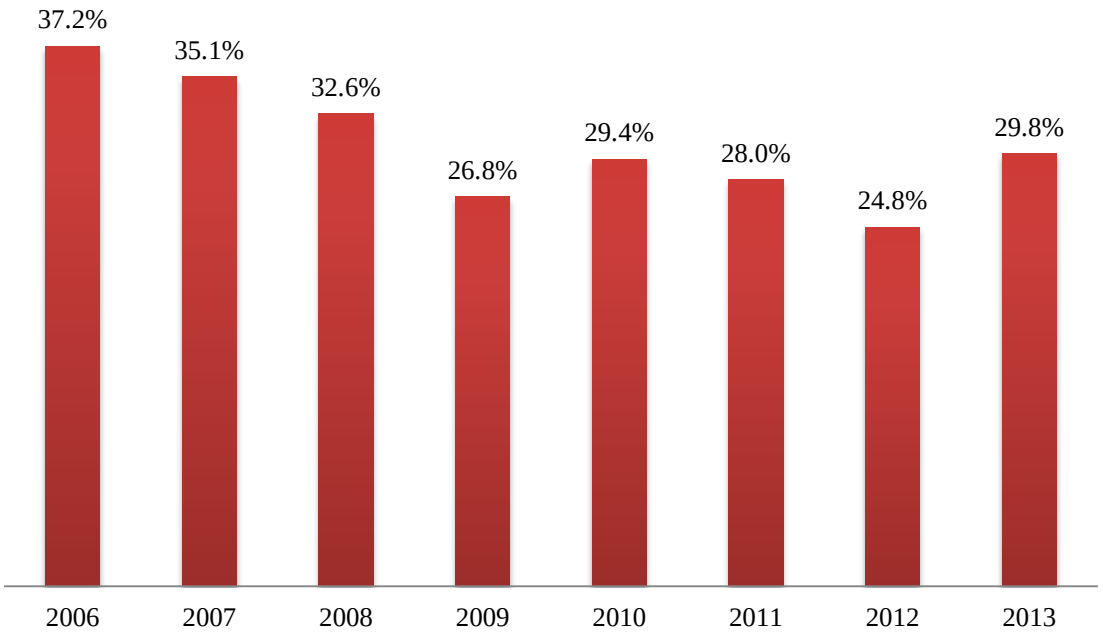


Figure 4. Foreign market development as percent of CBB budget, 2006-13.

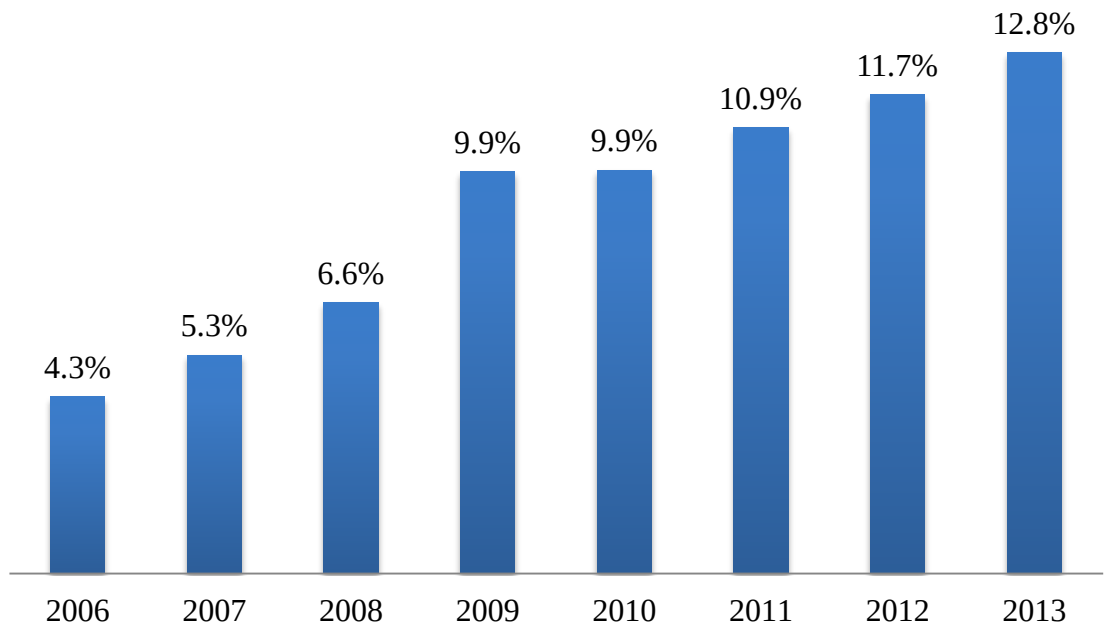


Figure 5 shows CBB expenditures on channels marketing as a percentage of their total budget from 2006-13. This category includes all programs that support beef promotion and marketing in retail and foodservice. This category has declined over time. In 2006, CBB invested almost 19.5% of its budget in channels marketing, and by 2013 this had declined to 16.9%.

Figure 5. Annual expenditures on channels marketing as percent of CBB budget, 2006-13.

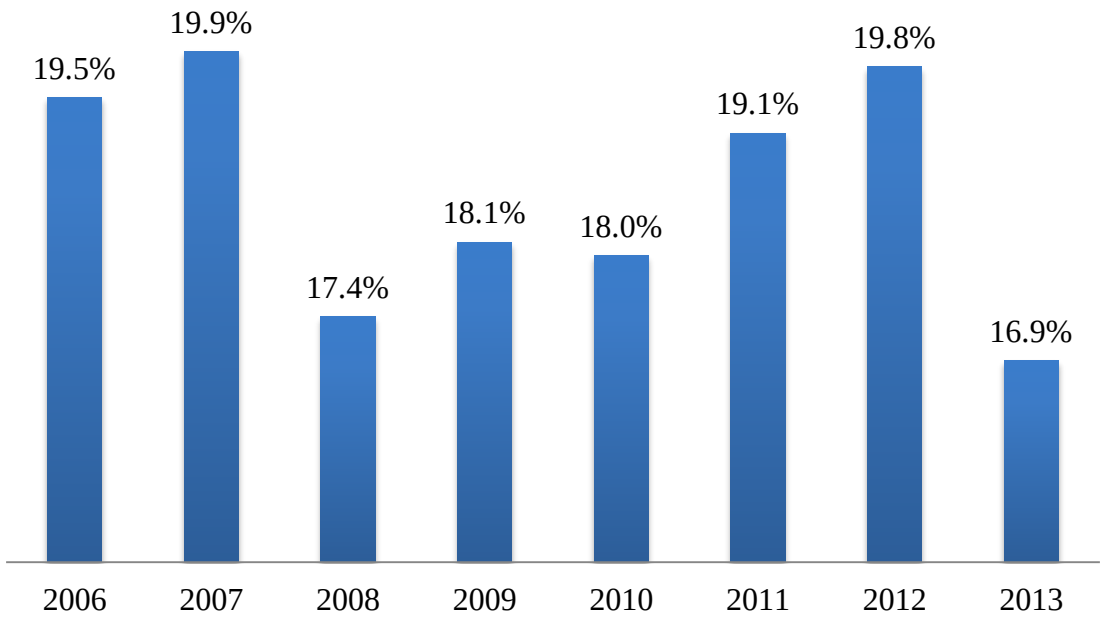


Figure 6 presents CBB expenditures on public relations as a percent of the total budget. Public relations (PR) include all CBB activities that proactively share positive beef messages with consumers. PR is one of the most commonly used marketing strategies by checkoff programs and other firms in the United States. As true with channels marketing, CBB expenditures on PR activities declined over this period from 16.8% of the total budget in 2006 to 12.8% in 2013.

One category that CBB has substantially increased spending on is industry information. This category includes all programs that focus on sharing information with consumers on industry specific information (this can include topics such as animal care and handling, production technology, etc). As illustrated in Figure 7, in 2006, the CBB spent just 3.4% of its budget industry information and by 2013 this category almost tripled to 10.5%.

Figure 6. Annual expenditures on public relations as percent of CBB budget, 2006-13.

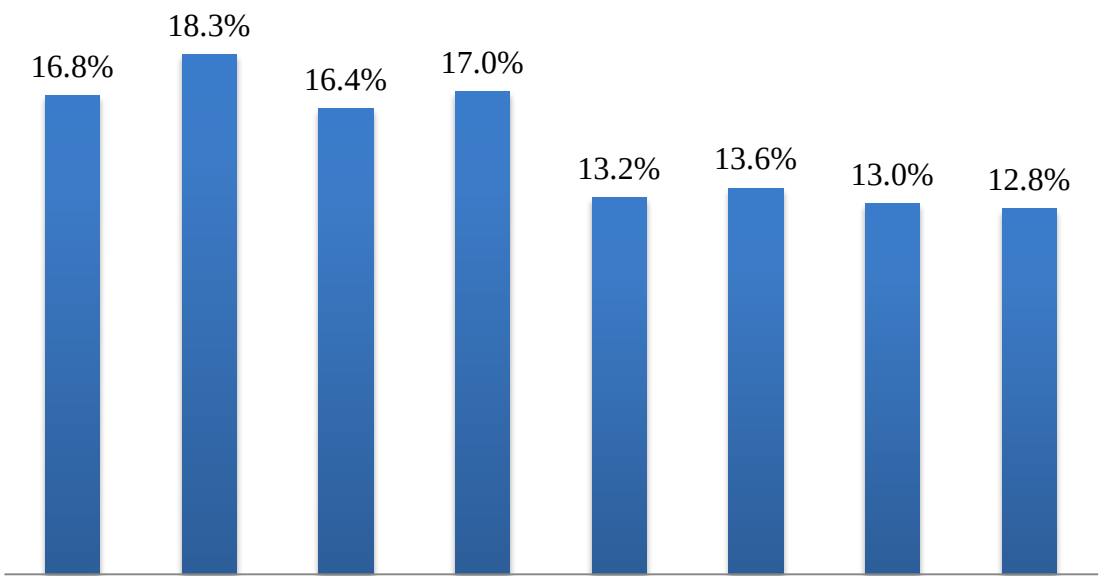


Figure 8 shows CBB expenditures on new product development as a percent of its total budget over this time period. This category includes new product and culinary development to bring new, relevant beef culinary techniques, recipes, and cookery for existing and newly identified beef cuts to consumers (including retail, foodservice and direct to consumer). Expenditures in this category have fluctuated over time, and there is no overall trend.

Figure 9 shows CBB expenditures on beef safety research as a percent of the total budget.

This category of spending includes all the research projects focusing on pre and post-harvest

Figure 7. Annual expenditures on industry information as percent of CBB budget, 2006-13.

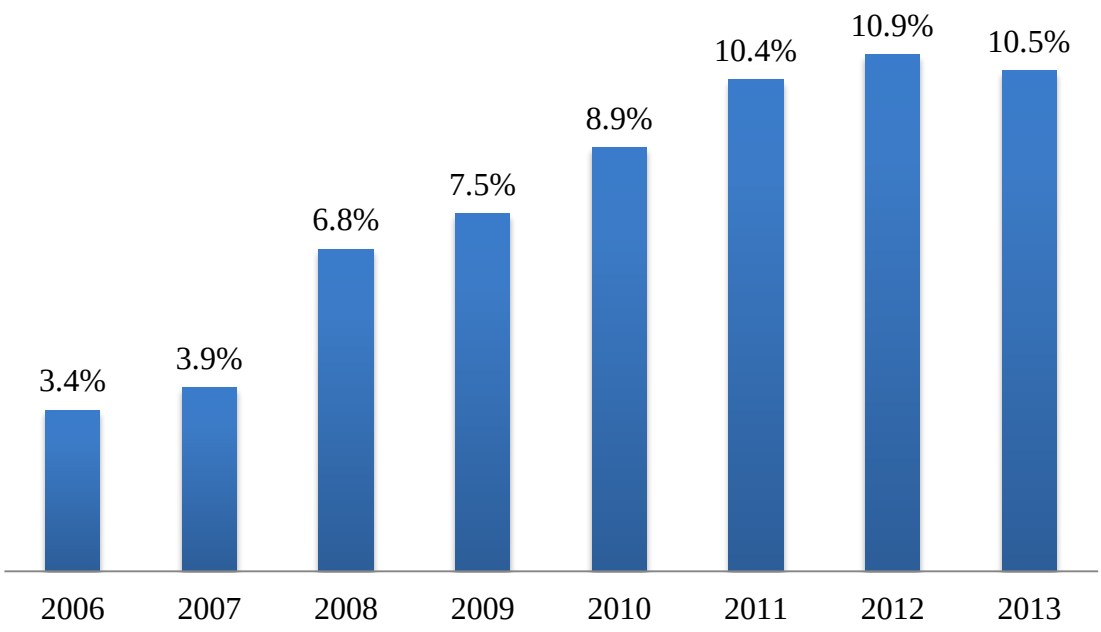
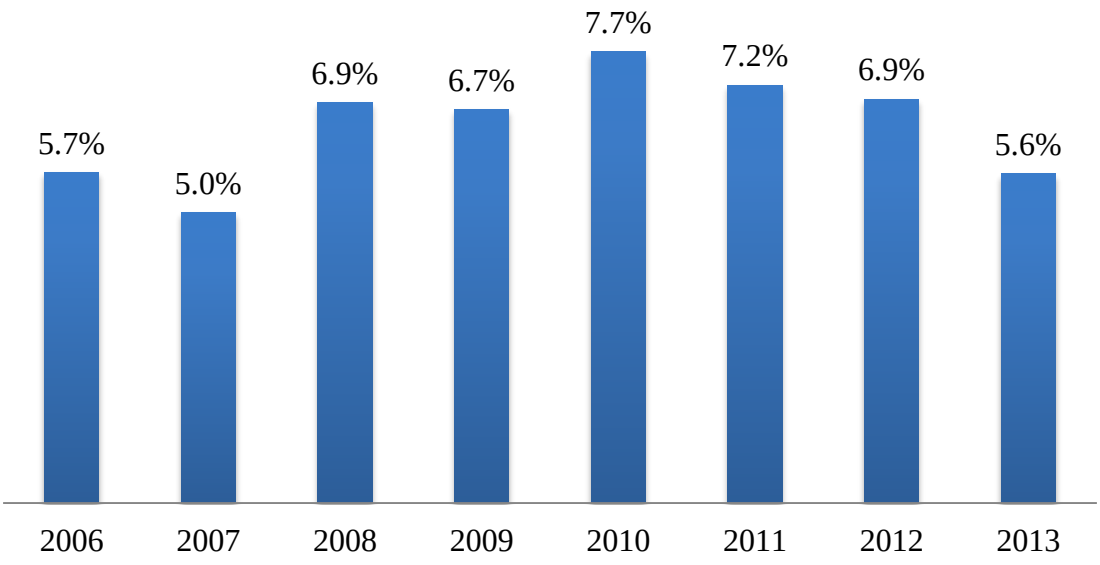


Figure 8. Annual expenditures on new product development research as a percent of the CBB budget, 2006-13.



safety as it relates to beef and beef products. Since 2006, CBB expenditures on beef safety research have declined from 5.7% of the total budget in 2006 to 3.6% in 2013.

Figure 9. Annual expenditures on beef safety research as a percent of CBB budget, 2006-13.

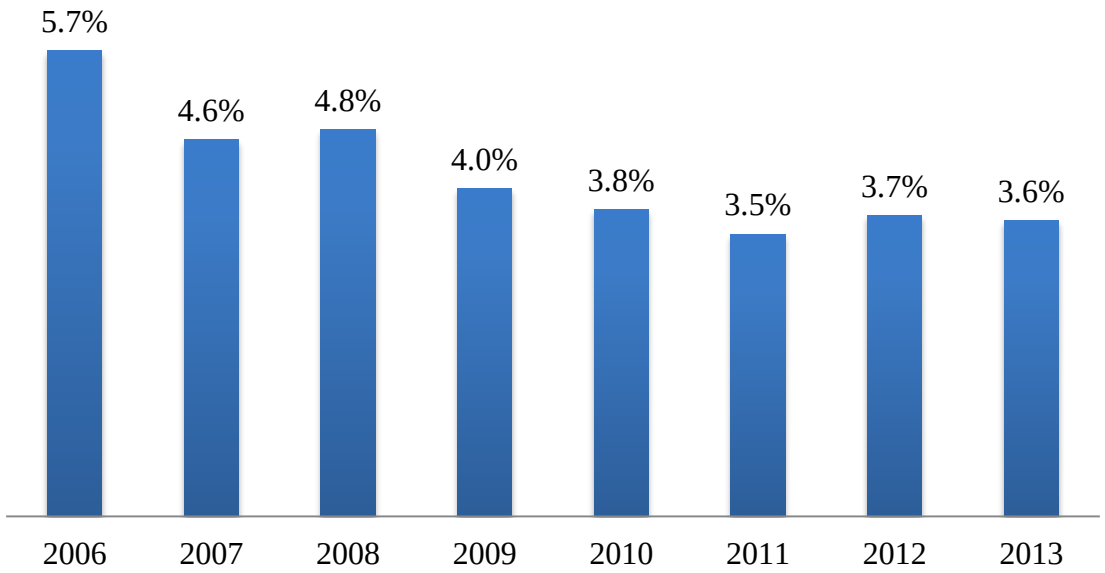


Figure 10 shows CBB expenditures on product enhancement research. This category includes all research programs focused on product quality and product enhancement including muscle profiling (identifying new cuts within undervalued areas of the carcass, i.e. flat iron steak), tenderness, shelf-life, etc. Similar to food safety research, expenditures on this category declined over this period from 5.2% of the CBB budget in 2006 to 2.7% in 2013.

Another activity that has increased over time as a share of CBB's budget is nutritional research, which is shown in Figure 11. Nutritional research includes all research projects focusing on beef's role in human nutrition. Nutritional research was only 2.1% of the budget in 2006 and this grew to 5.1% in 2013.

Figure 10. Annual expenditures on new product enhancement research as percent of CBB budget, 2006-13.

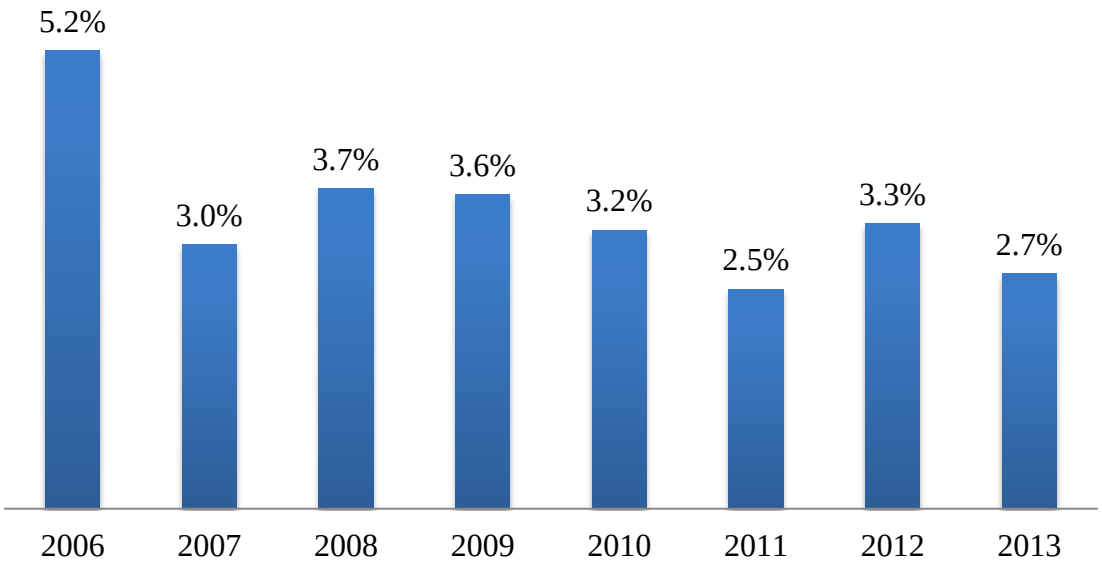
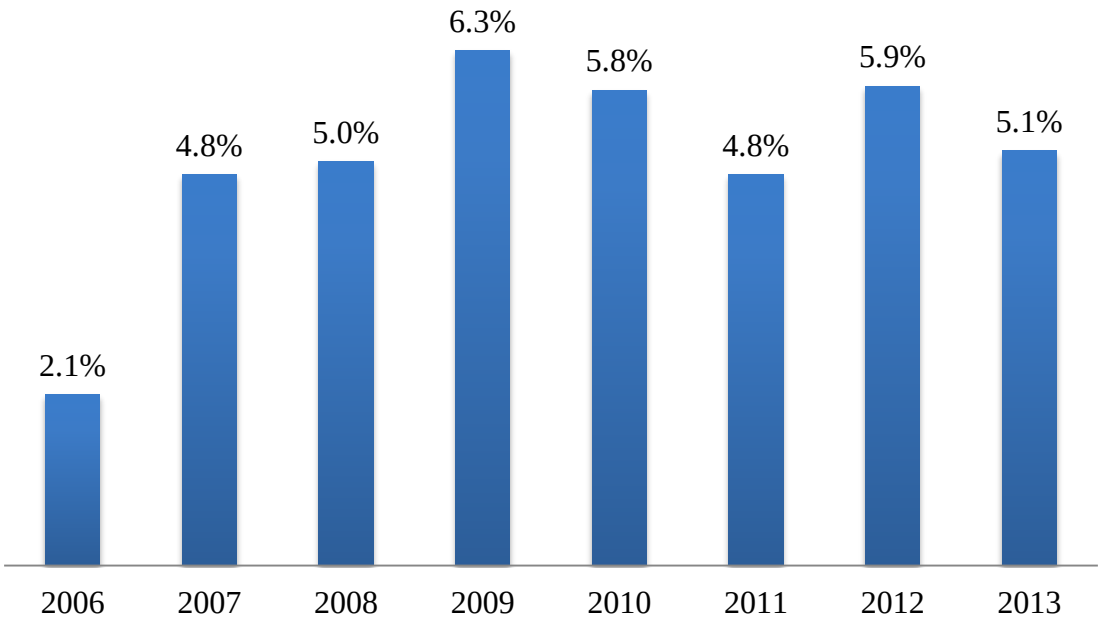


Figure 11. Annual expenditures on nutritional research as a percent of the CBB budget, 2006-13.



Methodology

This study quantifies the relationship between the various marketing activities of the CBB and the domestic and international demand for U.S. beef. Several econometric models are estimated. The econometric approach quantifies economic relationships using economic theory and statistical procedures with data. It enables one to simultaneously account for the impact of a variety of factors affecting demand and supply for a commodity. By casting the economic evaluation in this type of framework, one can filter out the effect of other factors and, hence, quantify directly the net impact of the CBB's activities on beef demand.

The three econometric equations to be estimated include: (1) retail domestic beef demand, (2) retail domestic beef supply, and (3) U.S. beef export demand. The model also includes two equilibrium conditions requiring retail domestic and international demand to equal retail supply, and a farm-to-retail conversion equation. The three econometric equations are used to test whether various activities by the CBB such as advertising, public relations, channel marketing, new product marketing, and export market development and promotion activities have a statistically significant impact on beef demand.

To compare the relative importance of each factor on beef demand, the results from the econometric model are converted into "elasticities." An elasticity measures the percentage change in beef demand given a 1% change in a specific demand factor, holding all other factors constant. For example, the computed own price elasticity of demand measures the percentage change in beef quantity demanded given a 1 percent change in price, holding constant all other beef demand determinants. Since elasticities are calculated for each demand factor in each

model, one can compare them to determine which factors have the largest impact on beef demand.

Retail Beef Demand and Supply

The domestic demand equation for beef is estimated with retail per capita demand as the dependent variable, measured in pounds for each month from 2006.1 through 2013.12 (i.e., year.month). The advantage of using monthly rather than quarterly or annual data is that one does not need to go back as many years to have a sufficient number of observations to estimate the model. This is advantageous since it is less likely there has been a major structural change in the beef industry since 2006, which would be less true if one had to go back to say 1970. The following demand determinants are included to ascertain their impacts on domestic beef demand:

1. Retail price for beef products ($/lb.),
2. Retail price for chicken products ($/lb.),
3. Retail price for pork products ($/lb.),
4. Per capita disposable income,
5. Time trend,
6. Generic pork advertising expenditures,
7. CBB beef advertising expenditures,
8. CBB expenditures on public relations,
9. CBB expenditures on beef safety research,
10. CBB expenditures on total channels marketing,

11. CBB expenditures on total industry information,

12. CBB expenditures on new product development,

13. CBB expenditures on product enhancement research, and

14. CBB expenditures on nutritional research.

Mathematically, the beef domestic demand model is represented by the following equation:

$$\ln(PCCON_t) = \text{[illegible]}\ln(RBP_t/CPI_t) + \text{[illegible]}\ln(RCP_t/CPI_t) + \text{[illegible]}\ln(RPP_t/CPI_t) + \text{[illegible]}\ln(PCINC_t/CPI_t) + \text{[illegible]}\ln(TREND_t) + \text{[illegible]}\ln(PADV_{t-n}/CPI_{t-n}) + \text{[illegible]}\ln(BADV_{t-n}/CPI_{t-n}) + \text{[illegible]}\ln(FSAFE_{t-n}/CPI_{t-n}) + \text{[illegible]}\ln(CHANEL_{t-n}/CPI_{t-n}) + \text{[illegible]}\ln(PR_{t-n}/CPI_{t-n}) + \text{[illegible]}\ln(INDUST_{t-n}/CPI_{t-n}) + \text{[illegible]}\ln(NEWPROD_{t-n}/CPI_{t-n}) + \text{[illegible]}\ln(PRODENHANCE_{t-n}/CPI_{t-n}) + \text{[illegible]}\ln(NUTRES_{t-n}/CPI_{t-n})$$

where: $PCCON_t$ is per capita beef domestic demand year/month t; RBP_t is retail price for beef products in year/month t; CPI_t is the retail consumer price index for all items in year/month t; RCP_t is retail price for chicken products in year/month t; RPP_t is the retail price for pork products in year/month t; $PCINC_t$ is per capita disposable income in year/month t; $TREND_t$ is a linear trend term in year/month t; $PADV_{t-n}$ is generic pork advertising in year/month t, t-1, and so on; $BADV_{t-n}$ is generic beef advertising in year/month t, year/month t-1, and so on; PR_t is CBB public relations in year/month t; $FSAFE_{t-n}$ is CBB-sponsored marketing expenditures on food safety issues year/month t, t-1, and so on; $CHANEL_{t-n}$ is CBB-sponsored channels marketing expenditures year/month t, t-1, and so on; PR_{t-n} is CBB-sponsored public relations marketing expenditures year/month t, t-1, and so on; $INDUST_{t-n}$ is CBB-sponsored marketing expenditures on industry information year/month t, t-1, and so on; $NEWPROD_{t-n}$ is CBB-sponsored expenditures on new product development year/month t, t-1, and so on; $PRODENHANCE_{t-n}$ is CBB-sponsored expenditures on new product enhancement research

year/month t, t-1, and so on and $NUTRES_{t-n}$ is CBB-sponsored expenditures on nutritional research year/month t, t-1, and so on. In this equation, "ln" is the natural logarithmic operator, and the α and γ are the coefficie

variables such as RBP, RCP, RPP, PCINC, PADV, and all CBB expenditures are deflated by the retail consumer price index for all items to account for the effects of inflation over time. Hence, all monetary variables are expressed on a "real", inflation adjusted, rather than nominal basis. Not shown in this equation are monthly dummy variables to capture seasonality in per capita demand.[1]

The retail price for beef products is expected to be negatively related to per capita beef demand, i.e., a lower price results in higher quantity demanded reflecting the law of demand. The retail price chicken and pork products are included because they represent the most important substitute products for beef. The relationship between PCCON and RCP (and RPP) is expected to be positive because chicken and pork are substitutes for beef, e.g., an increase in the chicken price results in an increase in beef demand since beef is now relatively less expensive. The relationship between per capita income and beef demand is expected to be positive, i.e., as consumers become wealthier, the demand for beef should increase. The time trend term is included to capture changes in beef availability over time, and is expected to be negative given recent decreases in production. Generic pork advertising is included because it is expected to have a negative impact on per capita beef demand. The seven CBB marketing activities are expected to each have a positive impact on the demand for beef.

It is well documented in the literature that advertising and marketing campaigns have a "carry-over effect" on demand, i.e., past, as well as current advertising has an effect on current

[1] The initial specification of the model included 12 separate dummy variables corresponding to the months January through December. The final model consisted of only those months that had a significant seasonality, which included February (negative), June (positive), August (positive), October (positive), and December (negative).

demand. To capture this carry-over effect, current and various lagged CBB marketing expenditures (and generic pork advertising) were included in the initial model and the lag-length that provided the best statistical fit was chosen for the final model.[2] All eight CBB marketing activities were originally included as separate variables in the per capita beef demand equation. However, due to statistical insignificance of the original specification, the final model consisted of four separate variables: (1) new product development + product enhancement research, (2) nutritional research, (3) beef safety research, and (4) promotion, which included generic advertising, public relations, industry information, and channel marketing. While a single elasticity is estimated for the aggregate category of "promotion," we are still able to estimate a separate and unique benefit-cost ratio for generic advertising, public relations, industry information, and channel marketing in the simulation section.

In addition to the retail beef demand model, a retail beef supply model is estimated. This model is represented mathematically by the following equation:

$$\ln(RSUP_t) = \square_0 + \square_1 \ln(RBP_t/STEERP_t) + \square_2 \ln(TREND_t)$$

where: $RSUP_t$ is total retail supply of beef in year/month t, RBP_t is retail beef price in year/month t, $STEERP_t$ is the 5-market average price of steers in year t/month , and $TREND_t$ is a linear time trend variable for year t to measure technological progress in the beef retail sector over time. In this equation, "ln" is the natural logarithmic operator, and the $\square$s are the

[2] Specifically, most of these variables were specified as a second-degree polynomial distributed lag (PDL). The model was then solved without end point restrictions being imposed, alternative length of lags were specified, and the final model was chosen based on the best statistical. A PDL structure was used for generic pork advertising and all CBB sponsored marketing activities with the exception of new product development and product enhancement research, which were aggregated and included as a 6-month lagged variable.

coefficients to be estimated with statistical regression analysis. Not shown in this equation are monthly dummy variables to capture seasonality in retail beef supply.[3]

The following data sources were used for the variables in the model: PCCON, RSUP, RBP, RCP, RPP, PADV came from Mr. Rick Husted of the National Cattlemen's Beef Association, a contractor to the Beef Checkoff Program; CPI, POP, STEERP came from the Livestock Marketing Information Center, BADV, FSAFE, CHANEL, INDUST, PR, NEWPROD, PRODENHANCE, and NUTRES came from the CBB.

Econometric Results. To address the potential problem of price endogeneity, an instrumental variable regression approach is used in which the retail beef price is regressed on a set of variables, which includes all exogenous variables from the demand equation. Hence, the model consists of two equations: (a) a price equation used as an instrumental variable for the endogenous retail beef price; and (b) a demand equation for U.S. beef, which includes the predicted retail beef price from the price equation as one of the exogenous (instrumental) variables.

The retail beef demand model is estimated in logarithmic form with monthly data from 2006.1 through 2013.12. The elasticities are summarized in Table 1. The coefficient of variation (R^2) indicates that the explanatory variables explain over 89% of the variations in monthly per capita demand for U.S. beef. The elasticity signs are consistent with economic theory and all estimated coefficients (except for the retail pork price) are statistically significant at the 5% significance level or better, and most coefficients are significant at the 1% level or better.

[3] The initial specification of the model included 12 separate dummy variables corresponding to the months January through December. The final model consisted of only those months that had a significant seasonality, which included February (negative), March (positive), May (positive), June (positive), July (positive), August (positive), and October (positive).

Several econometric diagnostic tests performed indicate no statistical problems with the model. The estimated own price elasticity is negative and equal to -0.431. The interpretation of this is a 1% increase in the retail beef price, holding all other demand factors constant, leads to a 0.431% decrease in per capita beef quantity demanded. As expected, both chicken and pork are found to

Table 1. Retail beef demand elasticities.[a]

Demand Factor	Elasticity	p-value
Retail beef price	**-0.431**	**0.001**
Retail chicken price	**0.150**	**0.001**
Retail pork price	0.023	0.375
Per capita disposable income	**0.691**	**0.000**
Time trend	**-0.048**	**0.000**
Generic pork advertising	**-0.003**	**0.001**
Generic beef advertising	**0.018**	**0.000**
CBB public relations	**0.018**	**0.000**
CBB beef safety research	**0.009**	**0.000**
CBB channels marketing	**0.018**	**0.000**
CBB industry information	**0.018**	**0.000**
CBB new product development	**0.012**	**0.005**
CBB product enhancement research	**0.012**	**0.005**
CBB nutritional research	**0.013**	**0.000**

[a] Coefficients in bold indicates statistical significance from zero (p-value under 0.05 or better). The non-bolded coefficient is not statistically significant from zero.

be substitutes commodities for beef with elasticities of 0.150 and 0.023, respectively. That is, a 1% increase in the chicken (or pork) price, holding all other demand factors constant, results in a 0.150% (0.023%) increase in per capita beef demand. However, the coefficient on the retail pork price is not statistically significant.

Per capita disposable income has a positive impact on beef demand, indicating that beef is what economists refer to as a “normal good” - demand increases as consumer income increases. Interestingly, the estimated income elasticity is actually larger than the price elasticity in absolute

value, and hence appears to be a very significant driver of per capita beef demand. That is, a 1% increase in per capita income results in a 0.691% increase in per capita beef demand, holding constant all other demand factors. The trend term is negative and significant, which may reflect a decline in beef availability since 2006 due to decreasing production over this period. Generic pork advertising is found to have a carry-over effect of two months and has a cumulative elasticity value of -0.0035. That is, a 1% increase in generic pork advertising decreases beef demand by 0.0035% over a two-month period.

The statistical results indicate that all eight CBB demand-enhancing activities have a positive and statistically significant impact on increasing per capita beef demand. All estimated elasticities had similar values. Generic beef advertising, CBB public relations, channel marketing, and industry information activities have a one-month carry over effect with a cumulative elasticity of 0.018. In other words, holding all other factors constant, increasing these promotion expenditures by 10% increases per capita beef demand by 0.18%. The estimated beef safety research elasticity is 0.009 meaning a 10% increase in this activity results in a 0.09% increase in per capita beef demand. This variable had a three-month carry-over effect. New product development and product enhancement research have an elasticity of 0.012, and nutritional research has an elasticity of 0.013. Nutritional research had a one-month carry-over effect, while new product development and product enhancement research had a six-month lag effect on per capita beef demand.

Because there is error inherent in any statistical model, a 90% confidence interval is computed for the seven CBB demand-enhancing elasticities. This interval can be interpreted as the range of possible values where one can be confident that the true population elasticity could be expected to fall 90% of the time. The 90% confidence interval for the generic beef

advertising, CBB public relations, channel marketing, and industry information is (0.011, 0.025). The 90% confidence interval for the new product development and product enhancement research elasticity is (0.003, 0.021). The confidence interval for the food safety marketing elasticity is (0.003, 0.015). The 90% confidence interval for the nutritional research elasticities is (0.007, 0.019). Because none of the lower bound estimates is zero or negative, this provides statistical confidence that all CBB activities have a positive and statistically significant impact on per capita beef demand.

The demand model is simulated over the entire sample by setting all independent variables equal to historical levels to determine how well *predicted* coincided with *actual* per capita beef demand from 2006 through 2013. The average prediction error (mean absolute percentage error) is only 2.78%, which indicates the model has a high degree of accuracy. A second-set of counterfactual scenarios is simulated with the demand model to determine the impact of the eight categories of domestic demand-enhancing CBB activities. Each scenario is identical to the baseline, except that CBB expenditures are reduced to 1% of historical levels of the specific CBB activity in order to determine how it impact domestic demand. Specifically, the following nine scenarios are simulated:

1. No CBB beef advertising,
2. No CBB public relations,
3. No CBB channel marketing,
4. No CBB beef safety research,
5. No CBB nutritional research,
6. No CBB new product development marketing,
7. No CBB producer information marketing,

8. No CBB product enhancement research, and

9. No CBB activities at all.

Total domestic beef demand is simulated for each of these nine scenarios and compared with the baseline scenario to determine the impact of CBB activities on total domestic market demand.

The results of the simulation clearly show the CBB's positive impact on domestic beef demand. From 2006 to 2013, all CBB's promotion and research activities increased total domestic beef demand by 15.7 billion pounds in total, or 2.1 billion pounds per year. This represents an annual increase in domestic beef demand of 11.3 percent. In other words, had there been no CBB activities over the period 2006-2013, domestic beef demand would have been 11.3% lower than it actually was. Hence, the efforts of the CBB clearly have a positive and substantial effect on domestic beef demand.

The following are the impacts of the specific eight CBB programs on domestic beef demand:

1. Had there been no generic beef advertising by the CBB, domestic beef demand would have been 0.7% lower over this period than it actually was;

2. Had there been no CBB channels marketing, domestic beef demand would have been 0.6% lower over this period than it actually was;

3. Had there been no CBB industry information marketing, domestic beef demand would have been 0.2% lower over this period than it actually was;

4. Had there been no CBB new product development, domestic beef demand would have been 1.2% lower over this period than it actually was;

5. Had there been no CBB public relations, domestic beef demand would have been 0.5% lower over this period than it actually was;

6. Had there been no CBB nutritional research, domestic beef demand would have been 3% lower over this period than it actually was;

7. Had there been no CBB beef safety research, domestic beef demand would have been

2.1% lower over this period than it actually was; and

8. Had there been no CBB product enhancement research, domestic beef demand would have been 0.4% lower over this period than it actually was;

Note that the percentage impacts of these seven individual activities sum to less than 11.3% indicating that there are positive synergistic impacts of these activities collectively.

The retail beef supply model is estimated in logarithmic form with monthly data from 2006 through 2013. The elasticities are summarized in Table 2. The coefficient of determination indicates that the explanatory variables explain over 65% of the variations in monthly retail supply of U.S. beef. The elasticity signs are consistent with economic theory and all estimated coefficients are statistically significant at the 6.5% significance level or better. Several econometric diagnostic tests performed indicate no statistical problems with the model.

Table 2. Retail beef supply elasticities.[a]

Supply Factor	Elasticity	P-value
Retail beef price	**0.083**	0.065
Steer price	**-0.083**	0.065
Time trend	**-0.032**	0.000

[a] Coefficients in bold indicates statistical significance from zero (p-value under 0.1 or better).

Since an output (beef price) to input (steer price) ratio is specified, the own price elasticity and the input price elasticity are the same in absolute value. The results indicate that the own-price elasticity of supply is 0.083. That is, holding all other supply factors constant, a 1% increase in the retail beef price results in a 0.083% increase in quantity supplied by beef retailers. The impact of the steer price is exactly the negative of the retail price impact. Both results indicate that retailers of beef are not very responsive to changes in either the main output or input price.

The trend variable is negative and statistically significant for the period 2006.1 through 2013.12. Rather than picking up the effects of technology on supply, the trend variable may be picking up increases in other retailing costs such as energy prices.

Beef Export Demand Model

Similar to Dwyer (1995) and Global Insight, Inc. (2006 and 2009), an Armington-type market share trade model (Armington, 1969) is used to model the impact of U.S. beef export promotion expenditures on U.S. market share for beef. The model measures export demand in terms of the U.S. share of the export market. The Armington model distinguishes commodities by type and source of origin. Thus, similar products produced in different countries are assumed to be imperfect substitutes. The model is based on a two-step budgeting procedure commonly used in consumer theory. In the first stage, consumers allocate expenditures to a group of commodities, while in the second stage, expenditures are allocated to individual commodities within a group. In context of the Armington trade model, an importer first decides how much of a particular commodity to import and then decides the share to import from each country.

Panel data from seven countries/regions and annual observations from 1995-2013 are used to estimate the Armington model. The seven regions include: Mexico, Japan, Russia, China combined with Hong Kong, Taiwan, European Union (29 countries combined), and South Korea. Collectively, these countries comprise 77% of total U.S. beef exports. Hence, there are 133 observations in total (7 times 19). The following export demand determinants are included to ascertain their impacts on U.S. beef market share:

1. U.S. beef market share in the previous year;
2. Gross Domestic Product in each importing country,
3. Annual real exchange rate per U.S. dollar for U.S. agricultural trade constructed by the Economic Research Service, USDA,

4. Total annual foreign market development expenditures (CBB, U.S. Meat Export Federation (USMEF), and USDA/Foreign Agricultural Services (FAS) combined) in each importing country.[4]

Mathematically, the beef Armington trade model is represented by the following equation:

$$\ln(MS_{it}) = \alpha_0 + \alpha_1 \ln(MS_{it-1}) + \alpha_2 \ln(ER_{it}) + \alpha_3 \ln(GDP_{it}) + \alpha_4 \ln(EXPROM_{it}) + \alpha_4 BSE_{it}$$

where: MS_{it} is U.S. beef market share of imports in country i period t, ER_{it} is the exchange rate of the U.S dollar to country i's currency in period t, GDP_{it} is Gross Domestic Product in country i period t, $EXPROM_{it}$ is combined export promotion expenditures to country i period t, and BSE_{it} is a dummy variable equal to 1 for 2004, 2005, and 2006 and 0 otherwise and is included to capture the negative effects of the bovine spongiform encephalopathy (BSE) outbreak on U.S. beef exports. In this equation, "ln" is the natural logarithmic operator, and the αs are the coefficients to be estimated with statistical regression analysis. All monetary variables such as GDP and EXPROM are deflated by each country's consumer price index to account for the effects of inflation over time. Hence, all monetary variables are expressed on a "real", inflation adjusted, rather than nominal basis.

The lagged market share variable is included to reflect rigidities in international trade; i.e., U.S. trade share in one year should be positively correlated with trade shares in the previous year[5]. Accordingly, it is hypothesized that the sign of the estimated coefficient would be

[4] Expenditures by USMEF, CBB and FAS are used for a variety of activities in foreign markets designed to enhance U.S. export meat demand including advertising, promotion, trade servicing, technical assistance, and other activities. In this report, I use the term "foreign market development" as short hand for all these activities, and they are combined into one variable.

[5] Specifically, the lagged dependent variable in the model is included in the model to account for dynamics. In the framework of a partial adjustment model if $\alpha_1 = 0$, market adjusts fully to any changes in price in the current period. On the other hand if $0<\alpha_1<1$ the period of adjustment is longer than one year, and the adjustment occurs in a geometrically declining manner (Nerlove, 1958; Giliches,1967).

positive. This technique, is also called a partial adjustment model, allows for the calculation of short-run effects (i.e., one year) and long-run effects (i.e., longer than one year). As Dwyer (1995) pointed out, this characteristic is especially important in international trade for several reasons:

> "First, importing firms (wholesalers, distributors, etc) in other nations adjust their purchases *gradually over a period of years* in response to changes in export prices or exchange rates. This is because they are unsure whether the changes are temporary or permanent which would affect their decision on how much to adjust their prices to the next link in the distribution chain (the "sticky price" effect). The rate of adjustment can and should be measured so long run importer responses to these changes can be better understood. Second, partial adjustment models help explain the distributed lag effect that export promotion has on market share. Previous research indicates the effects of promotion on market share extend beyond the period of initial expenditure, sometimes well beyond the initial period. FAS has long held the view that its partnership with agricultural organizations in carrying out foreign market development (whether it be FMD or MPP/TEA) is intended to boost long-term demand for U.S. products. In this sense, it is an investment whose benefits are fully realized over a period of years, not months. Therefore, FAS sponsored export promotions like MPP are expected to have a distributed lag effect on U.S. market share. Modeling that effect is vital to achieving our stated objective of quantifying the short and long-run impact of MPP on exports." (Dwyer, 1995, page 6)

The U.S. exchange rate variable, ER, is included to measure the impact of the value of the U.S. dollar on U.S. beef market share in each importing country.[6] The coefficient for the ER variable is expected to be negative, because a stronger U.S. dollar should weaken the U.S. market share of world trade. GDP in each importing country is expected to be positively related with U.S. market share. That is, as countries become wealthier, they demand more U.S. beef products. Hence, U.S. beef is what economists referred to as a "normal good" meaning demand increases with income.

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[6] An earlier import demand model was estimated using the U.S. beef price and the rest-of-the world beef price in each importing country as explanatory variables. However, the results were highly statistically insignificant due to a very high correlation between these two independent variables. Hence, the Armington model was adopted and the exchange rate variable was used instead of the price variables.

Finally, unlike the majority of past export promotion studies, which only incorporated FAS expenditures, this analysis used combined FAS and cooperator expenditures (CBB and USMEF). Similar to Dwyer (1995), promotion expenditures were multiplied by the exchange rate variable, ER, to reflect the impact of the relative value of the U.S. dollar on promotion effectiveness[7]. This variable is then deflated by dividing it by the world price deflator to express promotion expenditures in real terms to account for any loss in purchasing power due to inflation.

There is no explicit price variable included in the model. However, using the ER variable can be interpreted broadly as a *de facto* measure of the U.S. price relative to other countries' prices. The ER variable reflects the value of the U.S. dollar relative to other countries' currencies. Hence, any changes in the value of the U.S. dollar are similar to a change in the relative U.S. price. Dwyer (1995) and Global Insight, Inc. (2006 and 2010) used an identical approach, and argued "where price is not explicitly modeled, including exchange rates as a proxy for price behavior would seem appropriate." (page 9)

The following data sources are used for the variables: market share of U.S. beef imports in each country and annual beef USDA/FAS and USMEF come from USMEF, a contractor to the beef checkoff, CBB export promotion expenditures come from the CBB, and GDP, ER, and CPI come from the international macroeconomic data set of the Economic Research Service, USDA.

Econometric Results. The Armington model is estimated in logarithmic form with annual data from 1985 through 2013 and the seven countries. The elasticities are summarized in Table 3. The R-squared indicates that the explanatory variables explain over 86% of the variations in U.S.

[7] It is assumed that the strengthening of the U.S. dollar decreases the effective cost of U.S. promotion.

beef market share. The elasticity signs are consistent with economic theory and all estimated coefficients, except the one for GDP which is marginally significant, are statistically significant at better than the 1% significance level. Several econometric diagnostic tests performed indicate no statistical problems.

Market share in the previous year is a significant determinant of market share of U.S. beef in the current year. The results indicated that one-year lagged market share had an elasticity or partial adjustment coefficient of 0.329. That is, a 1% increase in market share of U.S. beef in the previous year increased U.S. market share in the current year by 0.329% holding all other factors constant. This estimate is used to derive the long-run elasticities by using the following formula:

Long-run elasticity = (1/(1-0.329)) short-run elasticity (SRE)= 1.49 SRE.

The value of the U.S. dollar has the most important impact on U.S. beef market share. The short- and long-run elasticities estimate are -0.644 and -0.961, respectively. That is, a 1% increase in the value of the U.S. dollar decreases U.S. beef market share by 0.644% in the short-run and 0.961% in the long-run, holding all other demand determinants constant.

GDP is positive indicating that U.S. beef is a normal good. The short- and long-run elasticities for GDP are 0.104 and 0.155, respectively. In other words, holding all other demand factors constant, a 1% increase in GDP results in a 0.104% increase in market share of beef exports in the short-run and 0.155% in the long-run.

The results clearly indicate that the BSE incident in 2004 in Washington State had a decimating impact on U.S. beef export market share in 2004, 2005, and 2006. Over this three-year period, U.S. market share of world beef exports fell by 2.6 percentage points.

Table 3. Beef export demand elasticities.[a]

Demand Factor	Elasticity	P-value
Market share in previous year	**0.329**	0.000
GDP	0.104	0.155
Value of U.S. $	**-0.644**	0.000
BSE	**-2.558**	0.000
Beef foreign market development	**0.167**	0.000

[a] Coefficients in bold indicates statistical significance from zero (p-value under 0.1 or better). The non-bolded coefficient is not statistically significant from zero.

The statistical results indicate that U.S foreign market development programs have the effect of increasing market share of U.S. beef exports. The estimated results indicate that a 1% increase in foreign market development expenditures increase U.S. beef market share by 0.167% in the short-run and 0.249 in the long-run.

Because there is error inherent in any statistical model, a 90% confidence interval is computed for the foreign market development elasticity. This interval can be interpreted as the range of possible values where one can be confident that the true population promotion elasticity could be expected to fall 90% of the time. The 90% confidence interval for the elasticity is (0.100, 0.235).

The estimated Armington trade model is simulated for two scenarios to gauge the overall impact of CBB funds for export promotion on export demand. Recall that foreign market development programs comes from funds from three source: USDA/FAS, USMEF, and the CBB. An in-sample simulation is conducted for the past five years for two scenarios: (1) baseline scenario, where export promotion expenditures are set equal to historical levels, and (2) no-CBB contribution scenario, where CBB contributions to export promotion are eliminated.

Hence, the difference in outcomes of the two scenarios provides a measure of the impact of the CBB on U.S. beef exports.

Overall, the results indicate that CBB contributions to foreign market development for U.S. beef have a substantial impact on the export market. Over the period 2009-2013, CBB contributed $4.8 million per year, on average, to foreign market development programs to these seven countries. The average annual difference in total revenue from beef exports to these seven countries over this period is simulated to be $232 million per year. In other words, every dollar invested in export promotion by CBB yielded an increase in gross (before costs are netted out) beef export revenue of $48.39. In terms of breakdown by the seven countries, this return of 48.39:1.00 is as follows:

Japan	29.46:1.00	South Korea	26.12:1.00
Russia:	14.34:1.00	Mexico	124.78:1.00
Taiwan	29.14:1.00	China/Hong Kong	48.03:1.00
EU	16.32:1.00		

Based on the simulation results, CBB funds for export promotion to Mexico had the highest payout in additional export revenue followed by China/Hong Kong. The lowest return was in the Russia and the EU.

Equilibrium Displacement Model

The net benefits of each of the nine CBB activities are measured through simulation of an equilibrium displacement model (EDM) using a marginal analysis. That is, the endogenous variables in the model such as prices and quantities are simulated under two scenarios: (1) baseline scenario where all exogenous variables (e.g., CBB advertising expenditures) are set

equal to historical levels, and (2) counterfactual scenario, where CBB expenditures are increased by 1% above their historical levels. The endogenous variables are then determined under both scenarios to determine the impact of a 1% increase in expenditure levels on prices, quantities, and producer profits (producer surplus[8]). To compute the corresponding marginal benefit-cost ratio (BCR), the increase in producer surplus due to the 1% simulated increase in CBB expenditures was divided by the 1% increase in costs associate with each activity.

The EDM consists of seven equations and endogenous variables as follows (for simplicity, the only exogenous variables presented are for the nine CBB activities):

(1)	Qrd = f(RBP | BADV, FSAFE, CHANEL, PR, INDUST, NEWPROD, PRODENHANCE, NUTRES)	Retail beef demand
(2)	Qrs = f(RBP)	Retail beef supply
(3)	Qx =f (USP | EXPROM)	Export beef demand
(4)	Qfs = f(STEERP)	Farm supply
(5)	USP = f(RBP)	Export price-retail price linkage
(6)	Qrs = Qrd + Qx	Market clearing condition
(7)	Qfs = □Qrs	Farm to retail conversion

where the seven endogenous variables are defined as follows: Qrd is retail beef demand, Qrs is retail beef supply, RBP is retail price for beef ($/lb.), Qx is export beef demand, USP is the U.S. unit value (export price) for beef product exports ($/lb.), Qfs is commercial farm beef supply, and STEERP is the farm beef price ($/cwt.). Since a farm beef supply equation is not estimated in this study, the own price elasticity of beef supply is taken from a previous study by Marsh, who estimated an intermediate (i.e., 18-month) own supply elasticity for beef to be 0.61. That is, a 1% increase in the beef price would lead to a 0.61% increase in quantity supplied of beef over

[8] Producer surplus is a measure used by economists that is similar to profitability or net revenue. Technically, it is defined as the total revenue (price times quantity sold) minus the area of the supply curve under the price.

an 18-month period. The export price-retail price linkage equation is estimated using annual data from 2006-13 and is the following:

$$USP = 0.078 + 0.556\ RBP$$
$$(0.14)\ \ (4.64) \qquad R^2=0.78$$

where values in parentheses are t-values and R^2 is the coefficient of determination.

The exogenous variables are defined as follows: BADV is beef generic advertising expenditures, FSAFE is CBB expenditures on food safety research, CHANEL is CBB expenditures on channels marketing, PR is CBB expenditures on public relations, INDUST is CBB expenditures on industry information, NEWPROD is CBB expenditures on new product development, PRODENHANCE is CBB expenditures on product enhancement research, NUTRES is CBB expenditures on nutritional research, EXPROM is CBB expenditures on foreign market development, and □ is a conversion factor from farm to retail quantity. The EDM transforms these seven equations by taking the logarithmic differential of each equation, setting them equal to zero, and then solving the seven equations for the seven endogenous variable values.

The EDM is a static model that assumes instantaneous adjustment. The crucial parameters to the model are the own price elasticities of demand and supply and the elasticities for the nine CBB activities. In the EDM, the estimated coefficients from the econometric model are used. For variables that had a carry-over effect such as food safety research, the sum of the current and lagged coefficients are used.

The EDM is simulated for the most recent 7-year period, 2006-2013. The focus here is on computing a marginal BCR, which is based on a small change (1%) between two equilibrium levels.

Simulation Results. How do these marginal benefits compare with the marginal costs? To answer this question, the following BCR is computed for each CBB activity:

BCR = □PS/□Costs

where: □PS is the chang

increase in the CBB activity, and □Cost is the respe

marginal BCRs for the CBB activities and the overall combined return.

The highest marginal BCRs are for product enhancement research, nutritional research, industry information, and beef safety research. Based on the period 2006-13, an extra dollar invested in product enhancement research, nutritional research, industry information, and beef safety research yielded an extra $43.00, $29.70, $27.90, and $22.70, respectively in producer surplus (i.e., incremental profit). Clearly if the CBB had an additional dollar to spend on activities, these would be its highest priorities based on these very high marginal BCRs. The next highest return is for new product development, where an extra dollar invested in it earned $19.90 in incremental producer surplus. Foreign market development and PR are the next two highest marginal BCRs. An extra dollar invested in foreign market development and PR yielded $14.20 and $12.70 in incremental producer surplus. Finally, beef advertising had marginal BCRs of 6.4. It should be noted that there is generally an inverse relationship between the amount of money spent on a promotion or research activity and its marginal BCR, i.e., the greater the budget for an activity, the lower its marginal BCR. This is due to what economists refer to as "diminishing returns" which means as more and more money is spent on an activity, the marginal or incremental gains from it increase at a decreasing rate. This concept helps explain why the CBB activity with the lowest expenditures (product enhancement research) has the

highest marginal BCR, while the activity with the highest investment (advertising) has the lowest marginal BCR.

Table 4. Marginal benefit-cost ratios for CBB activities.

CBB Marketing Activity	Marginal benefit-cost ratio
Generic beef advertising	6.4
Public relations	12.7
Beef safety research	22.7
Channels marketing	10.6
Industry information	27.9
New product development	19.9
Nutritional research	29.7
Product enhancement research	43.0
Foreign market development	14.2
All activities combined	11.2

Collectively, the overall marginal BCR for all CBB activities is $11.20. Hence, the CBB has a very high marginal BCR for its activities over the period 2006-13. All of these numbers presented are “point estimates,” which are estimates rather than exact measures. That is, there is uncertainty about the precision of these estimates and therefore it is useful to construct confidence intervals around these point estimates. The confidence intervals give a lower and upper bound to the point estimate where one can be reasonable confidant that the true measurement lies. It is especially important to estimate the lower bound confidence interval for the BCR, which is done and the results are presented in Table 5.

All lower bound estimates for the marginal BCR for CBB activities are well above 1.0. For all activities combined, the lower bound estimate is 6.3. Hence, this provides additional

empirical evidence that the CBB checkoff program has been a highly profitable venture for beef producers.

Table 5. Lower bound for 90% confidence interval for marginal BCRs.

CBB Marketing Activity	Marginal BCR lower bound conf interval
Generic beef advertising	4.0
Public relations	7.9
Beef safety research	8.3
Channels marketing	6.6
Industry information	17.4
New product development	4.2
Nutritional research	9.0
Product enhancement research	15.9
Foreign market development	8.5
All activities combined	6.3

Optimal Allocation of Domestic CBB Activities[9]

Kinnucan and Thomas (1997) derive the optimal condition for allocation of checkoff activities. The condition is that the share of the fixed total checkoff budget should equal the elasticity for that activity divided by the sum of all checkoff activity elasticities. So, for example, the domestic demand elasticity for advertising is equal to 0.018, while the sum of all CBB elasticities is equal to 0.118. Hence, the optimal share of the CBB budget devoted to advertising over the period

[9] Foreign market development is not included in this analysis since its elasticity was derived from a completely different type of model than the domestic demand model and with different type data. Specifically, the domestic demand model used monthly time series data while the foreign Armington model used annual time series coupled with cross sectional data. Hence, the estimated elasticities are not perfectly comparable between the two models.

2006-2013 should have been 15.25% (i.e., 0.018/0.118). That is, 15.25% of the entire CBB budget should be devoted to advertising.

Figure 10 shows the actual CBB budget shares for all domestic activities for 2006-13. Advertising comprised the largest portion of the budget with 34%, followed by channels marketing (20%) and PR (17%). Industry information (8%) and new product development (7%) were the next largest components of the CBB budget. Finally, beef safety research (5%), nutritional research (5%), and product enhancement research (4%) were the smallest budget shares.

Figure 11 shows what the optimal allocation would have been over this period based on the Kinnucan-Thomas optimal condition. Recall that this is an overall average for the entire period of 2006-13. Figure 12 graphs the difference between the optimal and the actual budget shares, which provides a graphical way to view the difference between the optimal and actual budget shares. By far, the largest discrepancy between the optimal and the actual budget is advertising. The optimal budget share is significantly smaller than the actual by a difference of 18.5 percentage points. The optimal solution suggests reducing advertising substantially.

The optimal model also shows a smaller budget share for channels marketing (15%) compared with the actual budget share (20%). The optimal and actual budget allocations for public relations, beef safety research, and new product development are very close suggesting the actual allocation is near optimal for these activities. While the optimal solution recommends reducing advertising and channels marketing, it recommends increasing industry information (by 7 percentage points), product enhancement research (by 6.4 percentage points), and nutritional research (by 5.6 percentage points).

Figure 10. Actual allocation of CBB budget across activities

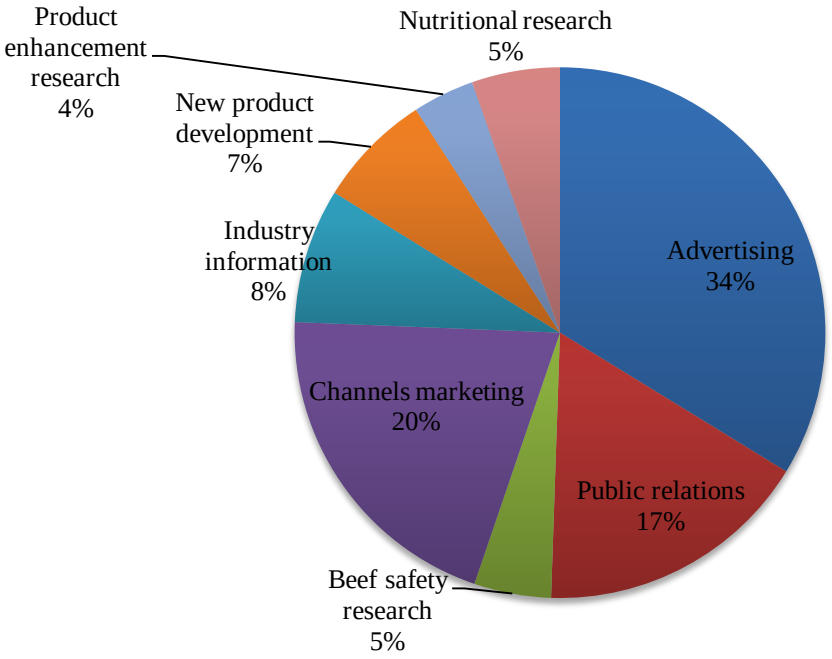
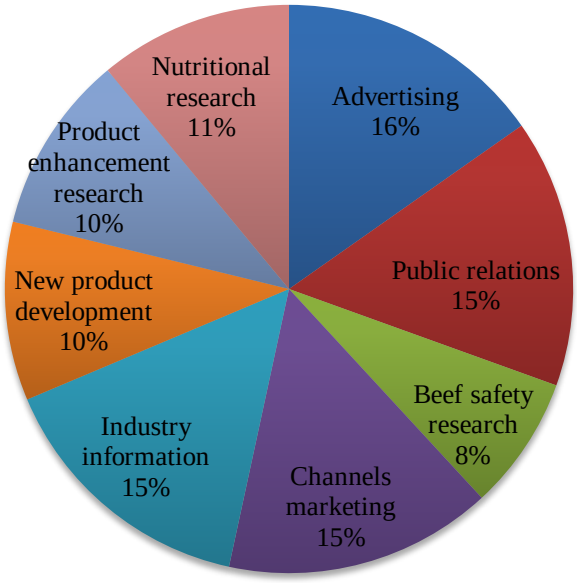
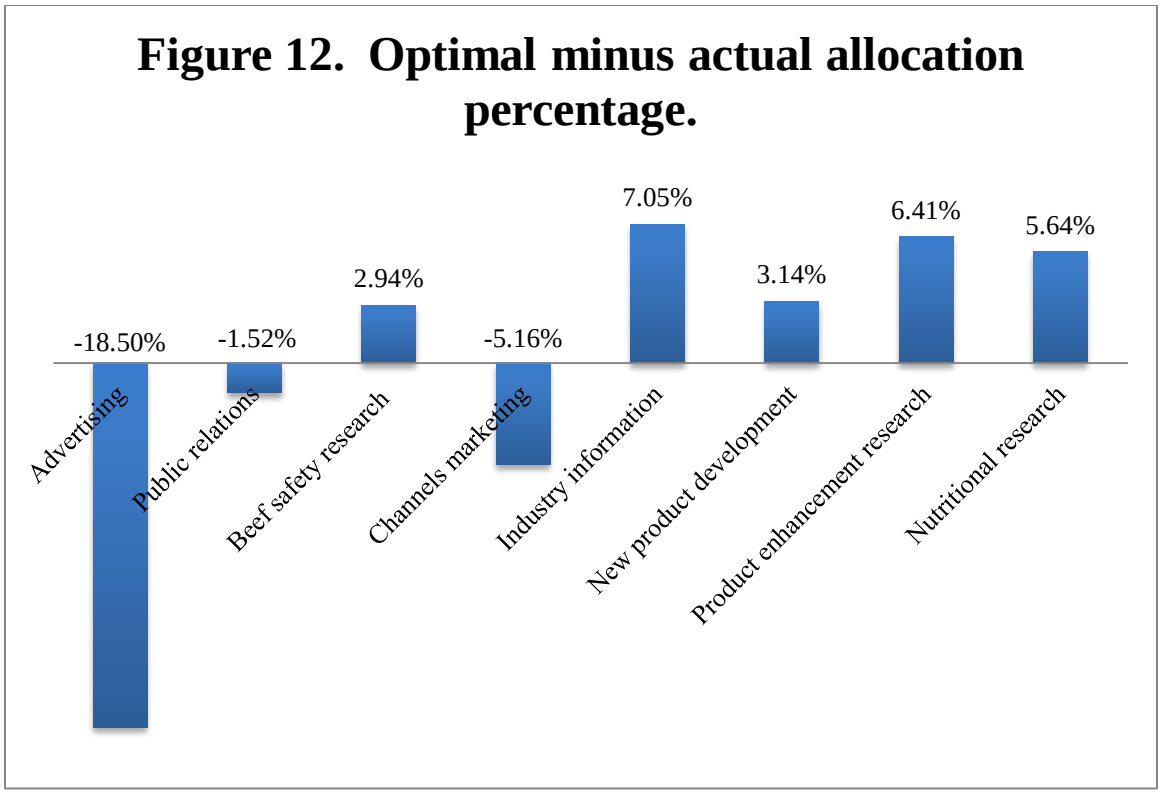


Figure 11. Optimal allocation of CBB activities.





Summary and Conclusions

In this study, an independent evaluation was conducted of the economic effectiveness of the programs funded by the Cattlemen's Beef Promotion and Research Board (CBB), which has a central mission to increase the demand for beef through implementing consumer advertising, marketing partnerships, public relations, educational programming, research, and new product development.

More specifically, this research addressed three important objectives:

1. Quantify and measure the economic benefit to cattlemen of CBB-funded programs for the period 2006-2013 in terms of net return on investment.
2. Quantify and compute marginal rates of return on investment for alternative existing and

potential checkoff-funded activities.

1. Estimate the optimal allocation of the CBB budget across the various program activities.

In this study, the impacts of all factors affecting domestic and export beef product demand for which data were available were measured statistically. In this way, the analysis netted out the impacts of other important factors besides CBB activities affecting beef demand over time. In addition, the value of the incremental sales generated by CBB activities was estimated. These benefits to beef producers were then compared with the costs associated with the CBB.

To carryout this research, three econometric equations were estimated, including: (1) retail domestic beef demand, (2) retail domestic beef supply, and (3) U.S. beef export demand. These three equations were used to test whether various activities by the CBB such as advertising, export market development and promotion activities, nutritional research, and other CBB activities had a statistically significant impact on beef demand.

The retail domestic beef demand model indicated that the own price elasticity was negative and equal to -0.431. The interpretation of this is a 1% increase in the retail consumer price index, holding all other demand factors constant, led to a 0.431% decrease in per capita beef quantity demanded. As expected, both chicken and pork products were found to be substitutes for beef with elasticities of 0.150 and 0.028, respectively. That is, a 1% increase in the chicken (pork) price, holding all other demand factors constant, resulted in a 0.15% (0.028%) increase in beef demand. Per capita disposable income was the most important demand determinant for beef demand. A 1% increase in per capita income resulted in a 0.691% increase in per capita beef demand, holding constant all other demand factors, indicating that beef is what economists refer to as a “normal good” - demand increases as consumer income increases.

Generic pork advertising was found to have a carry-over effect of one month and had a cumulative elasticity value of -0.0035. That is, a 1% increase in generic pork advertising decreased per capita beef demand by 0.0035% over a one-month period.

The statistical results indicated that all eight demand-enhancing domestic activities by the CBB had a positive and statistically significant impact on increasing per capita beef demand. Generic beef advertising, channels marketing, public relations, and industry information had a one-month carry over effect with a cumulative elasticity of 0.0181 meaning a 1% increase in their expenditures increased per capita beef demand by 0.0181%. New product development and product enhancement research each had an elasticity of 0.0118. Nutritional research and beef safety research had elasticites of 0.0132 and 0.009, respectively. All elasticities were statistically different from zero.

The domestic demand model was simulated from 2006 through 2013 by setting all independent variables equal to historical levels to determine how well *predicted* coincided with *actual* per capita beef demand. The average prediction error (mean absolute percentage error) was only 2.78%, which indicated the model had a high degree of accuracy. A second-set of counterfactual scenarios was simulated with the demand model to determine the impact of the eight categories of domestic demand-enhancing CBB activities. Each scenario was identical to the baseline, except that CBB expenditures were reduced to 1% of historical levels in order to determine how it impacted domestic demand. The results of the simulation clearly showed the positive impact on domestic beef demand due to the CBB's promotion programs. From 2006 to 2013, the CBB's promotion activities increased total domestic beef demand by 15.7 billion pounds in total, or 2.1 billion pounds per year. In other words, had there been no CBB-funded

domestic marketing activities over the period 2006-2013, domestic beef demand would have been 11.3% lower than it actually was.

In terms of the eight individual domestic CBB program areas and the one foreign market development activity:

1. Had there been no generic beef advertising by the CBB, domestic beef demand would have been 0.7% lower over this period than it actually was;

2. Had there been no CBB channels marketing, domestic beef demand would have been 0.6% lower over this period than it actually was;

3. Had there been no CBB industry information marketing, domestic beef demand would have been 0.2% lower over this period than it actually was;

4. Had there been no CBB new product development, domestic beef demand would have been 1.2% lower over this period than it actually was;

5. Had there been no CBB public relations, domestic beef demand would have been 0.5% lower over this period than it actually was;

6. Had there been no CBB nutritional research, domestic beef demand would have been 3% lower over this period than it actually was;

7. Had there been no CBB beef safety research, domestic beef demand would have been 2.1% lower over this period than it actually was;

8. Had there been no CBB product enhancement research, domestic beef demand would have been 0.4% lower over this period than it actually was; and

9. Had there been no CBB foreign market development expenditures, foreign beef demand would have been 6.4% lower than it actually was.

Note that the percentage impacts of the eight individual domestic activities summed to less than 11.3% indicating that there are positive synergistic impacts of these activities collectively.

The retail beef supply model indicated that the own price elasticity is 0.083. That is, holding all other supply factors constant, a 1% increase in the retail beef price resulted in a 0.083% increase in quantity supplied by beef retailers. By construction of the model, the impact of the steer price on retail beef supply was the exact opposite of the retail price impact, i.e., a 1% increase in the steer price resulted in a 0.083% decrease in retail beef supply, reflecting that the steer price is a major cost to beef retailers. The trend variable was negative and statistically significant, which has had a negative impact on retail beef supply. Rather than picking up the effects of technology on supply, the trend variable may have picked up increases in other retailing costs such as energy prices.

An Armington-type market share trade model (Armington, 1969) was used to model the impact of U.S. beef export promotion expenditures on U.S. market share for beef. The model measured export demand in terms of the U.S. share of the export market. The Armington model distinguishes commodities by type and source of origin. Based on the export demand model, the value of the U.S. dollar had the most important impact on U.S. beef market share in the world market. The long-run elasticity estimate was -0.961 indicating a 1% increase in the value of the U.S. dollar decreased U.S. market share of beef exports by 0.961%, holding all other demand determinants constant. GDP was positive indicating that U.S. beef is a normal good. The short- and long-run elasticities for GDP were 0.104 and 0.155, respectively. The results clearly indicate that the BSE incident in 2004 in Washington State had a decimating impact on U.S. beef export market share in 2004, 2005, and 2006.

The statistical results indicated that U.S. foreign market development programs had the effect of increasing market share of U.S. beef exports. The estimated results indicated that a 1% increase in foreign market development expenditures increased U.S. beef market share by

0.167% in the short-run and 0.249% in the long-run. The estimated Armington trade model was simulated for two scenarios to gauge the overall impact of CBB funds for export promotion. An in-sample simulation was conducted for the past five years for two scenarios: (1) baseline scenario, where export promotion expenditures were set equal to historical levels, and (2) no-CBB contribution scenario, where CBB contributions to export promotion were eliminated. Overall, the results indicated that CBB contributions to foreign market development for U.S. beef had a substantial impact on the export market. Over the period 2009-2013, CBB contributed $4.8 million per year, on average, to foreign market development programs to these seven countries. The average annual difference in total revenue from beef exports to these seven countries over this period was simulated to be $232 million per year. In other words, every dollar invested in export promotion by CBB yielded an increase in gross (before costs are netted out) beef export revenue of $48.39. In terms of breakdown by the seven countries, this return of 48.39:1.00 was as follows:

Japan	29.46:1.00	South Korea	26.12:1.00
Russia:	14.34:1.00	Mexico	124.78:1.00
Taiwan	29.14:1.00	China/Hong Kong	48.03:1.00
EU	16.32:1.00		

Based on the simulation results, CBB funds for export promotion to Mexico had the highest payout in additional export revenue followed by China/Hong Kong. The lowest return was in the Russia and the EU.

The net benefits of each of the seven CBB activities were measured through simulation of an equilibrium displacement model (EDM) using a marginal analysis. The EDM was simulated for the most recent 7-year period, 2006-2013. A BCR was computed based on the marginal

analysis, which measured the benefits to the industry in terms of additional profits from an extra dollar invested in each activity. The highest marginal BCRs were for product enhancement research, nutritional research, industry information, and beef safety research. Based on the period 2006-13, an extra dollar invested in product enhancement research, nutritional research, industry information, and beef safety research yielded an extra $43.00, $29.70, $27.90, and $22.70, respectively in producer surplus (i.e., incremental profit). Clearly if the CBB had an additional dollar to spend on activities, these would be its highest priorities based on these very high marginal BCRs. The next highest return was for new product development, where an extra dollar invested in it earned $19.90 in incremental producer surplus. Foreign market development and PR were the next two highest BCRs. An extra dollar invested in foreign market development and PR yielded $14.20 and $12.70 in incremental producer surplus. Finally, beef advertising had marginal BCRs of 6.4. It should be noted that there is generally an inverse relationship between the amount of money spent on a promotion or research activity and its marginal BCR, i.e., the greater the budget for an activity, the lower its marginal BCR. This is due to what economists refer to as "diminishing marginal returns" which means as more and more money is spent on an activity, the marginal or incremental gains from it increase at a decreasing rate. This concept helps explain why the CBB activity with the lowest expenditures (product enhancement research) had the highest marginal BCR, while the activity with the highest investment (advertising) had the lowest marginal BCR.

Collectively, the overall marginal BCR for all CBB activities was $11.20. Hence, the CBB has had a very profitable benefit-cost ratio for its activities over the period 2006-13.

Based on the domestic demand results, an optimal allocation of the eight CBB programs for the period 2006-13 was derived. The optimal rule is that the share of the fixed total checkoff

budget should equal the elasticity for that activity divided by the sum of all checkoff activity elasticities. So, for example, the domestic demand elasticity for advertising is equal to 0.018 while the sum of all CBB elasticities is equal to 0.118. Hence, the optimal share of the CBB budget devoted to advertising over the period 2006-2013 should have been 15.25% (i.e., 0.018/0.118).

Comparing the optimal solution to the actual budget allocation, the main divergence was that the model suggest allocating far less to advertising (16%) than the actual allocation (34%). The optimal model also reduced the budget share of channels marketing from 20% to 15% of the total budget. The optimal and actual budget allocations for public relations, beef safety research, and new product development were very close suggesting the actual allocation was near optimal for these activities. While the optimal solution recommended reducing advertising and channels marketing, it recommended increasing industry information (by 7 percentage points), product enhancement research (by 6.4 percentage points), and nutritional research (by 5.6 percentage points).

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