

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

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## Executive Summary

This research study has two central objectives:

1. To measure whether the CBB promotion, educational, and research activities increased consumption of beef products in the United States and foreign markets compared to what would have occurred in the absence of these activities.
2. To measure the benefits of the CBB activities in terms of incremental profitability for the entire industry and compare these benefits with the cost of the checkoff to compute a benefit-cost ratio (BCR) for its stakeholders.

To address these two objectives, 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 study finds that the CBB had a positive and significant impact on beef demand compared to what it would have been in its absence. Had there not been any domestic CBB demand enhancing activities over the latest 5-year period, 2014 through 2018, total domestic beef demand would have been 14.3% lower than it actually was. Similarly, had there not been any CBB contributions to the FAS and USMEF's foreign market development program over the past 5 years, U.S. beef export demand would have been 5.5% lower than it actually was in the eight foreign markets studied here.

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 marginal BCR 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 nine CBB activities (including foreign market development) is \$11.91. In other words, an extra dollar invested in CBB activities over the period, 2014-18, returned \$11.91 to beef industry producer profit.

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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 2019, the CBB had a budget of \$40.5 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. With almost \$1 billion spent on checkoff programs each year by U.S. farms and firms, the government wants stakeholders to have independent information on the effectiveness of these programs. 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.

### **Objective and Scope**

The primary purpose of this study is to provide an independent economic evaluation of the effectiveness and impacts of the CBB marketing and research programs over the past five years, 2014-2018. Specifically, this study has two general objectives:

1. To measure whether the CBB promotion, educational, and research activities increased consumption of beef products in the United States and foreign markets compared to what would have occurred in the absence of these activities.
2. To measure the benefits of the CBB activities in terms of incremental profitability for the entire industry and compare these benefits with the cost of the checkoff to compute a rate of return on investment of this campaign to its stakeholders.

To address these two goals, four important questions are addressed regarding the CBB marketing campaign:

1. What is the overall responsiveness of beef products demand to the CBB checkoff program?
2. What is the responsiveness of beef products demand to the specific CBB advertising, promotion, education, and research activities?

3. What is the overall marginal benefit-cost ratio (BCR) for the CBB checkoff program to the stakeholders of the program?
4. What are the marginal BCRs for the specific CBB advertising, promotion, education, and research activities?

In this study, the impacts of all factors affecting domestic and foreign beef product demand (“demand drivers”) for which data are available are measured statistically. In this way, we can net out the impacts of other demand drivers (e.g., retail beef price, exchange rates, consumer income, etc.) besides CBB demand enhancing activities affecting beef demand over time. In addition, the profitability of the incremental sales generated by CBB activities is estimated. The benefits (profits) 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. These benefits to beef producers are compared with the costs associated with the CBB. Based on the estimated impacts from the demand models, an overall marginal BCR and activity specific marginal BCRs are derived.

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 is a national and internationally renowned expert in the economics of generic advertising and promotion programs. Dr. Kaiser has extensive experience in conducting economic evaluation studies of domestic and international checkoff programs. Dr. Kaiser has written 135 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.

### **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 \$40.5 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. Product enhancement research,
8. Nutritional research, and
9. Foreign market development.

Figure 1 presents the total budget for these nine activities over the time period 2006-18. Because the budget is based on number of head of cattle, which has decreased since 2006, the budget has declined over this period. In 2006, these nine CBB activities totaled \$42.8 million and by 2018 it totaled \$36, which is a decline of 15.9%. Hence, the budget that the CBB operates has substantially declined since 2006 in nominal terms. Factoring in the impact of inflation on eroding these nominal expenditures, this decline is even more severe.

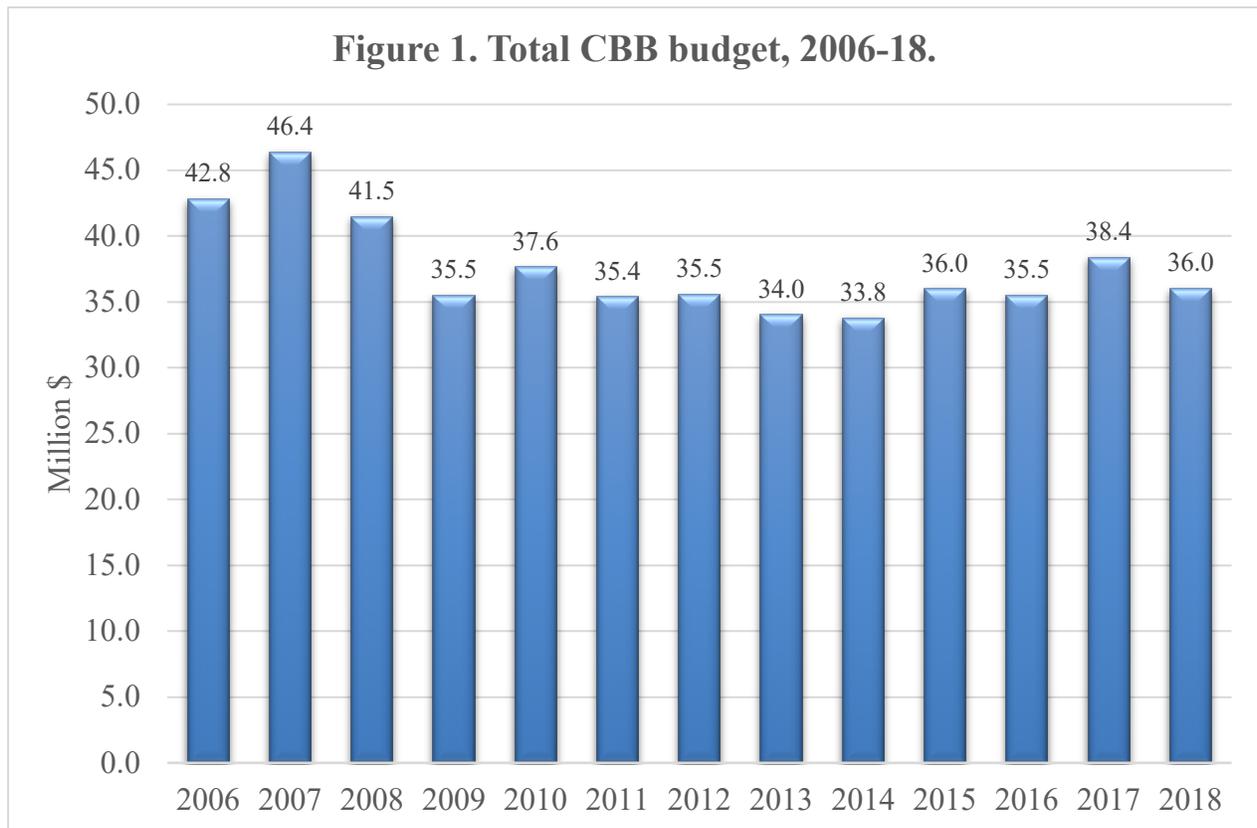
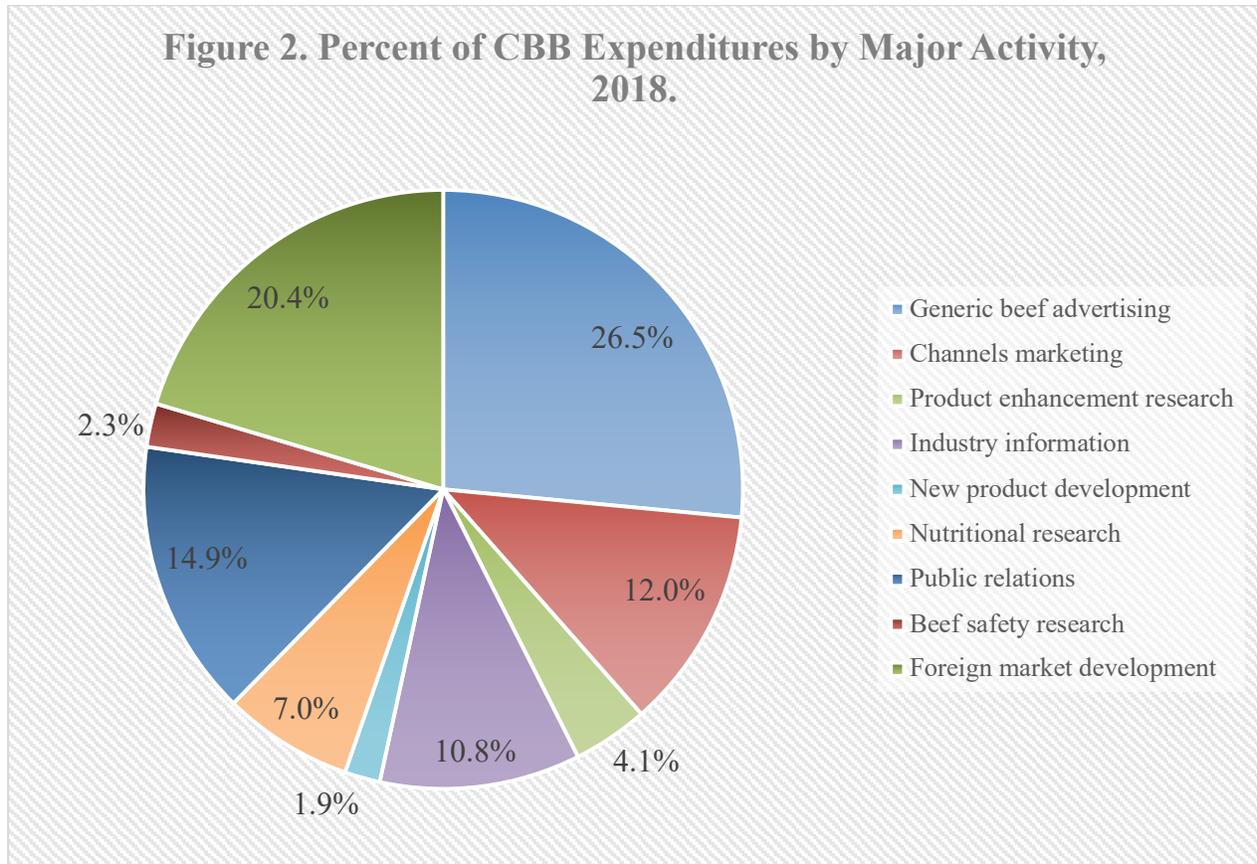


Figure 2 illustrates the percent of the 2018 CBB budget spent on each of these activities. In 2018, generic beef advertising expenditures was the largest category of the CBB budget, accounting for 26.5% of the spending. This was followed in importance by foreign market development activities (20.4%) and public relations (14.9%). CBB contributions to channels marketing activities represented 12% of the 2018 budget, while industry information comprised 10.8%. The remaining activities included new product development (1.9%) and nutritional research (7%), beef safety research (2.3%), and product enhancement research (4.1%). The relative magnitudes of these activities have varied over time.

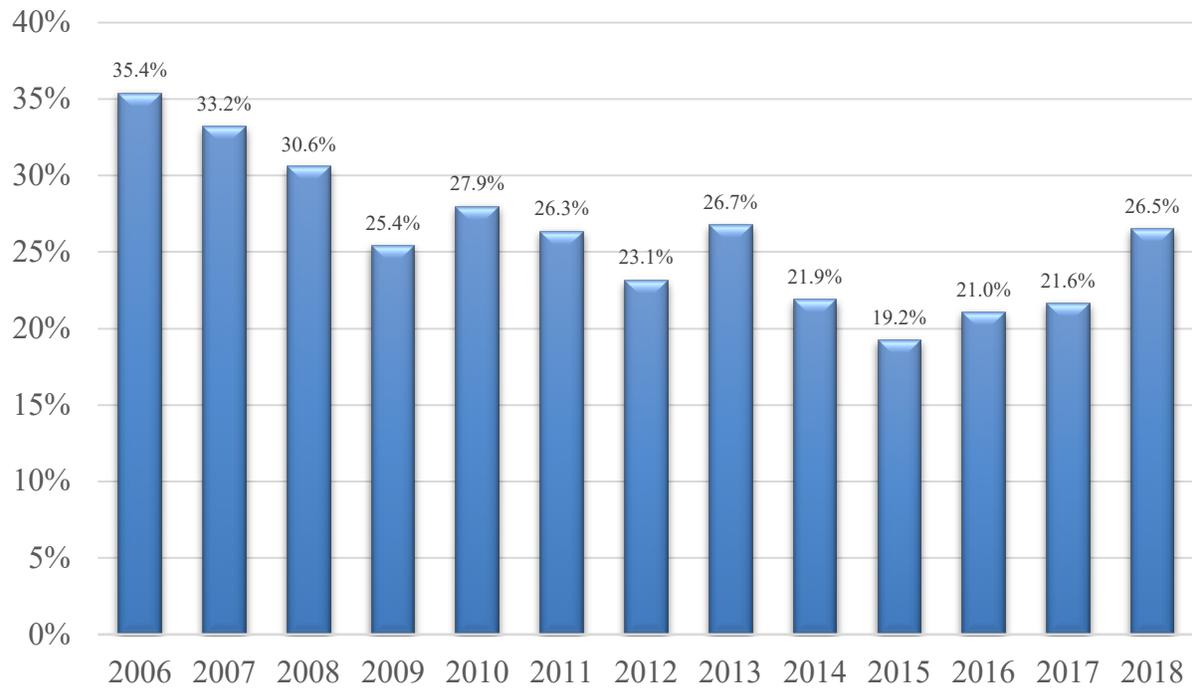
Figure 3 displays annual generic beef advertising expenditures as a percentage of the total



CBB budget for 2006 through 2018. These expenditures are devoted to all domestic media advertising such as radio, print, outdoor, and web advertising. Similar to other checkoff programs, the CBB has fairly consistently decreased their reliance on generic advertising over time. For example, in 2006, the CBB devoted 35.4% of their budget on advertising. By 2018, this share decreased to 26.5%. Hence, while advertising is still the most important activity by the CBB, it has declined somewhat. However, in recent years, i.e., since 2015, the CBB has increased the share of the budget devoted to advertising, increasing from 19.2% to 26.5%.

Figure 4 presents CBB contributions to foreign market development programs as a percent of the total budget from 2006-2018. 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 2018, the U.S. exported about 2.7 billion pounds of beef (commercial carcass weight) which represents 13% of the total supply of U.S. beef. There has been a steady positive trend over this period in this category of activities. In 2006, the CBB invested 9.7% of its budget into this activity, and by 2018 it comprised 20.4% of the CBB budget.

**Figure 3. Beef advertising as a percent of CBB budget, 2006-18.**



**Figure 4. Foreign market development as percent of CBB budget, 2006-18.**

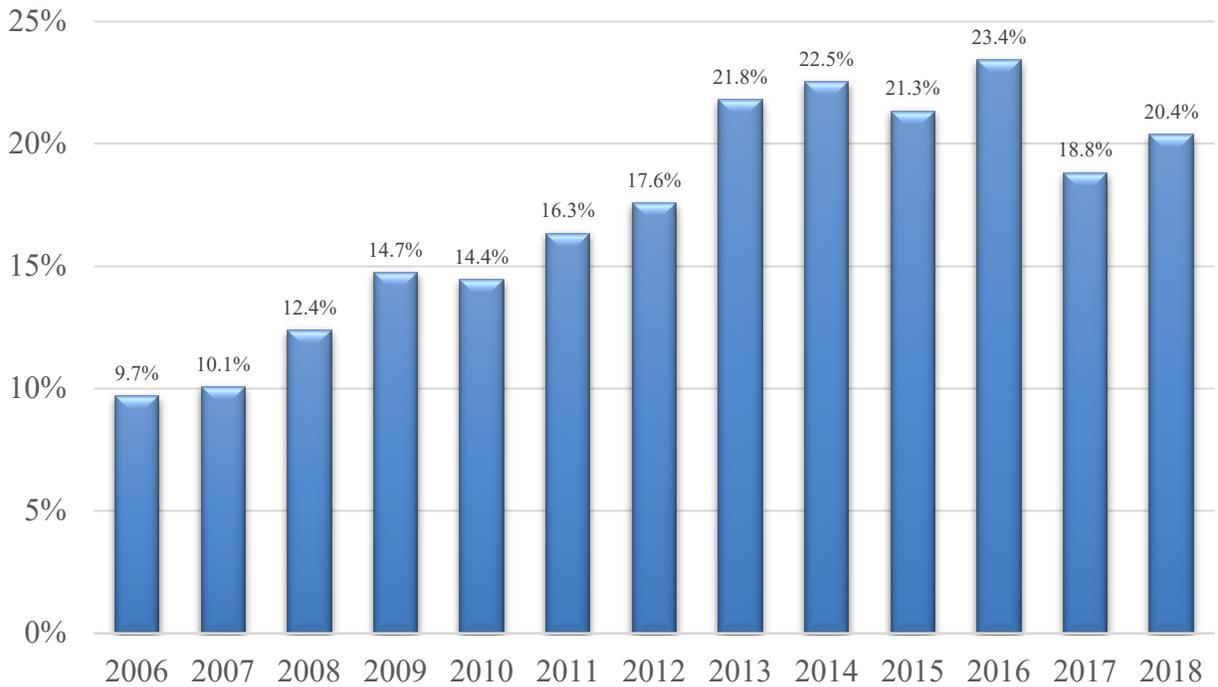


Figure 5 shows CBB expenditures on channels marketing as a percentage of their total budget from 2006-13. This category includes all programs that support beef promotion and marketing in retail and foodservice. This category has declined over time. In 2006, CBB invested 18.5% of its budget in channels marketing, and by 2018 this had declined to 12%.

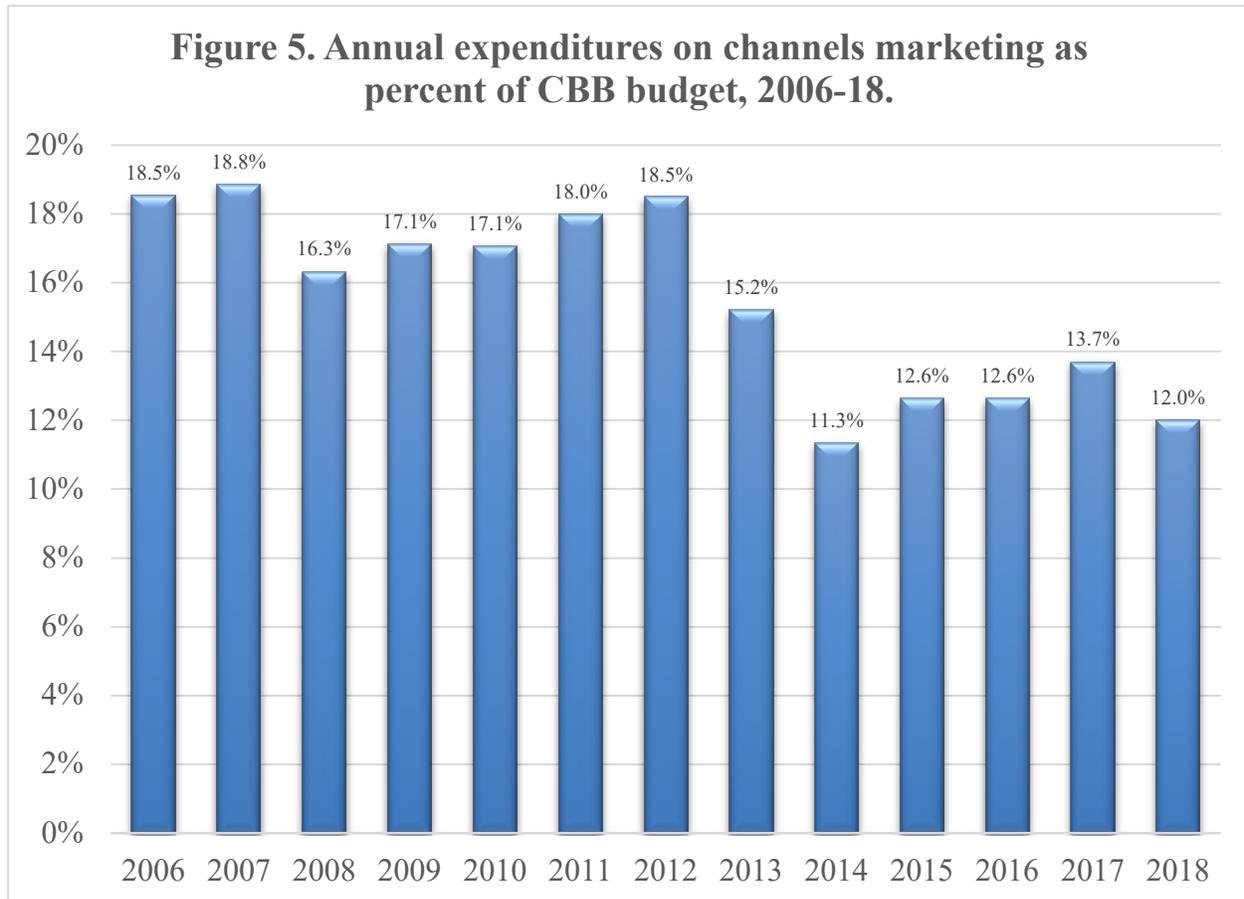
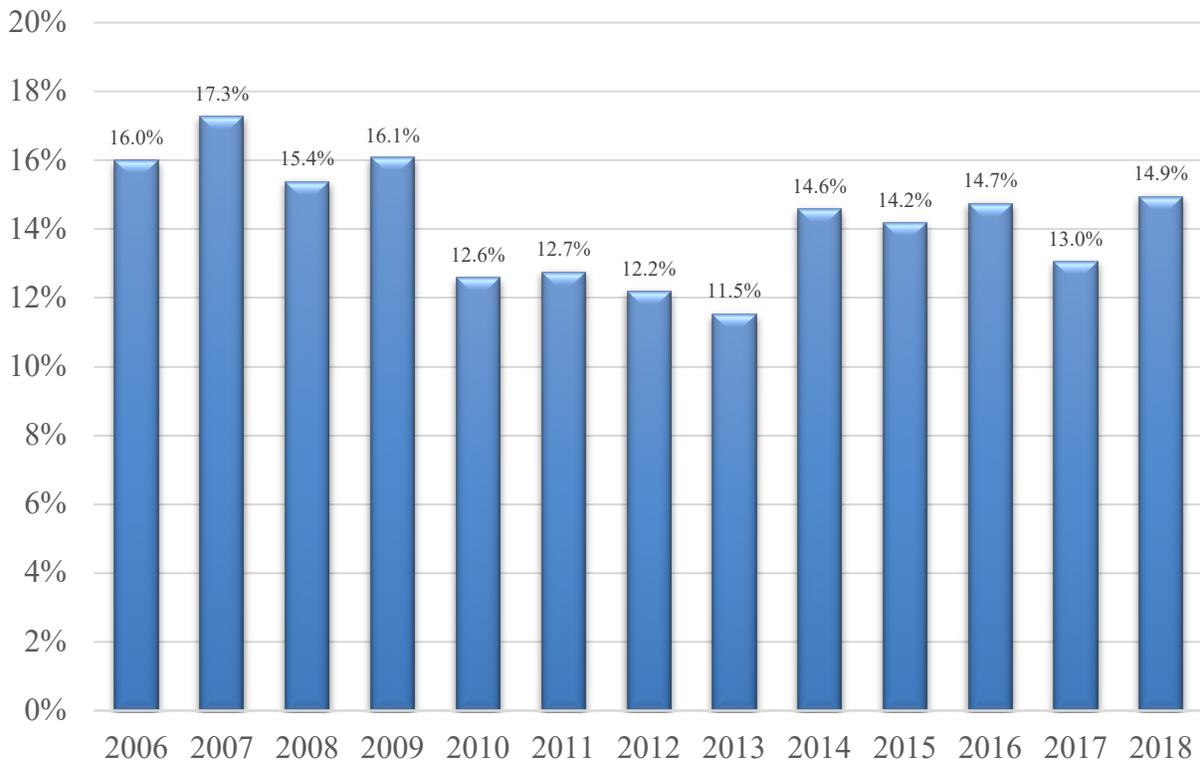


Figure 6 presents CBB expenditures on public relations as a percent of the total budget. Public relations (PR) include all CBB activities that proactively share positive beef messages with consumers. PR is one of the most commonly used marketing strategies by checkoff programs and other firms in the United States. PR expenditures have declined slightly over time from 16% in 2006 to 14.9% in 2018. However, in the past five years, the CBB has devoted a fairly consistent share of the budget to PR.

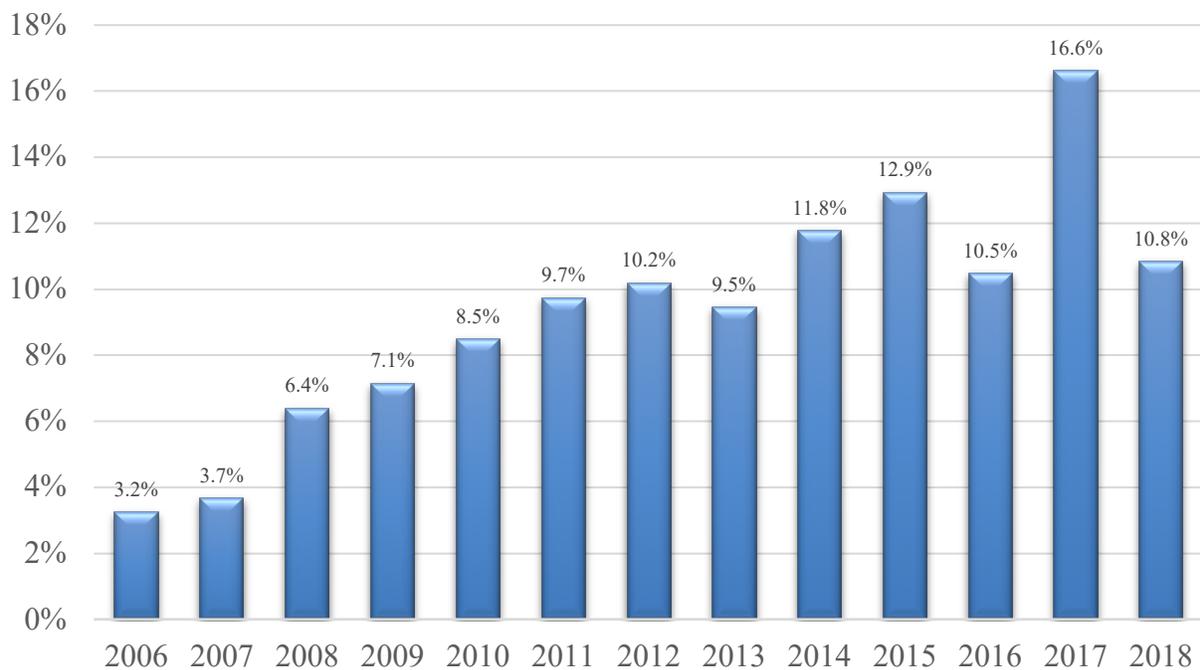
One category that CBB has substantially increased spending on is industry information. This category includes all programs that focus on sharing information with consumers on industry specific information (this can include topics such as animal care and handling, production technology, etc). As illustrated in Figure 7, in 2006, the CBB spent just 3.2% of its budget industry information and by 2018 this category almost tripled to 10.8%.

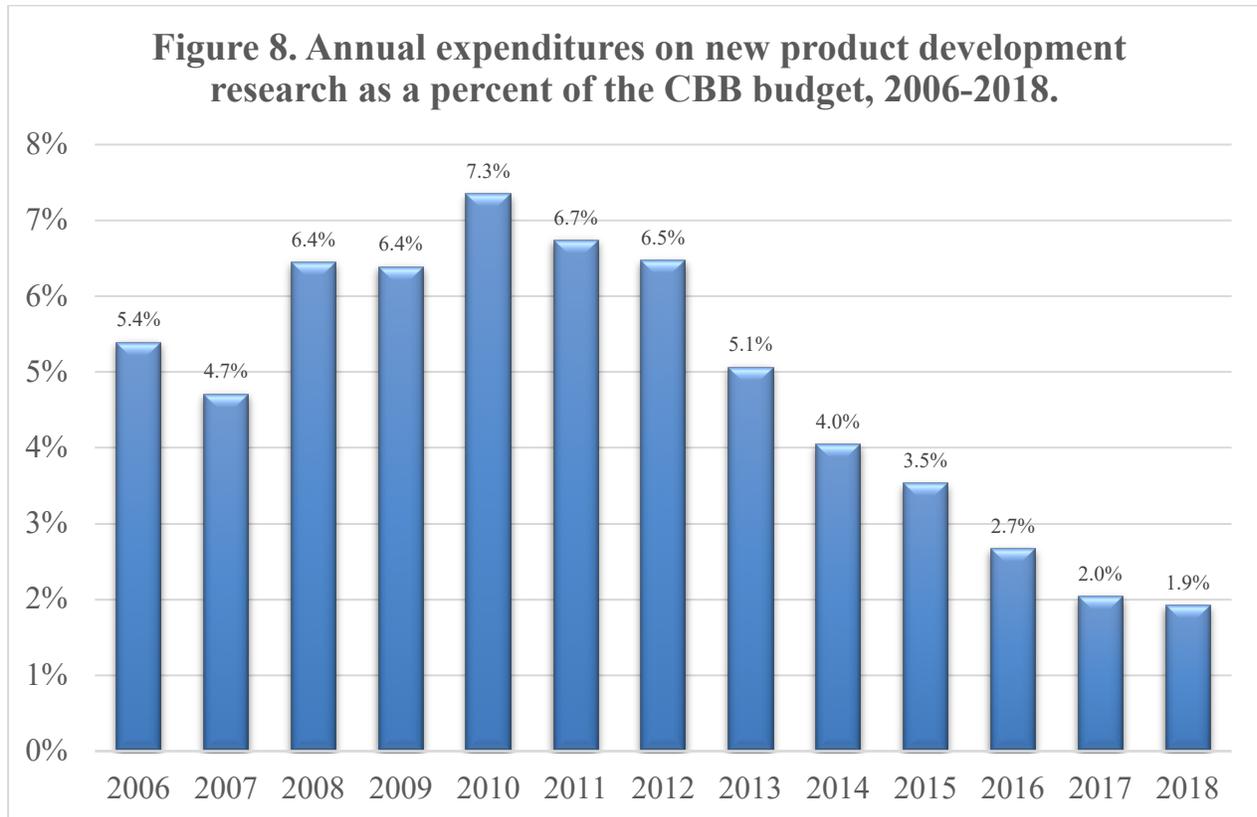
Figure 8 shows CBB expenditures on new product development as a percent of its total

**Figure 6. Annual expenditures on public relations as percent of CBB budget, 2006-18.**



**Figure 7. Annual expenditures on industry information as percent of CBB budget, 2006-18.**





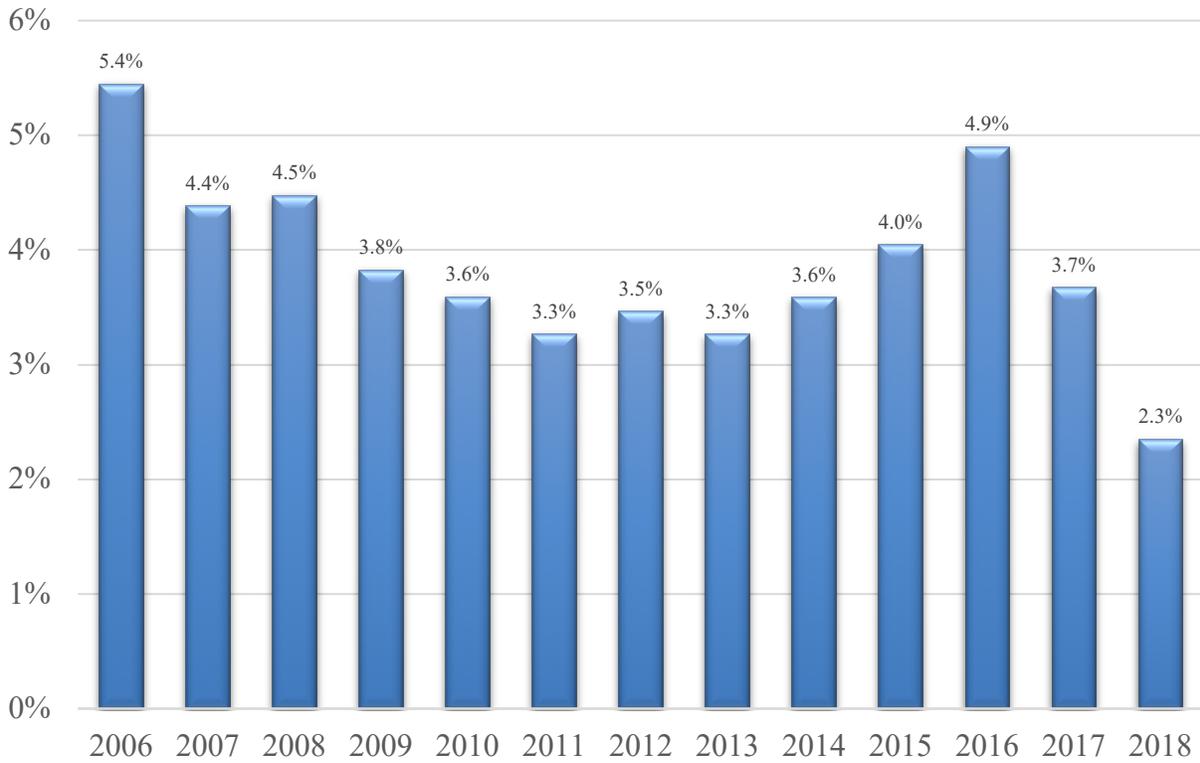
budget over this time period. This category includes new product and culinary development to bring new, relevant beef culinary techniques, recipes, and cookery for existing and newly identified beef cuts to consumers (including retail, foodservice and direct to consumer). Expenditures in this category reached a high of 7.3% of the CBB budget in 2010, but has since then consistently declined. In 2018, this category represented 1.9% of the budget.

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 safety as it relates to beef and beef products. Since 2006, CBB expenditures on beef safety research have declined from 5.4% of the total budget in 2006 to 2.3% in 2018.

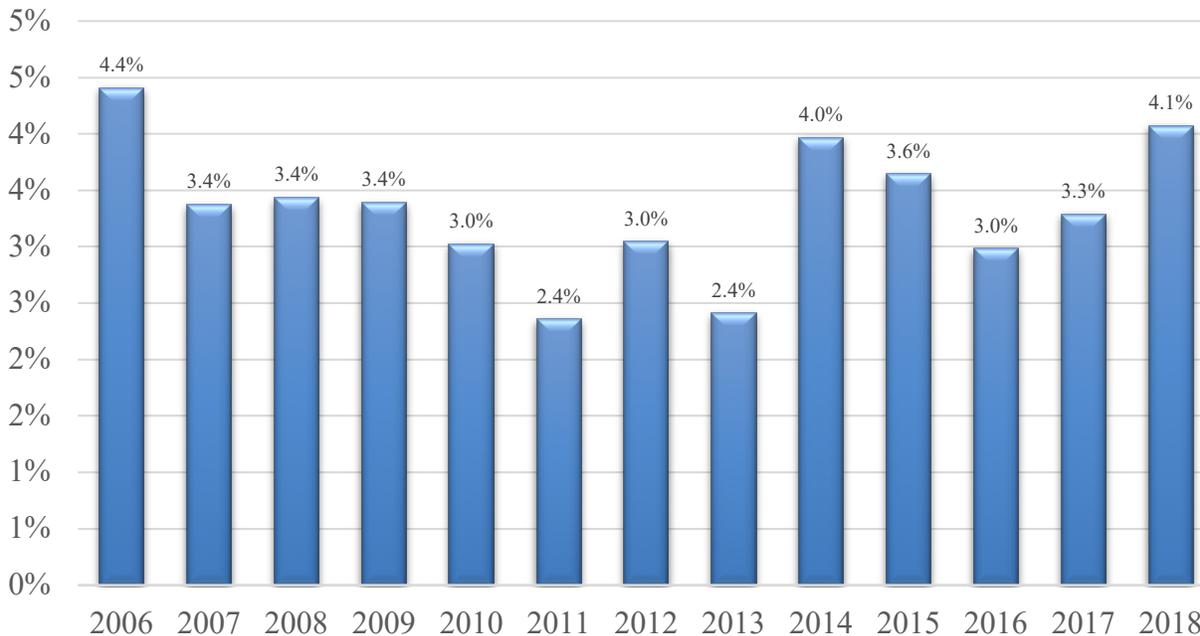
Figure 10 shows CBB expenditures on product enhancement research. This category includes all research programs focused on product quality and product enhancement including muscle profiling (identifying new cuts within undervalued areas of the carcass, i.e. flat iron steak), tenderness, shelf-life, etc. This category has been fairly stable over time. In 2006, the CBB devoted 4.4% of the budget to this category, and in 2018, they devoted 4.1%.

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% of the budget in 2006 and this grew to 7% in 2018.

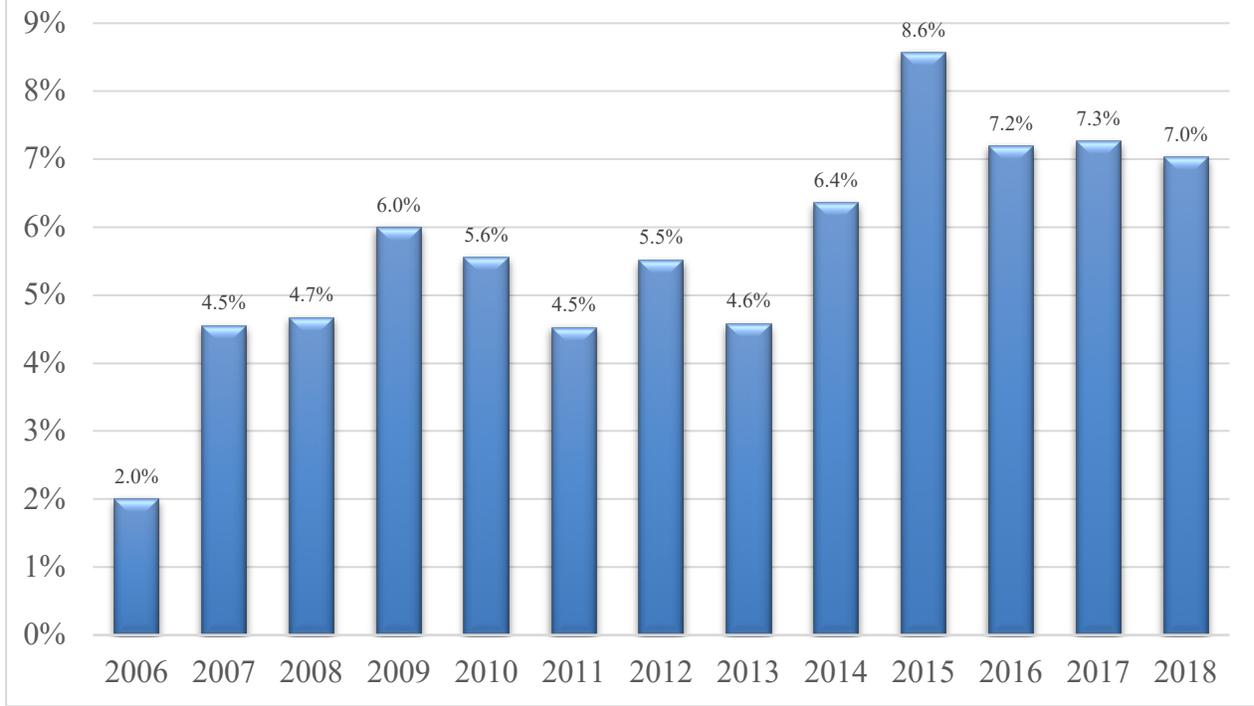
**Figure 9. Annual expenditures on beef safety research as a percent of CBB budget, 2006-18.**



**Figure 10. Annual expenditures on new product enhancement research as percent of CBB budget, 2006-18.**



**Figure 11. Annual expenditures on nutritional research as a percent of the CBB budget, 2006-18.**



### **Data Limitations**

This analysis is based on secondary data from government sources, private vendors, the CBB, and USMEF. The accuracy of the results depends primarily on the quality of this secondary data, the bulk of which mainly measure demand and demand drivers for beef and beef products. While these data are judged to be the best available for this economic evaluation, there are errors in data from any data source.

In addition, there are many factors that impact both the demand and supply of beef. The models have used all available secondary data sources to control for these factors over time in order to get an accurate measure of the impact of the focal factor here, CBB demand enhancing activities. However, it is almost certainly true that not all demand and supply drivers have been accounted for in the model. For example, it is difficult to obtain a measure on how consumers perceptions regarding beef products has changed over time. These perceptions undoubtedly have an impact on beef demand.

### **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 import demand. 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. A detailed discussion of the econometric model and the results is presented in the Appendix of this report. Here, we focus on a general overview of the model and a discussion of the results.

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% 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 following demand drivers are included to ascertain their impacts on domestic beef demand:

- Retail price for beef products (\$/lb.),
- Retail price for broiler products (\$/lb.),
- Retail price for pork products (\$/lb.),
- Real disposable income (in real 2012 bil \$),
- Time trend,
- Generic pork advertising expenditures,
- CBB beef advertising expenditures,
- CBB expenditures on public relations,
- CBB expenditures on beef safety research,
- CBB expenditures on total channels marketing,
- CBB expenditures on total industry information,
- CBB expenditures on new product development,
- CBB expenditures on product enhancement research, and
- CBB expenditures on nutritional research.

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 for broilers and pork products are included because they represent the most important substitute products for beef. The relationship between beef demand and the broiler and pork

price is expected to be positive because broilers and pork are substitutes for beef, e.g., an increase in the pork price results in an increase in beef demand since beef is now relatively less expensive. The relationship between disposable 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 eight CBB marketing activities are expected to each have a positive impact on the demand for beef. All monetary variables in the model are deflated by the Consumer Price Index for all items to remove the effects of inflation.

In addition to the retail beef demand model, a retail beef supply model is estimated primarily to get an estimate of the own price elasticity of supply necessary to simulate the benefit-cost ratio (details are provided in the Appendix).

### **Beef Import Demand Model**

Using both time series and importing country-level data, an import demand model for U.S. beef is estimated. Data on key demand drivers for U.S. beef imports to selected regions are collected and used on an annual basis over the period 2006-2018 for the following eight importing regions: Mexico, Japan, South Korea, Taiwan, Hong Kong, China, European Union, and Russia and surrounding regions. Russia and surrounding regions includes: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Ukraine, and Uzbekistan. ASEAN, the Caribbean, and the Middle East countries are not included because of a lack of consistent import data on these countries. These data compose the bulk of total U.S. meat exports.

The import demand equation for U.S. beef is estimated with imports of U.S. beef as the dependent variable, which is measured on a volume basis (in pounds) for each calendar year for each region. The following import demand drivers are included to ascertain their impacts on annual import demand for U.S. beef:

- Unit value (price) of annual beef imports from the U.S. to each importing region in dollars per pound,
- Unit value (price) of annual beef imports from the rest-of-the-world (ROW) exporters to each importing region in dollars per pound,
- Average annual GDP for each importing region,
- Average annual real exchange rate (ER) of each importing region's currency relative to U.S. dollar,
- Total annual U.S. Meat Export Federation (USMEF), CBB, and USDA, Food and Agricultural Service (FAS) beef export promotion expenditures to each importing region, and
- Imports of beef in the previous year for each importing region.

Both the U.S. and ROW beef prices are computed as the total value of imports divided by the total quantity of imports and come from USMEF's Office. Hence, price is computed as a unit

value measure and reflects the overall category including muscle cuts, variety meats and processed beef products: “total beef” in the data set. The U.S. price is expected to be negatively related to the volume of imports from the U.S. in each importing region, i.e., a lower price results in higher U.S. import quantity demanded reflecting the law of demand. The import price of all competing regions is included because these regions are the other source for beef imports in the foreign markets and the chief competitors to U.S. beef. The relationship between the ROW price and the import demand for U.S. beef is expected to be positive because ROW beef is a close substitute with U.S. beef. Again, the ROW price is a unit value estimated by dividing the value of non-U.S. imports for each importing region by the total quantity of non-U.S. imports.

The relationship between GDP and the demand for U.S. beef is expected to be positive, i.e., as regions become wealthier, the demand for U.S. beef should increase. The ER has been shown to be an important determinant of the demand for U.S. imports. The relationship between ER and the import demand for U.S. beef is expected to be negative. As the U.S. dollar becomes cheaper, U.S. beef becomes relatively cheaper and hence import demand increases.

Imports in the previous year are included to capture dynamic effects of international trade rigidities, i.e., imports from the U.S. last year should be highly correlated with imports from the U.S. this year. As is the case for domestic CBB expenditures, CBB beef export promotion expenditures are deflated by the Consumer Price Index in each importing region.

### **Econometric Results**

The retail beef demand model is estimated with monthly data from 2006.1 through 2018.12. The elasticities are summarized in Table 1. The coefficient of variation ( $R^2$ ) indicates that the explanatory variables explain 79% 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 and broiler prices) are statistically significant at the 5% significance level or better, and most coefficients are significant at the 1% level or better. Several econometric diagnostic tests performed indicate no statistical problems with the model.

The estimated own price elasticity (based on the average for the entire period, 2006-2018) is negative and equal to -0.29. The interpretation of this is a 1% increase in the retail beef price, holding all other demand factors constant, leads to a 0.29% decrease in per capita beef quantity demanded. As expected, both broilers and pork are found to be substitutes commodities for beef with elasticities of 0.05 and 0.03, respectively. That is, a 1% increase in the broiler (or pork) price, holding all other demand factors constant, results in a 0.05% (0.03%) increase in per capita beef demand. However, the coefficients on both of these are not statistically significant.

Real, inflation adjusted 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 1.21% 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 three months and has a cumulative elasticity value of -0.03. That is, a 10% increase in generic pork advertising decreases beef demand by 0.3% over a three-month period.

Table 1. Retail beef demand elasticities.<sup>a</sup>

Demand Factor	Elasticity	p-value
Retail beef price	<b>-0.288</b>	0.000
Retail broiler price	0.047	0.409
Retail pork price	0.026	0.655
Disposable income	<b>1.211</b>	0.000
Time trend	<b>-0.186</b>	0.000
Generic pork advertising	<b>-0.031</b>	0.000
Generic beef advertising	<b>0.0048</b>	0.000
CBB public relations	<b>0.0037</b>	0.000
CBB beef safety research	<b>0.0034</b>	0.000
CBB channels marketing	<b>0.0039</b>	0.000
CBB new product development	<b>0.0090</b>	0.005
CBB product enhancement research	<b>0.0026</b>	0.005
CBB industry information	<b>0.0024</b>	0.005
CBB nutritional research	<b>0.0047</b>	0.000

<sup>a</sup> 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.

The statistical results indicate that all eight CBB domestic demand-enhancing activities have a positive and statistically significant impact on increasing per capita beef demand. All estimated elasticities have similar values. The activities of the CBB all have a positive and statistically significant impact on beef demand. For example, holding constant all other demand drivers, a 10% increase in advertising and nutritional research increase beef demand by 0.48% and 0.47%, respectively. The rest of the CBB activities have similar, but slightly smaller demand impacts.

Because there is error inherent in any statistical model, a 90% confidence interval is computed for the eight 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 collective impact of generic beef advertising, public relations, channel marketing, and industry information is (0.035, 0.107). A 90% confidence interval for the collective impact of new product development, food safety marketing, product enhancement research, and nutritional research elasticity is (0.0001, 0.142). 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 period, 2006-18, by setting all independent variables equal to historical levels to determine how well *predicted* coincided with *actual* per capita beef demand from 2006 through 2018. The average prediction error (mean absolute percentage error) is only 3%, which indicates the model has a high degree of accuracy.

A counterfactual scenario is simulated with the demand model to determine the impact of the domestic demand-enhancing CBB activities. The scenario is identical to the baseline, except that CBB expenditures are eliminated in order to determine how the CBB impacts domestic demand. The simulation is conducted for the most recent 5-year period, 2014-18.

The results of the simulation clearly show the CBB's positive impact on domestic beef demand. From 2014 to 2018, all CBB's promotion and research activities increased total domestic beef demand by 12.8 billion pounds in total, or 2.6 billion pounds per year. This represents an annual increase in domestic beef demand of 14.3 percent. In other words, had there been no CBB activities over the period 2014-2018, domestic beef demand would have been 14.3% lower than it actually was. Hence, the efforts of the CBB clearly have a positive and substantial effect on domestic beef demand.

The retail beef supply model is also estimated with monthly data from 2006 through 2018. The elasticities are summarized in Table 2. The coefficient of determination indicates that the explanatory variables explain over 64% of the variations in monthly retail supply of U.S. beef. The elasticity signs are consistent with economic theory and all estimated coefficients (except the retail pork price) are statistically significant at the 10% significance level or better. The retail pork price is significant at the 11% level. Several econometric diagnostic tests performed indicate no statistical problems with the model.

The results indicate that the long-run own-price elasticity of supply is 0.144. That is, holding all other supply factors constant, a 10% increase in the retail beef price results in a 1.44% increase in quantity supplied by beef retailers. The impact of the steer price is even larger, i.e., a 10% increase in the steer price results in almost a 2% decrease in retail beef supply. The retail pork price is negative, reflecting opportunity costs for beef retailers to sell pork products. The trend variable is negative and statistically significant for the period 2006.1 through 2018.12, and is likely capturing increases in other retailing costs such as energy prices.

Table 2. Retail beef supply elasticities.<sup>a</sup>

Supply Factor	Elasticity	P-value
Retail beef price	<b>0.144</b>	0.085
Steer price	<b>-0.194</b>	0.000
Retail pork price	-0.151	0.110
Time trend	<b>-0.034</b>	0.016

<sup>a</sup> Coefficients in bold indicates statistical significance from zero (p-value under 0.1 or better).

The import demand equation for U.S. beef is estimated for the eight regions with time series data from 2006 through 2018 for the eight regions. The estimation results are presented in Table 3. The model fits the data quite well in terms of the coefficient of variation with over 91% of the variation in the independent variables explaining the variation in U.S. imports for beef. Statistical diagnostics are run on the model and no statistical problems are found.

Table 3. U.S. beef import demand elasticities.<sup>a</sup>

Demand Factor	Elasticity	p-value
U.S. beef imports in previous year	<b>0.543</b>	0.000
U.S. beef price	<b>-1.782</b>	0.000
Rest of world beef price	<b>1.564</b>	0.000
Gross Domestic Product	<b>3.521</b>	0.000
Real U.S. Exchange Rate (Weighted for Agricultural Trade)	<b>-1.507</b>	0.000
CBB+USMEF+FAS foreign market expenditures	<b>0.097</b>	0.007

<sup>a</sup> Coefficients in bold indicates statistical significance from zero (p-value under 0.05 or better).

The estimated coefficient on the lagged dependent variable is 0.543. This implies that there is a positive correlation between imports in the previous year and current imports. This estimate is used to derive the long-run elasticities by using the following formula:

$$\text{Long-run elasticity} = (1/(1-0.543)) \text{ short-run elasticity (SRE)} = 2.19 \text{ SRE.}$$

GDP is the most important elasticity of demand for U.S. beef. Specifically, holding constant all other import demand drivers, a 1% increase in real, inflation adjusted GDP in each country increases important demand for U.S. beef by 3.52%. The long-run elasticity for GDP is 7.71. Clearly, GDP is the most important demand driver for U.S. beef imports.

The U.S. beef price is an important demand driver for U.S. beef imports to the eight regions. Specifically, the findings indicate a price elasticity of -1.78, i.e., a 1% increase in the U.S. beef reduces important quantity demanded for U.S. beef by 1.78%, holding all other demand drivers constant. The long-run price elasticity is -3.9. Relatedly, the ROW price elasticity is 1.56 (long-run is 3.43) meaning a 1% increase in the ROW price increases the demand for U.S. imports by 1.56%, (3.43% in the long-run) holding constant all other demand drivers. The value of the U.S. dollar also has an important impact on U.S. beef imports. The short- and long-run elasticities estimate are -1.51 and -3.3, respectively. That is, a 1% increase in the value of the U.S. dollar decreases U.S. beef imports into these eight regions by 1.5% in the short-run and 3.3% in the long-run, holding all other demand determinants constant.

The coefficient for the foreign market development expenditures by the CBB, USMEF, and FAS combined is positive and statistically significant indicating that U.S. beef export promotion has a positive impact for U.S. beef imports to the eight regions. The short-run export

promotion elasticity is 0.097 meaning that a 10% increase in beef export promotion results in a 0.97% increase in U.S. beef imports in the short-run. The long-run elasticity is 0.212. Because the estimated promotion elasticity is positive and statistically significant, this provides evidence that U.S. beef export promotion has had a positive impact on U.S. beef imports to the eight foreign markets. A 90% confidence interval for the foreign market development expenditures for beef is (0.039, 0.156).

Similar to the retail beef domestic demand model, the import demand model is simulated under two scenarios: (1) a baseline, where all exogenous variables are set equal to historical levels, and (2) a no-CBB export promotion scenario, which is identical to the baseline except that CBB export promotion expenditures are set equal to zero (note that there is still USMEF and FAS export promotion expenditures in this scenario). Based on the most recent 5-year period (2014-18), the results indicate that had there not been any CBB export promotion to these eight foreign markets, U.S exports to these markets would have been 5.5% lower.

### 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 BCR 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<sup>1</sup>). 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 is a static model that assumes instantaneous adjustment (see details of the model in the Appendix). 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 5-year period, 2014-2018. 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 marginal BCR is computed for each CBB activity:

$$\text{BCR} = \Delta\text{PS}/\Delta\text{Costs}$$

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<sup>1</sup> 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.

where:  $\Delta PS$  is the change in producer surplus (i.e., incremental profit) associated with the 1% increase in the CBB activity, and  $\Delta Cost$  is the respective 1% change in cost. Table 4 presents the marginal BCRs for the CBB activities and the overall combined return.

The highest marginal BCRs are for new product development and foreign market development. That is, if the CBB had an additional dollar to invest, producer profits would increase by \$54.43 and \$24.45, respectively, if it were placed in new product development or foreign market development. The next tier of high return activities include: beef safety research (15.61), product enhancement research (14.22), and nutritional research (10.97). All top five CBB activity have very high marginal BCRs indicating, in part, that they are under-invested in and beef producers would benefit by investing more in these activities. All CBB activities had marginal BCRs substantially higher than 1 indicating that the benefits of the activities greatly exceed the costs. Collectively, the overall marginal BCR for all CBB activities is \$11.91. Hence, the CBB has a very high marginal BCR for its activities over the period 2014-18.

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

CBB Marketing Activity	Marginal benefit-cost ratio
Generic beef advertising	3.71
Public relations	4.41
Beef safety research	15.61
Channels marketing	5.32
Industry information	3.24
New product development	54.43
Nutritional research	10.97
Product enhancement research	14.22
Foreign market development	24.45
All activities combined	11.91

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 definitely true for generic beef advertising which has the lowest marginal BCR, but the highest amount of money spent on it. This is due to what economists refer to as “diminishing returns” which means as more money is spent on an activity, the marginal or incremental gains from it increase at a decreasing rate.

All 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. It is especially important to estimate the lower bound confidence interval for the BCR. Collectively, the lower bound 90% confidence interval for the BCR is 7.59. Hence, this provides additional empirical evidence that

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

### **Summary and Conclusions**

This research study had two central objectives:

1. To measure whether the CBB promotion, educational, and research activities increased consumption of beef products in the United States and foreign markets compared to what would have occurred in the absence of these activities.
2. To measure the benefits of the CBB activities in terms of incremental profitability for the entire industry and compare these benefits with the cost of the checkoff to compute a rate of return on investment of this campaign to its stakeholders.

To address these two objectives, econometric models of the domestic and international beef markets were constructed, which enabled 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 main highlights of the study include:

The CBB had a positive and significant impact on beef demand in the United States compared to what it would have been in its absence. Had there not been any domestic CBB marketing over the latest 5-year period, 2014 through 2018, total domestic beef demand would have been 2.6 billion pounds per year (14.3%) lower than it actually was.

The CBB had a positive and statistically significant impact on U.S. beef exports. Specifically, had there not been any CBB contributions to the FAS and USMEF's foreign market development program over the past 5 years, U.S. beef export demand would have been 5.5% lower than it actually was in the eight foreign markets studied here.

All nine individual CBB demand enhancing activities had marginal BCRs well above 1.0 indicating their marginal benefits were well greater than their marginal costs.

The overall benefits of the CBB are substantially greater than their costs. Collectively, the overall BCR for all nine CBB activities (including foreign market development) is \$11.91. In other words, an extra dollar invested in CBB activities over the period, 2014-18, returned \$11.91 to beef industry producer profit.

The lower bound 90% confidence interval on this overall BCR is 6.59, which is still substantially above 1.0 adding credence to the findings that the CBB has been profitable for its stakeholders.

**References**

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## Appendix. Econometric Models

This Appendix describes the econometric model and results in detail. 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.

### 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 2018.12 (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:

- Retail price for beef products (\$/lb.),
- Retail price for broiler products (\$/lb.),
- Retail price for pork products (\$/lb.),
- Real disposable income (in real 2012 bil \$),
- Time trend,
- Generic pork advertising expenditures,
- CBB beef advertising expenditures,
- CBB expenditures on public relations,
- CBB expenditures on beef safety research,
- CBB expenditures on total channels marketing,
- CBB expenditures on total industry information,
- CBB expenditures on new product development,
- CBB expenditures on product enhancement research, and
- CBB expenditures on nutritional research.

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

$$\begin{aligned}
 PCCON_t = & \beta_0 + \beta_1 RBP_t/CPI_t + \beta_2 RBRP_t/CPI_t + \beta_3 RPP_t/CPI_t \\
 & + \beta_4 INC_t/CPI_t + \beta_5 TREND_t + \beta_6 PDL \ln (PADV_{t-n}/CPI_{t-n}) \\
 & + \beta_7 \ln (BADV_{t-n}/CPI_{t-n}) + \beta_8 \ln (FSAFE_t/CPI_{t-n}) + \beta_9 \ln (CHANNEL_{t-n}/CPI_{t-n}) \\
 & + \beta_{10} \ln (PR_{t-n}/CPI_{t-n}) + \beta_{11} \ln (INDUST_{t-n}/CPI_{t-n}) + \beta_{12} \ln (NEWPROD_{t-n}/CPI_{t-n}) \\
 & + \beta_{13} \ln (PRODENHANCE_{t-n}/CPI_{t-n}) + \beta_{14} \ln (NUTRES_{t-n}/CPI_{t-n})
 \end{aligned}$$

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  $t$ ;  $RBRP_t$  is retail price for broiler products in year/month  $t$ ;  $RPP_t$  is the retail price for pork products in year/month  $t$ ;  $INC_t$  is 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;  $CHANNEL_{t-n}$  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  $\beta$ s are the coefficients to be estimated with statistical regression analysis. The natural logarithm of all checkoff activity expenditures is used since to reflect diminishing returns to these activities. All monetary variables such as  $RBP$ ,  $RBRP$ ,  $RPP$ ,  $PCINC$ ,  $PADV$ , 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.<sup>2</sup>

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 for broiler and pork products are included because they represent the most important substitute products for beef. The relationship between  $PCCON$  and  $RBRP$  (and  $RPP$ ) is expected to be positive because broilers and pork are substitutes for beef, e.g., an increase in the broiler price results in an increase in beef demand since beef is now relatively less expensive. The relationship between disposable 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 eight CBB marketing activities are expected to each have a positive impact on the demand for beef.

Several specifications are used for the eight checkoff activities. As was previously mentioned, the natural logarithm operator was applied to these expenditures to reflect possible diminishing returns to scale. In addition, it is well documented in the literature that marketing campaigns have a “carry-over effect” on demand, i.e., past, as well as current marketing expenditures have an effect on current 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

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<sup>2</sup> 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).

model.<sup>3</sup> 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 two separate variables: (1) new product development + product enhancement research + nutritional research + beef safety research, and (2) promotion, which included generic advertising + public relations + industry information + 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 all eight CBB activities 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:

$$RSUP_t = \eta_0 + \eta_1 PDL RBP_t/CPI_t + \eta_2 STEERP_t/CPI_t + \eta_3 RPP_t/CPI_t + \eta_4 TREND_t$$

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,  $RPP_t$  is retail pork price in year/month  $t$ , and  $TREND_t$  is a linear time trend variable for year  $t$  to measure other variables that may influence beef retail sector over time such as other costs of production. In this equation, the  $\eta$ s are the coefficients to be estimated with statistical regression analysis. Not shown in this equation are monthly dummy variables to capture seasonality in retail beef supply.<sup>4</sup> For the price variable, a second-degree polynomial distributed lag specification is used with five month lags. The steer price is included since this represents the largest variable cost to beef retailers, while the retail price of pork represents opportunity cost for beef retailers. The trend term is included to capture other potential retail beef supply drivers that are not included in the model for beef retailers.

The following data sources were used for the variables in the model: PCCON, RSUP, RBP, RBRP, RPP, PADV came from the National Cattlemen’s Beef Association; 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 endogeneity test is performed on the retail beef price, which consisted of the following. First, the retail beef price is regressed on all other explanatory variables in the beef demand equation. The residuals from this regression are then included in the original beef demand equation, and a t-test on the estimated coefficient on this residual term is used to test the null hypothesis that the retail beef price is exogenous. In this case, the t-value on the residual term is not statistically significant and

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<sup>3</sup> Specifically, some of these variables are specified as a second-degree polynomial distributed lag (PDL). The model is then solved without end point restrictions being imposed, alternative length of lags are specified, and the final model is chosen based on the best statistical. A PDL structure is used for generic pork advertising and for the following CBB sponsored marketing activities: generic beef advertising, public relations, industry information, and channels marketing. For these four CBB activities, a 4-month lagged specification for the PDL is used.

<sup>4</sup> 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 January (positive), February (negative), March (positive), May (positive), July (positive), August (positive), and October (positive).

the null hypothesis therefore could not be rejected. Hence, ordinary least squares is used to estimate the retail beef demand equation.

The retail beef demand model is estimated with monthly data from 2006.1 through 2018.12. The elasticities are summarized in Table 1. The coefficient of variation ( $R^2$ ) indicates that the explanatory variables explain 79% 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 and broil prices) are statistically significant at the 5% significance level or better, and most coefficients are significant at the 1% level or better. Several econometric diagnostic tests performed indicate no statistical problems with the model.

The estimated own price elasticity (based on the average for the entire period, 2006-2018) is negative and equal to -0.29. The interpretation of this is a 1% increase in the retail beef price, holding all other demand factors constant, leads to a 0.29% decrease in per capita beef quantity demanded. As expected, both broilers and pork are found to be substitutes commodities for beef with elasticities of 0.05 and 0.03, respectively. That is, a 1% increase in the broiler (or pork) price, holding all other demand factors constant, results in a 0.05% (0.03%) increase in per capita beef demand. However, the coefficients on both of these are not statistically significant.

Table 1. Retail beef demand elasticities.<sup>a</sup>

Demand Factor	Elasticity	p-value
Retail beef price	<b>-0.288</b>	0.000
Retail broiler price	0.047	0.409
Retail pork price	0.026	0.655
Disposable income	<b>1.211</b>	0.000
Time trend	<b>-0.186</b>	0.000
Generic pork advertising	<b>-0.031</b>	0.000
Generic beef advertising	<b>0.0048</b>	0.000
CBB public relations	<b>0.0037</b>	0.000
CBB beef safety research	<b>0.0034</b>	0.000
CBB channels marketing	<b>0.0039</b>	0.000
CBB new product development	<b>0.0090</b>	0.005
CBB product enhancement research	<b>0.0026</b>	0.005
CBB industry information	<b>0.0024</b>	0.005
CBB nutritional research	<b>0.0047</b>	0.000

<sup>a</sup> 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.

Real, inflation adjusted 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 1.21% 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 three months and has a cumulative elasticity value of -0.03. That is, a 10% increase in generic pork advertising decreases beef demand by 0.3% over a three-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 have similar values. Since the individual CBB activities were aggregated into two variables in the regression, the following simple simulation procedure is used to simulate the elasticities for each activity. First, an in-sample simulation is conducted from 2006.01 through 2018.12 to get predicted values of beef consumption. Then, eight counterfactual scenarios are simulated which are identical to the first, except in each, one of the eight CBB activity expenditures is decreased by 1%. Then an elasticity value is computed for the activity. Those elasticities are reported in Table 1. For example, holding constant all other demand drivers, a 10% increase in advertising and nutritional research increase beef demand by 0.48% and 0.47%, respectively. The rest of the CBB activities have similar, but slightly smaller demand impacts.

Because there is error inherent in any statistical model, a 90% confidence interval is computed for the eight 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 collective impact of generic beef advertising, public relations, channel marketing, and industry information is (0.035, 0.107). A 90% confidence interval for the collective impact of new product development, food safety marketing, product enhancement research, and nutritional research elasticity is (0.0001, 0.142). 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 2018. The average prediction error (mean absolute percentage error) is only 3%, which indicates the model has a high degree of accuracy.

A counterfactual scenario is simulated with the demand model to determine the impact of the domestic demand-enhancing CBB activities. The scenario is identical to the baseline, except that CBB expenditures are eliminated in order to determine how the CBB impacts domestic demand. The simulation is conducted for the most recent 5-year period, 2014-18.

The results of the simulation clearly show the CBB's positive impact on domestic beef demand. From 2014 to 2018, all CBB's promotion and research activities increased total domestic beef demand by 12.8 billion pounds in total, or 2.6 billion pounds per year. This represents an annual increase in domestic beef demand of 14.3 percent. In other words, had there been no CBB activities over the period 2014-2018, domestic beef demand would have been

14.3% lower than it actually was. Hence, the efforts of the CBB clearly have a positive and substantial effect on domestic beef demand.

The retail beef supply model is also estimated with monthly data from 2006 through 2018. The elasticities are summarized in Table 2. The coefficient of determination indicates that the explanatory variables explain over 64% of the variations in monthly retail supply of U.S. beef. The elasticity signs are consistent with economic theory and all estimated coefficients (except the retail pork price) are statistically significant at the 10% significance level or better. The retail pork price is significant at the 11% level. Several econometric diagnostic tests performed indicate no statistical problems with the model.

The results indicate that the long-run own-price elasticity of supply is 0.144. That is, holding all other supply factors constant, a 10% increase in the retail beef price results in a 1.44% increase in quantity supplied by beef retailers. The impact of the steer price is even larger, i.e., a 10% increase in the steer price results in almost a 2% decrease in retail beef supply. The retail pork price is negative, reflecting opportunity costs for beef retailers to sell pork products. The trend variable is negative and statistically significant for the period 2006.1 through 2018.12, and is likely capturing increases in other retailing costs such as energy prices.

Table 2. Retail beef supply elasticities.<sup>a</sup>

Supply Factor	Elasticity	P-value
Retail beef price	<b>0.144</b>	0.085
Steer price	<b>-0.194</b>	0.000
Retail pork price	-0.151	0.110
Time trend	<b>-0.034</b>	0.016

<sup>a</sup> Coefficients in bold indicates statistical significance from zero (p-value under 0.1 or better).

### Beef Import Demand Model

Using both time series and importing country-level data, an import demand model for U.S. beef is estimated. Data on key demand drivers for U.S. beef imports to selected regions are collected and used on an annual basis over the period 2006-2018 for the following eight importing regions: Mexico, Japan, South Korea, Taiwan, Hong Kong, China, European Union, and Russia and surrounding regions. Russia and surrounding regions includes: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Ukraine, and Uzbekistan. ASEAN, the Caribbean, and the Middle East countries are not included because of a lack of consistent import data on these countries. These data compose the bulk of total U.S. meat exports.

The import demand equation for U.S. beef is estimated with imports of U.S. beef as the dependent variable, which is measured on a volume basis (in pounds) for each calendar year for

each region. The following import demand drivers are included to ascertain their impacts on annual import demand for U.S. beef:

Unit value (price) of annual beef imports from the U.S. to each importing region in dollars per pound,

Unit value (price) of annual beef imports from the rest-of-the-world exporters to each importing region in dollars per pound,

Average annual GDP for each importing region,

Average annual real exchange rate (ER) of each importing region's currency relative to U.S. dollar,

Total annual USMEF, CBB, and FAS beef export promotion expenditures to each importing region, and

Imports of beef in the previous year for each importing region.

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

$$\ln(M_{it}) = \alpha_0 + \alpha_1 \ln(USP_{it}) + \alpha_2 \ln(ROWP_{it}) + \alpha_3 \ln(GDP_{it}) + \alpha_4 \ln(ER_{it}) + \alpha_5 \ln(FAS_{it} + CBB_{it} + USMEF_{it}) + \alpha_6 \ln(M_{it-1})$$

where  $M_{it}$  is U.S. import quantity in importing region  $i$  in year  $t$ ,  $USP_{it}$  is U.S. unit value of imports in region  $i$  in year  $t$ ,  $ROWP_{it}$  is the unit value of all non-U.S. imports in region  $i$  in year  $t$ ,  $GDP_{it}$  is GDP in importing region  $i$  in year  $t$ ,  $ER_{it}$  is the U.S. exchange rate in importing region  $i$  in year  $t$ ,  $FAS_{it} + CBB_{it} + USMEF_{it}$  are beef export promotion expenditures in importing region  $i$  in year  $t$ , and  $M_{it-1}$  is imports in the previous year to region  $i$ . In this equation, "ln" is the natural logarithmic operator, and the  $\alpha$ s are the coefficients to be estimated with statistical regression analysis.

Both the U.S. and ROW beef prices are computed as the total value of imports divided by the total quantity of imports and come from USMEF's Office. Hence, price is computed as a unit value measure and reflects the overall category including muscle cuts, variety meats and processed beef products: "total beef" in the data set. The U.S. price is expected to be negatively related to the volume of imports from the U.S. in each importing region, i.e., a lower price results in higher U.S. import quantity demanded reflecting the law of demand. The import price of all competing regions is included because these regions are the other source for beef imports in the foreign markets and the chief competitors to U.S. beef. The relationship between the ROW price and the import demand for U.S. beef is expected to be positive because ROW beef is a close substitute with U.S. beef. Again, the ROW price is a unit value estimated by dividing the value of non-U.S. imports for each importing region by the total quantity of non-U.S. imports.

The relationship between GDP and the demand for U.S. beef is expected to be positive, i.e., as regions become wealthier, the demand for U.S. beef should increase. The ER has been shown to be an important determinant of the demand for U.S. imports. The relationship between ER and the import demand for U.S. beef is expected to be negative. As the U.S. dollar becomes cheaper, U.S. beef becomes relatively cheaper and hence import demand increases.

Imports in the previous year ( $M_{it-1}$ ) are included to capture dynamic effects of international trade rigidities, i.e., imports from the U.S. last year should be highly correlated with imports from the U.S. this year. 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).<sup>5</sup>

Beef export promotion expenditures are deflated by the Consumer Price Index (CPI) in each importing region.

The following data sources are used for the variables: the quantity, value, and therefore price of U.S. and ROW beef imports come from USMEF. Importing country GDP, ER, and CPI come from the Economic Research Service, USDA. Annual beef FAS and USMEF export promotion expenditures are provided by USMEF. And, CBB expenditures come from the CBB.

**Econometric Results.** The import demand equation for U.S. beef is estimated for the eight regions with time series data from 2006 through 2018 for the eight regions. A fixed effects model is used with cross sectional seemingly unrelated regression. The estimation results are presented in Table 3. The model fits the data quite well in terms of the coefficient of variation with over 91% of the variation in the independent variables explaining the variation in U.S. imports for beef. Statistical diagnostics are run on the model and no statistical problems are found.

The estimated coefficient on the lagged dependent variable is 0.543. Not surprisingly, this implies that there is a positive correlation between imports in the previous year and current imports. This estimate is used to derive the long-run elasticities by using the following formula:

$$\text{Long-run elasticity} = (1/(1-0.543)) \text{ short-run elasticity (SRE)} = 2.19 \text{ SRE.}$$

GDP is the most important elasticity of demand for U.S. beef. Specifically, holding constant all other import demand drivers, a 1% increase in real, inflation adjusted GDP in each country increases important demand for U.S. beef by 3.52%. The long-run elasticity for GDP is 7.71. Clearly, GDP is the most important demand driver for U.S. beef imports.

The U.S. beef price is also an important demand driver for U.S. beef imports to the eight regions. Specifically, the findings indicate a price elasticity of -1.782, i.e., a 1% increase in the

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<sup>5</sup> 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).

U.S. beef reduces important quantity demanded for U.S. beef by 1.782%, holding all other demand drivers constant. The long-run price elasticity is -3.9. Relatedly, the ROW price elasticity is 1.564 (long-run is 3.425) meaning a 1% increase in the ROW price increases the demand for U.S. imports by 1.564%, (3.425% in the long-run) holding constant all other demand drivers. The value of the U.S. dollar also has an important impact on U.S. beef imports. The short- and long-run elasticities estimate are -1.507 and -3.3, respectively. That is, a 1% increase in the value of the U.S. dollar decreases U.S. beef imports into these eight regions by 1.5% in the short-run and 3.3% in the long-run, holding all other demand determinants constant.

Table 3. U.S. beef import demand elasticities.<sup>a</sup>

Demand Factor	Elasticity	p-value
U.S. beef imports in previous year	<b>0.543</b>	0.000
U.S. beef price	<b>-1.782</b>	0.000
Rest of world beef price	<b>1.564</b>	0.000
Gross Domestic Product	<b>3.521</b>	0.000
Real U.S. Exchange Rate (Weighted for Agricultural Trade)	<b>-1.507</b>	0.000
CBB+USMEF+FAS foreign market expenditures	<b>0.097</b>	0.007

<sup>a</sup> 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.

The coefficient for the foreign market development expenditures by the CBB, USMEF, and FAS combined is positive and statistically significant indicating that U.S. beef export promotion has a positive impact for U.S. beef imports to the eight regions. The short-run export promotion elasticity is 0.097 meaning that a 10% increase in beef export promotion results in a 0.97% increase in U.S. beef imports in the short-run. The long-run elasticity is 0.212. Because the estimated promotion elasticity is positive and statistically significant, this provides evidence that U.S. beef export promotion has had a positive impact on U.S. beef imports to the eight foreign markets. A 90% confidence interval for the foreign market development expenditures for beef is (0.027, 0.167).

Similar to the retail beef domestic demand model, the import demand model is simulated under two scenarios: (1) a baseline, where all exogenous variables are set equal to historical levels, and (2) a no-CBB export promotion scenario, which is identical to the baseline except that CBB export promotion expenditures are set equal to zero (note that there is still USMEF and FAS export promotion expenditures in this scenario). Based on the most recent 5-year period (2014-18), the results indicate that had there not been any CBB export promotion to these eight foreign markets, U.S exports to these markets would have been 5.5% lower.

### 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<sup>6</sup>). 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) | $Q_{rd} = f(RBP   BADV, FSAFE, CHANEL, PR, INDUST, NEWPROD, PRODENHANCE, NUTRES)$ | Retail beef demand                |
| (2) | $Q_{rs} = f(RBP)$   | Retail beef supply                |
| (3) | $Q_x = f(USP   EXPROM)$   | Export beef demand                |
| (4) | $Q_{fs} = f(STEERP)$  | Farm supply                       |
| (5) | $USP = f(RBP)$  | Export price-retail price linkage |
| (6) | $Q_{rs} = Q_{rd} + Q_x$   | Market clearing condition         |
| (7) | $Q_{fs} = \delta Q_{rs}$  | Farm to retail conversion         |

where the seven endogenous variables are defined as follows:  $Q_{rd}$  is retail beef demand,  $Q_{rs}$  is retail beef supply,  $RBP$  is retail price for beef (\$/lb.),  $Q_x$  is export beef demand,  $USP$  is the U.S. unit value (export price) for beef product exports (\$/lb.),  $Q_{fs}$  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 an 18-month period. The export price-retail price linkage equation is estimated using annual data from 2006-18 and is the following:

$$USP = -2.068 + 1.481 RBP \quad R^2=0.97$$

(-3.30) (12.92)

where values in parentheses are t-values and  $R^2$  is the coefficient of determination. AR(1) and AR(2) terms are used in the estimation to correct for auto-correlation.

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

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<sup>6</sup> 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.

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  $\delta$  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 5-year period, 2014-2018. 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:

$$\text{BCR} = \Delta\text{PS}/\Delta\text{Costs}$$

where:  $\Delta\text{PS}$  is the change in producer surplus (i.e., incremental profit) associated with the 1% increase in the CBB activity, and  $\Delta\text{Cost}$  is the respective change in cost. Table 4 presents the marginal BCRs for the CBB activities and the overall combined return.

The highest marginal BCRs are for new product development and foreign market development. That is, if the CBB had an additional dollar to invest in these two activities, producer profits would increase by \$54.43 and \$24.45, respectively, if it were placed in new product development or foreign market development. The next tier of high return activities include: beef safety research (15.61), product enhancement research (14.22), and nutritional research (10.97). All top five CBB activity have very high marginal BCRs indicating, in part, that they are under-invested in and beef producers would benefit by investing more in these activities. All CBB activities had marginal BCRs substantially higher than 1 indicating that the benefits of the activities greatly exceed the costs.

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 definitely true for generic beef advertising which has the lowest marginal BCR, but the highest amount of money spent on it. 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.

Collectively, the overall marginal BCR for all CBB activities is \$11.91. Hence, the CBB has a very high marginal BCR for its activities over the period 2014-18. All 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. It is especially important to estimate the lower bound confidence interval for the BCR. Collectively, the lower bound 90% confidence interval for the BCR is 7.59. Hence, this provides additional empirical evidence that the CBB checkoff program has been a highly profitable venture for beef producers

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

CBB Marketing Activity	Marginal benefit-cost ratio
Generic beef advertising	3.71
Public relations	4.41
Beef safety research	15.61
Channels marketing	5.32
Industry information	3.24
New product development	54.43
Nutritional research	10.97
Product enhancement research	14.22
Foreign market development	24.45
All activities combined	11.91