An Economic Analysis of the National Pork Board Checkoff Program

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Introduction

The National Pork Board's (NPB) central mission is to increase the demand for hogs and pork products, reduce production costs, and improve the profitability of hog and pork producers. The program is funded by a mandatory assessment on U.S. hog producers and importers of hogs and pork products. In 2020, the NPB had a budget of $80 million in total revenue and spent $70.3 million on various activities for their overall mission.

Under existing agricultural legislation, the NPB is required to have an independent analysis of the economic effectiveness of the program conducted at least once every five years. With almost $1 billion spent on checkoff programs each year by U.S. farms and firms, the government wants stakeholders to have independent information on the effectiveness of these programs. Accordingly, the purpose of the research reported here is to conduct such an economic evaluation for the most recent period of performance for the NPB Checkoff Program.

Objective and Scope

Under existing agricultural legislation, the NPB is required to have an independent analysis of the economic effectiveness of the program conducted at least once every five years. Accordingly, the purpose of the research reported here is to conduct such an economic evaluation for the most recent period of performance for the NPB, 2016-2020.

The overall goal of the research is to independently evaluate the economic effectiveness of the programs funded by the Pork Promotion, Research, and Consumer Information Act of 1985. Specifically, this research has two important objectives: (1) quantify and measure the economic benefit to producers of NPB-funded programs for the period 2016-2020 in terms of net return on investment; and (2) quantify and compute marginal rates of return on investment for alternative existing and potential checkoff-funded activities.

In this study, the impacts of all factors affecting domestic and export pork product demand for which data are available are measured statistically. In this way, the analysis nets out the impacts of other important factors besides NPB[1] activities affecting pork demand and supply over time. In addition, the value of the incremental sales generated by NPB activities are estimated. These benefits to hog and pork producers are then compared with the costs associated with the NPB.

This independent evaluation was carried out by Dr. Harry M. Kaiser. Dr. Kaiser is one of the most eminent agricultural economists in the world who has extensively studied the economics of commodity promotion programs. Dr. Kaiser is the Gellert Family Professor of Applied Economics and Management at Cornell University, and is the Associate Dean for Academic Affairs in the Charles H. Dyson School. Dr. Kaiser has been involved in commodity promotion research for 33-years, and is one of the leading experts on this topic in the world. He has written 150 refereed journal articles, five books, 17 book chapters, and over 150 research bulletins. Dr. Kaiser has conducted over 130 economic evaluation studies of domestic and international checkoff programs in the United States, Canada, and Europe on such commodities as fluid milk, cheese, butter, salmon, peanuts, red meat, pork, raisins, walnuts, blueberries, potatoes, beef, wheat, watermelons, high-valued-agricultural commodities, and bulk agricultural commodities. In 2012, Dr. Kaiser conducted the economic evaluation study for the CBB. In 2005, Kaiser was the lead author of a book on all commodity checkoff programs in California. In 2006, 2010, and 2015, Dr. Kaiser was a principal (or co- principal) investigator on three comprehensive economic studies investigating the overall benefits and costs of all FAS programs to cooperators and the general economy. Dr. Kaiser received the Distinguished Member Award from the Northeastern Association of Agricultural and Resource Economics in 2002 and then again in 2009. In 2006, Professor Kaiser received the highest award given to alumni of the University of Wisconsin-Eau Claire—the Alumni Distinguished Achievement Award. In 2009, Professor Kaiser received the Outstanding Achievement Award from the Board of Regents of the University of Minnesota, which is the highest award conferred by the university to an alumnus. Professor Kaiser received the Outstanding Alumni Award from the Department of Applied

[1] On the export side, the contributions from the U.S. Meat Export Council (USMEF) and the Foreign Agricultural Service of the USDA are measured in terms of their returns to hog producers. The NPB provides some of USMEF's funds for developing foreign markets for U.S. pork products.

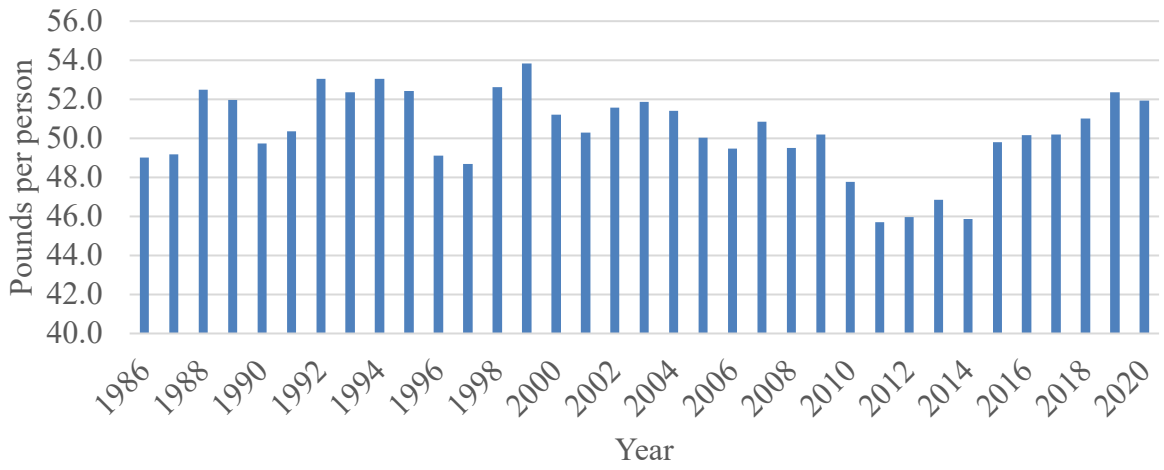
Economics, University of Minnesota, in 2009. In 2017, he was elected a Fellow of the Agricultural and Applied Economics Association.

Background

The NPB was implemented in 1986 and is designed to increase the overall demand (both domestic and foreign) for U.S. hogs and pork products, decrease farm production costs, improve farm efficiency, and improve the overall profitability of hog and pork production. The NPB is funded by a mandatory assessment of 0.4% of the market value of all hogs sold in the United States. In addition, this program collects assessments on hogs and pork products from foreign markets imported into the United States. Collectively, this program raises around $60 million on an annual basis.

Per capita retail pork consumption in the U.S. has fluctuated overtime, as displayed graphically in Figure 1. In 2020, consumption per person was almost 52 pounds, which was

Figure 1. Per capita retail pork consumption



higher than the 49 pounds person consumed in 1986. But, consumption has been steadily increasing since 2014. Indeed, the average annual increase since 2014 has been 1.9% per year.

Some of the increase in per capita consumption of retail pork products since 2014 has been due to more favorable retail pork prices and increasing real disposable income of U.S. consumers. For example, since 2014, the real retail pork price declined by almost 4% and real per capita disposable income rose by 18%. In addition, the real retail price for beef and broilers increased from 2014-2020 by 9.5% and 1.9%, respectively, making pork more economically affordable relative to its two main substitutes. Finally, the 1.9% increase in NPB advertising, promotion, and demand enhancing activities contributed to this increase in consumption. However, to rigorously determine the impact of each of these pork demand drivers on consumption, one needs to utilize econometric modeling, which is described later in this report.

The NPB invests in a variety of activities to accomplish its overall objectives of improving profitability for the hog and pork sectors. In this report, these activities are divided into five broad categories:

- Domestic media advertising,
- Domestic promotion,
- Foreign market development,
- Farm-level, production research, and
- Pork product, "demand-enhancing" research.
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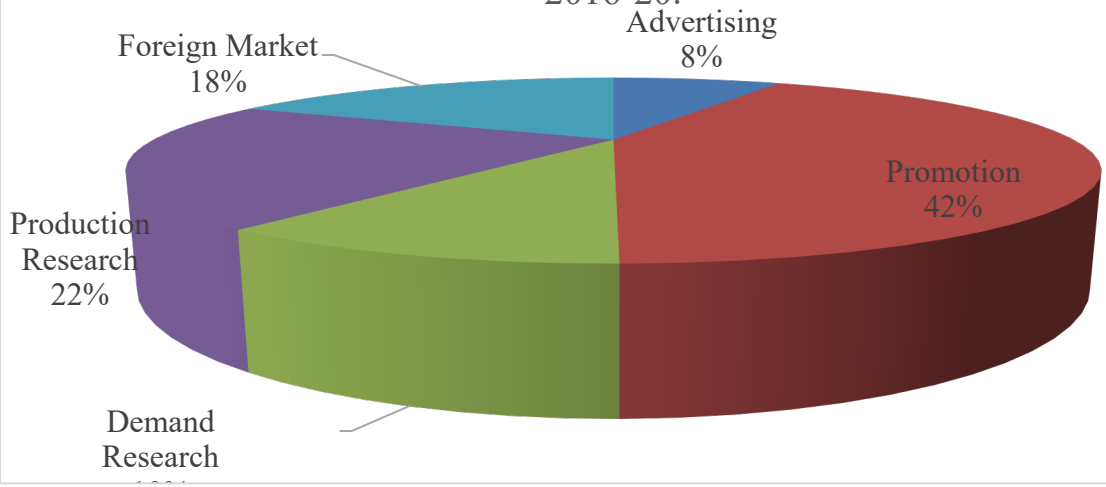
Figure 2 illustrates the percent of the NPB budget spent on each of these activities on average for the period 2015-2020. On average, promotion expenditures was the largest category of the NPB budget, accounting for 42% of the spending. This was followed in importance by production enhancing research (22%) and foreign market development (18%). NPB contributions to demand enhancing research represented 10% of the budget in the past five years, while advertising research comprised 8%. The relative magnitudes of these five activities have varied, considerably, over time.

Figure 2. Percent of NPB expenditures by major activity in 2016-20.



Domestic generic pork advertising once accounted for the majority of the NPB expenditures. Figure 3 displays generic pork advertising from 1986, which is the year the Pork checkoff program began, through 2020 in real, inflation-adjusted (2020) dollars. These expenditures are devoted to all domestic media advertising such as television, radio, print, outdoor, and web advertising. Generic pork advertising steadily increased from 1986 until reaching a high in 1998. Since 1998, generic pork advertising has generally declined, and, since 2016, have decreased substantially.

Figure 3. Real, inflation-adjusted generic pork advertising expenditures.

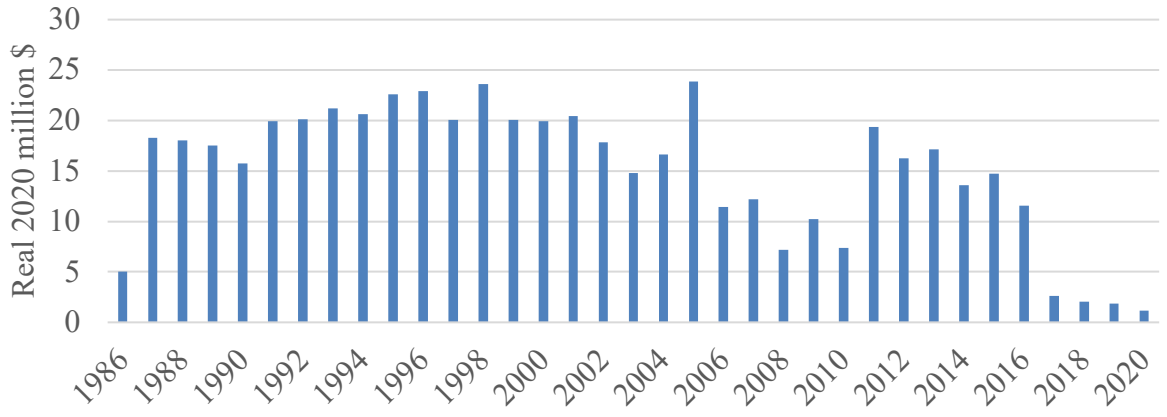
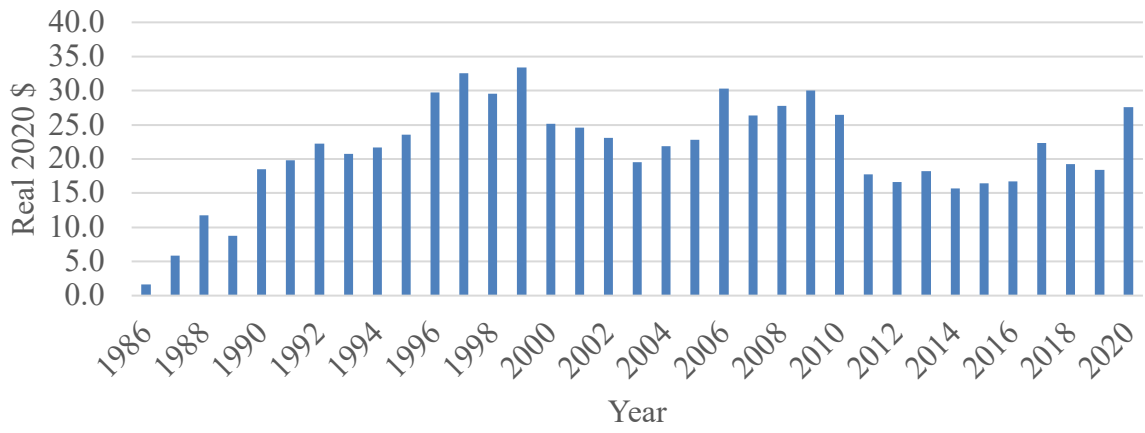


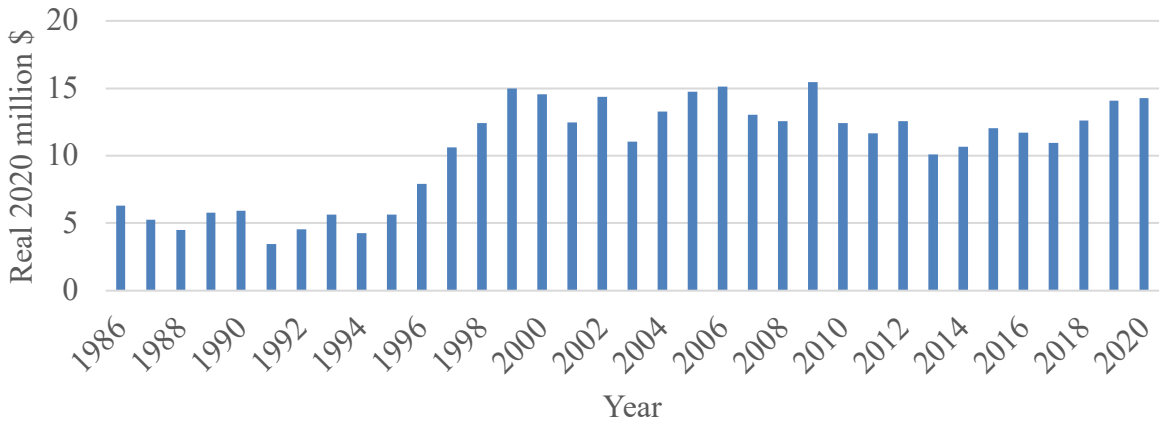
Figure 4 presents generic promotion expenditures over this time-period, which include all non-media demand enhancing activities such as merchandising, food service marketing, consumer research, and consumer public relations. Expenditures on these activities were significantly higher in the late 1990s. Since 2000, spending on promotion has trended downwards, however, have been on the upswing since 2010.

Figure 4. Real, inflation-adjusted generic pork promotion expenditures.



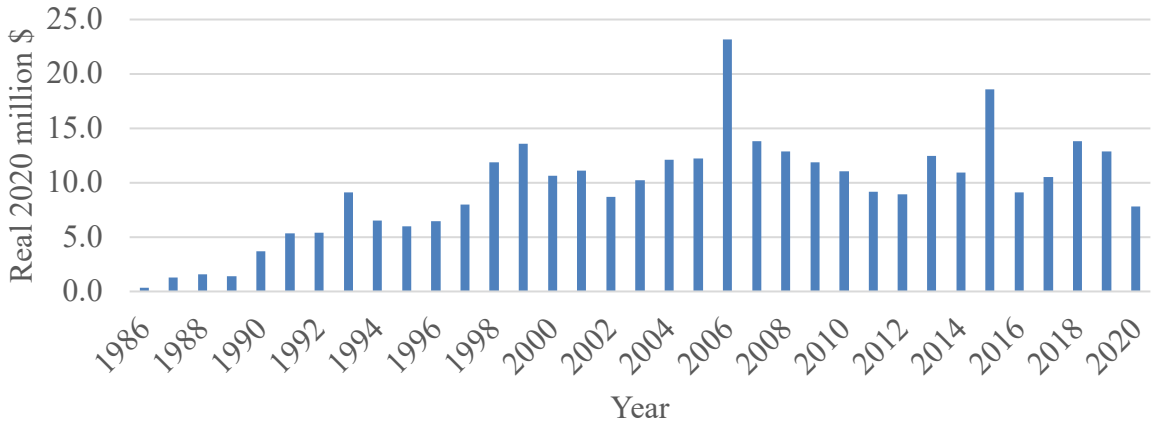
Over time, foreign markets have become an important source of demand for U.S. pork products. For example, in 1987 pork exports only represented 0.7% of commercial disappearance. By 2020, this figure grew to 29.8%. This growth in export demand was enhanced by the foreign market development programs of the NPB, combined with the U.S. Meat Export Federation (USMEF), and matching dollars are provided by U.S. Department of Agriculture (USDA)/Foreign Agricultural Service (FAS). Specifically, export marketing programs are designed to stimulate export demand in important international markets for U.S. pork products including Japan, Mexico, South Korea, China, Taiwan, Southeast Asia, Russia, Central Europe, and Latin America. Figure 5 presents total expenditures on pork foreign market development by the NPB, the U.S. Meat Export Federation, and the USDA/FAS. Combined foreign market development expenditures have increased steadily over time, increasing from just over $6 million in 1986 to $14 million in 2020. Since 2009, export marketing expenditures have declined by 7.8%.

Figure 5. Real, inflation-adjusted NPB, USMEF, and government pork export promotion expenditures.



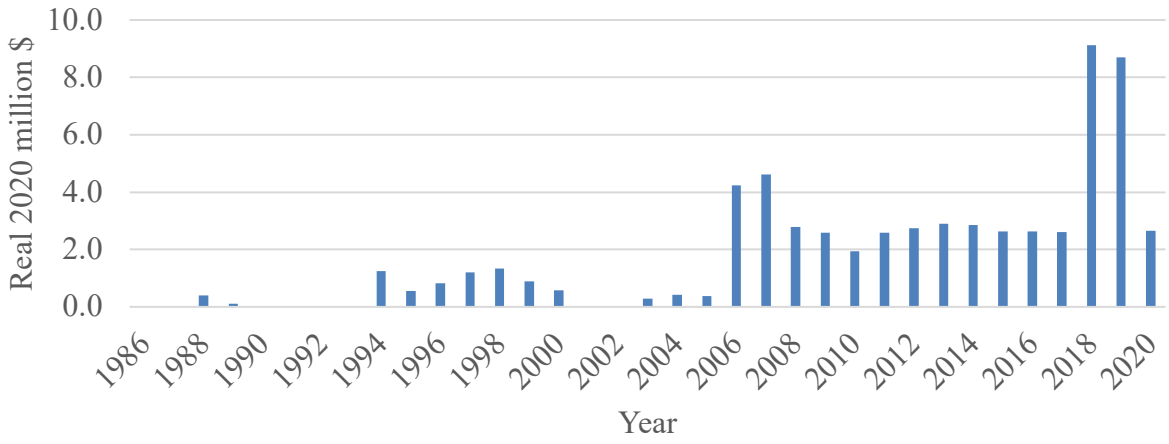
NPB-sponsored production-level research has steadily grown in importance over time, as depicted in Figure 6. This type of research is designed to improve farm efficiency and lower costs in hog production, and producer education to raise the level of expertise of hog producers. In 1986, around $0.3 million was spent on this research. By 2015, this grew to $18.6 million, but since then has decreased steadily.

Figure 6. Real, inflation-adjusted Pork Checkoff Program expenditures on production-level research.



NPB-sponsored research on pork products has been more sporadic over time, as shown in Figure 7. This category of research includes new pork product design and development, as well as market chain research designed to improve the efficiency of pork processing. In 1986, there were no funds allocated to pork product research, but by 2018 there was over $9 million spent, but has since declined.

Figure 7. Real, inflation-adjusted PCP demand enhancing research expenditures.



Data Limitations

The econometric model used in this study is based on secondary data from government sources, private venders, and the NPB. Therefore, the accuracy of the results presented here depends on the quality of this secondary data. While these data are judged to be the best available for this economic evaluation, there are errors in data from any data source. To deal somewhat with the potential errors in data, all parameter estimates for the checkoff activities include a 90% confidence interval.

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

Methodology

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

The four econometric equations to be estimated include: (1) retail domestic pork demand, (2) retail domestic pork supply, (3) U.S. pork export demand, and (4) commercial farm pork supply. The model also includes two equilibrium conditions requiring retail domestic and international demand to equal retail domestic supply, and a farm-to-retail conversation equation to assure that farm supply is equal to domestic and international demand. The four econometric equations are used to test whether various activities by the NPB such as advertising, export market development and promotion activities, production research, and post-farm gate research have a statistically significant impact on demand and supply. A more detailed discussion of the econometric model, results, and data sources is presented in the Appendix of this report. Here, we focus on a general overview of the model and a discussion of the results.

To compare the relative importance of each factor on pork demand or supply, the results from the econometric model are converted into "elasticities." An elasticity measures the percentage change in pork demand 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 pork quantity demanded given a 1% change in price, holding constant all other pork demand determinants. Since elasticities are calculated for each demand and supply factor in each model, one can compare them to determine which factors have the largest impact on pork demand and supply.

Retail Pork Demand and Supply

The domestic demand equation for pork is estimated with retail per capita consumption as the dependent variable measured in pounds for each calendar year from 1976 through 2020. The following demand determinants are included to ascertain their impacts on annual per capita domestic pork demand:

1. Retail price for pork products ($/cwt.),
2. Retail price for beef products ($/cwt.),
3. Retail price for broilers ($/cwt.),
4. Per capita disposable income,

5. Retail domestic per capita pork consumption in the previous year

6. Time trend,

7. Generic pork advertising expenditures,

8. Generic pork promotion expenditures,

9. Demand-enhancing research expenditures by the pork checkoff program.

The retail price for pork products is expected to be negatively related pork demand, i.e., a lower price results in higher quantity demanded reflecting the law of demand. The retail prices for beef and broiler products are included because they represent the most important substitute products for pork. The relationship between per capita consumption and the retail beef/broiler price is expected to be positive because beef and broilers are substitutes for pork. The relationship between per capita income and pork demand is expected to be positive, i.e., as consumers become wealthier, the demand for pork should increase. The time trend term is included to capture changes in consumer preferences for pork over time.

The last three variables in the model are pork checkoff program activities. Generic pork advertising is expected to have a positive impact on per capita pork demand. Generic advertising is measured by NPB expenditures on media advertising. It is well documented in the literature that advertising has a "carry-over effect" on demand, i.e., past, as well as current advertising has an effect on current demand. To measure this carry-over effect, a lag specification begins with expenditures from one years ago, and two years ago, and so on is estimated and the model with the best statistical fit is chosen as the final model. As was the case in the last evaluation of the pork checkoff program, the best model indicated a lag length of three years for advertising.

Generic pork promotion is expected to have a positive impact on pork demand, but unlike advertising, only current promotion expenditures are included as no carry-over effect is detected in several specifications. That is, the impacts of pork promotion are more immediately felt and not as long-lasting as advertising. This may be true because advertising is more "informational" in nature while promotion activities are aimed at more instantaneous purchases of the products via discounts, etc.

Finally, NPB expenditures on pork demand enhancing research are included, and are expected to have a positive impact on pork demand. Because research is expected to have a lagged effect before it is felt, a lag specification begins with expenditures from five years ago, three years ago, and so on, and the model with the best statistical fit is chosen as the final model. The best model uses demand enhancing research expenditures lagged four years.

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

Pork Export Demand Model

An export demand equation for U.S. pork is estimated with exports of U.S. pork as the dependent variable. U.S. exports are measured on a quantity basis (million pounds) for each calendar year from 1976 through 2020. The following export demand determinants are included to ascertain their impacts on annual pork export demand:

1. Unit value (price) of annual pork exports from the U.S. in dollars per pound,

2. Unit value (price) of annual pork exports from all other countries in dollars per pound,

3. Average annual world (net of U.S.) GDP,

4. Annual exchange rate per U.S. dollar for U.S. agricultural trade constructed by the Economic Research Service, USDA,

5. U.S. pork exports lagged one year,

6. Total annual foreign market development expenditures (USMEF, USDA/FAS, and NPB combined).[2]

The U.S. pork price is computed as the total value of exports divided by the total quantity of exports and come from the Livestock Marketing Information Center. Hence, price is computed as a unit value measure and reflects the overall category including muscle cuts, variety meats and processed pork products. The U.S. price is expected to have a negative impact on imports of U.S. pork, i.e., a lower U.S. price increases the quantity demanded of U.S. pork imports reflecting the law of demand. The price from the rest-of-the-world is also computed as a unit value for all "pork meat" exports from the world excluding the U.S. These data come from the USDA Global Agricultural Trade System (GATS) data set. The export price of all competing countries is included because these countries are the other source for pork exports in the foreign markets and the chief competitors to U.S. pork. The relationship between the ROW price and the export demand for U.S. pork is expected to be positive because ROW pork is a close substitute with U.S. pork.

The relationship between world (minus U.S.) GDP and the demand for U.S. pork is expected to be positive, i.e., as countries become wealthier, the demand for U.S. pork should increase. The agricultural trade weighted U.S. exchange rate has been shown to be an important determinant of the demand for U.S. exports. As the U.S. dollar becomes cheaper, U.S. pork becomes relatively less expensive and hence export demand increases. Exports, lagged one year, are included as an explanatory variable to reflect rigidities in international markets, i.e., exports last year should be correlated with exports this year.

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

This analysis combines USDA/FAS with NPB and USMEF expenditures to measure the total foreign market development impact. Market promotion activities have a carry-over effect. To measure the carry-over effect of export promotion, a lag specification begins with expenditures from one years ago, and two years ago, and so on is estimated and the model with the best statistical fit is chosen as the final model. The best model indicated a lag length of one year for promotion.

Hog Supply Model

U.S. hog production is measured on a quantity basis (million pounds, carcass basis) for each calendar year from 1976 through 2020. Of key interest here is the impact of production-research expenditures sponsored by the NPB on hog production. If the production-level research is effective, it should have the results of improving yields and thereby increasing supply.

The following supply determinants are included to ascertain their impacts on annual hog supply:

1. Expected price of hogs measured on a per cwt. basis,

2. Total feed and non-feed finishing costs,

3. Lagged expenditures on production research by the NPB,

4. Production lagged one year.

Farm supply in the previous year is included to capture biological constraints on production from year to year. It is assumed that hog producers have naive price expectations, where the expected price is a function of the price in the previous year. Total costs of producing feeder pigs and the costs of finishing those pigs are used as the measure of production costs, which impact the supply curve. A negative relationship is expected since increases in costs discourage increases in supply. An output price- input price ratio is used in the supply function estimation.

The impact of NPB production-level research is hypothesized to have a positive, but delayed effect on supply. This type of research should have a positive effect on supply as it is designed to decrease farm costs and improve managerial ability. It takes time to do research, and the impact of research on actual production is often not felt for years. To measure this time effect, a lag model is used with a host of alternative lag lengths. The final model included NPB research expenditures lagged five years.

Simulation Model

This study uses an equilibrium displacement model (EDM) to simulate the impacts of the NPB on domestic and international markets.

The net benefits of each of the five NPB activities are measured through simulation of the EDM using a marginal analysis. That is, the endogenous variables in the model such as prices and quantities are simulated under two scenarios: (1) baseline scenario where all exogenous variables (e.g., NPB expenditures) are set equal to historical levels, and (2) counterfactual scenario, where NPB expenditures are increased by 1% above their historical levels. The differences between the two scenarios determine the impacts of a 1% increase in expenditure levels on prices, quantities, and producer profits (producer surplus). Producer surplus is a measure used by economists that is similar to profitability or net revenue. Technically, it is defined as the total revenue (price times quantity sold) minus the area of the supply curve under the price. To compute the corresponding marginal benefit-cost ratio (BCR), the increase in producer surplus due to the 1% simulated increase in NPB expenditures was divided by the 1% increase in costs.

Results

Retail Pork Demand. The retail pork demand elasticities are summarized in Table 1. The elasticity signs are consistent with economic theory and all estimated coefficients (except per capita consumption in the previous year) are statistically significant at the 10% significance level or better. Per capita consumption in the previous year is not statistically significant based on a two-tailed t-test, but is statistically significant based on a one-tailed t-test and is therefore included in the model as a significant variable.

Table 1. Retail pork demand elasticities.

Demand Factor	Elasticity	P-value*
Retail pork price	-0.341	0.002
Retail beef price	0.143	0.030
Retail broiler price	0.208	0.050
Per capita disposable income	0.510	0.004
Per capita consumption in previous year	0.211	0.130
Time trend	-0.300	0.000
Generic pork advertising	0.023	0.050
Generic promotion	0.039	0.002
Demand-enhancing research	0.001	0.080
R-Square	0.70	

*The P-value measures the statistically significant of the estimated elasticity. Generally, values less than 0.100 are considered statistically significantly different from zero.

The estimated own price elasticity is negative and equal to -0.341. The interpretation of this is a 1% increase in the retail pork price, holding all other demand factors constant, leads to a 0.341% decrease in per capita pork quantity demanded. As expected, beef and broilers are found to be substitutes for pork with elasticities of 0.143 and 0,208, respectively. That is, a 1% increase in the beef or broiler price, holding all other demand factors constant, results in a 0.143% or 0.208% increase, respectively, in pork demand. Both the own and cross price elasticities of demand are inelastic indicating that U.S. consumers are not very sensitive to small price changes when making their purchase decisions. This result is common in the food and agricultural economics literature.

Per capita disposable income has a positive impact on pork demand, indicating that pork is what economists refer to as a "normal good, " i.e., demand increases as consumer income increases. Indeed, the estimated income is the most important driver of per capita pork consumption with an estimated income elasticity of 0.51. That is, a 1% increase in per capita income results in a 0.51% increase in per capita pork demand, holding constant all other demand factors. The trend term is negative, which may reflect a declining trend in consumer preference for pork commodities over time. Finally, per capita consumption of pork in the previous year is

positively correlated with current per capita consumption. A 1% increase in previous year's consumption is associated with a 0.211% increase in current consumption.

The statistical results indicate that all three-pork checkoff program demand enhancing activities have a positive and statistically significant impact on increasing pork demand. Generic pork advertising has a three-year carry over effect with an elasticity of 0.023, i,e. a 1% increase in advertising expenditures results in a 0.023% increase in per capita pork demand. The estimated promotion elasticity is 0.039 meaning a 1% increase in promotion expenditures results in a 0.039% increase in per capita pork demand. Finally, demand enhancing pork research is found to have a lagged effect of four years, i.e., research four years ago has a significant impact on today's pork demand. Specifically, a 1% increase in demand enhancing research increases per capita pork demand by 0.001% holding all other factors constant.

Because there is error inherent in any statistical model, a 90% confidence interval is computed for the three pork checkoff program elasticities. This interval can be interpreted as the range of possible values where one can be confident that the true population elasticity could be expected to fall 90% of the time. The 90% confidence interval for the generic pork advertising elasticity is (0.003, 0.042). The 90% confidence interval for the generic pork promotion elasticity is (0.020, 0.06). The 90% confidence interval for the demand enhancing research elasticity is (0.0001, 0.003). Because the lower bound estimates of the elasticities of all three NPB activities are greater than zero, this adds credence to the conclusion that the NPD activities have had a positive and statistically significant impact on pork demand.

Retail Pork Supply. The retail pork supply model is estimated in logarithmic form (except for the TREND term) with annual data from 1976 through 2020. The elasticities are summarized in Table 2. The elasticity signs are consistent with economic theory and all estimated coefficients are statistically significant at the 1% significance level or better (except for the trend term, which is significant at the 7% level).

Table 2. Retail pork supply elasticities.

Supply Factor	Elasticity	P-value*
Retail pork price	0.182	0.010
Hog price	-0.200	0.000
Time trend	0.002	0.077
Retail pork supply in the previous year	0.360	0.001
R-Square	0.95	

*The P-value measures the statistically significant of the estimated elasticity. Generally, values less than 0.100 are considered statistically significantly different from zero.

The results indicate that the own-price elasticity of supply is 0.182, which is inelastic. It is not at all surprising that this elasticity is so small given that the retail market does not influence the supply of pork as much as the farm hog market. That is, holding all other supply

factors constant, a 1% increase in the retail pork price results in a 0.182% increase in quantity supplied by pork retailers. The impact of the hog price is similar in size, but reverse sign. That is, a 1% increase in the hog price is found to be associated with a 0.2% decrease in pork supply. impact. The trend variable is positive and statistically significant, which has had a positive impact on retail pork supply. Finally, retail supply in the previous year is positive and statistical significant; a 1% increase in the previous year's supply increases current year pork supply by 0.36% holding all other supply factors constant.

U.S. Export Pork Demand. The export demand model is estimated in logarithmic form with annual data from 1976 through 2020. The elasticities are summarized in Table 3. The elasticity

Table 3. Pork export demand elasticities.

Demand Factor	Elasticity	P-value*
Exports lagged one year	0.705	0.000
U.S. price	-0.366	0.035
U.S. agricultural trade adjusted exchange rate	-0.952	0.004
World minus U.S. GDP	0.358	0.063
Pork foreign market development	0.213	0.000
R-Square	0.99	

*The P-value measures the statistically significant of the estimated elasticity. Generally, values less than 0.100 are considered statistically significantly different from zero.

signs are consistent with economic theory, but both other country's export price is not significant and therefore omitted from the model. All other estimated coefficients are statistically significant at better than the 10% significance level.

Lagged exports are a significant determinant of current exports. The estimated elasticity for lagged exports is 0.705 indicating a 1% increase in last year's U.S. pork exports increases this year's exports by 0.705% holding all other factors constant.

The price of U.S. pork is a significant factor in explaining annual variations in exports of U.S. pork. The estimated own-price elasticity is -0.366 indicating that a 1% increase in the U.S. pork price decreases U.S. pork exports by 0.366%, holding constant other demand factors.

The U.S. agricultural trade adjusted exchange rate is the most significant export demand driver. The estimated elasticity is -0.952 indicating that a 1% increase in the U.S. agricultural trade adjusted exchange rate decreases U.S. pork exports by 0.952%, holding constant other demand factors. World minus U.S. GDP is also significant; a 1% increase in world GDP increases U.S. pork exports by 0.358%, holding all other factors constant.

The statistical results indicate that U.S foreign market development programs have the effect of increasing the export demand for U.S. pork. The model indicates that there is a one-year carry-over effect of foreign market development. The estimated results indicate that a 1% increase in foreign market development expenditures increase U.S. pork exports by 0.213%.

Because there is error inherent in any statistical model, a 90% confidence interval is computed for the foreign market development elasticity. This interval can be interpreted as the range of possible values where one can be confident that the true population export promotion elasticity could be expected to fall 90% of the time. The 90% confidence interval for the elasticity is (0.126, 0.300).

Hog Supply. The hog supply model is estimated in logarithmic form with annual data from 1976 through 2020. The elasticities are summarized in Table 4. The R-squared indicates that the explanatory variables explain 97% of the variations in farm supply for U.S. hogs. The elasticity signs are consistent with economic theory and all estimated coefficients are statistically

Table 4. Commercial hog supply elasticities.

Supply Factor	Elasticity	P-value*
Supply lagged one year	0.980	0.000
Expected price	0.126	0.000
Total production costs	-0.126	0.000
Production research	0.015	0.000
R-Square	0.97	

*The P-value measures the statistically significant of the estimated elasticity. Generally, values less than 0.100 are considered statistically significantly different from zero.

significant at better than the 1% significance level. Several econometric diagnostic tests performed found no statistical problems.

The expected price is positive and statistically significant from zero. The own-price elasticity is equal to 0.126, i.e., a 1% increase in price this year, holding all other supply factors constant, results in a 0.126% increase in hog quantity supplied next year. The elasticity of hog supply with respect to total production costs is -0.126. That is, a 1% increase in costs this year results in a 0.126% decrease in hog supply next year. Supply lagged one year has a very large positive effect on supply in the current year. Specifically, a 1% increase in hog supply in the previous year causes a 0.98% increase in supply in the current year. This is not surprising given the reproductive life cycle of hogs.

The statistical results indicate that NPB-sponsored production-level research has a positive and statistically significant impact on hog supply. The elasticity for production research is 0.015. That is, a 1% increase in research expenditures results in a 0.015% increase in hog supply over four-years. The 90% confidence interval for the production-level research elasticity is (0.008, 0.022).

Simulation Results. The equilibrium displacement model is simulated for the most recent 5-year period, 2016-2020. The focus here is on computing a marginal benefit-cost ratio, which is

based on a small change (1%) between two equilibrium levels. As argued in the RTI study of the Pork checkoff program,

> *With declining marginal returns to research and promotion, these estimates of marginal returns can be considered conservative lower bounds for the point estimates of historic average returns that have been generated by the Pork Checkoff Program.*

Hence, these estimates can be thought of as a lower bound on the true average impacts.

Based on the econometric parameters and the EDM, it is clear that the NPB activities have impacted both prices and quantities in the market over the time period 2016-2020. Table 5 presents the marginal impacts of a 1% increase of the NPB activities on key market variables. Foreign market development is found to have the largest impact on the farm-level hog price, a

Table 5. Marginal impacts of NPB activities on price, production, and producer surplus.

Pork Checkoff Program Activity	Hog price ($/cwt.)	Farm production (lbs)	Producer surplus ($)
Pork advertising	0.0073	304,371	1,995,544
Pork non-advertising promotion	0.0124	516,107	3,383,765
Foreign market development	0.0258	1,074,547	3,170,324
Farm production research	-0.0354	1,901,596	9,664,372
Demand enhancing research	0.0004	18,527	121,467
All five expenditure categories combined	0.0105	3,815,149	18,335,471

1% increase in advertising increases the hog price by $0.0258 per cwt., holding all other factors constant. Promotion and advertising have the second and third largest impact. Specifically, a 1% increase in promotion and advertising increases the hog price by $0.0124 per cwt. and $0.0073 per cwt., respectively. Demand enhancing research has the fourth largest impact of the hog price; a 1% increase in demand enhancing research increases the hog price by $0.0004 per cwt. Since farm production research increases supply, it has the impact of reducing the hog price. A 1% increase in this activity decreases the hog price by $0.0354 per cwt. holding constant all other factors. Collectively, a 1% increase in all five activities results in a $0.0105 per cwt. increase, holding all other factors constant.

All five NPB activities have positive impacts on commercial hog production. As expected, farm production research has the largest impact; on average over this period, a 1% increase in NPB-sponsored production research increases hog production by 1.9 million pounds per year, holding all other variables constant. A 1% increase in foreign market development increases production by approximately 1.1 million pounds per year. A 1% increase in promotion and generic pork advertising increases production by 516,107 pounds and 304,371 pounds, respectively per year. Demand enhancing research has the smallest impact on hog production.

A 1% increase in all five NPB activities combined increases hog production by 3.8 million pounds per year.

All five NPB activities benefit hog producers in terms of increasing producer surplus. Even though farm production research decreases the hog price, it has the largest positive impact on producer surplus of all five activities. A 1% increase in farm production research increases producer surplus by $9.7 million per year, holding all other factors constant. Foreign market development has the next highest impact on producer surplus. A 1% increase in this activity results in a $3.2 million per year increase in producer surplus. A 1% increase in domestic promotion and advertising results in respectively a $3.38 million and $2 million per year increase in producer surplus. Finally, demand enhancing research has the smallest impact; a 1% increase in this activity leads to a $121,467 increase in producer surplus. Collectively, a 1% increase in all five of these activities increases producer surplus by $18.3 million.

How do these marginal benefits compare with the marginal costs? To answer this question, the following benefit-cost ratio is computed for each NPB activity:

$$BCR = \Delta PS/\Delta Costs$$

where: ΔPS is the change in producer surplus (i.e., industry-wide profits to hog producers) associated with the 1% increase in the NPB activity, and $\Delta Cost$ is the respective change in cost. Overhead for administering the NPB is incorporated in the costs by increasing each activity expenditures by 12.7%, which is the overall average overhead associated with the NPB.

Table 6 presents the marginal BCRs for the five activities and the overall combined return for the current 2021 study as well as the last two studies conducted in 2018 (Kaiser, 2017)

Table 6. Marginal benefit-cost ratio by NPB activity 2021, 2018, and 2012.

Pork Checkoff Program activity	2021 BCR	2018 BCR	2012 BCR
Pork advertising	42.16	14.20	18.00
Pork non-advertising promotion	13.05	12.40	2.60
Foreign market development	20.09	24.70	19.10
Farm production research	71.58	83.30	52.40
Demand enhancing research	1.37	8.30	3.00
All five expenditure categories combined	27.57	25.50	17.40

and 2012 (Kaiser , 2012). The highest marginal BCR continues to be for production research. Based on the period 2016-20, an extra dollar invested in production research yields $71.58 in producer surplus. The next highest return is for pork advertising where an extra dollar invested would return $42.16 in producer surplus. This is followed by foreign market development, where an extra dollar invested yields $20.09 in producer surplus. Domestic pork promotion and

demand enhancing research have marginal BCRs of 13.05 and 1.37, respectively. Collectively, the overall marginal BCR for all five activities is $27.57 for an additional dollar invested in the NPB. The overall BCR is the highest of any previous evaluation study for the pork checkoff program.

All of these figures presented are "point estimates," which are estimates rather than exact measures. That is, there is uncertainty about the precision of these estimates and therefore it is useful to construct confidence intervals around these point estimates. The confidence intervals give a lower and upper bound to the point estimate where one can be reasonable confidant that the true measurement lies. It is especially important to estimate the lower bound confidence interval for the BCR, which is done and the results are presented in Table 7.

Table 7. Lower bound for 90% confidence interval for marginal BCRs.

Pork Checkoff Program Activity	Marginal benefit-cost ratio
Pork advertising	5.50
Pork non-advertising promotion	6.69
Foreign market development	11.89
Farm production research	38.18
Demand enhancing research	0.14
All five expenditure categories combined	13.60

The lower bound of the 90% confidence interval for the marginal BCR for all five NPB activities combined is 13.60, which is well above 1.0. Hence, one can be reasonable assured that an extra dollar invested in the NPB would return greater than one dollar in producer surplus to the industry. In fact, all the NPB, except demand enhancing research, have lower bound marginal BCRs greater than 1.0. This finding gives credence to the conclusion that the NPB has been profitable to hog producers over this period.

Conclusions

The Pork Checkoff Program's (PCP) central mission is to increase the demand for hogs and pork products, reduce production costs, and improve the profitability of hog and pork producers. The overall goal of the research is to independently evaluate the economic effectiveness of the programs funded by the Pork Promotion, Research, and Consumer Information Act of 1985.

The statistical results indicate that all three-pork checkoff program demand enhancing activities have a positive and statistically significant impact on increasing per capita pork demand. Generic pork advertising has a three-year carry over effect with an elasticity of 0.022 meaning a 10% increase in advertising results in a 0.22% increase in per capita pork demand holding all other demand factors constant. The estimated domestic pork promotion elasticity is 0.039 meaning a 10% increase in promotion expenditures results in a 0.39% increase in per capita pork demand holding other factors constant. Finally, demand enhancing pork research is found to have a lagged effect of five years, i.e., research four years ago has a significant impact on today's pork demand. Specifically, a 10% increase in demand enhancing research increases per capita pork demand by 0.014% holding all other factors constant.

The results indicate that U.S foreign market development programs have the effect of increasing the export demand for U.S. pork. The model indicates that there is a one-year carry-over effect of foreign market development. The estimated results indicate that a 10% increase in foreign market development expenditures increase U.S. pork exports by 2.13% when holding other demand factors constant.

NPB-sponsored production-level research has a positive and statistically significant impact on hog supply. The elasticity for production research, lagged five years, is 0.015. That is, a 10% increase in research expenditures results in a 0.15% increase in hog supply over five-years.

All five NPB activities have positive impacts on commercial hog production. As expected, farm production research has the largest impact; on average over this period, a 1% increase in NPB-sponsored production research increases hog production by 1.9 million pounds per year, holding all other variables constant. A 1% increase in foreign market development increases production by approximately 1.1 million pounds per year. A 1% increase in promotion and generic pork advertising increases production by 516,107 pounds and 304,371 pounds, respectively per year. Demand enhancing research has the smallest impact on hog production. A 1% increase in all five NPB activities combined increases hog production by 3.8 million pounds per year.

All five NPB activities benefit hog producers in terms of increasing producer surplus. Even though farm production research decreases the hog price, it has the largest positive impact on producer surplus of all five activities. A 1% increase in farm production research increases producer surplus by $9.7 million per year, holding all other factors constant. Foreign market development has the next highest impact on producer surplus. A 1% increase in this activity results in a $3.2 million per year increase in producer surplus. A 1% increase in domestic

promotion and advertising results in respectively a $3.38 million and $2 million per year increase in producer surplus. Finally, demand enhancing research has the smallest impact; a 1% increase in this activity leads to a $121,467 increase in producer surplus. Collectively, a 1% increase in all five of these activities increases producer surplus by $18.3 million.

The highest marginal BCR continues to be for production research. Based on the period 2016-20, an extra dollar invested in production research yields $71.58 in producer surplus. The next highest return is for pork advertising where an extra dollar invested would return $42.16 in producer surplus. This is followed by foreign market development, where an extra dollar invested yields $20.09 in producer surplus. Domestic pork promotion and demand enhancing research have marginal BCRs of 13.05 and 1.37, respectively. Collectively, the overall marginal BCR for all five activities is $27.57 for an additional dollar invested in the NPB. The overall BCR is the highest of any previous evaluation study for the pork checkoff program.

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Appendix. Econometric and Simulation Models

This Appendix describes the econometric model and results in detail. The four econometric equations to be estimated include: (1) retail domestic pork demand, (2) retail domestic pork supply, (3) U.S. pork export demand, and (4) commercial farm pork supply. The model also includes two equilibrium conditions requiring retail domestic and international demand to equal retail domestic supply, and a farm-to-retail conversation equation to assure that farm supply is equal to domestic and international demand. The four econometric equations are used to test whether various activities by the NPB such as advertising, export market development and promotion activities, production research, and post-farm gate research have a statistically significant impact on demand and supply.

Retail Pork Demand and Supply

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

$$\ln(PCCON_t) = \beta 0 + \beta 1 \ln(PPORK_t/CPI_t) + \beta 2 \ln(PBEEF_t/CPI_t) + \beta 3 \ln(PBROIL_t/CPI_t) + \beta 4 \ln(PCINC_t/CPI_t) + \beta 5 \ln(PCCON_{t-1}) + \beta 6 \ln(TREND_t) + \beta 7 \ln(PADV_{t-n}) + \beta 8 \ln(PROM_t) + \beta 9 \ln(DRES_{t-n})$$

where: $PCCON_t$ is per capita pork domestic consumption year t, $PPORK_t$ is retail price for pork products in year t, CPI_t is the retail consumer price index for all items in year t, $PBEEF_t$ is retail price for beef products in year t, $PBROIL_t$ is the retail price for broiler products in year t, $PCINC_t$ is per capita disposable income in year t, $PCCON_{t-1}$ is per capita pork domestic consumption in the previous year, $TREND_t$ is a linear trend term in year t, $PADV_{t-n}$ is generic pork advertising in year t, year t-1, and so on, $PROM_t$ is generic pork promotion in year t, and $DRES_{t-n}$ is pork checkoff program sponsored demand enhancing research in year t, year t-1, and so on. In this equation, "ln" is the natural logarithmic operator, and the βs are the coefficients to be estimated with statistical regression analysis. All monetary variables such as PPORK, PBEEF, PBROIL, PCINC, PADV, PROM, and DRES 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. All variable definitions for the econometric model are listed together in Appendix Table 1.

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

$$\ln(RSUP_t) = \eta 0 + \eta 1 \ln(PPORK_t/CPI_t) + \eta 2 \ln(HOGP_t/CPI_t) + \eta 3 TREND_t + \eta 4 \ln(RSUP_{t-1})$$

where: $RSUP_t$ is total retail supply of pork in year t, $PPORK_t$ is retail price for pork products in year t, $HOGP_t$ is the hog price in year t, and $TREND_t$ is a linear time trend variable for year t to measure technological progress in the pork retail sector over time. In this equation, "ln" is the natural logarithmic operator, and the ηs are the coefficients to be estimated with statistical regression analysis. The output price ($PPORK_t/CPI_t$) is expected to be positive reflecting the law

of supply, while the hog price represents the main variable cost to pork retailers and is expected to have a negative impact on retail pork supply. The trend variable is also expected to be positive since it is capturing technological growth in the retail supply chain, which has a positive impact on supply. Retail pork supply, lagged one year, is also included in the model to represent capacity constraints in pork retailing from one year to the next.

The following data sources were used for the variables in the model: PCCON, PPORK, CPI, PBEEF, PBROIL, PCINC, RSUP, and HOGP come from the Livestock Marketing Information Center, PADV, PROM, and DRES come from the National Pork Board.

The retail pork demand model is estimated in logarithmic form with annual data from 1976 through 2020. The elasticities are summarized in Table A1. The R-squared indicates that the explanatory variables explain 70% of the variations in annual per capita demand for U.S. pork. The elasticity signs are consistent with economic theory and all estimated coefficients (except per capita consumption in the previous year) are statistically significant at the 10% significance level or better. Per capita consumption in the previous year is not statistically significant based on a two-tailed t-test, but is statistically significant based on a one-tailed t-test and is therefore included in the model as a significant variable. Several econometric diagnostic tests performed indicate no statistical problems with the model.

Table A1. Retail pork demand elasticities.

Demand Factor	Elasticity	P-value
Retail pork price	-0.341	0.002
Retail beef price	0.143	0.030
Retail broiler price	0.208	0.050
Per capita disposable income	0.510	0.004
Per capita consumption in previous year	0.211	0.130
Time trend	-0.300	0.000
Generic pork advertising	0.023	0.050
Generic promotion	0.039	0.002
Demand-enhancing research	0.001	0.080
R-Square	0.70	

The retail pork supply model is estimated in logarithmic form (except for the TREND term) with annual data from 1976 through 2020. The elasticities are summarized in Table A2. The R-squared indicates that the explanatory variables explain 95% of the variations in annual retail supply of U.S. pork. The elasticity signs are consistent with economic theory and all estimated coefficients are statistically significant at the 1% significance level or better (except for the trend term, which is significant at the 7% level). Several econometric diagnostic tests performed indicate no statistical problems with the model.

Table A2. Retail pork supply elasticities.

Supply Factor	Elasticity	P-value
Retail pork price	0.182	0.010
Hog price	-0.200	0.000
Time trend	0.002	0.077
Retail pork supply in the previous year	0.360	0.001
R-Square	0.95	

Pork Export Demand Model

Mathematically, the pork export demand model is represented by the following equation:

$$\ln(X_t) = \alpha 0 + \alpha 1 \ln(ER_t * USP_t/WCPI_t) + \alpha 2 \ln(ROWP_t/WCPI_t) + \alpha 3 \ln(GDP_t/WCPI_t) + \alpha 4 \ln(X_{t-1}) + \alpha 5 \ln(T) + \alpha 6 \ln(ER((FAS_{t-n}+NPB_{t-n}+USMEF_{t-n}))/WCPI_{t-n})$$

where: X_t is U.S. pork exports year t, USP_t is U.S. unit value of pork exports in year t, $WCPI_t$ is the world consumer price index in year t, $ROWP_t$ is the unit value of all non-U.S. pork exports (rest-of-the-world) in year t, GDP_t is gross domestic product in the world net of the U.S. in year t, ER_t is the U.S. agricultural trade exchange rate constructed by the Economic Research Service, USDA in year t, and FAS_t, NPB_t, $USMEF_t$ are FAS, NPB and USMEF foreign market expenditures in year t. 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 USP, ROWP, GDP, and foreign market development expenditures are deflated by the world consumer price index to account for the effects of inflation over time. Hence, all monetary variables are expressed on a "real", inflation adjusted, rather than nominal basis.

The U.S. pork price is computed as the total value of exports divided by the total quantity of exports and come from the Livestock Marketing Information Center. The ROWP is also computed as a unit value for all "pork meat" exports from the world excluding the U.S. These data come from the USDA Global Agricultural Trade System (GATS) data set.

This analysis combines USDA/FAS with NPB and USMEF expenditures to measure the total foreign market development impact. Market promotion activities have a carry-over effect. To measure the carry-over effect of export promotion, a lag specification begins with expenditures from one years ago, and two years ago, and so on is estimated and the model with the best statistical fit is chosen as the final model. The best model indicated a lag length of one year for promotion.

The following data sources are used for the variables: the quantity U.S. pork exports come from Livestock Marketing Information Center. GDP, ER, and WCPI come from the international macroeconomic data set of the Economic Research Service, USDA. Annual pork

USDA/FAS, NPB, and USMEF export promotion expenditures come from FAS, NPB, and USMEF.

The export demand model is estimated in logarithmic form with annual data from 1976 through 2020. The elasticities are summarized in Table 3. The elasticity signs are consistent with economic theory, but both other country's export price is not significant and therefore omitted from the model. All other estimated coefficients are statistically significant at better than the 10% significance level. Several econometric diagnostic tests performed indicate no statistical problems.

Table A3. Pork export demand elasticities.

Demand Factor	Elasticity	P-value*
Exports lagged one year	0.705	0.000
U.S. price	-0.366	0.035
U.S. agricultural trade adjusted exchange rate	-0.952	0.004
World minus U.S. GDP	0.358	0.063
Pork foreign market development	0.213	0.000
R-Square	0.99	

Hog Supply Model

Mathematically, the hog supply model is represented by the following equation:

$$\ln (FSUP_t) = \gamma 0 + \gamma 1 \ln (HOGP_{t-1}/COST_{t-1}) + \gamma 2 \ln(RES_{t-n}/CPI_{t-n}) + \gamma 3 \ln (FSUP_{t-1})$$

where: $FSUP_t$ is U.S. hog production in year t, $HOGP_{t-1}$ is the hog price in the previous year t-1, CPI_t is the consumer price index for all items, $COST_{t-1}$ is total costs in year t-1, $TREND_t$ is a linear trend term, and RES_{t-n} are lagged values of NPB expenditures on production-level research. In this equation, "ln" is the natural logarithmic operator, and the γs are the coefficients to be estimated with statistical regression analysis. All monetary variables are deflated by the CPI for all items and therefore reflected in real, inflation adjusted terms.

It is assumed that hog producers have naive price expectations, where the expected price is a function of the price in the previous year. Total costs of producing feeder pigs and the costs of finishing those pigs are used as the measure of production costs, which impact the supply curve. A negative relationship is expected since increases in costs discourage increases in supply. An output price- input price ratio is used in the supply function estimation.

The impact of NPB production-level research is hypothesized to have a positive, but delayed effect on supply. This type of research should have a positive effect on supply as it is

designed to decrease farm costs and improve managerial ability. It takes time to do research, and the impact of research on actual production is often not felt for years. To measure this time effect, a lag model is used with a host of alternative lag lengths. The final model included NPB research expenditures lagged five years.

The following data sources were used for the variables: commercial hog production and the hog price came from Livestock Marketing Information Center. COST came from the Iowa State University "Estimated Costs and Returns Series." The source of the data is http://www.econ.iastate.edu/estimated-returns/. The production-level research expenditures came from the NPB.

The hog supply model is estimated in logarithmic form with annual data from 1976 through 2020. The elasticities are summarized in Table A4. The R-squared indicates that the explanatory variables explain 97% of the variations in farm supply for U.S. hogs. The elasticity signs are consistent with economic theory and all estimated coefficients are statistically significant at better than the 1% significance level. Several econometric diagnostic tests performed found no statistical problems.

Table A4. Commercial hog supply elasticities.

Supply Factor	Elasticity	P-value
Supply lagged one year	0.980	0.000
Expected price	0.126	0.000
Total production costs	-0.126	0.000
Production research	0.015	0.000
R-Square	0.97	

Equilibrium Displacement Model

The EDM consists of several equations and endogenous variables as follows (for simplicity, the only exogenous variables presented are for the five NPB activities):

(1)	Qrd = f(PPORK | PADV, PROM, DRES)	Retail pork demand
(2)	Qrs = f(PPORK)	Retail pork supply
(3)	Qx =f (USP | FAS+NPB+USMEF)	Export pork demand
(4)	Qfs = f(HOGP*(1-t) | FRES)	Farm supply
(5)	USP = f(PPORK)	Export price-retail price linkage
(6)	Qrs = Qrd + Qx	Market clearing condition
(7)	Qfs = δ Qrs	Farm to retail conversion

where the seven endogenous variables are defined as follows: Qrd is retail pork demand, Qrs is retail pork supply, PPORK is retail price for pork, Qx is export pork demand, USP is the U.S.

unit value (export price) for pork exports, Qfs is commercial farm pork supply, and HOGP is the farm hog price. The exogenous variables are defined as follows: PADV is pork advertising expenditures, PROM is pork promotion expenditures, DRES is demand-enhancing pork product research expenditures, FAS+NPB+USMEF is total expenditures on foreign market development, FRES is farm-level, production research expenditures by the NPB, t is the assessment rate for the NPB, and δ is a conversion factor from farm to retail quantity. The EDM transforms these seven equations by taking the logarithmic differential of each equation, setting them equal to zero, and then solving the seven equations for the seven endogenous variable values.

The EDM is a static model that assumes instantaneous adjustment. The crucial parameters to the model are the own price elasticities of demand and supply and the elasticities for the five NPB activities. In the EDM, the estimated coefficients from the econometric model are used.

The EDM is simulated for the most recent 5-year period, 2016-2020. The focus here is on computing a marginal BCR, which is based on a small change (1%) between two equilibrium levels. As argued in the RTI study, "with declining marginal returns to research and promotion, these estimates of marginal returns can be considered conservative lower bounds for the point estimates of historic average returns that have been generated by the Pork Checkoff Program." Hence, these estimates can be thought of as a lower bound on the true average impacts.

The following tables list all the data used in the models.

Year	Generic Beef Advertising $	Non-advertising Promotion $	Demand Enhancing Research $	Farm Production Research $	USMEF and NPB Export Promotion $	USDA/FAS Export Promotion $	Retail Beef Price $/cwt
1976	84,449	739	0	5,783	26,878	458,276	145.66
1977	324,871	2,841	0	22,249	103,398	350,094	145.85
1978	364,153	3,185	0	24,939	115,900	324,870	178.79
1979	330,629	2,892	0	22,643	105,231	272,934	222.43
1980	484,684	4,239	0	33,193	154,262	247,274	233.59
1981	2,330,651	20,385	0	159,614	741,785	204,236	234.67
1982	1,796,834	15,716	0	123,055	571,885	195,479	238.36
1983	1,702,789	14,893	0	116,615	541,953	239,762	234.08
1984	1,642,012	14,362	0	112,453	522,609	309,986	235.48
1985	2,823,396	24,695	0	193,359	898,613	425,187	228.63
1986	1,974,432	17,269	0	135,218	628,410	2,465,052	226.78
1987	7,431,597	65,000	0	508,950	2,365,282	2,067,873	238.38
1988	7,792,946	278,029	176,140	685,650	5,083,074	1,670,399	250.34
1989	8,214,148	466,029	52,833	664,082	4,117,046	2,233,733	265.66
1990	7,785,430	660,070	0	1,814,904	9,168,472	2,270,268	281.02
1991	10,292,776	945,236	0	2,753,021	10,243,086	836,510	288.33
1992	10,778,008	840,284	0	2,880,423	11,932,816	1,604,627	284.61
1993	11,732,968	1,448,171	0	5,029,473	11,478,491	1,683,069	293.44
1994	11,889,430	1,061,859	717,718	3,744,555	12,518,914	1,384,512	282.88
1995	13,373,093	1,668,663	328,620	3,542,249	13,936,874	1,681,094	284.33
1996	14,101,200	2,380,505	499,754	3,964,487	18,310,150	2,483,007	280.23
1997	12,613,613	4,344,043	751,534	5,032,255	20,453,515	2,339,954	279.53
1998	15,143,537	5,670,747	856,304	7,610,122	18,914,804	2,286,204	277.12
1999	13,112,077	4,896,604	586,112	8,895,040	21,834,930	4,924,176	287.77
2000	13,258,413	5,245,188	383,896	7,077,691	16,720,904	4,439,172	306.42
2001	14,031,181	5,159,988	0	7,626,106	16,853,986	3,385,699	337.73
2002	12,512,295	4,842,221	0	6,106,208	16,165,659	5,234,473	331.54
2003	10,631,629	4,526,245	207,094	7,330,528	14,042,846	3,412,074	374.62
2004	12,110,743	4,365,762	306,360	8,844,903	15,926,649	5,311,154	406.53
2005	17,623,253	4,761,504	272,896	9,046,471	16,844,433	6,155,436	409.09
2006	8,612,019	4,182,772	3,196,786	17,436,910	22,787,038	7,192,424	397.02
2007	9,581,412	4,684,067	3,621,285	10,843,882	20,705,730	5,546,610	415.84
2008	6,208,414	4,914,395	2,405,606	11,172,815	24,081,058	5,972,450	432.45
2009	9,123,300	5,529,843	2,301,877	10,619,991	26,792,467	8,293,215	425.97
2010	6,551,098	4,533,912	1,713,662	9,781,023	23,449,151	6,475,720	438.40
2011	17,808,822	6,028,336	2,372,593	8,435,853	16,334,639	4,730,038	480.73
2012	15,386,010	7,144,325	2,586,286	8,435,853	15,733,311	4,744,539	498.59
2013	16,417,661	7,532,134	2,779,232	11,947,900	17,430,683	2,144,245	528.94
2014	13,015,577	7,032,459	2,733,658	10,462,408	15,060,110	3,190,642	597.03
2015	14,300,056	7,643,846	2,541,729	18,003,314	15,970,421	4,023,419	628.89
2016	11,167,563	7,188,254	2,543,461	8,788,399	16,147,450	4,145,229	596.38
2017	2,533,000	8,046,562	2,502,365	10,135,002	21,477,717	2,502,303	590.86
2018	2,004,000	8,940,313	8,807,522	13,330,295	18,541,892	3,244,269	592.33
2019	1,837,000	10,481,712	8,512,320	12,589,786	18,048,649	3,306,692	604.37
2020	1,181,000	8,875,917	2,641,848	7,802,914	27,577,876	5,393,095	653.55

Year	Retail Broiler Price $/cwt	Retail Pork Price $/cwt	Consumer Price Index All Items 2020=1	U.S. Population million	Pork Consumption Pounds/person	Disposable Income $/person
1976	59.68	134.04	0.217	218.0	45.5	20,346
1977	60.07	125.35	0.221	220.2	47.0	20,780
1978	66.48	143.55	0.241	222.6	47.0	21,497
1979	67.68	152.48	0.265	225.1	53.7	21,672
1980	70.86	147.51	0.297	227.7	57.3	21,584
1981	73.18	161.24	0.326	230.0	54.7	21,891
1982	71.36	185.56	0.341	232.2	49.1	22,156
1983	72.47	179.67	0.352	234.3	51.7	22,714
1984	81.01	171.44	0.368	236.3	51.5	24,062
1985	76.33	170.82	0.382	238.5	51.9	24,565
1986	83.50	188.76	0.392	240.7	49.0	25,268
1987	78.48	199.35	0.406	242.8	49.2	25,597
1988	85.37	194.05	0.432	245.0	52.5	26,559
1989	92.70	193.46	0.468	247.3	52.0	27,080
1990	89.92	224.91	0.495	250.2	49.7	27,303
1991	88.03	224.17	0.516	253.5	50.3	27,138
1992	86.92	209.49	0.536	256.9	53.1	27,895
1993	89.02	209.08	0.554	260.3	52.4	27,990
1994	90.09	209.54	0.577	263.5	53.0	28,411
1995	91.67	206.09	0.592	266.6	52.4	29,011
1996	97.27	233.71	0.615	269.7	49.1	29,586
1997	100.19	244.97	0.628	273.0	48.7	30,304
1998	104.37	242.69	0.641	276.2	52.6	31,712
1999	105.59	241.44	0.654	279.3	53.8	32,409
2000	107.12	258.20	0.666	282.4	51.2	33,645
2001	110.52	269.39	0.686	285.2	50.3	34,216
2002	107.39	265.75	0.701	288.0	51.6	34,894
2003	103.44	265.80	0.717	290.6	51.9	35,474
2004	106.96	279.17	0.729	293.3	51.4	36,325
2005	105.58	282.69	0.739	296.0	50.0	36,526
2006	104.93	280.73	0.753	298.8	49.5	37,570
2007	111.52	287.05	0.786	301.7	50.8	38,093
2008	120.69	293.65	0.866	304.5	49.5	38,188
2009	127.82	291.98	0.894	307.2	50.2	37,814
2010	126.32	311.36	0.886	309.8	47.8	38,290
2011	129.13	343.35	0.921	312.0	45.7	38,804
2012	142.22	346.68	0.947	314.2	46.0	39,797
2013	149.62	364.39	0.957	316.4	46.9	39,038
2014	153.33	401.88	0.959	318.6	45.9	40,240
2015	148.83	385.25	0.970	320.9	49.8	41,537
2016	146.37	374.67	0.966	323.2	50.2	42,005
2017	147.19	378.42	0.961	325.2	50.2	42,914
2018	149.71	374.45	0.965	326.9	51.0	44,133
2019	149.50	384.33	0.978	328.5	52.4	44,913
2020	156.29	402.93	1.000	330.5	51.9	47,471

Year	U.S. Hog Production carcass base mil lbs	Hog Price $/cwt	Feed and non-Feed Finishing Costs $/cwt	Term number	Real Ag Trade adjusted Exchange Rate Index
1976	12,488	58.49	49.20	1	76.51
1977	13,052	55.11	46.70	2	75.59
1978	13,209	65.03	45.56	3	71.88
1979	15,271	56.87	50.66	4	73.05
1980	16,433	53.66	57.68	5	76.94
1981	15,717	59.50	64.43	6	82.84
1982	14,121	74.38	57.04	7	93.35
1983	15,117	64.92	70.71	8	96.91
1984	14,720	66.72	72.92	9	102.17
1985	14,728	60.19	62.73	10	111.46
1986	13,998	69.18	58.03	11	111.03
1987	14,312	69.91	53.41	12	108.45
1988	15,623	60.15	64.71	13	101.61
1989	15,759	60.80	68.67	14	101.79
1990	15,300	75.08	64.57	15	106.39
1991	15,948	67.48	64.03	16	107.22
1992	17,184	58.54	60.33	17	107.91
1993	17,030	62.55	65.92	18	107.07
1994	17,658	54.42	59.21	19	111.16
1995	17,811	57.74	70.63	20	107.57
1996	17,086	72.28	75.78	21	106.38
1997	17,244	69.72	69.69	22	107.91
1998	18,980	43.23	56.96	23	115.55
1999	19,278	44.48	54.86	24	115.49
2000	18,928	59.44	57.43	25	118.25
2001	19,138	51.62	58.65	26	123.85
2002	19,664	50.10	64.23	27	124.68
2003	19,945	55.30	65.73	28	120.87
2004	20,509	70.02	70.04	29	116.85
2005	20,684	67.52	67.23	30	113.54
2006	21,054	63.87	79.08	31	111.79
2007	21,943	64.97	96.11	32	107.32
2008	23,347	67.18	101.17	33	102.49
2009	22,999	58.99	92.06	34	105.56
2010	22,437	74.61	107.04	35	100.00
2011	22,758	89.08	124.35	36	95.79
2012	23,253	86.10	143.70	37	96.58
2013	23,187	89.58	124.25	38	97.73
2014	22,843	102.88	106.66	39	99.89
2015	24,501	71.74	97.65	40	109.20
2016	24,941	66.52	94.79	41	113.22
2017	25,584	71.76	95.13	42	113.28
2018	26,315	66.82	97.94	43	112.89
2019	27,616	69.43	99.52	44	115.26
2020	28,303	63.42	110.51	45	118.88

Year	World Export Pork Price $/lb	U.S. Export Pork Price $/lb	U.S. Pork Exports mil lbs	Consumer Price Index 2010=1	World - U.S. GDP bil $
1976	1.80	1.93	316	0.229	18,465
1977	2.19	1.80	294	0.248	19,143
1978	2.34	2.19	288	0.262	19,857
1979	2.25	2.34	291	0.280	20,719
1980	2.51	2.25	252	0.308	21,284
1981	2.71	2.51	307	0.335	21,618
1982	2.59	2.71	214	0.356	21,926
1983	2.16	2.59	219	0.372	22,358
1984	1.87	2.16	164	0.388	23,160
1985	3.08	1.87	128	0.404	23,999
1986	3.69	3.08	86	0.415	24,746
1987	3.96	3.69	109	0.428	25,636
1988	3.55	3.96	195	0.444	26,800
1989	3.98	3.55	268	0.468	27,739
1990	3.57	3.98	243	0.495	28,558
1991	3.22	3.57	290	0.521	29,027
1992	3.26	3.22	420	0.543	29,365
1993	3.09	3.26	446	0.565	29,729
1994	3.21	3.09	549	0.594	30,527
1995	3.33	3.21	787	0.628	31,492
1996	3.22	3.33	970	0.654	32,498
1997	2.58	3.22	1,044	0.678	33,637
1998	2.54	2.58	1,230	0.698	34,239
1999	2.75	2.54	1,277	0.716	35,203
2000	2.62	2.75	1,287	0.737	36,755
2001	2.44	2.62	1,559	0.759	37,602
2002	2.41	2.44	1,612	0.780	38,483
2003	2.51	2.41	1,717	0.803	39,613
2004	2.52	2.51	2,181	0.826	41,470
2005	2.46	2.52	2,666	0.852	43,123
2006	2.62	2.46	2,995	0.878	45,246
2007	2.61	2.62	3,141	0.907	47,570
2008	2.56	2.61	4,651	0.952	48,760
2009	2.84	2.56	4,094	0.971	48,102
2010	3.04	2.84	4,223	1.000	50,443
2011	3.01	3.04	5,196	1.041	52,223
2012	3.07	3.01	5,379	1.078	53,541
2013	3.33	3.07	4,986	1.114	54,970
2014	2.78	3.33	5,092	1.153	56,428
2015	2.76	2.78	5,010	1.191	57,797
2016	2.79	2.76	5,239	1.224	59,522
2017	2.70	2.79	5,632	1.262	61,681
2018	2.73	2.70	5,876	1.308	63,580
2019	2.66	2.73	6,321	1.366	65,183
2020		2.66	7,280	1.418	61,712