Exploring the Dynamic Relationship Between Advertising and Revenues Within the Pork Industry

Jeffrey Hyde and Ken Foster[*]

Selected Paper
Presented at the 1999 AAEA Annual Meeting
Nashville, TN
August 8-11, 1999

ABSTRACT: This research tests for causality between indexed retail pork revenues and pork advertising. Evidence was found of feedback between revenues and total pork advertising, but not between revenues and generic advertising. In fact, generic advertising was found to have no significant impact on indexed retail pork revenues.

[*] Hyde is a Graduate Research Assistant and Foster is Associate Professor in the Department of Agricultural Economics, Purdue University.

Exploring the Dynamic Relationship Between Advertising and Revenues Within the Pork Industry

Introduction

Pork checkoff programs have come under considerable scrutiny, particularly over the past year. Under the mandatory program, pork producers pay $0.45 per $100 of value. The funds collected go toward several different programs, including export development, and initiatives targeted at swine health, pork safety, and meat quality. A large percentage of the funds go toward pork promotion in the form of generic advertising. It is estimated that the *Pork – The Other White Meat* campaign, funded by checkoff dollars, has reached a consumer recognition level of 87% (Korsmeyer). The campaign uses TV, radio, and magazine advertisements. Estimates show that TV ads will reach about 80 million consumers in 1999 (Simpson).

Despite this success, hog prices received by the producer have dipped to 60-year lows in portions of the Midwest, dropping below $10.00/cwt (Smith, December 14, 1998). While farm-level prices are at the lowest point in a generation, retail prices have held steady. Over the first three quarters of 1998, pork consumption increased by 7.6% while retail prices fell by only 0.6% (Smith, November 30, 1998). Thus, it appears that any benefits resulting from the checkoff program are accruing to pork retailers. Of every dollar in retail pork revenue, only $0.24 is returned to the producer. This compares to $0.44 at the inception of the program in 1985.

A 1996 survey showed that 88% of pork producers believe that the checkoff program has benefited the pork industry. However, only 72% believe that they have personally benefited from the program. In response, a group of family farm

organizations began a petition drive in the spring of 1998 for a national referendum on the pork checkoff program. These groups believe that the program represents nothing more than a tax on pork producers (Marberry). Meanwhile, as borne out above, the benefits may accrue to larger producers or to pork retailers.

This begs the question; Does the checkoff program really benefit anyone? It increases the costs of production, and therefore the price charged. It may also effect the quantity sold if it is successful. Therefore, a more relevant question is; Does generic pork advertising have a significant impact on retail revenues? The retail level is where almost all benefits originate. They are then potentially fed back through the supply chain to the pork producer. So it makes sense to first look at the retail level.

However, this assumes that the causality relationship flows only from advertising to revenues. It may also be the case that advertising is a result of changes in pork producer revenues. As revenues increase, total value of production increases, and checkoff funding increases. Thus, changes in advertising may result from changes in revenues. Finally, it is quite possible that they cause each other. The objective of this research is to determine the direction of causality between advertising and revenues at the retail level. Both total pork advertising and generic advertising are analyzed.

Methodology and Data

The first step of the analysis is to test for cointegrating relationships between generic or total pork advertising and pork revenues. This will be done using Johansen's trace test. Using the notation of Johansen and Juselius, the following model is specified.

$$X_t = \prod_1 X_{t-1} + \ldots + \prod_k X_{t-k} + \mu + \phi D_t + \varepsilon_t \qquad (1)$$

The ε's are IID normal and the X's are fixed. By rewriting this model, one arives at the following specification.

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k+1} + \prod X_{t-k} + \mu + \phi D_t + \varepsilon_t \quad (2)$$

Where

$$\prod = -(I - \prod_1 - ... - \prod_k) \quad (3)$$

Johansen and Juselius specify a test for the rank of Π. If it has full rank, then X_t is stationary. If Π has rank of zero, then the model corresponds to a traditional VAR model. If the rank of Π is r, somewhere between zero and full, then there are matrices, referred to as α and β, that make the following relationship hold: $\Pi = \alpha\beta'$. Here, β is the cointegrating vector. So the test is truly a test of the elements of the cointegrating vector.

If the series under investigation are shown to be cointegrated, then a test for causality can be performed (Dawson and Tiffin). The method tests the elements of the α matrix. Suppose the number of equations in the system is 2. Then ΠX_{t-k} can be rewritten as $\begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \begin{bmatrix} \beta_1 & \beta_2 \end{bmatrix} \begin{bmatrix} y_{1t-k} \\ y_{2t-k} \end{bmatrix}$. If $\alpha_1 = 0$, then y_1 does not cause y_2. If $\alpha_2 = 0$, then y_2 does not cause y_1. If neither α_1 nor α_2 equals zero, then there is evidence of feedback between y_1 and y_2.

Finally, the system can be estimated using a traditional VAR specification. Once estimated, the coefficients can be used to generate dynamic and long run multipliers. The dynamic multipliers show the effect of a shock in some variable t periods ago on the current period's value of the dependent variable. Alternatively, it shows how a shock today impacts the dependent variable t periods in the future. The long run multiplier

shows the total effect of the shock on the dependent variable after it passes completely through the system.

Augmenting the system to first order makes computation of dynamic multipliers relatively simple. The following equations outline the process of calculating multipliers. Note that these equations apply to the augmented system.

$$y_t = \alpha + \pi_0 y_{t-1} + \pi_1 x_{t-1} + \pi_4 x_{t-4} + \varepsilon_t \quad (4)$$

where endogenous variables are denoted as y and exogenous variables as x. This equation can be rewritten as

$$(I - \pi_0 L) y_t = \alpha + \pi_1 L x_t + \pi_4 x_t \quad (5)$$

where L is the lag operator. The dynamic multipliers can be found in the following manner.

$$(I - \pi_0 L)^{-1} (\pi_1 L + \pi_4 L^4) \quad (6)$$

This generates an infinite polynomial in L. The j^{th} term of the polynomial is the matrix of dynamic multipliers j periods ago on the current period. As a final note, the system can also be checked for stability using the eigenvalues of π_0. If they are all less than one in absolute value (or their modulus is less than one if imaginary), then the system is stable and the multipliers will converge to zero over time.

Data

The data used in this analysis have been used in an earlier study of advertising impacts on meat demand (Brester and Schroeder). The data are quarterly observations on consumption and prices of beef, pork, and poultry as well as total advertising for the three

meats and generic advertising of pork. The data cover the period from 1970 quarter one to 1993 quarter 4. These data were used to generate the following variables.

Table 1. Description of data used

Variable	**Definition**
Porktr	Indexed retail level pork revenue
Beeftr	Indexed retail level beef revenue
Pltrytr	Indexed retail level poultry revenue
Tprkadv	Per capita total pork advertising expenditures
Gprkadv	Per capita generic advertising expenditures
Beefadv	Per capita total beef advertising expenditures
Pltryadv	Per capita total poultry advertising expenditures
D2	Dummy variable; =1 if quarter 2
D3	Dummy variable; =1 if quarter 3
D4	Dummy variable; =1 if quarter 4

Results

The method described earlier was used to analyze two different models. One in which total pork revenue and total pork advertising were the dependent variables and another in which generic pork advertising was used in place of total pork advertising. This section presents the results of each of those models separately. However, before doing so, the results of the cointegration test and its bearing on the subsequent causality test are discussed.

Cointegration

The results of Johansen's test for cointegration show no evidence of any cointegrating relationship between pork revenues and either advertising measure. The calculated test statistic is 17.441 but the critical value for the test is 32.093. Thus, the

hypothesis of less than one cointegrating relationship can not be rejected. The figure below shows that both advertising variables, which are very similar in value, trend upward much more quickly than does the index of per capita pork revenues. This is particularly true for the period following 1986.

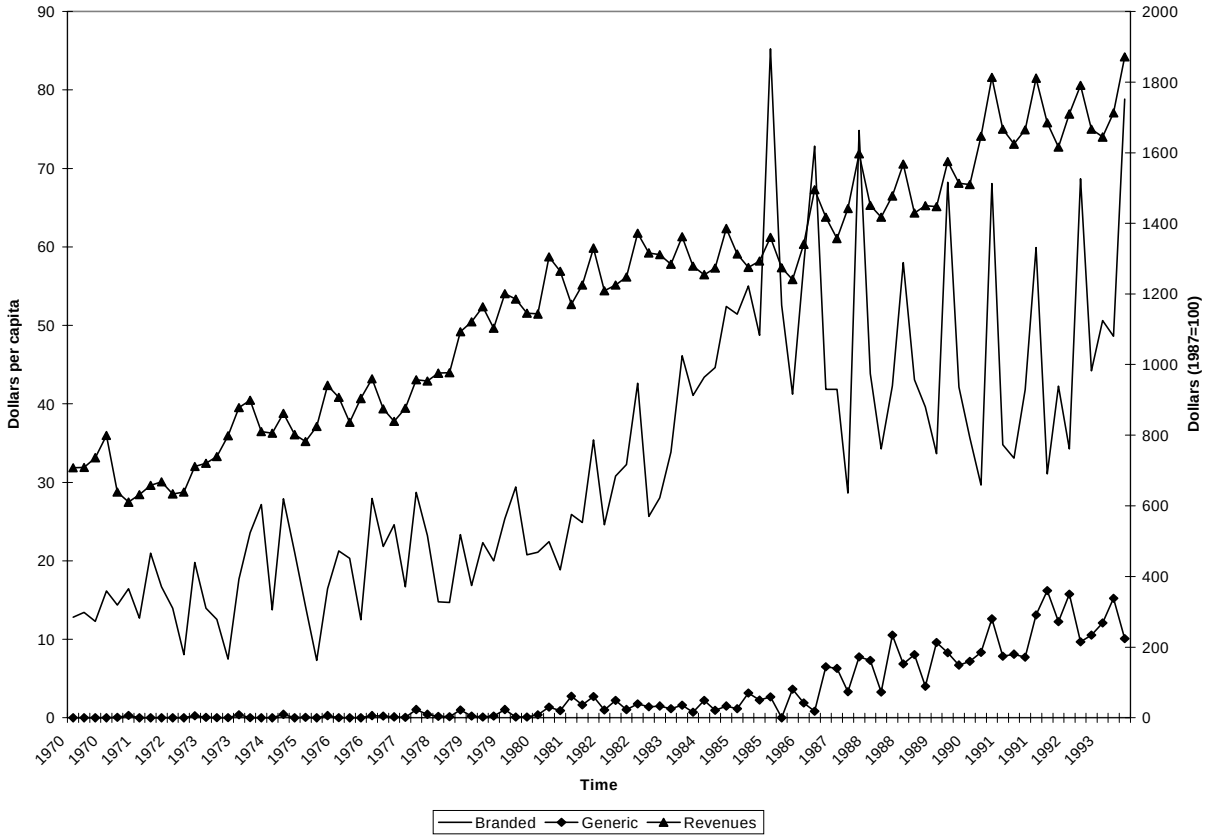

Figure 1. Total Pork Revenues and Per Capita Advertising Levels

This result leads to the fact that a Dawson and Tiffin causality test can not be performed on these data because a cointegrating relationship is required for that test. However, the VAR estimations may still be insightful, yielding some evidence of causality. This is revisited in the discussions that follow.

The two models presented and discussed in this section were tested for specification of the lag structure. Likelihood ratio tests were used to determine the number of lags that should be included. Those tests suggested that both models include the first and fourth lags of the dependent and independent variables as well as quarterly dummy variables.

Pork Revenues and Total Pork Advertising: The results of this analysis indicate that feedback may exist between total pork advertising (branded plus generic) and pork retail revenues (Table 1). Both first and fourth lags of pork advertising are significant in explaining pork revenue. Furthermore, the fourth lag of pork revenue is significant in explaining total pork advertising. This implies that pork companies might view the increase in revenues last year as a signal to advertise more this year, attempting to gain market share in an expanded market.

Table 1. Coefficient Estimates for Total Advertising Model

Variable	Revenue Equation Coefficient	Advertising Equation Coefficient
Constant	16.481	-2.046
$Porktr_{t-1}$	0.438**	-.001
$Porktr_{t-4}$	-.034	.048**
$Beeftr_{t-1}$	.256**	.0002
$Beeftr_{t-4}$	.007	-.026*
$Pltrytr_{t-1}$	.052	-.007
$Pltrytr_{t-4}$	.101**	.010
$Tprkadv_{t-1}$	-1.220**	.111
$Tprkadv_{t-4}$	1.296**	.287**
$Beefadv_{t-1}$	-.042	-.197**
$Beefadv_{t-4}$	-.075	-.072
$Pltryadv_{t-1}$	-.146	.191**
$Pltryadv_{t-4}$	-.095	.166
D2	-14.126	3.008
D3	9.387	1.156
D4	47.897**	6.084

R^2 = .99 for Revenue Equation and .89 for Advertising Equation

Note: * signifies the variable is significant at a 90% level while ** denotes a 95% confidence level.

The negative coefficient on the first lag of pork advertising in the revenue equation is somewhat bothersome. However, the long run multiplier is what is of most interest. It shows that each additional advertising dollar spent has a total impact of 0.18 on indexed pork revenues. Thus the long run effect is positive. Converting this to an elasticity shows that a one percent increase in total advertising has a long-run impact of .0054% (or a 6.42 increase evaluated at the mean) on indexed pork revenues.

These results also suggest that in the minds and strategies of consumers and producers, pork may be related to beef much differently than how it is related to poultry. The advertising equation shows that the first lag of beef advertising has a significantly negative impact on pork advertising while the first lag of poultry advertising has a significantly positive effect. This implies that synergies may exist between pork and beef such that pork retailers and processors gain spillover benefits from beef advertising. On the other hand, poultry advertising may negatively impact pork's market share. Thus, pork advertising is increased. These coefficient signs may reflect strategic behavior of several significant meat processors who are active in both the beef and pork industries.

It is also interesting that the coefficient on D4, the fourth quarter dummy, is large and statistically significant. There are at least two reasons why this might be true. On the demand side, it is plausible that the holiday season brings with it increased demand for ham. Also, it has become common practice to "tailgate" before football games in the fall. Pork products such as sausage, kielbasa, and bratwurst are commonly consumed at these parties.

On the supply side, pork slaughter is typically increased in the fall because of increased conception during the cooler winter and spring months earlier in the year. The

increased number of pigs marketed in the fall may push prices down. However, if retail demand is inelastic, total revenues will increase despite the increase in quantity.

Pork Revenues and Generic Pork Advertising

The results from this analysis did not meet with *a priori* expectations (Table 2). There is no evidence of feedback between advertising and revenues. It was expected that feedback would be more apparent with generic advertising because of the expected link between pork revenues and increased checkoff dollars. However, the model shows no significant imapct of generic advertising on pork retail revenues. Furthermore, the fact that revenues do not impact generic advertising may reflect the decision to use increased checkoff dollars for programs other than advertising.

Table 2. Coefficient Estimates for Generic Advertising Model

Variable	Revenue Equation Coefficient	Advertising Equation Coefficient
Constant	16.024	-2.254
$Porktr_{t-1}$	0.357**	0.006
$Porktr_{t-4}$	0.003	0.006
$Beeftr_{t-1}$	0.320**	-0.007**
$Beeftr_{t-4}$	-0.052	-0.003
$Pltrytr_{t-1}$	0.051	0.003
$Pltrytr_{t-4}$	0.127**	0.004**
$Gprkadv_{t-1}$	1.058	-0.107
$Gprkadv_{t-4}$	-2.094	0.088
$Beefadv_{t-1}$	0.046	-0.032
$Beefadv_{t-4}$	-0.223	0.023
$Pltryadv_{t-1}$	-0.141	-0.027
$Pltryadv_{t-4}$	-0.061	-0.016
D2	-4.517	0.661
D3	11.676	1.177
D4	63.881**	0.261

R^2 = .99 for Revenue Equation and .89 for Advertising Equation

Because of the unexpected results, two other models were tested. First a dummy variable was added to represent the period since the checkoff program was implemented (1985-93). Second, the sample size was shortened to reflect the post-checkoff period so that the original model was estimated over the period 1985-93. Neither model formulation added any information beyond that presented in Table 2.

Dynamic multipliers

Because of the difficulty in interpreting advertising's impacts on revenues using a price index, the dynamic multipliers have been converted to elasticities to avoid the problem associated with the units. Therefore, the constant used to derive the price index (1 / base year price) will cancel in the elasticity equation. Note also that no analysis of elasticities is performed for the generic advertising case because the relationship was shown earlier to be insignificant.

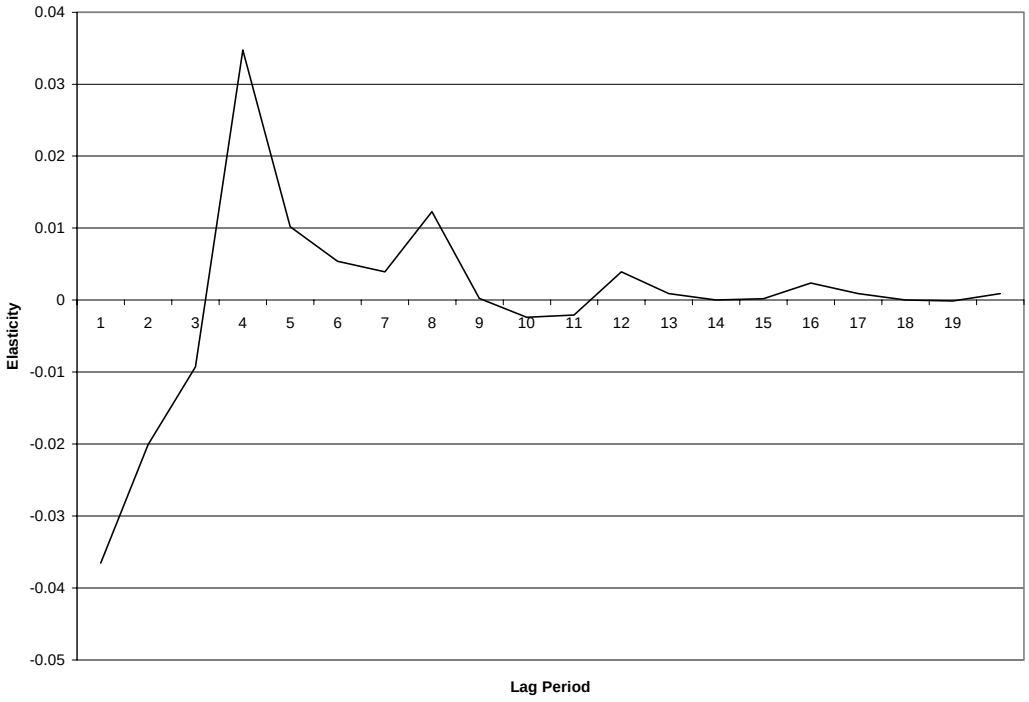

Figure 2. Elasticities of Total Advertising on Pork Revenues

The impact of total pork advertising on pork revenues is quite inelastic, with values near zero even in the earliest periods following an increase in advertising (Figure 2). The long run elasticity is .0054. There is evidence of seasonality in this relationship, with peaks every four periods beginning with the third lag.

Although the absolute values of the elasticities in Figure 2 are relatively small, this reflects only that the magnitudes of the revenue and advertising variables are quite different. The reported elasticities are evaluated at the mean pork revenue level (1189.7) and the mean total pork advertising per capita (35.657). Therefore, given a one percent increase ($0.35) in total advertising, a .034 percent increase in indexed revenues (representing the third lag's elasticity) is 40.45. The opposite argument holds for the elasticities of revenues on advertising (Figure 3).

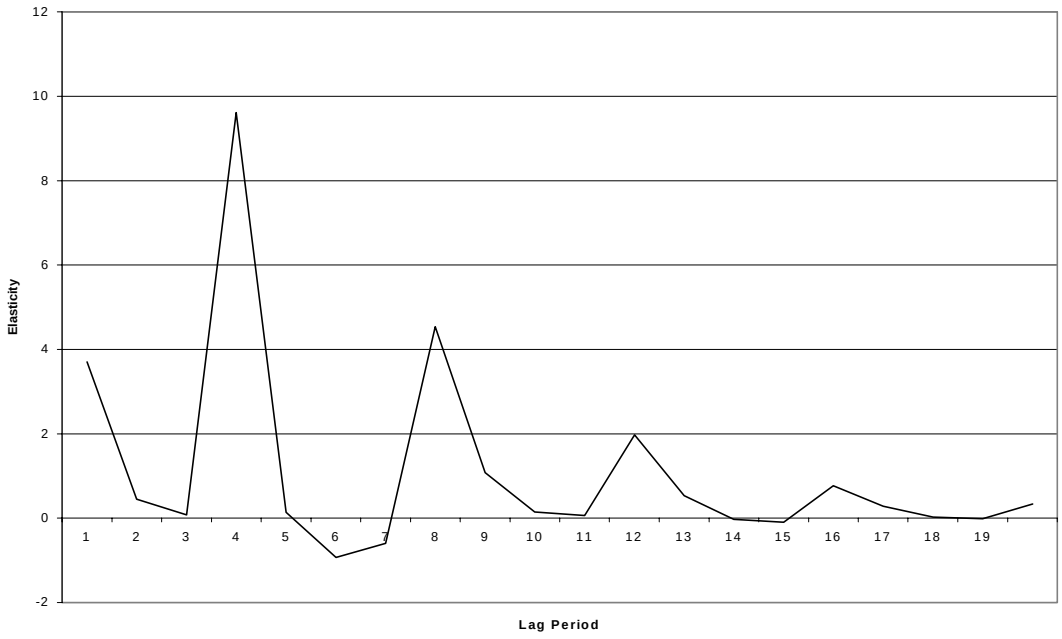

Figure 3. Elasticities of Pork Revenues on Total Pork Advertising

Here, the cyclical relationship between revenues and advertising is even more pronounced. The large elasticity estimates are due again to the relative magnitudes of

advertising and revenues. Looking at the third lag's elasticity again, a one percent increase in indexed pork revenues leads to a 9.61% increase in total pork advertising. Evaluated at their means, this means that an increase of 11.90 in indexed revenues leads to an increase in total pork advertising per capita of $3.43 three periods into the future. The long-run elasticity in this case is 22.02. This implies that a one percent increase in indexed pork revenue leads to a long-run increase in total advertising of 22%.

Conclusions

The relationship between total pork advertising and pork revenues met with *a priori* expectations. That is, there is evidence of feedback between the two series. Also, the data show that fourth quarter pork consumption differs significantly than the other three, possibly due to the holidays and increased pork consumption during events such as tailgate parties. The story for generic advertising is quite different. No evidence of feedback was found. In fact, there is no evidence in this research that shows that generic advertising has had a significant impact on revenues.

Further research should focus specifically on generic advertising. If there truly is no significant impact, then checkoff dollars might be better spent elsewhere. There is strong anecdotal evidence that the checkoff funded export enhancement programs have been successful. Maybe this avenue should be pursued further. It might be beneficial to update the data to include more recent years and/or to include actual prices rather than indexed prices. The problem, of course, lies in the fact that the term 'pork price' means nothing at the retail level given the variety of products sold. However, including prices received at slaughter may make it easier to discern the true effects on pork producers.

References

Brester, G. and T. Schroeder, "The Impacts of Brand and Generic Advertising on Meat Demand," *American Journal of Agricultural Economics* 77(1994), pp. 969-79.

Dawson, P.J. and R. Tiffin, "Estimating the Demand for Calories in India," *American Journal of Agricultural Economics*, 80(1998), pp. 474-81.

Johansen, S., "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, 12(1988), pp. 231-54.

Johansen, S. and K. Juselius, "Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics*, 52(1990), pp. 169-210.

Korsmeyer, C. "Helping Pork Producers Remain Competitive," http://www.moormans.com/feedfacts/swine/April97hogff/porkbord.html, April, 1997.

Marberry, S. *Feedstuffs*, 70(18), May 4, 1998, p. 8.

Smith, R., *Feedstuffs*, 70(51), December 14, 1998, p. 26.

Smith, R., *Feedstuffs*, 70(49), November 30, 1998, P. 26.