The Impact of Pork Advertising on US Meat Demand in the Presence of Competing Beef Advertising and Food Safety Events

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Abstract

We examine the effects of domestic advertising and promotion expenditures on meat demand, extending previous efforts in several areas, including the use of more recent data, employing a complete demand system and simultaneously measuring the impacts of generic pork and beef advertising and food safety information on the demand for beef, pork, and poultry. Using the Generalized Almost Ideal Demand System (GAIDS), own- and cross- beef and pork advertising and own- and cross- beef, pork, and poultry food safety effects are measured jointly and consistently. To allow for a more complex dynamic response of advertising and food safety effects, the flexible distributed lag technique of Mitchell and Speaker (1986) is employed. The coefficients on pork advertising in the pork and poultry equations are highly significant. The coefficients on beef advertising are only statistically significantly different from zero in the poultry equation indicating the primary impact from these efforts is a cross-commodity effect. To investigate the economic significance of these effects, elasticities for price, expenditure, food safety and advertising are calculated and compared. Consistent with previous work we find the impacts of advertising and food safety effects to be economically small compared with price and expenditure effects.

Key words: food safety, Generalized Almost Ideal Demand System, generic advertising, meat demand, polynomial inverse lag

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The Impact of Pork Advertising on US Meat Demand in the Presence of Competing Beef Advertising and Food Safety Events

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 primary goal of the Program is to increase the profitability of hog and pork producers and importers by expanding the demand for hogs and pork and reducing production costs. The Program is funded by a mandatory assessment of 0.4% of the market value of all hogs sold in the United States, as well as an equivalent amount on imported hogs, pork, and pork products. The revenues are collected and managed by the National Pork Board, a quasigovernmental, nonprofit entity that administers the program. Assessments have totaled around $60 million annually in recent years. These funds are invested in programs intended 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.

However, a key question from the standpoint of those paying assessments is the return they are receiving on their investment. Producers need to have accurate estimates of the net returns provided by program expenditures to make well-informed decisions concerning their support for the checkoff programs in which they participate. It is important for funders to have confidence that estimated returns are continuing over time, clearly explained, and robust to different methods and researchers conducting the studies. Several previous studies have examined the effects of advertising on pork demand and the returns to producers (e.g., Brester and Schroeder (1995); Piggott, Piggott, and Wright (1995); Piggott et al. (1996); Kinnucan et al. (1997); Davis et al. (2001); and Hyde and Foster (2003)). The current article improves upon previous efforts in several areas, including the use of more recent data, a state-of-the-art meat demand system, more complex lag structures, and simultaneous examination of the effects of food safety information.

In this article, we focus on the effects of domestic advertising and promotion expenditures, which account for the majority of Pork Checkoff Program expenditures. To establish whether the a Program has been sufficiently effective at increasing the market demand that producers are receiving a positive net return on their investment, one sufficient criteria to establish that expenditures on pork advertising have had statistically significant market effects on the demand for pork. In addition, there might be important cross-commodity effects on the demands for other meat products (beef and poultry) from pork advertising that can have price feedback effects to the pork market. These effects must also be accounted for in developing a complete understanding of the Program's promotion and advertising activities on consumer demands for meats. Finally, in establishing whether there are statistically significantly impacts from pork advertising on consumer demand for meats,[1] other important factors that might have economic impacts on the demand for meats such as income, seasonality, advertising expenditures for other meats, and food safety events must be accounted for in consumer demand model. This is a challenging task for existing econometric modeling techniques, especially considering some of the inherent data limitations. The best available data to measure these impacts over the course of the Program are highly aggregated quarterly disappearance data. The nature of the data contributes to the challenge of using the most state-of-the-art techniques in terms of flexible functional forms and lag structures to test for possible impacts of advertising and food safety beyond contemporaneous impacts on demand.

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1 In a recent article, Davis (2005) argued that statistical insignificance of the generic advertising variables in the demand equation does not necessarily mean statistical insignificance of net returns to producers. Although a legitimate argument, it should not overshadow the importance of obtaining precise structural estimates of consumer preference parameters. Deep structural parameter estimates are essential in predicting behavioral changes when changes in the economic environment occur (Lucas, 1976).

The article extends a recent model of U.S. meat consumption (Piggott and Marsh, 2004) to provide updated and more precise estimates of own- and cross-commodity impacts of pork and beef advertising and food safety information on U.S. meat demand. Piggott and Marsh (2004) found the existence of pre-committed levels of consumption, seasonal factors, time trends, and contemporaneous own- and cross-commodity food safety concerns using quarterly data spanning the period 1982(1)-1999(3). However, that study did not attempt to measure the impact of generic advertising on demand. This paper extends this work by employing more recent data (1982(1)-2005(4)) and *simultaneously* measuring the impacts of generic pork and beef advertising and food safety information on the demand for beef, pork, and poultry. Using the Generalized Almost Ideal Demand System (GAIDS), own- and cross- beef and pork advertising and own- and cross- beef, pork, and poultry food safety effects are measured jointly and consistently. To allow for a more complex dynamic response of advertising and food safety effects, the flexible distributed lag technique of Mitchell and Speaker (1986) is employed. This distributed lag, known as the polynomial inverse lag (PIL), is simple to implement and has the desirable property of flexibility. In addition, alternative forms with different degrees of polynomial are straightforward to compare using nested models.

The remainder of the article proceeds as follows. The next section includes a brief outline of incorporating the PIL structure for generic advertising expenditures into the GAIDS. This is followed by a discussion of the generic advertising data and the updated Piggott and Marsh (2004) food safety index data. The econometric results are subsequently presented and discussed. The final section concludes and discusses potential future research.

The PIL Structure for Generic Advertising and Food Safety

Studies of advertising typically find prolonged effects on product demand. An empirical issue is determining the appropriate length and shape of the distributed lag structure for the advertising expenditure variables. Brester and Schroeder (1995) used a second-order exponential lag specification to represent the lasting effect of advertising. Piggott et al (1996) included lagged advertising expenditures in the demand estimation without imposing *a priori* structure on the shape of the distributed lags. Kinnucan et al (1997) imposed the restriction that only contemporary and one-quarter lagged advertising expenditures enter the demand equations.

Protracted effects on consumer demand may not just occur due to advertising; it is possible that food safety information may have protracted effects on demand as well. Previous authors have followed several alternative strategies to assess the impacts of information on food safety. Using an Almost Ideal Demand System (AIDS) model, Burton and Young (1996) used contemporary and cumulative numbers of BSE articles as the demand shifters for transitory and permanent quality shocks, respectively. This practice appears to be appropriate for their case, because their sample ends in the third quarter of 1993 when BSE in Great Britain showed no sign of relenting. However, for food safety incidents that are more or less transitory, it seems to be more appropriate to allow the effect of media on consumption to depreciate over time. Smith, van Ravenswaay, and Thompson (1988) constrained their milk media index to follow a second-order Almon polynomial. Dahlgran and Fairchild (2002) specified a geometric decay for their media index. The advantage of this approach is that it reduces the multicollinearity among lagged indices. A potential drawback is that it imposes a specific structure on the distributed lag, which may lead to inconsistent parameter estimates if the imposed structure is incorrect (Judge et al., 1988). Alternatively, Marsh, Schroeder, and Mintert (2004) and Piggott and Marsh (2004) did not impose any functional structure on the distributed lags of media indices and consider linear forms of lagged variables. To identify the appropriate lag length, they started with a relatively large number of lags and sequentially reduced the number of lagged variables included in the model and select the preferred model as the one with the best statistical fit. These approaches do not allow for possible non-linearities and could suffer from problems of multicollinearity of the lagged media indices, which are highly co-linear.

In this article, we use an alternative econometric approach to investigate the lag structures of advertising expenditures and food safety indices. The approach, which was originally proposed by Mitchell and Speaker (1986), is called the polynomial inverse lag (PIL). The PIL has several advantages over other commonly used lag structures such as the Almon (1965) lag. First, the researcher does not need to specify *a priori* the lag length or impose an endpoint restriction, because the PIL has an infinite distributed lag structure. Second, the PIL is linear in the transformed exogenous variables (i.e., the food safety media indices and advertising expenditures). As we explain below, this latter property makes it convenient to test for the most appropriate specification for the lag structure.

For the purposes of illustrating the PIL, consider the simple linear model of:

$$(1) \qquad q_t = b + \sum_{i=0}^{\infty} w_i X_{t-i} + e_t \, ,$$

where q_t is quantity of pork demanded in period t, X_τ is generic pork advertising expenditure (or pork safety media index) in period τ with $\tau \le t$, b is a collection of other explanatory variables (e.g., own and substitute meat prices, seasonal dummy variables) and their associated coefficients, and e_t is the regression residual. The infinite lag distribution for X means that the equation cannot be estimated directly. To derive an estimable form, Mitchell and Speaker (1986) propose the following transformation:

(2) $$q_t = b + \sum_{j=2}^{n} a_j Z_{jt} + R_t + e_t,$$

where $Z_{jt} = \sum_{i=0}^{t-1} \frac{X_{t-i}}{(i+1)^j}$, $j = 2,\ldots,n,$ $R_t = \sum_{j=2}^{n}\sum_{i=t}^{\infty} \frac{a_j X_{t-i}}{(i+1)^j},$ and n is the degree of polynomial for the PIL structure, which has to be determined using standard inference methods. With the sample t=1,2,…,T, data are available to calculate Z_{jt}, but the remainder term R_t cannot be calculated because it includes infinite lags. However, Mitchell and Speaker (1986) showed that for t>8, R_t becomes negligible. Therefore, a practical solution to the unobserved R_t problem is to delete the first eight data points and conduct an econometric analysis on the remaining data without the R_t term. Clearly, this practical solution involves trade-offs between employing a flexible lag structure that lets the data speak and the required truncations of the sample to ensure that this remainder term is zero.

After dropping the first eight data points, the Z_{jt}'s (t= 9, 10, 11,…,T) are computed as follows:

For j = 2

$$Z_{2t} = \sum_{i=0}^{t-1} \frac{X_{t-i}}{(i+1)^2} = \frac{X_t}{1^2} + \frac{X_{t-1}}{2^2} + \frac{X_{t-2}}{3^2} + \frac{X_{t-3}}{4^2} + \ldots + \frac{X_1}{t^2};$$

For j = 3

$$Z_{3t} = \sum_{i=0}^{t-1} \frac{X_{t-i}}{(i+1)^3} = \frac{X_t}{1^3} + \frac{X_{t-1}}{2^3} + \frac{X_{t-2}}{3^3} + \frac{X_{t-3}}{4^3} + \ldots + \frac{X_1}{t^3};$$

and so on, until reaching the term Z_{nt}. A remaining issue is selection of the appropriate n—the degree of the polynomial. The selection process can start with a relatively high degree, e.g., $n = 5$, in which case Eq. (2) can be written as

(3) $$q_t = b + a_2 Z_{2t} + a_3 Z_{3t} + a_4 Z_{4t} + a_5 Z_{5t} + e_t.$$

To determine the optimal n, regression Eq. (3) can be estimated a number of times, successively dropping the highest-degree term. The choice of appropriate degree is then determined by the ability of the model to fit the data. The model with the best fit can be selected based on the Akaike information criterion (AIC), the Schwarz criterion, adjusted R^2, or standard inference such as the likelihood ratio tests where the null of degree n-1 (the restricted model) can be evaluated against the alternative model of degree n (the unrestricted model).

Finally, the weights (w_i) on X_τ in Eq. (1) can be recovered using estimates of a_j ($j = 2, ..., n$). The formula for calculating weight w_i is

(4) $$w_i = \sum_{j=2}^{n} \frac{a_j}{(i+1)^j}, \quad i = 0, ..., t-1.$$

Eq. (4) along with the estimated values for a_j can be used to calculate the weights on current and lagged pork advertising expenditures in the demand equation.

Incorporating Advertising and Food Safety into the GAIDS

The demand literature has had a long tradition of constructing indices as demand shifters to approximate consumers' perception of product quality. For instance, Carfton, Hoffer, and Reilly (1981) argue that product recalls lower consumers' perception of the quality of a recalled automobile. The underlying assumption, either implicit or explicitly stated, of empirical studies of the economics of food safety has been that food safety information signals the quality of a product. If food safety information negatively affects the perceived product quality, generic advertising may work to mitigate or even reverse the adverse effect.

We modeled meat demand in a demand system framework that contains the three major meats consumed by U.S. consumers: beef, pork, and poultry (chicken and turkey). A demand system is chosen over a single-equation approach because a system approach for closely related goods in consumption corresponds well to an underlying consumer preference structure and is fully consistent with consumer demand theory. Specifying demand in this way allows for important cross-commodity relationships to be estimated consistently and estimation with seemingly unrelated regressions (SUR) provides efficiency gains. The demand system also allows us to investigate the own- and spillover-effects of the demand shift variables of generic advertising and food safety on demand in an integrated fashion.

Consider the following generalized expenditure function:

$$(5) \qquad E(\mathbf{p},u) = \mathbf{p}'\mathbf{c} + E^{*}(\mathbf{p},u)$$

where **p** is a 3×1 vector of prices of beef, pork, and poultry; **c** is a 3×1 vector of precommitted beef, pork, and poultry quantities; and u is utility. The quantities contained in **c** can be thought of as subsistence levels of meats that a household consumes in each period regardless of prices and incomes (or as reflecting consumer preferences for some minimum level of variety in their meat consumption). The supernumerary expenditure (E^{*}) is the discretionary expenditure remaining after all subsistence quantities have been purchased and is allocated across the meats, rationed according to prices and incomes, to determine the level of supernumerary quantities of each of the meats.

The GAIDS model (Bollino, 1990) can be written in budget share form as

(6) $$w_i = \left(\frac{p_i c_i}{M}\right) + \left(\frac{M^*}{M}\right)\left(\alpha_i + \sum_{j}^{N} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{M^*}{P}\right)\right) + e_i$$

where $\ln P = \delta + \sum_{j=1}^{N} \alpha_j \ln p_j + \frac{1}{2}\sum_{k=1}^{N}\sum_{j=1}^{N} \gamma_{kj} \ln p_k \ln p_j$; i, j = b for beef, p for pork, and c for poultry; e_i is a stochastic error term; $N = 3$; and c_i , α_i , γ_{ij} , β_i , and δ are parameters to be estimated. Within-equation and cross-equation demand restrictions implied by economic theory can be imposed using parametric restrictions. The homogeneity condition is imposed by $\sum_{j=1}^{N} \gamma_{ij} = 0$, adding up by $\sum_{i=1}^{N} \beta_i = 0$ and $\sum_{i=1}^{N} \alpha_i = 1$, and symmetry by $\gamma_{ij} = \gamma_{ji}, i \neq j$.

Demand shifters such as food safety information, seasonality, and advertising and promotion expenditures can be incorporated into the demand system Eq. (6) using a translating procedure originally proposed by Pollak and Wales (1981). This procedure specifies the precommitted quantities **c** as a function of the demand shifters. This procedure has the desirable property that the resultant elasticity estimates are invariant to unit of measurement of the nonprice and nonincome demand shifters (Alston, Chalfant, and Piggott, 2001). Following Piggott and Marsh (2004), we adopt a linear specification and write the precommitted quantities as

(7) $$\begin{aligned} c_i = {} & c_{i0} + \kappa_{i1} qd1 + \kappa_{i2} qd2 + \kappa_{i3} qd3 + \varphi_i D0205 + \tau_i T + \phi_{i,b} bfs_t + \phi_{i,p} pks_t + \phi_{i,c} pys_t \\ & + \sum_{j=2}^{n} \omega_{i,j,b} ZBDE_{jt} + \sum_{j=2}^{n} \omega_{i,j,p} ZPDE_{jt} \end{aligned}$$

where $qd1,\ qd2,\ qd3$ are quarterly dummy variables; $D0205$ is a dummy variable equal to one for year 2002 through 2005 and zero for all other years[2]; bfs_t , pks_t , and pys_t denote,

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[2] This dummy variable was included based on plots of residuals from partial leverage regressions identifying a structural change that has taken place since 2002. Possible explanations for this structural change observed in our meat demand system include the high protein/low carbohydrate diet fad and public concern over BSE and avian influenza during this period. However, the data do not allow us to distinguish the potential effects of these factors.

respectively, the media food safety indexes for beef, pork, and poultry; $ZBDE$ and $ZPDE$ are the polynomial inverse lags for generic beef (BDE) and pork (PDE) promotion expenditures; n is the appropriate lag length to be determined through statistical testing; c_{io}, κ_i, φ_i, τ_i, ϕ_{ib}, ϕ_{ip}, ϕ_{ic}, $\omega_{i,j,b}$, $\omega_{i,j,p}$ are parameters, along with those in equation Eq. (6), to be estimated by regression. Note that we restrict the lag length for both beef and pork promotions to be equal. This does not seem to be an implausible assumption and has the benefit of making statistical testing later in this section tractable. Piggott and Marsh (2004) found that only contemporaneous food safety information affects U.S. meat demand. Following their finding, we maintain that only contemporary food safety media indices enter Eq. (7).[3]

Generic Advertising and Food Safety Data

Unlike many previous studies of generic advertising that used checkoff programs' advertising expenditures tracked by the Leading National Advertisers (LNA), we obtained generic pork advertising expenditures from the National Pork Board. Dr. Ron Ward of University of Florida kindly provided us the Cattlemen's Beef Board's expenditures on beef promotion. Kinnucan and Belleza (1991) and Kinnucan et al (1997) noted that the LNA data may understate the true Program expenditures and may not correspond well with the true expenditures at turning points. Hence, the levels of advertising efforts should be measured with less error using our data.

The food safety indices for beef, pork, and poultry are based on Piggott and Marsh's (2004) original series extended to 2005(4). The sample period for Piggott and Marsh's series is from 1982(1) to 1999(3). Since then there have been several food safety events that may have had significant effects on U.S. meat demand. The food safety index for beef peaked at 1,210 in the first quarter of 2001 caused by reports of foot-and-mouth disease in the Great Britain.

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[3] We plan to apply the PIL structure to food safety indices in future research.

Although foot-and-mouth disease is not considered a food safety issue, there were anecdotal accounts that some consumers avoided pork and beef products for fear of contracting the disease through consuming meat of sick animals. This index spiked again in 2003(4) and 2004(1) when the first U.S. case of bovine spongiform encephalopathy (BSE) was found in Washington State. The poultry index reached one of its highest points in 2002(4) when fear of listeria contamination of chicken and turkey products prompted a massive recall. Outbreaks of avian influenza in Asia and warning of potential worldwide avian influenza pandemic again resulted in high levels of media attention in 2004(1) and 2005(4), respectively. The pork index reached one of its highs in 2001(1) as a result of the foot-and-mouth disease reported in the Great Britain. Unlike beef and poultry, pork received less media attention partly because it was less often implicated in large-scale outbreaks than beef and poultry. However, listeria and other bacteria contaminations have been traced to products with pork as the ingredient from time to time.

Table 1 contains the summary statistics for food safety index data and beef and pork generic advertising data over the 1982(1)-1999(3) and 1999(4)-2005(4) sample periods. Although beef food safety had the highest quarterly average (147.2) during the 1982(1) to 1999(3) period, the average poultry food safety index was the largest (466.1) among all meat species during the 1999(4) to 2005(4) period. The standard deviation for poultry food safety more than doubled since 1999(4), suggesting media coverage of issues related to poultry safety had been much more volatile during the later part of the sample. After the 1982(1) to 1999(3) period, the standard deviations for beef and pork food safety increased and decreased to some extent, respectively. On average, the Cattlemen's Beef Board spent more on beef advertising than the National Pork Board on pork advertising. However, the Pork Board has increased its advertising expenditures over the course of the program while the Beef Board's advertising expenditures have changed little in nominal terms. In 1987, the debut year of both programs, the Beef Board spent about 27.3 million dollars on beef advertising and promotion in contrast to the 9.8 million dollars expenditures by the Pork Board on pork advertising and promotion. In 2005 the Pork Board's expenditures on advertising and promotion activities were 35 million dollars, while the Beef Board's expenditures on the same activities were 28.2 million dollars. Taking into account the effect of inflation inon media costs over the past two decades, the real generic beef advertising expenditures likely have fallen since the inception of the checkoff program.

Empirical Results

In the econometric analysis, the demand for beef, pork, and poultry is treated as weakly separable from outside goods. That is, the equations estimated are conditional demand frunctions with meat expenditures as the expenditures variable. The system in Eq. (6) is estimated using iterated nonlinear estimation techniques. Because of the singular nature of the share system, one of the equations must be deleted. Although choice of the equation to delete does not affect the econometric results, we chose to delete the poultry equation and estimate the beef and pork equations. Homogeneity and symmetry conditions are imposed during estimation.

Inferences concerning the appropriate degree of polynomial (*n*) for generic beef and pork promotion and autocorrelation structure were investigated using likelihood ratio (LR) tests. The test statistic for LR test is $LR = 2(LL^U - LL^R)$, where LL^U and LL^R are the maximized log-likelihood value in the unrestricted (*n*=*j*) and restricted models (*n*=*j-1*), respectively. Table 2 presents the LR test results for the joint significance of generic beef and pork promotion. The test was performed under three different autocorrelation correction (for the residual matrix **R** of the system Eq. [6]) schemes: (1) a null **R** matrix ($\mathsf{N}-\mathsf{R}^{\mathsf{matrix}}$) with all elements restricted to zero (i.e., no autocorrelation); (2) a diagonal **R** matrix ($D-R^{\text{matrix}}$) with all diagonal elements restricted to be equal and all off-diagonal elements restricted to zero; and (3) a full **R** matrix ($F-R^{\text{matrix}}$) where all elements are nonzero (Berndt and Savin (1975)). Under all specifications, we reject the null hypothesis that generic beef and pork expenditures are jointly significantly equal to zero.

To investigate the distributed lag structure of generic beef and pork promotion effects, we tested alternative degrees of polynomial for beef and pork promotion expenditures (BDE and PDE). The results in Table 22 indicate that, in all three autocorrelation corrections, the LR test fails to reject the null hypothesis that the coefficients on the fourth degree polynomials of BDE and PDE are zero (i.e., $\omega_{i,4,b} = \omega_{i,4,p} = 0$). Under all three autocorrelation correction schemes, the null hypothesis that the highest degree polynomial for both BDE and PDE is second degree (n=2) is rejected in favor of a third ($n = 3$) degree polynomial for both generic promotion activities. Thus, we use a third degree polynomial for both generic beef and generic pork promotion in our econometric estimation.

Table 3 presents LR test results for alternative autocorrelation corrections under various lag length specifications for generic beef and pork promotions. When $n = 3$, a diagonal specification for the **R** matrix is preferred to no autocorrelation correction. The test results in Tables 2 and 3 together suggest that the preferred model is the one with $n = 3$ for BDE and PDE and with a diagonal **R** matrix. This suggests that only $ZBDE_{2t}$, $ZBDE_{3t}$, $ZPDE_{2t}$, and $ZPDE_{3t}$ enter the specification for precommitted quantities in Eq. (5.11). Table 4 reports the estimated coefficients and their standard errors for the preferred GAIDS model. The adjusted R^2 is 0.982 for the beef equation and 0.894 for the pork equation, suggesting a good model fit.

Inspecting the results in Table 4 indicates that a number of the coefficients are individually significant at the 1% or 5% level. Based on results from the preferred model, the constant components (c_{i0}'s) of the precommitted quantities are estimated to be 14.2 pounds of beef, 7.3 pounds of pork, and 7.2 pounds of poultry. When compared with the sample means, these estimates suggest that these constant components account for a significant portion of total meat consumption.[4] Of particular interest are the estimated coefficients (the $\omega_{i,j,p}$'s) on the pork and beef advertising and food safety variables. The coefficients on $ZPDE$ in the pork and poultry equations are highly significant with p-values less than 1%, suggesting the economic effects of pork promotion on meat demand are precisely estimated. The coefficients associated with $ZBDE$ are statistically significant in the poultry equation but not in the beef or pork equation, implying that cross-commodity effects are very important for beef promotion.

The estimated coefficients on beef media index are statistically significant in all three of the meat demand equations. The coefficients associated with the pork index are not statistically significant in any of the three equations, reinforcing the conception that pork is less often implicated in contamination incidences. The coefficient on poultry index is precisely estimated in the poultry equation but not in the beef and pork equations. In general, the results are consistent with findings in Piggott and Marsh (2004). This suggests their results are robust to sample updating and inclusion of generic advertising.

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[4] The percentages of average meat consumption that are precommitted are 81% for beef, 57% for pork, and 34% for poultry.

Estimates of Elasticities

Economic significance of generic advertising and food safety information depends on the magnitudes of the estimated demand elasticities. Table 5 presents these elasticities evaluated at the sample means. Notice that because the beef and pork checkoff programs did not exist before 1987, the reported generic advertising elasticities are averages over the 1987 to 2005 period. The estimated uncompensated cross-price elasticities are all negative, which indicate gross complements between meat species. This result is consistent with Piggott and Marsh (2004) and is at least partially reflective of the choice of functional form. Because we are estimating a conditional demand system and the version of GAIDS we are using contains precommitted quantities, it is not unexpected that we find complementarity, especially when precommitted quantities account for a relatively large share of consumption. For instance, an increase in the price of a product will result in increased expenditures to purchase the precommitted quantity of that product. Because this is a conditional demand system, we hold meat expenditures fixed. Thus, an increase in spending on fulfilling purchases of precommitted quantities reduces the amount of supernumerary income remaining for meat purchases. It is certainly possible that an increase in the price of one product could cause a large enough substitution towards other products that the quantities of those products purchased would increase even with less supernumerary income. However, in our case, at least at the sample means, it results in a reduction in the supernumerary quantity purchased for all three meats.

Consistent with prior expectations, the own-food safety elasticities are negative for beef and poultry. The estimated own-food safety elasticity for pork is positive, although the estimated coefficients on pork media index are not statistically significant in Table 4. The spillover effect of beef media index on pork is negative but positive on poultry. For poultry safety, an increase in poultry index adversely affects pork demand but positively influence demand for beef.

The economic effects of beef and pork generic advertising are relatively small, although the beef and pork markets are sufficiently large relative to generic advertising expenditures that even a small effect on demand may substantially affect producer returns. The estimated own-effect of beef advertising is negative although trivial in magnitude with an elasticity of -0.0013. The cross-commodity effects by beef advertising on pork and poultry are positive and negative, respectively; and these effects are larger in magnitude than the own-effect with the cross-elasticity of beef advertising estimated at 0.0119 for pork and -0.0137 for poultry. For pork advertising, the own-effect is positive and its cross-effect on poultry is positive as well. Interestingly, the estimated effect of pork advertising on poultry (0.0380) is larger than its own effect (0.0207). Consistent with previous studies, generic pork advertising is found to reduce demand for beef.

Conclusion

The objective of this article has been to examine the effects of domestic advertising and promotion on meat demand while simultaneously accounting for the impacts of food safety information. In formulating a preferred model, inferences are made with respect to the most appropriate choice of degree of polynomial for the PIL’s for beef and pork advertising and for the food safety indices for beef, pork, and poultry. Inferences investigating the appropriateness of alternative corrections for autocorrelations were also evaluated. Under all specifications considered, we reject the null hypothesis that generic beef and pork advertising expenditures are not jointly statistically different from zero. For advertising, it was determined that a third degree polynomial for both generic beef and generic pork promotion provides the best fit and that a diagonal R-matrix correction is sufficient. These inferences culminated in a preferred model that boasts a high adjusted R-squared, a large number of coefficients that are individually statistically significantly different from zero, and 100% of sample observations are consistent with theoretical curvature restrictions.

The coefficients on pork advertising in the pork and poultry equations are highly significant with p-values less than 1%, suggesting the economic effects of pork promotion on meat demand are precisely estimated. The coefficients on beef advertising are only statistically significantly different from zero in the poultry equation indicating the primary impact from these efforts is a cross-commodity effect. To investigate the economic significance of these effects elasticities for price, expenditure, food safety and advertising variables are calculated and compared and contrasted. Most of our estimated elasticities are consistent with expectations in terms of signs and relative magnitudes. Consistent with previous work we find the impacts of advertising and food safety effects to be economically small compared with price and expenditure effects. However, cost-benefit analyses are needed to evaluate whether such practices are profitable to producers.

In terms of advertising elasticities, generic pork advertising appears to help demand for poultry more than pork. Because poultry producers do not have their own checkoff program, an interesting question for future research to examine is whether this result suggests a “free rider” problem or is an artifact of misspecification such as omitting branded poultry advertising. However, compiling a consistent series for branded poultry advertising is a challenge because the LNA data do not allow accurate identification of advertising expenditures by meat species (Kinnucan et al, 1997).

Table 1. Summary Statistics of Food Safety Index and Generic Advertising Data

Variable	**Sample period**	**Average**	**Std. Dev.**	**Minimum**	**Maximum**
Beef food safety	1982(1)-1999(3)	174.2	245.0	3	1283
	1999(4)-2005(4)	402.2	219.3	185	1210
Pork food safety	1982(1)-1999(3)	43.1	46.9	0	292
	1999(4)-2005(4)	117	68.0	54	395
Poultry food safety	1982(1)-1999(3)	153.0	135.7	6	582
	1999(4)-2005(4)	466.1	283.9	96	1547
Beef Generic Advertising ($1,000)	1987(1)-2005(4)	7,711.8	2,540.3	2,482.2	14,042.8
Pork Generic Advertising ($1,000)	1987(1)-2005(4)	5,602.7	2,180,9	1,747.5	12,290.4

Table 2. Hypothesis Tests for the Significance of Generic Promotion

Model	H_0 : No Adv[a] $H_a : n = 2$	$H_0 : n = 2$ $H_a : n = 3$	$H_0 : n = 3$ $H_a : n = 4$
$N - R^{matrix}$	**24.13**[c]	**18.12**	8.04
$D - R^{matrix}$	**19.53**	**15.88**	5.61
$F - R^{matrix}$	**18.56**	**16.04**	5.32
df[b]	6	6	6
$\chi_{0.05,df}$[d]	12.59	12.59	12.59

[a] No Adv denotes a model with no generic promotion variables included.

[b] df denotes degree of freedom.

[c] Bold numbers indicate statistical significance at 5% level.

[d] Critical value for chi-square distribution at 5% level.

Table 3. Hypothesis Tests for Autocorrelation Corrections

Model	$H_0: \text{N-R}^{\text{matrix}}$ $H_a: \text{D-R}^{\text{matrix}}$	$H_0: \text{N-R}^{\text{matrix}}$ $H_a: \text{F-R}^{\text{matrix}}$	$H_0: \text{D-R}^{\text{matrix}}$ $H_a: \text{F-R}^{\text{matrix}}$
No Ads	**11.78**	**14.88**	3.10
$n = 2$	**7.18**	9.31	2.13
$n = 3$	**4.93**	7.23	2.29
$n = 4$	2.50	4.50	1.99
Degree of freedom	1	4	3
$\chi_{0.05,df}$	3.84	9.49	7.82

Table 4. Estimated Parameters for the Generalized Almost Ideal Demand Model for U.S. Meat Consumption with Food Safety and Generic Advertising Variables [a]

Parameters	Estimates	Parameters	Estimates
δ	15.8019 (13.6695)	τ_p	0.0596** (0.0111)
α_b	6.3235 (5.2406)	τ_c	0.1566** (0.0169)
α_p	–1.7911 (1.8978)	ϕ_{bb}	–0.0014** (0.0003)
γ_{bb}	4.1095 (2.2963)	ϕ_{bp}	–0.0023 (0.0013)
γ_{bp}	–1.2118 (0.9188)	ϕ_{bc}	–0.0003 (0.0002)
γ_{pp}	0.3114 (0.3491)	ϕ_{pb}	–0.0016** (0.0003)
β_1	0.4925** (0.1326)	ϕ_{pp}	–0.0017 (0.0012)
β_2	–0.1689** (0.0520)	ϕ_{pc}	–0.0007 (0.0004)
c_{10}	14.1665** (1.1223)	ϕ_{cb}	–0.0019** (0.0004)
c_{20}	7.3004** (1.3069)	ϕ_{cp}	–0.0017 (0.0018)
c_{30}	7.1534* (3.6867)	ϕ_{cc}	–0.0015* (0.0007)
κ_{b1}	–0.1488 (0.0999)	$\omega_{b,2,b}$	–2E–7 (1.281E–7)
κ_{b2}	0.5022** (0.0981)	$\omega_{b,3,b}$	2.497E–7 (1.306E–7)
κ_{b3}	0.8423** (0.0872)	$\omega_{p,2,b}$	–1.36E–7 (9.379E–8)
κ_{p1}	–1.1915** (0.0851)	$\omega_{p,3,b}$	1.897E–7 (9.905E–8)
κ_{p2}	–1.5868** (0.0911)	$\omega_{c,2,b}$	–3.23E–7** (1.18E–7)
κ_{p3}	–1.1941** (0.0779)	$\omega_{c,3,b}$	3.709E–7** (1.26E–7)
κ_{c1}	–2.3966** (0.1083)	$\omega_{b,2,p}$	1.824E–7 (1.691E–7)
κ_{c2}	–1.5827** (0.1184)	$\omega_{b,3,p}$	–2.68E–7 (1.718E–7)
κ_{c3}	–1.1027** (0.1037)	$\omega_{p,2,p}$	5.273E–7** (1.855E–7)

(continued)

Table 4. Estimated Parameters for the Generalized Almost Ideal Demand Model for U.S. Meat Consumption with Food Safety and Generic Advertising Variables[a] (continued)

Parameters	Estimates	Parameters	Estimates
φ_b	–1.2831** (0.2593)	$\omega_{p,3,p}$	–5.94E–7** (1.962E–7)
φ_p	–1.7978** (0.2948)	$\omega_{c,2,p}$	8.562E–7** (3.067E–7)
φ_c	–2.34596** (0.5345)	$\omega_{c,3,p}$	–9.06E–7** (3.233E–7)
τ_b	0.0597** (0.0129)	ρ [b]	0.2055** (0.0815)
Log Likelihood = 816.5807			

[a] ** and * indicate statistical significance at the 1% and 5% levels, respectively.

[b] The estimated diagonal elements of the **R** matrix.

Table 5. Estimated Price, Expenditure, Food Safety, and Generic Advertising Elasticities[a]

	Beef q	**Pork q**	**Poultry q**
Uncompensated (Marshallian) Price Elasticities			
Beef p	–0.7835	–0.2610	–0.0598
Pork p	–0.1222	–0.6526	–0.1785
Poultry p	–0.1051	–0.2196	–0.4190
Expenditure Elasticities			
Expenditure	1.0108	1.1333	0.6573
Food Safety Elasticities			
Beef safety	–0.0011	–0.0019	0.0048
Pork safety	–0.0024	0.0014	0.0036
Poultry safety	0.0027	–0.0005	–0.0055
Long-Run Generic Advertising Elasticities[b]			
Generic beef ads	–0.0013	0.0119	–0.0137
Generic pork ads	–0.0287	0.0207	0.0380

[a] The price, food safety, and expenditure elasticities are sample averages over the period 1982(1)–2005(4). Advertising elasticities are averages over the 1987(1)–2005(4) period.

[b] The long-run advertising elasticities are calculated assuming that advertising expenditures have been constant over a period of nine quarters. The results are not sensitive if more than nine quarters of stable promotion expenditures are assumed.

References

Almon, S. 1965. “The Distributed Lag between Capital Appropriations and Net Expenditures.” *Econometrica* 33(1):178-196.

Alston, J.M., J.A. Chalfant, and N.E. Piggott. 2001. “Incorporating Demand Shifters in the Almost Ideal Demand System.” *Economics Letters* 70(1):73-78.

Berndt, E.R., and N.E. Savin. 1975. “Evaluation and Hypothesis Testing in Singular Equation Systems with Autoregressive Disturbances.” *Econometrica* 43(5-6):937-957.

Bollino, C.A. 1990. “GAIDS: A Generalized Version of the Almost Ideal Demand System.” *Economic Letters* 33:127-29.

Brester, G.W., and T.C. Schroeder. 1995. “The Impacts of Brand and Generic Advertising on Meat Demand.” *American Journal of Agricultural Economics* 77(4):969-979.

Burton, M., and T. Young. 1996. “The Impact of BSE on the Demand for Beef and Other Meats in Great Britain.” *Applied Economics* 28(6):687-693.

Crafton, S.E., G.E. Hoffer, and R.J. Reilly. 1981. “Testing the Impact of Recalls on the Demand for Automobiles.” *Economic Inquiry* 19(4):694-703.

Dahlgran, R.A., and D.G. Fairchild. 2002. “The Demand Impacts of Chicken Contamination Publicity—A Case Study.” *Agribusiness* 18(4):459-474.

Davis, G.C., O. Capps, Jr., D.A. Bessler, J.H. Leigh, J.P. Nichols, and E. Goddard. 2001. “An Economic Evaluation of the Pork Checkoff Program.” Department Technical Report 01-1. College Station, TX: Texas A&M University.

Davis, G.C. 2005. “The Significance and Insignificance of Demand Analysis in Evaluating Promotion Programs,” *American Journal Agricultural Economics* 87(3):673-688.

Hyde, J., and K. Foster. 2003. “Estimating Dynamic Relationships between Pork Advertising and Revenues.” *Review of Agricultural Economics* 25(2):279-293.

Judge, G.G., R.C. Hill, E.G. William, H. Lutkepohl, and T. Lee. 1988. *Introduction to the Theory and Practice of Econometrics*. New York: John Wiley and Sons.

Kinnucan, H.W., and E. Belleza. 1991. “Advertising Evaluation and Measurement Error: The Case of Fluid Milk in Ontario.” *Canadian Journal of Agricultural Economics* 39(2):283-297.

Kinnucan, H.W., H. Xiao, C-J Hsia, and J.D. Jackson. 1997. “Effects of Health Information and Generic Advertising on U.S. Meat Demand.” *American Journal of Agricultural Economics* 79(1):13-23.

Lucas, R.E. 1976. “Econometric Policy Evaluation: A Critique.” In K. Brunner and A. Metzler (eds.), *The Phillips Curve and Labor Market*, Carnegie-Rochester Conference Series on Public Policy. Amsterdam: North-Holland.

Marsh, T.L., T.C. Schroeder, and J. Mintert. 2004. “Impacts of Meat Product Recalls on Consumer Demand in the USA.” *Applied Economics* 36(9):897-909.

Mitchell, D.W., and P.J. Speaker. 1986. “A Simple, Flexible Distributed Lag Technique: The Polynomial Inverse Lag.” *Journal of Econometrics* 31(3):329-340.

Piggott, R.R., N.E. Piggott, and V.E. Wright. 1995. “Approximating Farm-Level Returns to Incremental Advertising Expenditure: Methods and an Application to the Australian Meat Industry.” *American Journal of Agricultural Economics* 77(3):497-511.

Piggott, N.E., J.A. Chalfant, J.M. Alston, and G.R. Griffith. 1996. “Demand Response to Advertising in the Australian Meat Industry.” *American Journal of Agricultural Economics* 78(2):268-279.

Piggott, N.E. 1997. *The Benefits and Costs of Generic Advertising of Agricultural Commodities*. PhD dissertation, University of California, Davis.

Piggott, N.E., and T.L. Marsh. 2004. “Does Food Safety Information Impact U.S. Meat Demand?” *American Journal of Agricultural Economics* 86(1):154-174.

Pollak, R.A., and T.J. Wales. 1981. “Demographic Variables in Demand Analysis.” *Econometrica* 49(6):1533-1551.

Smith, M.E., E.O. van Ravenswaay, and S.R. Thompson. 1988. “Sales Loss Determination in Food Contamination Incidents: An Application to Milk Bans in Hawaii.” *American Journal of Agricultural Economics* 70(3):513-520.