Executive Summary

The primary goal of the Pork Checkoff Program is to increase the profitability of hog and pork producers and importers through expansion of the demand for hogs and pork and reductions in production costs. The purpose of this study is to assess how well the Program's goals are being met.

The Pork Checkoff Program is funded by a mandatory assessment collected from hog producers and hog and pork importers, and the revenues are collected and managed by the National Pork Board, a quasigovernmental, nonprofit entity that administers the program. The primary goal of the Pork Checkoff Program is to increase the profitability of hog and pork producers and importers through expansion of the demand for hogs and pork and reductions in production costs. The purpose of this study is to assess how well the Program's goals are being met. Davis et al. (2001) previously conducted a study that focused on the Program's performance from inception of Program activities in 1987 through 1998. Although we use data covering the entire time frame of the Program for estimation purposes, the focus of the current study is on the period from 1999 through 2005.

ES.1 INTRODUCTION

Instituted in 1986, the Pork Checkoff Program aims to help the pork industry more effectively address important issues affecting a wide spectrum of market participants in a joint and organized manner. The Program is funded by a mandatory assessment on the market value of all hogs sold in the United States, as well as an equivalent amount on imported hogs, pork, and pork products (currently 0.4% of market value). Assessments have totaled around $60 million annually in recent years. These funds are invested in programs attempting to increase domestic pork consumption, increase export demand for U.S. pork, conduct research to improve production

practices, and conduct outreach to provide producers with knowledge necessary to compete in modern agriculture.

The economic value of the Program to those paying assessments depends not only on whether promotion and research have been effective in increasing sales and/or lowering the cost of hog production, but also on the cost-effectiveness of these activities. It is unlikely that Program promotion and research activities would not have at least some positive impacts on sales and production costs. The key question is whether the costs of the Program are justified by its benefits.

ES.1 STUDY OBJECTIVES

To assess how successfully the Pork Checkoff Program is meeting its economic goals, the National Pork Board directed that this study must address the following key issues:

1. Measure the economic and financial benefit to producers (and, if possible, other pork value chain participants) of pork checkoff-funded programs in terms of net return on investment. Define, as possible, historic benefits achieved.
2. Define and quantify, as possible, the influence that specific pork checkoff-funded programs (demand enhancement, science, and outreach) have had on enhancing pork demand and resulting net return on investment to producers and value chain participants. Isolate the influence of specific pork check-off funded programs net of other macro-economic factors such as shifts in meat demand, changes in consumer incomes, global trade issues, and health and safety concerns, for example.

To examine these issues, we developed and applied econometric and equilibrium displacement models of the markets for U.S. hogs and pork. Using the econometrically estimated parameters within the equilibrium displacement model, we can obtain empirical evidence of the Program's effectiveness in enhancing the demand for—and in the case of agricultural research, the supply of—U.S. hogs and pork. These models can tell us whether the Program has had statistically significant market effects, while controlling for factors that are economically important but outside the sphere of the Program's influence (e.g., income, prices of substitutes, food safety events).

ES.2 DATA AND METHODS

We describe the study approach used by the team of researchers from RTI and North Carolina State University to accomplish these objectives.

ES.2.1 Data

The data used in the econometric modeling come from various sources in the public domain, with the exception of commodity research and promotion expenditures. These data are not publicly available at the appropriate level of detail and were obtained from the appropriate organizations or researchers that have access. We used quarterly data for 1982 through 2005 on prices of hogs and pork, prices of substitute meats, input costs, hog and pork quantities produced and consumed in the United States, income, and trade data obtained from a variety of public data sources, as well as Pork Checkoff research and promotion expenditures provided by the National Pork Board and generic beef promotion expenditures from Dr. Ron Ward at the University of Florida.

Consistent with the previous evaluation conducted by Davis et al. (2001), the various program activities of the National Pork Board were grouped into four categories: retail advertising and promotion aimed at increasing the demand for pork (PDE), postfarm research expenditures expected to directly increase the demand for hogs (HDE), agricultural production research expected to shift hog supply (HSE), and foreign market development expenditures aimed at increasing exports (FMD).

ES.2.2 Econometric Models

The economic questions in this study relate to the degree of influence that the Pork Checkoff Program has on the hog and pork markets and the profitability of producers. To quantify these effects, econometric models were developed that statistically estimate the relationship between economic variables for domestic demand for hogs, supply of pork, domestic supply of hogs, import demand for Canadian hogs, domestic demand for pork, and export demand for U.S. pork. Table ES-1 lists the components and the variables used to estimate the model.

Table ES-1. Econometric Model Components and Variables

Market Component	Dependent Variable	Explanatory Variables[a]
Domestic inverse demand for hogs	Hog price	Hog quantity Retail price of pork Index of marketing costs Capacity constraint (=1 in 1998[4]) Polynomial inverse lag structure on National Pork Board postfarm marketing research expenditures
Pork supply	Pork quantity	Hog quantity Retail price of pork Index of marketing costs Capacity constraint (=1 in 1998[4])
Domestic supply of hogs	Inventory of sows	Inventory of sows at 1 quarter lag Hog price at 5 quarter lag Corn price at 1 quarter lag
	Pounds per market hog	Ratio of hog price to corn price
	Pigs per litter	Severe drought (=1 in 1998) Polynomial inverse lag structure on National Pork Board production research expenditures
Import demand for Canadian hogs	Number of hogs imported from Canada per capita	Number of hogs imported from Canada per capita at 1 quarter lag Canadian hog price at 5 quarter lag Real U.S. per capita personal consumption expenditures Real Canadian per capita disposable income
Domestic demand for pork	Demand system (GAIDS) with per capita retail consumption of beef, pork, and poultry	Prices of beef, pork, and poultry Media food safety indices for beef, pork, and poultry Structural change variable (=1 for 2002–2005) Polynomial inverse lag structures on National Pork Board domestic promotion expenditures and beef promotion
Export demand for U.S. pork	Net trade in pork	Net trade in pork at 1 quarter lag Trade volume weighted gross domestic product of major importers of U.S. pork U.S. retail pork price Polynomial inverse lag structure on National Pork Board foreign market development expenditures

[a]In addition, we include quarterly dummy variables to account for seasonality and a trend variable to account for changes in technology and other changes taking place over time that are not explicitly included in the model.

Estimation of the econometric models summarized in Table ES-1 yields values for parameters that capture the nature (sign) and magnitude of the economic effects of interest. Of particular interest are the parameters capturing the effects of Program expenditures because they are key determinants of Program returns to producers.

ES.2.3 Using Econometric Model Parameters to Simulate Return on Investment

The parameter estimates in the econometric model provide empirical evidence on the size of Program effects on U.S. hog and pork supply and demand. In this phase of the study, we used the econometrically estimated parameters to quantify the return on investment provided by the program. For instance, a program that successfully raises the demand for U.S. hogs and pork will increase the quantity purchased in the market and raise the price above the level that would prevail if there were no demand-enhancing program. These changes in the market will, all else equal, raise the well-being of those domestic producers and importers that obtain a higher price for their product. However, producers and importers must also pay for the Program through an assessment on the hogs or hog equivalents they produce or import. Net returns were estimated using the economic measure of producer surplus, subtracting out the assessment paid by producers. This net return measure was then divided by the cost to estimate the benefit-cost ratio for the program:

Benefit-cost ratio = Net return to producers/Program cost

Thus, a program with a positive net return will have a positive benefit-cost ratio. The larger the ratio, the higher the rate of return producers are receiving on the assessments paid to fund the Program.

We relied on an equilibrium displacement model (EDM) to account for all linkages between market levels as well as endogeneity of prices and quantities. Within this model, we simulated the effects of a 1% increase in overall Program expenditures as well as individual components and combinations of Program components to generate estimates of marginal returns to the Program. Assuming declining marginal returns for promotion and research, these estimates place a lower bound on the point estimate of average historical returns

from 1999 through 2005 and provide information on the relative marginal returns available across alternative Program activities.

ES.3 KEY RESULTS

Results of the analysis can be reviewed from two perspectives: econometric estimation of the market model and calculation of Program rate of return.

ES.3.1 Econometric Estimation

General Results

Estimated elasticities of prices, expenditures, input costs, food safety events, and other parameters have the expected signs and reasonable magnitudes in almost all cases.

In general, the estimated econometric model conforms quite well to expectations based on economic theory. Estimated elasticities of prices, expenditures, input costs, food safety events, and other parameters have the expected signs and reasonable magnitudes in almost all cases. In addition, the predictive power of the models is generally very good, indicating that they are well suited for simulating the demand effects of altering program expenditures.

Because the majority of Program expenditures have been devoted to domestic retail promotion, one of the most important components of this study is our retail meat demand system. We modeled domestic demand for pork within a Generalized Almost Ideal Demand System (GAIDS) framework (Bellino, 1990), which contains the major meat species consumed by Americans: beef, pork, and poultry (chicken and turkey). A demand system is chosen over an ad hoc single equation approach because a system approach for closely related goods corresponds well to an underlying consumer preference structure and is fully consistent with consumer demand theory.

As shown in Table ES-2, the Marshallian own-price elasticities of demand are –0.7614 for beef, –0.6413 for pork, and –0.3788 for poultry, all of which fall within typical ranges reported in the literature.[1] These parameters indicate, for example, that the quantity of pork demanded would fall by 0.6413% in response to a 1% increase in the price of pork. The

[1] All cross-price elasticities in the model are negative, implying that these products are all complements. This is at least in part reflective of the GAIDS functional form and the presence of pre-committed quantities, as explained in more detail in Section 5.6.

Table ES-2. Estimated Price, Expenditure, Food Safety, and Generic Advertising Elasticities with Structural Change for Pork Advertising between 1987–1998 and 1999–2005[a]

	Beef q	Pork q	Poultry q
Uncompensated (Marshallian) Price Elasticities[a]			
Beef p	–0.7614	–0.2824	–0.0707
Pork p	–0.1232	–0.6413	–0.1887
Poultry p	–0.1092	–0.2401	–0.3788
Expenditure Elasticities			
Expenditure	0.9938	1.1638	0.6382
Food Safety Elasticities			
Beef safety	–0.0023	–0.0007	0.0057
Pork safety	–0.0047	0.0023	0.0077
Poultry safety	0.0052	–0.0022	–0.0090
Long-Run Generic Advertising Elasticities (1987–1998)			
Generic beef promotion	0.0066	0.0027	–0.0208
Generic pork promotion	–0.0213	0.0181	0.0279
Long-Run Generic Advertising Elasticities (1999–2005)			
Generic beef promotion	0.0025	0.0053	–0.0118
Generic pork promotion	–0.0226	0.0206	0.0218

[a] The price, food safety, and expenditure elasticities are sample averages over 1982(1) through 2005(4).

expenditure elasticities are also within the range of results typically reported in the literature. The estimated own-food safety elasticities of demand are negative for beef and poultry, indicating negative publicity about these two species adversely affects their own demands. The own-food safety elasticity of demand for pork is not statistically significantly different from zero. This is not surprising given that there has been much less negative publicity about pork than both beef and poultry over the last 2 decades. However, negative publicity about beef or poultry food safety has negative effects on pork demand, perhaps reflective of a general increase in concern about meat safety.

The econometric models were rigorously tested to determine the proper time lag structure between the research and promotion expenditures, respectively, and their supply or demand response.

Program Effects

The econometric models were rigorously tested to determine the proper time lag structure between the research and promotion expenditures, respectively, and their supply or demand response. The promotion elasticities presented in

Table ES-2 reflect long-run responses across all lags included in the final models.

To investigate whether the effectiveness of PDE in affecting pork demand has changed since the last program evaluation in 1998, we conducted an additional econometric analysis of the demand system by interacting a dummy variable named "post98" with the coefficients on pork promotion variables. The post98 variable is defined to be equal to one for years after 1998 and zero otherwise. The joint significance of the six interaction terms is tested using the likelihood ratio test, and we find strong statistical evidence that the effectiveness of National Pork Board's promotion effort, as measured by PDE, differs between the previous evaluation period of 1987 through 1998 and 1999 through 2005. As shown in Table ES-2, the estimated own-promotion elasticity for pork has increased from 0.0181 to 0.0206 between 1987 through 1998 and 1999 through 2005. This is within the range of meat promotion elasticities found in the literature and is not a trivial response given the size of the pork market.

Interestingly, these findings suggest that pork promotion has a negative cross-effect on beef consumption, whereas beef promotion is found to have a positive effect on pork consumption (beef promotion elasticity of pork demand is 0.0053 for 1999 through 2005). Beef promotion is found to hurt demand for poultry, on the other hand, while pork promotion has a positive effect on poultry consumption.

Elasticities for other components of the Pork Checkoff Program were estimated to be 0.006 for the elasticity of pigs per litter with respect to production research, 0.012 for the elasticity of hog price with respect to post-farm market research, and 0.3121 for the elasticity of export demand with respect to foreign market development expenditures.

ES.3.2 Benefit-Cost Ratio Calculations

Based on our equilibrium displacement model above, our estimated parameters, and average levels of prices, quantities, Program expenditures, and other variables from 1999 through 2005, a 1% increase in annual domestic promotion expenditures would have resulted in an average farm-level hog price increase of $0.00956/cwt. Increases in postfarm research or foreign market development of 1% would increase farm-level

hog prices by $0.00413/cwt and $0.00609/cwt, respectively. A 1% increase in production research, on the other hand would reduce farm-level hog price by $0.0095/cwt. This is because of the increase in hog supply and the estimated inelastic demand for hogs. A 1% increase in all expenditure categories would raise the farm-level hog price by $0.01026/cwt, increase U.S. hog supply by 478,096 (liveweight) pounds, and benefit U.S. producers $1,809,166 in producer surplus.

Incorporating the estimated changes in prices and quantities resulting from marginal changes in Pork Checkoff activities and the average levels of prices and quantities over the 1999 through 2005 period, we calculated net changes in producer surplus and computed point estimates for marginal benefit-cost ratios for the Pork Checkoff Program using the methods described above. Table ES-3 presents results of these calculations, accounting for the additional assessment necessary to fund an increase in these activities.

Table ES-3. Simulated Point Estimates of Marginal Benefit-Cost Ratios for Pork Checkoff Expenditures, 1999–2005

National Pork Board Program Expenditure Categories	Marginal Benefit-Cost Ratios
Production research (HSE)	19.5
Postfarm research (HDE)	56.2
Domestic promotion (PDE)	7.1
Foreign market development (FMD)	28.0
Production research and postfarm research combined	24.4
All four expenditure categories combined	13.8

Our results indicated an overall marginal benefit-cost ratio to producers of 13.8, indicating that producers would gain an additional $13.80 for each additional $1 of Program expenditures.

Our results indicated an overall marginal benefit-cost ratio to producers of 13.8, indicating that producers would gain an additional $13.80 for each additional $1 of Program expenditures. Our point estimates of marginal benefit-cost ratios range from 7.1 for domestic promotion up to 56.2 for postfarm research, with production research and foreign market development in between at 19.5 and 28.0, respectively. The relative magnitudes across the four categories are consistent with other studies of generic promotion and research programs,

including the previous study of the Pork Checkoff Program (Davis et al., 2001).

The benefits of postfarm research are estimated to be particularly high, but this is consistent with several previous studies finding this category of expenditure to yield very high returns (e.g., Davis et al. [2001]; Murray et al. [2001]; Alston et al. [1997]). Although these findings must be interpreted with care when applied to specific programs within these broad categories necessary for econometric estimation, the relative magnitudes of benefit-cost ratios across the categories examined suggest potential increases in the net benefits to producers from reallocation of Program funds away from domestic promotion (and possibly production research, although there may be a need for production research to generate products being developed and marketed under the postfarm research category) toward postfarm research and foreign market development. However, the imprecision associated with category-level rate of return estimates precludes definitive conclusions regarding optimal reallocation of expenditures.

ES.3.3 Comparisons to Previous Studies

The point estimates of price, expenditure, and advertising elasticities are generally within the range of those estimated in previous studies. Our domestic promotion elasticity was 0.0206 for 1999 through 2005, which is a bit larger in magnitude than pork advertising elasticities presented in previous published studies other than Piggott (1997), although in the range of generic advertising elasticities presented in the literature for other commodities. Brester and Schroeder (1995), Kinnucan et al. (1997), Boetel and Liu (2003), and Hyde and Foster (2003) all found smaller elasticities for promotion (<0.007) than our estimate, and none found statistically significant effects of pork promotion. Piggott (1997) estimated a statistically significant elasticity of 0.034 for pork promotion. In the previous evaluation of the Pork Checkoff Program conducted by Davis et al. (2000), they estimated a much larger promotion elasticity than any of the published studies, with an elasticity of 0.11. However, Kinnucan and Zheng (2006) cite the Davis et al. (2000) estimates as a case of implausibly high promotion elasticity/own-price elasticity.

Although any economic model, especially one as complex as this one, is an imperfect representation of reality, we attempted to account for some of the most important criticisms of past generic research and promotion evaluations.

Although any economic model, especially one as complex as this one, is an imperfect representation of reality, we attempted to account for some of the most important criticisms of past generic research and promotion evaluations (e.g., as summarized in Kinnucan and Zheng [2006]) in developing our models. Kinnucan and Zheng (2006) raise concerns about the previous Pork Checkoff evaluation relying on a single-equation model rather than a meat demand system, not accounting for income or meat expenditures in their demand model, and incorporating a lag structure that had beef advertising affect pork demand in the same quarter as expenditures but no effects for pork promotion expenditures until 11 quarters after the expenditure (with no effects for the first 10 quarters). In this study, we rely on a meat demand system that deals with the first two points and use a flexible lag structure that we tested extensively to determine the preferred lag structure and which yields lag structures that appear more plausible than used in the previous study. Our demand system also accounts for cross-commodity impacts of beef and pork promotion on beef, pork, and poultry demand.

We generate marginal benefit-cost ratios, which do not provide exactly the same information as the average benefit-cost ratios generated by Davis et al. (2000). However, assuming expenditures are high enough to have reached the point of declining marginal returns our estimates can be considered a lower bound on the point estimate of average return.

We present marginal benefit-cost ratios simulated using an EDM. The EDM allows us to consistently account for all market linkages and endogeneity of prices and quantities. We generate marginal benefit-cost ratios, which do not provide exactly the same information as the average benefit-cost ratios generated by Davis et al. (2000). However, assuming expenditures are high enough to have reached the point of declining marginal returns our estimates can be considered a lower bound on the point estimate of average return. Keeping in mind that our models are specified with very different structures, the qualitative implications of our findings have many similarities to Davis et al. (2000).

Similar to the previous evaluation of the Pork Checkoff Program, we find marketing chain research (HDE) to have the largest estimated return. Davis et al. estimate average benefit-cost ratios of 116.3 and 197.5 in their time-series and structural models, respectively. Our point estimate of marginal benefit-cost ratio, accounting for increasing assessments to fund these activities, is 56.2. The category with the second highest marginal return in our model is foreign market development (FMD), with an estimated ratio of 28.0, which is higher than the 12.5 average return estimated in the previous

study's structural model (they did not include FMD in the time-series model). In contrast to the previous study, which estimated the benefit-cost ratio for production research and extension (HSE) to be negative, between -1 and -9.2, we estimated a fairly sizable marginal benefit-cost ratio of 19.5. Finally, for domestic pork promotion (PDE), the category that tends to receive the majority of Pork Checkoff funding, we estimate a benefit-cost ratio of 7.1. The previous evaluation of the program estimated an average ratio between 15.3 and 22.5.

The overall point estimate generated for the marginal return to Pork Checkoff Programs from our study is 13.8, which is within the range of estimates from Davis et al. for overall average return (4.8 to 26.2) and just slightly below the value of 16 that they suggest using as an overall average return to the Pork Checkoff Program for 1986 through 1998.

The overall point estimate generated for the marginal return to Pork Checkoff Programs from our study is 13.8, which is within the range of estimates from Davis et al. for overall average return (4.8 to 26.2) and just slightly below the value of 16 that they suggest using as an overall average return to the Pork Checkoff Program for 1986 through 1998. If the models were directly comparable, this would suggest that overall marginal returns are less than average, which is expected assuming declining returns to research and promotion activities, but that additional expenditures above historical levels would still be quite profitable for the average hog producer. Although the models differ considerably, they yield qualitatively similar conclusions for the effectiveness of the Program.

Although the point estimates suggest very strong returns to producer investment in Pork Checkoff activities, another important consideration in assessing the returns to the Program and individual components is the variability surrounding these estimates. As with any economic model, the "true" values of parameters are unknown and must be estimated. In addition to the point estimate, econometric models also generate measures of precision on that estimate. The following section describes a sensitivity analysis conducted to assess the precision of our point estimates and present more information on the distribution of estimated returns.

ES.3.4 Sensitivity Analysis

The estimates of the rate of return and the associated changes in producer surplus, farm-level hog prices, and hog quantity supplied presented above are based on point estimates of the model parameters. As noted previously, these values should be thought of as estimates rather than exact measurements. Generally, studies that measure the demand and supply

responses to advertising and research report point estimates and do not calculate the precision with which these estimates are measured.[2] However, it may be more informative to know how precisely the benefit-cost ratio is measured.[3] Thus, we generate and present distributions around our benefit-cost ratios.

Although the mean returns generally indicate large returns to producers, the confidence intervals reflect that we, as econometricians, can only measure these values with some imprecision.

Table ES-4 presents 90% confidence intervals for the National Pork Board activities presented as point estimates in Table ES-3. We used the Monte Carlo integration technique described in Piggott (2003) to generate empirical distributions for the benefit-cost ratios. We consider, simultaneously, uncertainties in estimating all demand and supply elasticities in generating our distributions. In so doing, the estimated ranges of benefit-cost ratios are wider than if one is to consider uncertainty in one National Pork Board activity at a time while holding all other estimated elasticities fixed at their point estimates.[4] Although the mean returns generally indicate large returns to producers, the confidence intervals reflect the imprecision with which these returns can be measured. This reflects imperfect data, factors that are influencing markets that cannot be captured, and the less than perfect ability of any economic model to capture all the complexities of reality.

Confidence intervals are larger for some categories than others, reflecting differences in data quality, the ability of the expenditure data to accurately represent the Program activity level, and the number of parameters needed for rate of return calculations (because each parameter is associated with a distribution around it), as well as underlying variability in the effects of the categories modeled.

[2] A plausible explanation for not reporting precision of the estimated return on investment is that it was not calculated as part of the evaluation because the cost entailed by this exercise is not negligible. The difficult and cost of conducting this precision analysis increases as the underlying demand and supply econometric models get more sophisticated.

[3] Both of our peer reviewers suggested placing distributions around the estimates as the single most important issue to consider for the final report.

[4] Although evaluating one source of uncertainty at a time renders a tighter confidence interval for the investigated National Pork Board activity, it may result in an overly optimistic estimate of profitability for this activity. For this reason, we decide to take the comprehensive approach by considering all sources of uncertainty simultaneously, although doing so entails greater analytical resources.

Results in Table ES-4 indicate that three of the six combinations of National Pork Board activities analyzed have a positive lower bound on their confidence interval (accounting for additional assessments to fund the additional activity). In other words, we can say, at a 90% confidence level, that these activities would result in a positive marginal return to hog farmers for additional dollars invested.[5] These activities are foreign market development, production research and marketing chain research combined, and a simultaneous increase in all four expenditure categories. Notice that the medians of the simulated return distributions are not exactly the same as the point estimates of returns reported in Table ES-3; they tend to be higher. This is because we have discarded random draws that violate theoretical curvature restrictions or imply demand or supply curves that contradict the fundamental economic theories of demand and supply. That is, demand has to be downward sloping, while supply has to be upward sloping.

Table ES-4. Median Values and 90% Confidence Intervals for the Simulated Marginal Benefit-Cost Ratios Under Various National Pork Board Expenditure Scenarios (1999–2005)[a] [b]

Effects of a 1% Increase in	Median and 90% Confidence Interval for the Benefit-Cost Ratio with a Simultaneous Tax Increase[c,d]
Production research (HSE)	25.97 (–4.69 123.84)
Marketing chain research (HDE)	70.57 (–47.73 194.90)
Domestic demand promotion (PDE)	10.39 (–11.39 58.68)
Foreign market development (FMD)	32.67 (8.35 82.84)
Production research and marketing chain research	32.53 (0.07 119.92)
All four expenditure categories	20.11 (2.09 64.37)

[a] Producer benefits are measured in 2004 dollars.

[b] A 90% confidence interval indicates a 90% statistical probability that the true estimate falls in this range.

[c] The 90% confidence intervals are in parentheses.

[d] The magnitude of the tax rate increase is calculated so that the 1% increase in research and promotion expenditures is equal to the increase in tax revenue.

[5] Note that the marginal benefit-cost ratio only needs to be greater than zero, not one, for the program to be profitable. This is because when the producer surplus is calculated, the cost of the checkoff assessment to hog producers has been taken into account.

For HSE, HDE and PDE, although these expenditures are profitable on average, the returns are measured imprecisely.

For HSE, HDE, and PDE, although these expenditures are profitable on average, the returns are measured imprecisely. As with any investment activity, there is some uncertainty regarding the magnitude of net benefits. The confidence intervals for these three categories include negative values, indicating that our simulations find that it is possible for these activities to result in negative returns with certain combinations of parameter values. The imprecision partly arises from the variability around the various elasticities implied by the estimated demand and supply parameters. These elasticities are calculated as functions of these econometric parameter estimates.[6] Although most of these parameters are individually precisely estimated and statistically significant, it does not suggest that the elasticities derived from them are necessarily statistically different from zero at conventional levels of significance.

In addition, there is considerable overlap across the distributions estimated for different Program categories. This indicates uncertainty regarding the relative returns to each category. In fact, none of these point estimates of rates of return are statistically significantly different from one another at any standard level of significance. While some categories have larger point estimates than others, it is important for decision makers to consider the distributions of potential returns in addition to the point estimates. Important questions for consideration include the extent to which one point estimate must exceed another to justify reallocation given the uncertainties and the optimal risk-return tradeoffs.

Finally, following Piggott (2003), we report results from the sensitivity analysis in an alternative way. Table ES-5 reports the probabilities that a marginal increase in National Pork Board expenditures on these activities would result in a net welfare gain to hog producers, taking into account the variability in all

[6] For instance, it is possible that a random draw from the parameter distributions results in a case where pork promotion has minimal effect on pork demand, but has a substantial positive cross-effect on poultry that results in reallocation of expenditures away from pork. There are numerous parameters involved in the simulations in order to capture complexities of the market and uncertainty surrounding the true value of each parameter. Thus, random draws from the estimated distribution can result in combinations of parameters where the returns to generic promotion and research would be negative. The probability of these negative outcomes depends on the estimated distributions of all the parameters.

estimated parameters, with the median value our best estimate of what marginal returns would equal on average. For example, there is a 96.9% probability that a 1% increase in all expenditure categories would bring positive net gains to hog farmers based on random draws from our simulation model allowing all elasticities to vary simultaneously. Similarly, FMD (99.5%), HSE and HDE combined (95.1%), and HSE (91.3%) have probabilities greater than 90%. The probabilities for PDE and HDE activities are lower, between 78.3% and 83.9%, highlighting the fact that returns to these individual subcategories are not as precisely estimated.

Table ES-5. Estimated Probabilities that the Net Gains to Hog Producers Are Greater Than Zero Under Various National Pork Board Expenditure (1999–2005) Accounting for Increase in Assessment to Fund Additional Expenditures[a]

1% Increase in	Probability of Positive Benefit-Cost Ratio
Production research (HSE)	0.913
Marketing chain research (HDE)	0.835
Domestic demand promotion (PDE)	0.783
Foreign market development (FMD)	0.995
Production research and marketing chain research	0.951
All four expenditure categories	0.969

[a] The magnitude of the tax rate increase is calculated so that the 1% increase in research and promotion expenditures is equal to the increase in tax revenue.

ES.4 CONCLUSIONS AND IMPLICATIONS

Based on the results of our analyses, we present the following conclusions about the Pork Checkoff Program's success in meeting its goals:

- The Pork Checkoff Program has a significant positive effect on the demand for hogs and pork.
- The returns to producers, on average, substantially outweigh the costs.
- Marginal increases in Program expenditures would increase producer profitability, on average.
- Although all point estimates of marginal returns are positive and generally fairly large, marginal returns cannot be measured precisely for all expenditure categories.

  - Confidence intervals may be wider for some categories than others based on factors such as differences in data quality, the ability of the expenditure data to accurately represent the Program activity level, and the number of parameters needed for rate of return calculations, as well as underlying variability in the effects of the categories modeled.
  - The confidence intervals for some categories include negative values. As with any investment activity, there is some uncertainty regarding the magnitude and even sign of net benefits. Negative values indicate that certain combinations of model parameters exist that can result in negative returns for these activities. Important considerations are the probability of this outcome and examination of the entire distribution of returns in making decisions.

- Marginal returns for postfarm research, foreign market development, and production research may all be higher than for domestic promotion based on our estimated point estimates and distributions.
- Differences in marginal returns across Program categories imply that there may be benefits from reallocation of Program expenditures towards categories with higher marginal returns, but the imprecision associated with category-level return estimates precludes definitive conclusions regarding optimal reallocation.
  - Although some distributions are more heavily weighted towards larger positive values, the distributions for all of the categories overlap with one another, indicating that the differences in estimated rates of return are not statistically significant.
- When considering reallocation of expenditures, it is important to consider the sizes of the confidence intervals around the rate of return estimates as well as the point estimates.

Overall, the results of the study indicate that the average hog producer experiences net benefits as a result of the Program. It is also important to note that there have been several years of low prices and high production costs for the average hog producer during 1999 through 2005. However, the econometric models presented in this study suggest market conditions for hog farmers would have been significantly worse without the Program.