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Consumer Responses to Food Safety Information from Print Media

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Abstract

A panel of independent judges evaluated a range of articles in popular print media sources for positive or negative bias about pork. From this came the development of an information variable reflecting consumer perceptions about food safety. The primary data from this evaluation was then used to estimate the impact of print media information on the consumer demand for pork.

Keywords: food safety, consumer perceptions, media bias, pork demand

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Introduction

A long-standing policy objective in the food and agricultural sector is the assurance of a safe food supply for the general public. Public awareness of food safety continues to be publicized by events reported in the print media.

Newspaper and magazine headlines such as "Aging Population May Demand Pathogen-Free Food" (*Feedstuffs,* 1993); "Mad Cow Disease Hits Again" (*Sioux City Journal,* 1996); "Hudson Meat Plant Closed: Recall of Hamburger Patties Reaches 25 Million Pounds" (*Sioux City Journal,* 1997); "Spray Kills Salmonella in Chickens" (USA Today, 1998); and "Group Finds Meat Safety Violations" (*Lincoln Journal Star,* 2005) notified consumers of a new danger in town - food borne pathogens. These bacteria and parasites exist to some degree in all farm animals, some remaining in meat and poultry products after slaughter. Pathogens can be introduced into meat and poultry products in slaughter plants, processing plants, grocery stores, restaurants, and even at home.

A USDA report (Aldrich, 1999) synthesized research from economics, nutrition education and marketing on the use of information. The report found several themes that emerged including: the importance of motivational knowledge, the value of time to consumers, the changing effects of economic variables, and the high value of enhanced health and life expectancy. Yet, the pace of dietary change has been slow, with many changes offsetting other changes. One explanation of the slow rate of change is the difficulty people have in changing consumption habits and patterns. Aldrich observed that the forces of rising incomes and convenience are outweighing nutrition and health information. Research by Blisard, Blaylock and Smallwood found that 59 percent of those surveyed thought that their current diets were healthy, but many feel they lack the information to change their dietary behavior.

As consumers have become more removed from the farm, they look to the food industry to help them achieve healthier diets; to universities and scientific agencies to evaluate the safety and benefits of those dietary changes; and to the government to enforce and regulate food safety and consistency standards. In a majority of instances information associated with this process is transmitted from those in the scientific and enforcement community to consumers through the media. Whether the message is "nutritionally improved," "light," "low fat," "low sodium," "packed in water," "cholesterol free," or "organic," consumers receive a variety of messages in their efforts to consume a healthy diet. The consumption of meat items is no exception.

Food safety information can be costly to gather and difficult to understand. Scientific studies are often complex, contradictory and open for interpretation. The public frequently relies on the media for information regarding their food purchases

and consumption. The nation's media agenda may not be strictly informational in nature because most media organizations are profit-seeking entities. As informational reliance on the media has grown, concerns over possible misinformation, or bias, toward food and agricultural commodities have also grown (Jones; Foster). As stated by Jones, "There is a tendency for consumer concerns about food safety issues, however, to be exaggerated by the popular press."

Objectives

The first objective of this study was to develop and define an information variable that captured the extent of positive and negative information about food safety appearing in popular print media sources. This was done to establish an original data set for use in a supply and demand model.

The second objective was to specify and estimate a supply and demand model for pork that included an information variable in the specification. The purpose of the model was to evaluate the role of information in explaining consumer behavior.

This study adds to and builds upon past studies that constructed variables, usually an index, to measure the number of positive and negative articles appearing in medical journals or popular print media. Once the variables were constructed, they were used in models to assess the significance and possible impact of positive or negative information on consumer food demand. Tactical actions by managers can then be considered.

Information Variable

A review of literature covering past research on the development of an information variable is given in Appendix A. Following the groundwork from these previous studies an information variable INFO was defined and data developed for use in this study.

The information variable was defined using primary data generated from the computerized InfoTrac SearchBank. Data for the information variable INFO started as the total number of articles (N = 114) pertaining to food safety and pork consumption. The articles were published in the lay press and were accessible to the average consumer. See Appendix B for a sample listing of the newspapers and magazines. Each article was evaluated by a panel of judges and determined to be positively or negatively biased, or unbiased. The information variable was included in the demand equation as direct test of the hypothesis that health and food safety information affected the consumption of pork. Two information variables that were statistically significant, and included one-at-a-time in the demand equation, were as follows:

INFOB4 was a 4-quarter moving average of negatively biased articles.

INFOA3 was a 3-quarter moving average of positively biased articles.

Focus Group Insights

In constructing an information variable, a number of the previous studies reviewed here tabulated the articles containing positive or negative information about a particular food product, such as cholesterol attributes and egg consumption. In doing economic research this was a standard practice that led to the construction of an information variable, the same as done in this study. However, a researcher from the disciplines of marketing or psychology might ask the question, "Did you talk to any actual consumers about their perceptions of the information and how they reacted to it?"

In response to such a question, five face-to-face focus groups, containing six to ten participants each, were conducted in three cities in the Northern Plains region of the U.S. It should be noted that while focus group participants do not constitute a random sample of the population of U.S. consumers, it is expected that they can provide useful insights about consumer behavior.

The focus group results indicated that their information came from a variety of sources, with television being reported by 85.2 percent, followed by magazines (29.6 percent), newspapers (22.2 percent), and radio (14.8 percent). Respondents reported hearing or reading about the health and safety attributes of consuming beef (81.5 percent), poultry (66.7 percent) and pork (51.9 percent) within the past six months. When asked to respond to the general nature of the information received, 51.9 percent of those that received information about beef said the information was negative. Twenty-two percent said the pork information they received was negative, and 33.3 percent said that poultry information was negative. Consumers also reported gaining information from reading nutritional labels, with 92.6 percent having read at least one label in the last 30 days.

Two hypotheses were tested utilizing this data. (See Appendix C for details on the statistical test). The first hypothesis tested was that consumers have not altered their pork consumption levels in response to food safety concerns. The results of this test supported previous research that consumers have changed their levels of pork consumption due to health and food safety concerns (van Ravenswaay; Henderson; Kinnucan, et.al.).

The second hypothesis tested was that consumers respond to information in an identical manner regardless of the presence of information bias. Over 66 percent of those surveyed said that they respond differently to information they perceive to be biased than information perceived as objectively reported.

Model Results

With the insights gained from the focus groups, a more formal analysis proceeded using a supply and demand model. (Details on the supply and demand model, associated statistics and a discussion of the variables are given in Appendix D. The theoretical background for the research is contained in Wade).

In the demand equation, which contains the information variable, all variables were statistically significant. Two versions of the demand equation were estimated – one with a negative information variable, and one with a positive variable to see how consumers responded to both types of information bias.

The INFOB4 information variable represented a four-quarter moving average of negatively biased articles pertaining to the health attributes or safety of consuming pork. The statistically significant, negative sign indicated a direct and negative relationship between the quantity of pork demanded and the negative nature of the information consumers receive.

The information variable INFOA3 was a three quarter moving average of positively biased articles pertaining to the health attributes or safety of consuming pork. The statistically significant, positive sign indicated a direct and positive relationship between the quantity of pork demanded and the positive nature of the information consumers receive.

Results from the supply and demand model and the focus group insights showed that consumers can and do differentiate between biased and unbiased information, positive and negative, and they respond differently to each.

Implications for Managers

Managers in the food manufacturing and marketing segment of the supply chain are acutely aware of the impact that catastrophic news regarding food safety can have on an agribusiness. Whether its salmonella in chicken, e-coli in hamburger, Alar in apples or even suspected mad cow disease, the economic costs to the industry and financial impacts on the firm are enormous. Much effort goes into monitoring, testing and preventing such events.

Less catastrophic for managers but still potentially damaging are the warnings from consumer organizations, the media, government and scientists who believe they are serving the public good by reporting information that is negative about a food product. Three questions confront the manager: a) how reliable is the information, b) how will consumers respond to it, and c) what, if anything, should the managers do?

If a negative report is published in the popular media, managers will first need to make a judgment on the reliability of the information, and that will likely be related to the source of the information. With negative information that appears to receive significant media exposure and public attention, the managers can expect a negative response by consumers as demonstrated by the research in this study.

What to do about a negative report is more complicated. It can be ignored and managers can hope that consumers do not significantly change consumption patterns. However, with significant media exposure managers will most likely be forced to respond. Depending on circumstances, they can question the reliability and the source of the information, and try to persuade consumers that good science is not present and that only selected opinions are being expressed. The source of the information might be a vested interest group with a record of opinionated public statements that tout the groups own values but are not credible to a large segment of the general public. If additional tactical action is deemed necessary, managers can do their own internal investigations and use those findings to make adjustments, if needed. Any adjustments that focus on improving consumers' welfare can be part of a public campaign showing concern for their customers and that the food firm is committed to correcting any real problems.

If a positive report appears in the popular media, again managers have a choice of doing nothing, or starting a campaign that cites the message and appeals to the authority of the source. A purely hypothetical example might be, "the New England Journal of Medicine recently reported on research showing that eating twelve to sixteen ounces of lean pork every two weeks provides an excellent source of protein without any associated negative effects related to heart disease."

In either case of negative or positive reports, once managers have responded with tactical actions, they can use the services of consumer research firms such as Information Resources, Inc. (www.infores.com) or A.C. Nielsen (www.acnielsen.com) to track any changes in sales volume, by geographic location. These services can show whether or not an information campaign by the food firm is effectively reinforcing a positive media report, or countering an original negative media report.

Conclusions

Consumers are overwhelmed by warnings from consumer protection organizations, the media, government, and various scientific studies. They have often received conflicting information. This study shows that the reporting of information can be positive, neutral or negative, and perceived as biased. Focus group insights showed consumers are reasonably intelligent in their evaluation of information. They responded differently to information perceived as biased versus information perceived as objectively reported. In addition, the more formal supply and demand analysis showed that consumers do respond as expected to positive or negative

information. Managers need to be aware of public media articles about their firm's food products, and consider selected tactical actions in response.

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Appendix: A

Literature Review on Information Variables

Consumer research on food products has traditionally focused on the importance of advertising as a primary source of consumer information (Green, Carman, and McManus; Kaiser; Capps, Seo, and Nichols). More recently, time-series demand studies included attitudinal variables and information pertaining to health concerns as possible explanations for changes in consumer preferences (Gao and Spreen; Brown and Schrader; Capps and Schmitz). Each of these models included an information variable, but the structure of that variable received relatively little attention. The studies on advertising are numerous, and the three summarized here discuss time lags and advertising effectiveness.

Previous research has concluded that advertising does influence consumer demand, but has failed to consistently and uniformly address the rate of advertising decay and structural lag. Lee and Brown examined the influence of lag structures on advertising effectiveness. Summarizing previous advertising research on agricultural commodities, the authors classified lag structure assumptions into four categories: (1) zero lag effects, (2) monotonic decreasing lag structures, (3) bell-shaped lag structures, and (4) monotonic increasing structures.

While the structure of the lagged variable was debated, Lee and Brown sought to answer the question as to why the advertising variable was lagged in so many previous regressions seeking to estimate advertising effects. Often, no explanation was given for assuming a lagged structure. Common arguments that were given included the fact that it takes time for advertising to reach its full impact, printed materials may not be read immediately, and frequency of shopping may not coincide with frequency of advertising. For these reasons, distributed lags and/or cumulated advertising variables tended to be used.

Lee and Brown tested the data interval and the necessity of a lagged variable structure using weekly, biweekly, triweekly, and monthly data for the time periods t-1 and t through t+7, where the period t+7 is used in analysis of the advertising decay function. It was concluded that, in general, for frequently consumed commodities, the lag structure of advertising should take the shape of a monotonic decreasing function. More importantly, the authors stated that researchers placing too much emphasis on statistical goodness-of-fit and statistical tests could lead to incorrect conclusions about the length of advertising lagged effects. It was recommended that the nature of the product being promoted (frequency of purchase and use) and advertising frequency be considered in any econometric model.

Reberte et. al. included a “stock of advertising goodwill” variable generated by an advertising campaign in their demand equation for fluid milk. While previous

studies cited by the authors assumed that advertising elasticities were constant over time, the assumption ran counter to the advertising wear out theory, which states that the effectiveness of an advertising campaign will eventually decay. To test this hypothesis, two major milk advertising campaigns in New York City were examined. Results of the study indicated that the first campaign was effective for twice as long as the second campaign, and that it had a higher average advertising elasticity. It was concluded that advertising effectiveness diminishes over time.

Schmit, Reberte, and Kaiser conducted an economic analysis of generic egg advertising in California using a double log functional form. Supply and demand equations were estimated on a per capita basis using quarterly data, 1985 through June 1995. The demand equation contained lagged, as well as current, generic advertising expenditures variables to account for delays in the demand response to advertising. Based on the significance of the lagged coefficients, three lags were included in the final specification. Results indicated that generic advertising had a positive and statistically significant impact on California per capita egg consumption.

While a large amount of research focused on methods that try to measure a consumer's response to advertising, the same cannot be said about non-advertising types of information that come from scientific, government and popular media sources. Six studies are summarized here describing how previous researchers defined and quantified information variables.

Menkhaus et.al. examined the effects of perceived product attributes on the perception of beef. In the empirical model, a variable QUALBF was included representing the consumer's perception of beef quality. The variable was determined by a range of characteristics that could be classified into four broad categories: health, convenience, appeal, and merchandising. As suggested by Capps and Schmitz, the perception of quality depends on information available to consumers at time t. Therefore, the QUALBF variable was included without lag. Data for the analysis was collected via questionnaire in Denver and Los Angeles. The dependent variable in the model was a measure of quality or overall opinion and was coded zero (fair), one (good), or two (excellent or very good). An ordered probit technique was used to take into account the discrete nature of the dependent variables in the model.

Results from the estimated model indicated that high cholesterol content and being high in calories, among other things, significantly and adversely affected the quality perception of beef among survey respondents. These results lent support to the findings of previous research that suggested the importance of assessing the effects of convenience and health related factors in analysis of beef demand.

Menkhaus et.al. utilized an interesting definition of "health" in their study. Health included such things as portion sizes cut too large, high cholesterol, high in calories, containing artificial ingredients, and not well trimmed. Pathogen contamination, antibiotic/other residues, and fat content were not included in the model, yet are indicated by consumer surveys to be of great concern.

In their widely cited article, "Cholesterol Information and Shell Egg Consumption," Brown and Schrader investigate how information about cholesterol affects U.S. demand for shell eggs. Supply and demand equations for shell eggs were specified. Of major significance was the inclusion of a cholesterol information index in the demand function.

Clinical studies link cholesterol in the diet to an increased risk of heart attacks. Consumers receiving health information from physicians, neighbors, and the popular press, Brown and Schrader argued, would reduce their level of egg consumption in an effort to reduce blood cholesterol levels. An index based on articles in medical journals served as a proxy for information reaching consumers from many sources. Therefore, a cholesterol index was constructed by scanning all articles in English connecting human health to cholesterol. Articles unrelated to cholesterol and heart disease, and those appearing in foreign journals were discarded. The number of articles supporting and attacking the linkage was calculated by quarter. A running total, lagged two quarters, was calculated, with each article supporting the link adding one unit to the total and each article attacking the link subtracting one unit from the total. In essence, a net influence variable was created. The equal weighting of the pro and con articles was justified by including both supporting and attacking articles in the regression. The coefficients were found to be of similar size, but opposite in sign in the directions predicted. The lag was justified, argued Brown and Schrader, because there appeared to be a two-quarter lag before a new article had an effect on egg consumption. The cholesterol information index was then a simple sum, lagged two quarters. When the index was used to predict shell egg demand in a fixed coefficients regression, its coefficient was always negative and different from zero at a one percent level of significance.

Capps and Schmitz also created a theoretical framework in which to empirically identify and assess the impacts of cholesterol information on the demand for meat. In their study, a Rotterdam model was used to simultaneously investigate the impacts of prices, total expenditure, and cholesterol information on the consumption of beef, pork, poultry, and fish. The model was modified by the inclusion of a term corresponding to the cholesterol index developed by Brown and Schrader. Annual data over the period 1966 to 1988 was used.

The coefficients associated with the cholesterol variable were -0.000884 for pork, -0.000219 for beef, 0.000892 for poultry, and 0.00021 for fish. The pork, poultry, and

fish coefficients were all statistically significant at the .10 level. Capps and Schmitz concluded that there existed evidence to indicate that cholesterol information, lagged one-half year, was a statistically significant determinant in the consumption of pork, poultry, and fish.

Chang and Kinnucan examined the roles of cholesterol information and advertising in explaining consumption trends for fats and oils, focusing on butter. An additional hypothesis of importance in this study was whether consumers respond disproportionately to unfavorable information as suggested by previous researchers. Demand equations were formulated for butter, margarine, shortening, and salad oil. Each equation included a measure of consumer awareness of cholesterol - the Brown and Schrader cholesterol information index. While Brown and Schrader used a "net publicity" approach, "total publicity," which is the summation of both positive and negative articles, may be appropriate. In the study, an "effective negative publicity" measure ($INFO_t$) was developed as a hybrid of both approaches, using the formula $INFO_t = \Sigma K_t NEG_t$. Here NEG_t are negative articles in Brown and Schrader's index, and K_t is a weighting factor that was calculated as the number of negative articles in period t divided by the sum of negative and positive articles in period t. The demand equations were estimated as a system using seemingly unrelated regressions.

The estimated coefficient of the cholesterol information index was significant in the case of butter (-0.75) and salad oils (0.65). The negative sign on the butter coefficient indicates that as information pertaining to cholesterol increases, the demand for butter decreases. Chang and Kinnucan also concluded, based upon advertising and cholesterol elasticity measures, that incremental percentage increases in cholesterol information had a greater impact on demand for butter and salad oils than similar incremental percentage increases in advertising expenditures. Results also suggested that favorable information disseminated by disinterested sources is more effective than favorable information disseminated by sources with a vested interest.

Kinnucan et. al. also utilized Brown and Schrader's cholesterol index in evaluating the effects of health information on U.S. meat demand. A Rotterdam model was estimated using seemingly unrelated regressions with homogeneity and symmetry imposed. Brown and Schrader's cholesterol index was updated through 1993. Following Chang and Kinnucan, the negative and positive data series were combined into a single "net publicity" index using the formula $Z_t = w_t NEG_t$. Here Z_t is the net publicity index, NEG_t is negative articles in Brown and Schrader's index, and wt is a weighting factor which was calculated as the number of negative articles in period t divided by the sum of negative and positive articles in period t. Kinnucan et. al. concluded that poultry benefited from the dissemination of cholesterol information, largely at the expense of beef. Pork and fish were found to be unaffected by health information.

Robenstein and Thurman studied health risks, the demand for red meat, and their impact on futures markets, employing a similar methodology. Instead of using Brown and Schrader's cholesterol index as a demand proxy for health information, this study utilized cholesterol information from the *Wall Street Journal.* Articles related to cholesterol and red meat consumption were gleaned from the *Wall Street Journal* Index and National Newspaper Index from 1971 to 1990. Irrelevant articles were culled, with the remaining 52 articles being categorized as to either strengthening the link between cholesterol and red meat consumption (33 articles), or weakening the link (19 articles). Articles were further classified as strong, moderate, or weak. Event study regressions were run. Results provided no evidence of immediate futures market adjustments to public information linking red meat consumption and cholesterol or heart disease.

Appendix: B

InfoTrac SearchBank Newspapers and Magazines - A Partial Representation by Category

General Consumer

Redbook
Working Woman
Woman's Day
Parents
Better Homes and Gardens
Family Circle
Good Housekeeping
Consumer's Research Magazine

Agricultural
Successful Farming
Organic Gardening
Mother Earth News

Medical, Health and Fitness
Health
The Lancet
New England Journal of Medicine
Vegetarian Times

News Magazines and Newspapers

Time
U.S. News and World Reports
Newsweek
New York Times

Business
Wall Street Journal
The Economist
Business Week

Appendix: C

Focus Groups

It was hypothesized that (1) consumers have not altered their pork consumption levels in response to food safety concerns, and that (2) consumers respond the same to information regardless of the presence of informational (media) bias. In order to test the two hypotheses, five face-to-face focus groups (Zarkin and Anderson; Newsom, Scott, and Turk), containing six to ten participants each, were conducted in three cities in the Northern Plains region of the U.S. Adult subjects were recruited from three retail grocery locations and the local community college, and were distributed equally across locations. Individuals exiting the grocery stores and the college cafeteria were approached at random (approximately every fifth person) and asked if they would be willing to participate in a study of consumer attitudes about food safety. Those interested were verbally screened to ensure that they were not full-time students, were nineteen years of age or older, and that they were adults with food purchasing (either at-home or away-from-home) responsibility for their households. Participants were not selected based upon gender or ethnicity, but were approached at random. Those individuals meeting the stated criteria were asked to attend a focus group conducted at the local college, where meeting space had been made available. Several alternative dates and times were made available to those interested in participating. Only those individuals that arrived at the focus group meetings actually took part in the study.

It should be noted that while focus group participants do not constitute a random sample of the population of U.S. consumers, it is expected that they can provide useful insights about consumer behavior (Lin, Payson, and Wertz; Sapp, Harrod, and Zhao). For consistency among interviews, the same enumerator conducted all interviews and led all focus group discussions. At the start of each focus group participants completed a brief written questionnaire. The questionnaire was pre-tested in two additional focus groups to ensure respondent understanding. Several questions were modified as a result of the pre-testing.

The questionnaire includes items on meat consumption, perceptions of key food attributes (Food Marketing Institute; Krondl and Lau), nutrition labels, health and food safety information, concerns about food safety, and social demographic characteristics. The questionnaire also solicits information on possible changes in pork consumption based on health and safety concerns.

As suggested by Sapp, Harrod, and Zhao, upon completing the questionnaire, participants were instructed to read two articles pertaining to food safety and pork consumption. Both articles were presented in identical format as retrieved from the InfoTrac SeachBank to prevent biasing the reader. Though the articles are labeled“Article One” and “Article Two,” which article was read first was determined

by the respondent. Given the new information presented in the articles, the respondent was again asked the impact of this new knowledge on their consumption of beef, fish, pork, and poultry.

The subjects were then provided the written definition of "bias" used in this research, and were asked whether bias exists in either of the two articles, the type of bias present, and whether the degree of bias indicated would alter their consumption of beef, fish, pork or poultry. The primary data generated via the questionnaire was then summarized. Two null hypotheses were tested using a Chi-Square Goodness-of-Fit test. The first null hypothesis tested was that consumers have not altered their pork consumption levels in response to food safety concerns. Was there a statistical difference between those respondents that answered the question yes and those that answered no? Under the null hypothesis the observed probabilities would equal 0.50 for those answering yes and 0.50, or 50 percent, for those answering no. For the test of hypothesis the expected probability of a yes response was set equal to 0.05 and the expected probability of a no response was set at 0.95. The null hypothesis of not altering pork consumption was rejected at the 0.05 level of significance.

The second hypothesis tested was that consumers respond in an identical manner regardless of the presence of informational (media) bias. Using expected probabilities of 0.10 and 0.90, then the null hypothesis was rejected at the 5 percent level of significance. Survey results were also tabulated for analysis by demographic and socioeconomic characteristics such as gender, age, household size, income level, and place of residence.

Upon completion of the questionnaire, respondents were asked to orally comment on their reactions or perceptions of meat (pork) safety, media bias, sources of consumption information, the two articles, their consumption habits, the questionnaire, or any comments in general related to the subject of study. Discussions lasted anywhere from ten minutes to thirty-five minutes.

A demographic profile of the respondents and the questionnaire are available from the authors.

Appendix: D

Supply and Demand Model

The supply and demand model was made up of four equations describing a static equilibrium situation where price and quantity are simultaneously determined. Key variables were quantities supplied and demanded, prices of pork and substitutes, cash costs of production, technology, income and population, and the information variable.

The model was defined by three behavioral equations and a fourth identity equation as follows:

(1) $$Qs_t = ß_0 + ß_1\, PP_{t-4} + ß_2\, Qs_{t-4} + ß_3\, TCSCST_{t-4} + ß_4\, TECH_{t-4} + ß_5\, DUM4 + ß_6\, Z_t + u_{2t},$$

(2) $$Qd_t = \alpha_0 + \alpha_1 PP_t + \alpha_2\, PB_t + \alpha_3 PC_t + \alpha_4 YD_t + \alpha_5 POP_t + \alpha_6 INFO_t + \alpha_7 DUM4 + \alpha_8\, Z_t + u_{1t},$$

(3) $$PP_t = \gamma 0 + \gamma_1\, PP_{t-1} + \gamma_2\, PP_{t-2} + \gamma_3\, PP_{t-4} + \gamma_4\, DUM4 + u_{3t},$$

(4) $$Qd_t = Qs_t.$$

In the first equation: Qs_t is the quantity supplied in quarter t; PP_{t-4} is the price of pork lagged four quarters; Qs_{t-4} is supply lagged four quarters; $TCSCST_{t-4}$ represents the total cash costs per hundredweight lagged four quarters. A technology $TECH_{t-4}$ variable was included in the supply equation defined as the percentage of total hog inventories owned by operations one thousand head and greater, lagged four quarters. A dummy DUM variable was used in the supply equation to account for seasonality in pork markets. Z_t represented other explanatory or dummy variables that may have been needed to further explain quantity supplied.

In equation two: Qd_t is the quantity demanded in quarter t; the price of substitute goods are the price of poultry PC and price of beef PB; YD is disposable personal income; POP is a population variable; and a dummy DUM variable accounts for seasonality in pork markets. The information variable INFO is described in a previous section of this article.

The third equation defined the dynamic relationship between the current level pork price (pp_t) in the demand equation and the lagged prices of pork (PP_{t-1}, PP_{t-2}, and PP_{t-4}) in the supply equation. The fourth identity equation specified that the quantity demanded must equal the quantity supplied in equilibrium. The two-stage least squares estimation procedure provided consistent, asymptotically efficient estimates of the model parameters.

Estimated Supply and Demand Model

The four-equation model was estimated using the two-stage least squares (SYSLIN option in SAS).

Pork Supply Equation

The estimated parameters and statistics for pork supply equation (1) are given in Table 1.

Table 1. Simultaneous Equation Parameter Estimates: Pork Supply

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	8	4284453.13	535556.641	37.517	0.0001
Error	23	328327.745	14275.119		14275.119
C Total	31	4612780.875			
Root MSE		119.478	R-Square	0.9288	
Dep Mean		4281.187	Adj R-SQ	0.9041	
C.V.		2.791			

Variable	Parameter Estimate	Standard Error	t-Value	P-Value
Intercept	2500.284	438.355	5.704	0.0001
PP_{t-4}	5.834	1.844	3.164	0.0043
Q_{t-4}	0.168	0.067	2.513	0.0194
$TCSCST_{t-4}$	-27.356	6.184	-4.424	0.0002
$TECH_{t-4}$	15.335	3.171	4.837	0.0001
DUM4	265.008	57.097	4641	0.0001
DUM24	427.287	128.065	3.336	0.0029
DUMQ9	1710.788	124.391	13.753	0.0001
DUM25	329.313	122.683	2.684	0.0132

The seasonal dummy variable DUM4 verifies a higher level of pork production in the fourth quarter relative to all other quarters. The higher production corresponds to higher demand by consumers.

The lagged total cash cost ($TCSCST_{t-4}$) variable was a significant determinant of pork supply, and is of the expected (negative) sign. This relationship was expected as feed costs, interest expense and capital costs represent major costs of production in the swine industry. The lagged factor may be an indication that producers relate current input costs more heavily in the production decision than they do costs incurred closer to the actual marketing date.

The technology ($TECH_{t-4}$) variable was significant and positive. Technology has changed as larger producers have come to dominate the swine industry, taking advantage of economies of scale and new production practices that may not be readily available to smaller producers.

The sign on the lagged quantity supplied (Q_{t-4}) variable was positive, indicating the relationship between past and current hog marketings. The level of pork supply is primarily determined by producers' decisions about breeding herd size. Producers expand their herds by retaining gilts or by adjusting the culling rate. Utilization of the breeding-herd determines the placement of pigs on feed that in turn determines subsequent barrow and gilt slaughter. Domestic pork production is derived from the sum of barrow, gilt and sow slaughter multiplied by their respective market weights. As suggested by Hayenga and Hacklander, pork producers tend to expect the most recent price trend to be continued. Consequently, past marketings serve as a realistic measure of production expectations for producers incorporating normal marketing weights, growth trends and seasonality.

If producers' expectations were indeed adaptive, they would make production decisions based on the lagged price (PP_{t-4}) when the decision to breed must be made. Producers expect recent monthly price trends to continue and plan their marketings accordingly (Tryfos). The lagged price (PP_{t-4}) variable was positive and significant statistically.

The estimated price elasticity of supply for pork expresses the percentage change in quantity supplied in response to a one percent change in price, *ceteris paribus,* and is defined for a point on the supply curve. The elasticity of supply is 1.23 which is within the range of previous estimates of pork supply elasticities. Since an increase in quantity supplied is normally associated with a rise in price, the sign of the coefficient is usually positive as it is here.

Pork Demand Equation - Negative Bias

Table 2 gives the estimated parameters and statistics for pork demand equation (2) that includes an information variable reflecting negatively biased articles.

Table 2. Simultaneous Equation Parameter Estimates: Pork Demand-Negative Bias

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	5	4318702	863740.5	88.32	0.0001
Error	26	254269.4	9779.592		14275.119
C Total	31	4612781			
Root MSE		98.89182	R-Square	0.94440	
Dep Mean		4281.18750	Adj R-SQ	0.93370	
C.V.		2.30992			

Variable	Parameter Estimate	Standard Error	t-Value	P-Value
Intercept	5109.889	280.3904	18.22	0.0001
PP	-13.4349	1.729442	-7.77	0.0001
YD	0.377748	0.044295	8.53	0.0001
INFOB-4	-99.4536	56.31134	-1.77	0.0891
DUM4	443.2112	40.87139	10.84	0.0001
DUMQ9	1864.261	105.2925	17.71	0.0001

The negative sign on the pork price coefficient (PP) reflects the anticipated negative-sloping demand curve. The estimated own-price elasticity of demand is -0.581 which is within the range of previously estimated elasticities. Price elasticity is defined for a point on the demand curve, and hence for most demand curves, the magnitude of the elasticity coefficient varies along the curve.

The seasonal dummy variable DUM4 confirms higher consumption in the fourth quarter relative all other quarters, as it did for higher production. The positive sign on the disposable income (YD) coefficient reflects a positive relationship between disposable income and pork price. Since disposable income has risen steadily over the time period under consideration, the significant positive impact of disposable income on pork prices may reflect a willingness of consumers to increase pork consumption as incomes rise even if consumers have the ability to purchase substitutes to pork that may be more expensive.

The INFOB4 information variable was significant with a negative sign. This variable represents a four-quarter moving average of negatively biased articles pertaining to the health attributes or safety of consuming pork. The negative sign indicates a direct and negative relationship between the quantity of pork demanded and the negative nature of the information consumers receive.

Pork Demand Equation - Positive Bias

Table 3 gives the estimated parameters and statistics for pork demand equation (2) that includes an information variable reflecting positively biased articles.

Table 3. Simultaneous Equation Parameter Estimates: Pork Demand-Positive Bias

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	5	4404183	880836.7	137.98	0.0001
Error	26	165984.1	6384.002		
C Total	31	4612781			
Root MSE		79.89995	R-Square	0.96368	
Dep Mean		4281.18750	Adj R-SQ	0.95670	
C.V.		1.86630			

Variable	Parameter Estimate	Standard Error	t-Value	P-Value
Intercept	4702.470	228.7166	20.56	0.0001
PP	-10.1348	1.213031	-8.35	0.0001
YD	0.305043	0.025127	12.14	0.0001
INFOA3	465.9944	109.3263	4.26	0.0002
DUM4	432.5332	33.07996	13.08	0.0001
DUMQ9	1863.317	84.98275	21.93	0.0001

The INFOA3 information variable was significant with a positive sign. This variable represents a three-quarter moving average of positively biased articles

pertaining to the health attributes or safety of consuming pork. The positive sign indicates a direct and positive relationship between the quantity of pork demanded and the positive nature of the information consumers receive. These results dispute suggestions by Pember; Robertson and Kassarjian; Sapp, Harrod, and Zhao, that negative information received by consumers influence opinions more so than favorable information. These results show that positively biased information does increase the quantity of pork demanded.

The results also contradict conclusions drawn by Khan, Tes and Uhlenhopp that consumers "lump" all information together under one broad category of either good or bad. Results of this study from the focus group and regression analysis show that consumers can and do differentiate between biased and unbiased information, positive and negative, and they respond very differently to each.

Price Equation

The estimated parameters and statistics for price equation (3) are given in Table 4.

Table 4. Simultaneous Equation Parameter Estimates: Lagged Price Relationship

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	5819.005	1454.751	116.823	0.0001
Error	27	336.219	12.453		
C Total	31	6155.225			
Root MSE		3.529	R-Square	0.9454	
Dep Mean		208.172	Adj R-SQ	0.9373	
C.V.		1.695			

Variable	Parameter Estimate	Standard Error	t-Value	P-Value
Intercept	11.356	12.192	0.931	0.360
PP_{t-1}	1.983	0.164	12.052	0.0001
PP_{t-2}	-1.215	0.204	-5.948	0.0001
PP_{t-4}	0.192	0.091	2.118	0.044
DUM4	-10.973	1.970	-5.571	0.0001

All of the lagged price variables were statistically significant. The seasonal dummy variable DUM4 influences the current price of pork relative to all other seasonal time periods. The lagged price variables reconcile the time dimension that exists between current price in the demand equation and lagged price in the supply function. This is consistent with economic theory as pork supplies are fixed in the short-run for any one quarter and can only be adjusted subsequent to the biological lag in production that exists. Current pork prices are a function of past pork prices just as current quantities supplied are a function of previous levels of production and prices.

Description of the Data Set

Estimation of the supply and demand for pork products used quarterly data. Pork, beef, poultry, and corn prices were obtained from the U.S. Department of Agriculture (USDA) publication *Agricultural Outlook.* Interest rates were obtained from the Federal Reserve Bulletin. Commercial pork production levels, Consumer Price Index (CPI), population, and disposable personal income figures were also from USDA's *Agricultural Outlook.* All prices were at the retail level except for farm level pork price. Magazine and newspaper articles used in the development of the information variable INFO were obtained from InfoTrac SearchBank.

