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 2024, the NPB had a budget of approximately $81million 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 five-year period (2020-24) of performance for the NPB Checkoff Program.[1]

[1] It should be noted that there is a one-year overlap of this year's analysis and the analysis done in 2021. That is, the previous five-year study applied to 2016-20, while this year's study applies to 2020-24, i.e., 2020 is a part of both this and the previous study. This occurred because this year's analysis was completed in early 2025 and, therefore, we did not have 2025 data at our disposal. Thus, the most recent five-year period is 2020-24.

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, 2020-2024.

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 most recent five-year period in terms of return on investment (ROI); and (2) quantify and compute ROIs for alternative existing 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[2] 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. Dr. Kaiser has been involved in research on commodity promotion programs for 39-years, and is one of the leading experts on this topic in the world. He has written 160 refereed journal articles, five books, 17 book chapters, and over 150 research bulletins. Dr. Kaiser has conducted over 140 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, cranberries, raisins, walnuts, blueberries, potatoes, beef, wheat, watermelons, high-valued-agricultural commodities, bulk agricultural commodities, and paper and paper packaging. In 2011, 2016, and 2021 he conducted the economic evaluation of the National Pork Board Checkoff Program. In 2021, Dr. Kaiser conducted the economic evaluation study for the NPB. 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.

[2] 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.

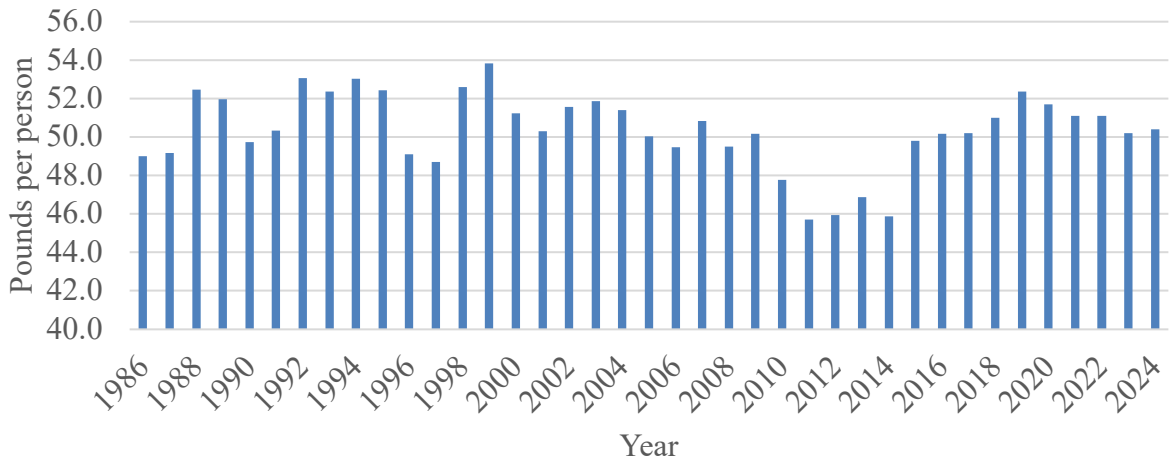
Professor Kaiser received the Outstanding Alumni Award from the Department of Applied Economics, University of Minnesota, in 2009. In 2017, he was elected a Fellow of the Agricultural and Applied Economics Association.

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 $0.35 per hundred pounds 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 $80 million on an annual basis.

Per capita retail pork consumption in the U.S. has fluctuated overtime, as displayed graphically in Figure 1. While per capita consumption has declined slightly since 2019, it is still about 10% higher in 2024 than in 2014. In 2024, annual consumption totaled 50.4 pounds per person.

Figure 1. Per capita retail pork consumption



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 7.7% and real per capita disposable income rose by 23.1%. In addition, the real retail price for beef increased by 2.1%, making pork more economically affordable relative to its main substitute. Finally, the 4.6% 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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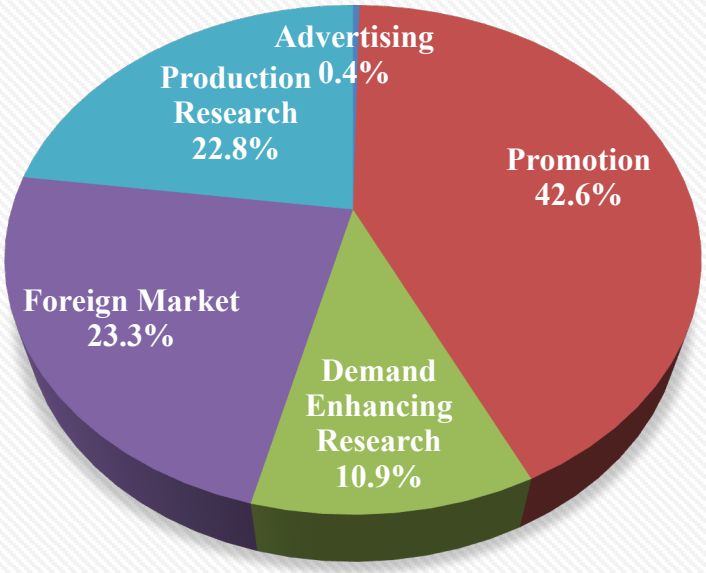
Figure 2 illustrates the percent of the NPB budget spent on each of these activities on average for the period 2020-2024. On average, promotion expenditures was the largest category of the NPB budget, accounting for 42.6% of the spending. This was followed in importance by foreign market development (23.3%) and production enhancing research (22.8%). NPB contributions to demand enhancing research represented 10.9% of the budget in the past five years, while advertising comprised 0.4%. The relative magnitudes of these five activities have varied, considerably, over time.

Figure 2. Percent of National Pork Checkoff Program expenditures by major activity in 2020-24



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 2024 in real, inflation-adjusted (2024) 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 and again in 2005. Since 2005, generic pork advertising has generally declined, and, in 2021 was phased out altogether.

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

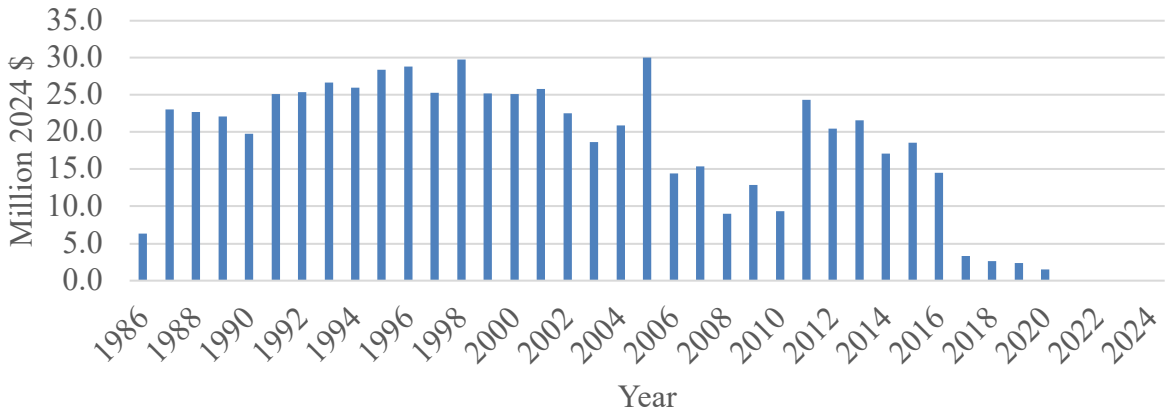
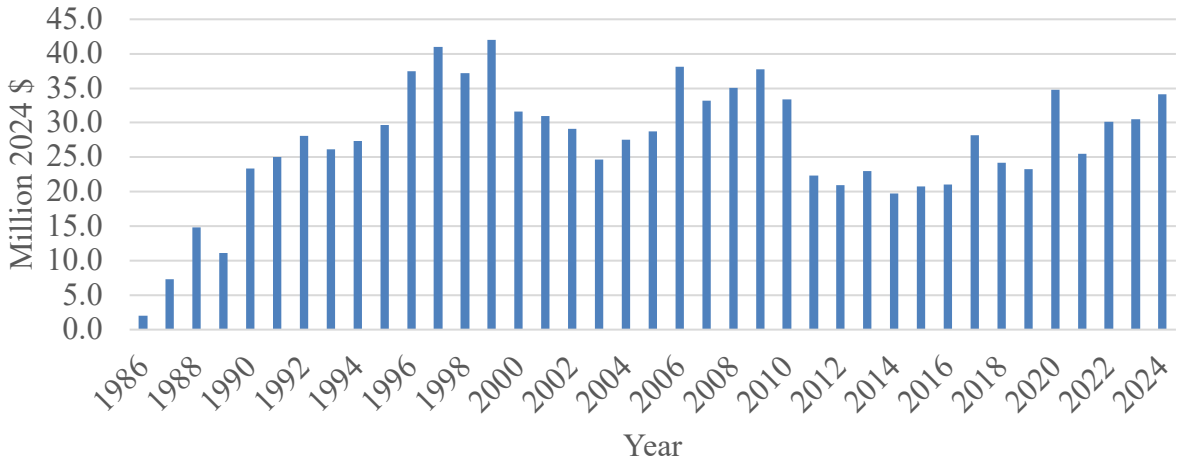


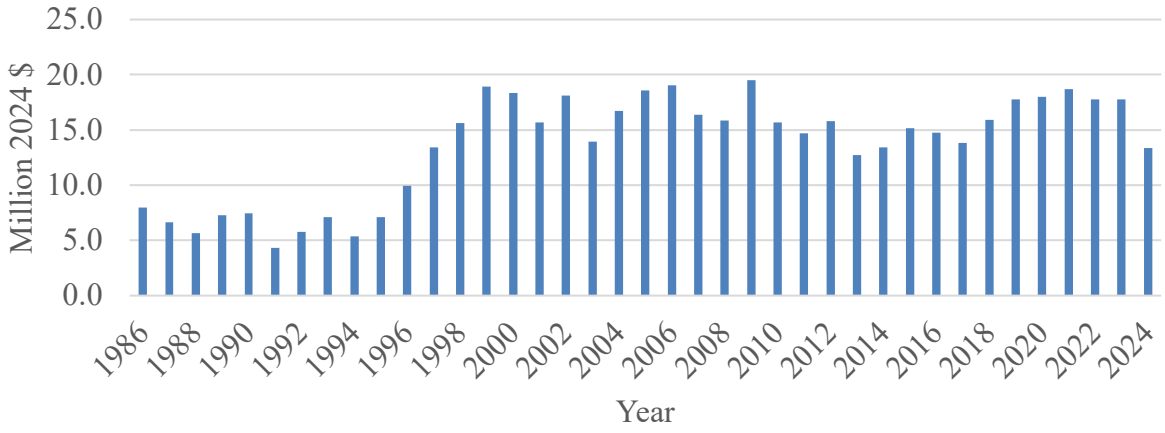
Figure 4 presents generic promotion expenditures over this time-period, which include all non-media demand enhancing activities such as merchandising, food service marketing, consumer research, and consumer public relations. Expenditures on these activities were significantly higher in the late 1990s. Since 2000, spending on promotion has varied a bit, but for the last four years have trended upwards.

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 3.1% of commercial disappearance. By 2024, this figure grew to 31.3%. 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 $8 million in 1986 to $13.3 million in 2024. However, in 2024, these expenditures decreased by 24.5% from the previous year.

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



NPB-sponsored production-level research has generally 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 $0.4 million was spent on this research. By 2015, this grew to $23.4 million, but since then has decreased steadily.

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 $11.5 million spent, but has since declined. Since 2020, there has been a renewed focus on nutrition research.

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

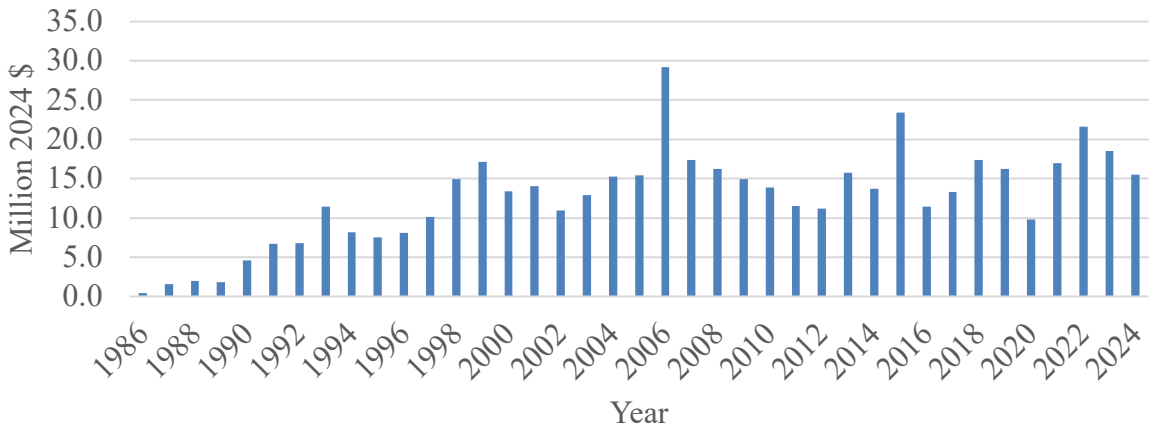
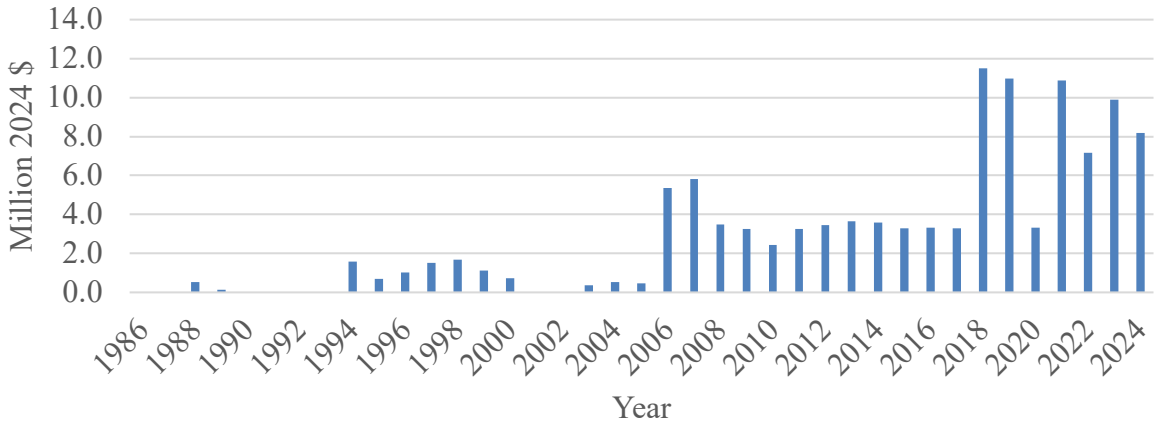


Figure 7. Real, inflation-adjusted PCP demand enhancing research expenditures



Data Limitations

The econometric model used in this study is based on secondary data from government sources, private vendors, 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 have changed over time. These perceptions undoubtedly have an impact on pork demand. The same is true for 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 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 2024. 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. Dummy variable to measure the impact of the Covid-19 pandemic on retail pork demand. This variable is equal to zero for all years except 2020 and 2021, where it is set to a value of 1.

8. Generic pork advertising expenditures,

9. Generic pork promotion expenditures,

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

The retail price for pork products is expected to be negatively related to 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, i.e., an increase in beef prices makes pork more affordable and should increase pork demand. 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[3]. The best model indicated a lag length of two 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. The highest marginal benefit-cost ratio (BCR) continues to be for advertising, which is not surprising since expenditures on this activity were extremely low[4]. Indeed, the NPB completely eliminated generic pork advertising in the last four years of this five-year evaluation period. Based on the period 2020-24, an extra dollar invested in advertising

[3] A second-degree polynomial distributed lag specification is used with current, one-year, and two-year lags for generic pork advertising expenditures.

[4] There is an inverse (negative) relationship between spending on an activity and its marginal BCR. When spending increases, the activity eventually experiences diminishing returns, i.e., each incremental increase in the activity experiences diminishing incremental increases. Likewise, when spending on an activity decreases, the marginal BCR for it generally increases for the same reason.

yields $93.79 in producer surplus. The next highest return is for farm production research where an extra dollar invested would return $55.50 in producer surplus. This is followed by foreign market development, where an extra dollar invested yields $26.39 in producer surplus. Domestic pork promotion and demand enhancing research have marginal BCRs of 5.52 and 2.30, respectively. Collectively, the overall marginal BCR for all five activities is $21.33 for an additional dollar invested in the NPB. ed 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 long 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.

There is a potential problem of endogeneity in the demand function since the retail pork, beef, and chicken prices may be endogenous with per capita pork demand, i.e., per capita demand may influence prices and vice versa. To deal with this potential problem, an instrumental variable regression approach is used where each retail price is regressed on a set of the following exogenous variable: retail price of pork, chicken, and beef in the previous year, Consumer Price Index for all items, and a linear trend term. The predicted price from each regression is used instead of the actual price for pork, beef, and chicken in the demand model.

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 2024. 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. Dummy variable to measure the impact of the Covid-19 pandemic on U.S. pork export demand. This variable is equal to zero for all years except 2020 and 2021, where it is set to a value of 1.

7. Total annual foreign market development expenditures (USMEF, USDA/FAS, and NPB combined).[5]

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 ("ROW") 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.

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 2024. Of key interest here is the impact of production-research expenditures sponsored by the NPB on hog production. If 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

[5] 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.

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.

5. Dummy variable to measure the impact of the Covid-19 pandemic on farm hog supply. This variable is equal to zero for all years except 2020 and 2021, where it is set to a value of 1. Covid-19 was not found to have a statistically significant impact on hog supply.

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 adaptive price expectations, where the expected price is a function of prices in previous years. 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[6].

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-, six-, and seven-years. Again, a second-degree polynomial distributed lag specification is used.

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

[6] A second-degree polynomial distributed lag specification is used with for the ratio of the hog price to total hog costs with one-year, two-year, and three-year lags.

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 model is estimated in logarithmic form with annual data from 1976 through 2024. The elasticities are summarized in Table 1. The elasticity signs are consistent with economic theory and all estimated coefficients (except per capita disposable income, Covid-19, and the trend term) are statistically significant at the 5% significance level or better. The trend term, Covid-19, and per capita disposable income are omitted from the final model due to their statistical insignificance. The R-square is 0.70 indicating that the variation over time in the demand drivers explain 70% of the variation in per capita pork demand.

Table 1. Retail pork demand elasticities.

Demand Factor	Elasticity	P-value*
Retail pork price	-1.300	0.000
Retail beef price	0.754	0.000
Retail broiler price	1.300	0.000
Per capita consumption in previous year	0.538	0.000
Generic pork advertising	0.004	0.000
Generic promotion	0.028	0.030
Demand-enhancing research	0.003	0.004
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 -1.30. The interpretation of this is a 1% increase in the retail pork price, holding all other demand factors constant, leads to a 1.3% decrease in per capita pork quantity demanded. As expected, beef and broilers are found to be substitutes for pork with elasticities of 0.754 and 1.30, respectively. That is, a 1% increase in the beef or broiler price, holding all other demand factors constant, results in a 0.754% or 1.3% increase, respectively, in pork demand. 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 0.538% 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 two-year carry over effect with an elasticity of 0.004, i,e. a 1% increase in advertising expenditures results in a 0.004% increase in per capita pork demand. The estimated promotion elasticity is 0.028 meaning a 1% increase in promotion expenditures results in a 0.028% 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 0.003% holding all other factors constant.

Because there is error inherent in any statistical model, a 95% 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 95% of the time. The 95% confidence interval for the generic pork advertising elasticity is (0.002, 0.006). The 95% confidence interval for the generic pork promotion elasticity is (0.002, 0.053). The 95% confidence interval for the demand enhancing research elasticity is (0.0001, 0.005). 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 2024. 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.

Table 2. Retail pork supply elasticities.

Supply Factor	Elasticity	P-value*
Retail pork price	0.335	0.001
Hog price	-0.168	0.000
Time trend	0.044	0.050
Retail pork supply in the previous year	0.467	0.002
R-Square	0.96	

*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 0.335, 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 0.335% increase in quantity supplied by pork retailers. The impact of the hog price indicates that a 1% increase in the hog price is found to be associated with a 0.168% 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 statistically significant; a 1% increase in the previous year's supply increases current year pork supply by 0.467% holding all other supply factors constant. The Covid -19 dummy variable is not statistically significant and hence omitted from the model.

U.S. Export Pork Demand. The export demand model is estimated in logarithmic form with annual data from 1976 through 2024. The elasticities are summarized in Table 3. The elasticity signs are consistent with economic theory, but both world (minus US) GDP and the rest of the world's export price are not significant and are therefore omitted from the model. All other

estimated coefficients are statistically significant at better than the 9% significance level.

Table 3. Pork export demand elasticities.

Demand Factor	Elasticity	P-value*
U.S. price	-0.790	0.000
U.S. agricultural trade adjusted exchange rate	-0.892	0.020
Exports lagged one year	0.701	0.000
Covid-19 pandemic	-0.094	0.018
Pork foreign market development	0.284	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.

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 -0.79 indicating that a 1% increase in the U.S. pork price decreases U.S. pork exports by 0.79%, holding constant other demand factors.

The U.S. agricultural trade adjusted exchange rate is the most significant export demand driver. The estimated elasticity is -0.892 indicating that a 1% increase in the U.S. agricultural trade adjusted exchange rate decreases U.S. pork exports by 0.892%, holding constant other demand factors.

Lagged exports are a significant demand driver for current exports. The estimated elasticity for lagged exports is 0.701 indicating a 1% increase in last year's U.S. pork exports increases this year's exports by 0.701% holding all other factors constant. While Covid-19 did not have an impact on either retail pork demand or supply, it did significantly reduce U.S. pork exports by 9.4% in 2020-21.

The statistical results indicate that U.S foreign market development programs have the effect of increasing the export demand for U.S. pork. The estimated results indicate that a 1% increase in foreign market development expenditures increase U.S. pork exports by 0.284%.

Because there is error inherent in any statistical model, a 95% 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 95% of the time. The 95% confidence interval for the elasticity is (0.157, 0.435).

Hog Supply. The hog supply model is estimated in logarithmic form with annual data from 1976 through 2024. 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

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 0.168, i.e., a 1% increase in price this year, holding all other supply factors constant, results in a 0.168% increase in hog quantity supplied next year. The elasticity of hog supply with respect to total feed and non-feed finishing costs is -0.168[7]. That is, a 1% increase in costs this year results in a 0.168% 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 0.914% increase in supply in the current year. This is not surprising given the reproductive life cycle of hogs. Covid-19 did not significantly impact hog supply and is not included in the final model.

Table 4. Commercial hog supply elasticities.

Supply Factor	Elasticity	P-value*
Expected price	0.168	0.000
Total production costs	-0.168	0.000
Supply lagged one year	0.914	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.

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 95% 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, 2020-2024. 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.*

[7] The own price elasticity (0.168) and the hog cost elasticity (-0.168) are the same value, except cost is the negative of the own price. This is due to the specification of the hog supply function where the hog price to total cost ratio is used, i.e., log(supply) = ß0 + ß1 log(hog price/ feed and non-feed finishing costs) + other supply shifters. Under this log specification, the own price elasticity is ß1 and the elasticity of supply regarding production costs is -ß1.

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 2020-2024. 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, costs, and producer surplus.

Pork Checkoff Program Activity	Hog price ($/cwt.)	Farm production (lbs)	1% increase ($)	Producer surplus ($)
Pork advertising	0.0008	59,867	2,362	221,544
Pork non-advertising promotion	0.0056	419,069	281,000	1,550,815
Foreign market development	0.0210	1,569,028	99,000	2,612,924
Farm production research	-0.0303	1,881,234	151,000	8,365,718
Demand enhancing research	0.0006	44,900	72,200	166,158
All five categories combined	-0.0022	3,974,098	605,562	12,917,158

1% increase in foreign market development increases the hog price by $0.021 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 $0.0056 per cwt. and $0.0008 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 $0.0006 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 $0.0303 per cwt. holding constant all other factors. Collectively, a 1% increase in all five activities results in a $0.0022 per cwt. decrease, 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 1.6 million pounds per year. A 1% increase in promotion and generic pork advertising increases production by 419,000 pounds and 60,000 pounds, respectively per year. Demand enhancing research has the smallest impact on hog production at 45,000 pounds. A 1% increase in all five NPB activities combined increases hog production by almost 4 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 $8.4 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 $2.6 million per year increase in producer surplus. A 1% increase in domestic promotion and advertising results in respectively a $1.6 million and $0.22 million per year increase in producer surplus. Finally, demand enhancing research has the smallest impact; a 1% increase in this activity leads to a $166,000 increase in producer surplus. Collectively, a 1% increase in all five of these activities increases producer surplus by $12.9 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.

Table 6 presents the marginal BCRs for the five activities and the overall combined return. The highest marginal BCR continues to be for advertising, which is not surprising since expenditures on this activity were extremely low[8]. Indeed, the NPB completely eliminated generic pork advertising in the last four years of this five-year evaluation period. Based on the period 2020-24, an extra dollar invested in advertising yields $93.79 in producer surplus. The next highest return is for farm production research where an extra dollar invested would return $55.50 in producer surplus. This is followed by foreign market development, where an extra dollar invested yields $26.39 in producer surplus. Domestic pork promotion and demand enhancing research have marginal BCRs of 5.52 and 2.30, respectively. Collectively, the overall marginal BCR for all five activities is $21.33 for an additional dollar invested in the NPB.

Table 6. Marginal benefit-cost ratio by NPB activity.

Pork Checkoff Program activity	BCR
Pork advertising	93.79
Pork non-advertising promotion	5.52
Foreign market development	26.39
Farm production research	55.40
Demand enhancing research	2.30
All five expenditure categories combined	21.33

[8] There is an inverse (negative) relationship between spending on an activity and its marginal BCR. When spending increases, the activity eventually experiences diminishing returns, i.e., each incremental increase in the activity experiences diminishing incremental increases. Likewise, when spending on an activity decreases, the marginal BCR for it generally increases for the same reason.

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 95% confidence interval for marginal BCRs.

Pork Checkoff Program Activity	Lower bound 95% confidence interval for marginal benefit-cost ratio
Pork advertising	46.90
Pork non-advertising promotion	0.39
Foreign market development	15.07
Farm production research	29.55
Demand enhancing research	0.08
All five expenditure categories combined	10.21

The lower bound of the 95% confidence interval for the marginal BCR for all five NPB activities combined is 10.21, 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.

How does the estimated overall return-on-investment for the National Pork Board Checkoff program compare to that for other promotion checkoff programs? Table 8 lists the estimated BCR's for selected food commodities.[9] The ROI's range in value from a low of 1.7 for California avocados to a high of 32.08 for watermelon promotion. The overall ROI for the National Pork Board Checkoff program of 21.33 is three-times higher than the overall median of all marginal ROIs in Table 8 (6.55).

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

Table 8. Estimated BCRs 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 (2023)	Beef	11.91	NA
Kaiser (2024)	Blueberries	19.29	NA
Murray et al. (2001)	Cotton	4.50	NA
Kaiser (2021)	Walnuts	11.62	NA
Kaiser (2024)	Peanuts	NA	11.10
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 (2024)	Soybeans	NA	12.30
Median		6.74	6.55

Conclusions

The National Pork Board Checkoff Program's central mission is to increase the demand for hogs and pork products, reduce production costs, enhance production, 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 for the most recent five year period, 2020-24.

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 two-year carry over effect with an elasticity of 0.004 meaning a 10% increase in advertising results in a 0.04% increase in per capita pork demand holding all other demand factors constant. The estimated domestic pork promotion elasticity is 0.028 meaning a 10% increase in promotion expenditures results in a 0.28% 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 0.03% 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 2.94% 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 three 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 1.6 million pounds per year. A 1% increase in promotion and generic pork advertising increases production by 419.000 pounds and 60,000 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 almost 4 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 almost $8.4 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 $2.6 million per year increase in producer surplus. A 1% increase in

domestic promotion and advertising results in respectively a $1.6 million and $222,000 per year increase in producer surplus. Finally, demand enhancing research has the smallest impact; a 1% increase in this activity leads to a $166,000 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 advertising, which is not surprising since expenditures on this activity were extremely low. Indeed, the NPB completely eliminated generic pork advertising in the last four years of this five-year evaluation period. Based on the period 2020-24, an extra dollar invested in advertising yields $93.79 in producer surplus. The next highest return is for farm production research where an extra dollar invested would return $55.50 in producer surplus. This is followed by foreign market development, where an extra dollar invested yields $26.39 in producer surplus. Domestic pork promotion and demand enhancing research have marginal BCRs of 5.52 and 2.30, respectively. Collectively, the overall marginal BCR for all five activities is $21.33 for an additional dollar invested in the NPB.

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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:

$$\ln(QP_t) = \beta 0 + \beta 1 \ln(PORKP_t/CPI_t) + \beta 2 \ln(BEEFP_t/CPI_t) + \beta 3 \ln(CHICKP_t/CPI_t) + \beta 4 \ln(PCINC_t/CPI_t) + \beta 5 \ln(QP_{t-1}) + \beta 6 \ln(TREND_t) + \beta 7 \ln(ADV_{t-n}) + \beta 8 \ln(PROMO_t) + \beta 9 \ln(DEMENHANCE_{t-n}) + \beta 10 \, COVID$$

where: QP_t is per capita pork domestic consumption year t, $PORKP_t$ is retail price for pork products in year t, CPI_t is the retail consumer price index for all items in year t, $BEEFP_t$ is retail price for beef products in year t, $CHICKP_t$ is the retail price for broiler products in year t, $PCINC_t$ is per capita disposable income in year t, QP_{t-1} is per capita pork domestic consumption in the previous year, $TREND_t$ is a linear trend term in year t, ADV_{t-n} is generic pork advertising in year t, year t-1, and so on, $PROMO_t$ is generic pork promotion in year t, $DEMENHANCE_{t-n}$ is pork checkoff program sponsored demand enhancing research in year t, year t-1, and so on, and COVID is a dummy variable to measure the impact the pandemic had on retail pork demand in 2020-21. 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 PORKP, BEEFP, CHICKP, PCINC, ADV, PROMO, and DEMENHANCE 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.

There is a potential problem of endogeneity in the demand function since the retail pork, beef, and chicken prices may be endogenous with per capita pork demand, i.e., per capita demand may influence prices and vice versa. To deal with this potential problem, an instrumental variable regression approach is used where each retail price is regressed on a set of the following exogenous variable: retail price of pork, chicken, and beef in the previous year, Consumer Price Index for all items, and a linear trend term. The predicted price from each regression is used instead of the actual price for pork, beef, and chicken in the demand model.

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

$$\ln(RSUP_t) = \eta 0 + \eta 1 \ln(PORKP_t/CPI_t) + \eta 2 \ln(HOGP_t/CPI_t) + \eta 3 \ln(TREND_t) + \eta 4 \ln(RSUP_{t-1}) + \eta 5 COVID$$

where: $RSUP_t$ is total retail supply of pork in year t, $PORKP_t$ is retail price for pork products in year t, $HOGP_t$ is the hog price in year t, and $TREND_t$ is a time trend variable for year t to measure technological progress in the pork retail sector over time, and all other variables are as previously defined. 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 ($PORKP_t/CPI_t$) 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. Covid 19 is expected to have a negative impact on retail pork supply.

The following data sources were used for the variables in the model: QP, PORKP, CPI, BEEFP, CHICKP, PCINC, RSUP, and HOGP come from the Livestock Marketing Information Center, ADV, PROMO, and DEMENHANCE come from the National Pork Board.

The retail pork demand model is estimated in logarithmic form with annual data from 1976 through 2024. Alternative functional forms including linear and semi-logarithmic are estimated, but the logarithmic form fit the data the best. 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 the trend term, Covid-19, and real per capita disposable income which are omitted from the model) are statistically significant at the 5% significance level or better. Several econometric diagnostic tests performed indicate no statistical problems with the model.

The retail pork supply model is estimated in logarithmic form with annual data from 1976 through 2024. 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. Covid is not statistically significant and is therefore omitted from the final model. 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 5% level). Several econometric diagnostic tests performed indicate no statistical problems with the model.

Table A1. Retail pork demand econometric results.
Dependent Variable: LOG(QP)
Sample (adjusted): 1980 2024
Included observations: 45 after adjustments
Huber-White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	-2.569247	0.823566	-3.119662	0.0035
LOG(PORKPF/CPI)	-1.295376	0.349402	-3.707412	0.0007
LOG(CHICKPF/CPI)	1.298931	0.267541	4.855077	0.0000
LOG(BEEFPF/CPI)	0.754028	0.170550	4.421144	0.0001
LOG(QP(-1))	0.538386	0.103696	5.191949	0.0000
LOG(PROMO/CPI)	0.027700	0.012581	2.201774	0.0340
LOG((DRES(-4))/CPI(-4))	0.002800	0.000899	3.114909	0.0035
PDL01	0.001599	0.000377	4.238175	0.0001

R-squared	0.700368	Mean dependent var	3.924627
Adjusted R-squared	0.643681	S.D. dependent var	0.044255
S.E. of regression	0.026417	Akaike info criterion	-4.269821
Sum squared resid	0.025820	Schwarz criterion	-3.948637
Log likelihood	104.0710	Hannan-Quinn criter.	-4.150087
F-statistic	12.35499	Durbin-Watson stat	1.796243
Prob(F-statistic)	0.000000	Wald F-statistic	11.56726
Prob(Wald F-statistic)	0.000000		

Lag Distribution of LOG((1+ADV)/CPI)	i	Coefficient	Std. Error	t-Statistic
. * |	0	0.00120	0.00028	4.23818
. * |	1	0.00160	0.00038	4.23818
. * |	2	0.00120	0.00028	4.23818
	Sum of Lags	0.00400	0.00094	4.23818

Where: QP is per capita consumption of pork, PORKPF is the retail pork price instrument, CPI is the Consumer Price Index for all items, CHICKPF is the retail chicken price instrument, BEEFPF is the retail beef price instrument, QP(-1) is per capita pork consumption in the previous year, PROMO is National Pork Board expenditures for non-advertising promotion activities, DRES(-4) is National Pork Board expenditures on demand enhancing research lagged four years, ADV is National Pork Board expenditures on generic pork advertising, PDL is the polynomial distributed lag specification, and LOG is the logarithmic operator.

Table A1 (Continued). Retail pork, beef, and chicken instrumental variable regressions.
Dependent Variable: PORKP
Sample (adjusted): 1977 2024
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PORKP(-1)	0.501319	0.195201	2.568219	0.0138
BEEFP(-1)	0.089956	0.063445	1.417872	0.1634
CHICKP(-1)	0.697864	0.335198	2.081949	0.0433
CPI	52.01335	77.46197	0.671469	0.5055
TREND	0.091630	0.854429	0.107241	0.9151

R-squared	0.981486	Mean dependent var	275.2007
Adjusted R-squared	0.979764	S.D. dependent var	97.66819
S.E. of regression	13.89360	Akaike info criterion	8.199066
Sum squared resid	8300.383	Schwarz criterion	8.393983
Log likelihood	-191.7776	Hannan-Quinn criter.	8.272726
Durbin-Watson stat	1.559199		

Dependent Variable: BEEFP
Sample (adjusted): 1977 2024
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PORKP(-1)	0.168939	0.284718	0.593358	0.5561
BEEFP(-1)	0.920230	0.092540	9.944169	0.0000
CHICKP(-1)	0.236462	0.488915	0.483646	0.6311
CPI	-121.9926	112.9850	-1.079724	0.2863
TREND	1.570230	1.246258	1.259956	0.2145

R-squared	0.987814	Mean dependent var	393.5926
Adjusted R-squared	0.986680	S.D. dependent var	175.5893
S.E. of regression	20.26502	Akaike info criterion	8.954002
Sum squared resid	17658.86	Schwarz criterion	9.148919
Log likelihood	-209.8961	Hannan-Quinn criter.	9.027662
Durbin-Watson stat	1.271037		

Dependent Variable: CHICKP
Sample (adjusted): 1977 2024
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PORKP(-1)	0.085508	0.060018	1.424694	0.1615
BEEFP(-1)	0.026313	0.019507	1.348881	0.1844
CHICKP(-1)	0.479768	0.103063	4.655084	0.0000
CPI	105.5357	23.81724	4.431064	0.0001
TREND	-1.221873	0.262711	-4.651011	0.0000

R-squared	0.985969	Mean dependent var	111.4786
Adjusted R-squared	0.984663	S.D. dependent var	34.49475
S.E. of regression	4.271867	Akaike info criterion	5.840311
Sum squared resid	784.7004	Schwarz criterion	6.035228
Log likelihood	-135.1675	Hannan-Quinn criter.	5.913971
Durbin-Watson stat	1.832681		

Where: PORKP is the retail pork price, BEEFP is the retail beef price, CHICKP is the retail chicken price, (-1) means variable is lagged one year, CPI is the Consumer Price Index for all items, and TREND is an annual trend variable.

Table A2. Retail pork supply econometric results.
Dependent Variable: LOG(RSUP)
Sample (adjusted): 1977 2024
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	3.642536	0.810950	4.491693	0.0001
LOG(PORKPF/CPI)	0.335458	0.076748	4.370894	0.0001
LOG(HOGP/CPI)	-0.167628	0.026946	-6.220917	0.0000
LOG(RSUP(-1))	0.466670	0.090770	5.141208	0.0000
LOG(TREND)	0.043761	0.021304	2.054166	0.0461

R-squared	0.957646	Mean dependent var	9.554775
Adjusted R-squared	0.953706	S.D. dependent var	0.131106
S.E. of regression	0.028209	Akaike info criterion	-4.200023
Sum squared resid	0.034217	Schwarz criterion	-4.005106
Log likelihood	105.8006	Hannan-Quinn criter.	-4.126364
F-statistic	243.0621	Durbin-Watson stat	1.509138
Prob(F-statistic)	0.000000		

Where: RSUP is retail supply of pork, PORKPF is the retail pork price instrument, CPI is the Consumer Price Index for all items, HOGP is the price hog producers receive for their hogs, RSUP(-1) is retail supply in the previous year, TREND is a trend term equal to 1 for 1976, 2 for

1977, and so on, and LOG is the logarithmic operator.

Pork Export Demand Model

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

$$\ln(USQ_t) = \alpha 0 + \alpha 1 \ln(USP_t/WCPI_t) + \alpha 2 \ln(ROWP_t/WCPI_t) + \alpha 3 \ln(GDP_t/WCPI_t) + \alpha 4 \ln(ER_t) + \alpha 5 \ln(USQ_{t-1}) + \alpha 6 \ln(TREND) + \alpha 7 \ln((FAS_{t-n}+NPB_{t-n}+USMEF_{t-n})/WCPI_{t-n})) + \alpha 8 COVID$$

where: USQ_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, FAS_t, NPB_t, $USMEF_t$ are FAS, NPB and USMEF foreign market expenditures in year t, and COVID is a dummy variable equal to 1 for 2020-21 to reflect the impact of the pandemic on U.S. pork export demand. 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.

Similar to the domestic demand estimation, there is a potential problem of endogeneity in the export demand function since the U.S. pork price may be endogenous with export demand. To deal with this potential problem, an instrumental variable regression approach is used in an analogous fashion as in the domestic demand estimation.

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 2024. The elasticities are summarized in Table A3. The elasticity signs are consistent with economic theory, but both ROW's export price and world GDP are not significant and therefore omitted from the model. All other estimated coefficients are statistically significant at better than the 8% significance level. Several econometric diagnostic tests performed indicate no statistical problems.

Hog Supply Model

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

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

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 $FRES_{t-n}$ are lagged values of NPB expenditures on farm 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 adaptive price expectations which is a function of previous prices lagged one, two, and three years. A second-degree polynomial distributed lag model is used to estimate this. Total costs of producing feeder pigs and the costs of finishing those pigs are used as the measure of production costs. 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 2024. The elasticities are summarized in Table A4. The R-squared indicates that the explanatory variables explain 98% 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 A3. Pork export demand elasticities.
Dependent Variable: LOG(USQ)
Sample (adjusted): 1979 2024
Included observations: 46 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	2.961427	1.619227	1.828914	0.0749
LOG(ER)	-0.891722	0.390262	-2.284929	0.0277
LOG(USQ(-1))	0.700964	0.056237	12.46450	0.0000
LOG(USPF/WCPI)	-0.785979	0.204472	-3.843949	0.0004
COVID	-0.093654	0.037902	-2.470947	0.0178
PDL01	0.070935	0.018162	3.905734	0.0004

R-squared	0.990723	Mean dependent var	6.859863
Adjusted R-squared	0.989563	S.D. dependent var	1.435101
S.E. of regression	0.146611	Akaike info criterion	-0.880962
Sum squared resid	0.859790	Schwarz criterion	-0.642443
Log likelihood	26.26212	Hannan-Quinn criter.	-0.791611
F-statistic	854.3330	Durbin-Watson stat	1.869966
Prob(F-statistic)	0.000000	Wald F-statistic	1568.787
Prob(Wald F-statistic)	0.000000		

Lag Distribution of LOG((FAS+NPBEXPORT)/ WCPI)	i	Coefficient	Std. Error	t-Statistic
. * |	0	0.05675	0.01453	3.90573
. *|	1	0.08512	0.02179	3.90573
. *|	2	0.08512	0.02179	3.90573
. * |	3	0.05675	0.01453	3.90573
	Sum of Lags	0.28374	0.07265	3.90573

Where: USQ is U.S. pork exports, ER is the USDA agricultural trade adjusted exchange rate, USQ(-1) is U.S. pork exports in the previous year, USPF is the U.S. export pork price instrument, WCPI is the world (not including U.S.) Consumer Price Index for all items, COVID is a dummy variable equal to 1 for 2020-21 and zero otherwise to measure the impact of the pandemic on pork export demand, FAS is USDA, Foreign Agricultural Service expenditures on pork foreign market development, NPBEXPORT is National Pork Board and USMEF expenditures on pork export promotion.

Table A4. Commercial hog supply elasticities.
Dependent Variable: LOG(FSUP)
Sample (adjusted): 1984 2024
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	0.632275	0.381952	1.655379	0.1068
LOG(SUP(-1))	0.913910	0.045637	20.02578	0.0000
PDL01	0.008681	0.007739	1.121686	0.2696
PDL02	-0.002407	0.002527	-0.952617	0.3473
PDL03	0.092774	0.024472	3.791088	0.0006
PDL04	-0.025308	0.006813	-3.714553	0.0007

R-squared	0.983840	Mean dependent var	9.920607
Adjusted R-squared	0.981531	S.D. dependent var	0.211503
S.E. of regression	0.028743	Akaike info criterion	-4.126379
Sum squared resid	0.028916	Schwarz criterion	-3.875613
Log likelihood	90.59078	Hannan-Quinn criter.	-4.035064
F-statistic	426.1681	Durbin-Watson stat	1.966679
Prob(F-statistic)	0.000000		

Lag Distribution of LOG(FRES(-5)/CPI(-5))	i	Coefficient	Std. Error	t-Statistic
. * |	0	0.00627	0.00522	1.20128
. *|	1	0.00773	0.00545	1.41893
. * |	2	0.00438	0.00176	2.48397
* . |	3	-0.00379	0.00982	-0.38549
	Sum of Lags	0.01460	0.00588	2.48397

Lag Distribution of LOG(HOGP(-1)/COSTHOG(-1))	i	Coefficient	Std. Error	t-Statistic
. * |	0	0.06747	0.01803	3.74223
. *|	1	0.08432	0.02400	3.51294
. * |	2	0.05055	0.02242	2.25453
* . |	3	-0.03383	0.03112	-1.08715
	Sum of Lags	0.16850	0.07474	2.25453

Where: FSUP is farm supply of hogs, SUP(-1) is farm supply in the previous year, FRES(-5) is National Pork Board funding of farm production enhancing research five years ago, CPI is the Consumer Price Index for all items, HOGP is the price hog producers receive for their hogs, COSTHOG is hog production costs, and LOG is the logarithmic operator.

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(PORKP | ADV, PROMO, DRES)	Retail pork demand
(2)	Qrs = f(PORKP)	Retail pork supply
(3)	USQ =f (USP | FAS+NPB+USMEF)	Export pork demand
(4)	Qfs = f(HOGP*(1-t) | FRES)	Farm supply
(5)	USP = f(PORKP)	Export price-retail price linkage
(6)	Qrs = Qrd + USQ	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, PORKP is retail price for pork, USQ is U.S. 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: ADV is pork advertising expenditures, PROMO 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	Pork Advertising	Pork Promotion	Demand Research	Production Research	Export Promotion	Retail Pork Price
1976	84,449	26,878	0	5,783	459,015	134.0
1977	324,871	103,398	0	22,249	352,936	125.4
1978	364,153	115,900	0	24,939	328,055	143.6
1979	330,629	105,231	0	22,643	275,825	152.5
1980	484,684	154,262	0	33,193	251,513	147.5
1981	2,330,651	741,785	0	159,614	224,621	161.2
1982	1,796,834	571,885	0	123,055	211,195	185.6
1983	1,702,789	541,953	0	116,615	254,656	179.7
1984	1,642,012	522,609	0	112,453	324,347	171.4
1985	2,823,396	898,613	0	193,359	449,882	170.8
1986	1,974,432	628,410	0	135,218	2,482,321	188.8
1987	7,431,597	2,365,282	0	508,950	2,132,873	199.4
1988	7,792,946	5,083,074	176,140	685,650	1,948,428	194.0
1989	8,214,148	4,117,046	52,833	664,082	2,699,762	193.5
1990	7,785,430	9,168,472	0	1,814,904	2,930,338	224.9
1991	10,292,776	10,243,086	0	2,753,021	1,781,746	224.2
1992	10,778,008	11,932,816	0	2,880,423	2,444,911	209.5
1993	11,732,968	11,478,491	0	5,029,473	3,131,240	209.1
1994	11,889,430	12,518,914	717,718	3,744,555	2,446,371	209.5
1995	13,373,093	13,936,874	328,620	3,542,249	3,349,757	206.1
1996	14,101,200	18,310,150	499,754	3,964,487	4,863,512	233.7
1997	12,613,613	20,453,515	751,534	5,032,255	6,683,997	245.0
1998	15,143,537	18,914,804	856,304	7,610,122	7,956,951	242.7
1999	13,112,077	21,834,930	586,112	8,895,040	9,820,781	241.4
2000	13,258,413	16,720,904	383,896	7,077,691	9,684,360	258.2
2001	14,031,181	16,853,986	0	7,626,106	8,545,687	269.4
2002	12,512,295	16,165,659	0	6,106,208	10,076,694	265.8
2003	10,631,629	14,042,846	207,094	7,330,528	7,938,319	265.8
2004	12,110,743	15,926,649	306,360	8,844,903	9,676,916	279.2
2005	17,623,253	16,844,433	272,896	9,046,471	10,916,940	282.7
2006	8,612,019	22,787,038	3,196,786	17,436,910	11,375,196	280.7
2007	9,581,412	20,705,730	3,621,285	10,843,882	10,230,677	287.1
2008	6,208,414	24,081,058	2,405,606	11,172,815	10,886,845	293.7
2009	9,123,300	26,792,467	2,301,877	10,619,991	13,823,058	292.0
2010	6,551,098	23,449,151	1,713,662	9,781,023	11,009,632	311.3
2011	17,808,822	16,334,639	2,372,593	8,435,853	10,758,374	343.4
2012	15,386,010	15,733,311	2,586,286	8,435,853	11,888,864	346.7

2013	16,417,661	17,430,683	2,779,232	11,947,900	9,676,379	364.4
2014	13,015,577	15,060,110	2,733,658	10,462,408	10,223,101	401.9
2015	14,300,056	15,970,421	2,541,729	18,003,314	11,667,265	385.3
2016	11,167,563	16,147,450	2,543,461	8,788,399	11,333,483	374.7
2017	2,533,000	21,477,717	2,502,365	10,135,002	10,548,865	378.4
2018	2,004,000	18,541,892	8,807,522	13,330,295	12,184,582	374.5
2019	1,837,000	18,048,649	8,512,320	12,589,786	13,788,404	384.3
2020	1,181,000	27,577,876	2,641,848	7,802,914	14,269,012	402.9
2021	0	20,681,608	8,833,516	13,781,487	15,197,128	450.3
2022	0	27,689,320	6,587,553	19,852,546	16,275,301	489.7
2023	0	30,351,583	9,827,505	18,395,577	17,661,524	480.9
2024	0	34,137,315	8,195,388	15,466,045	13,338,708	487.3

Year	Retail Beef Price	Retail Chicken Price	CPI 2024=1	U.S. Population	Per Capita Pork Consumption
1976	145.66	59.68	0.173	218.0	45.5
1977	145.85	60.07	0.175	220.2	47.0
1978	178.79	66.48	0.191	222.6	47.0
1979	222.43	67.68	0.210	225.1	53.7
1980	233.59	70.86	0.236	227.7	57.3
1981	234.67	73.18	0.259	230.0	54.7
1982	238.36	71.36	0.271	232.2	49.1
1983	234.08	72.47	0.280	234.3	51.7
1984	235.48	81.01	0.292	236.3	51.5
1985	228.63	76.33	0.303	238.5	51.9
1986	226.78	83.50	0.311	240.7	49.0
1987	238.38	78.48	0.322	242.8	49.2
1988	250.34	85.37	0.343	245.0	52.5
1989	265.66	92.70	0.372	247.3	52.0
1990	281.02	89.92	0.393	250.2	49.7
1991	288.33	88.03	0.409	253.5	50.3
1992	284.61	86.92	0.425	256.9	53.1
1993	293.44	89.02	0.440	260.3	52.4
1994	282.88	90.09	0.458	263.5	53.0
1995	284.33	91.67	0.470	266.6	52.4
1996	280.23	97.27	0.488	269.7	49.1
1997	279.53	100.19	0.499	273.0	48.7
1998	277.12	104.37	0.509	276.2	52.6
1999	287.77	105.59	0.519	279.3	53.8
2000	306.42	107.12	0.529	282.4	51.2
2001	337.73	110.52	0.544	285.2	50.3
2002	331.54	107.39	0.556	288.0	51.6
2003	374.62	103.44	0.569	290.6	51.9
2004	406.53	106.96	0.579	293.3	51.4
2005	409.09	105.58	0.587	296.0	50.0
2006	397.02	104.93	0.598	298.8	49.5
2007	415.84	111.52	0.624	301.7	50.8
2008	432.45	120.69	0.688	304.5	49.5
2009	425.97	127.82	0.709	307.2	50.2
2010	438.40	126.32	0.703	309.8	47.8
2011	480.73	129.13	0.731	312.3	45.7
2012	498.59	142.22	0.752	314.7	46.0

2013	528.94	149.62	0.759	317.1	46.9
2014	597.33	153.33	0.761	319.6	45.9
2015	628.94	148.83	0.770	322.1	49.8
2016	596.38	146.37	0.767	324.6	50.2
2017	590.86	147.19	0.763	326.9	50.2
2018	592.33	149.71	0.766	328.8	51.0
2019	604.37	149.50	0.777	330.5	52.4
2020	653.55	156.29	0.794	331.8	51.7
2021	724.97	152.70	0.812	332.5	51.1
2022	758.59	180.10	0.917	334.4	51.1
2023	787.57	191.40	0.995	337.1	50.2
2024	801.44	199.80	1.000	340.2	50.4

Year	Hog Production	Hog Price	Hog Production Costs	US Pork Exports	US Export Price
1976	12,488	42.88	32.00	311	1.93
1977	13,052	40.45	32.86	282	1.80
1978	13,209	48.15	31.64	237	2.19
1979	15,271	42.16	35.86	215	2.34
1980	16,433	39.74	41.63	186	2.25
1981	15,717	44.06	46.34	222	2.51
1982	14,121	55.05	41.88	153	2.71
1983	15,117	48.00	48.31	156	2.59
1984	14,720	49.36	50.33	116	2.16
1985	14,728	44.95	45.08	90	1.87
1986	13,998	51.66	41.50	60	3.08
1987	14,312	52.38	37.47	77	3.69
1988	15,623	44.54	44.30	139	3.96
1989	15,759	44.82	46.45	205	3.55
1990	15,300	55.55	42.55	181	3.98
1991	15,948	49.92	42.43	207	3.57
1992	17,184	43.24	42.28	309	3.22
1993	17,030	45.72	41.68	327	3.26
1994	17,658	39.53	43.28	391	3.09
1995	17,811	41.85	41.89	582	3.21
1996	17,086	52.89	50.42	676	3.33
1997	17,244	51.29	47.59	715	3.22
1998	18,980	31.68	42.43	882	2.58
1999	19,278	32.01	38.85	957	2.54
2000	18,928	42.76	38.86	966	2.75
2001	19,138	44.02	38.76	1,164	2.62
2002	19,664	36.48	38.06	1,213	2.44
2003	19,945	40.69	40.56	1,275	2.41
2004	20,509	52.43	42.99	1,648	2.51
2005	20,684	50.51	38.39	1,997	2.52
2006	21,054	47.70	38.92	2,243	2.46
2007	21,943	48.52	45.52	2,320	2.62
2008	23,347	49.87	54.28	3,454	2.61
2009	22,999	43.57	48.00	3,082	2.56
2010	22,437	56.56	47.65	3,165	2.84
2011	22,758	66.55	62.29	3,868	3.04
2012	23,253	64.13	66.17	3,991	3.01

2013	23,187	66.13	67.13	3,682	3.07
2014	22,843	77.18	58.23	3,800	3.33
2015	24,501	52.77	50.30	3,789	2.78
2016	24,941	48.96	47.60	3,947	2.76
2017	25,584	52.51	46.43	4,200	2.79
2018	26,315	49.17	48.05	4,366	2.70
2019	27,616	51.95	48.74	4,798	2.73
2020	28,303	45.96	47.76	5,527	2.66
2021	27,675	68.52	60.49	5,285	2.86
2022	26,996	73.10	71.41	4,727	2.99
2023	27,302	61.29	72.98	5,121	2.93
2024	27,790	63.81	64.21	5,371	3.01

Year	US Exchange Rate	World (Net of US) CPI	World (Net of US) GDP	Per Capita Real Disp Income 2017 $
1976	59.56	0.182	18,465	21,525
1977	60.88	0.194	19,143	21,981
1978	59.15	0.209	19,857	22,742
1979	60.33	0.232	20,719	22,932
1980	61.78	0.263	21,284	22,839
1981	64.05	0.290	21,618	23,134
1982	71.68	0.309	21,926	23,420
1983	73.83	0.320	22,358	24,035
1984	74.53	0.334	23,160	25,419
1985	78.25	0.346	23,999	25,972
1986	101.19	0.353	24,746	26,716
1987	100.07	0.366	25,636	26,962
1988	90.56	0.381	26,800	28,069
1989	86.57	0.399	27,739	28,614
1990	93.05	0.421	28,558	28,879
1991	94.83	0.439	29,027	28,738
1992	95.81	0.452	29,365	29,488
1993	93.69	0.465	29,729	29,579
1994	99.06	0.476	30,527	30,018
1995	99.88	0.489	31,492	30,644
1996	97.91	0.503	32,498	31,230
1997	98.70	0.514	33,637	31,959
1998	107.23	0.522	34,239	33,452
1999	106.23	0.533	35,203	34,143
2000	107.92	0.551	36,755	35,423
2001	112.93	0.566	37,602	36,102
2002	113.46	0.576	38,483	36,861
2003	111.58	0.589	39,613	37,451
2004	108.25	0.604	41,470	38,303
2005	104.90	0.624	43,123	38,395
2006	102.95	0.644	45,246	39,414
2007	98.56	0.662	47,570	39,955
2008	93.86	0.686	48,760	40,206
2009	96.75	0.684	48,102	39,948
2010	90.64	0.696	50,443	40,360
2011	86.54	0.717	52,223	40,908
2012	86.67	0.732	53,541	41,704

2013	87.09	0.742	54,970	40,798
2014	89.03	0.755	56,428	41,875
2015	96.30	0.756	57,797	43,179
2016	99.94	0.766	59,522	43,659
2017	100.00	0.782	61,681	44,710
2018	99.84	0.801	63,580	46,057
2019	101.86	0.815	65,183	47,251
2020	103.83	0.825	61,712	50,050
2021	104.24	0.863	65,635	51,698
2022	112.29	0.931	67,879	48,534
2023	114.25	0.969	69,734	50,579
2024	116.25	1.000	71,628	51,557