Habit, BSE, and the Dynamics of Beef Consumption

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Habit persistence is related to recurring food safety incidents in the context of the initial three cases of bovine spongiform encephalopathy (BSE) in Canadian cows. We test Engel functions, using generalized method of moments procedures, to analyze the dynamics of monthly beef expenditure shares of a sample of Canadian households during years 2002 through 2005. From microlevel panel data which followed meat expenditures by Canadian households before and after the first three BSE cases, which were discovered in 2003 and 2005, it is seen that households' reactions to these followed a similar general pattern: households reduced beef purchase expenditures following the discovery of BSE but expenditures subsequently recovered. Following the initial BSE event, we identify an immediate negative impact on beef expenditures. However, in the case of the second two BSE events, this negative impact was not evident until two months after the BSE announcements. The results suggest that habit persistence initially limited households' reductions of beef purchases following the first BSE event. However, households with higher beef expenditure shares reduced expenditure more than others following the second two BSE events, suggesting that habitual patterns of high levels of consumption tended to change with the recurrence of these food safety events.

La persistance des habitudes de consommation est liée aux incidents de sécurité alimentaire récurrents dans le contexte des trois premiers cas d'ESB décelés chez des bovins canadiens. À l'aide de la méthode des moments généralisés, nous avons estimé des courbes d'Engel pour analyser la dynamique des parts de dépenses mensuelles en viande de bœuf auprès d'un échantillon de ménages, au cours de la période de 2002 à 2005. D'après un panel de microdonnées sur les dépenses en viande des ménages canadiens effectuées avant et après la découverte des trois premiers cas d'ESB en 2003 et en 2005, la réaction des ménages semble avoir suivi une tendance générale similaire, à savoir une diminution des dépenses en viande de bœuf après l'annonce des cas d'ESB, suivie d'une reprise. Après l'annonce du premier cas d'ESB, nous avons observé un impact négatif immédiat sur les dépenses en viande de bœuf. Par contre, dans les deux autres cas, l'impact négatif ne s'est fait sentir que deux mois après leur annonce. Les résultats autorisent à penser que la persistance des habitudes a limité la diminution des dépenses des ménages en viande de bœuf après l'annonce du premier cas d'ESB. Toutefois, les ménages qui avaient une part des dépenses en viande de bœuf élevée ont diminué leurs dépenses plus que les autres ménages après l'annonce des deuxième et troisième cas, ce qui laisse supposer que les comportements habituels de consommation élevée ont eu tendance à changer avec la récurrence de ces incidents de sécurité alimentaire.

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INTRODUCTION

Canada's first detected case of bovine spongiform encephalopathy (BSE) in a domestically raised bovine animal was announced on May 20, 2003.[1] International borders to Canada's bovine exports were immediately closed following this announcement. The Canadian beef industry suffered major financial costs due to the consequent declines in cattle prices (LeRoy and Klein 2005). More than a year later two more BSE events were confirmed in Alberta. One of these was announced on January 2, 2005; the second on January 11, 2005. From 2003 until 2009, 16 cases in which a cow was affected by BSE were reported in Canada (CFIA 2009).

Consumers' responses to domestic BSE outbreaks have been explored in many nations where this animal disease has occurred. International evidence suggests that beef consumption fell dramatically after the discovery of BSE in most of these instances. For example, Japanese beef sales fell by 70% in response to the first of numbers of cases of BSE in Japan (Zielenziger 2001). The decline in beef purchases by western Europeans after numerous and widespread incidents of BSE, together with associated human deaths, has also been documented, for example in Great Britain (Burton and Young 1996) and Italy (Mazzocchi and Lobb 2005). Studies of beef consumption by U.S. consumers found negative, but short-lived, impacts of North American BSE (e.g., Kuchler and Tegene 2006). Unlike experience in other countries, statistics on aggregate Canadian beef disappearance suggest that Canadian beef consumption increased in both 2003 and 2005. According to Statistics Canada (2004), per capita beef consumption in Canada increased from 13.5 kg in 2002 to 14.2 kg in 2003, a 5% gain. During this period, Consumer Price Indexes (CPI) show that retail beef prices fell by 14% from May through September 2003 but then gradually increased (Boame et al 2004). In 2005, when price indexes for beef declined slightly relative to 2004 (Agriculture and Agri-Food Canada 2007), a 3.6% increase in Canadian beef consumption was reported (Statistics Canada 2006a).

Empirical studies on Canadian consumers' responses to domestic BSE incidents have mainly focused on the 2003 BSE incident. Using aggregate provincial data, Peng et al (2004) identified a significantly negative but small impact of Canada's first domestic BSE incident on the consumption of beef products other than ground beef in Alberta. Maynard et al (2008) examined BSE impacts on the retail sales of beef entrees in both Alberta and Ontario and concluded that while the 2003 BSE incident stopped some Ontario consumers from purchasing beef entrees in the short term, there was no evidence that Alberta consumers responded to the BSE event by reducing consumption. So far, to our knowledge, no published work has focused on the dynamics of consumer responses to recurring BSE cases in Canada.

Recurring food safety incidents are not new phenomena. Other familiar examples include multiple outbreaks of *Escherichia coli*, Listeria, Salmonella, and Avian Influenza. Surprisingly, empirical studies on the recurrence of food safety incidents are rare. Even so, habit persistence in food consumption has been recognized to exist. It is plausible to postulate that recurring food safety events may lead to changes in purchasing patterns for certain food products, including changes in habits. There is empirical evidence that consumers adjust their meat consumption habits during food safety shocks but gradually return to past consumption patterns as their concerns diminish (Mazzocchi and Lobb

[1]One earlier incident, in which BSE was detected, in December 1993, involved a cow imported from Britain; this caused little concern and received little publicity.

2005; Saghaian and Reed 2007). However, previous literature has paid little attention to how those adjustments were made, the specific role of consumption habits in shaping individuals' responses to food risks or how previous habits might be modified by food risks. The current study relates recurring food safety incidents to habit persistence in the context of the series of the first three incidents in Canada in which a domestic cow was found to have BSE. For this purpose we examine a sample of Canadian households' meat purchases, focusing on responses to the initial and two subsequent BSE incidents in Canada, with particular emphasis on the role of habit persistence on consumers' reactions.

LITERATURE REVIEW

In the context of varying national occurrence and as a major food risk concern for consumers, BSE events have attracted much attention worldwide. Previous studies mainly focused on consumer valuation of food risk reduction (Dickinson and Bailey 2002), the impacts of BSE events on meat demand (Burton and Young 1996), and consumers' responses to media reports on BSE (Piggott and Marsh 2004). Negative impacts of BSE occurrence on beef demand and price have been confirmed by empirical studies in Japan (Peterson and Chen 2005), Europe (Burton and Young 1996), and the United States (Schlenker and Villas-Boas 2009). Burton and Young (1996) showed that the substantial BSE outbreak in Great Britain reduced beef consumption in that region in both the short and long run. Jin and Koo (2003) identified a structural change in Japanese meat consumption associated with the BSE outbreak in that nation. A recent study by Schlenker and Villas-Boas (2009) found that the announcement of the first infected cow in the United States had negative impacts on both beef sales and cattle futures prices.

A common approach has been to estimate the effect of a food scare on consumer preferences by use of a single constant shifter on the intercept of an estimated demand function. However, in many circumstances it appears more plausible to postulate that impacts on demand of food safety events occur over time. Thus, there is growing interest in investigating the time and extent during which consumers have reacted to a BSE outbreak. Some studies have accounted for gradual changes in preferences by incorporating a continuous shift variable, such as a media index, into a demand function (Piggott and Marsh 2004). Others have used a time transition function to allow for gradual changes between particular time (Peterson and Chen 2005). Using such methods, Mangen and Burrell (2001) concluded that consumers in the Netherlands exhibited a 21-month preference shift illustrated by reductions in beef purchases subsequent to BSE events and the associated series of BSE-linked media stories in Europe in March 1996. Peterson and Chen (2005) similarly identified a transition period of two months for changes in meat consumption in Japan. Kuchler and Tegene (2006) examined U.S. consumers' retail purchases of beef products from 1998 through 2004 using Nielsen Homescan® data and concluded that most variance in purchases could be explained by trend and seasonality influences. These authors also concluded that the duration of BSE impacts on U.S. consumers was limited to no more than two weeks.

Recent literature that pays attention to the dynamics of consumer preferences in response to food safety concerns includes Adda (2007) who used the BSE scare in France as a natural experiment to study how previous consumption affected consumer responses

to this food risk. His study suggests that French consumers with low and high levels of consumption of beef products were less affected than those with intermediate-level consumption (Adda 2007). Mazzocchi and Lobb (2005) applied a stochastic approach to aggregate data on Italian household meat demand to measure time-varying impacts of two major BSE outbreaks (1996 and 2000) in Europe. These authors concluded that the influences of the second wave of BSE incidents on meat demand were much stronger than the impacts on demand generated by the first wave of BSE outbreaks (Mazzocchi and Lobb 2005). Recovery in beef consumption from the first BSE incidents took only a few months while the second wave of BSE outbreaks caused an upward shift in chicken demand for 14 months (Mazzocchi and Lobb 2005). In general, however, recurrence associated with food safety incidents has received relatively little attention in the literature on the impacts of food safety events on demand. There has been very little, if any, focus on habits in this context.

Habit formation has been examined in studies of consumer behavior (e.g., Pollak 1970; Browning and Collado 2007). The tendency for habit persistence to be exhibited in consumption of at least some goods and services suggests nonseparability in preferences across time. Scholars hold two different views regarding the theoretical explanations of consumer habits (Zhen and Wohlgenant 2006). One group views habits as subsistence consumption (Pollak 1970; Ryder and Heal 1973). This group argues that taste is endogenous and an individual's past consumption is an important factor determining current consumption patterns (Pollak 1970). Past consumption affects an individual's subsistence consumption that in turn affects his current utility level (Zhen and Wohlgenant 2006). The other group, however, considers habits as a process of learning-by-doing (Stigler and Becker 1977; Boyer 1978). These authors postulate that it is consumption capital, rather than taste, that changes over time. Consumers appreciate current consumption based on the knowledge they acquired from past consumption (Zhen and Wohlgenant 2006).

Regarding the modeling of habits, there are two issues. One relates to consumer rationality. Some studies model habits as "myopic" (Pollak 1970). These models assume that consumers do not consider the future effects of their current consumption when making decisions. Others, however, favor rational habitual consumption models (Zhen and Wohlgenant 2006). Zhen and Wohlgenant (2006) developed a theoretical model with rational habit formation to examine consumers' responses to food safety incidents. These authors found significant differences in the reaction patterns between myopic consumers and rational consumers and concluded that consumer's adjustments to a food safety incident depend not only on the degree of individual's habit persistence but also on whether the health impacts of a food safety incident are perceived to be transitory or permanent. The other issue concerns time aggregation. Heaton (1993) studied the interaction between time-nonseparable preferences and time aggregation based on aggregate consumption data on durables, nondurables, and services. He concluded that his data did not support model versions that did not account for time-nonseparability in preferences. However, time-nonseparability was observed to be particularly important over short periods of time, while for longer periods of time, preferences were observed to be more consistent with a time-separable model.

Perhaps due to data availability limitations, most empirical studies on consumption, which allow for time-nonseparable preferences are based on aggregate data. However, it has been argued that aggregation can distort estimates of preferences due to a number of factors unrelated to preferences (Dynan 2000). Microeconomic-level household data are

less affected by time averaging than aggregate data (Dynan 2000). There is growing interest in testing time-nonseparability in preferences using microeconomic-level data (Meghir and Weber 1996; Naik and Moore 1996). Studies which examined habit formation in the context of food consumption have had mixed findings. Naik and Moore (1996) found evidence of habit formation in households' food expenditure, while research by Dynan (2000) did not support this conclusion.

Although the empirical literature on habit formation has often rejected models without habit formation, it has been argued that it is important to distinguish between state dependence and heterogeneity to avoid overstatement of habit effects (Naik and Moore 1996; Keane 1997). However, to distinguish between state dependence and heterogeneity, panel data with several periods of observations for each micro unit are required. Using Spanish panel data on family expenditure, Browning and Collado (2007) concluded that both state dependence and heterogeneity should be considered in the analysis of demand behavior to avoid seriously biased estimates. The current study adds to the literature by examining habit persistence in the context of a series of food safety incidents using microeconomic-level household panel data.

MODEL SPECIFICATION AND ESTIMATION METHODS

This study uses Engel curve analysis to assess how multiple and recurring BSE incidents shaped the patterns of Canadian households' beef consumption over time. Thus, we focus on expenditures associated with beef consumption over time, by analyzing the dynamics of the sampled Canadian households' beef expenditure shares.

There is a long history of use of Engel curves to analyze consumer demand. Early studies include those by Working (1943) and Leser (1963). One Engel curve specification that underlines popular demand models, such as the Almost Ideal Demand System, is the Price-Independent Generalized Logarithmic (PIGLOG) or Working-Leser Engel Curve. The PIGLOG specification relates budget shares linearly to the logarithm of total expenditure. The consistency of this Engel curve specification with utility theory has been demonstrated by Muellbauer (1976). Some empirical studies have rejected the PIGLOG specification for some commodities and favored quadratic Engel curves (Blundell and Duncan 1998). Nonetheless, both parametric and nonparametric estimations of Engel curves for food support the PIGLOG specification (Banks et al 1997; Blundell and Duncan 1998).

The structure of the PIGLOG expenditure specification is as follows:

$$\omega_{ih} = \alpha_i + \beta_i \ln x_h \tag{1}$$

where ω_{ih} denotes budget share of the ith good for household h, x_{h} is the logarithm of the total expenditure for household h, and α_i and β_i are parameters. Following Pollak and Wales (1981), a translating approach is adopted to incorporate nonprice and nonincome variables into the model. Parameter α_i is augmented to be a function of demographics, dummy variables associated with BSE occurrences, time trend, and seasonal dummy variables. Since the impacts of BSE are the focus of this analysis, two sets of dummy variables associated with the first and second two BSE events are included in the model. Demographic variables are included to capture some of the household heterogeneities while the seasonality and trend effects that are evident in Canadian households' beef

expenditures are considered in the analyses by including a time trend and seasonal dummy variables. We introduce dynamics into the model by allowing current beef expenditure shares to depend on beef expenditure shares in the previous period. This enables the habit formation hypothesis to be tested based on the significance of the lagged beef share in the budget share equations.

The extended model takes the form

$$\omega_{ht} = \beta_0 + \beta_1 \ln x_{ht} + \beta_2 \omega_{ht-1} + \beta_3 t + \sum_{k=2}^{12} \gamma_k D_{kt} + \sum_{l} \delta_l z_{lht} + \sum_{i=1}^{2} \sum_{j=1}^{4} \alpha_{ij} \mathrm{BSE}_{ij} + \mu_h + \varepsilon_{ht} \tag{2}$$

where ω_{ht} denotes beef expenditure share for household h at time t; $\ln x_{ht}$ is the logarithm of total meat expenditure for household h at time t; ω_{ht-1} is the lagged beef expenditure share; t denotes time trend; D_{kt} are 11 monthly seasonal dummy variables with January as the base; z_{lht} are demographic variables including education of the household head, number of children in a household and a regional residence dummy variable; BSE_{ij} are two sets of dummy variables indicating the specific month that followed the first BSE incident and second pair of BSE events, respectively; μ_h captures unobservable individual characteristics; ε_{ht} is a random error term; and β_0, β_1, β_2, β_3, γ_k, δ_l, and α_{ij} are parameters to be estimated.

Models tested on panel data have been used in the literature to examine many dynamic relationships (Arellano and Bond 1991; Keane 1997; Browning and Collado 2007). One common feature of these models is the presence of a lagged dependent variable on the right-hand side, which complicates their estimation. The fixed effects and random effects approaches to estimation are not appropriate in this setting because the lagged dependent variable is correlated with the disturbance. For this reason, the approach that takes the first differences of the equations and then estimates the differenced equations has been widely used in empirical analysis of dynamic panel data (Browning and Collado 2007). Although taking first differences removes unobservable heterogeneity from the model, the differenced equations still have the problem of endogeneity due to the lagged dependent variable (Greene 2003). The idea of using lagged values of dependent variables as instruments for the differenced equations was first suggested by Anderson and Hsiao (1981). Based on this concept, Arellano and Bond (1991) developed a generalized method of moments (GMM) procedure which improves estimation efficiency by making use of all available moment conditions. Arellano and Bover (1995) unify the literature and develop a general framework for efficient instrumental variable (IV) estimators. Although using instruments in levels for equations expressed in first differences is a typical approach to estimate dynamic panel data models, Arellano and Bover (1995) argue that there are potential gains to estimating equations in levels using instruments in first differences.

Panel data have the advantage of enabling better analysis of dynamic effects (Kennedy 2003). However, the estimation of a model that is based on dynamic panel data is complex. Since the objective of this study is to examine how multiple BSE incidents affect sampled Canadian households' beef consumption patterns over time, we adopt the GMM approach developed by Arellano and Bond (1991) and Arellano and Bover (1995). Two

sets of models were estimated: Engel curves in differences with instruments in levels and Engel curves in levels with instruments in differences.

DATA

This study uses data from the Nielsen Homescan® panel which consists of a national sample of Canadian households. The available panel data set follows the purchases of meat by these households before and after the first BSE incident in Canada, covering the period from January 1, 2002 to December 31, 2007, during which 11 cases of BSE were confirmed in Canada. The data set contains detailed information on household purchase expenditures on a variety of food products, including processed packaged food items, categorized by universal product codes (UPCs) and other items without UPCs, which is the case for fresh meat purchases. This information includes detailed descriptions of the different meat products purchased by the household for home consumption, the household's expenditures to purchase the different specified meat products, and the dates on which these household purchases were made. The data set also reports information on household characteristics, including the region of residence, household income, age, and education level of the household head and composition of the household.

We investigate household expenditures on different meat purchases for the time from January 2002 to December 2005, based on individual household's total monthly expenditures on fresh meat purchased at retail grocery stores. Frozen meat purchases, which account for a small proportion of the data, are excluded from this study. The time period from January 2002 to December 2005 is selected because it encompasses the first three cases of BSE in Canada and is sufficiently long to assess the impacts of habit persistence, allowing examination of how Canadian consumers responded to the initial BSE event and enabling comparison of reactions to the series of two further BSE incidents. The size of the panel has varied, from a low of 8,849 households in 2003 to a high of 9,635 households in 2004. To avoid the problem of missing values and reduce the volume of data to a more manageable size, we selected from the complete database those households that stayed in the panel over the time period from 2002 to 2005 and that purchased at least one meat product (not necessarily a beef product) in each of the 48 consecutive months from January 2002 to December 2005. The final sample consists of 644 households.[2]

Table 1 provides descriptive statistics of the household characteristics for both the selected sample and the Canadian population; *t*-statistics suggest there are some relatively small but significant differences between the selected sample and the Canadian population. The mean of the household size in the selected sample (2.63) is slightly larger than the average household size in Canada, which was 2.5 persons in 2006 (Statistics Canada 2006b). The average age of the household head in the selected sample is 56.14. Counterpart statistics on the average age of household heads of the Canadian population are not available. We compare the distribution of the levels of education of household heads in the selected sample to that of the Canadian population aged 20 years and over (there is a lack of statistics on the education levels of household heads for the whole population).

[2]The panel consists of 14,176 households. Among these households, only 6,012 stayed in the panel from January 2002 till December 2005; 644 out of these 6,012 households purchased meat products (not necessarily beef products) in each of the 48 consecutive months from January 2002 till December 2005.

Table 1. Summary statistics of household characteristics: Selected sample versus Canadian population

	Selected sample mean (std.dev.)	Population mean
Household size	2.63 (1.14)	2.5
Household head age	56.14 (11.72)	–
Household income	59,310.95 (29,884.91)	69,548
Household head education (percent)[a]		
Not high school graduate	18.20	15.70
High school graduate	19.00	22.70
Some college	16.10	13.30
College graduate	18.40	20.30
Some university	9.70	5.40
University graduate	18.60	22.70

Source: Nielsen Homescan, National All Channels, daily from January 1, 2002 to December 31, 2005; Statistics Canada (2006b–d), 2006 Census of Population.
Note: We compare the distribution of the levels of education of household heads between the selected sample and the Canadian population aged 20 years and over.
[a]Household head education is described by the distribution of the levels of education of household heads.

It appears that the selected sample has a slightly lower level of education than the adult Canadian population. The average household income of the selected sample has a value of $59,311. The 2006 Census indicates average household income in 2005 of $69,548, appreciably higher than the selected sample mean of $59,311 (Statistics Canada 2006c). However, the methods to measure the sample household income are imprecise and likely to be downward biased. The 2006 Census recorded exact values of reported household income, while the Nielsen Homescan® panel data recorded income in categories. Households that selected $70,000 and above are assigned the value of $100,000, which is likely to underestimate the average household income of the selected sample. Despite their differences, we judge that the selected sample matches observable characteristics of the Canadian population reasonably well. Nevertheless differences in unobservable characteristics may remain. Basing the analyses on the selected sample has the advantages of making full use of the data from those households for which there are purchase records in every month during the time period considered and avoiding the problem of missing values in the data set.

DESCRIPTIVE ANALYSES

In this study, we apply Engel curve analysis since this enables assessment of the dynamics of beef expenditure shares following the food safety shocks associated with the first three Canadian BSE incidents, which is facilitated by the data available. Expenditures on meat products were grouped into four categories: beef, pork, poultry, and other. Monthly price indexes[3] for the different meat groups show that beef prices fell after the 2003

[3]The price indexes are monthly CPI for fresh or frozen meat products in Canada. These price data are published by Statistics Canada (2002–2007), CANSIM table 3260020-CPI, 2005 basket,

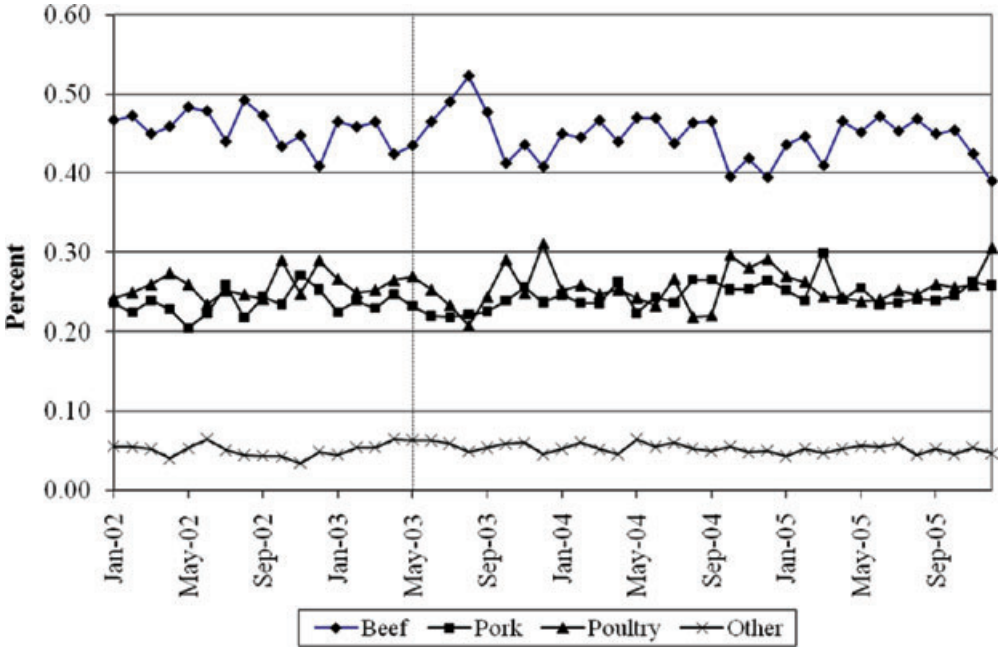
Source: Statistics Canada (2002–2007).

Figure 1. Monthly Consumer Price Indexes for meat products in Canada, 2002–07

announcement of the first BSE event, which rapidly led to closure of export markets for bovine animals and meat (Figure 1). A trough in beef prices occurred in September 2003. The Nielsen Homescan® data set contains no information on meat prices. To take into account the impacts of price variation over time, the reported household meat expenditures were deflated by monthly regional price indexes. These price indexes are aggregated monthly regional CPI for meat products in broad categories (i.e., beef, pork, etc.) (Statistics Canada 2002–2007). The regions for which these are reported are the Maritimes, Quebec, Ontario, Manitoba/Saskatchewan, Alberta and British Columbia. Monthly shares of individual household's deflated expenditures on each of the identified four meat categories were constructed for each household. Aggregated monthly deflated expenditure shares for each of the four meat categories averaged over the selected households are shown in Figure 2.

Figure 2 shows the pattern of seasonality in household's beef and poultry purchases. Poultry consumption peaks during the Christmas season, while beef consumption peaks during the summer months. There was a slight downward trend in the share of the expenditure on beef over the period examined (Figure 2). However, there was an increase in beef expenditure shares, which reached a peak in August 2003, following the first BSE incident in May 2003. This may be due to the combined effect of both declining beef price and seasonality, as the 2003 BSE discovery occurred just prior to the peak season of beef consumption. Both the second and third BSE cases occurred in the month of January

monthly (2002 = 100). This CPI compares, in percentage terms, prices in any given time period to prices in the official base period, which is 2002 = 100.



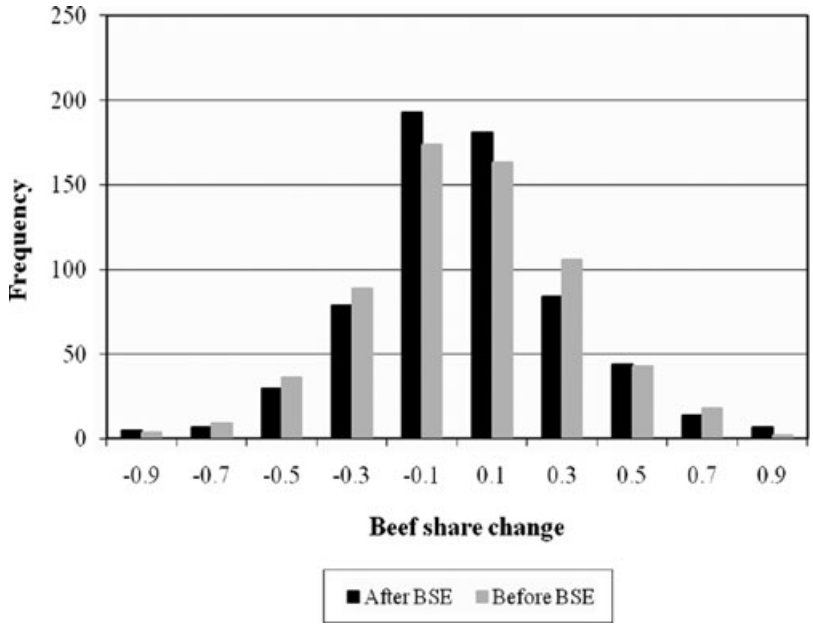
Source: Nielsen Homescan, National All Channels, daily from January 1, 2002 to December 31, 2005.

Figure 2. Average monthly expenditure shares for meat products from the selected Canadian households in the Nielsen Homescan® panel, 2002–05

2005, making it impossible to separate the impacts of these two cases using monthly data. For the purposes of this study, we group the second and third cases together and from now on refer to these as the "second BSE events." Figures 1 and 2 do not reveal patterns that might suggest how the second BSE events may have affected prices and purchases of meat products. Formal tests of the influence of these BSE incidents on beef demand, controlling for trend and seasonality, are discussed in the next section.

One attractive feature of panel data is that it allows researchers to investigate heterogeneity in micro units. Even so, Figure 3 shows that many households were relatively consistent in their beef consumption from April to May in 2002 and 2003, since for the majority of the selected households, the month to month changes in beef expenditure shares were less than 20% of their meat expenditure. Figure 4 depicts the distributions of changes in the values of beef expenditure shares from December 2002 to January 2003, and the changes from December 2004 to January 2005. Comparison of these distributions of changes suggests similar patterns of behavioral changes for the first and second BSE events (Figures 3 and 4). We had expected negative impacts of BSE on beef consumption that would shift the distribution of changes in beef expenditure shares at least somewhat toward the left after the BSE announcements. This pattern was not evident.

A possible explanation for the feature that most of the sampled households tended to be relatively consistent in the pattern of their beef consumption expenditures in the period following the three food safety events is that beef consumption is habit forming. If



Source: Nielsen Homescan, National All Channels, daily from January 1, 2002 to December 31, 2005.

Note: Beef share change before the 1st BSE incident = beef share in May 2002 − beef share in April 2002. Beef share change after the 1st BSE incident = beef share in May 2003 − beef share in April 2003.

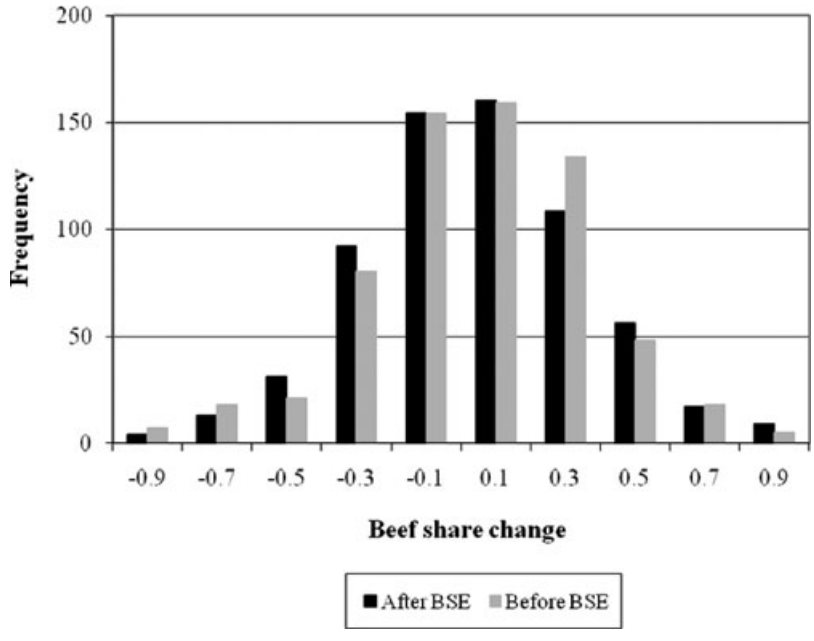
Figure 3. Adjustments of monthly beef expenditure shares following the 1st BSE incident for the selected Canadian households in the Nielsen Homescan® panel

this is the case, habit persistence may affect a household's ability or incentives to adjust to the BSE events in the short term. We postulate that habit persistence resulted in some households not changing their patterns of consumption.

RESULTS AND DISCUSSION

Impacts of BSE on Beef Purchases

Formal tests of the impacts of the first two BSE events in Canada on household's meat expenditures are reported in this section. We estimated two sets of models: Engel curves in differences and in levels. We initially transformed Equation (2) by taking first differences between equations in levels (each level represents a specific month). Taking first differences removed the unobservable household characteristics (μ_h) from the error term. Under the assumption that the errors are not serially correlated, lagged values of endogenous variables are valid instruments for the equations in first differences associated with later periods (Arellano and Bond 1991). Thus, we instrumented the two endogenous terms in the differenced equations (the differenced lagged beef share ($\omega_{ht-1} - \omega_{ht-2}$) and the differenced logarithm of total meat expenditure ($\ln x_{ht} - \ln x_{ht-1}$), with the values of beef share and logarithm of total meat expenditure, lagged two periods and more, respectively.



Source: Nielsen Homescan, National All Channels, daily from January 1, 2002 to December 31, 2005.

Note: Beef share change before the 2nd BSE events = beef share in January 2003 − beef share in December 2002. Beef share change after the 2nd BSE events = beef share in January 2005 − beef share in December 2004.

Figure 4. Adjustments of monthly beef expenditure shares to the 2nd BSE incidents for the selected Canadian households in the Nielsen Homescan® panel

Other explanatory variables in Equation (2) are assumed to be exogenous. Demographic variables are time-invariant and drop out in taking the first differences of the equations. The estimation results of this model version are presented in Table 2 (see equations in differences). The coding of the variables is described in the Appendix (Table A1).

In the Arellano–Bond approach, the validity of the instruments is conditional on the assumption of lack of serial correlation in errors (Arellano and Bond 1991). Lagged values are used as instruments for endogenous variables in our estimation, based on the assumption that the errors are not serially correlated. Therefore, testing for autocorrelation between the errors is necessary to justify the validity of these instrumental variables. We tested for serial correlation in the errors based on equations in levels. Durbin-Watson statistics suggest no evidence of autocorrelated errors in these equations in levels.[4]

Table 2 (equations in differences) shows that the lagged beef expenditure share has a positive effect on current beef share, giving evidence of habit persistence. There are also

[4]There are 46 Durbin-Watson (DW) statistics for each of the differenced equations. Each of the 46 DW statistics tests the autocorrelation between two consecutive levels. None of the DW statistics is significant. DW statistics for each of the equations are available from the authors upon request.

Table 2. Beef consumption Engel curve parameter estimates: Equations in differences and equations in levels

	Equations in differences	Equations in levels
ω_{ht-1}	0.02997***	0.02941***
	(0.00620)	(0.00621)
$\ln x_{ht}$	0.00263	0.00643
	(0.00654)	(0.00613)
February	−0.00105	−0.00376
	(0.00754)	(0.00819)
March	−0.00196	−0.00166
	(0.00728)	(0.00728)
April	−0.00935	−0.00878
	(0.00758)	(0.00758)
May	0.01654**	0.01710**
	(0.00759)	(0.00760)
June	0.02469***	0.02521***
	(0.00818)	(0.00818)
July	−0.00412	−0.00333
	(0.00790)	(0.00789)
August	0.02470***	0.02508***
	(0.00805)	(0.00805)
September	0.01803**	0.01873**
	(0.00752)	(0.00752)
October	−0.02472***	−0.02403***
	(0.00742)	(0.00743)
November	−0.01685**	−0.01645**
	(0.00735)	(0.00737)
December	−0.04857***	−0.04801***
	(0.00761)	(0.00764)
BSE11	−0.01972**	−0.02005**
	(0.00928)	(0.00931)
BSE12	−0.01045	−0.00996
	(0.00969)	(0.00970)
BSE13	0.04276***	0.04254***
	(0.01045)	(0.01044)
BSE14	0.05770***	0.05869***
	(0.01007)	(0.01008)
BSE21	−0.00797	−0.00791
	(0.01048)	(0.01051)
BSE22	0.00627	0.00986
	(0.00986)	(0.01034)
BSE23	−0.02040**	−0.02058**
	(0.01009)	(0.01011)
BSE24	0.02319**	0.02303**
	(0.00967)	(0.00969)

(*Continued*)

Table 2. Continued

	Equations in differences	Equations in levels
T	−0.00045***	−0.00048***
	(0.00014)	(0.00015)
NKID	–	−0.01998
		(0.01495)
EDU	–	0.01578*
		(0.00922)
QC	–	0.08444***
		(0.00969)
CONSTANT	–	0.38673***
		(0.025502)

Note: *,**,***denote significance at the 10%, 5%, and 1% levels, respectively.

significant seasonal effects on beef purchases. Beef expenditure shares increase during the summer, indicated by the significant positive coefficients for the monthly dummy variables of May, June, August, and September, but drop in winter, particularly over the Christmas season. The time trend has a significant negative influence on beef expenditure shares, indicating that these declined over the time considered in this study. This is consistent with the trend of declining consumption of beef in Canada since the late 1990s (Statistics Canada 2008).

The impact of BSE on beef expenditures is the focus of this model. It is possible that BSE had both contemporaneous and lagged effects on beef demand. However, the length of the impacts is an empirical question. Piggott and Marsh (2004) tested for length of impact up to three-quarters after food safety events, but only found evidence of contemporaneous effects. Following their procedure, we locate the BSE impacts on expenditure shares by searching over the time and iteratively estimating the model. We started estimation by including only one BSE dummy variable (which represents the month of the BSE occurrence) for each of the two BSE events. We then iteratively estimated the model by successively adding a further BSE dummy variable for each of the first and second BSE events considered (i.e., we extended the time periods by one more month every time we re-estimated the model). The impacts on beef expenditure shares vanished three months after the BSE announcements. This pattern was found for both the first and second BSE events. Consequently, four BSE event dummy variables for each of the first two BSE events indicating the specific months following the BSE announcements are included in the final model estimations.

Following the announcement of the first BSE case, made on May 20, 2003, there was an immediate negative impact on beef expenditure shares (Table 2). The BSE dummy representing May 2003 (BSE11) has a significant and negative effect on beef expenditure shares. One month later, the BSE impact is still negative but no longer significant. In the following two months, beef purchase expenditures increased. It appears that at the time of the announcement of the first BSE case, risk concerns may have been dominant for many consumers, leading to an immediate reduction in beef expenditures after the announcement of evidence of the initial Canadian BSE case. However, it seems that

concern about risk impacts diminished gradually and consumers resumed their previous consumption patterns as time passed.

Since the Homescan® data set contains no information on prices, we controlled for the effects of price on beef expenditures by deflating expenditures by monthly regional price indexes for the specific types of meats in question (beef, pork, poultry, and other). These provincial-level price indexes, which are aggregated across different meat cuts, do reveal the trend of price changes (Figure 1), but are likely to contain less information than actual prices associated with specific purchases. Consequently, it is possible that increases in households' beef purchase expenditures in the second and third months after the initial BSE announcement may be due to price effects that are not captured by the price indexes used in deflation. However, it is also possible that the initial BSE event caused some households to switch to higher priced beef cuts in order to obtain higher quality products. This type of behavior could have led to the increase in household beef expenditure shares indicated by our data in the second and third months following the first BSE event. It is also possible that the actions taken by the Canadian government in responding to the BSE cases, and media information about these actions (which included an initial focus by the media on precautionary actions taken and subsequent emphasis on the adverse financial effects of the BSE incidents on the beef industry), persuaded Canadian consumers that eating beef was both low risk and likely to support the beleaguered beef industry.

Following the announcements of the second and third BSE cases in January 2005, a negative impact on beef expenditures was not evident until two months after this second pair of BSE events and this reaction lasted only for one month. Expenditures on beef purchases increased in April 2005, the third month after the discovery of the second and third BSE cases (Table 2: equations in differences). The second two BSE events follow a similar general pattern to the 2003 case: consumers initially decreased beef purchases, but then resumed their earlier consumption patterns and temporarily reached a higher level of expenditure. These findings are generally consistent with the literature on consumers' responses to a single food safety incident, which suggests that consumers initially reduce purchases and then gradually return to their past consumption patterns (Mazzocchi and Lobb 2005; Saghaian and Reed 2007). However, the specific patterns of consumer responses that we observed relative to the first and the second Canadian BSE cases are different. The negative impact on sampled households' expenditures was slower to take effect following the second BSE events, suggesting that consumers did not respond to the news of the second BSE events as quickly as they had responded to the first BSE case. Even so, the magnitudes of the negative impacts on beef expenditure shares are similar. A possible reason for the slower response in the reduction of beef expenditure shares following the second BSE events might be that the second events were seen as less of a shock, compared to the first instance of a domestic case of BSE. As well, fewer media reports followed the second and third BSE incidents in Canada than occurred following the initial event (Boyd 2008).

The alternative approach to avoid estimation problems in estimating dynamic Engel curves proposed by Arellano and Bover (1995) estimates equations in levels, using lagged first differences of the endogenous variables as instruments. Use of this estimation method allowed us to examine the effects of household demographics on expenditures and to compare the findings with the results from estimating equations in first differences. Lagged first differences of beef expenditure shares and the logarithms of total meat expenditures

were used as instruments for the beef expenditure share and the logarithm of total meat expenditure respectively to estimate the equations in levels. These results are also presented in Table 2 (equations in levels).

The findings from the two estimation methods are consistent. The results from estimating equations in levels (Table 2) suggest that beef expenditure is habit forming. Again, beef expenditure shares increased during the summer months and decreased in winter. We also observe a declining trend in the beef expenditure share over the entire period (i.e., from January 2002 to December 2005). In each case, the same cycle is identified: the sampled households reduced their relative expenditures on beef after both BSE events but this decline was subsequently reversed. Again, the first BSE case was followed by an immediate negative reaction in beef expenditure shares by the selected households, while the reduction in beef expenditure shares following the second BSE events did not occur until two months after the BSE announcements. From the results of testing the model (Equation 2) in levels it is seen that household demographics evidently play a role in determining beef expenditure shares. Beef consumption is affected by the education level of household heads. Households with lower levels of education tend to have higher beef expenditure shares. Households located in Quebec have higher beef expenditure shares than households in other regions.

Impacts of Habits on Households' Responses to BSE Events

In examining the dynamic relationship between consumption habits and BSE shocks we tested two main hypotheses. The first hypothesis is that households with higher beef expenditure shares reacted less to the BSE events. This is based on evidence that beef consumption is habit forming, in that higher past beef expenditure shares lead to higher current beef expenditure shares (Table 2). Consequently, we expect that a household's response to a food risk event depends not only on views of risk *per se* but also on the household's desire, expressed through its habit, to adjust to that risk event. An associated hypothesis is that habit persistence in beef consumption, expressed through expenditures on beef purchases, tends to offset some of the negative impacts of the BSE events. The second main hypothesis relates to the recurrence involved in the first three Canadian BSE events and is based on the expectation that effects of habit persistence diminish following more than one risky event. The rationale for this hypothesis is that consumers may gradually alter their beef consumption habits over time following successive BSE cases. That is, according to this hypothesis, habit is expected to have less impact on adjustments in purchasing patterns following successive BSE cases.

To test these hypotheses, we interacted the lagged beef expenditure shares with those BSE dummy variables which are significant in Equation (2) (i.e., BSE11, BSE13, BSE14, BSE23, and BSE24), and introduced these interaction terms into Equation (2). The modified model is

$$\omega_{ht} = \beta_0 + \beta_1 \ln x_{ht} + \beta_2 \omega_{ht-1} + \beta_3 t + \sum_{k=2}^{12} \gamma_k D_{kt} + \sum\nolimits_l \delta_l z_{lht} + \sum_{i=1}^{2}\sum_{j=1}^{4} \alpha_{ij} \mathrm{BSE}_{ij} + \sum_{i=1}^{2}\sum_{j=1}^{4} \eta_{ij} \mathrm{BSE}_{ij} \omega_{ht-1} + \mu_h + \varepsilon_{ht} \quad (3)$$

Table 3 presents the results from estimating Equation (3) in differences and in levels. Two interaction terms are found to be significant, including the interaction between the BSE dummy variable indicating May 2003 (i.e., BSE11) and lagged beef shares, and the interaction between the BSE dummy variable representing March 2005 (i.e., BSE23) and lagged beef shares. Those terms that are not significant are excluded from the model. In general, the other model estimates are not sensitive to the inclusion of the interaction terms between lagged beef share and the BSE dummy variables. The same general cycle of behavior is identified for both the first and second BSE events: households reduced their beef expenditure shares following the BSE announcements but these recovered subsequently. However, again, the patterns of reaction and the impacts of habit persistence are different for the first and the two subsequent BSE incidents.

Following the first BSE incident, households' beef expenditure shares temporarily shifted downward (the coefficient on BSE11 is –0.0552). A noteworthy feature is the joint effect of BSE and habit persistence. The positive coefficient (0.0811) on the interaction between the lagged beef expenditure share and BSE11 suggests that habit persistence offset the negative BSE effect and that households with higher beef expenditures reduced expenditures relatively less following the first case of BSE than households with lower beef expenditures.[5] However, in the case of the second BSE events, the coefficient on the interaction between the lagged beef expenditure share and BSE23 is negative and significant, suggesting that households with higher beef expenditure shares reduced their expenditures relatively more than households with lower beef expenditure shares.[6] We expected that habit persistence would tend to offset part of the negative impacts of the BSE announcements. While this is evidently the case for the first BSE event, the evidence from households' adjustments to the second BSE events indicates some modification of habits: we did not find evidence that habit persistence continued to offset the negative impacts of the second BSE events. Instead, households with higher beef expenditure shares reduced their expenditures relatively more than other households following the second BSE events. This change in habit response for households that had previously habitually purchased relatively more beef may reflect households' reactions to the cumulative effects of more than one BSE incident. We also observe that the absolute value of the coefficient on the interaction between the lagged beef share and BSE11 (0.0811) is slightly greater than the absolute value of the coefficient on the interaction between the lagged beef share and BSE23 (0.0728), which suggests diminished impacts of habit persistence following successive risk events. As reported in Table 3, the findings from estimating equations in differences and in levels are consistent.

[5]Our results show that households reduced their beef expenditure shares in the month of the first BSE occurrence as the coefficient on the dummy variable representing May 2003 (BSE11) is negative and significant (–0.0552). However, we also found evidence that habit persistence offset some of the reduction in beef expenditure shares as the coefficient on the interaction term between habit and BSE11 is positive and significant (0.0811). The impact of habit on households' responses to BSE is calculated by 0.0811 * (lagged beef share). Therefore, taking both the BSE and habit impacts into account, the overall impact of BSE on households' beef expenditure shares in May 2003 is (–0.0552) + 0.0811 * (lagged beef share). (Note that these equations apply at the household level and that the lagged shares vary among households.)

[6]The impact of habit on households' responses to the second BSE events is calculated by (–0.0728) * (lagged beef share).

Table 3. The impacts of habit persistence on selected households' responses to BSE events: Equations in differences and equations in levels

	Equations in differences	Equations in levels
ω_{ht-1}	0.029034***	0.02887***
	(0.00630)	(0.00635)
ln x_{ht}	0.00189	0.00625
	(0.00655)	(0.00613)
February	−0.00110	−0.00376
	(0.00754)	(0.00819)
March	−0.00197	−0.00164
	(0.00728)	(0.00728)
April	−0.00938	−0.00878
	(0.00758)	(0.00758)
May	0.01654**	0.01711**
	(0.00759)	(0.00760)
June	0.02464***	0.02522***
	(0.00818)	(0.00818)
July	−0.00416	−0.00331
	(0.00790)	(0.00789)
August	0.02463***	0.02508***
	(0.00805)	(0.00805)
September	0.01802**	0.01877**
	(0.00752)	(0.00752)
October	−0.02468***	−0.02399***
	(0.00742)	(0.00743)
November	−0.01686**	−0.01643**
	(0.00735)	(0.00737)
December	−0.04859***	−0.04799***
	(0.00761)	(0.00764)
BSE11	−0.05516***	−0.05165**
	(0.01607)	(0.01797)
BSE12	−0.01043	−0.00993
	(0.00970)	(0.00970)
BSE13	0.04285***	0.04257***
	(0.01045)	(0.01044)
BSE14	0.05778***	0.05874***
	(0.01007)	(0.01008)
BSE21	−0.00809	−0.00794
	(0.01048)	(0.01051)
BSE22	0.00625	0.00986
	(0.00986)	(0.01034)
BSE23	0.01201	0.00894
	(0.01857)	(0.02048)
BSE24	0.02317**	0.02301**
	(0.00967)	(0.00969)

(*Continued*)

Table 3. Continued

	Equations in differences	Equations in levels
T	−0.00045***	−0.00048***
	(0.00014)	(0.00015)
$\omega_{ht-1} * \text{BSE11}$	0.08110**	0.07231**
	(0.03129)	(0.03664)
$\omega_{ht-1} * \text{BSE23}$	−0.072847**	−0.0663*
	(0.03531)	(0.04033)
NKID	–	−0.02074
		(0.01498)
EDU	–	0.01547*
		(0.00924)
QC	–	0.08525***
		(0.00971)
CONSTANT	–	0.38774***
		(0.02551)

Note: *,**,*** denote significance at the 10%, 5%, and 1% levels, respectively.

An interesting feature of the results in Table 3 is that the estimated parameters on the interaction between the lagged beef share and BSE11 are much larger than the parameters on the lagged beef share. Specifically, from the results of the equations in differences, in the month of the first BSE occurrence, the impacts of habit on beef expenditure shares, calculated by $(0.029 + 0.081) *$ (lagged beef share) is much greater than the usual impacts of habit, which is $0.029 *$ (lagged beef share). This suggests that habit is more important in determining beef purchases in the month of the first BSE occurrence than in other months. However, price changes associated with specific beef purchases may also have contributed to some component of the apparently large positive effects of habits on beef expenditures following that first BSE announcement. For example, it is possible that the initial BSE incident caused households that consume more beef products to switch to more expensive beef cuts in order to increase beef quality. We must acknowledge that lack of price data obscures precise interpretation. As noted previously, following the second BSE events we found negative impacts of habit on household's beef expenditures. In contrast to the first BSE case, here we found less difference (expressed in absolute value terms), between the impacts of habit following the second BSE announcements ($-0.044 *$ lagged beef share) and the usual habit impacts ($0.029 *$ lagged beef share).[7]

CONCLUSIONS

Food scares seem to be proliferating in number, as well as in media attention, contributing to the need to improve current understanding of consumer responses to food safety incidents. The question of how consumption patterns evolve over time in the presence

[7]The impact of habit in this case is (0.029–0.073) * (lagged beef share) = (–0.044) * (lagged beef share).

of a series of food scares is expected to be of interest for both policy makers and the food industry. There have been several previous analyses of the impacts of BSE and other food safety events on food consumption. However, few of these analyses considered the role of consumption habits and the interactions between habits and recurrent food safety incidents. Using Engel function analyses we examine the impact of the Canadian BSE outbreak on beef consumption and assess the role of consumption habits following the first three domestic BSE incidents in Canada.

Our analyses focus on the dynamics of monthly beef expenditure shares of a sample of Canadian households. The results suggest that the dynamics of beef expenditure shares were influenced by a number of factors, including habit, seasonality, time trend, food risk shocks, and household characteristics. Households' reactions to both the initial and two subsequent BSE cases followed the same general pattern. Households reduced their beef purchase expenditures following the announcement of the BSE occurrence; then, evidently as concern diminished, their expenditures on beef consumption recovered. Regarding the role of consumption habits, we found evidence that habit persistence limited households' reductions of beef purchases following the first BSE event. We also observed that households with higher beef expenditure shares reduced expenditure more than other households following the second BSE events, suggesting modification of habits following recurrence of BSE discoveries.

In summary, we found evidence of only temporary impacts of the first three BSE incidents on beef consumption in Canada. Sampled households reduced their beef expenditure shares following the BSE announcements. However, their beef consumption increased again fairly soon. However, we also observed evidence of cumulative effects of more than one BSE incident, with numbers of households modifying their beef consumption habits as the number of BSE events increased. Evidently, the reaction patterns exhibited by the sampled households suggest that the long-term impacts of recurrent food safety events can differ from the short-run effects.

The data set used in this study contains detailed information on household meat purchases before and after the first BSE case in Canada, which enabled us to give consideration to several important factors that influence consumer responses to food safety events, including habit persistence, household heterogeneities and the recurrence of food safety incidents. However, we must acknowledge the possibility that there might be behavioral differences between the analysis sample and the general population. We also acknowledge that the lack of price data that correspond to individual household's specific meat purchases in the Homescan® data may have limited our analysis. Future studies may give further insight on consumers' responses to recurrent food safety incidents and indicate the robustness of our conclusions.

APPENDIX

Table A1. Definition of the variables

Variables	Definition
ω_{ht-1}	Monthly beef expenditure share for household h at time $t-1$
$\ln x_{ht}$	The logarithm of total meat expenditure for household h at time t
February–December	Monthly seasonal dummy variables
BSE11	A dummy variable indicating the month when the 1st BSE incident occurred (1 = May 2003; 0 = otherwise)
BSE12	A dummy variable indicating one month after the 1st BSE occurrence (1 = June 2003; 0 = otherwise)
BSE13	A dummy variable indicating two months after the 1st BSE occurrence (1 = July 2003; 0 = otherwise)
BSE14	A dummy variable indicating three months after the 1st BSE occurrence (1 = August 2003; 0 = otherwise)
BSE21	A dummy variable indicating the month when the 2nd BSE incident occurred (1 = January 2005; 0 = otherwise)
BSE22	A dummy variable indicating one month after the 2nd BSE occurrence (1 = February 2005; 0 = otherwise)
BSE23	A dummy variable indicating two months after the 2nd BSE occurrence (1 = March 2005; 0 = otherwise)
BSE24	A dummy variable indicating three months after the 2nd BSE occurrence (1 = April 2005; 0 = otherwise)
T	Time trend
NKID	Number of children in a household
EDU	The education level of the household head (1 = high school and below; 0 = otherwise)
QC	Regional dummy variable (1 = Quebec; 0 = otherwise)

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