

## **Consumer Purchasing Behavior in Response to Media Coverage of Avian Influenza**

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# **Consumer Purchasing Behavior in Response to Media Coverage of Avian Influenza**

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## **Abstract**

Understanding consumer response to food safety information is important for quantifying consumer response to food safety events, predicting market impacts, and developing appropriate risk communication strategies. In this study, we present a methodology for analysis of consumer response to media coverage of avian influenza and an application using Italian data.

**Key Words:** Avian influenza, food safety, Italy, meat demand, media index

**JEL Classifications:** Q11, Q18

## **INTRODUCTION**

Consumer concerns regarding food safety can have substantial impacts on their consumption patterns. Understanding how consumers respond to food safety information is very important for developing appropriate risk communication strategies. In addition, this information is valuable for quantifying consumer response to food safety events and predicting potential market impacts.

Highly pathogenic avian influenza (HPAI) has emerged as a significant threat to the poultry sector in recent years as outbreaks in Asia, Africa, and Europe have led to the culling of tens of millions of poultry and anxiety regarding the safety of poultry consumption in affected regions. However, publicly available data for quantitative evaluation of the effects of HPAI concerns on meat sales are limited. In this study, we present a methodology for analysis of consumer response using Nielsen meat sales data combined with data on media coverage of avian influenza (AI). These data on media coverage are used to construct indices representing the amount of information on avian influenza being presented to consumers over time.

The majority of studies in the meat demand literature rely on national data at a quarterly or annual frequency, but the use of higher-frequency scanner data is becoming more common as these data have become more readily available. The use of these data has implications for meat demand parameter estimates (Capps and Love, 2002; Lensing and Purcell, 2006). Among other effects, there is some evidence that using data collected more frequently and/or for more disaggregated regions is more likely to reveal effects of food safety information on demand because of the often transitory nature of these effects as well as regionalized responses to certain information, such as recalls in a particular area (e.g., Kuchler and Tegene, 2006; Piggott and Marsh, 2004). In this study, we present a methodology for analysis of consumer response using

weekly Nielsen meat sales data for Italy combined with data on media coverage of AI and estimate a meat demand system to provide empirical evidence on consumer response.

## **MEDIA INDICES OF AVIAN INFLUENZA**

In this section, we briefly review the literature on food safety and describe the construction of media indices for avian influenza news. Because the vast majority of food safety studies in the economics literature are concerned with the demand side as opposed to the supply side and because of the stated objective of this project, we focus our attention on the effects of food safety on consumer demand.

### **Effects of Food Safety Information on Consumer Demand**

The demand literature has had a long tradition of constructing indices as demand shifters to approximate consumers' perceptions 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 product quality.

Smith, van Ravenswaay, and Thompson (1988) examined the effect of media coverage of the 1982 heptachlor contamination of fresh milk in Oahu, Hawaii, on milk sales. In that study, the authors used counts of newspaper articles on the incident to proxy public perceptions of milk safety. The newspaper indices were then included in the demand equation to assess the magnitude of the impact on milk sales. Their estimated media-elasticity of demand evaluated at the sample mean is  $-0.066$ , which implies that a 1% increase in negative media coverage reduced milk sales by 0.066%.

Burton and Young (1996) studied the impact of BSE on the demand for beef and other meats in Great Britain. They used the number of news articles on BSE as demand shifters in an

Almost Ideal Demand System (AIDS). They found that negative publicity about British beef had reduced beef market share by 4.5% by the end of 1993.

Following in the same vein, Marsh, Schroeder, and Mintert (2004) estimated a Rotterdam demand system for U.S. meat demand, where they used the quarterly number of beef, pork, and poultry recalls initiated by the Food Safety and Inspection Service (FSIS) as demand shifters. They found statistically significant but economically small effects of meat recalls on U.S. meat demand. The estimated own-effect elasticities of demand are  $-0.00052$ ,  $-0.0010$ , and  $-0.0014$  for beef, pork, and poultry recalls, respectively. In a related study, Piggott and Marsh (2004) provided a formal theoretical model that explores the link between food safety information and demand for foods within a meat demand system framework. They constructed quarterly media indices for beef, pork, and poultry safety using the Lexis-Nexis search tool to find news articles on meat safety from up to 50 English-language newspapers worldwide. The number of news articles in each quarter for each meat species was then used as a demand shifter in a Generalized Almost Ideal Demand System (GAIDS). They found that heightened public alert over food safety reduced per capita beef, pork, and poultry consumption by 2.21%, 0.99%, and 6.88%, respectively. Beach et al. (2007) updated Piggott and Marsh's food safety indices through 2005. With the extended sample, the authors again found that food safety information has a significant impact on consumer demand in the U.S.

Although many authors estimated regular demand equations with food safety media indices, some have used inverse demand to study the impact of food safety information on prices. Dahlgran and Fairchild (2002) estimated an inverse demand model for chicken using the U.S. weekly wholesale disappearance data during the period 1982 to 1991. They found evidence that negative publicity about *Salmonella* contamination of chicken depressed chicken demand.

However, the economic effect was estimated to be relatively small, with less than a 1% reduction in chicken price at the peak of the exposure. The media index used in Dahlgran and Fairchild's study was based on weekly television and print news stories about chicken contamination and food safety weighted by circulation and viewership data.

### **Transforming the Media Index**

An empirical issue for demand studies of food safety is determining the appropriate length and shape of the distributed lag structure for the variable measuring food safety. If advertising is expected to have protracted effects on consumer demand, it is not unreasonable to expect food safety information to have lasting effects on demand as well. Previous authors have followed several alternative strategies. In their 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. But for food safety incidences 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. Instead, these

authors started with a relatively large number of lags and sequentially reduced the number of lags, selecting the preferred model as the one with the best statistical fit. Although this approach is free from the danger of imposing incorrect functional structure, it may be plagued by multicollinearity of the lagged media indices.

In this analysis, we use an alternative approach to investigate the lag structure of media indices. This lag structure, which was originally proposed by Mitchell and Specker (1986), is known as 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 index of media information on avian influenza). As we explain below, this latter property makes it convenient to test for the best specification for the lag structure.

Consider the following regression equation:

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

where  $Y_t$  is poultry sales in period  $t$ ,  $X_{\tau}$  is the media index in period  $\tau$  with  $\tau \leq t$ ,  $b$  is a collection of other explanatory variables (e.g., meat prices, seasonal dummy variables) and their associated coefficients, and  $e_t$  is the regression residual. Although the empirical demand model may take a more sophisticated form, Eq. (1) can be used to provide a simple illustrative example of how the PIL works. This equation cannot be estimated directly as written due to the infinite lag distribution for  $X$ . To derive an estimable form of Eq. (1), Mitchell and Specker (1986) propose the following transformation:

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

PRELIMINARY – PLEASE DO NOT CITE OR QUOTE

where  $Z_{jt} = \sum_{i=0}^{t-1} \frac{X_{t-i}}{(i+1)^j}$ ,  $j = 2, \dots, n$ ,  $R_t = \sum_{j=2}^n \sum_{i=t}^{\infty} \frac{a_j X_{t-i}}{(i+1)^j}$ , and  $n$  is the degree of polynomial for

the PIL structure, which has to be determined empirically. With the sample  $t=1,2,\dots,T$ , data are available to calculate  $Z_{jt}$ , but the remainder term  $R_t$  cannot be calculated from the data because it includes infinite lags. Mitchell and Speaker showed that with  $t$  greater than eight,  $R_t$  becomes negligible. Therefore, a practical solution to the unobserved  $R_t$  problem is to exclude the first eight data points and conduct econometric analysis on the remaining data without the  $R_t$  term.

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

For  $j = 2$ :

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

For  $j = 3$ :

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

For  $j = 4$ :

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

For  $j = 5$ :

$$Z_{5t} = \sum_{i=0}^{t-1} \frac{X_{t-i}}{(i+1)^5} = \frac{X_t}{1^5} + \frac{X_{t-1}}{2^5} + \frac{X_{t-2}}{3^5} + \frac{X_{t-3}}{4^5} + \dots + \frac{X_1}{t^5};$$

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



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

To determine the optimal  $n$ , regression Eq. (3) is fit 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 other measures of model fit.

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

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

Eq. (4), along with estimated values for  $a_j$ , is used to calculate the weights on current and lagged media indices in the demand equation.

### **The Avian Flu Media Indices**

We used the LexisNexis Academic search engine to search news stories related to avian influenza. Because the focus is on the Italian case, we limited the scope of the search to European news sources. As described earlier, we constructed two media series, an Italy-specific index (*avit*) and an index pertinent to the rest of the world (*avrow*). While *avit* is intended to capture information on avian flu that is related to Italy, *avrow* is designed to reflect Italian consumers' exposure to information about the situation in the rest of the world reported by European news sources.

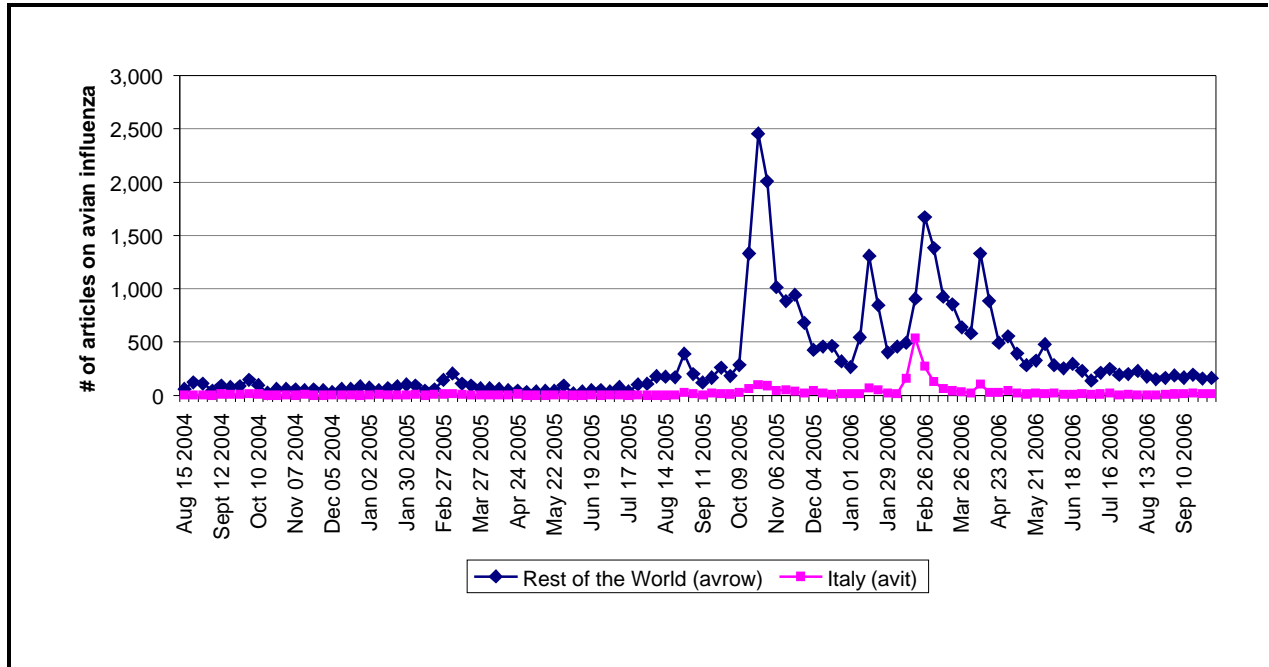
The keywords searched were *avian flu* or *avian influenza* or *bird flu* and not *Italy* for *avrow*, and *avian flu* or *avian influenza* or *bird flu* and *Italy* for *avit*. The sample period for the media indices is from the week ending on August 15, 2004, to the week ending on October 1,

2006. Because the PIL requires the first eight observations be dropped from the analysis, the media index sample starts 8 weeks earlier than the Nielsen data to maximize the number of usable observations in the demand model.

Both *avrow* and *avit* are presented in Figure 1. Not surprisingly, the number of European news articles about avian influenza that do not specifically mention Italy is far greater than those that do refer to Italy. The average index values over the sample period are 324.4 for *avrow* and 24.7 for *avit*. Figure 1 indicates that the first wave of concern in the European media started in late July 2005 when the virus apparently moved northwesterly from its origins in Southeast Asia to the Russian Federation and adjacent parts of Kazakhstan to affect domestic and wild birds. European media attention to the disease skyrocketed in October 2005 as a result of reports that the virus had been found in Turkey, Romania, and Croatia, resulting in a high of 2,455 articles in the week ending October 23, 2005.

After that, there were additional spikes in media attention in January through April 2006 as HPAI was identified in additional countries in Europe (e.g., Austria, France, Germany, Italy, Sweden, Switzerland) and elsewhere. Since then, the media has continued to be interested in following and reporting the disease situation in Europe and other parts of the world, but the number of articles has trended strongly downward from early April 2006 through the end of our sample period. Across the entire sample, *avit* was generally relatively flat with several articles per week. The exception was a spike of 539 articles in the week ending February 19, 2006, corresponding to the discovery of the H5N1 strain of HPAI in dead wild swans in southern Italy.

Figure 1. Media Indices of Avian Influenza Coverage



Qualitative assessment of these two media indices indicates that they correspond well to the HPAI outbreak situation and appear to reasonably reflect European consumers’ exposure to information about outbreaks and health risks. An advantage of media indices over variables based on the number of outbreaks or 0/1 indicator variables for whether an outbreak took place in a period or not is that they provide a continuous measure of consumer exposure to information regarding HPAI. Even if a country has not yet experienced an outbreak, consumers may respond to information on HPAI. For instance, additional media attention to outbreaks in nearby countries (or anywhere in the world, for that matter) may alter the perceived risk of poultry consumption. More generally, consumers are likely to respond not only to domestic outbreaks, but to any information that affects their perceived risk of poultry consumption. In addition, media attention may differ substantially between initial outbreaks in a region and subsequent outbreaks. To the extent that consumers are responding to new information received regarding

food safety, a media index may better capture the extent of information provided to consumers in a given period than an indicator variable for outbreaks or a count of outbreaks within that period.

## MODEL

We use a first-differenced linear-approximate version of the Almost Ideal Demand System (AIDS) model developed by Deaton and Muellbauer (1980) for this analysis. The model can be written in budget share form as:

$$(5) \quad \Delta w_i = \alpha_i + \sum \alpha_{is} \Delta Z_s + \sum_j^n \gamma_{ij} \Delta \ln p_j + \beta_i \Delta \ln(x/P) + e_i$$

where  $w_i$  is the budget share of the  $i$ th good;  $p_j$  is the price of the  $j$ th good;  $x$  is total expenditure on all  $i$  goods;  $Z_s$  includes demand shifters for media coverage of avian influenza and a time trend;  $P$  is a Stone index of prices defined as the price index defined by  $\ln P = \sum_i w_i \ln p_i$ ;  $e_i$  is the error term, and  $\alpha_i$ ,  $\alpha_{is}$ ,  $\gamma_{ij}$ , and  $\beta_i$  are parameters to be estimated.

Homogeneity, symmetry, and adding up are imposed on the system through the following parameter restrictions:

$$(6) \quad \sum_j \gamma_{ij} = 0; \quad \gamma_{ij} = \gamma_{ji}; \quad \sum_i \alpha_i = 1; \quad \sum_i \alpha_{is} = 0; \quad \sum_i \beta_i = 0; \quad \sum_i \gamma_{ij} = 0.$$

Following Chalfant (1997) and Green and Alston (1990), uncompensated elasticities were calculated using the formula below:

$$(7) \quad \begin{aligned} \varepsilon_{ij} &= -\delta_{ij} + \frac{\gamma_{ij} - \beta_i w_j}{w_i}, \\ \delta_{ij} &= 1, i = j \\ \delta_{ij} &= 0, i \neq j \end{aligned}$$

and expenditure elasticities were calculated as

$$(8) \quad E_i = 1 + \frac{\beta_i}{w_i}.$$

**DATA AND EMPIRICAL SPECIFICATION**

Following assessment of available Nielsen meat sales data for countries that had experienced animal outbreaks of HPAI H5N1, we chose to use Italian data in our empirical application because those data were the most complete and consistent available from Nielsen. These sales value and volume data for poultry, beef, and pork products were available from the week ending October 10, 2004 through the week ending October 1, 2006, giving us a total of 104 weekly observations. These data were combined with the weekly media series described above. Table 1 provides descriptive statistics.

Table 1. Descriptive Statistics

<b>Variable</b>	<b>Description</b>	<b>Average</b>	<b>Std. Dev.</b>	<b>Minimum</b>	<b>Maximum</b>
avrow	Media index ROW	342.3	440.2	17.0	2455.0
avit	Media index Italy	26.1	62.7	0.0	539.0
pfrhp	Price of fresh poultry	\$7.92	\$0.26	\$7.23	\$8.49
pfzrp	Price of frozen poultry	\$7.24	\$0.27	\$6.70	\$7.92
pbf	Price of beef	\$8.33	\$0.16	\$7.99	\$8.76
ppk	Price of pork	\$5.94	\$0.10	\$5.70	\$6.27
sfrhp	Budget share of fresh poultry	0.14	0.02	0.11	0.18
sfrzp	Budget share of frozen poultry	0.22	0.04	0.15	0.28
sbf	Budget share of beef	0.37	0.06	0.29	0.48
spk	Budget share of pork	0.26	0.02	0.23	0.31

Because consumer response is expected to differ between fresh and frozen/processed poultry, we estimated separate demand equations characterizing sales of these products as a function of the media indices, prices, and indicator variables capturing seasonality. Food safety information is expected to have lasting effects on demand. Thus, we investigate the lag structure of media indices using the polynomial inverse lag structure. The choice of appropriate degree of polynomial is determined based on the ability of the model to fit the data.

**RESULTS**

Our parameter estimates in Table 2 indicate that media information on AI had a statistically significant effect on sales of poultry products in Italy, both fresh and frozen. Both Italy-specific and non-Italy specific news regarding AI was found to impact Italian poultry demand, which suggests that consumers are responding to changes in the perceived risk of poultry consumption prior to outbreaks in their own country.

Table 2. LA-AIDS Parameter Estimates

	<b>Fresh Poultry</b>	<b>Frozen Poultry</b>	<b>Beef</b>
a	-0.00038 (0.001501)	-0.00072 (0.001273)	0.00900 (0.003008)
$\beta$	0.026840*** (0.009846)	-0.04714*** (0.008436)	0.068547*** (0.019793)
$\gamma_{fshp}$	-0.14522*** (0.026767)	-0.00502 (0.020436)	0.152543*** (0.045050)
$\gamma_{frzp}$	-0.00502 (0.020436)	-0.01304 (0.034571)	0.036319 (0.050021)
$\gamma_{bf}$	0.152543*** (0.045040)	0.036319 (0.050021)	-0.24959** (0.112920)
$\gamma_{pk}$	-0.00230 (0.023376)	-0.01825 (0.030445)	0.060733 (0.057997)
time	0.000014 (0.000025)	6.144e-6 (0.000021)	-0.00002 (0.000050)
z2avrow	-0.00004* (0.000020)	-0.00002 (0.000017)	0.000011 (0.000041)
z3avrow	0.000038* (0.000021)	0.000015 (0.000018)	-5.51e-6 (0.000042)
z2avit	-0.00004*** (0.000020)	-0.00003** (0.000013)	0.000011 (0.000030)

Standard errors are in parentheses. \*\*\*, \*\*, and \* denote significance at 1%, 5%, and 10%, respectively.

As described above, we started the estimation with a relatively high degree of polynomial for both *avrow* and *avit* and then sequentially reduced the degree of polynomial. The Akaike information criterion (AIC) was used to determine the model with the best fit. We found the

model performs best when both *avrow* enters with three as the highest degree of polynomial and *avit* with two as the highest degree of polynomial.

Table 3 presents the elasticities. As expected, all own-price elasticities are negative. They are also all elastic, which is likely due to the high frequency data used. Consumers are more price responsive in the short run than in the long run because of inventory behavior (e.g., Wohlgenant and Hahn [1982]; Hendel and Nevo [2006]). In our study, the price elasticity of demand for fresh poultry was estimated to be  $-2.0673$ , whereas in a study of Italian meat demand using monthly data, Fanelli and Mazzocchi (2002) found the own-price demand elasticity for poultry to be between  $-1.481$  and  $-1.250$ , depending on model specification. The other own-price elasticities that we estimated were  $-1.0138$  for frozen poultry,  $-1.7498$  for beef, and  $-1.1049$  for pork.

Table 3. Own-Price, Cross-Price, and Expenditure Elasticities

	<b>Fresh Poultry</b>	<b>Frozen Poultry</b>	<b>Beef</b>	<b>Pork</b>	<b>Expenditure</b>
Fresh Poultry	-2.0673	-0.0780	1.0201	-0.0670	1.1923
Frozen Poultry	0.0075	-1.0138	0.2543	-0.0275	0.7796
Beef	0.3897	0.0570	-1.7498	0.1160	1.1871
Pork	0.0172	-0.0293	0.3010	-1.1049	0.8160

Consistent with expectations, all expenditure elasticities are positive. Expenditure elasticities of less than one indicate that frozen poultry and pork are normal goods, while fresh poultry and beef have expenditure elasticities above one indicating they are luxury goods.

Based on the avian flu media index elasticities in Table 4, an increase in either *avrow* or *avit* media indices has negative effects for fresh and frozen poultry and positive effects on beef and pork in all cases except the short run elasticity for pork in response to European media coverage outside of Italy. Other than short run response to an increase in *avrow*, fresh poultry

sales are more responsive to media coverage of avian flu than frozen, which is consistent with our expectations that consumers may have greater concerns about the safety of fresh poultry.

For both it appears that non-Italy specific news had a more negative effect on long run poultry sales than Italy-specific news, although this may be reflective of the timing of these events. Outbreaks in Europe outside of Italy and associated media attention occurred prior to outbreaks in Italy and consumers may have already at least partially adjusted consumption due to changes in perceived risk prior to the Italian outbreaks. In addition, our estimates of lag weights indicate that the effects of media information dissipate over time, but that substantial negative consumption impacts may continue for a period of months after the news is provided.

Table 4. Avian Flu Media Index Elasticities

	<b>Fresh Poultry</b>	<b>Frozen Poultry</b>	<b>Beef</b>	<b>Pork</b>
SR – avrow	-0.0031	-0.0071	0.0209	-0.0205
SR – avit	-0.0079	-0.0037	0.0008	0.0058
LR – avrow	-0.0451	-0.0223	0.0297	0.0009
LR – avit	-0.0130	-0.0061	0.0013	0.0094

## CONCLUSIONS

The unique data used in this study provide an excellent opportunity to examine how consumers' perceptions of the likelihood of contracting the disease and health risk evolve due to changes in information. The data cover the period when cases of a highly pathogenic strain of H5N1 were found in wild birds in Italy for the first time. In early February 2006, Italian authorities announced that lab tests confirmed H5N1 in dead wild swans found in southern Italy. The timeframe covered by these data enables us to investigate how consumers behave when presented with information suggesting increased probabilities of future outbreaks in Europe and in Italy, as well as how consumers react in the short run and intermediate run when such predictions materialize.



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