An Economic Evaluation of the National Peanut Board
Dr. Harry M. Kaiser (Cornell University)

Executive Summary

The National Peanut Board (NPB) was implemented in 1999 and is designed to increase the overall demand for peanuts and peanut products as well as reduce production costs and improve the efficiency of peanut growers. The NPB invests in a variety of activities to accomplish its overall objectives of enhancing the demand and yield for peanuts. The overall objective of this study is to measure the effectiveness of the NPB in achieving these goals. Specifically, this research addresses three important questions regarding the National Peanut Board (NPB):

1. What is the responsiveness of peanut demand (and yield) to NPB demand and production-enhancing activities?

2. What is the marginal benefit-cost ratio (BCR) of all NPB programs to peanut growers? In other words, do the benefits of the NPB exceed the costs?

3. What are the marginal BCRs for the individual NPB activities? Are the marginal BCRs the same or different for the various activities?

To address these questions, econometric models of peanut demand, supply, and yields are developed, which enables us to net out the impacts of other important factors besides NPB activities affecting peanut demand and supply such as peanut prices, price of complimentary products such as bread, consumer income, changes in consumer preferences for peanuts, production costs, and technology.

The answer to the first question is a resounding yes. Had there not been any NPB marketing activities over the most recent 5-year period, 2014 through 2018, total domestic peanut demand would have averaged 14.4% less than it actually was. Had there not been any NPB-sponsored production research over this period, peanut yields would have averaged 3,462 pounds per acre compared with 3,880 pounds, or 10.8% less than it actually was.

While these results are important, the benefits of NPB’s marketing and production research programs to industry profitability relative to 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 NPB activities is $9.74. In other words, an extra dollar invested in NPB activities over the period, 2014-18, returned $9.74 to peanut growers’ profit. The marginal BCRs for the individual NPB marketing activities are 105.67 for public relations, 6.88 for advertising, 6.46 for reputation management, and 3.38 for business development. An extra dollar of NPB sponsored production research returned $1.79 to peanut grower profit.
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Introduction

Since 1999, U.S. peanut producers have authorized assessments for a generic promotion and research program managed by the National Peanut Board (NPB). The central mission of the NPB is to conduct activities that “strengthen peanuts’ position in the marketplace and to maintain, develop, and expand markets for peanuts. In addition, the NPB sponsors production-level research aimed at decreasing production costs and improving the efficiency of peanut growers. In recent years, approximately $10 million has been budgeted per year for such activities from an assessment of $3.55 per short ton on farmers’ stock peanuts.

Under the most recent enacted Farm Bill, all federally authorized checkoff programs are required to have an independent economic evaluation of its overall effectiveness 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.

Objective and Scope

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

1. To measure whether the NPB’s marketing and production research programs increases demand for peanuts, peanut products, and peanut yield compared to what would have occurred in the absence of the NPB.
2. To measure the benefits of the NPB checkoff program 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 the Board to its stakeholders.

To address these two goals, three important questions are addressed regarding the NPB:

1. What is the responsiveness of peanut demand and yield to NPB demand and production-enhancing activities?

2. What is the marginal benefit-cost ratio (BCR) of all NPB programs to peanut growers? In other words, do the benefits of the NPB exceed the costs?

3. What are the marginal BCRs for the individual NPB activities? Are the marginal BCRs the same or different for the various activities?

In this study, the impacts of all factors affecting domestic peanut product demand and supply for which data are available are measured statistically. In this way, we can net out the impacts of other important factors (e.g., prices and technology) besides NPB activities affecting peanut demand and supply over time. In addition, the value of the incremental peanut sales generated by NPB activities is estimated. These benefits to peanut producers are compared with the costs associated with the NPB. Based on the estimated impacts from the demand and supply models, a BCR is derived for each activity and overall for all activities conducted by the NPB.

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.
Background on Peanut Consumption and the NPB

Commercial disappearance of peanuts in the United States has been on the rise in the recent decade or so. In 2006, commercial disappearance, which is a measure of aggregate consumption, was 1.91 billion pounds and by 2018 this figure rose to 2.43 billion. This represents a total increase of 27.2% or 2.1% growth per year. As Figure 1 illustrates, the increase in peanut consumption since 2006 has been fairly steady. Increasing consumption of a commodity is vital to the overall economic health of an industry.

![Figure 1. Total peanut consumption in the United States, 2006-2018.](image)

With that in mind, the NPB was implemented in 1999 and is designed to increase the overall demand for peanuts and peanut products as well as reduce production costs and improve the efficiency of peanut growers. The NPB invests in a variety of activities to accomplish its
overall objectives of improving the demand and supply for peanuts. In this report, the promotion and research activities are divided into five categories:

1. Generic peanut advertising,
2. Public relations,
3. Reputation management,
4. Business development, and
5. Production-level peanut research.

Figure 2 displays the total expenditures on these five activities from 2006 through 2018. These expenditures have displayed a general positive trend over time increasing from $4.3 million in 2006 to $7 million in 2018.
Figure 3 illustrates the percent of the NPB expenditures on each of these activities over the most recent five years from 2014-2018. Generic peanut advertising and production research expenditures continue to be the two largest categories of NPB expenditures, each accounting for 30% of the spending. This is followed in importance by reputation management, which comprises 22% of NPB expenditures. NPB contributions to business development activities represents 13% of expenditures, while public relations have been 5% of the budget in recent years.

![Figure 3. Percent of NPB expenditures by five major activities for past 5 years.](image)

Figure 4 displays annual generic peanut advertising expenditures as a percentage of the total NPB spending from 2006 through 2018. These expenditures are devoted to influencer marketing and media advertising in trade and consumer outlets such as magazines, web
advertising, subway billboards and other outlets. Between 2006 and 2016, there was somewhat of a negative trend in advertising as a share of the expenditures. For instance, in 2006, advertising comprised 38% while in 2017 it comprised 30.2% of the expenditures, and in 2018 it dropped to only 15.2%. Yet, advertising remains one of the largest category of NPB expenditures.

Figure 4. Generic peanut advertising expenditures 2006-2018 as percent of NPB expenditures.

Figure 5 shows public relations (PR) expenditures as a percent of NPB expenditures. PR includes all NPB activities that proactively share positive peanut messages with consumers. These activities involve consumer outreach through events, social media, and other events. PR is one of the most commonly used marketing strategies by checkoff programs and other firms in the United States. Since 2006, public relations expenditures have fairly steadily declined as a
share of the total budget. In 2006, public relations comprised 24.7% of the entire budget, and this declined to 2.2% by 2018.

![Figure 5. Public relations expenditures 2006-2018 as a percent of NPB expenditures.](image)

Business development activities include tradeshows used to reach restaurant, foodservice, manufacturing and other decision makers. This also includes meeting costs associated with possible developers of new peanut/peanut butter products. Figure 6 displays expenditures on business development as a percent of total NPB expenditures. This category has gone up and down in importance over time. In 2006, these activities comprised 13.9% of NPB expenditures. In 2018, they represented 12.7% of expenditures. In 2011, they reached their highest share of the NPB’s total budget at 21%.

Figure 7 shows the budget share of reputation management from 2006-18. Reputation
Figure 6. Business development expenditures 2006-2018 as percent of NPB expenditures.

Figure 7. Reputation management expenditures 2006-2018 as percent of NPB expenditures.
management activities involve working through consumer channels, schools, and nutrition/health professionals to provide accurate nutrition and allergy information to reverse misperceptions and to communicate on how to manage and prevent the development of peanut allergies. This category of spending has typically been under 3% of the NPB budget until 2014. In 2014, the NPB decided to drastically increase expenditures in this category to combat the negative demand effects of peanuts allergies on peanuts and peanut products. In 2014, this represented 16.9% of the budget, and by 2018 this reached 39.3% of the budget as the NPB worked to increase awareness of early introduction of peanut containing foods to infants as a way to help prevent the development of peanut allergies.
Figure 8 displays production-level research expenditures as a percent of the total NPB expenditures. This is the second most important share of the NPB expenditures, and coincides with their mission to improve the efficiency and lower the cost of producing peanuts. The NPB puts up to 20% of assessment dollars, each year, back into production research through the states. Also, NPB has funded genomic research with these funds. These expenditures have increased in recent years. In 2006, they represented 20.2% of NPB expenditures, and by 2017, this increased to 39%, before falling back to 30.7% in 2018.

**Methodology**

This study quantifies the relationship between the advertising, public relations, reputation management, business development, and production research programs of the NPB and the domestic demand, supply, and yield for peanuts and peanut products. 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 yield 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 NPB’s activities on peanut demand and yield.

The three econometric models to be estimated are: (1) domestic peanut demand model, (2) domestic peanut yield model, and a domestic peanut supply model. These three models are used to test whether various activities by the NPB such as advertising, public relations, and production research have a statistically significant impact on peanut demand, supply, and yield. In order to isolate the effect of NPB activities on peanut demand, supply, and yield, the following demand, supply, and yield drivers are included in the models:
**Peanut demand:**

Retail price of peanuts in the U.S.
Consumer Price Index for all items
Retail price of white bread in the U.S.
Retail price of bologna deli meat in the U.S.
Retail price of ice cream per gallon. This data come from BLS.
Retail price of cookies.
Disposable real (inflation adjusted) income in the U.S.
Linear trend variable equals
Expenditures ($) on generic peanut advertising by the NPB in the U.S.
Expenditures ($) on peanut public relations by the NPB in the U.S.
Expenditures ($) on peanut reputation management by the NPB in the U.S.
Expenditures ($) on peanut business development by the NPB in the U.S.

**Peanut supply and yield:**
Grower peanut price
Linear trend term
Index of prices paid by farmers for the crop sector
Production research expenditures by NPB.

On the demand side, the retail prices for peanuts and competing/complimentary products are included in the peanut demand model because consumers consider the relative prices of products in making purchase decisions. Consumer income is included because it affects how much a consumer can purchase, as well as consumer’s purchasing decisions. The linear trend variable is included to capture other potentially important demand factors not specifically included in the model. The NPB demand enhancing activities are captured in the demand model by inclusion of the four separate activities: generic peanut advertising, public relations, reputation management, and business development.

On the supply/yield side, the grower price is included as it is expected to influence peanut supply decisions reflecting the law of supply. The trend term is included to capture improvements in technology and managerial ability over time. Production costs impact supply, and these costs are measured as the index of prices paid by farmers. Finally, NPB expenditures on production research is designed to enhance yield and/or improve production efficiency and
lower costs. This variable is measured as expenditures on NPB production research, and is included in the supply and yield models using various lagged specifications to account for the fact that current supply and yields are influenced by past research. A much more complete description of the econometric model is contained in the Appendix of this report.

To compare the relative importance of each factor on peanut demand, supply, and yield, the results from the econometric model are converted into “elasticities.” An elasticity measures the percentage change in peanut demand or yield given a 1% change in a specific demand or yield factor, holding all other factors constant. For example, the computed own price elasticity of demand measures the percentage change in peanut quantity demanded given a 1 percent change in price, holding constant all other peanut 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 peanut demand or yield.

The econometric results are then used to simulate the impacts of the NPB on market conditions for alternative funding scenarios. These simulations provide the information necessary to measure the benefits of the NPB in terms of increasing producer profitability. And, these procedures enable us to compute the rate of return on investment for the overall programs and the specific activities by the NPB.

Data and Data Limitations

The data used in this study come from a variety of courses. The peanut consumption data come from USDA, NASS *Peanut Stocks and Processing Report*. The retail peanut and peanut product price data come from IRI unit values based on total expenditures and volume of peanuts and peanut butter. The Consumer Price Index data come from the U.S. Bureau of Labor...
Statistics. The retail price data for bologna, white bread, ice cream, and cookies come from the U.S. Bureau of Labor Statistics. Disposable real (inflation adjusted) income in the U.S. come from the *Economic Report of the President*. All NPB expenditures come from the National Peanut Board. Peanut yield per acre and grower prices come from USDA, NASS. The Index of prices paid by farmers come from USDA’s *Agricultural Prices*.

In terms of data limitations, the demand models do not include two variables that are potentially important demand drivers for peanuts. The first is generic advertising from competing nuts, e.g., walnuts, pecans, and almonds. Unfortunately, we did not have access to this data for this study. It is likely that the omission of competing product advertising may bias the peanut advertising elasticities upwards, which mean the results of this study should be viewed as upper bounds estimates of the true impact of NPB advertising.

The second variable, which was included in the previous study, is branded peanut butter advertising. However, in the previous study, branded peanut advertising was not found to be statistically significant. Hence, its non-inclusion in the present study may not be a concern. Regardless, we should view the results from this study as upper bounds since inclusion of both competing product and branded peanut butter advertising is not included in the models.

**Results**

The full set of econometric results, including the estimated elasticity for all demand, supply, and yield drivers, is presented in the Appendix of this report. In this section, we focus on the estimated elasticities for each of the NPB activities.

Table 1 presents the econometric results related to the impacts of NPB activities on peanut demand. Actually, three separate domestic demand models are estimated for peanut
demand: (1) total peanut demand, (2) peanut butter demand and (3) snack peanut demand. The most important model is (1) because in this report, we are interested in how the NPB impacts the overall demand for all peanuts and peanut products. Models (2) and (3) are useful additions since they will measure how the NPB demand-enhancing activities specifically impact peanut butter and snack peanut demand.

Table 1. Estimated NPB demand elasticities.

<table>
<thead>
<tr>
<th>NPB Activity</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact on total peanut demand:</strong></td>
<td></td>
</tr>
<tr>
<td>NPB advertising</td>
<td>0.017</td>
</tr>
<tr>
<td>NPB public relations</td>
<td>0.040</td>
</tr>
<tr>
<td>NPB reputation management</td>
<td>0.008</td>
</tr>
<tr>
<td>NPB business development</td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Impact on peanut butter demand:</strong></td>
<td></td>
</tr>
<tr>
<td>NPB advertising</td>
<td>0.028</td>
</tr>
<tr>
<td>NPB public relations</td>
<td>0.084</td>
</tr>
<tr>
<td>NPB reputation management</td>
<td>0.010</td>
</tr>
<tr>
<td>NPB business development</td>
<td>0.092</td>
</tr>
<tr>
<td><strong>Impact on snack peanut demand:</strong></td>
<td></td>
</tr>
<tr>
<td>NPB advertising</td>
<td>0.060</td>
</tr>
<tr>
<td>NPB public relations</td>
<td>0.102</td>
</tr>
<tr>
<td>NPB reputation management</td>
<td>0.074</td>
</tr>
</tbody>
</table>

Regarding the total peanut demand model, all of the four marketing activities by the NPB are positive, and three are statistically significantly different from zero. Similar to the last study conducted 5 years ago, public relations activities by the NPB has the highest elasticity value of 0.04. In other words, increasing NPB public relations expenditures by 10% increases peanut
demand by 0.4%, holding all other peanut demand drivers constant. The public relations activities have a 1-quarter lag effect on demand. Generic peanut advertising by the NPB had an instant effect on demand with an elasticity of 0.017, which is statistically significant. In other words, holding the effect of all other demand drivers constant, increasing advertising expenditures by 10% increases peanut demand by 0.17%. The estimated elasticity for NPB reputation management is 0.008, and has a 4-quarter lag effect on demand. NPB business development activities have an estimated elasticity of 0.003, but is not statistically different from zero, which is similar to the findings in the previous study.

The results of the peanut butter demand model are somewhat different. Unlike the total peanut demand model, all four of the NPB marketing activities are positive and statistically significant. Of the four NPB activities, business development has the largest impact on increasing peanut butter demand. Holding all other factors constant, a 10% increase in NPB expenditures on business development programs increases peanut butter demand by 0.92%, which is statistically significant. Public relations has the next highest elasticity of 0.084, followed by generic advertising (0.028) and reputation management (0.010). In other words, a 10% increase in public relations, advertising, and reputation management expenditures, holding constant all other demand drivers, would each increase peanut butter demand by 0.84%, 0.28%, and 0.1%, respectively.

Regarding peanut snack demand, while NPB business development is not found to be statistically significant and hence omitted from the model, the other three NPB activities are statistically significant. Public relations by the NPB has the highest elasticity of 0.102, indicating a 10% increase in its expenditures raises snack peanut demand by 0.102%. Reputation management has an elasticity of 0.074, while NPB generic advertising has an elasticity of 0.060.
Table 2 presents the econometric results related to the impacts of NPB activities on peanut yield and supply. Production sponsored research by the NPB has a positive and statistically significant impact on peanut yield. The results indicate that both two-year and six-year lagged research collectively increase peanut yield. The research elasticity is 0.025, meaning that holding all other factors constant, an increase in NPB research expenditures of 10% results in a 0.25% increase in peanut yield.

Production sponsored research by the NPB has a positive and statistically significant impact on peanut supply. The results indicate that research expenditures, lagged two years, significantly increases peanut supply. The long-run research elasticity is 0.024, meaning that holding all other supply factors constant, an increase in NPB research expenditures of 10% results in a 0.24% increase in peanut supply.

Recall that the first main question posed in this research is what is the responsiveness of peanut demand (and yields) to NPB demand and production enhancing activities? To answer this important question, the elasticity values from the econometric models are used to build a simulation model. Two separate simulation models are constructed: (1) demand and (2) yield simulation models.

Table 2. Estimated NPB yield and supply elasticities.

<table>
<thead>
<tr>
<th>NPB Activity</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact on peanut yield:</strong></td>
<td></td>
</tr>
<tr>
<td>NPB production research</td>
<td>0.025</td>
</tr>
<tr>
<td><strong>Impact on peanut supply:</strong></td>
<td></td>
</tr>
<tr>
<td>NPB production research</td>
<td>0.024</td>
</tr>
</tbody>
</table>
For the demand model, the total peanut demand model is used in the simulation since this study is primarily concerned about how the NPB impacts overall peanut demand. Two scenarios are of interest in answering the first research question: (1) a baseline scenario in which NPB demand enhancing programs are in effect and expenditures are set at actual levels; and (2) a counterfactual no-NPB scenario, where NPB expenditures are eliminated. The difference between the two scenarios gives the impact of the NPB on the demand for peanuts. The simulation model is simulated for the last five years, 2014 through 2018.

Figure 9 displays the simulation results for the two demand scenarios. In this graph, the top blue line simulates quarterly historic peanut demand given the existence of the NPB, while the bottom red line simulates what demand would have been had there been no NPB advertising, public relations, reputation management, and business development programs over this period. A comparison of the two scenarios indicates that the NPB demand enhancing activities increased overall peanut demand by 1.7 billion pounds in total over this period, which translates to a 14.4% increase in peanut demand. Put differently, had there been no NPB in effect, peanut demand would have been 14.4% lower than it actually was. Hence, the answer to the first question posed in this research is clearly yes, the NPB has a significant impact on peanut demand. What about peanut yield?

Figure 10 displays the simulation results for the two yield scenarios. In this graph, the top blue line is annual historic peanut yields given the existence of NPB-sponsored production research activities, while the bottom red line simulates what peanut yields would have been had there been no NPB research over this period. A comparison of the two scenarios indicates that had there been no NPB in effect, peanut yield would have averaged 3,462 pounds per acre.

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1 Actually, since the demand model is a double logarithmic model and the log of zero is undefined, in this second counterfactual scenario, NPB expenditures are set to a very small, but positive level.
Figure 9. Total quarterly peanut demand with and without NPB, 2014-18.

Figure 10. Annual peanut yield with and without NPB production-research expenditures, 2013-2018.
compared with 3,880 pounds, or 10.8% less than it actually was. Therefore, the answer to the first question is clearly yes, the NPB has a significant impact on peanut yield as well as demand.

While the results indicate a positive impact of NPB promotion and research activities on peanut demand and yield, the impacts that NPB activities have on peanut producer profits compared with its cost is a more important question to be addressed. That is, a BCR should be computed. In this study, a marginal BCR is computed, which gives the incremental value in profit of an extra dollar invested in a NPB activity.

The results of the analysis are presented in Table 3. The highest marginal BCR is for public relations. Based on the period 2014-18, an extra dollar invested in public relations yielded an extra $105.67 in producer profit. Clearly if the NPB had an additional dollar to spend on activities, public relations should be the highest priority based on this very high marginal BCR. Generic peanut advertising had a marginal BCR of 6.88, i.e., an extra dollar for advertising would return $6.88 in producer profit. An extra dollar invested in reputation management returned an extra $6.46 in producer profits. Finally, an extra dollar invested in business development returned $3.38 in profits. 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, and vice versa. 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.

The marginal BCR for production research is found to be 1.79. This means that over this period, an extra dollar invested into production-level research by the NPB yielded an additional $1.79 in peanut grower profits. While this is the lowest marginal BCR, it is worth noting that
this estimate likely understates the full value of production research to the peanut industry. One
major benefit of production research is that it leads to lower cost and more efficient peanut
production, which enhances the competitive advantage of the U.S. peanut industry in the world
market. It is likely that NPB-sponsored production research has helped grow U.S. market share
in the world peanut market. Evidence of this can be seen by the growth in U.S. peanut exports,
which have increased by over 100% since 2011.

Collectively, the overall marginal BCR for all NPB activities is $9.74. Hence, the NPB has
a very high marginal BCR for its activities over the period 2014-18. How does this marginal
BCR compare to estimates for other commodity promotion organizations? Table 4 lists 21
selected studies of federal and state generic promotion programs. The median marginal BCR for
these studies was 6.3, indicating the marginal benefits were 6.3 times larger than the marginal
costs. The estimated marginal BCR for peanuts, 9.74, is therefore substantially higher than the
median marginal BCR from these studies.

Table 3. Marginal BCRs for NPB demand and supply activities.

<table>
<thead>
<tr>
<th>NPB Activity</th>
<th>Marginal benefit-cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic peanut advertising</td>
<td>6.88</td>
</tr>
<tr>
<td>Public relations</td>
<td>105.67</td>
</tr>
<tr>
<td>Reputation management</td>
<td>6.46</td>
</tr>
<tr>
<td>Business development</td>
<td>3.38</td>
</tr>
<tr>
<td>Production research</td>
<td>1.79</td>
</tr>
<tr>
<td>All activities combined</td>
<td>9.74</td>
</tr>
</tbody>
</table>

**Summary and Conclusions**

This study has two general objectives:
1. To measure whether the NPB’s marketing and production research programs increases demand for peanuts, peanut products, and peanut yield compared to what would have occurred in the absence of the NPB.

2. To measure the benefits of the NPB checkoff program 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 the Board to its stakeholders.

The analysis was based on three econometric models. The econometric approach enables one to simultaneously account for the impact of a variety of factors affecting demand, supply, and yield 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 NPB’s activities on peanut demand and supply. The three econometric models included a: (1) domestic peanut demand model, (2) domestic peanut yield model, and (3) domestic peanut supply model. These three models were used to test whether the various activities by the NPB had a statistically significant impact on peanut demand, supply, and yield.

The peanut demand and yield models were used to simulate two scenarios: (1) a baseline scenario in which NPB programs were in effect and expenditures were set at actual levels; and (2) a counterfactual no-NPB scenario, where NPB expenditures were eliminated. The results indicated that the NPB demand enhancing activities increased overall peanut demand by almost 14.4%. Put differently, had there been no NPB in effect, peanut demand would have been 14.4% lower than it actually was. Had there not been any NPB-sponsored production research over this period, peanut yield would have averaged 10.8% less than it actually was. Therefore, the NPB had a significant impact on peanut demand and yield over this period.

Marginal BCRs were computed for the major NPB activities. A marginal BCR measures the incremental benefits from an extra dollar invested in an activity, and provides a useful measure of the benefits relative to costs. All NPB activities (except business development) had
BCRs larger than one indicating that the NPB has been profitable for peanut farmers.

Collectively, the overall BCR for all NPB activities was $9.74. In other words, an extra dollar invested in NPB activities over the period, 2014-18, returned $9.74 to peanut producer profit.

The highest marginal BCR was for public relations. Based on the period 2014-18, an extra dollar invested in public relations yielded an extra $105.67 in producer profit. If the NPB had an additional dollar to spend, this would be its highest priority based on this very high marginal

Table 4. Estimated benefit-cost ratios for selected commodities.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Commodity</th>
<th>Average Benefit/Cost Ratio</th>
<th>Marginal Benefit/Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alston et al. (1997)</td>
<td>California Table Grapes</td>
<td>44.9</td>
<td>38.8</td>
</tr>
<tr>
<td>Alston et al. (1998)</td>
<td>California Dried Plums</td>
<td>NA</td>
<td>2.7</td>
</tr>
<tr>
<td>Crespi and Sexton (2005)</td>
<td>California Almonds</td>
<td>NA</td>
<td>6.2</td>
</tr>
<tr>
<td>Carter et al. (2005)</td>
<td>California Strawberries</td>
<td>NA</td>
<td>44.0</td>
</tr>
<tr>
<td>Carman and Craft (1998)</td>
<td>California Avocados</td>
<td>5.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Williams et al. (2004)</td>
<td>Florida Orange Juice</td>
<td>2.9-7.0</td>
<td>NA</td>
</tr>
<tr>
<td>Kaiser (1997)</td>
<td>All Dairy Products</td>
<td>3.4</td>
<td>NA</td>
</tr>
<tr>
<td>Ward (1996)</td>
<td>Beef</td>
<td>5.7</td>
<td>5.7-9.7</td>
</tr>
<tr>
<td>Kaiser and Schmit (1998)</td>
<td>Eggs</td>
<td>NA</td>
<td>.54-6.33</td>
</tr>
<tr>
<td>Murray et al. (2001)</td>
<td>Cotton</td>
<td>3.2-6.0</td>
<td>NA</td>
</tr>
<tr>
<td>Capps and Williams (2008)</td>
<td>Lamb</td>
<td>NA</td>
<td>44.5</td>
</tr>
<tr>
<td>Richards and Patterson (2007)</td>
<td>Potatoes</td>
<td>6.5</td>
<td>NA</td>
</tr>
<tr>
<td>Williams (1999)</td>
<td>Soybeans</td>
<td>1.7-7.9</td>
<td>NA</td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td>6.0</td>
<td>6.3</td>
</tr>
</tbody>
</table>
BCR. It is worth noting that the reason this marginal BCR is so high is due to the very small percentage of the budget devoted to public relations (approximately 5%). An extra dollar invested in generic advertising and reputation management also had high marginal BCRs of 6.88 and 6.46, respectively. And, an extra dollar invested into business development and production-level research sponsored by the NPB yielded an additional $3.38 and 1.79 in peanut grower profits.

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 NPB activity with the lowest expenditures (public relations) has the highest marginal BCR, while the activity with the highest investment (e.g., production research) has the lowest marginal BCR. Relatedly, it is also important to note that if one decreased expenditures on an activity such as generic advertising, its marginal BCR would increase.
References


Williams, Gary W., Oral Capps, Jr., and David A. Bressler. (2004). ‘Florida Orange Grower Returns from Orange Juice Advertising.’ College Station, TX: Department of Agricultural Economics, Texas A&M University.
Appendix: Econometric and Simulation Model

The econometric model used in this study consists of a retail demand, supply, and yield model to measure the impact of the NPB activities on impacting peanut demand and supply. The econometric results are then used to simulate marketing conditions under alternative NPB expenditure scenarios to measure the impact of the NPB on peanut demand and supply, which enables us to compute benefit cost ratio for the NPB. In this Appendix, a through description and documentation of the methodology.

Retail Peanut Demand

Actually, three separate domestic demand models are estimated for peanut demand: (1) total peanut demand, (2) peanut butter demand and (3) snack peanut demand. The most important model is (1) because in this report, we are interested in how the NPB impacts the overall demand for all peanuts and peanut products. Models (2) and (3) are useful additions since they will measure how the NPB demand-enhancing activities specifically impact peanut butter and snack peanut demand.

The factors that affect the demand for peanuts (and peanut products) include the retail price for peanut (and peanut products, e.g., peanut butter), retail price of complementary products for peanuts (e.g., price of bread for peanut butter), consumer income, and expenditures by the NPB on demand enhancing activities such as advertising, public relations, reputation management, and business development. The demand equation for total peanut consumption is estimated with retail demand as the dependent variable measured in pounds.

Mathematically, the demand model for total peanut consumption is represented by the following equation:

\[
\ln(CON_i) = \beta_0 + \beta_1 \ln(RPP_i/CPI_i) + \beta_2 \ln(RBP_i/CPI_i) + \beta_3 \ln(RBLP_i/CPI_i)
\]
\[ + \beta_4 \ln(\text{INC}_t/\text{CPI}_t) + \beta_5 \ln(\text{TREND}_t) + \beta_6 \ln(\text{NPBAD}_{t-n}/\text{CPI}_{t-n}) + \beta_7 \ln(\text{NPBPR}_t/\text{CPI}_{t-n}) \\
+ \beta_8 \ln(\text{NPBRM}_{t-n}/\text{CPI}_{t-n}) + \beta_9 \ln(\text{PCCON}_{t-1}) \]

where:

CON = total peanut demand measured as quarterly total peanuts (raw basis) used in primary products and in shell peanuts divided by U.S. population. The peanut consumption data come from USDA, NASS *Peanut Stocks and Processing Report*.

RPP = retail price of peanuts, $/lb, calculated as a weighted average between the retail price of peanut butter and retail price for peanut snacks. These data come from IRI unit values based on total expenditures and volume of peanuts and peanut butter.


RBP = Retail price of white bread in the U.S. per loaf, BLS.

RBLP = retail price of bologna deli meat in the U.S., $/lb, BLS.

INC = disposable real (inflation adjusted) income in the U.S. in bil. $. The source of these data is *Economic Report of the President*.

TREND = linear trend variable equals 1 for 2006.1, 2 for 2006.2, 3 for 2006.3…. 

NPBAD = expenditures ($) on generic peanut advertising by the NPB in the U.S. These data come from the NPB.

NPBPR = expenditures ($) on peanut public relations by the NPB in the U.S. These data come from the NPB.

NPBRM = expenditures ($) on peanut reputation management by the NPB in the U.S. These data come from the NPB.

NPBBD = expenditures ($) on peanut business development by the NPB in the U.S. These data come from the NPB.

In this equation, "ln" is the natural logarithmic operator, and the $\beta$s are the coefficients to be estimated with statistical regression analysis. The double logarithmic form is specified since it fits the data the best, and it is consistent with the concept of diminishing returns for the marketing variables, which simply means as more money is invested in an activity such as advertising, demand will increase but at a decreasing rate. All monetary variables such as RPP,
RBP, RBLP, INC, and all NPB expenditures are deflated by the 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.

The retail price for peanuts is expected to be negatively related to peanut demand, i.e., a lower price results in higher quantity demanded reflecting the law of demand. The retail price of bread and bologna products are included because they represent complimentary and substitute products for peanuts, which should influence the demand for peanuts. The relationship between CON and RBP is expected to be negative because bread and peanut butter are complimentary, i.e., if the price of bread falls, that increases the demand for peanut butter since they are often consumed in combination of each other. The price of bologna is expected to be positively related to peanut demand since deli meat is a substitute to peanut butter, i.e., if the price of bologna falls, that decreases the demand for peanut butter. The relationship between income and peanut demand is expected to be positive, i.e., as consumers become wealthier, the demand for peanuts should increase. The time trend term is included to capture changes in consumer preferences for peanuts over time, and is expected to be positive given increases in demand for peanuts. The four NPB marketing activities are expected to each have a positive impact on the demand for peanuts.

It is well documented in the literature that advertising and other marketing campaigns have a “carry-over effect” on demand, i.e., past, as well as current advertising has an effect on current demand. To capture this carry-over effect, current and various lagged PBAD and NPB marketing expenditures are included in the model and the lag-length that provided the best statistical fit is chosen for the final model. All four NPB marketing activities are included as separate variables in the peanut demand equation.
Using similar data and procedures, two separate demand equations are estimated for peanut butter and snack peanuts. Mathematically, the two demand models are represented by the following two equations:

\[(2) \ln(PBCON_t) = \beta 0 + \beta 1 \ln(RPBP_t/CPI_t) + \beta 2 \ln(RBP_t/CPI_t) + \beta 3 \ln(RBLP_t/CPI_t) + \beta 4 \ln(INC_t/CPI_t) + \beta 5 \ln(TREND_t) + \beta 6 \ln(NPBAD_{t-n}/CPI_{t-n}) + \beta 7 \ln(NPBPR_{t-n}/CPI_{t-n}) + \beta 8 \ln(NPBRMt_{t-n}/CPI_{t-n}) + \beta 9 \ln(PBCON_{t-1}) \]

\[(3) \ln(PSCON_t) = \beta 0 + \beta 1 \ln(RPSP_t/CPI_t) + \beta 2 \ln(INC_t/CPI_t) + \beta 3 \ln(TREND_t) + \beta 4 \ln(NPBAD_{t-n}/CPI_{t-n}) + \beta 5 \ln(NPBPR_{t-n}/CPI_{t-n}) + \beta 6 \ln(NPBRMt_{t-n}/CPI_{t-n}) + \beta 7 \ln(PSCON_{t-1}) + \beta 8 \ln(PICECREAM_t/CPI_t) + \beta 9 \ln(PCOOKIE_t/CPI_t) \]

where:

PBCON = total peanut butter demand measured as quarterly total peanut butter volume in all U.S. outlets. These data come from IRI.

RPBP = retail price of peanut butter, $/lb, calculated as a unit value from total expenditures on peanut butter divided by total volume sold of peanut butter. These data come from IRI.

PSCON = total peanut snacks demand measured as quarterly total peanut snack volume in all U.S. outlets. These data come from IRI.

RPSP = retail price of peanut snacks, $/lb, calculated as a unit value from total expenditures on peanuts divided by total volume sold of peanut snacks. These data come from IRI.

PICECREAM = retail price of ice cream per gallon. This data come from BLS.

PCOOKIE = retail price of cookies. This data come from BLS. Both the ice cream and cookie retail prices are included since they may be substitutes for peanut snacks.

All other variables are defined as before.

**Econometric Results:**

The combined retail peanut demand model is estimated in logarithmic form with quarterly data on total peanut consumption (raw basis) used in primary products and in shell peanuts (USDA) from 2006-quarter 1 (2006.1) through 2018, quarter 4 (2018.4). The advantage
of using quarterly rather than 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 peanut industry since 2006, which would be less true if one had to go back to say 1970. The peanut butter demand model is estimated in double logarithmic form with quarterly IRI data from 2010.1 through 2018.4. The peanut snack demand model is estimated in double logarithmic form with quarterly IRI data from 2010.1 through 2017.2 (due to data limitations, the data for this model do not go through 2018 like the other two models). All models are originally estimated with all the demand drivers in them as specified in equations (1), (2), and (3). The final models, presented below, only include the demand drivers that have coefficients that are statistically significantly different from zero.

**Total peanut demand model.** The estimated elasticities for the total peanut demand model are summarized in Table A1. The coefficient of variation indicates that the explanatory variables explain over 87% of the variations in the quarterly demand for peanuts. The elasticity signs are consistent with economic theory and most estimated coefficients are statistically significant at better than the 10% significance level. Several econometric diagnostic tests performed indicate no statistical problems. The final model does not include real disposable income and the retail price of bologna since their estimated coefficients are not statistically significant.

The estimated own price elasticity is negative and equal to -0.08, which is not statically significantly different from zero at conventional significance levels. The interpretation of this is a 1% increase in the retail peanut price, holding the effects of all other demand factors constant, leads to a 0.08% decrease in peanut quantity demanded. As expected, bread is found to be a compliment to peanut demand due to the complimentary nature of peanut butter and bread. The
elasticity for the price of bread is -0.382, which is statistically significantly different from zero. The trend term is positive and statistically significant, indicating increasing preferences over time for peanuts and peanut products.

Table A1. Total peanut demand elasticities.

<table>
<thead>
<tr>
<th>Demand Factor</th>
<th>Elasticity</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail peanut price</td>
<td>-0.080</td>
<td>0.190</td>
</tr>
<tr>
<td>Retail bread price</td>
<td>-0.382</td>
<td>0.015</td>
</tr>
<tr>
<td>Time trend</td>
<td>0.146</td>
<td>0.000</td>
</tr>
<tr>
<td>NPB advertising</td>
<td>0.017</td>
<td>0.060</td>
</tr>
<tr>
<td>NPB public relations</td>
<td>0.040</td>
<td>0.010</td>
</tr>
<tr>
<td>NPB reputation management</td>
<td>0.008</td>
<td>0.111</td>
</tr>
<tr>
<td>NPB business development</td>
<td>0.003</td>
<td>0.450</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>0.87</td>
<td></td>
</tr>
</tbody>
</table>

All of the four marketing activities by the NPB are positive, and three are statistically significantly different from zero. Similar to the last study conducted 5 years ago, public relations activities by the NPB has the highest elasticity value of 0.40. In other words, increasing NPB public relations expenditures by 10% increases peanut demand by 0.4%. The public relations activities have a 1-quarter lag effect on demand. Generic peanut advertising by the NPB had an instant effect on demand with an elasticity of 0.017, which is statistically significant. In other words, holding the effects of all other demand factors constant, increasing advertising expenditures by 10% increases peanut demand by 0.17%. The estimated elasticity for NPB reputation management is 0.008, and has a 4-quarter lag effect on demand. NPB business development activities have an estimated elasticity of 0.003, but is not statistically different from zero, which is similar to the findings in the previous study.
**Peanut butter demand model.** The estimated elasticities for the peanut butter demand model based on the IRI data are summarized in Table A2. The coefficient of variation indicates that the explanatory variables explain 90% of the variations in quarterly demand for peanut butter. The elasticity signs are consistent with economic theory and the majority of estimated coefficients are statistically significant at better than the 10% significance level. Several econometric diagnostic tests performed indicate no statistical problems. The final model does not include real disposable income and the retail price of bread.

The price elasticity is higher in the peanut butter model than the total peanut demand model. This is likely due to the fact that there are more substitutes available for peanut butter or snack peanuts compared with the broader category of total peanut demand. The results indicate that, holding all other demand factors constant, a 1% increase in the peanut butter price results in a 0.308% decrease in peanut butter demanded, which is statistically significant. The retail price of bologna is also significant and indicates a substitute relationship. Specifically, a 1% increase in the price of bologna results in a 0.375% increase in peanut butter demand, holding all other demand factors constant. The trend variable is positive and statistically significant indicating that there has been an increase in consumer preferences towards peanut butter since 2009.

Unlike the total peanut demand model, all four of the NPB marketing activities are positive and statistically significant. Of the four NPB activities, business development has the largest impact on increasing peanut butter demand. Holding all other factors constant, a 10% increase in NPB expenditures on business development programs increases peanut butter demand by 0.92%, which is statistically significant. Public relations has the next highest elasticity of 0.084, followed by generic advertising (0.028) and reputation management (0.010).
In other words, a 10% increase in public relations, advertising, and reputation management expenditures, holding constant all other demand drivers, would each increase peanut butter demand by 0.84%, 0.28%, and 0.1%, respectively.

**Table A2.** Peanut butter demand elasticities.

<table>
<thead>
<tr>
<th>Demand Factor</th>
<th>Elasticity</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail peanut butter price</td>
<td>-0.308</td>
<td>0.002</td>
</tr>
<tr>
<td>Retail bologna price</td>
<td>0.375</td>
<td>0.017</td>
</tr>
<tr>
<td>Time trend</td>
<td>0.457</td>
<td>0.000</td>
</tr>
<tr>
<td>NPB advertising</td>
<td>0.028</td>
<td>0.001</td>
</tr>
<tr>
<td>NPB public relations</td>
<td>0.084</td>
<td>0.000</td>
</tr>
<tr>
<td>NPB reputation management</td>
<td>0.010</td>
<td>0.050</td>
</tr>
<tr>
<td>NPB business development</td>
<td>0.092</td>
<td>0.005</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>0.90</td>
<td></td>
</tr>
</tbody>
</table>

**Snack peanut demand.** The estimated elasticities for the snack peanut demand model based on the IRI data are summarized in Table A3. The coefficient of variation indicates that the explanatory variables explain 63% of the variations in quarterly demand for snack peanuts. The elasticity signs are consistent with economic theory and the majority (except price, which is not significant) of estimated coefficients are statistically significant at better than the 10% significance level. Several econometric diagnostic tests performed indicate no statistical problems. The final model does not include real disposable income, trend variable, and retail price of cookies.

The results indicate that the snack peanuts are not at all responsive to the snack peanut price. The fact that snack peanut has no impact on snack peanut demand may be due to the fact that snack peanuts constitute a small share of one’s budget. The retail price of ice cream is
positive and statistically significant indicating that ice cream is a substitute to snack peanuts. The retail price of cookies is also found to be a substitute to snack peanuts, however, is not included in the final model because of the high degree of correlation with the price of ice cream.

Table A3. Snack peanut demand elasticities.

<table>
<thead>
<tr>
<th>Demand Factor</th>
<th>Elasticity</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail peanut price</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Retail ice cream price</td>
<td>2.569</td>
<td>0.000</td>
</tr>
<tr>
<td>NPB advertising</td>
<td>0.060</td>
<td>0.085</td>
</tr>
<tr>
<td>NPB public relations</td>
<td>0.102</td>
<td>0.004</td>
</tr>
<tr>
<td>NPB reputation management</td>
<td>0.074</td>
<td>0.020</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>0.63</td>
<td></td>
</tr>
</tbody>
</table>

While NPB business development is not found to be statistically significant and hence omitted from the model, the other three NPB activities are significant. Public relations has the highest elasticity of 0.102, indicating a 10% increase in its expenditures raises snack peanut demand by 0.102%. Reputation management has an elasticity of 0.074, while NPB generic advertising has an elasticity of 0.060. All are statistically significantly different from zero.

**Peanut Producer Yield and Supply Equations**

Unlike the three demand functions, the peanut grower yield and supply equations are estimated with annual data for the period 1987 through 2018. This longer time period is used because the effects of production research by the NPB on producer peanut yield per acre and overall supply have a much longer time lag than the impact of demand enhancing activities on retail demand.
**Peanut yield equation.** The factors that impact the yield of peanuts over time include the grower price of peanuts, variable production costs, technological progress in peanut production, and NPB expenditures on research. Mathematically, the yield model for all peanuts is represented by the following equation:

\[
\ln(YIELD) = \alpha_0 + \alpha_1 \ln(GPP_{t-1}/PP_{t-1}) + \alpha_2 \ln(TREND) + \alpha_3 \text{PDL} \ln \left( \frac{\text{NPBRESEARCH}_{t-n}/\text{CPI}_{t-n}}{} \right)
\]

where:

- **YIELD** = peanut yield per acre in pounds. These data come from USDA, NASS.
- **GPP** = grower peanut price, $ per lb. These data come from USDA, NASS.
- **TREND** = linear trend term, 1987=1, 1987=2, …. 
- **PP** = index of prices paid by farmers for the crop sector. These data come from USDA’s *Agricultural Prices*.
- **NPBRESEARCH** = production research expenditures by NPB. These data come from NPB.

In this equation, “ln” is the natural logarithmic operator, and the \(a\)s are the coefficients to be estimated with statistical regression analysis. NPBRESEARCH 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.

The expected grower peanut price is expected to be positively related to peanut yield. An increase in the expected price should increase yield of peanuts by farmers. As a proxy for the expected price, a naïve price expectations scheme is used with a one-year lag specification. That is, producers base their price expectations for the current year crop based on the previous year’s price. Peanut grower production costs are measured by the index of prices paid by crop farmers.
Like the grower price, this index of costs is lagged one year since farmers make production decisions based on output and input price expectations. To capture technological progress in peanut production since 1987, a linear time trend is included in the equation. To capture the lag effect of NPB research on yields, various lag specifications are tried, and the one with the best statistical fit is used as the final model.

**Peanut supply equation.** The factors that impact the supply of peanuts over time include the grower price of peanuts, variable production costs, technological progress, and NPB expenditures on research. Mathematically, the supply model for all peanuts is represented by the following equation:

(5) \[ \ln(\text{PRODUCTION}_t) = \alpha_0 + \alpha_1 \ln(\text{GPP}_{t-1}/\text{CPI}_{t-1}) + \alpha_2 \ln(\text{PP}_{t-1}/\text{CPI}_{t-1}) + \alpha_3 \ln(\text{TREND}_t) + \alpha_4 \text{PDL} \ln(\text{NPBRESEARCH}_{t-n}/\text{CPI}_{t-n}) \]

where:

- **PRODUCTION** = peanut production in pounds. These data come from USDA, NASS.
- **GPP** = grower peanut price, $ per lb. These data come from USDA, NASS.
- **PP** = index of prices paid by farmers for the crop sector. These data comes from USDA’s *Agricultural Prices*.
- **TREND** = linear trend variable equals 1 for 1986, 2 for 1987, 3 for 1988…. 
- **NPBRESEARCH** = production research expenditures by NPB. These data comes from NPB.

In this equation, “ln” is the natural logarithmic operator, and the \( \alpha \)s are the coefficients to be estimated with statistical regression analysis. All monetary variables such as GPP, PP, and NPBRESEARCH 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.
The expected grower peanut price is expected to be positively related to peanut supply. An increase in the expected price should increase quantity supplied of peanuts by farmers. As a proxy for the expected price, a naïve price expectations scheme is used with a one-year lag specification. That is, producers base their price expectations for the current year crop based on the previous year’s price. Peanut grower production costs are measured by the index of prices paid by crop farmers. Like the grower price, this index of costs is lagged one year since farmers make production decisions based on output and input price expectations. The time trend variable is used as a proxy for technological progress in peanut farming since 1986. To capture the lag effect of NPB research on supply, various lag specifications are tried, and the one with the best statistical fit is used as the final model.

**Econometric Results:**

The peanut yield model is estimated in logarithmic form with annual data from 1987 through 2018. The estimated elasticities for yield model are summarized in Table A4. The coefficient of variation indicates that the explanatory variables explain 86% of the variations in annual peanut yield per acre. The elasticity signs are consistent with economic theory and all estimated coefficients are statistically significant at better than the 5% significance level. Several econometric diagnostic tests performed indicate no statistical problems.

The grower price has a positive and statistically significant impact on yield of peanuts. Holding all other factors constant, a 1% increase in the grower price is found to increase yields by 0.25%. Production costs, as measured by the prices paid index, has a negative and statistically significant impact on peanut yields. A 1% increase in production costs, holding other yield factors constant, results in a 0.25% decrease in peanut yields. The time trend is positive and
significant, 0.35, indicating that there has been steady progress in technological and managerial improvement in peanut production since 1986.

Table A4. Peanut yield elasticities.

<table>
<thead>
<tr>
<th>Yield Factor</th>
<th>Elasticity</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower peanut price</td>
<td>0.251</td>
<td>0.035</td>
</tr>
<tr>
<td>Index of prices paid</td>
<td>-0.251</td>
<td>0.035</td>
</tr>
<tr>
<td>Time trend</td>
<td>0.350</td>
<td>0.003</td>
</tr>
<tr>
<td>NPB research&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.025</td>
<td>0.001</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>0.86</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>This elasticity is the long-run elasticity for research, i.e., the sum of the second and sixth year lag values, both of which are statistically significant.

Production sponsored research by the NPB has a positive and statistically significant impact on peanut yield. The results indicate that both two-year and six-year lagged research collectively increase peanut yield. The long-run research elasticity is 0.025, meaning that holding all other factors constant, an increase in NPB research expenditures of 10% results in a 0.25% increase in peanut yield.

The peanut supply model is estimated in logarithmic form with annual data from 1987 through 2018. The estimated elasticities for supply model are summarized in Table A5. The coefficient of variation indicates that the explanatory variables explain 40% of the variations in annual supply of peanuts. The elasticity signs are consistent with economic theory and all estimated coefficients (except production costs) are statistically significant at better than the 5% significance level. The proxy for production costs, the Prices Paid Index, is not statistically significant and hence deleted from the final model. Several econometric diagnostic tests performed indicate no statistical problems.

The grower price has a positive and statistically significant impact on quantity supplied
of peanuts. Holding all other supply factors constant, a 1% increase in the grower price is found to increase quantity supplied by 0.593%. The time trend is positive and significant, 0.436, indicating that there has been steady progress in technological and managerial improvement in peanut production since 1986.

Table A5. Peanut supply elasticities.

<table>
<thead>
<tr>
<th>Supply Factor</th>
<th>Elasticity</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower peanut price</td>
<td>0.593</td>
<td>0.025</td>
</tr>
<tr>
<td>Time trend</td>
<td>0.436</td>
<td>0.006</td>
</tr>
<tr>
<td>NPB research&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.024</td>
<td>0.002</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>0.40</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>The best model included just a two-year lag on research expenditures.

Production sponsored research by the NPB has a positive and statistically significant impact on peanut supply. The results indicate that research expenditures, lagged two years, significantly increases peanut supply. The long-run research elasticity is 0.024, meaning that holding all other supply factors constant, an increase in NPB research expenditures of 10% results in a 0.24% increase in peanut supply.

**Simulation Analysis**

It is clear from the estimated NPB elasticities that the majority of NPB activities have a statistically significant and positive impact on both peanut demand and yields. Recall that the first main question posed in this research is what is the responsiveness of peanut demand (and yields) to NPB demand and production enhancing activities? To answer this important question, the elasticity values from the econometric models are used to build a simulation model. Two separate simulation models are constructed: (1) demand and (2) yield simulation models.
For the demand model, the total peanut demand model is used in the simulation since this study is primarily concerned about how the NPB impacts overall peanut demand. Two scenarios are of interest in answering the first research question: (1) a baseline scenario in which NPB demand enhancing programs are in effect and expenditures are set at actual levels; and (2) a counterfactual no-NPB scenario, where NPB expenditures are eliminated. The difference between the two scenarios gives the impact of the NPB on the demand for peanuts. The simulation model is simulated for the last five years, 2014 through 2018.

Figure 8 displays the simulation results for the two demand scenarios. In this graph, the top blue line simulates quarterly historic peanut demand given the existence of the NPB, while the bottom red line simulates what demand would have been had there been no NPB advertising, public relations, reputation management, and business development programs over this period. A comparison of the two scenarios indicates that the NPB demand enhancing activities increased overall peanut demand by 1.7 billion pounds in total over this period, which translates to a 14.4% increase in peanut demand. Put differently, had there been no NPB in effect, peanut demand would have been 14.4% lower than it actually was. Hence, the answer to the first question posed in this research is clearly yes, the NPB has a significant impact on peanut demand. What about peanut yield?

The results of the estimated annual peanut yield model are used to build a similar simulation model to look at peanut yield. Again, the model is used to simulate two scenarios: (1) a baseline scenario in which NPB-sponsored production research is in effect and expenditures are set at actual levels; and (2) a counterfactual no-NPB scenario, where NPB production research expenditures are eliminated. The difference between the two scenarios gives the impact

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2 Actually, since the demand model is a double logarithmic model and the log of zero is undefined, in this second counterfactual scenario, NPB expenditures are set to a very small, but positive level.
of the NPB on the per acre yield of peanuts. The simulation model is simulated for the time period 2014 through 2018.

Figure 9 displays the simulation results for the two yield scenarios. In this graph, the top blue line is annual historic peanut yields given the existence of NPB-sponsored production research activities, while the bottom red line simulates what peanut yields would have been had there been no NPB research over this period. A comparison of the two scenarios indicates that had there been no NPB in effect, peanut yield would have averaged 3,462 pounds per acre compared with 3,880 pounds, or 10.8% less than it actually was. Therefore, the answer to the first question is clearly yes, the NPB has a significant impact on peanut yield as well as demand.

**Marginal Benefit-Cost Analysis**

While the results indicate a positive impact of NPB promotion and research activities on peanut demand and yield, the impacts that NPB activities have on peanut producer profits compared with its cost is a more important question to be addressed. That is, a BCR should be computed. A marginal BCR gives the incremental value in profit of an extra dollar invested in a NPB activity. Because the demand model is estimated separately from the supply model with different data sets, the marginal BCR calculation for the two models is computed separately below. First, consider the calculation of the marginal BCR for the demand activities.

**Marginal BCRs for NPB demand activities:**

The marginal benefit of NPB promotion is the additional net revenue\(^3\) from an extra dollar invested in promotion to peanut growers due to both higher volume sold in the market and

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\(^3\) In this report, the terms “profit” and “net revenue” are used interchangeably. Also, profit is measured by what economists refer to as “producer surplus” in the calculation of the BCRs for the NPB demand activities.
higher price. The cost of promotion is the cost of conducting the NPB promotion programs. The increase in demand due to NPB promotion just described assumed that all other demand determinants, including price, remained constant. However, an increase in demand generally will cause price to increase as well, provided that the demand increase is not perfectly offset by an increase in quantity supplied. Hence, to properly evaluate the full effect of NPB promotion programs on quantity and price, the peanut supply response based on the supply equation result must be incorporated into the model. Recall that based on that equation, the own price elasticity of supply is 0.593, which is statistically significant. This estimate is used as the supply response (elasticity) in the computation of the marginal BCR.

To compute the marginal BCR for the NPB demand-enhancing activities, the 0.593 supply response (from the estimated supply function listed in Table A5) is incorporated using a constant elasticity form and equated with predicted peanut demand quantities. Two scenarios are simulated for the marginal analysis. The first scenario is identical to the previous first scenario where all promotion expenditures are set to their historical levels over the simulation period. In the second “10% increase in NPB expenditures” scenario, NPB expenditures for each month in the simulation period are increased by 10% higher than their historical levels. The marginal changes in demand due to the 10% increased NPB scenario then affects the level of production and price for peanuts. The change in net revenue due to the 10% increase in NPB promotion programs is computed for the period 2014.1 through 2018.4 as the difference in producer surplus (ΔPS) between the two scenarios, which mathematically equals

$$\Delta PS_t = \frac{(P_t'Q_t' - P_tQ_t)}{(1 + \varepsilon)},$$

where $P_tQ_t$ represents total revenue (price times quantity) for the baseline scenario with 100% NPB promotion expenditures, $P_t'Q_t'$ represents total revenue for the scenario with 110% NPB
promotion expenditures, and \( \varepsilon \) represents the own price elasticity of supply, which in this case is equal to 0.593.

The marginal BCR is then computed as:

\[
BCR = \frac{\Delta P_{St}}{\Delta COST_t},
\]

where \( \Delta COST_t \) is the difference in costs of the NPB promotion programs for the 100% and 110% funding scenarios in period \( t \).

The results of the analysis are presented in Table A6. The highest marginal BCR is for public relations. Based on the period 2014-18, an extra dollar invested in public relations yielded an extra $105.67 in producer profit. Clearly if the NPB had an additional dollar to spend on activities, public relations should be the highest priority based on this very high marginal BCR. Generic peanut advertising had a marginal BCR of 6.88, i.e., an extra dollar for advertising would return $6.88 in producer profit. An extra dollar invested in reputation management returned an extra $6.46 in producer profits. Finally, an extra dollar invested in business development returned $3.38 in profits. 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, and vice versa. 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 NPB activities is $9.74. Hence, the NPB has a very high marginal BCR for its activities over the period 2014-18.
Table A6. Marginal BCRs for NPB demand and supply activities.

<table>
<thead>
<tr>
<th>NPB Marketing Activity</th>
<th>Marginal benefit-cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic peanut advertising</td>
<td>6.88</td>
</tr>
<tr>
<td>Public relations</td>
<td>105.67</td>
</tr>
<tr>
<td>Reputation management</td>
<td>6.46</td>
</tr>
<tr>
<td>Business development</td>
<td>3.38</td>
</tr>
<tr>
<td>Production research</td>
<td>1.79</td>
</tr>
<tr>
<td>All activities combined</td>
<td>9.74</td>
</tr>
</tbody>
</table>

**Marginal BCR for NPB production research:**

A slightly different procedure is used to compute the marginal BCR for production research using the estimated yield function. The marginal benefit of NPB production research is the additional net revenue from an extra dollar invested in research to peanut growers due to the higher volume sold in the market. The cost of promotion is the cost of conducting the NPB production research. To compute the marginal BCR for the NPB production research activities, two scenarios are simulated for the marginal analysis. The first scenario is identical to the previous first scenario where all research expenditures are set to their historical levels over the simulation period. In the second “10% increase in NPB expenditures” scenario, NPB research expenditures for each year in the simulation period are increased by 10% higher than their historical levels. The marginal changes in peanut supply due to the 10% increased NPB scenario then affects the level of production of peanuts. The change in net benefits due to the 10% increase in NPB research is computed for the period 2014 through 2018 as the difference in net revenue between the two scenarios, which mathematically equals

\[ \Delta NR_t = (P_t Q'_t - P_t Q_t)M_t, \]
where \( P_t Q_t \) represents total revenue (price times quantity) for the baseline scenario with 100% NPB promotion expenditures, \( P_t Q_t' \) represents total revenue for the scenario with 110% NPB promotion expenditures. Note that it is assumed that the grower price is the same in both scenarios.\(^4\) \( M_t \) represents a net margin factor for peanut growers, which transforms total revenue into net revenue or profit. In reality \( M_t \) varies from producer to producer. It is assumed that the net margin factor is equal to 10%. The model is also solved with a factor of 0.05 to see how sensitive the results are to this assumption. The marginal BCR is then computed as:

\[
BCR = \frac{\Delta NR_t}{\Delta COST_t},
\]

\( \Delta COST_t \) is the difference in costs of the NPB production research for the 100% and 110% funding scenarios in year \( t \).

The marginal BCR based on the 10% net margin factor for 2014-2018 is found to be 1.79. This means that over this period, an extra dollar invested into production-level research by the NPB yielded an additional $1.79 in peanut grower profits. If the net margin factor is reduced from 10% to 5%, this marginal BCR falls to 0.90. The breakeven net margin to make the benefits equal to the costs is about 5.6%.

Since the marginal BCRs are well above 1.0 for all of the NPB activities, as well as overall, it is clear that the answer to the second question posed in this research is that the benefits of the NPB are vastly higher than the costs. The answer to the third question posed in this research is that the marginal BCRs do vary among the various activities. The lowest is for production research and the highest is for public relations. Yet all five categories of NPB activities yield benefits that are substantially higher than their costs.

\(^4\) Note that this may slightly overstate net revenue as the same price is used between scenarios where in reality a higher quantity of peanut would likely reduce the price in the 101% scenario.