Does Food Safety Information Affect Consumers' Decision to Purchase Meat and Poultry? Evidence from U.S. Household Level Data

by

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Abstract

Many factors influence consumer purchasing habits, including food safety information. Concerns about food safety can be influenced by both idiosyncratic experiences and general media information. This study focuses on the reaction of consumers to changes in the amount of beef, pork, and poultry food safety information available in the media. A multinomial logit model is estimated to assess the probability that heterogeneous households avoid making purchases in response to changes in food safety information. Results of the model suggest that certain households respond to changes in the level of information available by choosing to avoid purchasing meat or poultry.

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For most consumers, the risks posed by foodborne pathogens amount to no more than a temporary case of 'food poisoning' with no lasting health effects. However, young children, the elderly, and people with compromised immune systems face an elevated risk of serious illness or even death if they come in contact with certain pathogens. As a result, every food recall notice posted by the Food Safety Inspection Service (FSIS) explicitly includes warnings targeted at these consumers. These warnings, along with recommendations from physicians and previous experience with foodborne illness, may affect the consumption decisions of households, regardless of their risk status.[1]

While idiosyncratic experiences are difficult to measure, the amount of food safety information available to consumers in the press can be quantified. Previous research on consumer responses to food safety information has employed various measures of media coverage to infer its effect on food demand (e.g. Burton and Young, 1996; Piggott and Marsh, 2004). These studies have used aggregate data to jointly estimate meat and poultry demand equations that quantify the own- and cross-commodity effect of food safety information on marginal purchases. This approach has shown that media information matters at the aggregate level, however it does not allow assessment of the likelihood that individual households will avoid purchasing meat and poultry products in response to food safety information. Examining discrete avoidance behavior at the disaggregate level (i.e., what mix of products households buy on a given purchase occasion) will provide insight into the demand for food products by households with and without elevated risk levels under different food safety information environments.

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[1] An example of a food safety warning from a physician would be providing information to pregnant women on the increased risks of miscarriage due to listeria contamination.

The objective of study is to investigate if the quantity of food safety information that is publicly available impacts heterogeneous consumers' decisions to purchase fresh meat and poultry in a discrete choice framework. A media index measuring the number of articles containing food safety information on beef, pork, or poultry published in U.S. regional newspapers is used as a proxy for food safety information available to consumers. The media index is a broad measure in that it includes reporting on domestic recall events as well as international issues, commentary on food contamination prevention, and other food safety-related topics. Commodity-specific, monthly parameters are constructed using the media index and a discrete choice model is estimated to measure the impact of food safety information on purchase behavior. Results from a multinomial conditional logit model will provide insight into different households' propensity to avoid consumption of a meat or poultry product or substitute to another when faced with food safety concerns.

Literature on Demand and Food Safety Information

The use of media indices to measure the impact of food safety information on demand has been employed in several aggregate-level demand studies. Smith, van Ravenswaay, and Thompson (1988) considered the effect of media publicity following a case of heptachlor contamination of fresh fluid milk in Hawaii on milk purchases. Significant negative effects on milk purchases were found from negative news coverage. However, positive news coverage did not appear to affect purchases, indicating that statements by the media assuring consumers of the safety of certain milk products were heavily discounted. Dahlgran and Fairchild (2002) studied the effect of adverse media coverage from salmonella contamination on the demand for chicken. Their model incorporated adverse media publicity from T.V. and print as a form of negative advertising, where publicity included both the number of stories aired and the percent of population exposed to the coverage. Their results did indicate a negative demand response to adverse media, however, the effect died out in a matter of weeks. Unlike paid advertising, media coverage of food safety events can end abruptly as other news events take priority in programming. This lack of frequent message repetition was considered by the authors to be a possible reason for the absence of long-run alterations in demand.

Burton and Young (1996) analyzed the effects of bovine spongiform encephalopathy (BSE) on meat demand in Great Britain using media indices incorporated into a dynamic AIDS model. The model considered publicity on BSE to be a form of negative advertising and measured its effect using an index of media coverage. The index included both the number of articles per quarter and the cumulative number of articles to date for each quarter. BSE publicity was shown to have both significant short-run and long-run effects on consumer expenditures on beef and among the other meats with a decline in market share for beef of 4.5 percent by the end of 1993.

A recent study by Piggott and Marsh (2004) analyzed the impact of food safety information on demand for beef, pork, and poultry using aggregate data on quarterly U.S. per capita disappearance of meat. The media index for food safety information measured bundles of contaminants reported individually for beef, pork, and poultry. Their findings indicated that effects of food safety information on meat demand were statistically significant, but with no lagged effect implying a relatively small economic impact.

Other work focusing on food safety information and consumer demand have examined the impacts of specific events or information campaigns on consumer-level purchase behavior. Schlenker and Villas-Boas (2006) employed event study analysis to investigate the effects of media coverage of BSE on consumer and financial markets. They compared analysis results using three data sources: UPC-level scanner data, diary files from the U.S. Consumer Expenditure Survey (CES), and cattle futures prices. Statistically significant negative effects on purchases and cattle prices from media coverage of BSE were found using the UPC scanner and futures data. However, the CES did not reveal any statistically significant effect on consumer purchases or expenditures.

Using a reduced form analysis and household level data from the U.S. Consumer Expenditure Survey, Shimshack, Ward, and Beatty (2007) examined responses to a U.S. national FDA advisory on exposure to methyl-mercury from store-bought fish. They employed both parametric and non-parametric methods to analyze changes in fish demand for households comprised of targeted consumers (i.e. households with young children, nursing mothers, and pregnant women) and non-targeted consumers. The analysis of subgroups of households in the sample revealed a short-run response to food safety information that was primarily determined by education level and newspaper readership. They also found spillover effects of decreased fish consumption among non-targeted households with high readership levels.

Data

Biweekly data from the time period January 1998 to December 2005 is used to analyze the effects of food safety information on U.S. household demand for meat and poultry. The data for this study come from two sources. Data on household purchases of meat and poultry were obtained from the Nielsen Homescan panel.[2] These panel data also contain information on

[2] The Nielsen Homescan panel is a nationwide survey of households and their retail food purchases. Households record purchase data by scanning the universal product codes (UPCs) of the items they purchase. Data include detailed product information, date of purchase, total quantity, total expenditure, and the value of any coupons used for every item purchased.

several demographic characteristics of the participating households. The data used to describe food safety information were obtained from searches of newspapers using the Lexis-Nexis academic search engine.

The products of interest for this study are fresh and frozen beef and veal, pork, chicken, and turkey. These groups do not include any processed products because it becomes difficult to determine the extent of processing and the value added to the final price from processing.[3] Each observation is a separate product purchase and includes the total quantity purchased in pounds, the total amount spent on the item in dollars, a product description (e.g. ground beef-bulk, rib eye steak, whole chicken), and the date of purchase. Prices per unit of product were subsequently calculated by dividing total expenditure by total quantity for each individual meat or poultry purchase. A biweekly periodicity was chosen for the empirical analysis to avoid excessive censoring rates, but still allow for short-run food safety effects. This frequency also reflects households' tendency to make meat and poultry purchases twice a month, which corresponds to the commonly used two-week pay period.

As mentioned previously, prices per unit of each meat and poultry product were calculated by dividing total expenditure by total quantity. This results in retail prices being available only for the households that actually made purchases. For the households that chose not to purchase a product in a given month, the price they faced for that product is not recorded. Therefore, the missing prices must be imputed for households without positive purchases in order to have a complete dataset for estimation purposes. Following Cox and Wohlgenant (1986), household income is used to capture hypothesized increases in quality that may be demanded from increased income. A variable for household size is used to account for

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[3] Examples of processed meat and poultry products include luncheon meats, frozen dinners, or soups that contain meat or poultry.

economies of size in purchasing meat and poultry products. Quadratic terms for both income and household size are also included in the regression. Other demographic variables were considered for the price equations; however, the coefficients were not statistically different from zero for most of the goods.

The final specification of the linear price regression is as follows:

$$p_{itn} = \alpha \overline{p}_{it} + \boldsymbol{\gamma}_r \mathbf{r}_n + \delta u_n + \eta i_n + \kappa i_n^2 + \tau s_n + \rho s_n^2 + \varepsilon_{it} \ , \qquad (1)$$

where p_{itn} is the observed price of good *i* in month *t* for consuming household *n*, $\overline{p}_{it}$ is the sample average monthly price for good *i* in month *t*, $\mathbf{r}_n$ is a vector of binary variables indicating the region in which the household is located, u_n is a binary variable indicating if the household is located in an urban area, i_n is household income, i_n^2 is household income squared, s_n is the size of household, s_n^2 is the squared size of household, ε_{it} is an iid error term, and $\alpha, \boldsymbol{\gamma}_r, \delta, \eta, \kappa, \tau,$ and ρ are the corresponding coefficients to be estimated.[4] The regression is estimated without a constant term so that all the regional binary variables can be included and standard errors are estimated using the robust sandwich estimator (Huber, 1967; White, 1980). The regression coefficients for each good were subsequently used to predict prices for the non-consuming households. Predicted prices were obtained by using the sample monthly average prices and the geographic and demographic characteristics of the non-consuming households. These predicted prices replace the zeros to provide a complete series of prices for subsequent demand analysis.

[4] Total household income is recorded as an interval in this dataset. Therefore, the midpoint of the interval is the value used in the price regression. To calculate the midpoint of the highest income range, an upper bound of $150,000 was used.

The grouping of purchases into various beef, pork, and poultry products of similar characteristics and average prices is intended to minimize the amount of quality and price variation that occurs when the daily purchases are aggregated to a monthly level. However, the number of equations that must be estimated is still relatively large (five beef, four pork, and six poultry groups), so the products are aggregated to the commodity level for estimation purposes. While aggregation is useful for estimation, it can mask variation in product prices and quality, making explicit consideration of this variation within aggregate commodities critical.

In order to account for the within-species price and quality variation that exists when purchases were aggregated, a Törnqvist (1936) price index was used. The expenditure share-weighted geometric price index defined as follows:

$$p_{nt}^{B} = \prod_{i=1}^{G} p_{\text{int}}{}^{w_i} \quad , \tag{2}$$

where p_{nt}^{B} is the index price of beef for household *n* in month *t*, p_{int} is the retail price of beef group *i* faced by the household *n* in month *t*, w_i is the beef group *i* share of total household expenditures on all groups of beef, and *G* is the number of groups specified for beef. The expenditure share is calculated as follows:

$$w_i = \frac{\overline{p}_i \overline{x}_i}{\sum_{j=1}^{G} \overline{p}_j \overline{x}_j} \quad , \tag{3}$$

where $\overline{p}_i$ is the average price of beef group *i* across the entire sample period and $\overline{x}_i$ is the average quantity purchased of beef group *i* across the entire sample period.[5] For beef, there are five subgroups with group 1 referring to ground beef, group 2 to roasts, group 3 to steaks, group 4 to frozen beef, and group 5 to other beef. A similar price index was calculated for the pork and

[5] The monthly retail price of each group is the observed group price if the household bought that group in month *t*. If the household did not purchase that group, then the predicted group price is used.

poultry aggregates as well, using four groups for pork and six groups for poultry. The summary statistics of the price and quantity indices are listed in table 2.

Following Piggott and Marsh (2004), food safety is measured using commodity-specific indices of newspaper articles. This specification of commodity-specific media indices allows the cross-commodity effects of food safety information to be explicitly modeled. Relevant articles from six major papers in each of four regions of the United States were found using the Lexis-Nexis search engine. The articles counts gathered from the regional newspaper search were aggregated to create indices that are 30-day rolling averages of the number of newspapers articles published during the previous two weeks.[6] The intuition for this specification of the indices is that each day of the month is a potential purchase occasion and the available and relevant information for each purchase occasion may change as time passes. At the beginning of the month, the articles most likely to impact household purchase decisions are the ones published in the latter half of the previous month. Over the course of the month, however, the most relevant food safety information becomes articles published in the current month. The rolling average specification captures this change in available information over the 30 day period. Figures 1-3 display the regional media indices for each of the three commodity groups.

Multiple Choice Models of Meat and Poultry Purchases

The data available for this study allow for investigation of multiple product purchase patterns. It is not only known if a household bought beef in a given month, but also if that household bought pork, poultry, all three meats, or none of them. Incorporating this information into a multinomial choice model will allow for any interactions among the three commodities

[6] The choice of a two week 'memory' for the media index is based on investigation of the household purchase data. These data indicate that, on average, fresh meat and poultry products are bought about 2 times per month.

and reveal the probabilities of a household purchasing each of the goods as well as combinations of them.

Logit Model Derivation

The household choice situation described above is estimated using a multinomial conditional logit model. The derivation of the logit model begins by specifying a random utility model where an individual, *n*, faces *J* alternatives. The utility a person gets from choosing one of the *J* alternatives is decomposed into an observed portion (i.e. known by the researcher), V_{nj} , and an unobserved portion, ε_{nj} , that is treated as random (Train, 2003). The utility of choosing a particular alternative is $U_{nj} = V_{nj} + \varepsilon_{nj}$, where ε_{nj} is distributed independently and identically as extreme value. Using Train's notation, the probability that individual *n* chooses alternative *j* is:

$$\begin{aligned} P_{nj} &= \Pr\text{ob}\left(V_{nj} + \varepsilon_{nj} > V_{ni} + \varepsilon_{ni}, \forall j \neq i\right) \\ &= \Pr\text{ob}\left(\varepsilon_{ni} < \varepsilon_{nj} + V_{nj} - V_{ni}, \forall j \neq i\right) . \end{aligned} \tag{4}$$

The portion of utility that is observable, V_{nj} , is specified as a linear function of parameters as follows:

$$V_{nj} = \alpha_j + \boldsymbol{\beta}'_n \mathbf{x}_n + \boldsymbol{\beta}'_j \mathbf{x}_j \ , \tag{5}$$

where α_j is an alternative-specific constant term for alternative *j*, $\mathbf{x}_n$ is a vector of characteristics describing household *n*, $\mathbf{x}_j$ is a vector of characteristics specific to alternative *j*, and the corresponding vectors of estimated coefficients are $\boldsymbol{\beta}_n$ and $\boldsymbol{\beta}_j$. If the utility of alternative *j* is greater than all other alternatives, then that will be the alternative that is chosen.

McFadden (1974) shows that if the error terms of the unobserved utility model are independent and identically distributed as Type I extreme value, then the probability of household *n* choosing any alternative *j* from *J* alternatives is:

$$P_{nj} = \frac{e^{V_{nj}}}{\sum_{j=1}^{J} e^{V_{nj}}} \ . \tag{6}$$

Estimation of this model requires that one of the *J* alternative-specific constants be normalized to zero. For the models described below, this is the ‘no meat or poultry was purchased’ option. Each of the alternative-specific constants are subsequently interpreted relative to this omitted option. The log likelihood function used in model estimation is as follows:

$$\underset{\max \beta}{\ln L}(\boldsymbol{\beta}) = \sum_{n=1}^{N} \sum_{j=1}^{J} \mathbf{d}_{nj} \ln P_{nj} \ , \tag{7}$$

where $\mathbf{d}_{nj}$ is an indicator vector with value equal to one if household *n* chose alternative *j* and zero otherwise.

Demand Model Specification

The multinomial conditional logit model is estimated using a choice set of eight different alternatives. The eight purchase alternatives a household faces in a given month are as follows: 1. beef; 2. pork; 3. poultry; 4. beef and pork; 5. beef and poultry; 6. pork and poultry; 7. beef, pork, and poultry; or 8. neither beef, pork, or poultry. Each household chooses one and only one of these alternatives.

The specification of the multinomial logit model follows the linear in parameters form shown in equation (5), which is comprised of parameters that vary across both alternatives and households. Using the media index as a proxy for food safety information, the model is specified as:

$$\begin{aligned} V_{nj} = \alpha_j &+ \sum_{k=1}^{3} \gamma_k Price_{nk} I_k^j + \sum_{k=1}^{3} \sum_{l=1}^{2} \nu_{lk} Price_{nl} I_l^j + \sum_{k=1}^{3} \beta_k M_{nk} + \sum_{k=1}^{3} \sum_{l=1}^{2} \phi_{lk} M_{nl} + \\ &\sum_{k=1}^{3} \eta_k Ed_n * M_{nk} + \sum_{k=1}^{3} \delta_k Age_n * M_{nk} + \sum_{k=1}^{3} \mu_k Urban_n * M_{nk} + \\ &\sum_{k=1}^{3} \rho_k Child_n * M_{nk} + \sum_{d=1}^{D} \sum_{k=1}^{3} \tau_k^d h_{nk}^d I_k^j \ , \end{aligned} \tag{8}$$

where α_j is the j^{th} alternative specific constant, I_k^j is an indicator function that is equal to 1 if commodity $k \in$ the j^{th} alternative and equal to 0 otherwise, I_l^j is an indicator function that is equal to 1 if commodity $l \in$ the j^{th} alternative and equal to 0 otherwise, h_{nk}^d is the d^{th} demographic characteristic of household *n* for commodity *k, d* indexes the total number of demographic variables included in the model, *k* and *l* each index the three commodities of interest, and *j* indexes the eight alternatives. The own-effect media index parameter, M_{nk}, is the interaction of the commodity- and region-specific media index variable for household *n* and the indicator function ($MI_{nk} * I_k^j$). This variable is the value of the media index for commodity *k* if the indicator function equals 1 for commodity *k* and equal to 0 otherwise. The cross-effect media index parameter, M_{nl}, is similarly defined as the interaction of the media index variable for household *n* and the indicator function ($MI_{nl} * I_l^j$). It equals the value of the media index for commodity *l* if the indicator function equals 1 for commodity *k* and 0 otherwise.

The variable *Price* used in the three binary choice models is a share-weighted geometric price index for each of the three commodities. The expected impact of *Price* on the probability of purchasing a commodity should be negative. That is, it would be expected that as the price of a good decreases, the probability of a household purchasing it would increase. The expected sign on the prices of the other goods in the model is positive, indicating that the three meat and poultry commodities are substitute goods.

The food safety information variable, *MI*, uses a commodity- and region-specific media index that is based on the number of food safety articles appearing in U.S. regional newspapers each month. The expected effect of an increase in the amount of food safety information available to the public would decrease the probability of purchase for some or possibly all households.

Interaction terms between the food safety variable and select demographic variables are included in the model. The education variable, *Ed*, used in the model is a binary variable equal to one if the head of household has a college or post college education and zero otherwise.[7] *Age* is measured as a binary variable equal to one if the head of household is aged 55 or older and zero otherwise. The effect of children, *Child*, is measured using a binary variable equal to one if children under the age of 18 are present in the household and zero otherwise. The final demographic variable used in the interaction terms with food safety information, *Urban*, is a binary variable indicating the location of the household in an urban area. *Urban* equals one if the household resides in an urban area and equals zero otherwise. The demographic variables for children and head of household aged 55 and older are used in the food safety interactions because these two groups of people are potentially the most susceptible to serious illness from foodborne pathogens. The education dummy variable is included to reflect possible differences in the gathering and processing of media information between households with and without college degrees. Finally, the urban location variable is interacted with food safety information to reflect possible differences information dissemination between urban and rural areas. For example, the limited availability of cable television or high speed internet connections in rural areas may impact the type and quantity of information that rural households will receive. There are no a priori expectations of the effect of the interaction terms on the probability of purchasing the three commodities. In addition to the interaction terms, the select household demographic

[7] Demographic information is provided for both the male and female in married households, but no designation is made for the primary person responsible for purchase decisions. Therefore, it was arbitrarily decided that the demographic information for the female head of household would be used in model estimation.

variables of *Ed*, *Age*, *Child*, and *Urban* also enter the model separately to account for the average effects of these characteristics.

Other variables included in the model are household specific. They include variables for household income, *Income*, and a quadratic household income term, $Income^2$. The expected effect of income on the probability of purchasing beef, pork, or poultry is positive, while the expected sign for the squared term is negative. This reflects a positive, but declining effect of income on the probability of meat and poultry purchases.[8] The size of the household is also included in the regression (*Hsize*) to account for possible differences in purchase patterns for large versus small families. Seasonal effects in the purchase patterns of households are accounted for using monthly dummy variables (*M1*-*M12*) with the parameter for December (*M12*) omitted from the regression. Annual effects in demand are also considered using year dummy variables (*Y1*-*Y8*) with the variable for 2003 (*Y6*) omitted from the regression. The expected signs for these variables are not known a priori, but are expected to vary by commodity. The geographic location of the household is included as binary variables for the central, western, and northeastern regions (*Central*, *West*, *Northeast*) with the variable for the southern region dropped from the regression. The race of the head of household is categorized into Caucasian, Hispanic, black, Asian, and Other race. The variables *Hispanic*, *Black*, *Asian*, and *Other* are included in the model and the variable *Caucasian* is omitted. The expected signs of the geographic location and race variables are not known a priori.

In addition to the household demographic and seasonal effects parameters, variables measuring purchase decisions made in previous time periods are included in the model. These

[8] The household income data were scaled by dividing each observation by 10,000. Therefore, the coefficients for the income variables can be interpreted as the change in the dependent variable caused by a change in total household income of $10,000.

state-dependent variables capture both inventory and purchase habit effects. The variables are specified following Moeltner and Englin (2004) and consist of total numbers of purchases (SD_{tp}) and total numbers of consecutive purchases (SD_{rp}). There are also corresponding totals for non-purchase (SD_{tnp}) and repeated non-purchase (SD_{rnp}). It is expected that households that consistently purchase one of the commodities are likely to purchase again in the next period, whereas households that rarely purchase meat or poultry are unlikely to purchase in the next period. By explaining the variability due to state dependence, second-order effects from food safety information may be more accurately identified.

Bundling the Alternatives

With the exception of the alternative-specific constants, the parameters in this model are specified such that alternatives are 'bundled' into the commodities of beef, pork, and poultry. For example, rather than estimating a price coefficient for each of the eight alternatives, one price parameter is estimated for each of the three commodities. This bundling specification alters the interpretation of the coefficients relative to the binary choice model. The estimated coefficient for the commodity-specific price coefficient, γ_k, can be interpreted as the effect of the price of the k^{th} commodity on the probability of choosing an alternative that includes that commodity. The corresponding interpretation of the cross-price coefficient, ν_k, is the effect of the price of commodity *l* on the probability of choosing an alternative that includes commodity *k*. Similar interpretations are made for both the own-media index and the cross-media index variables. The estimated coefficients for the media index, β_k, are interpreted as the effect of additional food safety articles pertaining to commodity *k* on the probability of purchasing that commodity. The interpretation of the cross-media index coefficient, ϕ_k, is the effect of an increase in the media index of commodity *l* on the probability of making a purchase that includes commodity *k*.

Interaction terms are specified between the food safety variable and the following four demographic variables: head of household with a college education or higher (*Ed*); head of household aged 55 or older (*Age*); location of the household in an urban area (*Urban*); and the presence of children in the household (*Child*). For example, the coefficient of the interaction term between the presence of children and the commodity-specific regional media index, ρ_k, would be interpreted as the effect of additional food safety articles pertaining to commodity *k* on the probability of purchasing commodity *k* for households with children present, relative to households without children. Interaction terms for the other demographic variables and the regional media index variable can be similarly interpreted. The model includes characteristics of the households that do not vary over the alternatives in the choice set, such as income, race, geographic location of the household, and seasonal effects (which are specific to the time period rather than the household, but still do not vary over alternatives). Commodity-specific coefficients are estimated for each household characteristic in the model, where k^{th} commodity-specific coefficient, τ_k^d, is interpreted as the effect of the d^{th} household characteristic on the probability of making a purchase that includes commodity *k*.

Alternative-specific constants, α_j, are estimated for each alternative, except alternative 8 (no beef, pork, or poultry purchased) which is dropped from the model for estimation. These parameters are not 'bundled' into commodity-specific coefficients, but rather are alternative-specific. The constants are interpreted as the average effect of non-included factors on the utility of an alternative relative to the omitted alternative of not purchasing beef, pork, or poultry. Summary statistics for the model parameters are given in table 3.

Estimation and Results

Computer limitations were met when attempting to estimate the 8-choice model using the full dataset of 1,604,746 biweekly household observations. Therefore, a bootstrap method is used to estimate the model by drawing, without replacement, 500 samples of the panel observations from 1,000 unique households from the full data sample. Each subsample is used to estimate the model and the resulting coefficients are saved. This procedure prevents the model results from being influenced by the specific sample that is used rather than the entire population of the Nielsen panel.

The estimated coefficients are calculated from the bootstrap dataset with *B* rows corresponding to the number of sample replications (500 in this study) and *K* columns corresponding to the number of parameters in the model. Parameter estimates are calculated as follows:

$$\bar{\beta} = \frac{1}{B}\sum_{b=1}^{B}\hat{\beta}_b \quad , \tag{9}$$

where $\hat{\beta}_b$ is the estimated parameter from the *b*th replication. To compute the variance of $\bar{\beta}$, note the following:

$$\begin{aligned} Var\left(\bar{\beta}\right) &= \frac{1}{B^2}\text{var}\left[\sum_{b=1}^{B}\hat{\beta}_b\right] \\ &= \frac{1}{B^2}\sum_{b=1}^{B}\text{var}\left(\hat{\beta}_b\right) \\ &= \frac{1}{B}\text{var}\left(\hat{\beta}_b\right) \ . \end{aligned} \tag{10}$$

Equation (10) is a result of bootstrap replications being independent, by construction, and the distribution of $\hat{\beta}_b$ being identical for all *b*.

The results given in table 4 indicate the price coefficients for beef, pork, and poultry all have the expected negative sign and are statistically significantly different from zero using a 95% confidence interval. The negative signs of all the price coefficients indicate that an increase in the price of any of the three meat commodities will decrease the likelihood of purchase, relative to purchasing no meat or poultry at all. Most of the cross-price coefficients are not statistically significantly different from zero. The two cross-price coefficients that are statistically significant are the effects of beef and poultry price on the probability of purchasing pork. Both of these coefficients have a positive sign, indicating that an increase in the price of beef or poultry will increase the probability of making a purchase that includes pork. The positive signs indicate that the beef and poultry are substitutes for pork, which is a more intuitive result than the negative cross-price coefficients estimated using the binary choice models.

The multinomial logit model results indicate that food safety information does have a statistically significant impact on the probability of purchasing fresh meat and poultry for certain households. The total marginal effect of food safety information for each type of household considered is the sum of the own-effect and the interaction effect.[9] The own-effects of food safety information are positive and statistically significant for both beef and pork. However, the interaction coefficients tend to be negative and higher in magnitude than the own-effect coefficients. A total negative effect for high education households suggests that these households are less likely to buy beef, pork, and poultry when the amount of food safety information increases. This negative effect also occurs for purchases of beef and poultry by elderly households and for pork and poultry purchases for households with children. The coefficient on beef purchases is positive and statistically significant for urban households, which is an

[9] Statistical significance of the individual coefficients for the own- and interaction effects does not imply that the total marginal effect is also statistically significant. Work is ongoing to calculate elasticities for the total effects and determine the corresponding statistical significance.

unexpected result. Over all, these results suggest food safety information impacts on purchase decisions differ, depending on the demographic characteristics of a given household.

Several of the household demographic parameters included in the model are statistically significantly different from zero. The households that are less likely to buy fresh beef and pork on a monthly basis are those with college educated heads and those with children present. However, households with heads age 55 and older are more likely to buy fresh beef and pork. Households in urban areas are more likely to purchase fresh poultry, relative to households in rural areas. The estimated coefficient for the effect of total household income is statistically significantly different from zero and has a positive sign for beef, pork, and poultry. The quadratic income parameter has a negative sign and is statistically significant for beef and pork. The opposite signs of the income parameters indicate that an increase in total household income will increase the probability that a household will purchase meat and poultry in a given month, but that effect tapers off for beef and pork as total household income increases. The effect household size has on the probability of purchase is positive and statistically significant for beef and pork, but not poultry.

The annual and monthly parameters were included in the model to control for year- and month-specific effects not otherwise specified in the model. The vast majority of these parameters are statistically significantly different from zero at the five percent level, indicating that time and season effects are important determinants in the probability of purchasing meat and poultry.

The parameters for regional effects (*Central, West, Northeast*) vary in sign and statistical significance across the three commodities. None of the regional parameters for beef were statistically significantly different from zero, which indicates that households in the west, central, and northeast regional are no more or less likely to purchase beef than households in the southern region. Household located in the western region are less likely to purchase pork, relative to households in the southern region. There is no statistically significant difference between households in the central and northeastern region and those located in the southern region. All of the regional coefficients for poultry were statistically significantly different from zero. Households located in the central region are less likely to purchase poultry than households in the southern region, while households in the western and northeastern regions are more likely to purchase poultry.

The estimated parameters for a Hispanic head of household indicate that these households are not statistically different from Caucasian households with regard to the probability of purchasing beef or pork. They are statistically significantly more likely to purchase poultry than Caucasian households. The coefficients for black heads of household are statistically significantly different from zero for beef, pork, and poultry. The signs of the coefficients indicate that these households are less likely to buy beef and more likely to buy pork or poultry than Caucasian households. The estimated parameters for Asian heads of household are statistically significantly different from Caucasian households for beef and pork, but the coefficient for poultry is not statistically significant. Asian heads of household are less likely to purchase beef and more likely to purchase pork than Caucasian households. Both the beef and pork parameters for the *Other* race are statistically significantly different from zero. The signs of the coefficients indicate that these households are less likely to purchase beef and more likely to purchase pork than Caucasian households.

The state dependent variables measuring the total number of past purchases and the total number of consecutive past purchases indicate a positive effect on the probability of purchase in the current period. Correspondingly, as the total number of periods (or total number of consecutive periods) with no purchase of meat or poultry increase, the probability of a household making a purchase declines. These state dependent variables are statistically significant, suggesting that discrete choice models that do not account for habit or inventory effects may be incorrectly attributing consumer behavior to other factors (e.g. food safety information).

The estimated coefficients for the alternative-specific constants are all statistically significantly different from zero at the 1 percent level and have a positive sign, except the parameter for the second alternative of purchasing pork only. The positive signs of these coefficients indicate that the average effect from non-included factors on the probability of households purchasing any of these combinations of meat and poultry is positive relative to purchasing none at all.

Conclusion

The objective of this study was to investigate if the quantity of food safety information available to consumers impacts their purchase decisions for fresh meat and poultry in a discrete choice framework. To estimate the interactions between beef, pork, and poultry purchase decisions in the presence of food safety information, a multinomial conditional logit model was employed. The specification of the 8-choice model is unique in the grouping of explanatory variables to isolate effects of the price, food safety information, and household characteristics into commodity-specific effects. The measure of food safety information used in the model is a commodity- and region-specific media index, which represents the general presence of food safety information available to the public in their regional newspapers. Interaction terms between the food safety information variables and select demographic characteristics were included to investigate any effects from food safety information that are specific to groups of households that may be considered high risk or differ in their access to or interpretation of food safety information.

Discrete choice models differ from marginal demand models in that it is not the quantity of meat and poultry purchased that is modeled, but instead the decision to purchase. It seems plausible that consumers may respond to a food safety announcement by choosing not to buy the commodity associated with the announcement. The results of the 8-choice model suggest that there are differences in avoidance behaviors between certain households and the general population. The households most likely to stop purchasing meat and poultry in a given two-week period, when the amount of food safety information increases, are households with college educated heads, elderly heads, and children. This result provides some assurance that food safety warning information provided by FSIS, the media, or others may be generating the intended effect of reducing exposure of high-risk groups to serious illness or death from foodborne pathogens.

References

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

Cox, T. and M. Wohlgenant. "Prices and Quality Effects in Cross-Sectional Demand Analysis." *American Journal of Agricultural Economics.* 68(1986): 908-919.

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

Huber, P. "The Behavior of Maximum Likelihood Estimates Under Nonstandard Conditions." In *Proceedings of the Fifth Berkeley Symposium in Mathematical Statistics*, Vol. 1. Berkeley: University of California Press, 1967.

McFadden, D. "Conditional Logit Analysis of Qualitative Choice Behavior." In *Frontiers in Econometrics*, ed. P. Zarembka, 105-142. New York: Academic Press, 1974.

Moeltner, K. and J. Englin. "Choice Behavior Under Time-Variant Quality: State Dependence Versus "Play-It-By-Ear" in Selecting Ski Resorts." *Journal of Business and Economic Statistics.* 22(2004): 214-224.

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

Schlenker, W. and S.B. Villas-Boas. "Consumer and Market Responses to Mad-Cow Disease." Department of Agricultural and Resource Economics, University of California-Berkeley. CUDARE Working Paper 1023, November 1, 2006. http://repositories.cdlib.org/are_ucb/1023/

Shimshack, J.P., M.B. Ward, and T.K.M. Beatty. "Mercury Advisories: Information, Education, and Fish Consumption." *Journal of Environmental Economics and Management*. 53(2007): 158-179.

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

Törnqvist, L. "The Bank of Finland's Consumption Price Index." *Bank of Finland Monthly Bulletin.* 10(1936): 1-8.

Train, K. *Discrete Choice Methods with Simulation*, 40-41. New York: Cambridge University Press, 2003.

White, H. "A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity." *Econometrica*, 48(1980):817-838.

Table 2 Summary Statistics of Quality-Adjusted Monthly Purchases and Price Indices

	Average	Minimum	Maximum	Std. Dev.
Beef				
Per Capita Quantity (lbs)	4.901	0	1,452.640	8.584
Geometric price index	3.046	0.170	8.006	0.493
Pork				
Quantity (lbs)	2.129	0	408.725	5.159
Geometric price index	2.480	0.055	10.795	0.476
Poultry				
Quantity (lbs)	3.101	0	1,911.060	6.468
Geometric price index	1.822	0.150	6.045	0.245

[a]Summary statistics based on 745,632 monthly observations.

Table 3 Summary Statistics of 8-Choice Model Variables

	Full Sample[a]			
	Average	**Minimum**	**Maximum**	**Std. Dev.**
Price				
Beef	3.209	0.577	12.638	0.562
Pork	2.534	0.627	12.219	0.509
Poultry	1.924	0.700	8.195	0.248
$MI_{(t-1)}$				
Beef	155.521	56.000	724.000	101.749
Pork	52.640	19.000	333.000	39.086
Poultry	201.551	98.000	738.000	110.039
$Recall_{(t-1)}$				
Beef	0.752	0	1	0.432
Pork	0.496	0	1	0.500
Poultry	0.631	0	1	0.483
Ed	0.393	0	1	0.488
Age	0.372	0	1	0.483
Urban	0.875	0	1	0.330
Child	0.296	0	1	0.456
Income	5.383	0.250	12.500	3.151
$Income^2$	38.910	0.062	156.250	43.477
Q1	0.250	0	1	0.433
Q2	0.250	0	1	0.433
Q3	0.250	0	1	0.433
Q4	0.250	0	1	0.433
South	0.366	0	1	0.482
Central	0.204	0	1	0.403
West	0.217	0	1	0.412
Northeast	0.213	0	1	0.410
Caucasian	0.766	0	1	0.423
Hispanic	0.076	0	1	0.264
Black	0.121	0	1	0.326
Asian	0.022	0	1	0.146
Other	0.016	0	1	0.126

[a] Number of observations in the full sample is 745,632

Table 4 Estimated Coefficients of 8-Choice Model

	Alternative	Bootstrap Sample		
		Coefficent	**Standard Error**	**t-statistic**
Price - Own	Beef	-1.143	0.007	-169.356
	Pork	-1.288	0.008	-159.253
	Poultry	-3.025	0.014	-216.064
Price - Beef	Pork	0.194	0.002	92.771
	Poultry	0.321	0.004	83.698
Price - Pork	Beef	0.086	0.002	35.194
	Poultry	0.038	0.004	9.019
Price - Poultry	Beef	0.058	0.002	27.538
	Pork	0.106	0.002	51.454
MI - Own	Beef	0.001	1.9E-04	2.918
	Pork	0.003	0.001	4.533
	Poultry	- 7.8E-05	2.9E-04	-0.269
MI - Beef	Pork	0.003	2.0E-04	13.089
	Poultry	-0.003	7.7E-05	-41.620
MI - Pork	Beef	0.001	8.3E-05	10.401
	Poultry	-0.003	9.4E-05	-31.629
MI - Poultry	Beef	-0.001	6.9E-05	-14.316
	Pork	0.007	2.1E-04	32.451
Ed*MI	Beef	-0.002	1.2E-04	-15.892
	Pork	-0.003	4.4E-04	-6.269
	Poultry	- 4.1E-04	1.6E-04	-2.636
Age*MI	Beef	-0.001	1.3E-04	-7.444
	Pork	0.001	4.9E-04	1.988
	Poultry	-0.001	1.8E-04	-4.923
Child*MI	Beef	0.000	1.4E-04	0.037
	Pork	-0.005	4.9E-04	-9.172
	Poultry	-0.002	1.9E-04	-9.052
Urban*MI	Beef	0.001	1.6E-04	5.196
	Pork	0.001	0.001	1.753
	Poultry	- 3.9E-04	0.000	-1.489
Ed	Beef	-0.044	0.002	-25.985
	Pork	-0.069	0.002	-34.476
	Poultry	0.058	0.002	24.802
Age	Beef	0.045	0.002	24.174
	Pork	0.116	0.002	52.820
	Poultry	-0.002	0.003	-0.968
Child	Beef	-0.003	0.002	-1.155
	Pork	-0.043	0.003	-15.951
	Poultry	0.045	0.003	14.682
Urban	Beef	0.092	0.002	39.130
	Pork	-0.012	0.003	-4.847
	Poultry	0.210	0.003	62.805
Income	Beef	0.114	0.001	109.656
	Pork	0.123	0.001	103.154
	Poultry	0.144	0.001	138.571
Income^2	Beef	- 3.5E-11	6.0E-13	-57.813
	Pork	- 4.0E-11	6.8E-13	-59.106
	Poultry	- 2.2E-11	6.1E-13	-36.210
Hsize	Beef	-0.061	0.001	-62.130
	Pork	-0.022	0.001	-24.549
	Poultry	-0.093	0.001	-101.446

Table 4 Estimated Coefficients of 8-Choice Model, cont.

		Bootstrap Sample		
	Alternative	**Coefficent**	**Standard Error**	**t-statistic**
Y1	Beef	-0.564	0.005	-113.906
	Pork	1.309	0.008	166.932
	Poultry	0.266	0.004	75.240
Y2	Beef	-0.487	0.005	-104.484
	Pork	0.106	0.003	37.810
	Poultry	-0.130	0.003	-49.715
Y3	Beef	-0.313	0.004	-89.063
	Pork	0.086	0.003	33.427
	Poultry	-0.009	0.002	-4.332
Y4	Beef	-0.224	0.003	-88.349
	Pork	0.123	0.002	50.515
	Poultry	-0.031	0.002	-15.884
Y5	Beef	-0.185	0.002	-84.233
	Pork	-0.020	0.002	-9.852
	Poultry	-0.106	0.002	-58.425
Y7	Beef	0.174	0.002	80.485
	Pork	0.131	0.002	57.068
	Poultry	0.265	0.002	114.809
Y8	Beef	0.051	0.002	22.973
	Pork	0.172	0.003	61.481
	Poultry	0.419	0.003	129.589
M1	Beef	0.110	0.002	47.203
	Pork	-0.265	0.002	-116.797
	Poultry	0.386	0.002	178.729
M2	Beef	0.045	0.003	16.958
	Pork	-0.253	0.002	-108.709
	Poultry	0.324	0.002	148.064
M3	Beef	-0.009	0.002	-4.004
	Pork	-0.094	0.002	-41.197
	Poultry	0.239	0.002	109.753
M4	Beef	0.057	0.002	25.852
	Pork	-0.231	0.002	-106.473
	Poultry	0.341	0.002	156.355
M5	Beef	0.148	0.002	69.584
	Pork	-0.261	0.002	-110.256
	Poultry	0.336	0.002	155.836
M6	Beef	0.142	0.002	67.281
	Pork	-0.226	0.002	-92.469
	Poultry	0.333	0.002	150.397
M7	Beef	-0.004	0.002	-1.816
	Pork	-0.191	0.003	-74.993
	Poultry	0.366	0.002	154.038
M8	Beef	0.065	0.002	30.449
	Pork	-0.155	0.002	-67.116
	Poultry	0.413	0.003	162.298
M9	Beef	0.078	0.002	34.809
	Pork	-0.122	0.002	-51.792
	Poultry	0.407	0.002	167.666
M10	Beef	0.110	0.002	52.055
	Pork	-0.153	0.002	-70.813
	Poultry	0.304	0.002	137.334
M11	Beef	0.066	0.002	32.555
	Pork	-0.081	0.002	-36.991
	Poultry	0.050	0.002	22.939

Table 4 Estimated Coefficients of 8-Choice Model, cont.

		Bootstrap Sample		
	Alternative	**Coefficent**	**Standard Error**	**t-statistic**
Central	Beef	0.009	0.002	4.566
	Pork	-0.042	0.002	-18.090
	Poultry	-0.099	0.002	-42.079
West	Beef	0.145	0.002	62.803
	Pork	-0.049	0.002	-20.825
	Poultry	0.451	0.003	170.400
Northeast	Beef	0.080	0.002	41.992
	Pork	0.073	0.002	34.503
	Poultry	0.097	0.002	49.577
Hispanic	Beef	-0.055	0.002	-23.873
	Pork	-0.063	0.003	-21.741
	Poultry	0.044	0.002	18.786
Black	Beef	-0.316	0.002	-143.562
	Pork	0.069	0.002	29.258
	Poultry	0.221	0.002	106.036
Asian	Beef	-0.183	0.005	-36.337
	Pork	0.076	0.006	12.849
	Poultry	-0.047	0.005	-8.909
Other	Beef	-0.175	0.006	-31.089
	Pork	-0.003	0.006	-0.422
	Poultry	0.041	0.006	6.943
$\mathbf{SD_{TP}}$	Beef	0.016	3.7E-05	420.527
	Pork	0.022	7.3E-05	306.188
	Poultry	0.020	5.2E-05	375.363
$\mathbf{SD_{TNP}}$	Beef	-0.012	3.7E-05	-326.332
	Pork	-0.009	3.5E-05	-243.074
	Poultry	-0.011	3.4E-05	-326.652
$\mathbf{SD_{RP}}$	Beef	0.101	2.3E-04	434.107
	Pork	0.099	0.001	170.773
	Poultry	0.103	3.8E-04	271.688
$\mathbf{SD_{RNP}}$	Beef	-0.078	1.5E-04	-521.143
	Pork	-0.048	1.1E-04	-447.683
	Poultry	-0.049	1.1E-04	-426.721
Constant	Alternative 1	1.280	0.019	66.088
	Alternative 2	0.387	0.018	21.710
	Alternative 3	2.552	0.022	116.351
	Alternative 4	2.921	0.029	99.380
	Alternative 5	4.837	0.034	143.788
	Alternative 6	3.945	0.032	123.089
	Alternative 7	6.841	0.043	158.849

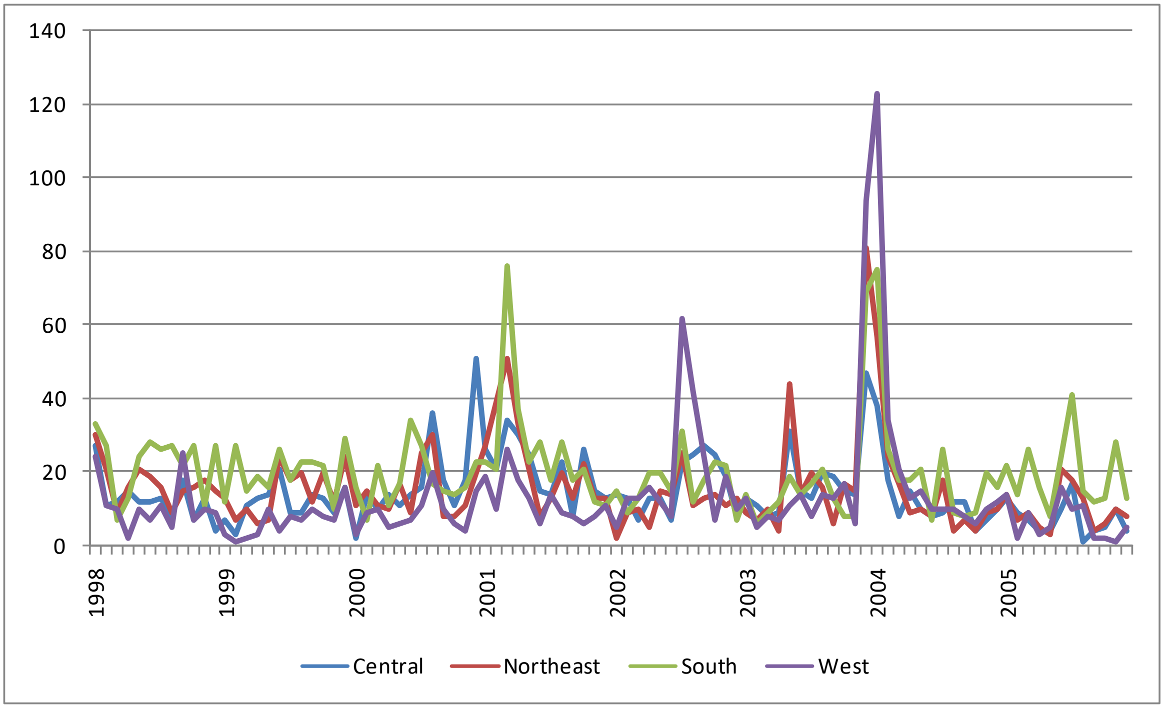

Figure 1 Beef Media Index by Region, 1998 to 2005

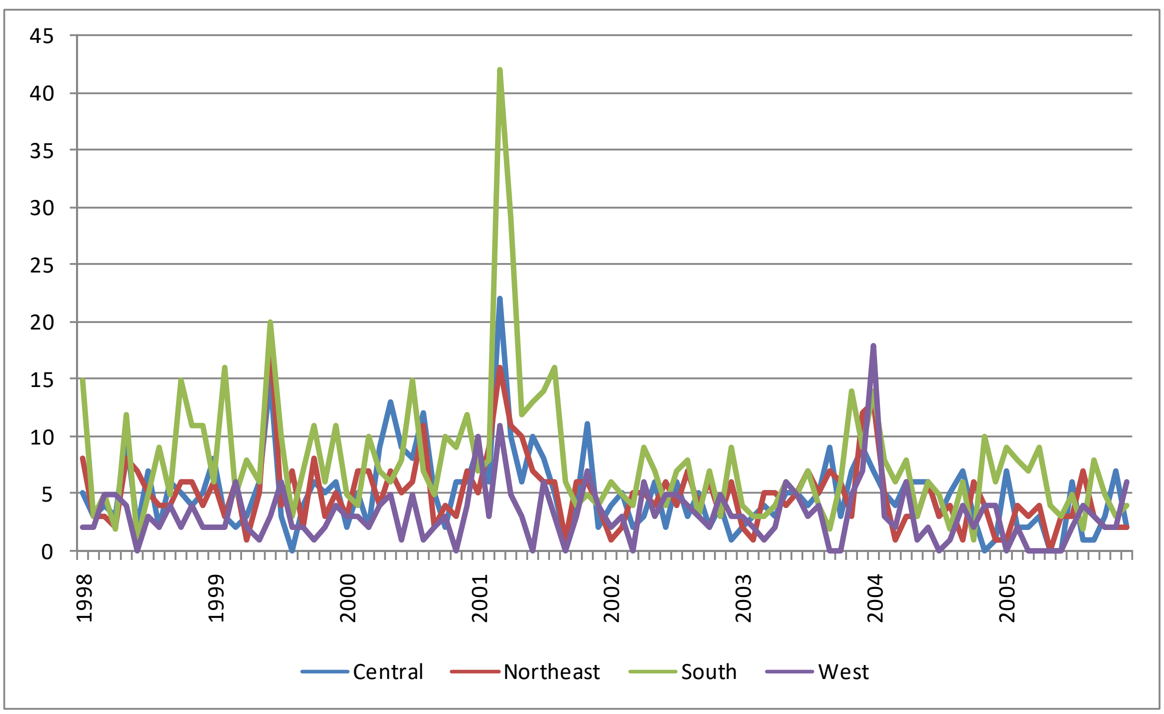

Figure 2 Pork Media Index by Region, 1998 to 2005

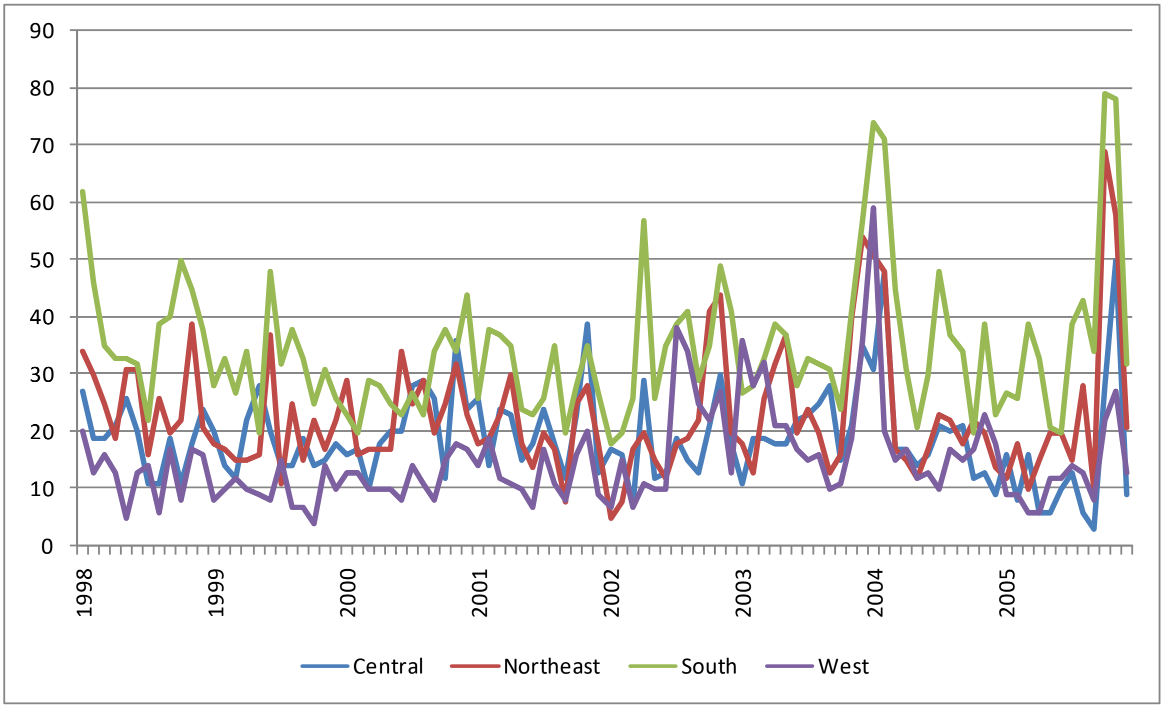

Figure 3 Poultry Media Index by Region, 1998 to 2005