USING LINKED HOUSEHOLD-LEVEL DATASETS TO EXPLAIN CONSUMER RESPONSE TO BSE IN CANADA

Xin Wang
Leigh Maynard
J. S. Butler

Department of Agricultural Economics
340 C.E. Barnhart Bldg
University of Kentucky
Lexington, KY 40546
Department of Agricultural Economics
319 C.E. Barnhart Bldg
University of Kentucky
Lexington, KY 40546
Martin School of Public and Administration
473 Patterson Office Tower
University of Kentucky
Lexington, KY 40506

joy.wang@uky.edu

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ABSTRACT

Household-level Canadian meat purchases from 2002-2008 and the Food Opinion Survey conducted in 2008 were used to explore consumer responses to Bovine Spongiform Encephalopathy (BSE) at the national level in Canada. Three measures of beef purchased were used to understand consumers' reaction under food risk. A random effects Logit model was applied to test whether any beef was purchased during a given month. Consumption in terms of unit purchases was measured with a random effects Negative Binomial model and consumption in terms of beef expenditure was measured with a standard random effects model. In this study, household heterogeneity in actual meat purchases was partially explained using data from a self-reported food opinions survey. Of special interest was the hypothesis that consumers responded consistently to BSE in a one-time survey and in actual meat purchase behavior spanning years. Regional differences appeared in the study, with consumers in eastern Canada reacting most negatively to BSE. Consumers were less likely to reduce beef purchases during BSE events when they believed food system decision makers were honest, as opposed to knowledgeable, about food safety.

KEY WORDS: BSE, food safety, food opinion survey, consumer behavior, Canada

INTRODUCTION

The British Secretary of State Health announced on March 20, 1996, that there existed a possible link between Bovine Spongiform Encephalopathy (BSE, popularly called "Mad Cow Disease") and variantCreutzfeldt-Jakob disease (vCJD), thus greatly disrupting the food chain (Labrecque and Charlebois, 2006). In May 2003, the discovery of the first native North American case of BSE in Canada struck the Canadian beef industry. Actually, unlike the BSE discoveries in the United Kingdom, no deaths were linked to Canadian-born BSE events. Due to the fact that BSE has become a global food safety problem in the last decade, many studies have been done on BSE impacts on meat consumption. Significant BSE impacts were found in Europe and Japan, but there is little evidence of retail BSE impacts in North America. Previous studies of North American consumer responses to BSE showed that few demographic variables were statistically significant determinants of behaviors (Maynard and Wang, forthcoming). Therefore, "who you are" may not have strong explanatory power, but "what you think" may be the key to explaining individual choices. Two large data sets at the national level in Canada were used in

this study. Nielsen Homescan data contains household-level meat purchases from 2002 to 2008, and a Food Opinions Survey conducted in 2008. The data were provided by the Consumer and Market Demand Network (CMD), hosted at the University of Alberta's Department of Rural Economy. Six provincial regions Alberta, Ontario, Maritimes, Quebec, Manitoba/Saskatchewan (Man/Sask) and British Columbia (BC) were included in the study. The Homescan data set provided demographic information and records of individual purchases of beef, pork, chicken, and other meats by each household in the panel. The opinion survey focused on consumers' nutritional priorities, food safety concerns, and trust in government and food industry decision makers. The survey was applied to those households that had been the participants of the meat panel for some periods before and after the BSE events. Thirteen BSE cases occurred during the study period; for the purpose of analysis they were aggregated into three periods termed "events". Meat purchase and survey data were merged by household ID at the national level. Only the households that participated in both panels were included in the analysis. A total of 813 households appeared in both data sources, ranging from 77 households in Quebec to 188 households in Manitoba/Saskatchewan.

The purpose of this study is to use the two linked data sources to understand consumer reaction to BSE by releasing the constraint of unobservable and persistent heterogeneity of each household. The research question is whether underlying opinions and concerns could better explain the behavior of Canadian consumers than the conventional emphasis on demographic variables. The main testable hypothesis was whether consumers responded consistently to BSE in self-reported attitudinal surveys and in their actual meat purchase behavior spanning several years. This analysis is one half of a pair of studies, and gains a much broader geographic scope at the expense of slightly less detailed data.

Much research has been done in the area of BSE and consumer behaviors under food risk. This study contributes to the body of work by doing a symmetric analysis in BSE occurrences and food opinion which could affect consumers' reaction to food risk and could also be influenced by it. This work will be important to scholars in this field because our use of two linked data sets for at-home beef consumption has nationwide coverage. General correspondence between the survey responses and actual purchase behavior spanning several years would be an encouraging sign of construct validity in the survey instrument, and would indicate persistence in

household behavior over time. An interesting question involves the time lag between the BSE events and when the survey conducted. Consumers' opinions and overall concerns about food safety may be consistent over time, but confidence in beef products specifically, and trust in government and manufacturers, may vary over time.

BACKGROUND

The beef sector plays an important role in Canadian agriculture and the agri-food industry. It depends on international markets to absorb its commodity surpluses and food products (CAFTA, 2008). Canadian beef was exported to 62 countries in 2007 and over 40% of beef products were exported in 2006. Only 50% of beef products were consumed by Canadians and much of the rest was shipped to the United States. This makes the beef industry predominately dependent on international markets, especially the United States and Japan (CAFTA, 2008).

On January 30, 2003, a six-year-old cow was diagnosed with pneumonia in Alberta and then on May 16, 2003 it tested positive for BSE (Labrecque and Charlebois, 2006). This diagnosis was confirmed by the Canadian Food Inspection Agency (CFIA) and at the U. K. Weybridge veterinary laboratory. On May 20, 2003, the CFIA made an announcement of its first BSE event and this ignited the crisis of beef industry. The confidence level in the quality of Canadian beef and in Canadian food safety policies had dramatically dropped for international traders and the price of Canadian beef products dropped on the international market (Labrecque and Charlebois, 2006). Including the United States and Japan, thirty-five countries issued an embargo on Canadian beef. The Canadian beef industry lost its major access to international markets. Some were angered that the United States and other countries had kept their borders closed to Canadian beef products despite the amount of scientific evidence already showing their products were safe to eat.

A few BSE studies focused on Canada and the US after the first discovery of BSE in Canada in May 2003 (Jin et al., 2004). The initial Canadian BSE crisis appeared to be mainly driven by international trade losses, and Canada's domestic demand did not decrease (Pennings et al, 2002; Maynard and Wang, forthcoming). The first BSE discovery had different impacts on the domestic beef market. At least, during the first few months, the domestic consumer trust in Canadian beef was not affected significantly. Some Canadian industry officials had denied the

seriousness of this event and believed that it would not impact the future of the industry, and many producers attempted to maintain the status quo. Canadian consumers continued to purchase Canadian beef products, as was indicated by a positive reaction to the BSE event in Alberta, Ontario and British Columbia from 2003 to 2005 (Maynard and Wang, forthcoming).

Pritchett and Thilmany(2005) used a linear AIDS model to explore the role of media coverage in BSE outbreaks by using an example of Canadian and U.S BSE impact on retail meat purchases. Their results showed that using a media index as the indicator of consumer's awareness of food safety is not always an appropriate method. A similar conclusion was made by other researchers. Several other studies analyzed how public health information affects meat markets in the U.S. (Piggott and Marsh, 2004). Two more recent studies evaluated the impact of BSE newspaper coverage on fast food beef purchases and impacts of BSE events on at-home beef consumption in Alberta and Ontario, Canada (Maynard et al., 2008; Maynard and Wang, forthcoming).

The study from Maynard et al. (2008) showed that BSE did not affect fast food beef consumption in the study areas. There was limited evidence showing that BSE media coverage affected the purchase of fast-food beef entrees (Maynard et al., 2008). At-home beef purchases increased in Alberta and Ontario following the first BSE discovery and then decreased after subsequent discoveries (Maynard and Wang, forthcoming). Their research concluded that we should evaluate BSE events individually instead of measuring the average or net consumer responses to BSE.

Ding et al. (2009) used the same data sources of the present study, finding that consumers' habits and trust were related to consumer behavior when facing the food risks identified by BSE in Canada. Their study of the linkage of trust and food risk was only focused on the generalized question of "trust, not trust or not sure of trust others" in the survey. Trust has been suggested as an important factor in analyzing consumer behavior under risk (Lobb, 2005).

The Lancaster (1966) approach of consumption theory can be operationalized in analysis of meat purchase behavior during BSE discoveries. Utility is derived from the properties or characteristics of the goods, such as meat type, food safety and quantity in this case. Tastes and preferences for meat type and food safety concerns can be explained by observable demographic

variables including household income, education and the presence of children, but unobserved effects such as habits can also influence the demand for meat. Panel data models are useful in controlling for unobserved household-level effects.

DATA DESCRIPTION

The Nielsen Homescan meat data represents household-level fresh meat purchases during calendar years 2002-2008 at the national level in Canada. The meat data set provides the following information about each household: a household ID number; primary language; household size; age and presence of children; and age, income and education level of the household head. The data set also provides meat purchase information such as purchase date, which of 45 meat types were purchased, quantity purchased, price paid, and codes which provide distinctions among supermarkets, mass merchandise stores, warehouse stores, and other store types. Collectively, from 2002 to 2008, 147 to 385 households participated in the meat panel in a study region. Households entered and exited the panel during the study period, with some reporting only a few purchases and others reporting dozens. This created 6,800 to 14,000 observations each year in a study region. The 45 meat type codes were first aggregated into six categories which included beef, pork, poultry, frozen poultry products, frozen seafood products and game products. The data were also aggregated by household ID and by month for each major meat category.

The Canadian Food Opinions Survey was designed by CMD and was conducted in March 2008. A representative sample of 5,000 households was selected from the Nielsen Homescan meat data. Among them, 4,090 households completed the survey and the response rate was 81.8%. The data set provides household ID numbers corresponding with the meat data sets, and the survey data were first categorized into six regions. The respondents provided their demographic information including household income, age, education level and presence and age of children, and whether they live in a rural or urban setting. The survey covered 113 questions, ranging from respondents' general trust in most people and trust in the food industry to their attitudes towards BSE impacts on confidence in beef products. It focused on respondents' food attitudes and risk perceptions regarding BSE and trust in government and food industry decision makers. The results of the survey provide some insight into nutritional priorities, the general and specific food safety considerations and trust expressed by the

household member who is responsible for grocery purchases. The self-reported Food Opinion Survey reveals consumer attitudes of general and specific food safety issues.

Based on the research questions, the meat purchase and survey data sets were merged by household ID at the national level. Only the households that participated in both panels were included in the analysis. Table 1 shows the scope of the meat purchase data, the survey data, and the merged data sets.

Table 1: Scope of meat purchase, opinion survey, and merged data sets

	Meat Purchases	Food Opinions Survey	Merged Data (Used)
Period	2002-2008	2008	Meat/Survey
	Availability/# of HHD	Availability/# of HHD	# of HHD/# of OBS
Alberta	Yes/385	Yes/527	147/7,517
Ontario	Yes/312	Yes/1,077	143/9,273
Maritimes	Yes/235	Yes/540	117/5,385
Quebec	Yes/147	Yes/985	77/4,493
Man/Sask	Yes/365	Yes/416	188/9,185
BC	Yes/328	Yes/545	141/6,395

*HHD=household, OBS=observation

The decrease in the number of households in the merged data sets suggests that t-tests should be employed to determine if the households in the merged data sets were significantly different from the ones who did not participate in the survey panel but only in the meat panel. The merged data was compared to the rest of the households which were only in the meat data for each region. Table 2 provides descriptive statistics of households' characteristics for the selected sample and for the full Homescan meat panel respectively in each region. Only the age of household head was statistically different from the selected sample and the remaining sample in most of the study regions, with average age being older in the merged sample. Chi-square tests were employed for the presence of children, which was a categorical variable. The original data sets provided the age and presence of children in eight groups. In previous studies, however, no specific age groups showed a significant impact on beef purchases, so it was deemed most meaningful to distinguish between the households with versus without children. Table 3 shows the consistent results that there is a greater probability of having no kids in the households of merged data sets than the remaining meat respondents.

Table 2: Summary statistics and t-test results of household characteristics: Selected sample versus those remaining in the full meat panel

	Definition		Alberta	Ontario	Maritimes	Quebec	Man/Sask	BC
Household Size	1=Single member	Mean(StdDev)						
	2=Two members	Selected Sample	2.48(1.29)	2.54(1.14)	2.21(1.09)	2.57(1.22)	2.41(1.15)	2.26(1.1)
	3=Three members	Remaining Sample	2.43(1.22)	2.7(1.23)	2.24(1.02)	2.47(1.24)	2.66(1.22)	2.6(1.32)
	4=Four members	P Value	0.74	0.23	0.86	0.62	0.04**	0.00***
	5=Five-Nine+ members							
Household Head Age	1=18-34	Mean(StdDev)						
	2=35-44	Selected Sample	3.74(1.02)	4.16(1.01)	4.07(0.97)	3.9(1.00)	4.0(1.11)	4.09(0.99)
	3=45-54	Remaining Sample	3.58(1.16)	3.7(1.2)	3.73(1.15)	3.8(1.14)	3.61(1.15)	3.74(1.09)
	4=55-64	P Value	0.16	0.00***	0.01**	0.58	0.00***	0.00***
	5=65+							
Income	1<$20,000	Mean(StdDev)						
	2=$20,000-$29,999	Selected Sample	4.62(1.61)	4.83(1.47)	3.89(1.69)	4.9(1.55)	4.38(1.52)	4.6(1.54)
	3=$30,000-$39,999	Remaining Sample	4.33(1.65)	4.74(1.53)	3.69(1.68)	4.24(1.75)	4.34(1.61)	4.32(1.67)
	4=$40,000-$49,999	P Value	0.09*	0.61	0.36	0.02**	0.81	0.12
	5=$50,000-$69,999							
	6=$70,000+							
Household Head Educ	1=Not high school grad	Mean(StdDev)						
	2=High school grad	Selected Sample	3.49(1.95)	4(1.65)	2.75(2.05)	3.66(2.17)	3.12(2.02)	3.29(1.98)
	3=Some college or tech	Remaining Sample	3.29(1.82)	3.66(1.81)	3.2(1.90)	3.55(1.96)	3.41(1.9)	3.34(1.83)
	4=College or tech grad	P Value	0.32	0.08*	0.08*	0.76	0.16	0.8
	5=Some university 6=University grad							
Household #		Selected Sample	147	143	117	77	188	141
		Remaining Sample	238	169	118	70	177	187

*, ** and *** denote statistical significance of the difference at .1, .05 and .01 levels respectively

Table 3: Percentage of households with children and Chi-square test results: Selected sample versus those remaining in the full meat panel

	Alberta	Ontario	Maritimes	Quebec	Man/Sask	BC
Selected Sample	14%	9%	7%	16%	11%	9%
Remaining Sample	24%	25%	13%	18%	25%	17%
P Value	0.01**	0.00***	0.14	0.78	.000***	0.06*

*, ** and *** denote statistical significance of the difference at .1, .05 and .01 levels respectively

EMPIRICAL METHODS AND MODEL SPECIFICATION

Independent variables were created from the meat purchase data sets, and additional interaction variables were created from the merged data sets. Demographic variables included: household size; dummy variables indicating the presence of children; four age group dummy variables with the under-35 age group excluded as the base; five income categories with the $70,000+ category excluded as the base; and five education categories with university graduates excluded as the base. In order to control for seasonality, monthly dummy variables were created excluding August as the base.

Key independent variables created from meat purchase data were dummy variables defining BSE events. Previous research (Maynard and Wang, forthcoming) demonstrated the importance of distinguishing among events when measuring BSE responses, due to evolving public perception of the threat to food safety. Thirteen cases of BSE were discovered in Canada during the study period. The four months beginning with the first BSE discovery in May 2003 were defined as a single event. The first four months of 2005 were defined as a second event, encompassing the second and third BSE discoveries in January 2005. Beginning in January 2006, no four-month period existed without at least one BSE discovery, so the remainder of the study period was treated as a third event. For each event, dummy variables were created that separately designated the month of occurrence and four subsequent months.

The Food Opinion Survey contained 113 questions, measuring variables such as general trust of respondents, worry characteristics, trust in the food industry, attitudes toward feed given to livestock, and BSE-specific questions about confidence in beef products. Judicious selection of independent variables was necessary to reduce collinearity and allow convergence of random effects Logit models. Therefore, factor analysis was used to create indices of some independent variables such as the worry trait, feed given to livestock, trust in government and food industry

decision makers that included manufacturers, retailers and farmers. Two indices referring to trust in government and decision makers of food industry were created. One was trust that decision makers have sufficient knowledge to control the safety of food products, named Index1. The second index was trust in decision makers take good care of food safety given they are well informed; this was named Index2.

Interaction terms were created between BSE dummy variables and key independent variables from the survey to test hypotheses regarding which consumer attributes and attitudes were most associated with BSE responses. Interaction terms relate to three specific hypotheses of special interest: (1) consumers' trust of government and industry decision makers did not affect reaction to each BSE event, (2) consumers reporting strong food safety concerns did not react strongly to each BSE event, and (3) consumers with specific demographic characteristics did not react strongly to each BSE event. The interaction terms between BSE events and variables regarding government and manufacturers were included in the regressions. Based on lack of statistical significance in preliminary study, the interaction terms involving retailers and farmers were not included. Other independent variables were not interacted with BSE dummy variables, and were intended merely to control for factors affecting general beef consumption. Examples include some demographic variables and seasonal monthly dummy variables.

Ultimately we wish to explain choice variables, such as number of beef purchases and monthly beef expenditures, as a function of the interaction terms between the BSE events and consumers' food safety opinions. Selected variable means of the merged data appear in Table 4, illustrating considerable similarity among study areas. It shows the similarity on beef consumption and trust in food industry among the study regions. Quebec leads the highest beef expenditures and beef unit purchases which are identical to the full meat panel.

Table 4: Selected variable means from the merged data sets

Variables	Alberta	Ontario	Maritimes	Quebec	Man/Sask	BC
# beef purchases / month	2.06	2.16	2.34	2.95	1.46	1.75
# pork purchases / month	1.22	1.33	1.42	1.39	1.15	1.04
# poultry purchases / month	1.18	1.50	1.39	1.45	0.90	1.08
Beef expenditure / month	$14.71	$12.64	$13.46	$16.70	$10.89	$13.43
trust that manuf. is knowledgeable on food safety	3.41	3.53	3.48	3.45	3.48	3.51
trust that manuf. is honest on food safety	2.92	2.94	2.93	2.81	2.84	2.82
trust that govt. is knowledgeable on food safety	3.23	3.17	3.40	3.42	3.26	3.28
trust that govt. is honest on food safety	2.96	2.91	2.99	2.79	2.94	2.87

The advantages of the data were the combination of two linked sources and a large number of observations at the national level. However, the biggest shortcoming is that product weights are not available. Unit beef prices of per pound could not be calculated. Therefore the demand system approach used in some previous studies is not practical in this case. Studies of North American consumer responses to BSE often have low explanatory power, with few demographic variables emerging as statistically significant determinants of behavior, which suggests the consideration of unobserved heterogeneity. Households with the same demographic characteristics may behave differently confronted with food safety issues such as BSE in this case. The solution to deal with the effects, unobserved to the researcher, which influence households purchase behaviors is to do the analysis by using panel data models. The repeated purchases taken on the same household can be grouped into clusters by household ID which created the repeated observations of each household up to 79 months from 2002 to 2008 in each province. The approach outlined in this study adds considerably more validity and explanatory to consumer beef consumption facing BSE in Canada. Understanding consumer heterogeneity is important for producers to develop niche markets, so the choice model provides meaningful information to beef producers also.

In order to test whether our results were robust, we used 3 measures of beef purchases to explore consumer reaction under food risk. First, for each household, there were or were not beef purchases in each month, which was modeled using random effects Logit. Logit is a model of a binomial outcome (yes or no). Second, the monthly number of beef units purchased by a household was a count data variable (0, 1, 2,…, an integer number of purchases). The most common count data estimators are the Poisson and Negative Binomial models. The Poisson

model assumes the mean and variance of occurrences is equal, which is not true in this study. The variance of unit purchases far exceeds the mean, because some households buy no beef, while some buy a large amount. The Negative Binomial model retains the count data aspect while relaxing the variance equality assumption. Random effects can be included in the Negative Binomial model. Third, standard linear random effects models for continuous dependent variables are used to explain variation in monthly expenditures on beef. All three types of regressions were estimated using routines available through the statistical package Stata.

In all cases, the econometric model estimates parameters relating demographic and other factors to the outcomes of interest (any beef purchase, how many times, or how much money spent), but the parameters are not always directly interpretable as effects on something one would observe in life. For example, the Logit estimates a propensity to purchase, which is not directly visible; only actual purchases are. The Negative Binomial estimates parameters related to the expected purchases and coefficient of variation (standard deviation divided by the mean), which is not how marketers of beef would think about this. In all cases, the marginal impact is the effect of unit increases in demographic and other variables on observed beef purchases or actual amount of money spent. Marginal impacts are the relevant marketing and economic estimates reported and discussed here, and were computed using Stata post estimation routines.

Model one: Random effects Logit model is used for dummy variable outcomes and panel data.

Based on the research questions, we first need to know whether consumer participated in beef consumption and in order to control for the households' heterogeneity, the choice model of this study is a random effect Logit model.

The utility that consumer n obtains from alternative *j* in choice period *t* is (Revelt and Train, 1998):

$U_{njt} = \beta_n^{'} x_{njt} + \varepsilon_{njt}$ where x_{njt} is a vector of observed variables, and β_n is unobserved for each n consumer and varies in the population with density $f\left(\beta_n / \theta^*\right)$ where θ^* are the true parameter of this distribution, and ε_{njt} is an observed random error term and it is distributed independent of

β_n *and* x_{njt}. Conditional on β_n, the probability that consumer n chooses alternative *I* in period *t* is as the standard Logit:

$$L_{nit}(\beta_n) = \frac{e^{\beta_n' X_{nit}}}{\sum_j e^{\beta_n' X_{njt}}}.$$

The random effects Logit model has been widely applied in market research when a consumer faces a choice among the alternatives in set *J* in each of *T* time periods or choice situations. The difference between the random effects Logit model and the mixed Logit model is that the random effects Logit model allows repeated purchases by each household (Train, 2003). It was used by Revelt and Train in 1998 to estimate the impact of rebates and loans on consumers' choice of efficiency level for refrigerators at home. The comparison of standard Logit and mixed Logit models with panel data showed that the mixed Logit model has more explanatory power. Uses of the model are varied, e.g., Campbell (2006) used the mixed Logit model and panel data to identify the determinants of willingness-to-pay for rural landscape improvements in Ireland.

Model two: Panel Negative Binomial model is used for units purchased count data.

The Poisson and Negative Binomial models are the most commonly used count data models (Cameron and Trivedi, 1998; Greene, 2008). The Poisson model requires the mean is equal to the variance for the dependent variable, while the model based on the Negative Binomial probability distribution relaxes this constraint by parameterizing the variance separately. In reality, count data often have the greater variance than the mean. In this study, for example, the mean of monthly beef units purchased in Alberta equals 2 while the variance is 8, thus motivating the use of the Negative Binomial model. For technical details of the probability distribution, the associated maximum likelihood estimators, and calculation of marginal impacts, see, for example, Cameron and Trivedi (1998).

Rimal et al. (1999) used a Negative Binomial regression model to explore the relationships between the selection of irradiated beef packages, the beef storage and cooking processes, and demographics of Georgia consumers. Kim et al. (2005) studied the factors which affected the

adoption of Best Management Practices by cattle producers by employing Negative Binominal model. Hausman et al.(1984) incorporated panel data and count data in the application to the patents-R&D relationship. Panel Negative Binomial models using both fixed effects and random effects were developed and estimated by Hausman et al. Kyureghian (2009) used the random effects Negative Binomial model to estimate consumer heterogeneity effects on food away from home purchases.

Model three: Random effect linear regression model for continues expenditure data.

A standard random effects model is applied for beef expenditures. The marginal impacts are the coefficients for the linear panel data model, so no transformation is required. With three dependent variables and six provincially-defined regions, a total of 18 regressions were estimated. Three measures of beef purchases regarding beef purchase participation, beef units purchased, and beef expenditures of each region were obtained from the regressions.

RESULTS

Qualitatively similar results from all three purchases were obtained in all provinces. Detailed regression results for one representative measure: number of beef units purchased, are reported in Tables 5-7 in which variables are categorized by the main hypotheses. Detailed results of all regressions are available from the authors upon request. Marginal effects of panel Negative Binomial models were calculated by Stata and were reported in the table for clarity of interpretation. Since most of the independent variables are interaction terms with the survey questions measured by arbitrary scales, the signs of parameters are often more meaningful than the magnitudes.

The independent variables that explain general beef consumption show that household size is predictably positively associated with the number of beef purchases in term of units in all provinces. Parameters on dummy variables for age of the household head are often statistically significant with positive and modest magnitude. Evidence was stronger in Alberta especially, in which older household heads were most likely to purchase more beef for all age groups. The exception is for the 45-54 age group in Manitoba / Saskatchewan, where older consumers purchase considerably fewer units of beef than the under-35 age group. Education level has significant impacts on beef consumption in most regions. Higher level educations induce

consumers to purchase less beef in Quebec and British Columbia but the results are not consistent in all regions.

Beef consumption significantly increased at .01 levels after the first BSE event only in Alberta. Given the fact that Alberta is Canada's dominant producer of beef cattle and Boyd and Jardine (2007) concluded that Alberta media coverage of the first event presented BSE as primarily a trade issue, and secondarily as a food safety issue, it is understandable that consumers reacted by consuming more beef in Alberta. Consumer confidence may have been preserved by prompt government press releases assuring consumers that infected animals did not enter the food stream, and industry organizations mounted publicity campaigns in Alberta that may have boosted support for ranchers. In contrast, negative impacts dominated for the third BSE event in most provinces. Recall that the third "event" was an extended series of BSE discoveries, and it appears that consumer' food safety fears became stronger when BSE became a pattern instead of an isolated event. Higher trust in media sources was linked to higher beef units purchased in the Maritimes and British Columbia. Higher concerns about animal disease were negatively associated with the number of beef units purchased in most provinces.

Table 5: NB regression results on monthly beef units purchased: independent variables that explain general beef consumption

	Alberta		Ontario		Maritimes		Quebec		Man/Sask		BC	
January	0.006		0.243	***	0.159	***	0.043		0.152	***	0.011	
February	-0.018		0.169	***	-0.054		-0.085		0.048		0.039	
March	0.069		0.199	***	0.057		0.016		-0.004		0.065	
April	0.006		0.100	*	-0.068		0.051		0.027		-0.083	
May	0.127	**	0.102	*	0.043		0.029		0.157	***	-0.090	
June	0.036		0.074		0.135	**	0.049		0.009		0.012	
July	-0.118	*	-0.007		-0.025		-0.059		-0.017		-0.051	
September	-0.076		0.072		0.033		0.054		0.010		-0.067	
October	-0.090		0.093	*	0.021		-0.023		0.032		-0.004	
November	0.053		0.158	***	0.016		-0.050		0.013		0.033	
December	-0.256	***	-0.014		-0.095		-0.161	**	-0.191	***	-0.155	**
Household size	0.028		0.050	**	-0.030		0.127	***	0.014		0.060	*
Age 35-44	0.288	*	0.150		0.270		0.212		-0.169		-0.547	
Age 45-54	0.361	**	0.114		0.379		0.421		-0.397	*	-0.716	
Age 55-64	0.335	*	0.058		0.413	*	0.271		-0.259		-0.735	
Age 65+	0.482	***	0.114		0.526	**	0.332		-0.229		-0.704	
< High school	-0.159		0.026		-0.236	***	0.492	***	-0.258	***	0.604	***
High school	0.326	***	0.036		-0.031		0.423	***	-0.195	***	0.269	***
Some college	0.089		0.111		-0.282	***	-0.100		0.019		0.340	***
College *BSE1	0.016		0.206	*	-0.098		-0.044		-0.032		0.342	***
Some university	-0.479	***	-0.491	***	-0.224	**	0.178	**	-0.066		0.240	***
trust in scientists	0.074		0.142	*	-0.161	*	0.167	**	-0.081		-0.033	
trust in consumer organizations	0.000		0.027		-0.118		0.052		0.122	**	-0.171	**
trust in media sources	0.016		0.005		0.178	***	-0.071		0.003		0.115	**
Animal welfare concern	0.417	***	-0.224	***	0.072		0.006		0.072		0.111	*
Animal disease concern	-0.206	***	-0.109		-0.036		-0.118	**	-0.024		-0.010	
retailer index1	-0.089		0.492	***	-0.260	***	-0.007		-0.147	***	0.012	
retailer index2	0.223	**	-0.456	***	0.038		0.024		0.010		0.055	

farmer index1	-0.024		-0.445	***	-0.060		-0.254	***	0.137	**	-0.168	**
farmer index2	-0.072		0.022		0.300	***	-0.016		-0.309	***	-0.013	
BSE event 1, t+0	1.020		0.034		0.036		1.069		0.354		-0.010	
BSE event 1, t+1	0.952		0.043		-0.078		0.787		0.583		-0.101	
BSE event 1, t+2	1.323	*	0.254		0.292		0.926		0.526		0.150	
BSE event 1, t+3	1.347	*	0.288		0.135		0.999		0.968		0.177	
BSE event 1, t+4	0.935		0.195		-0.029		0.875		0.600		-0.098	
BSE event 2, t+0	0.102		-0.197		-1.205	*	0.597		-0.230		0.032	
BSE event 2, t+1	0.258		-0.212		-1.145	*	0.808		-0.041		-0.143	
BSE event 2, t+2	0.225		-0.284		-1.047		0.634		-0.097		-0.330	
BSE event 2, t+3	0.537		-0.058		-1.064		0.807		0.066		0.059	
BSE event 2, t+4	-0.029		-0.106		-1.133	*	0.570		-0.171		-0.167	
BSE event 3	0.229		0.208		-0.847	**	0.496		-0.966	***	0.173	

*, ** and *** denote statistical significance at the .10, .05 and .01 levels respectively

Based on the research questions, a set of testable hypotheses was the strength of interaction between BSE responses and demographic variables. The impact on households with children varied across the provinces. For households with children, the significant negative effect after the first BSE event was found in Quebec and the significant negative impact was found in Alberta after the third BSE events. However, the significant positive effect after the BSE event was appeared in Maritimes. After the first BSE event, households in the lower income brackets purchased significantly more beef, but with modest magnitudes compared to those earning over $70,000 per year in most provinces. However, the positive sign became negative after the second and third events in most cases. Compared with urban residents, rural residents reduced beef consumption after the first and/or third BSE events in Alberta, Ontario and Quebec. The exception is after the third event in British Columbia, where rural consumers purchased considerably more units of beef than urban residents. There was no statistically significant impact found in the Maritimes and Manitoba / Saskatchewan.

Table 6: NB regression results on monthly beef units purchased: interaction terms between demographic variables and BSE events

	Alberta		Ontario		Maritimes		Quebec		Man/Sask		BC	
Interaction between have children and BSE events												
have Children *BSE1	-0.073		-0.123		0.279		-0.423	***	-0.101		0.071	
have Children *BSE2	-0.138		0.103		0.384	*	0.043		0.002		-0.013	
have Children *BSE3	-0.138	**	0.005		-0.057		0.007		0.070		0.005	
Interaction between income and BSE events												
Income < $20K *BSE1	0.366	*	0.081		0.013		-0.152		0.154		0.268	
Income $20-$30K *BSE1	0.463	***	0.289	*	-0.344		0.020		0.003		0.124	
Income $30-$40K *BSE1	0.358	**	0.153		-0.056		0.416	*	0.021		0.069	
Income $40-$50K *BSE1	0.240		0.332	**	0.127		0.309		0.110		0.303	*
Income $50-$70K *BSE1	0.000		0.109		0.389	*	0.017		0.249	*	0.038	
Income < $20K *BSE2	-0.251		0.154		-0.131		-0.120		0.352		-0.684	**
Income $20-$30K *BSE2	-0.074		-0.254		-0.467	**	-0.417		-0.278		0.022	
Income $30-$40K *BSE2	0.044		0.005		-0.017		0.116		0.270		-0.112	
Income $40-$50K *BSE2	-0.141		-0.019		-0.199		0.140		0.173		0.141	
Income $50-$70K *BSE2	0.305	**	0.131		-0.500	***	-0.019		-0.201		-0.039	
Income < $20K *BSE3	-0.129		0.016		-0.320	***	-0.190		-0.213	*	-0.123	
Income $20-$30K *BSE3	0.031		-0.017		-0.143		-0.226	**	0.075		-0.189	*
Income $30-$40K *BSE3	0.028		0.176	**	-0.072		-0.164		0.088		0.112	
Income $40-$50K *BSE3	0.011		0.045		-0.357	***	0.136		0.056		0.213	***
Income $50-$70K *BSE3	0.011		0.052		-0.198	**	0.125	*	-0.029		-0.063	
interaction between resident areas and BSE events												
rural*BSE1	0.133		-0.196	**	0.230		-0.330	**	0.132		0.215	*
rural*BSE2	-0.099		0.043		0.137		-0.095		-0.089		-0.112	
rural*BSE3	-0.187	***	0.034		0.101		-0.208	**	0.039		0.288	***

*, ** and *** denote statistical significance at the .10, .05 and .01 levels respectively

Moving from demographics to interaction terms involving the opinion survey responses, wide variation was observed across regions. As expected, consumers with high worry trait levels purchased fewer beef units after the second and the third BSE events in Alberta, Quebec and British Columbia. The opposite, unexpected result occurred in one region: Manitoba / Saskatchewan.

Consumers' food attitudes can be described by either optimism or pessimism, but these two attitudes can be present in an individual at the same time (de Jonge et al., 2007). Therefore, variables measuring both attitudes were included in the analysis. Households with higher optimism about food product safety purchased more beef units after the second and third BSE events in Ontario. Unexpected significant negative impacts of optimism on BSE response were found in Quebec and British Columbia, although the magnitudes were modest. Similarly, consumers with higher levels of confidence in beef safety appeared to be the most disillusioned by BSE discoveries, with beef unit purchases falling in Alberta, Ontario and Quebec.

Consumer trust in food system decision makers significantly affected BSE responses in some regions. Trust that manufacturers are knowledgeable in food safety had significantly negative impacts on BSE response, which suggests that consumers tend to believe that industry knowledge alone is perhaps necessary but not sufficient to inspire confidence. Meanwhile, and as expected, trust in the government to be honest about food safety contributed to higher beef unit purchases during BSE events, *ceteris paribus*. In particular, trust in the government honesty about food safety had statistically significant positive impacts at the .01 level on beef units purchased after the third BSE events in most study regions. The increasing impact of confidence in beef safety exhibited in 2008 was perhaps an indication that consumers viewed the government's response to BSE as transparent and effective at communicating up-to-date information.

As expected, consumers who were more concerned about feed given to livestock purchased fewer beef units when BSE occurred in most provinces. For consumers in Alberta and Ontario, higher perceived BSE risk to the family led to lower beef units purchased after BSE events, but conflicting results were found in Quebec and Manitoba / Saskatchewan. In a similar result, the more consumers in Ontario were concerned about BSE and vCJD, the less beef they purchased when BSE occurred.

Table 7: NB regression results on monthly beef units purchased: interaction terms between food opinion survey and BSE events

	Alberta		Ontario		Maritimes		Quebec		Man/Sask		BC	
Interaction between worry trait and BSE events												
worry trait index*BSE1	0.011		0.055		0.033		0.082		0.028		0.019	
worry trait index*BSE2	-0.122	**	-0.013		0.006		-0.136	**	0.129	**	0.146	**
worry trait index*BSE3	-0.040		0.026		0.014		0.010		0.074	***	-0.061	*
interaction between food attitudes and BSE events												
optimism index *BSE1	-0.140		-0.153		0.038		-0.240	*	-0.133		-0.110	
optimism index *BSE2	0.062		0.249	***	0.049		-0.013		0.041		-0.308	**
optimism index *BSE3	0.076		0.238	***	0.115	**	-0.109		0.215	***	-0.091	
pessimism index*BSE1	-0.167		0.036		-0.096		-0.109		-0.153		-0.112	
pessimism index*BSE2	0.111		0.082		0.071		0.014		-0.124		-0.092	
pessimism index*BSE3	0.035		0.056		0.090	*	-0.120	**	0.042		0.076	
interaction between general trust and BSE events												
don't trust *BSE1	-0.004		-0.056		0.066		0.160	**	-0.213	***	-0.086	
not sure of trust*BSE1	0.016		-0.071		-0.068		-0.125		-0.059		-0.103	
don't trust*BSE2	-0.013		-0.004		-0.046		-0.028		0.025		-0.088	
not sure of trust*BSE2	-0.044		0.015		-0.021		-0.117		-0.266	**	-0.054	
don't trust*BSE3	0.134	***	0.010		-0.071	**	-0.044		-0.046		0.038	
not sure of trust*BSE3	-0.005		-0.013		0.000		-0.140	***	0.164	***	0.027	
interaction between confidence of beef and BSE events												
confidence in the safety of beef *BSE1	-0.003		0.150	*	-0.120		0.113		-0.127		0.008	
confidence in the safety of beef *BSE2	-0.192	**	-0.146	*	0.134		-0.046		0.025		0.070	
confidence in the safety of beef *BSE3	-0.011		-0.146	***	0.038		-0.079	*	-0.072		0.024	
interaction between the trust index and BSE events												
manufacturers index 1*BSE1	0.037		0.090		0.033		0.079		0.051		-0.126	
manufacturers index 2*BSE1	-0.117		-0.113		-0.074		-0.037		0.175		0.110	
manufacturers index 1*BSE2	-0.164	*	-0.010		-0.076		-0.092		-0.193	**	0.163	*
manufacturers index 2*BSE2	0.260	**	-0.014		-0.022		-0.098		0.131		0.038	
manufacturers index 1*BSE3	-0.092	**	-0.006		-0.040		-0.097	*	-0.160	***	-0.064	

manufacturers index 2*BSE3	-0.086		0.026		0.017		0.322	***	-0.007		0.111	
government index 1*BSE1	0.004		0.028		0.158		-0.030		0.168	**	-0.025	
government index 2*BSE1	-0.023		-0.041		-0.070		0.062		0.039		0.198	
government index 1*BSE2	-0.079		0.067		0.024		-0.188	**	0.030		-0.080	
government index 2*BSE2	0.100		-0.010		0.079		0.074		-0.040		0.116	
government index 1*BSE3	-0.052		0.018		0.047		0.129	***	0.010		-0.124	***
government index 2*BSE3	0.142	**	-0.117	**	0.006		-0.262	***	0.194	***	0.172	***
interaction between feed index and BSE events												
feed index *BSE1	-0.157	*	0.048		0.121		-0.265	***	-0.007		-0.024	
feed index *BSE2	0.089		0.023		0.095		0.169	*	-0.010		0.020	
feed index *BSE3	-0.011		-0.202	***	0.009		0.075	*	0.011		-0.042	
interaction between the knowledge extent of BSE news and BSE events												
BSE news *BSE1	0.072		-0.089	*	0.008		0.072		-0.091	*	0.090	
BSE news *BSE2	-0.205	***	-0.066		-0.132	**	-0.008		0.034		0.063	
BSE news *BSE3	-0.017		0.034		-0.078	***	0.118	***	-0.021		0.010	
interaction between BSE risk to the family and BSE events												
risk *BSE1	0.031		0.074		0.031		-0.050		0.217	***	-0.014	
risk *BSE2	0.102		0.021		0.011		0.145	**	0.031		0.091	
risk *BSE3	-0.197	***	-0.141	***	0.005		0.039		0.021		0.034	
interaction between BSE&vCJD concern and BSE events												
Disease*BSE1	0.078		-0.008		-0.129		-0.014		-0.122	*	-0.011	
Disease*BSE2	0.042		-0.131	***	0.093		0.050		0.003		-0.066	
Disease*BSE3	0.028		0.041		0.027		-0.023		0.038		-0.040	
interaction between BSE impact on beef safety confidence and BSE events												
Impact*BSE1	0.010		-0.194	***	-0.051		0.171	***	-0.047		0.031	
Impact*BSE2	-0.038		0.041		-0.013		-0.144	**	-0.046		-0.027	
Impact*BSE3	0.071	**	0.136	***	0.001		-0.034		-0.020		0.017	

*, ** and *** denote statistical significance at the .10, .05 and .01 levels respectively

CONCLUSIONS

In all regions of Canada, results regarding purchase participation, beef units purchased and expenditures were substantially similar. However, regional differences also appeared in each measure of beef consumption. Contrary to what many would expect, but consistent with some prior studies, significant positive impacts occurred after the first BSE event in the prairie province of Alberta. In contrast, significant negative impacts on beef consumption occurred after the second and third events in the Maritimes and Manitoba / Saskatchewan. Households' level of trust that manufacturers have sufficient knowledge to control the food safety and to take good care of food safety affect consumers' beef purchases but differ in most provinces. Knowledge has a negative effect, and honesty has a positive effect, suggesting the importance of manufacturing processes and communication policies that credibly establish trust among consumers. The trust of government to take good care of food safety has a significantly positive influence in all provinces except Ontario and the Maritimes. Consumers' trust in the government and manufacturers has a stronger influence on consumer reaction to food risks than their trust in farmers and retailers. This result is consistent with de Jonge et al. (2007).

Households with perceived higher risk of BSE to their family consumed less beef in general, suggesting persistent BSE impacts in addition to short-run effects. In Ontario, optimism about food products correlated with more positive BSE impacts. Similarly, in British Columbia, consumers with high worry trait values were more likely to reduce beef purchases in response to BSE. In most provinces, concerns about animal feed correlated with lower beef purchases. While many parameters were of the expected sign, there were also several instances of unexpected but statistically significant parameters.

Three issues are likely to generate discussion. First, studies using different data and different models have produced conflicting evidence of Canadian BSE impacts. The integration of actual purchase data with survey data of the same households, and the use of panel data models to control for household heterogeneity, are intended to contribute to the literature by enhancing validity and explanatory power. Second, the national scope of the analysis demonstrates modest but interesting regional variation in BSE responses. Third, the most publicized BSE events occurred years before the survey was administered. The general correspondence between the survey responses and actual purchase behavior spanning several

years is an encouraging sign of construct validity in the survey instrument, and also indicates persistence in household behavior over time.

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