An Economic Evaluation of the National Peanut Board

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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 production-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 yields) to NPB demand and production-enhancing activities?

2. What is the marginal benefit-cost ratio (BCR) of all NPB programs to peanut growers?

3. What are the BCRs for the individual NPB 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 that the NPB significantly impacted both peanut demand and yields. Had there not been any NPB marketing activities over the most recent 5-year period, 2019 through 2023, total domestic peanut demand would have averaged 4.6% less than it actually was. Additionally, had there not been any NPB-sponsored production research over this period, peanut production would have been 2% lower and peanut yields would have averaged 1.7% less than they actually were.

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 (for all peanut growers) from an extra dollar invested in each activity. Collectively, the overall BCR for all NPB activities is $11.10. In other words, an extra dollar invested in NPB activities over the period, 2019-23, returned $11.10 to peanut growers' profit. The marginal BCRs for the individual NPB activities are 7.24 for advertising/public relations, 8.59 for reputation management, and 27.36 for business development. An extra dollar of NPB sponsored production research returned $12.45 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 production-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, 2019-2023. Specifically, this study has two general objectives:

1. To measure whether the NPB's marketing and production research programs increase 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 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?

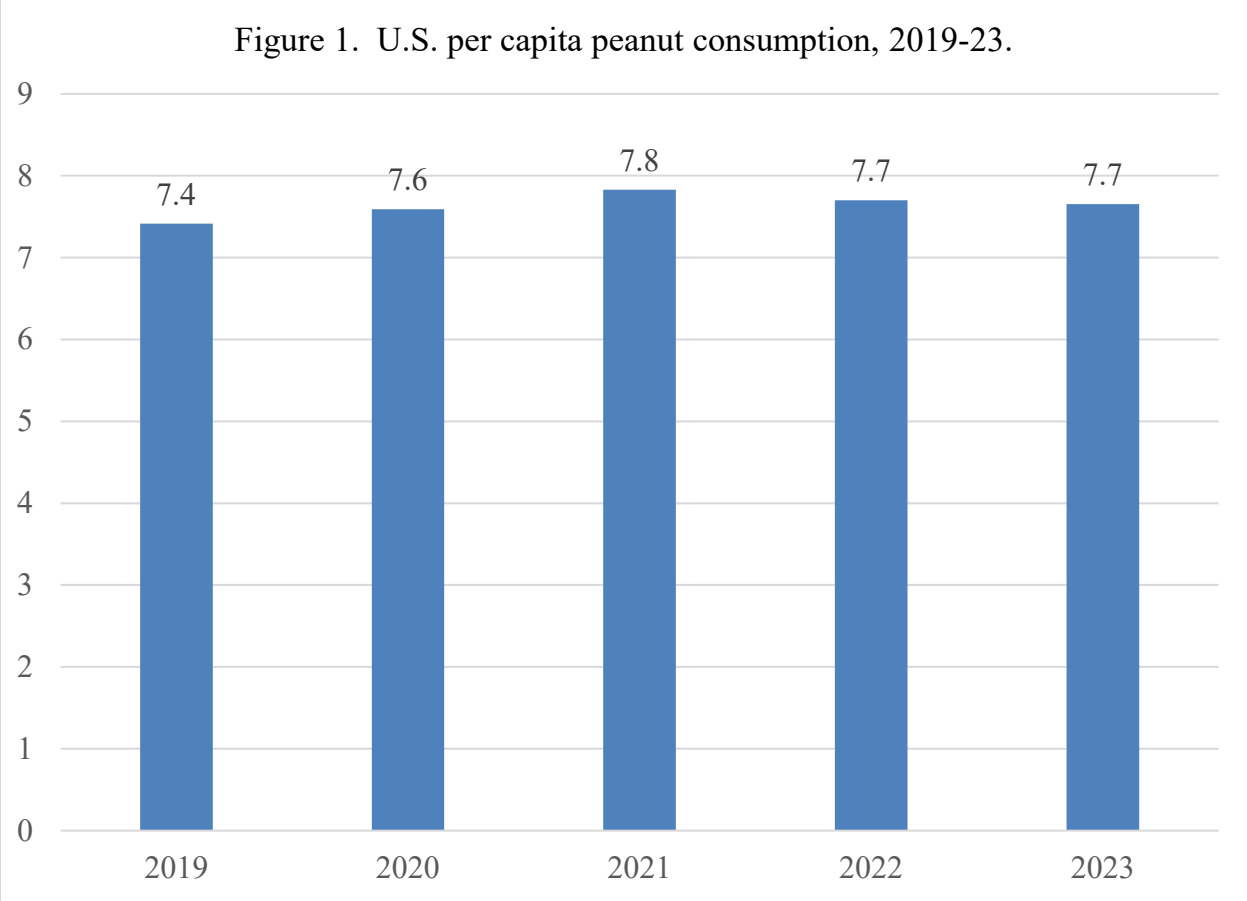
In this study, the impacts of all factors affecting domestic peanut product demand and supply for which data are available are measured statistically. In this way, we can net out the impacts of other important factors (e.g., prices and technology) besides NPB activities affecting peanut demand and supply 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 over 150 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

Per capita peanut commercial disappearance in the United States has risen, in general, over the past five years. In 2019, per capita consumption was 7.4 pounds per person and by 2023 this figure rose to 7.7 pounds. This represents a total increase of a little over 2% over 5-years. As Figure 1 illustrates, the increase in per capita consumption since 2019 has been fairly-steady. Increasing consumption of a commodity is vital to the overall economic health of an industry.

Figure 1. U.S. per capita peanut consumption, 2019-23.



SOURCE: USDA, National Agricultural Statistics Service, Peanut Stocks and Processing.

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 four categories:

1. Generic peanut advertising and public relations[1],
2. Reputation management,
3. Business development, and
4. Production-level peanut research.

Figure 2 displays the total expenditures on these four activities from 2019 through 2023. These expenditures have displayed a general positive trend over time increasing from $7.7 million in 2019 to $8.7 million in 2023.

Figure 2. NPB total promotion and research expenditures, 2019-2023.

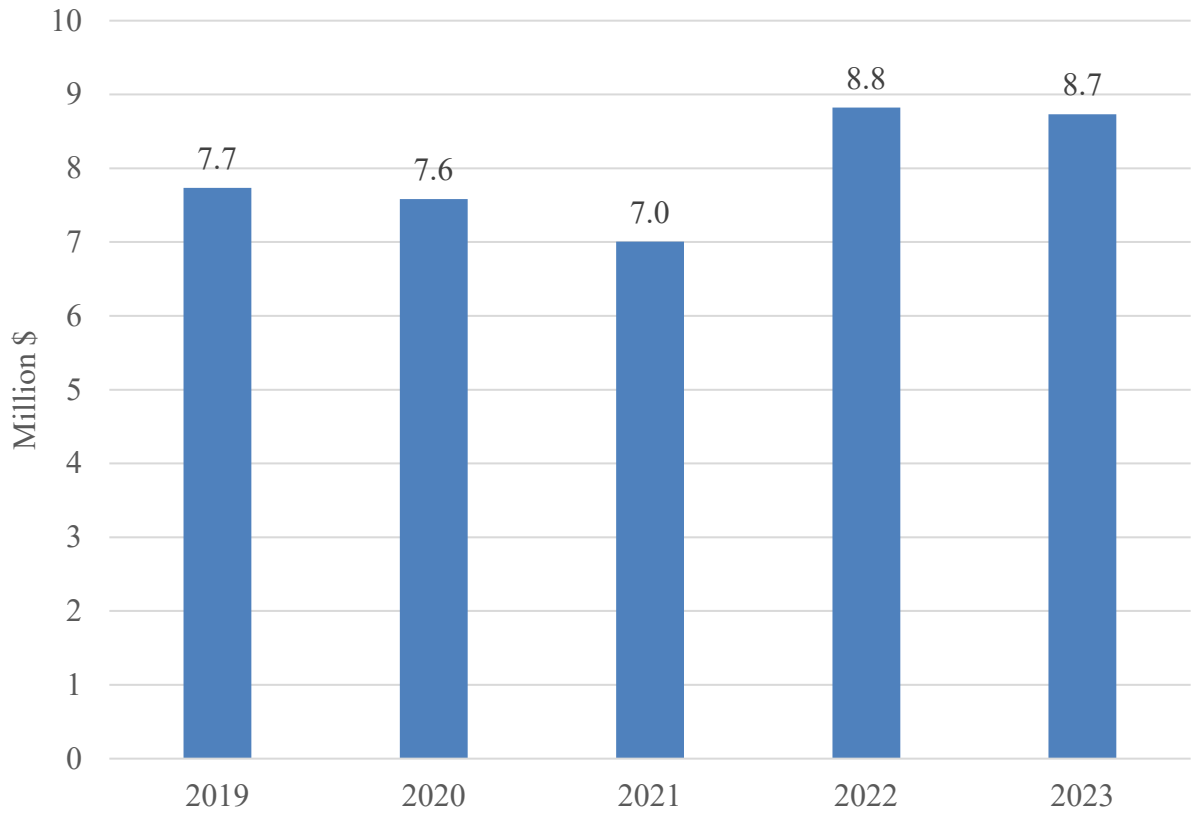


Figure 3 illustrates the percent of the NPB expenditures on each of these activities over the most recent five years from 2019-2023. Generic peanut advertising and public relations accounted for 33.4% of spending, while reputation management accounted for 30%. This is followed by production-enhancing research, which comprised 26.1% of NPB

[1] In previous reports, public relations and advertising were treated as separate categories. In this report, they are combined since they are very similar activities.

Figure 3. Percent of NPB budget by major activities for past 5 years.

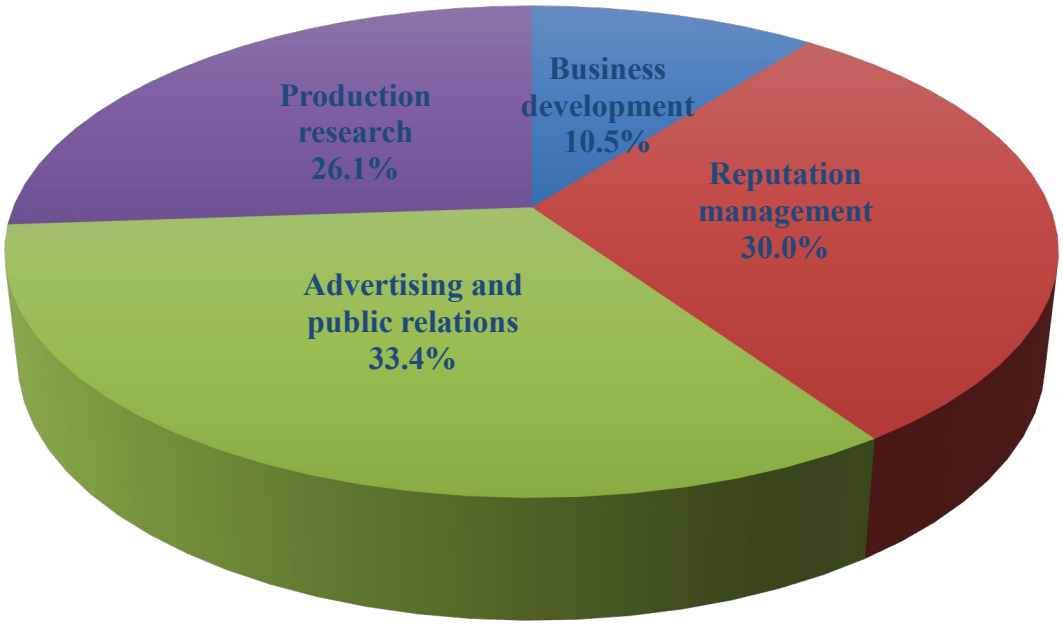
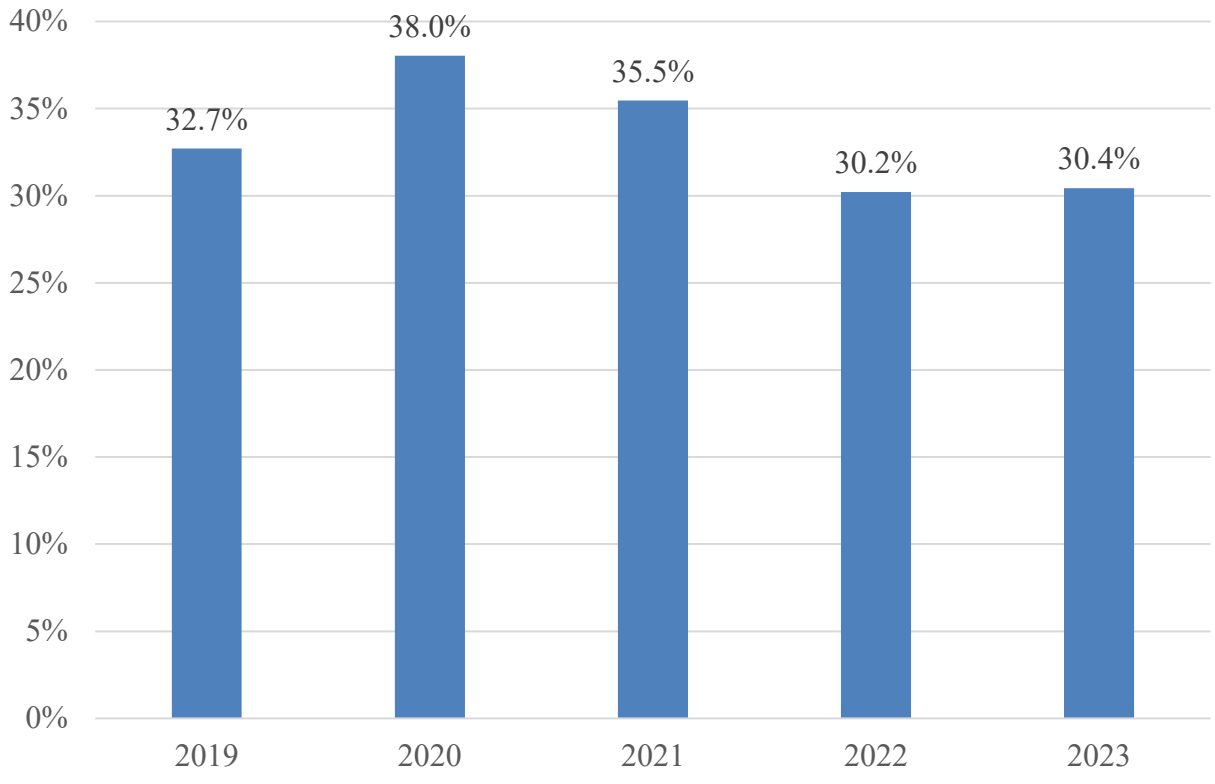


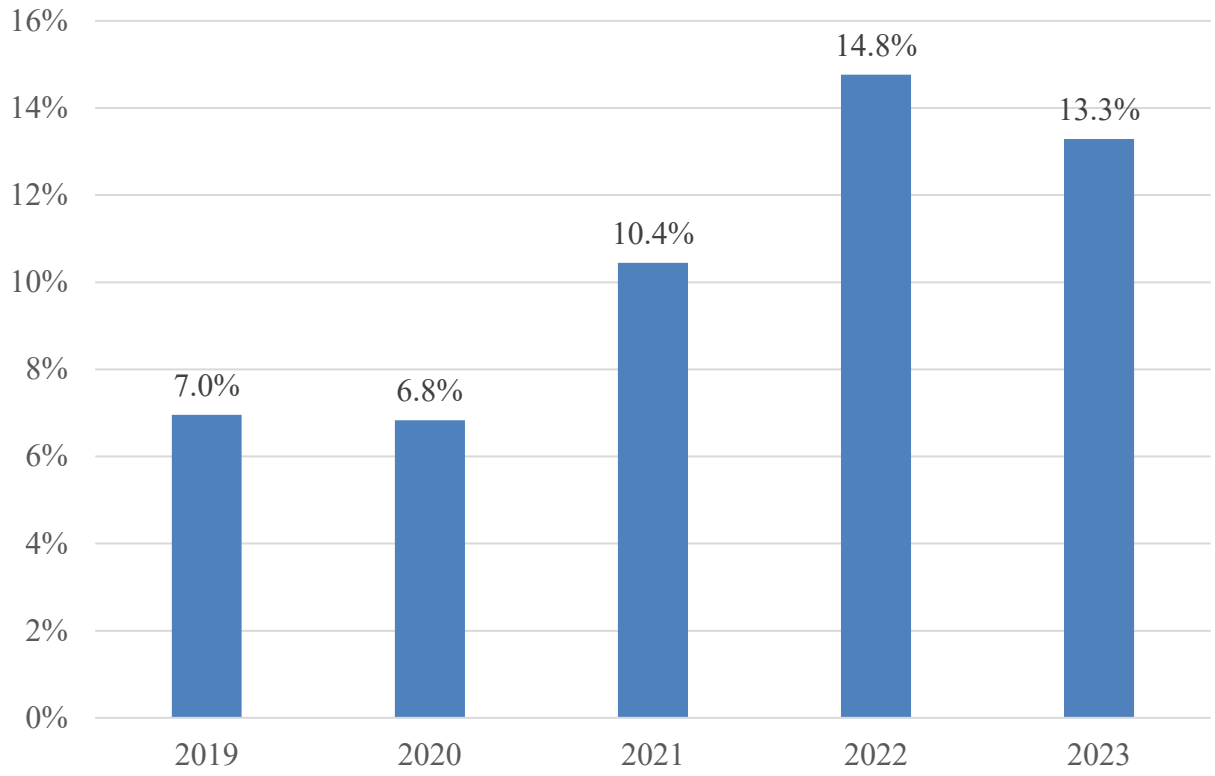
Figure 4. Advertising plus public relations expenditures as a percent of NPB expenditures, 2019-23.



expenditures. NPB contributions to business development activities represented 10.5% of expenditures.

Figure 4 displays annual generic peanut advertising expenditures plus public relations as a percentage of the total NPB spending from 2019 through 2023. Advertising expenditures are devoted to influencer marketing on various social platforms and other digital marketing. Public relations include all NPB activities that proactively share positive peanut messages with consumers. These activities involve consumer outreach through events, social media, and other activities. Over the past 5-years, there has been a slight negative trend in these activities as a share of the expenditures. For instance, in 2019, advertising plus public relations comprised 32.7% while in 2023 it comprised 30.4% of the expenditures.

Figure 5. Business development expenditures as percent of NPB expenditures, 2019-23.



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 5 displays expenditures on business development as a percent of total NPB expenditures. This category has increased in the

past 5-years. In 2019, these activities comprised 7% while in 2023 it comprised almost double that at 13.3% of NPB expenditures.

Figure 6 shows the budget share of reputation management from 2019-23. Reputation 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 was typically a small percentage of the NPB budget until 2019. In 2019, 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 2019, this represented 40.3% of the budget. In 2023, it was 29.7% 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 7 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 and has increased the impact of NPB dollars by participating in USDA's NIFA research, which provides dollar for dollar matching funds. These expenditures have increased in recent years. In 2019, they represented 20% of NPB expenditures, and by 2023, this increased to 26.6%.

Figure 6. Reputation management expenditures as percent of NPB expenditures, 2019-23.

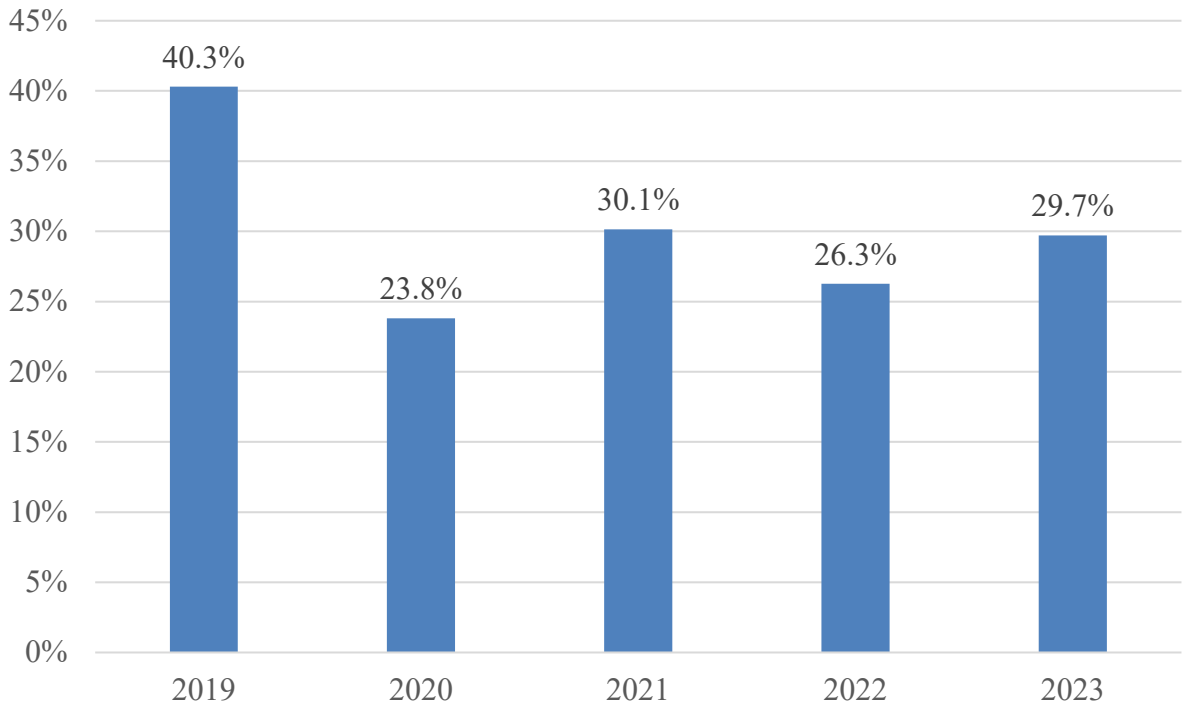
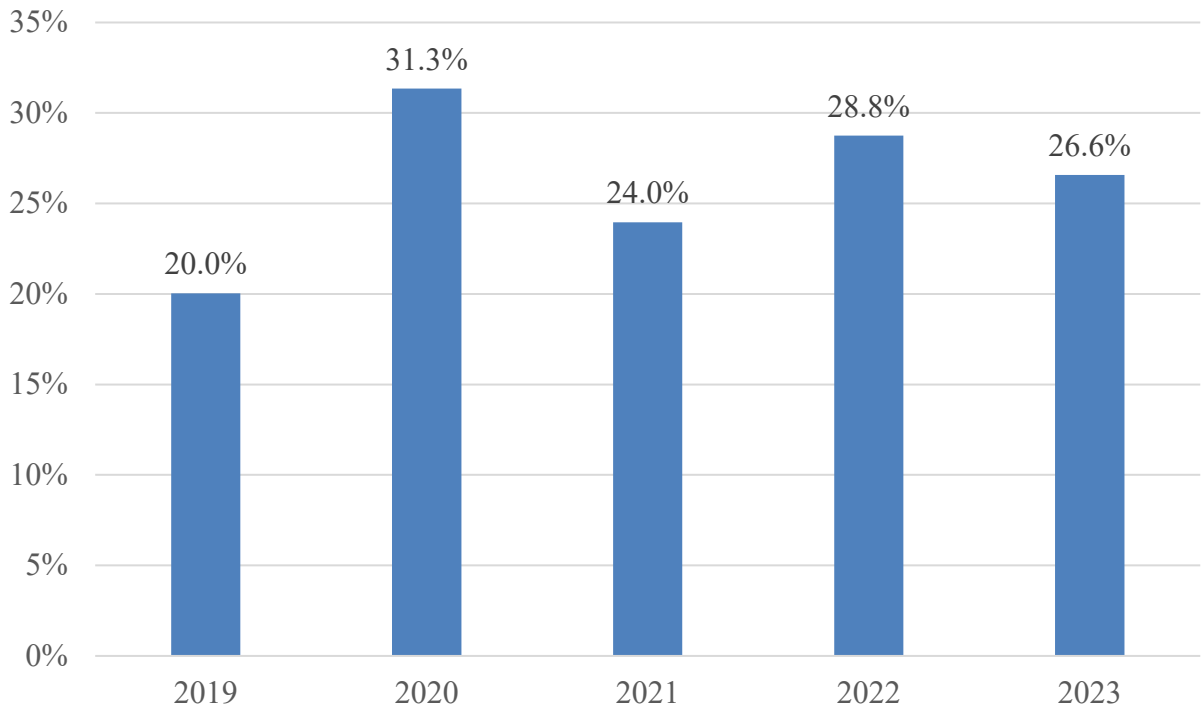


Figure 7. Production research expenditures as percent of NPB expenditures, 2019-23.



Methodology

This study quantifies the relationship between the advertising plus 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 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 1 for 2006 quarter 1, 2 for 2006 quarter 2, and so on.
Expenditures ($) on generic peanut advertising and public relations by the NPB in the U.S.
Expenditures ($) 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 equal to 1 for 1980, 2 for 1981, and so on.
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 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 plus 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, including results, is contained in Appendix 1 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 or supply) given a 1% change in a specific demand or supply 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% 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 a marginal BCR 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 sources. 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 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 Appendix 1 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 measure how the NPB demand-enhancing activities specifically impact peanut butter and snack peanut demand.

Table 1. Estimated NPB long-run demand elasticities.

NPB Activity	Elasticity
Impact on total peanut demand:	
NPB advertising and public relations	0.014
NPB reputation management	0.015
NPB business development	0.017
Impact on peanut butter demand:	
NPB advertising and public relations	0.019
NPB reputation management	0.048
NPB business development	0.019
Impact on snack peanut demand:	
NPB advertising and public relations	0.044
NPB business development	0.032

Regarding the total peanut demand model, all four marketing activities by the NPB are positive and statistically significantly different from zero at the 10% level or better. Business development has the highest elasticity[2] value of 0.017. In other words, increasing NPB business development expenditures by 10% increases peanut demand by 0.17%, holding all other peanut demand drivers constant. Reputation management had an elasticity of 0.015, i.e., a 10% increase in NPB expenditures on reputation management increased per capita demand by 0.15%, holding all other demand factors constant. Reputation management had a shorter lagged impact on

[2] All elasticities reported here are long-run elasticities which means demand has enough time to fully adjust to the demand-enhancing activity. Details of this are provided in the Appendix.

demand with expenditures in 11, 12, 13, and 14 months ago impacting current peanut demand. Generic advertising and public relations expenditures lagged two months has an elasticity of 0.014. That is, holding all other demand drivers constant, a 10% increase in generic peanut advertising and public relations increases per capita peanut demand by 0.14%.

The results of the peanut butter demand model are similar, but the elasticities are slightly larger. Similar to the total peanut demand model, all four of the NPB marketing activities are positive and statistically significant. Of the four NPB activities, reputation management 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 0.48%, which is statistically significant. Reputation management has a lagged effect of one quarter on peanut butter demand. The remaining three activities are similar in magnitude. Both business development and advertising/public relations has an elasticity of 0.019. In other words, a 10% increase in business development or advertising/public relations expenditures, holding constant all other demand drivers, would each increase peanut butter demand by 0.19%. Business development has a 12-quarter-lagged effect, while advertising and public relations has a four-quarter lagged effect on peanut butter demand.

Regarding peanut snack demand, while NPB reputation management is not found to be statistically significant and hence omitted from the model, the other three NPB activities are statistically significant. Advertising and public relations by the NPB has the highest elasticity of 0.044, indicating a 10% increase in its expenditures raises snack peanut demand by 0.44%. Business development has an elasticity of 0.032, i.e., a 10% increase in its expenditures raises snack peanut demand by 0.32% holding all other demand factors constant.

Table 2 presents the econometric results related to the impacts of NPB activities on peanut yield and supply. The results indicate that lagged research expenditures from 2 through 11 years ago collectively increase peanut yield. The long-run research elasticity is 0.017, meaning that holding all other factors constant, an increase in NPB research expenditures of 10% results in a 0.17% 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 13 and 14 years, significantly increase peanut supply. The long-run research elasticity is 0.020, meaning that holding all other supply factors constant, an increase in NPB research expenditures of 10% results in a 0.2% 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 simulate total demand and total production and yields with and without the NPB.

For the demand model, the total peanut demand model is simulated for two scenarios: (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. One can use the estimated elasticities of peanut demand with respect to advertising/public relations, business development, and reputation management to determine the combined impact of all these activities on peanut demand. Since these elasticities sum in value to 0.046, had there not been any advertising/public relations, business development, and reputation management by the NPB, total peanut demand would have been 4.6% (0.046*100 = 4.6%) lower than it actually was over this period.[3]

Table 2. Estimated NPB yield and supply elasticities.

NPB Activity	Elasticity
Impact on peanut yield:	
NPB production research	0.017
Impact on peanut supply:	
NPB production research	0.020

The results of the estimated annual peanut yield model are used in a similar simulation for peanut yields and total peanut supply. 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 of the NPB on the per acre yield of peanuts. One can use the estimated elasticities of peanut yield with respect to production research to determine the impact of all these research activities on peanut yields and production. For the yield model, the elasticities sum in value to 0.017, which implies that had there not been production research by the NPB, average national peanut yields would have been 1.7% (0.017*100 = 1.7%) lower than they actually were over this period. Likewise, had there not been production research, total national peanut production would have been 2% (0.02*100 = 2%) lower than it actually was.

Therefore, the answer to the first question is clearly yes, the NPB has a significant impact on peanut yield, production, 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 marginal BCR should be computed. In this study, a BCR is computed, which measures the profits returned to

[3] This calculation follows from multiplying the elasticity value by 100% in order to get an estimated of the total impact of the NPB. In other words, since an elasticity is a percentage measure of how demand (or supply) changes given a 1% change in an explanatory variable, multiplying the elasticity value by 100% gives an estimate of how demand (or supply) would change given a 100% change in the explanatory variable, holding constant all other factors.

the peanut industry for an extra dollar invested in the NPB (the details of the BCR simulation model are presented in Appendix 2 of this report).

The results of the analysis are presented in Table 3. The highest marginal BCR is for business development. Based on the period 2019-23, an extra dollar invested in business development returned $27.36 in producer profit. Reputation management has an average BCR of 8.59, i.e., each dollar invested in reputation management returned $8.59 in peanut producer profit. Generic peanut advertising/public relations has a marginal BCR of 7.24, i.e., each dollar invested in advertising/public relations returned $7.24 in producer profit. The marginal BCR for production research is found to be 12.45. This means that over this period, an extra dollar invested into production-level research by the NPB yielded an additional $12.45 in peanut grower profits. 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 advertising/public relations and the highest is for business development. Yet all five categories of NPB activities yield benefits that are substantially higher than their costs.

Collectively, the overall BCR for all NPB activities is $11.10. Hence, the NPB has a very high marginal BCR for its activities over the period 2019-23. In the previous 5-year evaluation for the period, 2014-18, the overall BCR was computed to be 9.74. Consequently, the already excellent performance of the marketing and research programs of the NPB is even higher in the current evaluation period. How does this BCR compare to estimates for other commodity promotion organizations? Table 4 lists the estimated BCRs for selected food commodities.[4] The BCR's range in value from a low of 1.7 for California avocados to a high of 32.08 for watermelon promotion. The overall BCR for NPB marketing/research of 11.10 is higher than the overall median of all marginal BCRs in Table 7 (7.10).

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

NPB Activity	2019-23 Marginal BCR
Generic peanut advertising and public relations	7.24
Reputation management	8.59
Business development	27.36
Production research	12.45
All activities combined	11.10

[4] In this table, some of the BCRs are marginal and some are average. A marginal BCR, which is used in this study, is interpreted as the return at the margin, i.e., the net revenue return on an *extra* dollar invested in the promotion activity. An average BCR gives the return in net revenue, on average, for each dollar invested in promotion.

Table 4. Estimated Return-on-Investment for Selected Commodities.

Author(s)		Average BCR	Marginal BCR
Alston et al. (1998)	California Dried Plums	NA	2.70
Crespi and Sexton (2005)	California Almonds	NA	6.20
Kaiser (2022)	Tart Cherries	2.05	NA
Kaiser (2021)	Cranberries	7.70	NA
Schmit et al (1997)	California Eggs	NA	6.90
Carman and Craft (1998)	California Avocados	5.00	1.70
Williams et al. (2004)	Florida Orange Juice	5.00	NA
USDA (2020)	All Dairy	4.78	NA
USDA (2020)	Fluid Milk	3.37	NA
USDA (2020)	Cheese	3.63	NA
USDA (2020)	Butter	15.67	NA
USDA (2020)	Dairy Exports	6.74	NA
Kaiser (2019)	Beef	NA	11.91
Kaiser (2021)	Pork	NA	27.57
Kaiser (2020)	Blueberries	NA	18.74
Murray et al. (2001)	Cotton	4.50	NA
Kaiser (2021)	Walnuts	11.62	NA
Kaiser (2019)	Peanuts	NA	9.74
Kaiser et al. (2012)	Raisins	9.95	NA
Kaiser (2022)	Pears	NA	4.80
Ward (2008)	Honey	6.80	NA
Capps and Williams (2015)	Lamb	NA	7.10
Kaiser (2017)	Watermelons	32.08	NA
Richards and Patterson (2007)	Potatoes	6.50	NA
Kaiser (2019)	Soybeans	NA	12.34
Median		6.50	7.10

Summary and Conclusions

This study had 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 4.6%. Put differently, had there been no NPB in effect, peanut demand would have been 4.6% lower than it actually was. Had there not been any NPB-sponsored production research over this period, peanut yields would have averaged 1.7% less than it actually was, while peanut production would have been 2% lower. Therefore, the NPB had a significant impact on peanut demand and yield over this period.

Marginal BCRs were computed for the major NPB activities for the past five most recent years, 2019-23. A marginal BCR measures the incremental benefits from an extra dollar invested in an activity and provides a useful measure of the returns to peanut producers. All NPB activities had BCRs larger than one indicating that the NPB has been profitable for peanut farmers. Collectively, the overall BCR for all NPB activities was 11.10. In other words, each dollar invested in NPB activities over the period, 2019-23, returned $11.10 to peanut producer profit. The highest BCR was for business development. Based on this 5-year period, an extra dollar invested in business development yielded $27.36 in producer profit. An extra dollar invested in reputation management returned $8.59 in industry-wide producer profit. Generic peanut advertising/public relations had a marginal BCR of 7.24. Finally, production-enhancing research had a marginal BCR of 12.45, i.e., an extra dollar invested in production research returned $12.45.

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Appendix 1: Econometric Models

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 Appendix 1, a through description and documentation of the methodology.

Retail Peanut Demand Models

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 potentially 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 per capita demand as the dependent variable measured in pounds per person.

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

$$(1)\quad \ln(CON_t) = \beta 0 + \beta 1 \ln(RPP_t/CPI_t) + \beta 2 \ln(RBP_t/CPI_t) + \beta 3 \ln(INC_t/CPI_t)$$

$$+ \beta 4 \ln(TREND_t) + \beta 5 \ln((NPBPR_t + NPBAD_{t-n})/CPI_{t-n}) + \beta 6 \ln(NPBRM_{t-n}/CPI_{t-n})$$

$$+ \beta 7 \ln(PCCON_{t-1})$$

where:

CON = per capita peanut demand measured as monthly 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.

CPI = Consumer Price Index for all items in U.S. Bureau of Labor Statistics (BLS).

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

$PCCON_{t-1}$ = per capita peanut demand in the previous month, measured as monthly 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*.

In this equation, "ln" is the natural logarithmic operator, and the βs 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, 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 is included because it represents a complimentary product 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 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. Per capita peanut consumption in the previous period is expected to be positively related with current per capita consumption. This variable represents habit formation on the part of consumers, i.e., peanut demand levels last month should be positively correlated with demand levels in the current year.

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 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 peanuts used to produce peanut butter and snack peanuts. Unlike total peanut demand, both peanut butter and peanut snack demand are estimated on a quarterly rather than monthly basis due to data availability. Mathematically, the two demand models are represented by the following two equations:

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

$$(3)\quad \ln(PSCON_t) = \beta 0 + \beta 1 \ln(RPSP_t/CPI_t) + \beta 2 \ln(INC_t/CPI_t) + \beta 3 \ln(TREND_t)$$
$$+ \beta 4 \ln(NPBAD_{t-n}/CPI_{t-n}) + \beta 5 \ln(NPBPR_t/CPI_{t-n}) + \beta 6 \ln(NPBRM_{t-n}/CPI_{t-n})$$
$$+ \beta 7 \ln(PSCON_{t-1}) + \beta 8 \ln(PICECREAM_t/CPI_t) + \beta 9 \ln(PCOOKIES_t/CPI_t)$$

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 monthly 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 monthly data on total peanut consumption (raw basis) used in primary products and in shell peanuts (USDA) from January 2006 (denoted 2006.01) through December 2023 (2023.12). The advantage of using monthly 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 2023.4. The peanut snack demand model is estimated in double logarithmic form with monthly IRI data from 2010.1 through 2023.4. 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 57% of the variations in the monthly demand for peanuts. The elasticity signs are consistent with economic theory and all estimated coefficients, except for the retail price, 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 since its estimated coefficient is not statistically significant.

The estimated own price elasticity is negative and equal to -0.07, which is not statistically 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 0.07% 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 -0.07, but is not statistically significantly different from zero. The trend term is positive and statistically significant, indicating increasing preferences over time for peanuts and peanut products. Per capita demand in the previous month is positively correlated with current per capita demand and is statistically significant, i.e., a 1% increase in per capita demand in the previous month increases current per capita demand by 0.17%, holding all other demand factors constant. This indicates that there is a positive correlation between peanut demand in the previous month and current peanut demand. This estimate is used to derive the long-run elasticities by using the following formula:

$$1/(1 - 0.17) = 1.21.$$

In other words, the long run elasticities for all demand factors are 21% larger than the short run elasticities.

All four marketing activities by the NPB are positive and statistically significantly different from zero at the 10% level or better. Business development has the highest long-run elasticity value of 0.017. In other words, increasing NPB business development expenditures by 10% increases peanut demand by 0.17%, holding all other peanut demand drivers constant. Business development has a long-lagged effect, taking 31 months before its effects are felt on per capita peanut demand. Reputation management has an elasticity of 0.15, i.e., a 10% increase in NPB expenditures on reputation management increased per capita demand by 0.15%, holding all other demand factors constant. Reputation management has a shorter lagged impact on demand with expenditures in 11, 12, 13, and 14 months ago impacting current peanut demand. Generic advertising expenditures, lagged two months, and current public relations expenditures has an elasticity of 0.014. That is, holding all other demand drivers constant, a 10% increase in generic peanut advertising and public relations increased per capita peanut demand by 0.14%.

Table A1. Total peanut demand elasticities.

Dependent Variable: LOG(PCQ)
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	-1.624849	0.335753	-4.839415	0.0000
LOG((1+PR+ADV(-2))/CPI(-2))	0.010681	0.005234	2.040973	0.0427
LOG(TREND)	0.089223	0.025606	3.484488	0.0006
LOG(BUSDEV(-31)/CPI(-31))	0.014317	0.008211	1.743666	0.0830
LOG(PWEIGHT/CPIBREAD)	-0.074533	0.056375	-1.322098	0.1878
LOG(PCQ(-1))	0.169761	0.071789	2.364734	0.0191
PDL01	0.001302	0.002252	0.578014	0.5640
PDL02	-1.84E-05	0.000613	-0.030080	0.9760

R-squared	0.569150	Mean dependent var	-0.574650
Adjusted R-squared	0.552111	S.D. dependent var	0.093625
S.E. of regression	0.062658	Akaike info criterion	-2.659977
Sum squared resid	0.694902	Schwarz criterion	-2.520718
Log likelihood	254.0478	Hannan-Quinn criter.	-2.603538
F-statistic	33.40229	Durbin-Watson stat	2.004239
Prob(F-statistic)	0.000000	Wald F-statistic	29.82015
Prob(Wald F-statistic)	0.000000		

Lag Distribution of LOG((1+REP(-11))/CPI(-11))	i	Coefficient	Std. Error	t-Statistic
. * |	0	0.00128	0.00166	0.77325
. * |	1	0.00253	0.00218	1.16026
. * |	2	0.00374	0.00184	2.03776
. *|	3	0.00491	0.00223	2.20030
	Sum of Lags	0.01247	0.00612	2.03776

where: PCQ is per capita peanut demand in pounds, PR and ADV(-2) are current NPB public relations and two-month lagged advertising expenditures, CPI is Consumer Price Index for All Items, TREND is a trend variable equal 1 for 2006.01, 2 for 2006.02, etc., BUSDEV(-31) are NPB business development expenditures lagged 31 months, PWEIGHT is the weighted average retail peanut price. CPIBREAD is the Consumer Price Index for bread, PCQ(-1) is per capita peanut demand lagged one month, and REP(-11) is NPB reputation management expenditures lagged 11 months, and PDL is a polynomial distributive lag distribution for 11, 12, 13, and 14 months.

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 47% 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 estimated own price elasticity is negative and equal to -0.02, which is not statistically 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 0.02% 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 -0.02, but is not statistically significantly different from zero. The trend term is positive but not statistically significant. Per capita demand in the previous month is positively correlated with current per capita demand and is statistically significant, i.e., a 1% increase in per capita demand in the previous month increases current per capita demand by 0.17%, holding all other demand factors constant. Real disposable income is negative and statistically significant. Specifically, a 1% increase in real income is correlated with a 0.615% decrease in peanut butter demand. The demand for peanut butter is higher in the first quarter of the year, on average.

Similar to the total peanut demand model, all four of the NPB marketing activities are positive and statistically significant for the peanut butter demand model. Of the four NPB activities, reputation management has the largest impact on increasing peanut butter demand. Holding all other factors constant, a 10% increase in NPB expenditures on reputation management programs increases peanut butter demand by 0.48%, which is statistically significant. Reputation management has a lagged effect of one quarter on peanut butter demand. The remaining activities are similar in magnitude. Both business development and advertising/public relations had an elasticity of 0.019. In other words, a 10% increase in business development and advertising/public relations expenditures, holding constant all other demand drivers, would each increase peanut butter demand by 0.19%, respectively. Business development has a 12-quarter-lagged effect, while advertising and public relations has a four-quarter lagged effect on peanut butter demand.

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 56% 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 and retail price of cookies.

The estimated own price elasticity is negative and equal to -0.08, which is not statistically significantly different from zero at conventional significance levels. The interpretation of this 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. Peanut snack demand, lagged one quarter, is positive and significant indicating that a 1% increase in lagged demand increases current demand by 0.34%. Quarter 3 has a significant and negative impact on snack demand. The trend variable is negative and marginally statistically significant.

Table A2. Peanut butter demand elasticities.

Dependent Variable: LOG(QPB)
Huber-White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	21.79075	1.936745	11.25122	0.0000
LOG((PR(-4)+ADV(-4))/CPI)	0.016371	0.008673	1.887632	0.0674
LOG(BUSDEV(-12)/CPI(-12))	0.017364	0.010150	1.710773	0.0960
LOG(REPMAN(-1)/CPI(-1))	0.041804	0.020221	2.067333	0.0462
LOG(PBP/CPIBREAD)	-0.054767	0.248716	-0.220200	0.8270
LOG(RINC)	-0.614723	0.192987	-3.185305	0.0030
LOG(TREND)	0.092355	0.066594	1.386836	0.1743
DUM1	0.040947	0.031008	1.320546	0.1952
LOG(QPB(-1))	0.112056	0.093113	1.203441	0.2369
R-squared	0.482054	Mean dependent var		19.10560
Adjusted R-squared	0.363667	S.D. dependent var		0.061587
S.E. of regression	0.049128	Akaike info criterion		-3.008520
Sum squared resid	0.084475	Schwarz criterion		-2.643572
Log likelihood	75.18743	Hannan-Quinn criter.		-2.873179
F-statistic	4.071831	Durbin-Watson stat		1.844454
Prob(F-statistic)	0.001649	Wald F-statistic		5.123256
Prob(Wald F-statistic)	0.000286			

where: QPB is quarterly peanut butter demand, PR(-4)+ADV(-4) are quarterly NPB expenditures on public relations and advertising lagged four quarters, CPI is Consumer Price Index for All Items, TREND is a trend variable equal 1 for 2006.01, 2 for 2006.02, etc., BUSDEV(-12) are NPB business development expenditures lagged 12 quarters, PBP is the retail peanut butter price, CPIBREAD is the Consumer Price Index for bread, RINC is real disposable income, DUM1 is a quarterly dummy variable for quarter 1, QBP(-1) is per capita peanut butter demand lagged one month, and REP(-11) is NPB reputation management expenditures lagged 11 months, and PDL is a polynomial distributive lag distribution for 11, 12, 13, and 14 months.

Regarding peanut snack demand, while NPB reputation management is not found to be statistically significant and hence omitted from the model, the other three NPB activities are statistically significant. Advertising/public relations by the NPB has the highest long-run elasticity of 0.44, indicating a 10% increase in its expenditures raises snack peanut demand by 0.44%. Business development has a long-run elasticity of 0.032.

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 1980 through 2023. 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.

Table A3. Snack peanut demand elasticities.

Dependent Variable: LOG(QSNACK)
Huber-White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.48627	3.389457	3.388822	0.0015
LOG((PR(-2)+ADV(-5))/CPI(-6))	0.029242	0.015081	1.939049	0.0591
LOG(BUSDEV(-4)/CPI(-4))	0.021004	0.005796	3.623544	0.0008
LOG(QSNACK(-1))	0.337998	0.168776	2.002643	0.0515
DUM3	-0.076703	0.033734	-2.273738	0.0280
TREND	-0.003918	0.002484	-1.577255	0.1221
LOG(PSNACK/CPI)	-0.083372	0.322480	-0.258535	0.7972
R-squared	0.555289	Mean dependent var		18.22256
Adjusted R-squared	0.493236	S.D. dependent var		0.118116
S.E. of regression	0.084084	Akaike info criterion		-1.984825
Sum squared resid	0.304015	Schwarz criterion		-1.717141
Log likelihood	56.62062	Hannan-Quinn criter.		-1.882889
F-statistic	8.948657	Durbin-Watson stat		1.738204
Prob(F-statistic)	0.000002	Wald F-statistic		11.48918
Prob(Wald F-statistic)	0.000000			

where: QSNACK is quarterly peanut snack demand, PR(-2)+ADV(-5) are quarterly NPB expenditures on public relations (lagged two quarters) and advertising lagged five quarters, CPI is Consumer Price Index for All Items, TREND is a trend variable equal 1 for 2006.01, 2 for 2006.02, etc., BUSDEV(-12) are NPB business development expenditures lagged four quarters, QSNACK(-1) is peanut snack demand lagged one quarter, and PSNACK is the retail peanut snack price.

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:

$$(4) \quad \ln(YIELD) = \alpha 0 + \alpha 1 \ln(GPP_{t-1}/PP_{t-1}) + \alpha 2 \ln(TREND) + \alpha 3 \ln(YIELD_{t-1}) + \alpha 4 \text{ PDL } \ln (NPBRESEARCH_{t-n}/CPI_{t-n})$$

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*.

$YIELD_{t-1}$ = yield in previous year.

NPBRESEARCH = production research expenditures by NPB. These data come from NPB.

In this equation, "ln" is the natural logarithmic operator, and the αs 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 1980, a linear time trend is included in the equation. Yield in. the previous year is included to capture the dynamic effects of yields over time. 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:

$$(5)\quad \ln(PRODUCTION_t) = \alpha 0 + \alpha 1 \ln(GPP_{t-1}/CPI_{t-1}) + \alpha 2 \ln(PP_{t-1}/CPI_{t-1}) + \alpha 3 \ln(TREND_t) + \alpha 4 \ln(PRODUCTION_{t-1}) + \alpha 5 \text{ PDL ln } (NPBRESEARCH_{t-n}/CPI_{t-n})$$

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 1980, 2 for 1981, 3 for 1982….

$PRODDUCTION_{t-1}$ = production in previous year.

NPBRESEARCH = production research expenditures by NPB. These data come from NPB.

In this equation, "ln" is the natural logarithmic operator, and the αs are the coefficients to be estimated with statistical regression analysis. All monetary variables such as 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 1980. Production in previous year is included to capture the dynamic effects of peanut production from year to year. 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 1980 through 2023. The estimated elasticities for yield model are summarized in Table A4. The coefficient of variation indicates that the explanatory variables explain 88% 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 except for price and the index of prices paid by farmers in the crop sector, both of which are not statistically significant. Several econometric diagnostic tests performed indicate no statistical problems.

The time trend is positive and significant, 0.429, indicating that there has been steady progress in technological and managerial improvement in peanut production since 1980. Interestingly, peanut years in the previous year are negatively correlated with yields in the current year. Specifically, a 1% increase in peanut yield in the previous year has a -033% association with peanut yields in the current year. Production sponsored research by the NPB has a positive and statistically significant impact on peanut yield. The results indicate that lagged research expenditures from 2 through 11 years ago collectively increase peanut yield. The long-run research elasticity is 0.017, meaning that holding all other factors constant, an increase in NPB research expenditures of 10% results in a 0.17% increase in peanut yield.

The peanut supply model is estimated in logarithmic form with annual data from 1980 through 2023. The estimated elasticities for supply model are summarized in Table A5. The coefficient of variation indicates that the explanatory variables explain 73% of the variations in annual supply of peanuts. The elasticity signs are consistent with economic theory and all

estimated coefficients (except grower price and production costs) are statistically significant at better than the 5% significance level. Both price and the index of prices paid are of the correct sign, but have a p-value of 0.273, which is not considered statistically significant. Several econometric diagnostic tests performed indicate no statistical problems.

Table A4. Peanut yield elasticities.

Dependent Variable: LOG(YIELD)
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	9.302282	1.195208	7.782981	0.0000
LOG(TREND)	0.429318	0.102050	4.206929	0.0002
LOG(YIELD(-1))	-0.332097	0.173829	-1.910487	0.0664
PDL01	0.000244	0.000501	0.486742	0.6302
PDL02	1.98E-05	7.22E-05	0.274602	0.7856

R-squared	0.896796	Mean dependent var	8.059479
Adjusted R-squared	0.882053	S.D. dependent var	0.204456
S.E. of regression	0.070217	Akaike info criterion	-2.335724
Sum squared resid	0.138052	Schwarz criterion	-2.108980
Log likelihood	43.53944	Hannan-Quinn criter.	-2.259431
F-statistic	60.82700	Durbin-Watson stat	2.095178
Prob(F-statistic)	0.000000		

Lag Distribution of LOG(NPBRES(-2)/CPI(-3))	i	Coefficient	Std. Error	t-Statistic
.* |	0	0.00026	0.00043	0.61232
. * |	1	0.00057	0.00072	0.78549
. * |	2	0.00091	0.00088	1.03743
. * |	3	0.00129	0.00090	1.42942
. * |	4	0.00172	0.00082	2.08218
. * |	5	0.00218	0.00070	3.11521
. * |	6	0.00268	0.00071	3.75143
. * |	7	0.00322	0.00106	3.02894
. * |	8	0.00380	0.00169	2.24696
	Sum of Lags	0.01663	0.00480	3.46698

[a]This elasticity is the long-run elasticity for research, i.e., the sum of the second to 11 lag values in the PDL specification.

The time trend is positive and significant, 0.026, indicating that there has been steady progress in technological and managerial improvement in peanut production since 1980. Similar to the yield model, peanut production in the previous year is negatively associated with peanut production in the current year. Specifically, a 1% increase in peanut production in the last year is associated with a 0.43% decline in peanut production in the current year. Production sponsored research by the NPB has a positive and statistically significant impact on peanut supply. The results indicate that research expenditures, lagged 13 and 15 years, significantly increases peanut supply. The long-run research elasticity is 0.020, meaning that holding all other supply factors

constant, an increase in NPB research expenditures of 10% results in a 0.2% increase in peanut supply.

Table A5. Peanut supply elasticities.

Dependent Variable: LOG(PRODUCTION)
Included observations: 30 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	32.25352	4.147411	7.776784	0.0000
LOG(PRICE(-1)/IPP(-1))	0.195262	0.174832	1.116857	0.2751
TREND	0.026218	0.009935	2.639126	0.0144
LOG(PRODUCTION(-1))	-0.433694	0.182815	-2.372302	0.0260
PDL01	0.005931	0.025693	0.230840	0.8194
PDL02	0.000495	0.015239	0.032473	0.9744

R-squared	0.733107	Mean dependent var	22.23974
Adjusted R-squared	0.677504	S.D. dependent var	0.233539
S.E. of regression	0.132624	Akaike info criterion	-1.025740
Sum squared resid	0.422139	Schwarz criterion	-0.745501
Log likelihood	21.38610	Hannan-Quinn criter.	-0.936089
F-statistic	13.18470	Durbin-Watson stat	1.927174
Prob(F-statistic)	0.000003		

Lag Distribution of LOG(NPBRES(-13)/CPI(-13))	i	Coefficient	Std. Error	t-Statistic
. * |	0	0.00643	0.01061	0.60574
. *|	1	0.01384	0.01085	1.27580
	Sum of Lags	0.02027	0.00705	2.87577

Appendix 2: 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. One can use the estimated elasticities of peanut demand with respect to advertising/public relations, business development, and reputation management to determine the combined impact of all these activities on peanut demand. Since these elasticities sum in value to 0.046, had there not been any advertising/public relations, business development, and reputation management by the NPB, total peanut demand would have been 4.6% (0.046*100 = 4.6%) lower than it actually was over this period.[5]

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 of the NPB on the per acre yield of peanuts. One can use the estimated elasticities of peanut yield with respect to production research to determine the impact of all these research activities on peanut yields and production. For the yield model, the elasticities sum in value to 0.0134, which implies that had there not been production research by the NPB, average national peanut yields would have been 1.7% (0.013*100 = 1.7%) lower than they actually were over this period. Likewise, had there not been production research, total national peanut production would have been 1.7% (0.017*100 = 1.7%) lower than it actually was.

Therefore, the answer to the first question is clearly yes, the NPB has a significant impact on peanut yield, production, as well as demand.

Marginal Benefit-Cost Analysis

[5] This calculation follows from multiplying the elasticity value by 100% in order to get an estimated of the total impact of the NPB. In other words, since an elasticity is a percentage measure of how demand (or supply) changes given a 1% change in an explanatory variable, multiplying the elasticity value by 100% gives on an estimate of how demand (or supply) would change given a 100% change in the explanatory variable, holding constant all other factors.

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 marginal BCR should be computed. A marginal BCR gives the incremental value in peanut producers' profit for 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 BCR for the demand activities.

BCRs for NPB demand activities. To evaluate the full effect of the NPB's marketing programs on quantity and price, one needs to incorporate the retail supply response of peanuts into the model. That is, if demand increases due to NPB activities, price will increase which will eventually induce a positive supply response, which will increase peanut supply. We adopt the 0.195 supply response (from the estimated peanut supply function listed in Table A5) using a constant elasticity form and equated with predicted peanut demand quantities.

The simulation procedure for computing the average BCR begins on the demand side, where predicted quantities of peanut demand (Q_t^D) are estimated from the peanut demand equation. Then, using a procedure similar to that in Alston et al. (1996), supply is defined in constant elasticity form and equated with the predicted demand quantities. Changes in demand due to NPB marketing then affect the level of production and the resulting farm price. Specifically, the supply function is defined as:

(1) $Q_t^S = A_t P_t$

where $A_t = Q_t^D / P_t$ and P_t is the retail peanut price. The defined value, A_t, varies by year and ensures that, given the actual values of prices and other variables, the supply equation passes through the quantity defined by Q_t^D. This makes possible combining of the supply response and estimated demand model to simulate past retail prices and quantities.

Given the simulation procedures described above, the change in net economic benefits due to the NPB marketing is computed for each month from 2019 to 2023 as the difference in profit (i.e., producer surplus[6]) between the following two scenarios: (1) historic or baseline scenario with NPB marketing expenditures set to actual levels, and (2) 1% reduced NPB scenario where NPB marketing expenditures are reduced by 1% of actual expenditures. The difference between the baseline and 1% reduced NPB expenditures scenarios provides a measure of the marginal impact of the NPB marketing spending, i.e., how an extra dollar spent impacts the market.

To do this, we first must translate the retail peanut price into the peanut growers' price. This is done by using the following estimated price transmission equation:

(2) GP = 0.163705513952 + 0.0226921439804*PWEIGHT

[6] 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.

where: GP is the farm peanut price, PWEIGHT is the weighted retail price for peanut butter and peanut snack foods. An AR(1) term is appended to correct for autocorrelation.

The change in profits (also known as producer surplus, PS) is computed as follows:

(3) $\Delta PS_t = (GP_t'Q_t' - GP_tQ_t)/(1 + \varepsilon)$,

where $GP_t Q_t$ represents total revenue to peanut farmers for the baseline scenario with 100% NPB marketing expenditures, $GP_t' Q_t'$ represents total revenue to peanut farmers for the scenario with the 1% reduced marketing expenditures, and ε represents the own price elasticity of supply, which is set to 0.195 based on the estimated supply elasticity..

A marginal BCR is computed and is equal to:

(4) $BCR = \Sigma \Delta PS / \Sigma \Delta Cost_t$

where: ΔNR_t is monthly producer surplus as defined above and $\Delta Cost_t$ is equal to a 1% reduction in cost of the NPB spending on marketing/research. The change in producer surplus and change in costs are summed over the period 2019.01 through 2023.12. This is computation is done separately for advertising and public relations, reputation management, and business development, as well as for overall NPB marketing for all these activities combined.

All NPB activities had marginal BCRs larger than one indicating that the NPB has been profitable for peanut farmers. Collectively, the overall BCR for all NPB activities was 11.10. In other words, each dollar invested in NPB activities over the period, 2019-23, returned $11.10 to peanut producer profit. The highest BCR was for business development. Based on this 5-year period, an extra dollar invested in business development yielded $27.36 in producer profit. An extra dollar invested in reputation management returned $8.59 in industry-wide producer net revenue. Finally, generic peanut advertising/public relations had a marginal BCR of 7.24.

BCRs for NPB supply activities. A slightly different procedure is used to compute the marginal BCR for production research using the estimated yield function. The benefit of NPB production research is the additional net revenue from each 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. 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 "1% decrease in NPB expenditures" scenario, NPB research expenditures for each year in the simulation period are decreased by 1% of their historical levels. The changes in peanut supply due to the 1% decreased NPB scenario then affects the level of production of peanuts. The change in net benefits due to the 1% decrease in NPB research is computed for the period 2019 through 2023 as the difference in net revenue between the two scenarios, which mathematically equals:

(6) $\Delta NR_t = (P_tQ_t' - P_tQ_t)M_t$,

where P_tQ_t represents total revenue (price times quantity) for the baseline scenario with 100% NPB promotion expenditures, P_tQ_t' represents total revenue for the scenario with 1% reduction in NPB research expenditures. Note that it is assumed that the grower price is the same in both scenarios. M_t represents a net margin factor for peanut growers, which transforms total revenue into net revenue or profit. It is assumed that the net margin factor is equal to 10% based on the USDA/ERS cost and returns study, i.e., net revenue is equal to 10% of total gross revenue (price times quantity). The marginal BCR is then computed as:

(7) $BCR = \Delta NR_t/\Delta COST_t,$

where: $\Delta COST_t$ is the difference in costs of the NPB production research for the 100% and 1% reduced funding scenarios in year t.

The marginal BCR based on the 10% net margin factor for 2019-2023 is found to be 12.45 This means that over this period, an extra dollar invested into production-level research by the NPB yielded an additional $12.45 in peanut grower profits.

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 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.