SOBRE O VALOR ECONÔMICO DO SISTEMA DE IDENTIFICAÇÃO ANIMAL DOS EUA (NAIS): NOTÍCIAS A RESPEITO DO MAU DA VACA LOUCA AFETAM O CONSUMO DE CARNES?

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APRESENTAÇÃO ORAL

Comercialização, Mercados e Preços

Sobre o Valor Econômico do Sistema de Identificação Animal dos EUA (NAIS): Notícias a Respeito do Mau da Vaca Louca afetam o Consumo de Carnes?

Grupo de Pesquisa: Comercialização, Mercados e Preços.

Resumo

Esse artigo investiga os efeitos de notícias a respeito do mau da vaca louca ou BSE sobre o consumo das carnes bovina, suína e de aves nos EUA. Presume-se que o sistema nacional de identificação animal (NAIS) poderia em tese atenuar a percepção de risco dos consumidores sobre contrair o mau da vaca louca ao consumir carnes. Sistemas de equações de demanda são estimados incorporando-se, como *proxy* da percepção de risco do consumidor, três séries de índices de segurança do alimento separadamente construídos para as carnes bovina, suína e de aves considerando-se notícias veiculadas sobre BSE ou mau da vaca louca na imprensa escrita. Essas séries de índices são construídos somando-se o número de referências nos principais jornais norte americanos à problemas de *food safety* relacionados com cada uma das carnes. Utiliza-se o melhor modelo estimado, escolhido com base em testes de especificação, para se construir três cenários simulando-se respectivamente os casos em que o NAIS não está implementado, está implementado apenas para bovinos, e está implementado para suínos e bovinos. Utilizando-se as diferenças entre as receitas estimadas para cada cenário e para cada tipo de carne como uma medida do potencial ganho advindo da implementação do NAIS, conclui-se que o impacto do mau da vaca louca sobre o consumo de carnes nos EUA seria suficiente para cobrir os custos com a implementação do NAIS. Naturalmente, esse resultado fica condicionado a quanto dos ganhos com o

NAIS seriam transmitidos aos pecuaristas que são aqueles que, em última instância, arcarão com os custos de implementação e manutenção do NAIS.

Palavras-chaves: Sistema nacional de identificação animal, segurança do alimento, sistema de equações de demanda, setor de carnes, EUA.

On the Economic Value of the United States National Animal Identification System (NAIS): Does Mad Cow Disease News Impact Meat Consumption?

Abstract

This article investigates the willingness to pay for the National Animal Identification System (NAIS) in the US. We assume that with the NAIS in place, consumers' concerns about Bovine Spongiform Encephalopathy (BSE) or mad cow disease will be reduced and by inference consumers will be willing to pay for the NAIS. To estimate this level of willingness to pay a generalized almost ideal demand system including beef, pork and poultry is estimated, including indexes of perception of BSE based on news coverage of BSE in the U.S. We found that while news indexes of BSE were not individually significant, that they were jointly significant in test of preferred models. Using the preferred model, we constructed three scenarios on the basis of hypothesized impacts of the NAIS on consumers' food safety concerns about meat. Our conclusion is that the impact of BSE on consumer demand for meat was in itself sufficient to cover previously estimated costs of implementing the NAIS. However, it does so at the expense of pork and poultry which lose consumption relative to beef if the NAIS reduces consumers concerns as assumed. Other disease and pathogen potential would be expected to further enhance its value.

Key Words: Animal Identification System, Food Safety, System of Demand Equations, Meat Industry, USA.

1. Introduction

Meat safety systems have been designed assuming that most of the risk of food-borne illness originates from bacterial contamination. Hence, meat and poultry inspections in the United States have traditionally concentrated on detecting bacterial contamination in meat processing and packing plants and subsequent food preparation facilities (Bailey and Slade, 2004). However, with the advent of Bovine Spongiform Encephalopathy (BSE) in the United Kingdom in 1986 and the subsequent proof in laboratory of its linkage to fatal new variant Creutzfeldt-Jakob disease (vCJD) in humans in March 1996, the need for monitoring farm production has brought animal traceability systems to the forefront.

Unlike bacterial contamination, BSE originates exclusively at the farm level. The accepted theory is that the main vector of BSE transmission is the use of feeds made of meat and bones from contaminated animals (Nardone, 2003). This is the reason why, as a precautionary measure against BSE, the Food and Drug Administration (FDA) established on August 4, 1997, regulations that prohibit the feeding of most mammalian proteins to cattle in the U.S. (USDA/APHIS, 2007). Further, with the discovery of the first US case of Mad-Cow Disease on December 30, 2003, the Food and Drug Administration (FDA) proposed enhancing the existing ruminant feed ban by removing the exemption for blood products and banning plate waste and poultry litter to further reduce the risk of BSE spreading (Coffey et al., 2005).

The BSE incubation period ranges from 2 to 8 years and BSE infected animals cannot be detected until symptoms appear (e.g. animal inability to stand or walk), nor can they be confirmed until brain tissue is tested (Nardone, 2003). Thus, after December 30, 2003, the Food Safety Inspection Service (FSIS) of USDA issued rules designating certain tissues (e.g., small intestine and tonsils of all cattle; brains, eyes, spinal cord of cattle over 30 months of age) as specified risk materials (SRM) not allowed in human food (Coffey et al., 2005).

As a result of the fear of BSE, calls have increased throughout the supply chain for animal tracking in addition to quality control point specific strategies such as HACCP (Hazard Analysis and Critical Control Point) protocols. Possible benefits of animal tracking include improved access and stability for international trade (Brown et al., 2001). For instance, within days of the discovery of the first case of BSE in a cow in Washington state in 2003, 53 countries, including major markets such as Japan, Mexico, South Korea and Canada, banned imports of U.S. cattle and beef products (Coffey et al., 2005).

The implementation of a national animal identification system (NAIS) would allow for backward tracing all premises where an animal has passed during its life. In theory, this would make it possible to find and to test cohort animals for BSE, minimizing the chance of a BSE infected animal entering the human food chain. As a side benefit, the implementation of a NAIS would minimize the risk of products derived from animals with any other disease transmissible from animals to humans (zoonosis) entering the human food chain (Disney et al., 2001). Furthermore, a NAIS could give to the Food and Drug Administration (FDA) the necessary tools to more effectively ensure the compliance of feed manufacturers and farmers regarding the use of illegal drugs in meat products (Caporale et al., 2001).

Despite all potential benefits of the NAIS, it was the discovery of the first US case of Mad-Cow Disease or BSE on December 30, 2003 that accelerated the process for implementation of the US NAIS as one of the responses to that incident (Gray, 2004). For instance, the fear of BSE made the Animal and Plant Health Inspection Service (APHIS) announce, immediately after the first BSE case in the U.S., that they would conduct BSE tests on 'as many cattle as possible' from the population of high-risk cattle in a 12- to 18-month period beginning in June 2004. This measure represented more than a tenfold increase in testing relative to previous surveillance levels (Coffey et al., 2005).

Because of all reasons previously mentioned, we will put a special focus on the role played by BSE on consumers' concerns on eating meat in general and their linkages with the implementation of the U.S. NAIS.

The U.S. NAIS is being implemented with three components: premises identification, animal identification and animal tracking. The stated goal is to have 100% of premises identified and 100% of new animals identified by January 2009. The voluntary NAIS should be capable of identifying the herd mates of the suspect animals when there is a disease outbreak within 48 hours of discovery. However, estimates of costs of implementation are limited to rudimentary evaluations. Estimated costs will include all aspects of increased record keeping, including tagging methods, possible software investments, possible investments in readers if technologies such as radio frequency identification tags become the preferred method of identification, increased handling of livestock and other associated costs. Estimates found range from approximately $8/head for small scale cattle operations to as little as $2/head for larger operations (Dhuyvetter and Blasi spreadsheet template on beefstockerusa.com). The per head decline indicates the economies of scale which likely exist given fixed investment in readers, handling facilities, and record keeping systems. The question this paper seeks to address is whether there is evidence that the increased costs apparent for implementation of the NAIS can possibly be paid by consumers willing to pay for perceived improvements in safety and more rapid intervention in the supply chain. If not, the implementation will represent an additional cost burden on the animal agriculture sector.

2. BACKGROUND

Previous research on consumer willingness to pay for meat product traceability (Hobbs (2003) and Dickinson and Bailey (2002)) found conflicting results. Both studies used market experiments to determine whether consumers were willing to pay for traceability attributes. Dickinson and Bailey found that the consumers were willing to pay for a combination of traceability and attributes desired by consumers, but that traceability alone with no other factor yielded the lowest willingness to pay by consumers. Hobbs also conducted laboratory experiments of Canadian consumers and found limited or no willingness to pay for traceability per se.

An alternative approach to analyzing consumer willingness to pay is to use an event study methodology. Using this method actual food safety events are included in analysis methods to determine if market prices have been impacted by the events. For example, Thomsen and McKenzie (2001) measured the impact of product recalls on share prices for food companies affected. Other studies have tried to associate detected structural changes in commodity price time series with food safety crisis events. Carter and Smith (2004) combined ‘market experiments’ and econometric methods to develop a procedure capable of detecting and measuring the price impact of the U.S. corn supply contamination with genetically modified Starlink corn. However both studies examined specific events rather than broader ongoing events related to food safety as would be the case with an NAIS in place.

Another alternative approach to analyzing consumer willingness to pay is by using systems of demand equations to study the impact of very specific events on time and multi events on the demand for products. For example, Mazzocchi et al. (2004) employed a dynamic Almost Ideal Demand System (AIDS) for estimating the consumer welfare losses in Italy associated with withholding information on the potential link between BSE and a variant Creutzfeldt-Jakob disease (vCJD) in humans. In this type of study, the time of an impact is pre defined and imposed on the model by the researcher. The problem is that the data behavior is often used as a guide to defining the time of impacts. Besides the fact that this approach creates endogeneity with the data set in use, this type of procedure is suitable to studying a limited number of events over time. As further examples of studies using systems of demand equations that could be adapted to analyzing consumer willingness to pay, Burton et al. (1999) estimated a static modified version of the AIDS model, augmented for seasonal variation, trend and media effect to study the effect of noticed events associated with BSE on the market for beef in the U.K. Also, Verbeke and Ward (2001) estimated modified Almost Ideal Demand System (AIDS) incorporating explanatory variables on advertising expenditures for beef/veal and pork/mixture, and on number of negative news associated with beef/veal and pork in press. Their modified AIDS model allows for time varying intercepts in the expenditure share equations for each meat item. However, this type of modeling does not account for the fact that by modifying the intercept of the AIDS model makes estimates sensitive to the units by which quantities and prices are measured. Regarding this issue, Alston et al. (2001) shows that the use of Generalized Almost Ideal (GAI) model is a manner for flexibly and parsimoniously incorporating demand shifters in the Almost Ideal Demand System (AIDS) model and even though obtaining invariant estimates to changes in the units of measurement of quantities and prices. Piggott and Marsh (2004) used the GAI model that incorporates pre-committed quantities and varying intercepts for the expenditure share equations accounting for food safety events' impact on demand for each meat commodity over time. Their model's structure will be adapted to the current situation, focusing on news events regarding broader food safety events but also on events related only to BSE. Following is a description of the model originally developed by Piggott and Marsh (2004). Then the procedures of collecting news and market information on BSE and more general food safety concerns are described followed by the results interpreted in light of the implementation of the NAIS.

3. THE DEMAND MODEL

The Generalized Almost Ideal (GAI) model is recommended by Alston et al. (2001) as a manner for flexibly and parsimoniously incorporating demand shifters in the Almost Ideal Demand System (AIDS) model. According to them, the use of the GAI model allows for obtaining invariant estimates to changes in the units of measurement of quantities and prices, even when demand shifters are used.

The GAI model originates from a generalized expenditure function given as:

$$E(\mathbf{p},u)=\sum\nolimits_{i=1}^{N}p_ic_i+E^*(\mathbf{p},u) \tag{1}$$

Where, p_i is the price of good *i*, c_i is the pre-committed quantity with good *i*, $\mathbf{p}\in\Re^n_{++}$ is the vector of prices for a group of *N* commodities, $\sum\nolimits_{i=1}^{n}p_ic_i$ stands for the pre-committed expenditure on the *N* goods, and $E^*(\mathbf{p},u)$ denotes the supernumerary (beyond pre-committed) expenditure.

Applying Shephard's lemma to (1) and using dual identities yields the generalized Marshallian demand function as:

$$q_i=c_i+q_i^*(\mathbf{p},x^*)\quad\forall\ i \tag{2}$$

where, $q_i^*(\mathbf{p},x^*)$ is the Marshallian demand function for good *i*, $x^*=x-\sum\nolimits_{i=1}^{n}p_ic_i$ is the supernumerary expenditure, and x is the total expenditure on the *N* goods.

Pre-multiplying (2) by p_i / x yields the generalized Marshallian budget share equations as:

$$w_i = p_i c_i / x + x^* w_i^*(\mathbf{p}, x^*) / x \quad \forall\ i \tag{3}$$

Finally, the GAI model is obtained by assigning the supernumerary expenditure share $w_i^*(\mathbf{p}, x^*)$ to be the AIDS budget share equation given as:

$$w_i^*(\mathbf{p}, x^*) = \alpha_i + \sum\nolimits_{j=1}^{n} \gamma_{i,j} \ln p_j + \beta_i (\ln x^* - \ln a(\mathbf{p})) \quad \forall\ i \tag{4}$$

where $\ln a(\mathbf{p})$ is the translog price index given as:

$$\ln a(\mathbf{p}) = a_0 + \sum\nolimits_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum\nolimits_{i=1}^{n} \sum\nolimits_{j=1}^{n} \gamma_{i,j} \ln p_i \ln p_j \tag{5}$$

Demand shifters are incorporated in the GAI model to account for time trend, seasonal patterns and food safety indexes for meat, as proposed by Piggott and Marsh (2004). These demand shifters are introduced in the system of equations by modifying pre-committed quantities, redefining c_i's as:

$$c_i = c_{i,0} + \tau_i t + \sum\nolimits_{k=1}^{3} \theta_{i,k} D_k + \sum\nolimits_{m=0}^{L} \phi_{i,m} bf_{t-m} + \pi_{i,m} pk_{t-m} + \kappa_{i,m} py_{t-m} \quad \forall\ i \tag{6}$$

where t is a linear time trend, D_k are dummy variables accounting for seasonal patterns in quarterly meat demand, bf_{t-m} are news events indexes accounting for beef safety issues, pk_{t-m} are news events indexes accounting for pork safety issues, and py_{t-m} are news events indexes accounting for poultry safety issues.

In addition to initial impact of the event occurring, the duration of time that the event remains affecting the demand is unknown. Therefore, a search is going to be conducted to determine the length of L in (6).

In following, we will describe how we incorporate the restrictions originated from the consumer theory into the demand system and how we deal with the issue of autocorrelation problems that are common to exist in time series studies.

3.1. Homogeneity, Symmetry and Adding-up Constraints

Instead of testing for homogeneity of degree zero in prices and expenditure (absence of monetary illusion), and symmetry of the Slutsky substitution matrix, we impose such restrictions on the parameters of the system of demand equations as maintained hypotheses, as for instance Fisher et al. (2001) and Piggott and Marsh (2004) did. To do so we use equations (7) and (8). Finally, adding-up (budget shares must sum one) is guaranteed by imposing the restrictions given by (9).

$$\sum\nolimits_{j=1}^{n} \gamma_{i,j} = 0 \quad \forall\ i \tag{7}$$

$$\gamma_{i,j} = \gamma_{j,i} \quad \forall\ i, j \tag{8}$$

$$\sum\nolimits_{i=1}^{n} \alpha_i = 1,\ \sum\nolimits_{i=1}^{n} \beta_i = 0, \text{and } \sum\nolimits_{i=1}^{n} \gamma_{i,j} = 0 \quad \forall\ j \tag{9}$$

As the budget shares sum to unity, the error covariance matrix will be singular if the system is estimated with all equations included. The equation for poultry is deleted from the system to solve this problem.

3.2. Autocorrelation Corrections

Autocorrelation is a recurrent concern in econometric work using time series data. Even though parameter estimates are unbiased and consistent, they are not efficient under serial correlation. Further, the estimates of the variances of the estimated parameters are biased and inconsistent (Berndt, 1996 pp. 477). For instance, Fisher et al. (2001) impose autocorrelation corrections as a maintained hypothesis in their study. Despite this, in the present article, two types of autocorrelation corrections will be used to search for the best model specification.

Berndt and Savin (1975) showed that maximum likelihood estimation of a system of n-1 equations satisfies invariance, and respects the adding-up constraint if it is imposed that $\mathbf{1}'\bar{R}=0$, where **1** stands for a 1×n vector of ones, and $\bar{R}$ is an n×(n-1) matrix with elements $R_{i,j}$-$R_{i,n}$ where i=1,…,n, j=1,…,n-1 and n is used here to index the good whose share equation is deleted from the system of equations. Finally, $R_{i,j}$ are elements of an n×n autocovariance matrix R. Since in practice only n-1 equations are estimated in the system, let $\bar{R}^*$ be a matrix formed by the first n-1 rows of $\bar{R}$. It is the first n-1 elements of $\bar{R}^*$ not $\bar{R}$ or R that are estimated. Therefore, the constraint $\mathbf{1}'\bar{R}=0$ can be easily imposed after estimating the system of equations (Piggott et al., 1996). However, solving for individual $R_{i,j}$ is not important (Fisher et al., 2001).

Finally, autocorrelation corrections are introduced in the GAI model by transforming the original GAI model to:

$$W_t = \bar{R}^* W_{t-1} + \Upsilon_t C_t - \bar{R}^* \Upsilon_{t-1} C_{t-1} + \frac{x_t^*}{x_t} W_t^*(\mathbf{p}_t, x_t^*) - \bar{R}^* \frac{x_{t-1}^*}{x_{t-1}} W_{t-1}^*(\mathbf{p}_{t-1}, x_{t-1}^*) \qquad (10)$$

where $W_t = \begin{pmatrix} w_{b,t} \\ w_{p,t} \end{pmatrix}$, $\bar{R}^* = \begin{pmatrix} \rho_{b,b} & \rho_{b,p} \\ \rho_{p,b} & \rho_{p,p} \end{pmatrix}$, $\Upsilon_t = \begin{pmatrix} \frac{p_{b,t}}{x_t} & 0 \\ 0 & \frac{p_{p,t}}{x_t} \end{pmatrix}$, $C_t = \begin{pmatrix} c_{b,t} \\ c_{p,t} \end{pmatrix}$ with subscripts b, p and c denoting respectively beef, pork and poultry; $W_t^*(\mathbf{p}_t, x_t^*) = \begin{pmatrix} w_{b,t}^*(\mathbf{p}_t, x_t^*) \\ w_{p,t}^*(\mathbf{p}_t, x_t^*) \end{pmatrix}$; $w_{i,t}$ are observed shares, $p_{i,t}$ are observed prices at time t; $c_{i,t}$ are pre-committed quantities as given by (6); Finally, the supernumerary expenditure shares $w_{i,t}^*(\mathbf{p}_t, x_t^*)$ are assigned to be the AIDS budget equations as given by (4) with $x_t^* = x_t - \sum_{i=1}^{n} p_{it} c_{it}$.

Models have been estimated employing a Null $\bar{R}^*$ matrix (N-R$^{\text{matrix}}$) wherein all elements are zeros, a Diagonal $\bar{R}^*$ matrix (D-R$^{\text{matrix}}$) in which its elements must be equal across the main diagonal and all off main diagonal elements are zeros, and a Full $\bar{R}^*$ matrix (F-R$^{\text{matrix}}$) wherein every element may assume any Real value.

4. DATA AND ESTIMATION PROCEDURE

Two Full Information Maximum Likelihood (FIML) algorithms available in the software EViews have been used in the models estimation. These two algorithms are Berndt, Hall, Hall, and Hausman (BHHH) algorithm for maximum likelihood problems and the Marquardt algorithm (see technical details in Quantitative Micro Software, 2004). These algorithms have been combined with different starting values for the systems' parameters so that the chance of obtaining a global maximum for the multivariate likelihood function was improved. Finally, FIML's estimators are asymptotically efficient for linear and nonlinear simultaneous models under the assumption that contemporaneous errors are jointly normally distributed (Quantitative Micro Software, 2004).

We estimate the systems of demand equations using quarterly data from 1982(4) to 2006(4), providing a total of 97 observations. The length of the time series has been found to be suitable for obtaining models' estimates with desirable properties in statistical and economic terms. Furthermore, it incorporates the recent period after December 2003 when the first BSE case in the U.S. was announced.

The series for per capita meat quantities and retail prices are from the United States Department of Agriculture, Economic Research Service (USDA/ERS, 2005a and 2005b). Per capita quantities are quarterly per capita disappearance measured on a retail weight basis (pounds) for beef, pork and poultry calculated by following the following steps: First, this formula is applied: per capita disappearance of meat type i= (production + beginning stocks + imports - ending stocks -exports). Second, the disappearance on a carcass weight basis is converted to a retail weight basis and finally divided by population. Therefore, should an export ban occur (due to BSE, for example) then domestic disappearance will increase one for one by identity. Thus, it must be true that retail prices will drop to clear the market.

Prices are in dollars per pound for choice retail beef value, pork retail value, chicken as whole fryers retail price and turkey as average U.S. retail prices for whole frozen birds. As proposed by Piggott and Marsh (2004) the time series for poultry quantity is constructed by summing quarterly chicken and turkey quantities in pounds. Further, the time series for poultry price has been constructed summing chicken and turkey price series weighted by their respective quantities and divided by the poultry quantity series.

As presented in equation (6), food safety indexes can be incorporated in the system of demand by modifying pre-committed quantities. In following, we will discuss how we computed the food safety indexes employed in the present study.

4.1 Meat Safety News Events Indexes

Indexes have been computed by summing the number of references to meat safety issues found in the top fifty English language news articles in circulation in the US over the entire sample period. The academic version of the Lexis-Nexis has been used. We conducted the search so that indexes for beef, pork and poultry could be independently computed. References on food safety issues related to each type of meat have been separately taken and then summed to generate three quarterly indexes series one for each type of meat (e.g. beef, pork and poultry) over the entire sample period.

To account for meat safety issues related and not related to the NAIS, two sets of indexes have been created. First, in order to account for meat safety issues that are seemingly not related with the NAIS, a search has been conducted with these keywords: *food safety* or *contamination* or *product recall* or *outbreak* or *salmonella* or *listeria* or *E. coli* or *trichinae* or *staphylococcus* or *foodborne*. This search is narrowed to separately collect beef, pork and poultry information by conducting a search within the previously obtained results with these additional keywords: (a) *beef* or *hamburger*, (b) *pork* or *ham*, and (c) *chicken* or *turkey* or *poultry*. Second, accounting for the food safety issue that was the main reason behind the intent of putting the NAIS in place, a search was conducted for these keywords: *BSE* or *Bovine Spongiform Encephalopathy* or *Mad Cow*. Then the same steps taken to produce the three series of indexes (BSE-only indexes) for beef, pork and poultry of seemingly not related with the NAIS were also undertaken.

Finally, a third set of aggregate food safety indexes for each type of meat was obtained by summing the series of indexes seemingly not related to the NAIS and BSE-only food safety indexes, so called ‘related to the NAIS food safety indexes’.

First, we estimated all models using the three series of BSE-only food safety indexes. Figure 1 presents a plot of these three series of indexes for the period 1982:1 to 2006:4. Second, we also estimated all models using the three series with the aggregate food safety indexes. Ultimately, we proceed with comparisons of the results obtained with the two approaches, so that we could choose the best approach to use in the analysis of the value for the U.S. NAIS.

Figure 1. Beef, Pork, and Poultry Media Articles Mentioning BSE 1982:1 – 2006:4

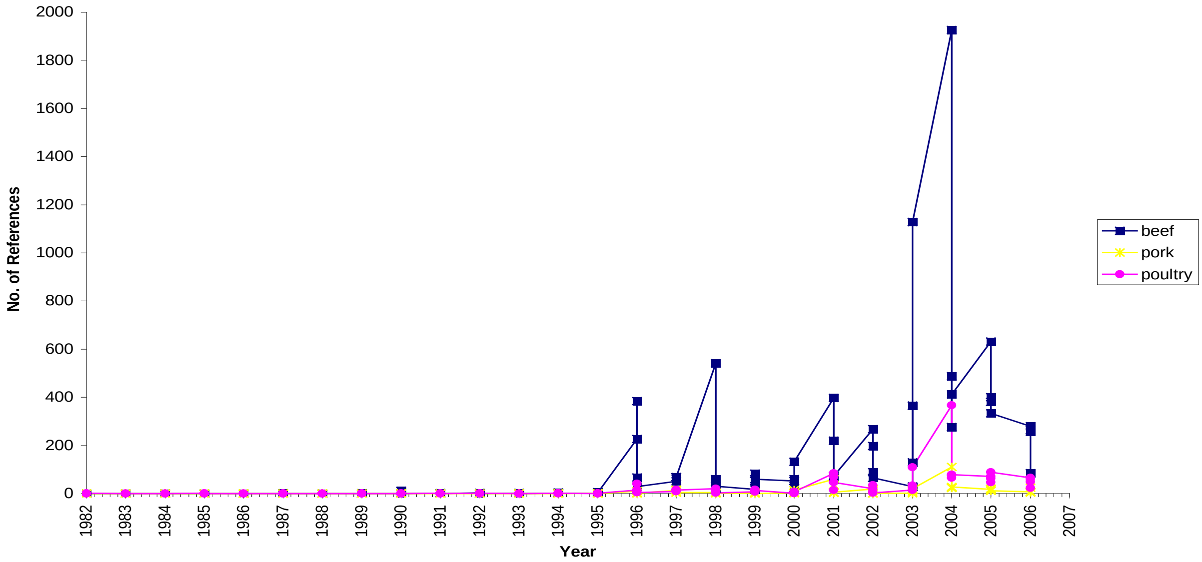

Figure 1 shows clear peaks in the time series for BSE-only food safety indexes for beef, pork and poultry. A peak for the beef series is observed in 1996 after scientists in Europe linked BSE in beef to a variant Creutzfeldt-Jacob disease (CJD) in humans. Also in April, 1996, in a ten-minute segment about mad cow disease, a very popular show in the U.S. called Oprah Show broadcasted for the U.S. consumers a very negative perspective on the risk of catching BSE by eating beef products. This show caused a very negative repercussion for beef producers leading the Texas cattle feeders association to sue Oprah. This incident caused another peak in news during the period 1997-1998 when the jury rejects lawsuit against Oprah. The third observed peak (2000-2001) in Fugure 1 is due to news about a consumer in Germany dying from eating beef and a mad-cow outbreak in this same country. The fourth and highest peak in the series occurs in 2003-2004 as a result of the announcement of the first case of BSE in the US in December 2003. Also, during this same period of time, the first case of BSE in Canada was announced in May 2003. Associated with the peak in 2005-2006 are the second and third cases of BSE in Canada that were respectively confirmed on January 2 and 11, 2005. Further, in June 2005, the United States Agriculture Secretary confirmed that a second American cow has tested positive for BSE. In March, 2006, a cow in Alabama became the third confirmed case of mad cow disease in the US since December 2003. Finally, we can notice that the series for BSE-only news for pork and poultry follow in general the peaks observed for the beef series but, as expected, with much lower intensity if compared with the peaks observed in the series of BSE-only food safety index for beef.

In following, we present the main results obtained with models estimations and select the estimated model to be used in the study of the evidence of willingness to pay for the U.S. NAIS.

5. HYPOTHESIS TESTING AND MODEL SELECTION

We conducted a series of tests in the search for the most suitable specification for the system of demand equations to be employed. In so doing, we have used adjusted Likelihood Ratio (LR) test because asymptotic test statistics such as the Likelihood Ratio (LR) without any adjustment are biased toward rejection of restrictions imposed on demand systems in finite samples (Moschini et al., 1994). Although there is no accepted way of sizing-correct the LR test, Moschini et al. (1994) found that the method proposed by Italianer (1985) performed well when applied to non-linear system of equations as it is the case in this study. Therefore, following Moschini et al. (1994), we use the adjusted likelihood ratio test whose test statistic is given by the following formula:

$$LRs = ((MT - 0.5((k^u + k^r) - M(M+1)))/MT)LR \qquad (11)$$

where $LR = 2(LL^U - LL^R)$ is the usual likelihood ratio, LL^U and LL^R are the maximized log-likelihood value in the unrestricted and restricted models; M is the number of estimated equations; T is the sample size, k^u is the number of parameters in the unrestricted model and k^r is the number of parameters in the restricted model.

This adjusted likelihood test statistic follows an asymptotic Chi-squared distribution with degrees of freedom equal to the number of added variables, under the null hypothesis that the additional set of regressors is not jointly significant. All the tests conducted in the present study are respectively reported in Table 1 for the models estimated with BSE-only food safety indexes and in Table 2 for the models estimated with the aggregate food safety indexes. We discuss each of these tables in following.

Table 1. Hypothesis Test for Significance of the BSE-only Food Safety Indexes and Autocorrelation Corrections

	Lag Lengths for Food Safety				Autocorrelation Corrections		
Model	H_0: *No-FS* H_a: *L*=0	H_0: *L*=0 H_a: *L*=1	H_0: *L*=1 H_a: *L*=2	***Model***	H_0: N-R^{matrix} H_a: D-R^{matrix}	H_0: D-R^{matrix} H_a: F-R^{matrix}	H_0: N-R^{matrix} H_a: F-R^{matrix}
N-R^{matrix}	18.373*	15.330	19.241*	*No-FS*	20.308*	5.062	27.540*
D-R^{matrix}	17.576*	21.246*	10.509	*L*=0	20.812*	3.239	23.871*
F-R^{matrix}	15.677	24.355*	6.499	*L*=1	25.534*	6.501	31.810*
				L=2	15.690*	2.597	18.125*
Df	9	9	9		1	3	4
$\chi^2_{0.05,df}$	16.919	16.919	16.919		3.841	7.815	9.488

Notes: An *denotes the rejection of H_0 at the 5% level, *L* stands for the lag length of food safety indexes included in models, *No-FS* indicates a model estimated with no food safety indexes included, *df* denotes degrees of freedom. Reported test statistics are adjusted likelihood ratio tests calculated by adjusting the usual *LR* test statistic according to equation (11) in the text.

Table 2. Hypothesis Test for Significance of the Aggregate Food Safety Indexes and Autocorrelation Corrections

	Lag Lengths for Food Safety					Autocorrelation Corrections		
Model	H_0: *No-FS* H_a: *L*=0	H_0: *No-FS* H_a: *L*=1	H_0: *L*=0 H_a: *L*=1	H_0: *L*=1 H_a: *L*=2	***Model***	H_0: N-R^{matrix} H_a: D-R^{matrix}	H_0: D-R^{matrix} H_a: F-R^{matrix}	H_0: N-R^{matrix} H_a: F-R^{matrix}
N-R^{matrix}	19.512*	42.019*	22.397*	11.892	*No-FS*	20.308*	5.062	27.540*
D-R^{matrix}	7.925	34.029*	23.951*	5.612	*L*=0	10.285*	7.448	17.661*
F-R^{matrix}	10.484	33.736*	22.879*	4.227	*L*=1	11.373*	6.426	17.710*
					L=2	4.678*	4.932	9.580*
df	9	18	9	9		1	3	4
$\chi^2_{0.05,df}$	16.919	28.869	16.919	16.919		3.841	7.815	9.488

Notes: An *denotes the rejection of H_0 at the 5% level, *L* stands for the lag length of food safety indexes included in models, *No-FS* indicates a model estimated with no food safety indexes included, *df* denotes degrees of freedom. Reported test statistics are adjusted likelihood ratio tests calculated by adjusting the usual *LR* test statistic according to equation (11) in the text.

First, we conducted tests for detecting first order autocorrelation in the models estimated with BSE-only food safety indexes as presented in Table 1 and for the models estimated with the aggregate food safety indexes, as presented in Table 2. Because the qualitative results are the same, regardless of the table being used, we will discuss the results for Table 1 and 2 together. For the four classes of models grouped according to the inclusion or not of the food safety indexes and to the lag length for food safety indexes (the three last columns in Table 1 and Table 2), we found that[1] D-R^{matrix} $\succ$ N-R^{matrix}, D-R^{matrix}$\succ$F-R^{matrix}, and F-R^{matrix}$\succ$N-R^{matrix}. These results imply that the final order of preferences for the autocorrelation corrections is D-R^{matrix}$\succ$F-R ^{matrix}$\succ$N-R^{matrix}. In other words, first order autocorrelation in the residuals is detected in all models, but a $\overline{R}^*$ matrix with identical elements in its diagonal is adequate to correct for the detected autocorrelation.

Once we found it is necessary to use a D-R^{matrix} to correct for autocorrelation in the models, we investigated the appropriate lag length for food safety indexes only within this group of models. Therefore, examining the results reported in Table 1 from column 2 to column 4 for the models estimated with a D-R^{matrix} we observe that H_0: *No-FS* is rejected against H_a: L=0, H_0: L=0 is rejected against H_a: L=1 and H_0: L=1 is not rejected against H_a: L=2. Hence, the order of preferences for models estimated with a D-R^{matrix} and with BSE-only food safety indexes is L=1$\succ$ L=0 $\succ$No-FS$\succ$ and L=1$\succ$$L$=2. In other words, for the models estimated with BSE-only food safety indexes we should prefer the one estimated with L=1 and a D-R^{matrix} to correct for autocorrelation.

Following the same step for the models estimated with the aggregate food safety indexes we look at the results for the models estimate with a D-R^{matrix} reported in Table 2 from column 2 to column 5. First, despite the fact that H_0: *No-FS* is not rejected against H_a: L=0, we found that H_0: No-FS is rejected against H_a: L=1. Therefore, we conclude that the coefficients of the current and one period lagged food safety indexes are jointly statistically significant from zero. Second, we observe that H_0: L=0 is rejected against H_a: L=1 and H_0: L=1 is not rejected against H_a: L=2 for the models estimated with a D-R^{matrix}. As a consequence of this, the order of preferences for the lag length for food safety indexes in the models is given as L=1$\succ$No-FS$\succ$$L$=0 and L=1$\succ$$L$=2. The main implication of these findings is that the effect of food safety information on demand for meat lasts one period (L=1).

Summing up, regardless of the food safety indexes being used (BSE-only food safdty indexes or aggregate food safety indexes), the preferred model is the one estimated with a D-R^{matrix} to correct for first-order autocorrelation and with the inclusion of food safety variables lagged up to one time period (L=1).

Having selected the two preferred models, we then proceed comparing the results obtained with each of them. First, based on the maximum log likelihood values obtained for the model estimated with BSE-only food safety indexes (787.7828) and with aggregate food safety indexes (783.8719) we tend towards choosing the first model specification. Furthermore, it is also true that the model estimated with BSE-only food safety indexes presented a higher number of individually statistically significant coefficients than the other model. Finally, we also found that the model estimated with the not related to the NAIS aggregate food safety indexes (e.g. maximum log likelihood equals 784.4289) presented worse results than the model estimated with BSE-only food safety indexes. Therefore, we present in Table 3 the estimates for the preferred model estimated with the BSE-only food safety indexes.

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[1] The symbol $\succ$ means “is preferred to”.

Table 3. Estimates for the Model Estimated with a Diagonal $\overline{R}^{*}$ matrix and with Current and One Period Lagged BSE-only Food Safety Indexes

Parameter		Parameter		Parameter	
ρ	0.5613**	$\theta_{c,2}$	-1.5780**	$\kappa_{b,0}$	-0.0079
	(0.1149)		(0.3678)		(0.0124)
$c_{b,0}$	13.0351**	$\theta_{c,3}$	-1.2451**	$\kappa_{b,1}$	-0.0252
	(2.9350)		(0.2465)		(0.0167)
$c_{p,0}$	9.4978**	$\phi_{b,0}$	-3.14E-05	$\kappa_{p,0}$	-0.0136
	(1.9277)		(-0.0015)		(0.0098)
$c_{c,0}$	3.4819	$\phi_{b,1}$	0.0017	$\kappa_{p,1}$	-0.0265**
	(12.3098)		(0.0023)		(0.0129)
τ_b	0.0485*	$\phi_{p,0}$	0.0007	$\kappa_{c,0}$	-0.0548*
	(0.0276)		(0.0015)		(0.0304)
τ_p	0.0395**	$\phi_{p,1}$	0.0027**	$\kappa_{c,1}$	-0.0876
	(0.0137)		(0.0012)		(0.0538)
τ_c	0.1891**	$\phi_{c,0}$	3.71E-0.5	α_0	10.6067
	(0.0487)		(0.0044)		(21.0068)
$\theta_{b,1}$	-0.1177	$\phi_{c,1}$	0.0146**	α_b	3.3978
	(0.2104)		(0.0059)		(7.1118)
$\theta_{b,2}$	0.8310**	$\pi_{b,0}$	0.0102	α_p	-0.3876
	(0.2331)		(0.0290)		(1.1618)
$\theta_{b,3}$	0.9808**	$\pi_{b,1}$	-0.0048	γ_{bb}	1.5990
	(0.1998)		(0.0327)		(3.6041)
$\theta_{p,1}$	-1.0873**	$\pi_{p,0}$	0.0070	γ_{bp}	0.0435
	(0.1070)		(0.0192)		(0.6347)
$\theta_{p,2}$	-1.3280**	$\pi_{p,1}$	-0.0035	γ_{pp}	-0.1752
	(0.1214)		(0.0249)		(0.2304)
$\theta_{p,3}$	-1.0866**	$\pi_{c,0}$	0.0544	β_b	0.4179
	(0.0930)		(0.0666)		(0.2854)
$\theta_{c,1}$	-2.3600**	$\pi_{c,1}$	-0.0050	β_p	-0.0639
	(0.2706)		(0.0722)		(0.0619)
Log Likelihood	787.7828	R^2 beef	0.9777	R^2 pork	0.9060

Notes: numbers in parentheses are the estimated standard errors. An **denotes a coefficient statistically significantly different form zero at the 5% level by the z-test. An *denotes a coefficient statistically significantly different form zero at the 10% level by the z-test. $c_{b,0}$, $c_{p,0}$ and $c_{c,0}$ are intercepts and τ_b, τ_p, and τ_c, are time trend coefficients in the modified pre-committed quantities respectively for beef, pork and poultry. $\theta_{b,1}$, $\theta_{b,2}$, and $\theta_{b,3}$ are coefficients of the first, second and third seasonal dummies in the modified pre-committed quantity of beef. $\theta_{p,1}$, $\theta_{p,2}$, and $\theta_{p,3}$ are coefficients of the first, second and third seasonal dummies in the modified pre-committed quantity of pork. $\theta_{c,1}$, $\theta_{c,2}$, and $\theta_{c,3}$ are coefficients of the first, second and third seasonal dummies in the modified pre-committed quantity of poultry. $\phi_{b,0}$, $\pi_{b,0}$, and $\kappa_{b,0}$ are respectively the coefficients of beef, pork and poultry food safety indexes with zero lag in the modified pre-committed quantities of beef. $\phi_{b,1}$, $\pi_{b,1}$, and $\kappa_{b,1}$ are respectively the coefficients of beef, pork and poultry food safety indexes with one lag in the modified pre-committed quantities of beef. $\phi_{p,0}$, $\pi_{p,0}$, and $\kappa_{p,0}$ are respectively the coefficients of beef, pork and poultry food safety indexes with zero lag in the modified pre-committed quantities of pork.$\phi_{p,1}$, $\pi_{p,1}$, and $\kappa_{p,1}$ are respectively the coefficients of beef, pork and poultry food safety indexes with one lag in the modified pre-committed quantities of pork. $\phi_{c,0}$, $\pi_{c,0}$, and $\kappa_{c,0}$ are respectively the coefficients of beef, pork and poultry food safety indexes with zero lag in the modified pre-committed quantities of poultry. $\phi_{c,1}$, $\pi_{c,1}$, and $\kappa_{c,1}$ are respectively the coefficients of beef, pork and poultry food safety indexes with one lag in the modified pre-committed quantities of poultry. α_0 is the intercept of the translog price index. α_b and α_p are the intercepts respectively of the beef and pork share equations. γ_{bb}, γ_{bp}, and γ_{pp} are coefficients of the AIDS budget share equations. β_b and β_p are coefficients of the natural log of the real expenditure with meat, respectively in beef and pork AIDS budget share equations.

Results presented in Table 3 show that all intercept estimates of modified pre-committed quantities respectively for beef, pork and poultry ($c_{b,0}$, $c_{p,0}$ and $c_{c,0}$) are nonnegative, as a priori expected. Except for $c_{c,0}$, they are also individually statistically different from zero by the z-test at 5%. Time trend coefficients ($\tau_i \ \forall i$) are all statistically significantly different from zero, confirming the need for including the time trend variables in the models. With the exception of the coefficient for the first quarter dummy for beef $\theta_{b,1}$, all remaining seasonal coefficients ($\theta_{i,1}, \theta_{i,2}, \theta_{i,3} \quad \forall i$) are statistically different from zero by the z-test at 5% of significance across models.

Current own BSE-only food safety estimated coefficients for beef $(\phi_{b,0})$ and for poultry $(\kappa_{c,0})$ are both negative indicating that BSE references in the news under the context of beef and poultry respectively depress the pre-committed quantities for these two meats. It should be noticed that $\kappa_{c,0}$ is the only own BSE-only food safety coefficient individually statistically significant.

The only two cross-commodity food safety coefficient individually statistically different from zero are $\phi_{p,1}$ and $\phi_{c,1}$. Since both are positive we can conclude that BSE news in the beef context increases pre-committed quantities for pork and poultry in the quarter following the news report (spillover effect). In fact Except for $\phi_{p,1}$ and $\phi_{c,1}$, all the other food safety coefficients do not individually statistically differ from zero by the z-test at 10%. Despite this, BSE-only food safety indexes are kept in the model because they are jointly statistically different from zero as shown before with a series of specification tests used to find the appropriate lag length for BSE-only food safety indexes. Finally, the preferred model shows very high coefficient of determination (R^2) for the estimated equations for beef and pork, indicating that they fit the data well.

6. EXPENDITURE, PRICES AND FOOD SAFETY INDEXES ELASTICITIES

We show now the formulas used to calculate elasticities for the Generalized AIDS model estimated with autocorrelation correction (D-R^{matrix}) and contemporaneous food safety indexes that is the preferred model according to our previous analysis. The final computed elasticities are the sample means of the elasticities computed at every time observation using predicted expenditure shares.

The Marshallian price elasticities are calculated according to equation (12). These elasticities indicate the percentage change in the demand of the good *i* for each 1% increase in the price of a good *j*, holding constant group expenditure x_t, and all other prices p_{it}.

$$\eta_{i,j} = \frac{1}{x_t w_{i,t}} \left\{ c_{i,t} p_{i,t} (1 - w_{i,t}^*) + x_t^* \left[\gamma_{i,j} - \beta_i \left(\frac{c_{i,t} p_{i,t}}{x_t^*} + \alpha_j + \sum_{k=1}^{n} \gamma_{j,k} \ln p_{k,t} \right) \right] \right\} - \delta_{i,j} \quad \forall i, j \qquad (12)$$

where $w_{i,t}$ is the predicted value for the GAI share equation i at time t; $w_{i,t}^*$ stands for the predicted value for the AIDS share equation *i* at time *t*; and $\delta_{i,j}$ is the Kronecker delta ($\delta_{i,j} = 1$ for $i = j$, otherwise 0).

Expenditure elasticity of demand given by (13) indicates the expected percentage change in the demand of the good *i* for each 1% increase in the group expenditure x_t, holding constant all prices.

$$\eta_{i,x} = 1 + \frac{\frac{1}{x_t}\left[(x_t - x_t^*)w_{i,t}^* - p_{i,t}c_{i,t}\right] + \beta_i}{w_{i,t}} \quad \forall i \qquad (13)$$

From equation (13), it is possible to see that by the GAI model the ith good will be either a luxury good ($\eta_{i,x} > 1$) or a necessity ($\eta_{i,x} < 1$) over the whole expenditure range.

Hicksian or compensated price elasticities of demand are calculated using the elasticity form of the Slutsky equation given as (14).

$$\varepsilon_{i,j} = \eta_{i,j} + w_j \eta_{i,x} \quad \forall i, j$$

(14)

Compensated elasticities indicate the percentage change in the demand of a good *i* for each 1% increase in the price of good *j*, holding constant group expenditure (x_t,) and all other prices p_{it}. The only difference with the Marshallian price elasticity is that enough income compensation is assumed to occur after an increase in price of good *j* such that a representative consumer can return to her/his original level of utility before p_{jt} increases. As a consequence of the assumption that consumer's consumption set is convex, own-price Hickisian elasticities must be non positive. In other words, whenever the price of a good *i* increases the compensated demand for this same good should decrease as a result of the substitution effect.

Marshallian demand meat safety elasticities are provided for the direct (on pre-committed quantities demanded) and total (on the total quantities demanded) effects on consumption. Direct elasticities measure the percentage change in pre-committed quantity of the good *i* in response to a 1% increase in a food safety index (Piggott and Marsh, 2004). Food safety elasticities (Current Direct effect) are given as (15). We do not present the formulas for their lagged version because it is straightforward to obtain those from the formulas presented in (15).

$$\omega_{i,bf_t} = \frac{\phi_{i,0} bf_t}{c_{i,t}} \quad \forall i$$

$$\omega_{i,pk_t} = \frac{\pi_{i,0} pk_t}{c_{i,t}} \quad \forall i \qquad (15)$$

$$\omega_{i,py_t} = \frac{\kappa_{i,0} py_t}{c_{i,t}} \quad \forall i$$

The a priori expectation is that the own direct demand response to BSE news should be negative for beef. In other words, BSE news related to beef are expected to reduce the pre-committed quantity for this good. But it is not clear how consumers will react regarding BSE news in the context of poultry and pork. We also expect that the cross effect of BSE news in the beef context will increase the pre-committed quantities for poultry and pork since substitution is expected to occur in this case.

Total BSE-only current food safety elasticities (current total effect) include the sum of the direct and indirect elasticity given by (16). We do not present the formulas for the lagged BSE-only food safety elasticities because it is straightforward to obtain those from the formulas presented in (16).

$$\begin{aligned}
\Psi_{i,bf_t} &= \omega_{i,bf_t}\frac{p_{i,t}c_{i,t}}{w_{i,t}x_t} + \left(1+\frac{\beta_i}{w^*_{i,t}}\right)\frac{bf_t(-p_{b,t}\phi_{b,0} - p_{p,t}\phi_{p,0} - p_{c,t}\phi_{b,0})}{x^*_t}\frac{w^*_{i,t}}{w_{i,t}x_t} \quad \forall i \\
\Psi_{i,pk_t} &= \omega_{i,pk_t}\frac{p_{i,t}c_{i,t}}{w_{i,t}x_t} + \left(1+\frac{\beta_i}{w^*_{i,t}}\right)\frac{pk_t(-p_{b,t}\pi_{b,0} - p_{p,t}\pi_{p,0} - p_{c,t}\pi_{c,0})}{x^*_t}\frac{w^*_{i,t}}{w_{i,t}x_t} \quad \forall i \qquad (16) \\
\Psi_{i,py_t} &= \omega_{i,py_t}\frac{p_{i,t}c_{i,t}}{w_{i,t}x_t} + \left(1+\frac{\beta_i}{w^*_{i,t}}\right)\frac{py_t(-p_{b,t}\kappa_{b,0} - p_{p,t}\kappa_{p,0} - p_{c,t}\kappa_{c,0})}{x^*_t}\frac{w^*_{i,t}}{w_{i,t}x_t} \quad \forall i
\end{aligned}$$

Our a priori expectation regarding the signals of the total BSE-only food safety elasticities is that, the final demanded quantities for beef should decrease with more BSE news in the context of beef whereas the demand for pork and poultry should increase with more BSE news in the context of beef.

We present in following the estimates for all the elasticities discussed in this subsection.

6.1 Elasticity Results for the Preferred Model

Estimated elasticities are presented in Table 4. The following discussion is based on the values presented there.

Table 4. Estimated Price, Expenditure, and Food Safety Elasticities for the Generalized AIDS Model Estimated with a Diagonal $\overline{R}^{*}$ matrix and with Current and One Period Lagged Food Safety Indexes

Marshallian Price Elasticities		**Expenditure Elasticities**		**Hicksian Price Elasticities**	
$\eta_{b,b}$	-0.788	$\eta_{b,x}$	1.077	$\varepsilon_{b,b}$	-0.235
$\eta_{b,p}$	0.532	$\eta_{p,x}$	0.772	$\varepsilon_{b,p}$	0.843
$\eta_{b,c}$	0.388	$\eta_{c,x}$	1.018	$\varepsilon_{b,c}$	0.600
$\eta_{p,b}$	0.892			$\varepsilon_{p,b}$	1.282
$\eta_{p,p}$	-0.513			$\varepsilon_{p,p}$	-0.291
$\eta_{p,c}$	0.561			$\varepsilon_{p,c}$	0.720
$\eta_{c,b}$	0.571			$\varepsilon_{c,b}$	1.070
$\eta_{c,p}$	0.308			$\varepsilon_{c,p}$	0.603
$\eta_{c,c}$	-0.408			$\varepsilon_{c,c}$	-0.183

Food Safety Indexes Elasticities

Current Direct Effect		Lagged Direct Effect	
$\omega_{b,bf(t)}$	-0.0002	$\omega_{b,bf(t-1)}$	0.0120
$\omega_{b,pk(t)}$	0.0038	$\omega_{b,pk(t-1)}$	-0.0019
$\omega_{b,py(t)}$	-0.0090	$\omega_{b,py(t-1)}$	-0.0299
$\omega_{p,bf(t)}$	-0.0074	$\omega_{p,bf(t-1)}$	0.0314
$\omega_{p,pk(t)}$	0.0040	$\omega_{p,pk(t-1)}$	-0.0021
$\omega_{p,py(t)}$	-0.0237	$\omega_{p,py(t-1)}$	-0.0497
$\omega_{c,bf(t)}$	0.0003	$\omega_{c,bf(t-1)}$	0.1098
$\omega_{c,pk(t)}$	0.0228	$\omega_{c,pk(t-1)}$	-0.0020
$\omega_{c,py(t)}$	-0.0699	$\omega_{c,py(t-1)}$	-0.1087

Total Current Effect		Total Lagged Effect	
$\Psi_{b,bf(t)}$	-0.0016	$\Psi_{b,bf(t-1)}$	-0.0099
$\Psi_{b,pk(t)}$	0.0023	$\Psi_{b,pk(t-1)}$	-0.0228
$\Psi_{b,py(t)}$	-0.0101	$\Psi_{b,py(t-1)}$	-0.0483
$\Psi_{p,bf(t)}$	0.0009	$\Psi_{p,bf(t-1)}$	0.0260
$\Psi_{p,pk(t)}$	-0.0019	$\Psi_{p,pk(t-1)}$	-0.0002
$\Psi_{p,py(t)}$	-0.0247	$\Psi_{p,py(t-1)}$	-0.0365
$\Psi_{c,bf(t)}$	0.0281	$\Psi_{c,bf(t-1)}$	0.1138
$\Psi_{c,pk(t)}$	0.0413	$\Psi_{c,pk(t-1)}$	0.0471
$\Psi_{c,py(t)}$	-0.0123	$\Psi_{c,py(t-1)}$	-0.0146

Notes: $\eta_{i,j}$ and $\varepsilon_{i,j}$ represent the Marshallian and Hicksian price elasticities of demand for the *i*th good with respect to the *j*th price, and $\eta_{i,x}$ is expenditure elasticities for the *i*th good, where *i*, *j* = b for beef, p for pork, and c for poultry. $\omega_{i,k}$ measures the percentage change in the pre-committed quantity of the *i*th good in response to a 1% increase in the *k*th food safety variable, where *k* = *bf* for beef, *pk* for pork, and *py* for poultry food safety index, respectively. $\Psi_{i,k}$ measures the percentage change in the total quantity demanded of the *i*th good in response to a 1% increase in the *k*th food safety index variable. Estimates shown are the sample means of the elasticities computed at every data point using predicted expenditure shares.

The cross-price Marshallian elasticities show that beef, pork and poultry are gross-substitutes one to each other. However, the demand for pork and poultry are more sensitive to changes in beef prices than the other way around (0.892> 0.532 and

0.571>0.388). Also, pork demand is more sensitive to changes in poultry prices than the other way around (0.561>0.308).

As expected, the own price Hicksian elasticities are all negative. Especially in the case of compensated beef own-price elasticity (-0.235), it indicates that per capita compensated beef consumption changes less, proportionally, than retail price (i.e., beef demand is inelastic) as price changes.

By looking at the cross-price Hicksian elasticities it is possible to say that pork, beef and poultry are compensated substitutes one to each other. As for the Marshallian elasticities, the cross-price Hicksian elasticities show that demand for pork and poultry are more sensitive to changes in beef prices than the other way around (1.282> 0.843 and 1.070>0.600). Also, pork compensated demand is more sensitive to poultry price changes than the other way around (0.720>0.603).

Looking at expenditure elasticities, it is possible to see that beef and poultry are luxury goods ($\eta_{i,x} > 1$ with $i = b,c$) whereas pork is a necessity ($\eta_{p,x} < 1$). However, it should be noticed that these elasticities measure how a given meat demand changes in response to a change in meat expenditure. For instance, Schroeder et al. (2000 pp.11) points out that beef demand expenditure elasticities are generally larger than income elasticities because beef demand is more responsive to changes in meat expenditure than it is to changes in consumer disposable income.

As expected, we observe that for beef the current own BSE-only food safety direct elasticities is negative; indicating that food safety news about beef contemporaneously negatively affects its own pre-committed quantities. This is not the case when we look at the lagged BSE-only food safety direct elasticities for beef. It seems that the initial reduction in the pre-committed quantities for beef is recovery in the following quarter after a BSE reference to beef in news has occurred.

It is important to see from the results obtained for the food safety total current and lagged effect elasticities that, as expected, the BSE news under the context of beef will depress the demand for beef in the current and subsequent period($\Psi_{b,bf(t)}$=-0.0016, $\Psi_{b,bf(t-1)}$=-0.0099). In addition, BSE news under the context of beef will increase, in the current and in the next period after their publication, the final demand for pork ($\Psi_{p,bf(t)}$= 0.009, $\Psi_{p,bf(t-1)}$= 0.0260) and for poultry ($\Psi_{p,bf(t)}$= 0.0281, $\Psi_{c,bf(t-1)}$=0.1138). Therefore, we should expect that if the NAIS for beef low consumers' concerns on BSE in beef, this will cause a decrease in pork and poultry demand in current and lagged time.

7. ON THE ECONOMIC VALUE OF THE NAIS

Based on the estimates for the preferred model estimated with a D-R^{matrix} to correct for first-order autocorrelation and with the inclusion of BSE-only food safety indexes lagged up to one time period (*L*=1), it is now possible to simulate the consumer derived economic value from the implementation of NAIS. The model was estimated including the series for BSE-only food safety indexes for beef, pork and poultry. This value was constructed as a simple sum of the news articles on BSE under the contexts of beef, pork and poultry. Therefore, a higher or lower number of BSE news articles will alter the impact of the estimate on the endogenous variable in the estimated equations and allow for a calculation of the economic impact of NAIS with a bit more calculation including total revenue values. The following three scenarios were constructed using this logic.

Baseline Scenario - The baseline scenario assumes that the NAIS has not been implemented in the sample period and therefore that consumers have reduced their consumption by the full extent of any media reporting of BSE identified in the search of news articles. Results for this scenario are obtained by first plugging the time series for all exogenous variables into the preferred model. The predicted budget share series for beef, pork and poultry are then multiplied by the total population in the US and by the per capita expenditure allocated with meat consumption. Finally, the predicted revenue series are converted into Dollar of the September of 2005 using the CPI for all goods.

Scenario 1 – Scenario 1 assumes that the NAIS has been implemented only for beef and dairy cattle through the entire sample period. In order to model this scenario, the series of BSE-only food safety index for beef is pre-multiplied by a factor denoted f with $f \in [0,1]$. The factor f indicates our assumption on the confidence of the consumers in an event of BSE news assuming the NAIS for beef were in place. For instance, setting f equal to 1 would mean that we are assuming that, with NAIS in place, a BSE news would not affect consumers' confidence on eating beef. In other words, the factor f will indicate our assumption regarding how much the consumers are confident that in any BSE outbreak all animals will be found, tracked and removed from the food chain when the NAIS is in place. This adjusted series is then used in place of the original series of BSE-only food safety index for beef. In sequence, this adjusted series together with all remaining time series for all exogenous variables are plugged into the preferred model, producing the predicted budget shares series for each type of meat. Predicted budget shares are multiplied by the total expenditure series and by the total population in the US, and finally deflated using the CPI for all goods so that the predicted total revenue series are converted into dollars as of September of 2005.

Scenario 2 - Scenario 2 assumes that the NAIS has been implemented for both beef and pork.

The series of BSE-only food safety index for beef and pork are now pre-multiplied by the same factor $f \in [0,1]$ that now indicates our assumption on consumers' confidence on eating beef and pork if the NAIS for beef and pork were in place. Plugging these series and all other series of explanatory variables into the preferred model produce the predicted budget shares series for each type of meat. Predicted budget share series are multiplied by the total expenditure series and by the series of total population in the US and finally deflated by the CPI for all goods so that the predicted total revenue series are converted into dollars as of September of 2005.

The average change in quarterly revenue for each meat obtained by comparing scenarios 1 and 2 to the baseline scenario are presented in Table 5.

Table 5. Predicted Changes in the Total Revenue for Beef, Pork and Poultry Sectors under Three Alternative Scenarios Considering Various Potential Reductions in the Consumer Risk Perception about BSE (1982:4 – 2006:4)

Total Revenue Difference in Million of Dollars as of September 2005						
Consumer Confidence after a Reported BSE News when The NAIS is in Place (*f**100)	NAIS Beef – No NAIS			NAIS Beef & Pork – No NAIS		
	Beef	Pork	Poultry	Beef	Pork	Poultry
100%	174.425	-22.663	-151.763	201.161	-16.366	-184.795
90%	151.353	-19.553	-131.800	174.324	-13.774	-160.549
80%	129.289	-16.593	-112.696	148.684	-11.352	-137.332
70%	108.299	-13.795	-94.505	124.321	-9.111	-115.211
60%	88.456	-11.168	-77.288	101.324	-7.063	-94.261
50%	69.845	-8.725	-61.120	79.798	-5.224	-74.574
40%	52.569	-6.483	-46.086	59.869	-3.612	-56.257
30%	36.753	-4.460	-32.293	41.690	-2.250	-39.440
22%	25.566	-3.062	-22.504	28.911	-1.411	-27.499
20%	22.557	-2.680	-19.877	25.456	-1.164	-24.291
10%	10.196	-1.177	-9.019	11.428	-0.395	-11.033
0%	0.000	0.000	0.000	0.000	0.000	0.000

Source: Estimates detailed in text.

The results presented in Table 5 should be interpreted in the following way. If under Scenario 1 (NAIS implemented only for beef) the additional assumption is that the NAIS in place for beef would be capable of keeping the consumers' confidence on eating beef at the same level observed before BSE news about beef were reported, the beef sector would not have experienced any drop in its demand. Thus, no reduction in consumers' confidence on eating beef due to the fact of the NAIS for beef is in place would imply that no reduction for beef would be observed. Thereby, this would represent an average gain of $141.888 million per quarter for the beef sector. In other words, no reduction in demand will result in a decreased drop in revenue, which gives the benefit. As expected, the pork and poultry sector would lose with the NAIS implemented only for beef given any assumption regarding the factor *f* under Scenario 1. The pork and poultry sectors which seem to benefit by consumers switching to pork and poultry when a food safety event occurs in beef would have respectively lost revenue on average of $20.336 and $130.328 million per quarter, assuming consumers' confidence does not change after news report on BSE if the NAIS for beef is in place.

Alternatively, if the NAIS were in place during the sample period for beef and for pork (Scenario 2), and we assume *f*=1, the beef sector would increase in average its total revenues by $163.471 million per quarter. The pork would still lose $14.004 in average per quarter. Note that this figure is less than the expected loss if the NAIS were in place only for beef ($20.336). The poultry sector which seems to benefit by consumers switching to poultry when a food safety event occurs in beef and pork would have respectively lost revenue on average of $158.908 per quarter. Note that this figure implies a greater loss for poultry compared with the Scenario 1 wherein the NAIS would be in place only for beef. Once again, the no reduction in demand is what causes a decreased drop in revenue, which gives the benefit. Note that pork also has a positive spillover on beef as beef had on pork.

The total revenue effect is recognized as a gross measure of the economic value of the NAIS since the costs of producing, processing and transporting additional product were not taken into account. Also, how these changes in the total revenue at the retail level will be passed through to the producer level is not considered, so it is possible that even if consumers are willing to pay this value may not be passed back fully to producers. However, these figures may serve as a starting point for the meat industry to discuss how the benefits and costs with the NAIS will be shared among segments within each meat supply chain, and also on how much the US government will potentially need to contribute to the NAIS. For instance, preliminary estimates for the costs of the NAIS in the US are $550 million for a five year period (Gray, 2004). Using this figure one may calculate that the NAIS will create an additional cost of $27.5 million per quarter for the beef and pork sectors. Thus, it is straightforward to see that if we take Scenario 2 as given and with the NAIS being capable of sustaining the consumers' confidence at 30% of its level before BSE-news report the beef sector would certain afford the additional burden of the NAIS. However, the pork sector would never want to see the NAIS implemented. Note that under Scenario 1 (NAIS only for beef) if the NAIS would capable of sustaining the consumers' level of confidence on eating beef at 30% of its level before a BSE news has occurred. Therefore, if the defense of the NAIS is based on its effect on the demand side of the market for meats it is necessary to infer precisely what would be its capacity of sustaining consumers' confidence on eating beef after a BSE news event. If one thinks of the NAIS as not being capable of keeping the level of confidence on eating beef in some level equal or greater than 30% of level of confidence observed before a BSE news event, it is expected that the US Federal government will need to pay for a part of the costs with the NAIS; otherwise the NAIS is likely to be economically unfeasible in the U.S..

8. SUMMARY

The implementation of the NAIS in the U.S. is proceeding with proposed 100% coverage by 2009. However, relatively little information exists regarding the prospective costs or benefits to the identification system. This paper developed a method for analyzing expected benefits to the meat animal sector from improved confidence consumers may have in the meat supply with an animal identification process in place. A generalized meat demand system is estimated and food safety indexes are created from news reports to estimate the impacts of food safety events on meat consumption. This information is then used to evaluate the estimated increased revenues from the NAIS program. Results show that there is a significant cost to BSE news in terms of less meat consumed in aggregate. Therefore, an improvement in tracking animals and instilling confidence will result in positive benefits to the meat sector and in particular beef and pork because NAIS is not yet proposed for the poultry sector. However, the domestic U.S. positive returns are not great enough to offset the total estimated costs of NAIS implementation. This study does not include estimates of the potential for increased value of exports which is an important consideration given that export bans have resulted from previous cases of BSE. It is likely that many of the costs will be borne by the farm production level, and it is also not estimated how these additional values paid by consumers at the retail level will be allocated back to the farm level. This includes potential issues of imperfect price transmission from retail to farm level as well as simply identifying the increased revenue share contributed by farmers if NAIS is implemented.

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