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

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ABSTRACT OF DISSERTATION

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The Graduate School
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2011

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

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Agriculture at the University of Kentucky

By
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Lexington, Kentucky

Director: Dr. Leigh James Maynard, Professor of Agricultural Economics

Lexington, Kentucky

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

Household-level Canadian meat purchases from 2002-2008, a Food Opinions Survey conducted in 2008 at the national level and household-level egg purchases from 2002-2005 in Alberta and Ontario were used to explore consumer responses to Bovine Spongiform Encephalopathy (BSE) in Canada.

The opinions survey focused on nutritional priorities, general and specific food safety concerns, and trust in government and food industry decision makers. The egg data set contained specific product information allowing us to distinguish purchases of conventional eggs from those of value-added eggs with perceived health attributes. Thus, the egg purchase data appeared to be an interesting proxy of revealed willingness-to-pay for health attributes and animal welfare attributes in products other than meat, and it served as a proxy of awareness and concern for farm-level production practices. Three measures of beef purchases were used to understand consumers' reaction to 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. Regional differences appeared, with consumers in eastern Canada reacting most negatively to BSE. Consumers responded more to the perception that food decision makers are honest about food safety than to the perception that they are knowledgeable, in maintaining beef purchases during BSE events. Consumers who purchased value-added eggs reacted significantly more negatively to the second and third BSE events, as did those who reported increasing food safety concerns in the opinions survey. Their negative responses to BSE were stronger than those of consumers who purchased conventional products which indicated a relationship exists between concern for health and nutrition attributes and food safety. This study extends previous research by enlarging the time periods and more data sources which can be helpful to identify individual heterogeneity and the application of panel random effects models which also targets on controlling the unobserved and constant aspects of households.

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

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

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I received important emotional support from my family. I could not go such far without the patience, encouragement and love from my family. I owe too much for all of them who I love.

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Chapter One

Introduction and Problem Statement

Food safety has a big impact on the food industry and consumer confidence in food products, and therefore can result in enormous social and national economic losses. The case of Bovine Spongiform Encephalopathy (BSE) in cattle is an example of food safety issues. World-wide impacts were caused by BSE such as the negative influences on the beef industry and consumer concerns about beef products. The potential health risks from BSE are not limited to an individual country but can be result in the damage of international trade across many countries.

On March 20, 1996, the British Secretary of State Health made an announcement that there existed a possible link between Bovine Spongiform Encephalopathy (BSE), popularly called "Mad Cow Disease," and variant Creutzfeldt-Jakob disease (vCJD) and thus created environmental uncertainty in 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. Significant BSE impacts were found in Europe and Japan, but there is little evidence of retail BSE impacts in North America. Feuz et al. concluded that demographic were no significant impacts on consumers' preferences (2007). Previous studies of North American consumer responses to BSE also showed that few demographic variables were statistically significant determinants of behaviors (Maynard and Wang, 2011). Therefore, "who you are" may not have strong explanatory power, but "what you think" or "what else you do" may be the key to explaining individual choices.

Some observers referred to the Canadian government's response to BSE as transparent and effective at communicating up-to-date information (Boyd and Jardine, 2007). Sixteen BSE events have been confirmed in Canada up to May, 2009. The *Edmonton Journal* reported the most recent BSE discovery on May 15, 2009 (Loyie, 2009, p 1):

> *"EDMONTON — The Canadian Food Inspection Agency has confirmed bovine spongiform encephalopathy or mad cow disease in a*

dairy cow from northern Alberta. No part of the 80-month-old animal's carcass entered the human food or animal feed system, the agency said in a release Friday. … "

After the first BSE outbreak in 2003, the Canadian Food Inspection Agency (CFIA), which is the government agency responsible for the BSE investigation, made an announcement that the cow did not enter the food system immediately after the first BSE discovery announcement (Peng et al., 2004). The beef products were assured safe by retailers and the Canadian government. Positive reactions to the first event found by Maynard and Wang (2011) may reflect support of the ranchers and the struggling industry which was consistent with media emphasis identified by Boyd and Jardine (2007). Boyd and Jardine (2007) confirmed that the first BSE event was treated as a trade issue more than a food safety event by the public through media content analysis. However, consumers might begin to fear health consequences when BSE discoveries appear to become a pattern rather than an isolated instance which was demonstrated by the negative response to the second BSE event in December, 2003 and the third event occurred in January, 2005 at the national level in Canada (Maynard and Wang, 2011). Actually, serious meat safety concerns still existed among Canadian consumers (de Jonge et al., 2008). Concurrently, industry members and government agencies still have high concern about BSE outbreaks (Maynard and Wang, 2011). Therefore, in addition to the transparency of the government's responses, other steps are needed in order to retrieve consumer confidences in beef products and the industry. Coffey et al (2005) believed that the verification of animal age, alterations to beef processing and segregation of meat products were necessary to regain global beef markets. Increasing food production, processing and handling in order to meet food safety requirements is costly (Tonsor et al, 2007). More information about consumer preferences on nutrition, health and animal welfare and the interactions between food safety opinions and food risk such as BSE is needed before large investments are made regarding food safety protocols, policies and inspections.

Major data purchases by the Consumer and Market Demand Network, hosted at the University of Alberta, allowed an unusual opportunity to link household identifiers across distinct data sources to understand consumer reaction to BSE by releasing the constraint

of unobservable and persistent heterogeneity of each household in Canada. Thirteen cases of BSE were discovered in Canada during the study period from 2002 to 2008. BSE was first confirmed in an Alberta-born cow on May 20, 2003 (CFIA, 2009). A second pair of BSE outbreak occurred on January 2 and January 11, 2005. Additional discoveries occurred in January, April, July, and August of 2006, February, May, and December of 2007 and in February and June of 2008. For the purpose of this analysis they were aggregated into three periods termed "events". Previous research (Maynard and Wang, 2011) demonstrated the importance of distinguishing among events when measuring BSE responses, due to evolving public perception of the threat to food safety. Maynard et al. (2008) showed that Canadian media coverage of BSE lasting till July of 2003 after the first BSE confirmation announcement on May 20, 2003. Previous study found that no significant impacts on beef purchases existed four months after the month of BSE occurrence (Maynard and Wang, 2011). Therefore, four months beginning with the first BSE discovery in May, 2003 were defined as a first 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.

Based on the availability of data sources, this study includes two parts. The first part is to link household identifiers across three distinct data sources in two provinces: Alberta and Ontario, Canada which allowed testing two main hypotheses. The "province" refers to collections of provinces in this study. For instance, "province" Ontario refers to the collection of Toronto and Ontario. "Province" is used for simplicity in the context in this study. First, consumers responded consistently to BSE in self-reported attitudinal surveys and in their actual meat purchase behavior spanning several years. Second, consumers who regularly purchased other value-added foods with health or animal welfare attributes were more likely to react strongly to BSE. The primary data source was a series of Nielsen Homescan datasets containing household-level meat purchases from 2002-2008, the second was also Nielsen Homescan data containing household-level egg purchases from 2002-2005, and the third was a Food Opinions Survey conducted in 2008. The egg data set contained specific product information allowing us to distinguish purchases of

conventional eggs from those of value-added eggs with perceived health attributes (e.g., high Omega-3 eggs, organic eggs, low cholesterol egg product, etc.) and animal welfare attributes (e.g., free range and cage-free eggs). Thus, the egg purchase data appeared to be an interesting proxy of revealed willingness-to-pay for health attributes in products other than meat, and it served as a proxy of awareness and concern for farm-level production practices. The opinions survey focused on nutritional priorities, general and specific 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.

The other part of the study is to use two linked data sets to understand consumer reaction to BSE at the national level which gains a much broader geographic scope including four additional provinces: the Maritimes (abbreviated in table as Maritimes), Quebec, Manitoba/Saskatchewan (abbreviated in tables as Man/Sask), and British Columbia (abbreviated in tables as BC) and at the expense of slightly less detailed data because there are no egg purchase data of these four provinces. 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. The two data sources were Nielsen Homescan datasets containing household-level meat purchases from 2002-2008, and the Food Opinions Survey conducted in 2008. Both of the two data sources are at the national level.

Consumer reactions to BSE can be affected by trust of government and industry decision makers. As suggested by some recent literature, trust has been an important factor in analyzing consumer behavior under food safety issues (Ding et al., 2009; Maynard and Wang, 2011). Individuals' food attitudes, their trust in the food industry and their confidence in the safety of beef products after BSE discoveries are important for policy makers and the beef industry.

Key explanatory variables in each model were dummy variables defining BSE events. Additional explanatory variables relate to three specific hypotheses of special interest: (1) value-added egg consumers did not respond more strongly to each BSE event than conventional egg consumers, (2) consumers' trust of government and industry decision makers did not affect reaction to each BSE event, and (3) consumers reporting

strong food safety concerns did not react strongly to each BSE event. The opinion survey contained many questions regarding trust and concern for food safety. To conserve degrees of freedom, factor analysis was used to create indices for trust in government and manufacturers, a general worry trait, and indices for food safety optimism and pessimism. Interaction terms were then created between the BSE dummy variables and the location of household, presence of children in various age ranges, household income, and the value-added egg, trust, and concern variables. Remaining explanatory variables described each household's demographics, and included household size, education and age of the household head. Monthly dummy variables controlled for seasonality.

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 and consumer behavior under food risk. Previous studies provide us with the understanding of consumer perceptions of food safety in the meat industry and this helps meat producers and supply chain managers to incorporate the information into their decisions and strategies when facing a difficult situation such as the outbreak of BSE. The uniqueness of the data sources allow this study to answer the question of whether underlying food opinions and food safety concerns could better explain the behavior of Canadians than the conventional emphasis on demographic variables. This work will be important to scholars in this field because the use of linked data sets for at-home beef consumption has nationwide coverage and information about attitudes and related food purchasing behavior is usually unavailable, so the effects are relegated to the category of unobservable heterogeneity.

This study departs from previous work by employing panel data models. The advantages of the data were the combination of two and three 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. Most BSE impact studies were based on meat demand systems, but the demand system approach used in some previous studies is not practical in this case. Thus, we were concerned about confounded BSE responses and price effects. To help mitigate this problem, we estimated BSE responses using three distinct measures of beef purchases.

First, a random effects logit model explained variation in whether any beef was purchased during a given month. Second, the monthly number of beef units purchased by a household was modeled using a random effects negative binomial model. Third, a standard random effects model for continuous dependent variables was used to explain variation in monthly expenditures on beef.

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. The purpose of this study was to render a portion of that heterogeneity observable. Households with the same demographic characteristics may behave differently when 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 behavior, 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 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 power 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 various forms, linear regression (e.g. beef expenditures), dummy variable outcomes (e.g. purchase/no purchase of beef), or count data (e.g. number of beef purchases), panel data models allow a dependent variable to be measured repeatedly for a household, person, or agricultural producer. The model then controls for all available explanatory variables, e.g. income or age, and in addition estimates and removes from the variance fixed unmeasured aspects of households, such as a strong or weak desire to purchase beef under all conditions. The results are more statistical power in testing hypotheses, e.g. that consumers responded consistently to BSE in self-reported attitudinal surveys and in their actual meat purchase behavior spanning several years. Panel data models control for observed explanatory variables over time. Random effects models control for unobserved, time-invariant aspects that affect all of the observations over time of a household in choosing whether and how much beef to purchase. Random effects had

small correlations with explanatory variables in all provinces, the major assumption needed for consistent estimation of the model. Random effects accounted for 11% of the variation in household-level beef expenditures in Alberta. Data manipulations were largely performed in SAS, while Stata was used for model estimation.

This study contributes to the literature by doing an analysis of BSE reoccurrences, the awareness and concern for farm-level production, and food opinions which could affect consumers' reaction to food risk. 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 was 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.

Many studies have also been done on consumer preference of value added products. This study will contribute to the existing literature on food safety concerns by adding analysis of potentially correlated behavior between BSE and health concerns. At the same time, the understanding of how trust and food attitudes shape consumer reactions to BSE events will be received from this study. The results may suggest a relationship between food risk, nutrition, health and trust existing in Canada. The expected findings of the study will contribute to a better understanding of Canadian consumer reactions to BSE events. Such information will be useful in policy development, and to some extent may be generalizable to behavior in other countries.

Given the huge and negative impacts on the worldwide beef industry, there will be considerable opportunities for private firms to exploit consumer confidence in the products and consumer preparedness to move to higher quality and better sourced, regional or special products. The beef industry can have specific strategies in order to better satisfy consumer requirements of food safety. Given the unique data set in this study, information on consumer reactions to BSE and consumer preference for value added products will be useful for understanding customer demand.

Chapter Two

Literature Review

Previous food safety studies have been focused on the determinants of consumer choices under food risk and many studies have been done in health and nutrition concerns of food such as the preferences of value-added food products. However the study of the interaction effects between food safety events and health concerns is needed in order to have a complete understanding of the determinants of consumer confidence in beef product facing BSE outbreaks and further lead to an adequate and effective management under food risk from the beef industry side. From the perspective of public health, a healthy food choice, the preferences for value-added eggs in this study, might affect consumer concern about the safety of beef products. The general correspondence between the survey responses and actual purchase behavior spanning several years may exist and it suggests the persistence in household behavior over time.

Food Safety, Food Quality and Traceability Systems Study

From the late 20th century, consumer confidence in food quality and food safety reduced gradually in the United Kingdom and other countries where there are a series of problems of the food safety. Food safety and food quality have become important issues in consumer perceptions of food markets.

Consumers use intrinsic and extrinsic attributes to evaluate food quality (Hobbs, 2003a). Intrinsic quality attributes are inherent in the physical product, which for instance, include fat content, tenderness and color of the products. Brand name, price and country of origin are extrinsic quality attributes (Hoffman, 2000). Quality attributes can also be categorized by search, experience and credence attributes (Hobbs, 2003a). Search attributes are observable to the consumer prior to the purchase but experience attributes can only be known after consumption (Hobbs, 2003a). Some food safety problems are experience attributes such as immediate illness after consumption. Many food safety and quality attributes are credence attributes, such as the origin of product, animal welfare, environmental practices used on the farm or the presence of genetically modified organisms (Hobbs, 2003a). For instance, unequal information regarding BSE exists in beef characteristics which cannot be visually detected by the consumer when making a

purchase decision. Traceability systems can identify credence attributes that are related to food safety issues.

Traceability systems were launched by the government in some countries. Many studies have been done in this field in order to deal with and resolve the issue of food quality and safety and to restore consumer food confidence in quality and safety. The implementation of a rigorous traceability system has become a fundamental need for food safety (Loader and Hobbs, 1996; Jin et al., 2004; Labrecque and Charlebois, 2006). Traceability is the ability to trace and follow a product throughout all stages of its production, processing, and distribution (Banterle and Stranieri, 2008). Mandatory traceability and labeling initiatives have been introduced and implemented in some countries. BSE outbreaks in Europe induced a mandatory traceability and labeling system in the beef supply chain. The European Union members are required to have a beef labeling and traceability system. The traceability system has 3 main characteristics: breadth, depth and precision. The breadth is the amount of information the traceability system can record. The depth shows which sectors are involved in the food supply chain and the precision is the ability to track unit dimensions. European Traceability Systems include supply chain traceability and a supply chain and product traceability system. The supply chain traceability is based on information procedures to identify economic agents in the supply chain and it is mandated. The main purpose is to improve food product safety levels, by identifying customers and suppliers at each stage of the supply chain. The product traceability system is much more complex than supply chain traceability because this system also traces individual products and it is voluntary. It has a higher level of precision and breadth. The main goal is to provide a higher level of food safety and food quality. Gracia's study (2005) indicated consumers and retailers both had positive attitudes toward the traceability and labeling system for beef products in Spain.

Traceability in the agri-food supply chain has become the focus of recent Canadian industry initiatives and policy discussions (Hobbs, 2003b). Private sector initiatives and government mandatory regulation are the two major sources of traceability systems for livestock. Private sector livestock traceability systems include individual supply chain initiatives and industry-wide programs. The traceability of supply chain partnerships emerged in the UK beef industry as the result of the loss in consumer confidence because

of the BSE crisis (Hobbs, 2003b). The Canadian meat processing sector has also recognized the important role of the traceability system to restore consumer confidence. The Canadian Cattlemen' Association had established the Canadian Cattle Identification Agency (CCIA) and had implemented a national cattle identification system to facilitate the trace back of cattle. The Canadian Food Inspection Agency (CFIA) initiates a trace back procedure to use the CCIA database information to identify the last location of the animal and the origin of the herd (Hobbs, 2003b). By using this information, cattle can be tracked both backwards and forwards in the supply chain. This system allows the identification of cattle only of the origin of the herd and the final location of the cattle. A mandatory national cattle identification system was established by the CCIA which allows the trace back of cattle facing a food safety event or animal disease problem in July 2002 and 92-95 percent compliance was achieved by the fall of 2002 (Hobbs, 2003b; Lawrence et al. 2003). The system identifies all bovine and bison animals before they leave the farm of origin by using a unique identification number and this is just partial traceability since this system doesn't provide complete traceability through the supply chain. This may require the beef supply chain members to provide more detailed records for downstream firms (Loader and Hobbs, 1996). The national cattle identification system is helpful to speed and investigate BSE outbreaks in Canada (Lawrence et al. 2003).

As consumers are at the demand side of traceability, studies focused on the willingness to pay for it. Hobbs' (2003b) study concluded that some Canadian consumers indicated a willingness to pay for traceability assurance, but the traceability system itself did not deliver useful information to most consumers in their sample. As quality assurances with respect to food safety and humane animal treatment, traceability has more appeal. Hobbs suggests that the combination of traceability with quality assurances about enhanced on-farm production or processing methods may represent a more valuable product differentiation strategy in the Canadian red meat sector.

Extensive studies have been done on the impact of food safety scares and their results consistently show that food safety scares drive prices and demand down and consumers' willingness to pay for safety and quality assurance may be high (Saghaian and Reed, 2007). Several studies have examined consumer willingness to pay for food

safety assurances or risk reductions (Brown et al., 2005; Goldberg and Roosen, 2005; McCluskey et al., 2005). People believe that beef consumption would decline abruptly as a result of BSE discoveries (Jin et al., 2004). The worldwide beef markets have been adversely affected by food safety concerns in recent years (Tonsor et al., 2007). In order to meet modern consumer needs and perspectives, the beef industry needs to implement new technology and national branding strategies and thus focus on food quality and product labeling. Food safety policy may become internationalized.

BSE Studies

Since the initial British and the later Canadian BSE crises, food safety policies have drawn attention from trade policies, marketing channels, and science and national regulators worldwide. Most academic research considered BSE as a human-induced crisis (Pearson and Mitroff, 1993; Labrecque and Charlebois, 2006). It has been proven that BSE was caused by the intensive farming practice of recycling animal protein in ruminant feed and the root cause of BSE was meat-and-bone feed given to cattle. All these made any BSE event a social problem and meanwhile a technological disaster (Pearson and Mitroff, 1993; Labrecque and Charlebois, 2006).

The supply chain members, from the production sector, selling, slaughtering and processing to retailing sectors, suffered losses from BSE events, and macroeconomic effects also exist (Loader and Hobbs, 1996). British beef and dairy farmers suffered income losses immediately after the BSE event in March 1996 because of the fall of domestic demand and the ban of exports. The cattle slaughtering and meat processing sectors have incurred costs because of reduced sales, lower prices, unsold inventories and losses of domestic and export markets after the BSE crisis in March 1996. Meanwhile, retailers and the hotel, restaurant and trade industries also faced direct losses because of the need to reduce the beef prices in order to sell beef inventories. In the long term, the cost of advertising and promotion expenditures to reassure consumers also increased.

Consumer responses to domestic BSE discoveries have been explored internationally which suggests that beef consumption fell dramatically after the BSE events in most countries. Beef consumption declined by 70 percent after the first BSE

event in Japan in 2001 (McCluskey et al., 2005) and a decline also occurred in Great Britain (Burton et al., 1996) and Italy (Mazzocchi and Lobb, 2005).

BSE Studies in Europe

The studies of BSE and consumer responses have focused on the cases in European countries because it has mainly occurred in Europe (Jin et al., 2004). Before the government announcement was made in Britain, the British beef industry and the veterinary authorities denied any negative media coverage about BSE and rejected that BSE could affect human health (Palmer, 1996). On March 20, 1996, the U.K. government announced that there was a possible link between consumption of BSE-infected meat and the development of Creutzfeldt-Jacob disease (vCJD) (Jin et al, 2004). About 135 people had been affected with vCJD worldwide and it was believed that the reason they were infected was by eating products from BSE-infected animals. Even after the government announced that there existed uncertainty for consumers, they still believed that the BSE risks to humans were remote and they had not lied to the public. This made the public feel that they had been betrayed by the government. Hence, public trust towards the beef industry was affected severely by the BSE crisis in Britain. It has been demonstrated that in the two weeks following the announcement about BSE from the British government that caused the scare, the retail sale price of beef products fell over 33 % in Britain. Imports of British beef products were banned by countries including members of the European Union and Canada (Smith et al., 1999; Jin et al., 2004; Labrecque and Charlebois, 2006). Consumer demand of British cattle declined throughout the EU and the price dropped over 25% on the world markets. Supply structure has been changed as the result of the BSE crisis because of the reduction in the availability of beef cattle in Britain and meanwhile the imports declined since its price increased relative to the domestic price. All these factors affected beef prices throughout the European Union. Therefore, the reestablishment of consumer confidence was a big challenge for the British beef industry which could not be met by the enhancement of marketing strategies. The food safety policy and the traceability system are crucial to make the changes.

The BSE studies have addressed three different directions based on European cases (Jin et al., 2004). The first group investigated consumer reactions to the BSE crisis in

France. By using the contingent valuation method, the study done by Latouche, et al. (1998) showed that consumers would be willing to pay more for greater transparency. The second group investigated the structural changes after the BSE outbreak in Europe. Mangen and Burrell (2001) used a switching almost ideal demand system (AIDS) model to analyze a structural change in Dutch consumer preferences for meat and fish after the U. K. government's announcement of BSE. The third group did research on economic consequences of the BSE events in Europe. Burton et al. (1996) used a dynamic AIDS model to investigate the impact of BSE media coverage on the demand of beef and other meats in the U. K. BSE had both significant short-run and long-run impacts on beef consumption in the U.K. The consumption of beef and other meats have declined significantly as the result of the BSE crisis. The media index had significant effects on the allocations of consumer expenditure among meats.

BSE Studies in North America

The background of the Canadian beef industry is important to understand the consumer beef preferences and consumer reactions to the BSE events in Canada. Canada is a country known by its agricultural production surpluses and the beef sector plays an important role in Canadian agriculture and the agri-food industry. It is dependent on international markets to absorb its excess commodity surpluses and food products. Beef producers are about 26% of Canadian farmers and the number of beef farms is over 40% of the total farms in Alberta (CAFTA, 2008). The beef sector contributes $26 billion to the Canadian economy per year. It accounted for 20% of farm cash receipts in 2006. Canadian beef was exported to 62 countries in 2007. 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 predominantly 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 an industry-wide crisis. 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 the international markets (Roy and Klein, 2005). 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 Canadian BSE crisis was mainly driven by the international trade losses and Canada's domestic demand did not decrease (Pennings et al., 2002; Peng, et al., 2004; Maynard and Wang, 2011). 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 affect the future of the industry and many producers even attempted to maintain the status quo. Canadian consumers continued to purchase Canadian beef products and it was indicated by a positive reaction to the BSE event in Alberta, Ontario and British Columbia from 2003 to 2005 (Maynard and Wang, 2011).

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 information regarding health information affects future 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, 2011). 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 to show that BSE media coverage affected the purchase of fast-food beef entrees (Maynard et al., 2008). At-home beef purchases increased following the first BSE discovery and then decreased in the

other two events in the study areas (Maynard and Wang, 2011). Their research concluded that we should evaluate BSE events individually instead of measuring the average or net consumer responses to BSE.

Mutondo and Henneberry (2007) used the Rotterdam model to estimate the source-differentiated meat demand in the U.S. The 2003 BSE outbreaks in North America had small impacts on meat demand. The demand for U.S pork might be increased as the result of BSE outbreak in North America.

Based on both U.S and Canada samples, Steiner and Yang (2007) explored consumer valuation of beef labeling strategies from choice experiments that were conducted in Alberta (Canada) and Montana (US). Their analysis focused on three labeling attributes in beef steak: BSE testing, the use of genetically modified organisms and the use of growth hormones in the products. They concluded that consumers in both countries were willing to pay most for the guarantee of BSE testing compared with the other two attributes in 2007 which was after the first BSE outbreak in Alberta, Canada in 2003.

Maynard and Wang (2011) used Homescan meat purchases from 2002 to 2005 in Canada to examine consumer reactions to the BSE discoveries during the study period. Three measures of beef purchases were performed: binary logit model used for beef participation vs. nonparticipation, Poisson regression used for number of units purchased and consumption in terms of beef expenditure share was measured with a tobit regression. In order to control for the heterogeneity of each household, lagged total meat quantity and lagged expenditure shares of each meat type were included in the regression. Consumers reacted significantly positively to the first BSE event and reacted negatively to subsequent BSE events in all provinces. Few demographic variables had significant impacts on beef consumption.

Egg Consumption in Canada

This study uses consumer egg consumption as the proxy of willingness-to-pay for health attributes in order to see the linkage between food safety concerns and health concerns. Health information and nutritional concerns play an important role in egg demand (Hailu and Goddard, 2004). Canadian per capita total egg consumption began

declining in 1957. This may be attributed to cholesterol content and the probable links between this and risks of heart disease (McIntosh, 2000). The research on nutritional attributes of eggs and development of Omega-3 enhanced eggs and vitamin enriched eggs are strategic responses from the egg industry (Hailu and Goddard, 2004). Canadian egg consumption has increased since the mid 1990's. Hailu and Goddard's study (2004) showed that Canadian egg demand has undergone structural change which was consistent with egg-cholesterol news coverage, new products introduced into the market and the popularization of the Atkin's diet.

Consumer Preferences for Value Added Food Products

Health has become an increasingly important motivation when consumers make decisions on food purchases (Aschemann and Hamm, 2008; Chase et al., 2007). In order to follow this trend, the food industry has started to offer so-called value-added food products. By the definition from the U.S Department of Agriculture, Rural Business Development, the value-added products are defined and categorized as the following three types (Agricultural Marketing Resource Center, 2009):

> *"1. A change in the physical state or form of the product (such as milling wheat into flour or making strawberries into jam).*
>
> *2. The production of a product in a manner that enhances its value, as demonstrated through a business plan (such as organically produced products).*
>
> *3. The physical segregation of an agricultural commodity or product in a manner that results in the enhancement of the value of that commodity or product (such as an identity preserved marketing system)."*

The egg consumption for the same households in the study served as the indicator of consumer preferences for health and nutrition. The ten types of eggs were aggregated into two major categories based on the research hypothesis: conventional and value-added egg. There two value-added egg categories based on the definition of value-added products. Type one is a change in the physical state or form of the egg. Processed egg is categorized into the first type of value-added eggs. Type two: the production of a product in a manner that enhances its value, as demonstrated through a business plan (such as

organically produced products). Free range eggs, free run, Omega-3, vitamin enhanced, processed and organic eggs are all categorized into the second type. Consumers' preferences of value-added products serve as the individual difference variables besides of demographic variables in the study.

Many studies have been done on value-added products which identify consumer preferences on nutrition, health and environmental motivation. The existing studies have been focused on either consumer preferences or their choice of organic food and demographic factors such as gender, income, children, residence, and education are generally incorporated in the analysis (Durham, 2007). Sometimes, consumers' prior knowledge of the alternative product is also included. Loureiro, McCluskey and Mittelhammer (2001) showed that consumers who have children and strong food safety and environmental concerns will prefer organic apples. The main conclusion of both previous economic studies and market research is consumers who prefer organic products are more concerned about health and food risks (Davies et al., 1995; Jolly, 1991; Williams and Hammitt, 2000). A market research found that many consumers believed that organic products are healthier (Dimitri and Greene, 2002). Organic food products are products that were grown without using conventional pesticides, artificial fertilizers, human waste, sewage sludge, and were processed without ionizing radiation or food additives (Starks and Bukenya, 2008). Organic foods differ from conventional foods by producing and processing without the use of synthetic pesticides (Vandeman and Hayden, 1997). Some studies indicate that increased consumer preference for organic is because of pesticides concerns (Huang, 1996; Gifford and Bernard, 2004) and many believe that "they don't contain pesticides" (Barry, 2002). Pesticide residues in or on food are an important concern for consumers and in most cases, pesticide residues stay at the top of the list of food safety concerns (van Ravenswaay, 1998; Underhill and Figueroa, 1996). Durham's study in 2007 showed that both personal health and environmental protection concerns are motivations for organic products consumption but that environmental concerns are more influential in determining higher levels of purchases.

Chase et al. (2007) used Nielsen Homescan data from March 2003 to February 2006 combined with Nielsen Panel Track survey data in March 2006 to investigate consumer behavior for omega-3 products in Canada. Their results from an ordered probit model

show that an aging population is the most frequent purchasers of omega-3 products and the presence of children in the home increases the purchasing frequency of some omega-3 products. Their results also indicate that the knowledge and the utilization of the nutrition is an important purchase motivation for omega-3 products.

The Determinants of Consumer Confidence in Food under Risk

The Food Opinions Survey in Canada was designed to understand consumer confidence in food safety issues. Household heads' general trust of others, confidence in beef, trusts in the industry decision makers and the other factors were included in the survey. The survey questions were based on previous research of consumer confidence in food safety. Many studies have been done on the determinants of consumer confidence in the safety of food (de Jonge et al. 2007). General trust of others (de Jonge et al., 2007; de Jonge et al., 2008; Ding et al., 2009; Lobb, 2005), individual differences identified by demographics and personality characteristics (de Jonge et al., 2008), consumers' trust of specific groups and the industry decision makers (Grunert, 2002; Saba and Messina, 2003), the occurrence of food safety incidents (Maynard and Wang, 2011) are the determinants of consumer confidence in food safety. Research by de Jonge et al. in 2008 concluded that consumer feeling of optimism and pessimism about the food safety can simultaneously exist. Optimism about food indicates consumers are confident that food products are safe and on the other hand, pessimism about food indicates consumers worry about food safety (de Jonge et al, 2008). Therefore, these two were included as two separate variables in the analysis. Worry, concern and fear are often the emotions that affect consumer behavior facing food-related hazards and new food technologies (Setbon et al., 2005). 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 about trust of others: "Generally speaking, would you say that most people can be trusted" in the survey.

Economic Analysis of Food Safety

Food safety is the same as other quality attributes of food if the information is available (Antle, 2001). Consumers can purchase food products with different taste, nutritional characteristics and varying safety characteristics as well. The demand, supply, and market equilibrium issues can be analyzed by the economics literature on quality-differentiated products. However, given the fact that food safety information is usually imperfect, food safety is quite different from other food quality attributes. The imperfect safety information can be categorized into two cases. In some cases, a food market can be characterized by asymmetric information. The sellers of a food product know more about the safety issues than consumers. For instance, the producers of a fruit know what pesticides were applied to a crop and may know the health risks of those pesticides, but consumers may not know anything of that. In such cases, the economics analysis of the demand, supply and market equilibrium for the asymmetric information market can be applied. In other cases, both sellers and buyers don't have enough information about the safety attributes. The producers and processors may know more about the production process than consumers but it doesn't imply that they have enough information about the food safety attributes (Antle, 2001). The fruit producers may know pesticides were applied to a crop but they may not know whether pesticide residues contaminate the product. The market of this symmetric imperfect information for food safety differs from the markets where the information is asymmetric. Actually, even with the perfect information, market equilibrium for all levels of product quality and safety attributes does not exist because of the heterogeneity characteristic of consumers. Individuals have different knowledge of the safety of food products and also different attitudes towards risk facing the same safety information.

Including consumer concerns of food safety, the demand for each food is a function of expected marginal utility of food per dollar, the expected marginal health risk per dollar and the price of each food (Antle, 2001). Holding all other food attributes constant, consumer choice between more and less risky food is a function of relative prices of the foods and the risk susceptibility of the consumers. The consumer risk susceptibility is a function of consumer health capital and consumer knowledge of health. Many empirical studies have been done on the impacts of food safety on consumer demand. Some

researchers used contingent valuation surveys to estimate consumer willingness to pay for food safety (Buzby et al., 1995; Wessells and Anderson, 1995; Fu et al., 2008). Their results are different since the consumer coverage is different and the willingness to pay is for a specific food product. The supply side analysis of safety characteristics of food products is in the fields of production economics, productivity and industrial organization also.

Theoretical Model Review - Consumer Demand Theory

Consumer demand theory is about individual behavior with respect to the choices of quantities of a large number of goods (Barten, 1977). The conventional consumer demand theory can be used as the conceptual fundamental of consumer meat purchase behavior under BSE outbreaks in this study (Maynard and Wang, 2011).

Classic Consumer Demand Theory

Consumer Preferences and Utility

Consumer behavior is usually presented by "preferences" (Deaton and Muellbauer, 1980). The analysis of individual's choices begins with characterizing the rational behavior by using a basic set of axioms which usually employs the concept of "preference" (Nicholson, 2005). This preference is assumed to have completeness, transitivity and continuity which are three basic axioms of the individual's rational choice.

Completeness states the individual can always choose one of the following facing A and B situations. The assumption is the individual can always make the choice between two alternatives by having complete understanding of the situations.

1. "A is preferred to B,"
2. "B is preferred to A,"
3. "A and B are equally attractive."

The individual choice is transitive if we assume the individual is fully informed of difference choices. We then have the second axiom as transitivity. This can be expressed as: if an individual makes the decision "A is preferred to B" and "B is preferred to C," then this person must say that "A is preferred to C."

The assumption that people are able to rank in order from the most desirable to the least desirable among all possible situations is called completeness. This ranking is called

"utility" by economists. The higher ranking states higher utility. Utility refers to overall satisfaction of an individual. An individual's utility is affected by diversified dimensions including his or her consumption of physical commodities, psychological attributes, personal experiences and also cultural environment. Economists only devote attention to the individual's choice among quantifiable options while assuming that the other things which affect behavior are hold constant. Economists keep this consumption consistent in all economic analyses of utility-maximizing choices. Therefore, individual's preferences can be represented by the form of a utility function. Italic variables denote scalars, bold lower-case variables denote vectors, and bold upper-case variables denote matrices.

$$\mathrm{u}(q_{1,}q_2, \dots, q_n),$$

where $q_{1,}q_2, \dots, q_n$ are the quantities of each n goods that might be consumed in a certain period.

Utility Maximization and Marshallian Demand Function

The basic assumption economists make to explain individuals' behavior is that individuals are assumed to behave as if they maximized utility subject to a budget constraint. Economic restriction assumes the individual only can consume commodity bundles which are affordable within the budget, assuming no borrowing, e.g. for food.

$$utility = u(q_{1,}q_2, \dots, q_n),$$

subject to the budget constraint:

$$x = p_1q_1 + p_2q_2 + \cdots + p_nq_n,$$

where x denotes income and $p_{1,}p_2, \dots, p_n$ are the price of each n goods.

In order to maximize a function subject to a constraint, we set up the Lagrangian equation:

$$\mathcal{L} = u(q_{1,}q_2, \dots, q_n) + \lambda(x - p_1q_1 - p_2q_2 - \cdots - p_nq_n),$$

take derivatives with respect to choice variables and λ to get first-order conditions (f.o.c.'s):

$$\frac{\partial \mathcal{L}}{\partial q_1} = \frac{\partial u}{\partial q_1} - \lambda p_1 = 0$$

$$\frac{\partial \mathcal{L}}{\partial q_2} = \frac{\partial u}{\partial q_2} - \lambda p_2 = 0$$

$$\vdots$$

$$\frac{\partial \mathcal{L}}{\partial q_n} = \frac{\partial u}{\partial q_n} - \lambda p_n = 0$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = x - p_1 q_1 - p_2 q_2 - \cdots - p_n q_n = 0,$$

These $n+1$ equations can be solved for the optimal bundle $q_{1,} q_2, \ldots, q_n$ and λ. The optimal bundle is a function of all prices of goods and income.

The optimal bundle can be expressed as $\mathbf{q}^* = \mathbf{q}(\mathbf{p}, x)$, for an individual good, we can write it as $q_i^* = q_i(p, x)$, where $\mathbf{q} = \{q_{1,} q_2, \ldots, q_n\}$, $\mathbf{p} = \{p_{1,} p_2, \ldots, p_n\}$. $\mathbf{q}(\mathbf{p}, x)$ is the Marshallian demand function and it is also called the uncompensated demand function.

Expenditure Minimization and the Hicksian Demand Function

Given a budget constraint, again no borrowing, and the individual's desire to maximize utility, the optimal bundle will depend indirectly on the prices of goods and the individual's income. This can be reflected by the indirect utility function $\mathrm{v}(\mathbf{p}, x) = u(\mathbf{q}(\mathbf{p}, x))$.

The associated dual minimization problem is to achieve a given utility with the minimal expenditure. This can be mathematically stated as the following:

$$e = p_1 q_1 + p_2 q_2 + \cdots + p_n q_n \ ,$$

where e denotes the total expenditure.

subject to the constraint

utility=$\bar{u}$=u $(q_{1,} q_2, \ldots, q_n)$

minimal expenditures=e $(p_{1,} p_2, \ldots, p_n, u)$

$\frac{\partial e(\mathbf{p}, u)}{\partial p_i} = h_i(\mathbf{p}, u)$ for all i , this is the expenditure minimizing bundle needed to reach utility u. $\mathbf{h}^* = h(\mathbf{p}, u)$ is called Hicksian demand function. It is also called compensated demand function because the income must change in order to keep utility constant when prices changed. The expenditure function is $e(\mathbf{p}, u) = \mathbf{p} \times h(\mathbf{p}, u)$. The expenditure function and the indirect utility function are inverse functions of one another. They both depend on market prices but the expenditure function is subject to the constraint of constant utility while the indirect utility function is subject to the constraint of income.

The Slutsky Equation

An important relationship exists between the Marshallian and the Hicksian demand functions. The Marshallian demand function is from utility maximization. The

utility maximization problem (UMP) states how consumer spends wealth to maximize his or her utility. The Hicksian demand function is from expenditure minimization. The expenditure minimization problem (EMP) states that the minimized cost necessary to reach a fixed level of utility. If $\mathbf{q}^*$ (consumption vector) is an optimal bundle in the UMP when wealth is x, then $\mathbf{q}^*$is optimal in the EMP when the required level of utility is $u(\mathbf{q}(\mathbf{p}, x))$. The minimum expenditures are exactly the same as the budget. If $\mathbf{h}^*$ is optimal in the EMP when the required utility is u, then $\mathbf{h}^*$ is the optimal in the UMP when the cost is $\mathbf{p} \times \mathrm{h}^*$. The maximized utility is exactly u. This relationship can be expressed mathematically by the Slutsky equation which provides a more useful application of the identities.

$$h_i(\mathbf{p}, u) = q_i\big(\mathbf{p}, e(\mathbf{p}, u)\big),$$

take derivatives with respect to price

$$\frac{\partial h_i(\mathbf{p}, u)}{\partial p_j} = \frac{\partial q_i\big(\mathbf{p}, e(\mathbf{p}, u)\big)}{\partial p_j} + \frac{\partial q_i\big(\mathbf{p}, e(\mathbf{p}, u)\big)}{\partial x}\frac{\partial e(\mathbf{p}, u)}{\partial p_j}$$

$$= \frac{\partial q_i(\mathbf{p}, x)}{\partial p_j} + \frac{\partial q_i(\mathbf{p}, x)}{\partial x} h_j(\mathbf{p}, u)$$

$$= \frac{\partial q_i(\mathbf{p}, x)}{\partial p_j} + \frac{\partial q_i(\mathbf{p}, x)}{\partial x} q_j(\mathbf{p}, x)$$

$$\Rightarrow \frac{\partial q_i(\mathbf{p}, x)}{\partial p_j} = \frac{\partial h_i(\mathbf{p}, u)}{\partial p_j} - \frac{\partial q_i(\mathbf{p}, x)}{\partial x} q_j(\mathbf{p}, x),$$

By the Slutsky equation, the uncompensated demand response to a price change can be decomposed into two parts which are the compensated price effect and the income effect. The Hicksian demand function only illustrates the substitution effect. The last equation can be expressed in elasticities by doing the following conversion. We can multiply it by $\frac{p_j}{q_i}$, and multiply the last term on the right-hand-side by $\frac{x}{x}$. We can have:

$$\left[\frac{\partial q_i}{\partial p_j}\frac{p_j}{q_i}\right] = \left[\frac{\partial h_i}{\partial p_j}\frac{p_j}{q_i}\right] - \left[\frac{\partial q_i}{\partial x}\frac{x}{q_i}\right]\left[\frac{p_j q_j}{x}\right],$$

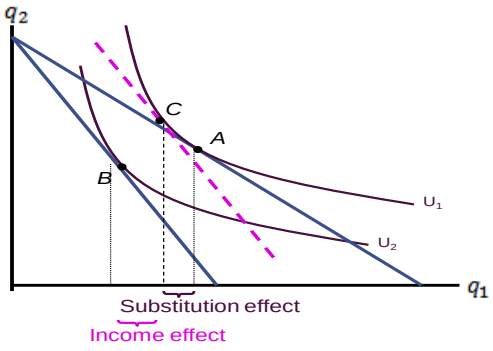
Let i=j, we can have the relationship for own-price elasticity. The left-hand-side term is Marshallian own-price elasticity, the first term on the right-hand-side is Hicksian elasticity and the second terms are income elasticity and the budget share. The above equation becomes:

$$\varepsilon_{ii} = \eta_{ii} - \theta_i \omega_i,$$

Income and Substitution Effects

The budget constraint will be shifted and this makes the individual choices differ when the parameters change. Positive changes in income lead the demand of normal goods to increase which can be denoted as $\frac{\partial q_i}{\partial x} \geq 0$ if the relative prices of all goods are constant. The demand of inferior goods decreases with positive changes in income which can be denoted as $\frac{\partial q_i}{\partial x} < 0$ if the relative prices of all goods are constant. The changes in a good's price cause the changes not only in the budget constraint but also its slope. A price change causes two different effects which are the substitution effect and the income effect. This can be illustrated by Figure 2.1. Assuming there are only two goods q_1, q_2, and the price of q_1 rise. An increase in the price of good q_1 means the budget constraint gets steeper which shifts inward. The initial utility-maximizing point A to the new point B can be analyzed as the substitution effect and the income effect. The substitution effect is the movement from point *A* to point *C*. The income effect is the movement from point *C* to point *B*. The price change alters the individual's "real" income and therefore the individual must move to a new indifference curve and this leads to a lower indifference curve. This is the income effect.

Figure 2. 1 The Substitution Effect and the Income Effect



Properties of the Demand Function

The first property of the demand function is homogeneity which states the individual demand functions are homogeneous of degree zero in all prices and income.

The physical quantities of the individual demand will not be affected if all prices and income change in the same proportions (i.e., general inflation or a change in units). The assumption of homogeneity is that the individual makes his decisions without the concerns of the monetary unit of account and this implies that q does not contain pure monetary goods (Barten, 1977). The demand function is that homogeneous of zero yields

$$0 = p_1 \frac{\partial q_1}{\partial p_1} + p_2 \frac{\partial q_1}{\partial p_2} + x \frac{\partial q_1}{\partial x},$$

Dividing the above equation by q_1, we get

$$0 = \varepsilon_{11} + \varepsilon_{12} + \varepsilon_{1x},$$

Engel aggregation or adding-up is the second property of the demand function. In fact, because the demand function satisfies the budget constraint it immediately imposes the adding-up restriction. If income rises, quantities of each product will increase to account for the entire income increase. This can be demonstrated by the following.

$$p_1 q_1 + p_2 q_2 = x,$$

taking the derivative with respect to total expenditure x, we have

$$p_1 \frac{\partial q_1}{\partial x} + p_2 \frac{\partial q_2}{\partial x} = 1$$

$$\Rightarrow \left[\frac{p_1 q_1}{x}\right]\left[\frac{\partial q_1}{\partial x}\frac{x}{q_1}\right] + \left[\frac{p_2 q_2}{x}\right]\left[\frac{\partial q_2}{\partial x}\frac{x}{q_2}\right] = 1$$

$$\Rightarrow \omega_1 \varepsilon_{1x} + \omega_2 \varepsilon_{2x} = 1,$$

Symmetry is the third property of the demand function. The cross-price derivatives of the Hicksian demands are symmetric, that implies for all $i \neq j$, we have

$$\frac{\partial h_i}{\partial p_j} = \frac{\partial h_j}{\partial p_i}$$

Lancaster's Approach to Consumer Theory

The Lancaster (1966) approach extended consumption theory activity analysis by starting from the properties or characteristics of the goods instead of the utility derived from the goods. Utility or preference orderings are assumed to rank collections of characteristics goods possess. For instance, a meal can be treated as a good which possesses nutritional and aesthetic characteristics. Different meals will possess these characteristics in different relative proportions or weighted differently. The assumptions of Lancaster's approach are the following (Lancaster, 1966, p134).

"1. The good, per se, does not give utility to the consumer; it possesses characteristics, and these characteristics give rise to utility.

2. In general, a good will possess more than one characteristic, and many characteristics will be shared by more than one good.

3. Goods in combination may possess characteristics different from those pertaining to the goods separately."

In Lancaster's approach, if the goods will provide one or more than one activity then each activity will produce one or more attributes. The goal is to maximize the utility provided by attributes with respect to the budget constraint. We assume the relationship between the level of activity (denoted by y_k, k is the number of attributes the activity holds) and the goods consumed in that activity to be both linear and objective. Then, we have q_j is the *jth* commodity

$$q_j = \sum_k a_{jk} y_k,$$

in which coefficienta_{jk} is determined by the intrinsic properties of the goods themselves. and a vector of total goods for a given activity vector is

$$\mathbf{q} = \mathbf{A}\mathbf{y},$$

in which **q** is a (j×1) vector, **A** is a (j×k) matrix and **y** is a (k×1) vector.

We assume that each consumption activity produces a fixed vector of characteristics and the relationship is also linear. We then have

$$z_i = \sum_k b_{ik} y_k,$$

In which z_i is the amount of the i^{th}characteristic and we shall assume that the coefficient b_{ik} is determined by the intrinsic properties of the goods themselves too.

$$\text{or } \mathbf{z} = \mathbf{B}\mathbf{y}$$

in which, **z** is a (i×1) vector, **B** is (i×k) matrix and **y** is a (k×1) vector.

We assume that the consumer maximizes the utility derived from the goods attributes (denotes by u(z)subject to the budget constraint. The model is:

$$\text{Maximize } u(z)$$

$$\text{subject to } \mathbf{pq} \leq x$$

$$\text{with } \mathbf{z}=\mathbf{Bq}$$

$$\mathbf{q},\ \mathbf{z} \geq 0$$

in which, u is defined on characteristics-space (C-space) and the budget constraint is defined on goods-space (G-space). The equation $\mathbf{z=Bq}$ is to do the transformation between G-space and C-space since we can relate the utility function to the budget constraint only after they both have been defined on the same space.

There are three different cases regarding the relationship between the number of characteristics (denote as r) and the number of goods (denote as n). We assume there is a one-to-one relationship between goods and activities. For the first case, $r = n$. In this case, the relationship between activities vectors and the characteristics vectors is a one-to-one relationship, assuming every characteristic can be independently determined by some combination of goods. The consumers' choice will be the utility maximization problem as with the traditional model. The second case, we have the number of characteristics is greater than the number of goods. We can arbitrarily choose n characteristics (because the other characteristics are then determined perfectly by these n characteristics) and consider the reduced $n\times n$ system $\bar{\mathbf{B}} = \bar{\mathbf{z}}$, and this can give us a one-to-one relationship between n characteristics and the n goods. In this case, it is generally most useful to analyze consumer behavior by transforming the utility function into G-space. Since the utility function derived from the reduced characteristics has the same properties as the original r dimensional utility function so we can analyze consumer behavior as if the utility function was only defined by n characteristics. In the third case, the number of goods is greater than the number of characteristics. For this case, the consumer will choose the most efficient combination of goods to achieve the collection of characteristics by the minimum cost by a given price vector.

Lancaster defined an intrinsic commodity group as the following. If there are some sets of characteristics which are derived only from some set of activities and these activities produce no other characteristics meanwhile these activities are from a particular set of goods which are used in no other activities. Substitution effects will occur only based on the relative price changes within the group and will not be affected by changes in the prices of goods outside the group. Intrinsically unrelated goods are goods from different intrinsic commodity groups and goods from the same group can be regarded as intrinsically related. If within a group and if the bundles of characteristics derived from the two goods differ only in a scalar then these two goods can be regarded as intrinsic

perfect substitutes. If a certain activity requires more than one good and if these goods are used in no other activity then these goods can be regarded as intrinsic total complements. In other words, food can be analyzed separately from transportation, art, or any other use of resources.

The Lancaster (1966) approach of consumption theory can be operationalized in analysis of meat purchase behavior in the presence of 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.

Chapter Three

Data and Explanatory Variables

This chapter explains the data and observable variables used to estimate the determinants of consumer behaviors when BSE events occurred from 2002 to 2008 in Canada. It first provides the details of the original data sets and how the original data sets were merged by the household ID in each province based on the availability of data. Selected explanatory variable means of each original data set and the merged data sets are exhibited. Tests of merged data sets and the whole meat panel were performed. Explanatory variables were created from the original and merged data sets. Factor analysis was applied to the Food Opinions Survey.

The Original Data Sets

Three data sets were used in this study: two Nielsen Homescan data sets, including meat purchases at the national level and egg purchases in Alberta and Ontario, and the Canadian Food Opinions Survey at the national level. The Nielsen household level data were purchased by the Consumer and Market Demand (CMD) Agricultural Policy Research Network, hosted at the University of Alberta's Department of Rural Economy. The Nielsen Homescan meat data represents household-level fresh meat purchases during calendar years 2002-2008 at the national level. The Nielsen Homescan egg data represents egg purchases during calendar years 2002-2005 in Alberta and Ontario only. The Canadian Food Opinions Survey was designed by the CMD Agricultural Policy Research Network, hosted at the University of Alberta's Department of Rural Economy. The survey was conducted in March 2008 by CMD.

Meat Purchase Data

Meat data provides information of meat purchases for each participant in the panel from 2002 to 2008 at the national level including six regions, Alberta, Ontario, Maritimes, Quebec, Manitoba/Saskatchewan (abbreviated in tables as Man/Sask), and British Columbia (abbreviated in tables as BC). The meat data were self-reported. The participants in the Homescan panel were given a hand-held scanner. The participants scanned product bar codes after each shopping trip. Then they uploaded their data to Nielsen electronically. 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. An example of meat data is shown in the Appendix 1. Selected variable means appear in Table 3.1. On the average, unit purchases of beef are highest in Quebec and this province also leads the beef expenditures as a percentage of total meat expenditures.

Table 3. 1 Selected Variable Means from Food-at-Home Scanner Date Meat, 2002-2008

	Alberta	Ontario	Maritimes	Quebec	Man/Sask	BC
# beef purchases / month	1.41	1.42	1.69	1.97	1.10	1.42
# pork purchases / month	0.90	1.00	1.14	1.05	0.89	1.00
# poultry purchases / month	0.87	1.02	1.14	1.10	0.78	1.02
Beef expenditure / month	$14.97	$12.32	$13.42	$16.10	$11.15	$12.32
Beef expenditure share	32%	29%	33%	35%	27%	29%
Household size	2.4	2.4	2.2	2.4	2.4	2.4
Age: 18-34	2%	2%	1%	2%	1%	2%
Age: 35-44	19%	13%	11%	15%	19%	13%
Age: 45-54	30%	23%	26%	27%	19%	23%
Age: 55-64	22%	21%	24%	27%	24%	21%
Age: 65+	28%	41%	36%	30%	36%	41%
Income: < $20,000	7%	6%	14%	12%	7%	6%
Income: $20,000-$29,999	12%	10%	18%	7%	15%	11%
Income: $30,000-$39,999	13%	12%	19%	10%	14%	12%
Income: $40,000-$49,999	10%	12%	12%	10%	15%	13%
Income: $50,000-$69,999	21%	22%	20%	23%	20%	23%
Income: $70,000+	35%	36%	17%	38%	28%	36%

Nielsen Homescan data provides consumer purchase and demographic information at the national level, but the self-reported data may contain errors and it cannot represent all of the meat purchases of each household (Maynard and Wang, 2011). The data do not provide the weight of each meat product. For the example shown in Appendix 1, household 3300007 purchased one unit (i.e., one package) of poultry for $9.34 on March 6, 2002. Without the information of weight of the meat product, the price per standardized unit could not be calculated.

Egg Purchase Data

Egg data provides information of egg purchases for each participant in the panel from 2002 to 2005 in Alberta and Ontario. Similar to the meat data, each observation in the egg data set includes the same basic demographic information about the households such as household ID number, primary language, income, household size, and age and presence of children. Data on the egg purchases also includes the number of units purchased and the amount of dollars spent monthly, and UPC codes allowing distinctions among ten types of eggs purchased from 2002 to 2005. The total number of households participating in the panel was 2,644 in Alberta and 4,874 in Ontario. The egg data was first aggregated by UPC for the entire survey period for each household ID. Based on the research questions, the ten types of eggs distinguished by UPC code were aggregated into two major categories, which include conventional and value-added eggs. Conventional eggs include normal, normal (Grade B), and normal/brown. According to the USDA definition of value-added products which appears in the literature review section, there are two categories of value-added eggs. The first category of value-added eggs includes processed eggs. The second category of value-added eggs includes omega-3, vitamin enhanced, organic eggs, and free range/free run, which reflects both consumers' preferences on nutrition and concerns for animal welfare. Then the percentage of two types of eggs, value-added eggs and conventional eggs, purchased by each household was calculated. Selected variable means appear in Table 3.2. Compared with Alberta, Ontario has the higher purchase rate of value-added eggs during the study periods. In order to be consistent with the meat panel, the categories of demographics in egg data have been re-categorized using the same categories as the meat data. The example of egg data can be found in Appendix 2.

Table 3. 2 Selected Variable Means from Food-at-Home Scanner Egg Data, 2002-2005

	Alberta	Ontario
% conventional egg purchases / month	93%	83%
% value-added egg purchases / month	7%	17%
Household size	2.6	2.6
Age: 18-34	8%	13%
Age: 35-44	27%	27%
Age: 45-54	28%	23%
Age: 55-64	19%	17%
Age: 65+	16%	17%
Income: < $20,000	6%	9%
Income: $20,000-$29,999	9%	10%
Income: $30,000-$39,999	12%	10%
Income: $40,000-$49,999	12%	10%
Income: $50,000-$69,999	23%	19%
Income: $70,000+	37%	39%

The Canadian Food Opinions Survey

The Canadian Food Opinions Survey was designed by CMD and was conducted in March 2008. The 5,000 households in the sample were picked 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 and the residential region which allows us to distinguish the respondents of different regions. In order to correspond with the meat data sets, the survey data were first categorized into six provinces. 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 the confidence of 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 consideration and trust expressed by the household member who is responsible for grocery purchases. Selected variable means appear in Table 3.3. The complete survey appears in Appendix 3.

Table 3. 3 Selected Variables Mean in Food Opinions Survey

	Alberta	Ontario	Maritimes	Quebec	Man/Sask	BC
Trust that manuf. is knowledgeable in food safety	3.5	3.5	3.4	3.4	3.5	3.4
Trust that manuf. is honest on food safety	2.9	2.9	2.9	3	2.9	2.8
Trust that gov is knowledgeable in food safety	3.3	3.3	3.3	3.4	3.30	3.2
Trust that gov is honest on food safety	2.9	2.9	2.9	3.1	2.9	2.8
Household size	2.2	2.2	2.0	2.0	2.0	2.0
Age: 18-34	1%	1%	<1%	1%	1%	1%
Age: 35-44	14%	13%	9%	13%	16%	8%
Age: 45-54	29%	25%	23%	25%	22%	21%
Age: 55-64	26%	22%	26%	22%	18%	28%
Age: 65+	28%	37%	39%	36%	42%	40%
Income: < $20,000	6%	7%	12%	13%	10%	10%
Income: $20,000-$29,999	11%	11%	16%	14%	17%	11%
Income: $30,000-$39,999	12%	11%	13%	14%	15%	12%
Income: $40,000-$49,999	11%	10%	15%	12%	12%	12%
Income: $50,000-$69,999	5%	5%	5%	5%	5%	5%
Income: $70,000+	53%	53%	35%	39%	38%	48%

Data Set Construction

This section focuses on how the data sets used in the analysis were constructed. Data manipulations were largely performed in SAS. Based on the research questions and the availability of the data sets, meat, egg purchase and survey data sets were merged in Alberta and Ontario; meat and survey data sets were merged in the remaining study

regions at the national level, including the Maritimes, Quebec, Manitoba/Saskatchewan and British Columbia. The scope of three data sets is illustrated by Table 3.4. Matching the households in the Homescan data sets with those in the survey data set, only those households that participated in both or all three data sets were selected. It creates one single data set for each province in the analysis.

Table 3. 4 Scope of Each Data Source

	Meat Purchases	Egg Purchases	Food Opinions Survey
Period	2002-2008	2002-2005	2008
	Availability/# of HHD	Availability/# of HHD	Availability/# of HHD
Alberta	Yes/385	Yes/2,644	Yes/527
Ontario	Yes/312	Yes/4,874	Yes/1,077
Maritimes	Yes/235		Yes/540
Quebec	Yes/147		Yes/985
Man/Sask	Yes/365		Yes/416
BC	Yes/328		Yes/545
Number of Observations	6,800 to 14, 000	11,822 to 22,169	

*HHD=household

Meat, Egg Purchases and the Food Opinions Survey in Alberta and Ontario

The egg data was first merged with the meat data by household ID and then with the survey in Alberta and Ontario. Only households that participated in all three panels were included in the analysis. In order to be consistent, the demographic information in meat purchase data was used in the merged ones. In Alberta and Ontario, respectively, 143 and 140 households participated in all three panels. Each household reported their meat purchases from only a few purchases up to dozens in each month. The merged data sets provided repeated observations of each household for up to 79 running months. These created 7,406 and 9,076 observations in Alberta and Ontario.

Meat Purchases and the Food Opinions Survey in the Maritimes, Quebec, Manitoba/Saskatchewan and British Columbia

The meat data was merged with the survey by household ID in the remaining four regions: the Maritimes, Quebec, Manitoba/Saskatchewan (abbreviated in tables as Man/Sask) and British Columbia (abbreviated in tables as BC). Again, only the households that participated in both panels were included in the analysis.

Scope of Merged Data Sets

The number of households and observations in the merged data sets and the ones used in the regressions are shown in Table 3.5. The number of households in the used data sets decreased because there were some respondents that replied to the question "Do you, or does any member of your household, eat beef?" that they did not eat beef, which induced the ending of the survey. Those respondents who did not eat beef were removed from the merged data sets because it was not necessary to include respondents who did not eat beef in the analysis.

Table 3. 5 Scope of Merged Data Sets

	Merged Data		Merged Data (Used)	
	Meat/Survey # of HHD	Meat/Survey/Egg #of HHD	Meat/Survey # of HHD/# of OBS	Meat/Survey/Egg # of HHD/# of OBS
Alberta	152	148	147/7,517	143/7,406
Ontario	151	148	143/9,273	140/9,076
Maritimes	118		117/5,385	
Quebec	80		77/4,493	
Man/Sask	198		188/9,185	
BC	153		141/6,395	

Tests of Merged Data Sets and the Full Meat Panel

Tests were employed in order to determine if the households in the merged data sets were significantly different from the ones who did not participate in the egg and the survey panel but only in the meat panel. We also needed to test if they were representative of the full Homescan meat panel. The merged data was compared to the

rest of the households which were only in the meat data set for each region. Table 3.6 gives 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 significantly different between the selected sample and the remaining sample in most of the study regions, in which the household head was older in the selected sample compared with the remaining sample. The 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. No specific age groups showed significant impact on beef purchases from previous studies; therefore it was meaningful to have the comparison between the households who had kids and the ones who did not. Table 3.7 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 data respondents.

Table 3. 6 Summary Statistics and t-test results of Household Characteristics: Selected Sample versus the Remaining Households in the Full Meat Panel

	Definition		Alberta	Ontario	Maritimes
HHD Size	1=Single member	Mean(Std Dev)			
	2=Two members	Selected Sample	2.50(1.3)	2.51(1.12)	2.21(1.09)
	3=Three members	Remaining Sample	2.42(1.22)	2.72(1.24)	2.24(1.02)
	4=Four members	P Value	0.57	0.11	0.86
	5=Five-Nine+ members				
HHD	1=18-34	Mean(Std Dev)			
Head	2=35-44	Selected Sample	3.73(1.02)	4.18(1.01)	4.07(0.97)
Age	3=45-54	Remaining Sample	3.59(1.16)	3.70(1.2)	3.73(1.15)
	4=55-64	P Value	0.25	<0.01***	0.01**
	5=65+				
Income	1<$20,000	Mean(Std Dev)			
					3.89(1.69
	2=$20,000-$29,999	Selected Sample	4.61(1.59)	4.83(1.48)	)
	3=$30,000-$39,999	Remaining Sample	4.33(1.66)	4.75(1.52)	3.69(1.68)
	4=$40,000-$49,999	P Value	0.11	0.64	0.36
	5=$50,000-$69,999				
	6=$70,000+				
HHD	1=Not high school grad	Mean(Std Dev)			
Head	2=High school grad	Selected Sample	3.50(1.94)	4.01(1.64)	2.75(2.05)
Education	3=Some college or tech	Remaining Sample	3.29(1.83)	3.66(1.81)	3.20(1.90)
	4=College or tech grad	P Value	0.28	0.08*	0.08*
	5=Some university				
	6=University grad				
HHD Number		Selected Sample	143	140	117
		Remaining Sample	242	172	118

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

(Continued)

Table 3.6 **Continued**

	Definition		Quebec	Man/Sask	BC
HHD	1=Single member	Mean(Std Dev)			
Size	2=Two members	Selected Sample	2.57(1.22)	2.41(1.15)	2.26(1.1)
	3=Three members	Remaining Sample	2.47(1.24)	2.66(1.22)	2.6(1.32)
	4=Four members	P Value	0.62	0.04**	<0.01***
	5=Five-Nine+ members				
HHD	1=18-34	Mean(Std Dev)			
Head	2=35-44	Selected Sample	3.9(1.00)	4.0(1.11)	4.09(0.99)
Age	3=45-54	Remaining Sample	3.8(1.14)	3.61(1.15)	3.74(1.09)
	4=55-64	P Value	0.58	<.0.01***	<0.01***
	5=65+				
Income	1<$20,000	Mean(Std Dev)			
	2=$20,000-$29,999	Selected Sample	4.90(1.55)	4.38(1.52)	4.60(1.54)
	3=$30,000-$39,999	Remaining Sample	4.24(1.75)	4.34(1.61)	4.32(1.67)
	4=$40,000-$49,999	P Value	0.02**	0.81	0.12
	5=$50,000-$69,999				
	6=$70,000+				
HHD	1=Not high school grad	Mean(Std Dev)			
Head	2=High school grad	Selected Sample	3.66(2.17)	3.12(2.02)	3.29(1.98)
Education	3=Some college or tech	Remaining Sample	3.55(1.96)	3.41(1.9)	3.34(1.83)
	4=College or tech grad	P Value	0.76	0.16	0.80
	5=Some university				
	6=University grad				
HHD number		Selected Sample	77	188	141
		Remaining Sample	70	177	187

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

Table 3. 7 Percentage of Households Having Children and Chi-square Test Results: Selected Sample versus the Remaining Households in the Full Meat Panel

	Alberta	Ontario	Maritimes	Quebec	Man/Sask	BC
Selected Sample	15%	10%	8%	18%	11%	10%
Remaining Sample	24%	25%	14%	19%	27%	18%
P Value	0.02**	<0.01***	0.13	0.95	<.0001***	0.04**

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

Explanatory Variables

This section discusses the explanatory variables needed in the analysis and how variables were created from the original data and the merged data sets. Independent variables of meat purchase variables and some interaction variables were created from the meat data sets and the merged data sets. Independent variables involving egg purchases were first created from the original egg data sets.

Explanatory Variables of Meat Purchases

Demographic information variables included: household size; dummy variables indicating the presence of children in three age groups (under 6, 6-12, 13-17); 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 data were dummy variables defining BSE events. Previous research (Maynard and Wang, 2011) 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. This choice was based on the results of previous study (Maynard and Wang, 2011) that the impacts on beef purchases diminishing four months after the month BSE occurrence. 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.

Explanatory Variables of Egg Purchases

The egg purchase data appeared to be an interesting proxy of revealed willingness-to-pay for health attributes in products other than meat, and it served as a proxy of awareness and concern for farm-level production practices. Because of the availability of egg purchase data, egg data only were available from 2002 to 2005 in Alberta and Ontario. Explanatory variables created from egg purchases were the percentages of value-added eggs and conventional eggs.

Explanatory Variables of the Food Opinions Survey

Dummy variables indicated the general trust of respondents at two levels (Don't trust people and don't know) with "people can be trusted" excluded as the base. The survey also provided the residential information, rural or urban, of each respondent, and dummy variables indicating the households' location were created with urban as the base. Respondents were asked how much they trusted several groups of people, but only the trust in scientists, consumer organizations and media sources were included in the analysis. The trust in others was categorized by different scales in which the lower scale indicates the lower trust level. The question and scales listed in the survey are as follows:

How much do you trust each of the following groups of people?

Cannot be trusted at all	*1*
Somewhat untrustworthy	*2*
Slightly untrustworthy	*3*
Somewhat trustworthy	*4*
Can be trusted a lot	*5*
Don't know	*6*

------ Canadian – Food Opinions Survey (University of Alberta, 2008)

The answer "don't know" indentified by "6" was replaced by "3.5" in order to be consistent with the overall scale from the lower level trust to the higher level. Question

24 to question 30, which tested respondents' attitudes towards eating beef, were included in an initial regression. However, none had a statistically significant impact on the dependent variables and were removed from the final regression. Additionally, these questions provided information similar to question "If a Canadian cow is found with BSE (mad cow disease) the risk to my family is:" which was included in the final regression. Other variables were created by applying factor analysis which is explained in the next section. Question 66 referring to the negative impact on households' confidence in the safety of beef products was measured by 6 scales too. The question and the scales of the answer are as follows:

> *If you have any awareness of a BSE (mad cow disease) incident in Canada over the past five years, has this had any impact on your confidence in the safety of beef products?*
>
> *1=A very small impact*
>
> *2=Some impact*
>
> *3=Moderate impact*
>
> *4=Large impact*
>
> *5=A very large impact*
>
> *6=Don't know*
>
> ------ Canadian – Food Opinions Survey (University of Alberta, 2008)

The answer to this question, "don't know" identified by"6" was replaced by "0" in order to be consistent with the overall scale of the negative impact on consumers' confidence in the safety of beef products.

Factor Analysis of the Food Opinions Survey

Several sets of questions referred to food attitudes, worry characteristics, trust in the food industry which included manufacturers, retailers, government and farmers, and feed given to livestock. The number of questions in each area varied from three to six. Their trust in government and food industry decision makers was measured with different scales, with answers usually scaled from one to five. As is common when using all of these answers at the same time in the regression, problems arose. A number of questions provided similar information and this created a collinearity problem when we included them all in the estimation. The number of coefficients was already quite large.

Meanwhile cross-section and time-series logit models are difficult to estimate with so many variables. Further, it was not necessary to include all of these questions because they referred to a limited number of concepts. The question arose how to summarize these questions in a way that preserved the information in them without overloading the estimation with too many repetitive and correlated measures. One standard way to do this is to take an index of a set of questions.

The six questions below refer to respondents' trust in the government.

43. The government has the competence to control the safety of food

44. The government has sufficient knowledge to guarantee the safety of food products

45. The government has honest about the safety of food

46. The government has sufficiently open about the safety of food

47. The government takes good care of the safety of our food

48. The government gives special attention to the safety of food

------ Canadian – Food Opinions Survey (University of Alberta, 2008)

One can just take a sum or mean of the answers of all six questions. This method is logical but it could be incorrect. There could be more than one valid concept involved in trust, which might be called trust that the government has sufficient knowledge to control the safety of food products and the trust that the government takes good care of the food safety given they are well informed. There could be a better weighted average than the most basic one, in which all questions count positively and equally. It would be very difficult if we search all of the possible combinations and weighting schemes without a plan.

Factor analysis is the statistical approach to find a way of condensing original variables into a smaller set of variables with the minimum of the loss of information (Hair et al, 1998). Factor analysis is a method of searching systematically for the best weighted average or weighted averages to summarize the data. Factor analysis makes data reduction possible. Summarizing means retaining as much variation defined as variance while keeping only one or two weighted averages in place of the original series of data. Factor analysis is the basic psychometric technique for turning sets of questions into indices of socially or psychologically relevant concepts.

Given six questions on trust in the government, factor analysis assumes that the six variables will be summarized by six linear equations. The most basic one possibility is just one variable per equation. That offers no data reduction at all but preserves the entire variance. A second possibility is an equation with weights of 1/6 for each, which would work well if all six variables essentially work as the same, with some random variation. Factor analysis looks for the best first linear function, or factor, to capture as much variation as possible. The weights are called factor loadings which are similar to regression coefficients. Having done this once, factor analysis continues to look for the best second linear function (factor) to capture as much remaining variation as possible. The second factor also has its factor loadings which could be very different from those of the first factor. Factor analysis continues until at some points where the additional linear function adds little but random variation.

The report of a factor analysis of trust in the government in Alberta from Stata 9 showed that the first factor explained most (93.8%) of the variance. The second factor appeared to be relevant too, which explained 11.1% of the variance. This requires examining the factor loadings indicated as Table 3.8 from Stata 9.

Table 3. 8 Factor Loadings of Trust in the Government in Alberta

Variable	Factor 1	Factor 2
The government has the competence to control the safety of food	0.7102	0.4319
The government has sufficient knowledge to guarantee the safety of food products	0.7172	0.4243
The government has honest about the safety of food	0.9112	-0.2214
The government has sufficiently open about the safety of food	0.9081	-0.2100
The government takes good care of the safety of our food	0.8957	-0.1330
The government gives special attention to the safety of food	0.8249	-0.1205

The first factor appears to be approximately a weighted average of the six variables, with a little less weight on the first two. The results show that the second factor clearly differentiates between the first two and the last four variables. The positive weights appear on the first two and the negative weights appear on the last four variables. Looking back the survey questions above, the first two questions are about trust in the

government's competence and knowledge regarding food safety, while the last four questions are whether the government is honest, open, caring and giving attention to food safety. So the first two questions appear to be different in people's perception. The factor analysis suggests two concepts here. Two indices referring to the trust in the government were created, one was trust in the government's knowledge of food safety and the other one was trust that the government is honest on food safety.

The following is an example of the worry characteristics of the respondents. The questions measured respondents' worry, discomfort and suspiciousness, as the keywords and factor analysis suggested, they measure the same concept and it easily summarizes as one factor. The report of the factor analysis from Stata9 showed that the first factor appeared to capture most of the variance and it is the weighted average of the three variables. See the result details in Appendix 4.

Please indicate to what extent you find the following statements characteristic of yourself.

12. Many situations make me worry

13. I know I shouldn't worry about things, but I just cannot help it

14. I notice that I have been worrying about things

------ Canadian – Food Opinions Survey (University of Alberta, 2008)

The same analyses have been done with other sets of Food Opinions Survey questions in Alberta. The results show similar conclusions for trust in manufacturers, retailers and farmers. Two indices for each of these were necessary. Other analyses supported one common factor, which was just a weighted average such as respondents' food attitudes regarding optimism and pessimism and animal feed. Factor analysis is applied to data sets in the form of correlations and can result in one clear common factor or several common factors. The factor analyses in the survey result in interpretable weighted averages that summarize the data and simplify the estimation. Based on the results of factor analyses in Alberta, the indices were created for the sets of survey questions in remaining areas. The details of indices appear in Appendix 4.

Missing Variables

Due to skip patterns, the survey sometimes terminated at a certain point which caused the problem of missing variables. For example, if respondents haven't seen, heard

or read about BSE then the survey would be ended from there. From one to ten percent of the households in the study regions, responded "no", creating missing values for these variables: the knowledge extent of BSE news over the past five years, the risk of BSE to my family and the impact on the confidence in the safety of beef products. The consumers who haven't heard about BSE will behave as if the risk of BSE to their family is very low. Therefore, the value of risk to my family was set to "very low" for those households who answered that haven't seen, heard or read about BSE. The same replacement was made for the extent of the BSE media impacts on consumers' beef purchases. The purchases will be similar from consumers who have not heard about BSE and who have heard very few messages. Again, the confidence in the safety of beef products was treated as "don't know" for households who have not heard about BSE.

Interaction Variables

Additional independent variables relate to four specific hypotheses of special interest: (1)value-added egg consumers did not respond more strongly to each BSE event than conventional egg consumers, (2) consumers' trust of government and industry decision makers did not affect reaction to each BSE event, (3) consumers reporting strong food safety concerns did not react strongly to each BSE event, (4) consumers with some specific demographic characteristics did not react strongly to each BSE event. Interaction variables between the three BSE events and egg preferences, the three BSE events and Food Opinions Surveys, and the three BSE events and some demographic variables were created in order to test the above hypotheses.

Descriptive Statistics of Variables Used in the Analysis

Choice variables were used to identify the interaction relationship between the BSE events and consumers' preferences for value-added products and the BSE events and consumers' food safety opinions. The definitions of the variables used in the analysis appear in Appendix 5. Table 3.9 gives the means of selected variables and again Quebec leads with the highest beef expenditures and beef unit purchases which is identical to the full meat panel shown in the previous section.

Table 3. 9 Selected Variables 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 in 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 gov is knowledgeable in food safety	3.23	3.17	3.40	3.42	3.26	3.28
Trust that gov is honest on food safety	2.96	2.91	2.99	2.79	2.94	2.87
% conventional egg purchases / month	93.90%	86.39%				
% value-added egg purchases / month	6.10%	13.61%				

Chapter Four
Models/Methodology

Model Specification

The data has the advantage of a large number of observations, but as indicated in Chapter Two, the biggest shortcoming is that product weights are not available. Unit beef prices per pound could not be calculated. Therefore the demand system approach used in some previous studies is not practical in this case. Own prices and substitute prices are important determinants in the analysis of consumer behavior. However, the purpose of this study is to estimate consumer responses to BSE outbreaks instead of estimating price elasticity. Price variation still needed to be controlled in order to avoid omitted relevant variables bias (Maynard and Wang, 2011). In the absence of price variables, three measures of beef purchases were evaluated in separate regressions: (1) Beef participation in a given month which was defined as the purchase of any beef products during a given month, (2) the units of beef purchased monthly, and (3) the monthly expenditures of beef. The different regression results from three measures may suggest that the decrease or increase of beef purchases is from beef price change rather than BSE events. For instance, if only beef expenditures decreased but the probability of beef purchased participation and the number of units increased, then the change in consumer behavior may be caused by beef price changes but not BSE events. On the other hand, if similar results are observed from all three measures during BSE events the impacts are probably attributable to BSE concerns. Therefore, the application of three different measures of beef purchase can help us to have a robust result and to make up for the weakness of the unique data.

The panel data are repeated observations of each household up to 79 months from 2002 to 2008 in each province. The repeated purchases by the same household can be grouped into clusters by household ID. 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 also suggests the consideration of unobserved heterogeneity. Households with the same demographic characteristics may behave differently when confronted with food safety issues such as BSE in this case. The solution to deal with effects, unobserved to the researcher, which influence household

purchase behavior, is to do the analysis by using panel data models. This method departs from the previous study done by Maynard and Wang (2011), in which lagged independent variables deal with the unobserved heterogeneity across households. The approach outlined in this study is an alternative methodology which adds explanatory power. Understanding unobserved consumer heterogeneity is important for producers to develop niche markets; therefore the choice model provides meaningful information to beef producers also.

Panel Data Model

Panel data models are commonly used in policy analysis, education research, and economics. If the data in a regression are repeated observations of a person or a household or a country over time then the data are called panel data. The structure of panel data is cross section units that are arranged over a time period. The observations are grouped by each unit, person, household or country. Panel data models control for not only observed explanatory variables over time but also unobserved aspects of a household which affect all observations in the group. Individual behavior can be affected by their repeated and unmeasured behavior which may not be explained by demographic variables. The unmeasured aspects of each individual or heterogeneity need to be controlled otherwise it will affect all of the observations of an individual in the model.

Panel data models incorporate a time dimension with cross-sectional data and spatial dimension to time-series data. Typical cross-sectional data analysis assumes homogeneity of behavior over time. Panel data models have either a fixed or random effect. Given the same income, education level and household size and other demographic information of households, they may have different purchase behavior of brand preferences and this is called heterogeneity (Jain et al., 1994). The heterogeneity has unobserved effects on household purchases. Panel data models have been used in many marketing studies such as brand choice (Bass, 1974; Bass et al., 1976; Jain et al., 1994). For instance, in the study of consumer behavior, the choice of brands from a consumer is recorded over a period of time and it goes with a set of brand attributes and a set of consumer characteristics of each purchase (Jain et al., 1994). It increases the precision of regression estimates by the enlarged sample size. Another important reason for using panel data model is that it is possible to control for some omitted variables. In this study, the impact

of omitted variables is assumed to differ between households but to be constant within each household.

Random Effects Model versus Fixed Effects Model

Fixed and random effects models are the most commonly used panel data models. Fixed effects model control the unobserved effects of household by creating dummy variables while random effects model control it with putting the unobserved effects in the disturbances (Greene, 2003).

Fixed effects model is structured as: $y_{it} = \alpha_i + x_{it}^{'}\beta + \varepsilon_{it}$, $y_i = \alpha_i L_T + x_i\beta + \varepsilon_i$

It is used when α_i is or might be correlated to x_{it}, where i=1,2,…n (number of individual), t=1,2,…T (number of time periods for each individual), α_i is the individual effect of each observation. The fixed effects model is estimated by the Least Squares Dummy Variable (LSDV) model. Dummy variable can be used to separate out the individual effect. The following LSDV adding dummy variables for each individual provides individual specific intercept effects. Adding dummy variables can be also used to separate out the time effect. Suppose we have a fixed effect model: $Y_{it} = \beta_{1i} + \beta_2 X_{2it} + \beta_3 X_{3it} + \mu_{it}$,

LSDV is structured as: $Y_{it} = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_4 D_{4i} + \beta_2 X_{2it} + \beta_3 X_{3it} + \mu_{it}$.

One of the disadvantages of fixed effect model is the disappearance of independent variables which do not vary over the time series. Fixed effects eliminate non-varying variables such as the presence of children in this study. Fixed effects are not always possible in nonlinear models such as logit, probit or negative binomial models. Fixed effects and random effects models have different costs and benefits. Fixed effects models use many degrees of freedom to estimate effects of the dummy variables and cannot estimate the effect of time unvarying variables such as gender and other demographic variables in this study. Random effects models avoid the loss of degrees of freedom, but the assumptions of random effects models are the effect should be drawn from a probability distribution independent of the explanatory variables. There should be no correlation between the unobserved individual effect and the independent observed variables of interest. The fixed effects model does not have this assumption. That might

be questionable, if, for example, women or people in Alberta differ in their beef purchases for unobserved reasons that remain the same over time.

In non-linear models, the use of random effects is virtually forced because of other considerations, including the loss of all observations that do not vary, e.g. households that always buy beef or never buy beef, or because fixed effects cannot be differenced out of the model. That would lead, e.g., to 142 dummy variables in the regression in the case of Alberta. The loss of time-invariant variables would remove many relevant explanatory variables. The time invariant variables such as demographic and survey variables will still provide information in the regression by using random effects models. Random effects models still require the disturbance to be uncorrelated with the explanatory variables, otherwise biased coefficient estimates will result.

Choice of Random Effects Models

As mentioned above, all random effects models assume that the individual (household in this study) effect is drawn from a distribution, usually normal, with a variance that is estimated as a part of the model, and that the individual effect is uncorrelated with the other explanatory variables. The random effect is part of the disturbance, so the random effect being uncorrelated with explanatory variables is the same requirement as in all regressions or similar models (logit and negative binomial models in this study). If the correlation between random effects and explanatory variables is not zero, there is some bias in the estimated coefficients, depending on how large the correlation is. Actually evaluating this correlation is straightforward in a linear regression and difficult in anything else, but linear approximations can be used to evaluate this issue for logit and negative binomial models.

As mentioned above, fixed effects avoid the problem of the correlation but lose the estimated effects of fixed household characteristics. All other explanatory variables still have estimates under both fixed and random effects, which can be compared using either a statistical test on the assumption of random effects.

There are two methods to test the correlation of random effects and explanatory variables. One is a Hausman test which compares estimated coefficients under random and fixed effects. The second method, which is used in this study, correlates the fixed or random effects with the fitted values from the model, and is easier to apply. Fixed effects

models were used in three beef purchase measurements, linear approximation of the logistic dependent variable, purchase beef or not, linear approximation of the negative binomial dependent variable, the unit of beef purchased linear approximation of beef expenditures. Correlation of the random effects and explanatory variables are reported in the regression result shown in Table 4.1.

Table 4. 1 Correlation of Fixed Effects and Explanatory Variables

	Alberta	Ontario	Maritimes	Quebec	Man/Sask	BC
Correlation between random effects and explanatory variables						
Beef purchase or not	-0.2181	-0.1983	-0.3065	-0.2174	-0.1155	-0.1782
Beef units purchased	-0.1276	-0.0908	-0.3216	<0.0001	-0.0773	-0.1593
Beef expenditures	-0.1092	-0.0044	-0.0787	-0.0042	-0.0274	-0.1295
Sample size	7406	9076	5385	4493	9195	6395
Standard error of the correlation	0.012	0.010	0.013	0.014	0.010	0.012

Taking Alberta as an example, for the logistic dependent variable, the linear approximation estimates a correlation of -0.2181. For the negative binomial dependent variable, the linear approximation estimates a correlation of -0.1276. For expenditures, the correlation of fixed effects with fitted values from the model is -0.1092. These correlations seem small, although they are all statistically significant with 7,406 observations. The standard error of a correlation is the inverse of the square root of the sample size (Stuart and Ord, 1987, pp. 329-330), 0.012 in Alberta. So the sample is so large that even a small correlation is statistically significant. Similar results appear in all other provinces.

However, that does not mean that coefficients change much. A direct comparison of estimated coefficients under fixed and random effects for expenditures shows that apart from the fixed household characteristics, which necessarily disappear, there are small changes with somewhat smaller t-values under fixed effects as required by the theory. However, all statistically significant coefficients keep the same sign in all provinces. In summary, the random effects model is better for this study, despite violating the independence of random effects and explanatory variables, because the correlation is small in magnitude and the changes in estimated coefficients are small. Given that the

cost of fixed effects is high—loss of household characteristics—the estimation in this study is performed by using random effects.

Therefore, the conclusion that random effects are relatively harmless in this application is reasonable. This means that for beef purchases, the unmeasured factors are assumed to be random effects.

Types of Models

As mentioned above, a major weakness of the Homescan data is a lack of price per pound for the vast majority of meat purchases. We know the cost of each unit, but not its weight. To test whether results were robust, three measures of beef purchases were modeled.

First, for each household, there are or are not beef purchases in each month, which is 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 is a count data variable (0, 1, 2,…, an integer number of purchases). Poisson and negative binomial are the two standard count data models discussed here. The Poisson model assumes the mean and variance is equal, which is not true here; there is much more variation than mean, because some households buy no beef, while some buy a large amount, more than under the Poisson. The negative binomial retains the count data aspect while relaxing the variance assumption. Random effects can be included in either poisson or negative binomial models. The likelihood function is complex, but the estimation is straightforward because the statistical program Stata provides these models.

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 was spent), but the parameters are not always directly interpretable as effects on something one would observe in life. For example, the logit model 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 demographics and other factors on observed purchases or actual amount of money spent. Marginal impacts have a somewhat complex form in these models, but again they are computed by statistical packages such as Stata. Marginal impacts are the relevant marketing and economic estimates and are therefore reported and discussed here.

Model one: Random Effects Logit Model

Standard Logit Model

The logit model is used when there is a discrete choice among a set of alternatives for the dependent variable. A binary choice model is used when the dependent variable has two choices. It is used when researchers need to analyze whether some events occurred or not. The decision of consumers to purchase beef or not is based on the utilities achieved by purchasing beef or stopping beef purchase. The utility difference is an unobservable variable and is denoted as y^* (y^* is propensity to purchase beef, y is actual purchase). The conceptual economic theory of binary choice model is the following, in which y_i (household i) is utility.

range of y_i is limited, $y_i = 0$ (decide not to purchase beef) or $y_i = 1$ (decide to purchase beef).

y_i^* is unobservable, $y_i^* = x_i^{'}\beta + u_i$

$$y_i = \begin{cases} 1 \, if \;\; y_i^* > 0 \\ 0 \, otherwise \end{cases}$$

Logit models are estimated by maximum likelihood. The logit model of discrete choice has been extensively used in the research of household brand-choice (Jain et al., 1994). The first reason is based on the economic conceptual theory: maximized utility of the household. Another is based on its excellent empirical performance (Guadagni and Little, 1983).

Mixed Logit Model

Mixed logit generalizes standard logit by allowing the parameter associated with each observed variable to vary randomly across households (Revelt and Train, 1998). Mixed logit model releases three limitations of the standard logit mode: "It [Mixed logit]

obviates the three limitations of standard logit by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time" (Train, 2003. P. 138). It allows efficient estimation when there are repeated behaviors by the same households. The early applications of the mixed logit model were restricted to the explanatory variables of each consumer that don't vary (Boyd and Mellman, 1980). Later, it was used when the explanatory variables of each consumer vary (Ben-Akiva et al., 1993). This method was applied to understand consumer response to label claims including nutrition, health and organic attributes on red leaf lettuce (Bond et al., 2008). The specification of the mixed logit model allows β_n being random (Train, 2003). The utility of consumer n for alternative i in the mixed logit model is:

$$U_{nj} = \beta_n' x_{nj} + \varepsilon_{nj}$$

where x_{nj} are observed variables that are related to the alternative and the consumer, β_n is the coefficients vector and the coefficients vary over consumers in the population with density $f(\beta)$, n represents the consumer's preference and ε_{nj} is the random error term that is iid. The density $f(\beta)$ is a function of parameters, the mean and covariance of the $\beta's$ in the population. The only difference from standard logit model is β varies over consumers rather than fixed. If β_n is observable for researchers, then the probability would be the same as standard logit. As before, this model is estimated by maximum likelihood.

Mixed Logit and Random Effects Model

A mix of random effects model and logit model has been widely applied in the market research field such as when a consumer faces a choice among the alternatives in set J in each of T time periods or choice situations. The only difference between the random effects logit model and the mixed logit model is that the random effects logit model allows the 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 the standard logit and mixed logit models with panel data showed that the mixed logit model has more explanatory power in their study. Campbell (2006) used the mixed logit model and panel

data to identify the determinants of willingness to pay for rural landscape improvements in Ireland.

The random effects logit model is used for dummy variable outcomes and panel data. Based on the research questions, we first need to know whether consumers participated in beef consumption and in order to control for the households' heterogeneity, the choice model of this study is the random effects 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 $\beta_n \; and \; x_{njt}$. Conditional on β_n, the probability that consumer *n* chooses alternative *i* in period *t* is as the standard logit.

The estimation from the log-likelihood function is not the marginal effect. To be intuitive, the marginal effect can be estimated by Stata.

Model two: Panel Negative Binomial Model

Poisson and negative binomial models are the most commonly used count data models (Cameron and Trivedi, 1998; Greene, 2008). Poisson model requires the mean to be equal to the variance for the dependent variable while the negative binomial model releases this constraint and allows the variance to be larger than the mean. In reality, count data often have greater variance than the mean. In this study, the mean of monthly beef units purchased is equal to 2 and the variance is 8 in Alberta. Similar results occurred in other provinces, as shown in Table 4.2. Therefore, the panel negative binomial model was used for count data in this study.

Table 4. 2 Mean and Variance of Monthly Beef Unit Purchased

	Alberta	Ontario	Maritimes	Quebec	Man/Sask	BC
Mean	2.06	2.16	2.34	2.95	1.46	1.75
Variance	8.00	8.09	7.15	10.65	4.45	4.92

The statistical estimation uses the negative binomial probability distribution. For technical details, see for example Cameron and Trivedi (1998). The estimation is by maximum likelihood, with marginal impacts estimated using the parameters of the model.

Rimal et al. (1999) used the negative binomial regression model to explore the relationships between the selection of irradiated beef packages, 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 the 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 both in fixed effects and random effects were developed and done. Kyureghian (2009) used the random effects negative binomial model estimated consumer heterogeneity effects on food away from home.

Model three: Random Effects Linear Regression Model

A standard random effects model is applied for beef expenditures. The structure of random effects model is:

$$y_{it} = \alpha_i + x_{it}\ \beta' + \varepsilon_{it},\ i = 1,2,...n,\ t = 1,2,...T,$$

$$y_i = \alpha_i L_T + x_i \beta + \varepsilon_i,$$

$$y_{it} = x_{it}\ \beta' + \mu_{it}\ \text{where}\ \mu_{it} = \alpha_i + \varepsilon_{it},$$

$$y_i = x_i \beta + \mu_i\ \text{where}\ \mu_i = \begin{pmatrix} \alpha_i + \varepsilon_{i1} \\ \alpha_i + \varepsilon_{i2} \\ . \\ . \\ . \\ \alpha_i + \varepsilon_{iT} \end{pmatrix}$$

in which α_i is the individual heterogeneity. The estimation is by feasible GLS or maximum likelihood under the assumption of normally distributed disturbances. In the present study, the marginal impacts are the coefficients for the linear panel data model, so no transformation is required. Du and Hayes (2008) used pooled regional time-series data and panel data estimation to quantify the impact of monthly ethanol production on monthly retail regular gasoline prices by using FGLS (Du and Hayes, 2008). They first

estimate the equation $\pi_{it} = X_{it}^{'}\beta + \varepsilon_{it}$ by regular OLS, where π_{it} is the ratio of gasoline and crude oil prices, and X_{it} is a vector of explanatory variables in region *i* and month *t*. Then they use the estimation residuals to estimate the assumed error AR(1) serial correlation coefficient ρ. Du and Hayes (2008) used this coefficient to transform the model to eliminate error serial correlation. Substitute $\hat{\Omega}$ for Ω by using estimated ρ and σ^2, then they obtain the FGLS estimator of β as

$$\hat{\beta}_{FGLS} = (X'\hat{\Omega}X)^{-1}X'\hat{\Omega}^{-1}y.$$

Mandal (2008) investigates the role of nutrition and ingredients information included in food labels as a useful tool when consumers are trying to lose weight. The data is from the National Longitudinal Survey of Youth 1979 (NLSY79). The random effects model was used to answer two questions, the relationship between willingness to lose weight and various personal characteristics and whether people who reported trying to lose weight in 2002 and 2004 NLSY79 surveys were more likely to read food labels.

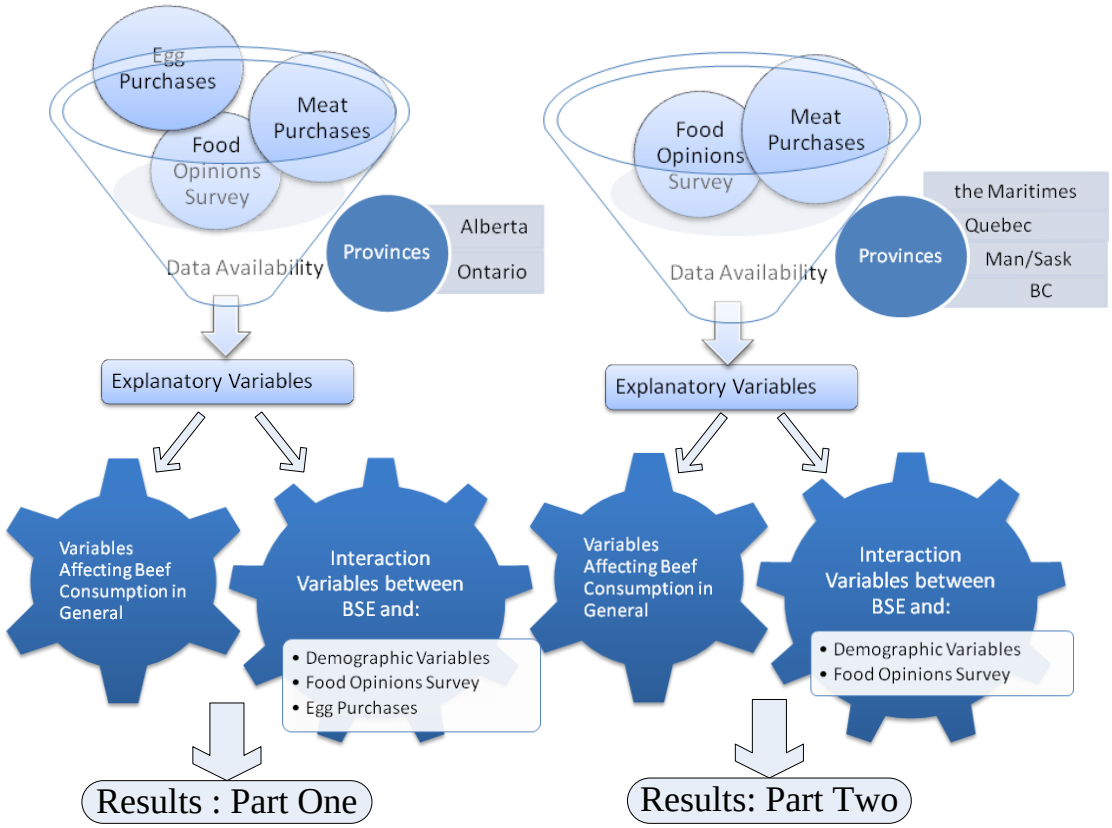
With three dependent variables and six provincially-defined regions, a total of 18 regressions were estimated. Three measures of beef purchases regarding beef purchase participation, beef units purchased, and beef expenditures of each region were obtained from the regressions.

Chapter Five

Results

This chapter contains estimation results of the panel logit model, panel negative binomial model and panel expenditures model in six provinces. Two parts are included based on the availability of data sources. Three data sources and three regressions for each of the two provinces: Alberta and Ontario are involved in Part One. Two data sources and three regressions for each of the four provinces: the Maritimes, Quebec, Manitoba/Saskatchewan (abbreviated in tables as Man/Sask), and British Columbia (abbreviated in tables as BC) are included in Part Two. Given the large number of explanatory variables of each regression, the results were categorized into many sections based on the main hypotheses. Three regression results were reported under each section. Figure 5.1`exhibits the construction of results section.

Figure 5. 1 Frames of Results Section



Marginal effects of panel logit and panel negative binomial models were calculated by Stata and were reported in the tables 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. Beef expenditures were measured in cents.

Part One: Meat Purchases, Egg Purchases and the Food Opinions Survey

This section addresses the results from the two provinces with the most complete data: Alberta and Ontario. The analysis is based on three regressions of the merged data sets including meat purchase from 2002 to 2008, egg purchases from 2002 to 2005 and the Food Opinions Survey conducted in 2008. Given the large number of explanatory variables, the results are categorized into four groups: (1) interaction terms between demographic variables and BSE events; (2) interaction terms between some survey questions and BSE events; (3) interaction terms between egg purchases and BSE events, and (4) the independent variables without interaction terms explaining general beef consumption. Three regression results are discussed respectively; random effects logit results which answer the question of whether beef purchases stopped or not after BSE events, random effects negative binomial results which explain how the units of beef purchased were affected by BSE events, and the random effects linear regression which gives information on how beef expenditures were affected by BSE events.

Qualitatively similar results from all three measures of purchases were obtained in the two provinces. Many interaction terms that were statistically significant in the beef participation model also appeared in the beef consumption findings. Consumer behavior in Ontario differed from that in Alberta. Fewer BSE-related parameters were statistically significant in Ontario. The key of tables is listed in Table 5.1. Detailed regression results for all three measures are reported in Tables 5.2- 5.13 in which variables are categorized by the main hypotheses.

Table 5. 1 Tables Key in Part One

		Measures of Beef Purchases		
Explanatory Variables		Participation	Units Purchased	Expenditures
	Demographic Variables and BSE Events	Table 5.2	Table 5.3	Table 5.4
Interaction Terms	Food Opinions Survey and BSE Events	Table 5.5	Table 5.6	Table 5.7
	Egg Purchases and BSE Events	Table 5.8	Table 5.9	Table 5.10
Affecting Beef Purchases in General		Table 5.11	Table 5.12	Table 5.13

Consumers who purchased value-added eggs reacted significantly more negatively to the second and third BSE events, as did those who reported increasing food safety concerns in the opinion survey. Consumers with higher trust in manufacturers displayed more moderate reactions to BSE, i.e., less positive after the first event, and less negative after subsequent events. Consumers with higher trust in government also had a less negative reaction to the second and third events.

Value-added egg purchasers and consumers ranking higher on an optimism index reacted less negatively to the second and third BSE events, and trust in government was more influential. In both provinces, however, the more risk consumers attached to BSE, the less beef they purchased.

Interaction between Demographic Variables and BSE Events

This section focuses on the discussion of whether a specific group of consumers identified by demographic characteristics behave differently from the others when BSE events occurred.

The significant negative impacts on households with children after BSE events were observed in beef participation and beef consumption in Alberta and Ontario. Compared with urban residents, rural residents reduced beef participation and beef consumption after the third BSE events in Alberta. There was no statistically significant impact found in Ontario. Given that Alberta is the largest producer of beef cattle and it was the origin

of the first BSE discovery in 2003, the stronger response of rural residents in Alberta was expected.

Table 5. 2 Marginal Effects from Logit Regression on Beef Participation: Interaction Terms between Demographic Variables and BSE Events

	Alberta		Ontario	
Interaction between have children and BSE events				
have Children *BSE1	-0.123		-0.146	**
have Children *BSE2	-0.058		0.775	
have Children *BSE3	-0.366	**	0.212	
Interaction between income and BSE events				
income < $20K *BSE1	0.058		-0.168	***
income $20-$30K *BSE1	0.128		1.109	
income $30-$40K *BSE1	0.602		0.260	***
income $40-$50K *BSE1	0.462		1.122	
income $50-$70K *BSE1	0.042		0.508	
income < $20K *BSE2	-0.580		0.315	
income $20-$30K *BSE2	-0.206		-0.572	
income $30-$40K *BSE2	0.077		0.186	
income $40-$50K *BSE2	-0.639		0.238	
income $50-$70K *BSE2	0.455		0.362	
income < $20K *BSE3	-0.437	*	-0.361	
income $20-$30K *BSE3	-0.024		0.048	
income $30-$40K *BSE3	-0.068		0.010	
income $40-$50K *BSE3	-0.133		0.248	
income $50-$70K *BSE3	-0.026		-0.120	

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

(Continued)

Table 5.2 Continued

	Alberta		Ontario
Interaction between resident areas and BSE events			
rural*BSE1	0.226		-0.347
rural*BSE2	-0.157		-0.059
rural*BSE3	-0.313	**	0.063

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

Table 5. 3 Marginal Effects from Negative Binomial Regression on Monthly Beef Units Purchased: Interaction Terms Between Demographic Variables and BSE Events

	Alberta		Ontario	
Interaction between have children and BSE events				
have Children *BSE1	-0.116		-0.154	
have Children *BSE2	-0.195		0.134	
have Children *BSE3	-0.127	*	0.000	
Interaction between income and BSE events				
income < $20K *BSE1	0.216		0.053	
income $20-$30K *BSE1	0.445	***	0.239	
income $30-$40K *BSE1	0.339	*	0.146	
income $40-$50K *BSE1	0.302		0.287	*
income $50-$70K *BSE1	0.076		0.123	
income < $20K *BSE2	-0.299		0.193	
income $20-$30K *BSE2	-0.019		-0.215	
income $30-$40K *BSE2	-0.022		0.026	
income $40-$50K *BSE2	-0.175		0.023	
income $50-$70K *BSE2	0.293	*	0.180	
income < $20K *BSE3	-0.177	*	0.093	
income $20-$30K *BSE3	0.076		-0.006	
income $30-$40K *BSE3	0.049		0.178	**
income $40-$50K *BSE3	0.022		0.097	
income $50-$70K *BSE3	0.027		0.063	

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

(Continued)

Table 5.3 Continued

	Alberta		Ontario	
Interaction between resident areas and BSE events				
rural*BSE1	0.097		-0.193	*
rural*BSE2	-0.074		0.059	
rural*BSE3	-0.190	***	0.051	

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

Table 5. 4 Regression Results on Monthly Beef Expenditures: Interaction Terms between Demographic Variables and BSE Events

	Alberta		Ontario	
Interaction between have children and BSE events				
have Children *BSE1	-507	**	-140	
have Children *BSE2	103		73.8	
have Children *BSE3	-62		-42	
Interaction between income and BSE events				
income < $20K *BSE1	126		21	
income $20-$30K *BSE1	750	**	-23	
income $30-$40K *BSE1	311		-159	
income $40-$50K *BSE1	360		212	
income $50-$70K *BSE1	-115		-158	
income < $20K *BSE2	-218		-165	
income $20-$30K *BSE2	-237		-18	
income $30-$40K *BSE2	112		-183	
income $40-$50K *BSE2	-378		114	
income $50-$70K *BSE2	-106		227	
income < $20K *BSE3	-622	***	93	
income $20-$30K *BSE3	-97		155	
income $30-$40K *BSE3	60		99	
income $40-$50K *BSE3	-66		129	
income $50-$70K *BSE3	-26		241	***

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

(Continued)

Table 5.4 Continued

	Alberta		Ontario
Interaction between resident areas and BSE events			
rural*BSE1	411	*	-179
rural*BSE2	13		-200
rural*BSE3	-267	***	94

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

Interaction between the Food Opinions Survey Responses and BSE Events

This section addresses the hypothesis that consumers' actual meat purchase behavior might be consistent with their responses to self-reported attitudinal surveys.

Consumers with high worry trait levels purchased fewer beef units after the second BSE event only in Alberta. The opposite, unexpected result occurred in Ontario. Beef expenditures significantly increased after the third BSE event in Ontario, although beef participation and beef units purchased did not increase. The explanation might be that consumers reacted to BSE events by purchasing more expensive beef products.

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. Similar results did not appear in Alberta, however, as expected, households with higher pessimism about the safety of food product purchased less beef units and spent less money on beef products after the first BSE event. 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 both provinces.

Consumer trust in food system decision makers significantly affected BSE responses in both provinces. Trust that manufacturers are knowledgeable in food safety had significantly negative impacts on BSE response in Alberta, 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 manufacturers to be honest about food safety contributed to higher beef unit purchases during BSE events in Alberta. Trust in the government is honesty about food safety had statistically

significant positive impacts at the .05 level on beef units purchased after the third BSE event in Alberta. However, the unexpected opposite result appeared in Ontario.

As expected, consumers who were more concerned about feed given to livestock purchased fewer beef units when BSE occurred in Ontario. For consumers in Alberta and Ontario, higher perceived BSE risk to the family led to lower beef units purchased after the third BSE events. The negative influences were not found after the first and the second BSE discoveries which suggest a conclusion consistent with Maynard and Wang's study that consumers' food safety fears became stronger when BSE became a pattern instead of an isolated event (Maynard and Wang, 2011). Media coverage had significant negative impacts on beef units purchased in two provinces. In a similar result, the more consumers in Ontario were concerned about BSE and vCJD, the associated human disease, the less beef they purchased when the second BSE event occurred.

Table 5. 5 Marginal Effects from Logit Regression on Beef Participation: Interaction Terms between the Food Opinions Survey Responses and BSE Events

	Alberta		Ontario	
Interaction between worry trait and BSE events				
worry trait index*BSE1	0.032		0.065	
worry trait index*BSE2	-0.199		0.068	
worry trait index*BSE3	-0.064		0.039	
Interaction between food attitudes and BSE events				
optimism index *BSE1	0.100		0.098	
optimism index *BSE2	-0.111		-0.020	
optimism index *BSE3	0.062		0.253	**
pessimism index*BSE1	-0.224		0.234	
pessimism index*BSE2	0.416		-0.064	
pessimism index*BSE3	0.199		-0.134	
Interaction between general trust and BSE events				
don't trust *BSE1	0.278	*	-0.071	
not sure of trust*BSE1	0.029		-0.077	
don't trust*BSE2	-0.153		0.108	
not sure of trust*BSE2	-0.096		0.001	
don't trust*BSE3	0.244	***	0.106	
not sure of trust*BSE3	0.179	**	0.068	

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

(Continued)

Table 5.5 Continued

	Alberta		Ontario	
Interaction between confidence of beef and BSE events				
confidence in the safety of beef *BSE1	0.042		0.274	
confidence in the safety of beef *BSE2	-0.098		0.028	
confidence in the safety of beef *BSE3	0.112		-0.268	***
Interaction between the trust index and BSE events				
manufacturers index 1*BSE1	-0.084		0.221	
manufacturers index 2*BSE1	0.008		-0.315	
manufacturers index 1*BSE2	-0.252		0.227	
manufacturers index 2*BSE2	0.862	***	0.050	
manufacturers index 1*BSE3	-0.094		-0.105	
manufacturers index 2*BSE3	0.116		0.304	**
government index 1*BSE1	-0.232		0.097	
government index 2*BSE1	-0.288		-0.358	
government index 1*BSE2	0.097		-0.133	
government index 2*BSE2	-0.355		0.004	
government index 1*BSE3	-0.045		0.076	
government index 2*BSE3	-0.019		-0.336	***
Interaction between feed index and BSE events				
feed index *BSE1	-0.114		0.189	
feed index *BSE2	0.021	*	0.238	***
feed index *BSE3	-0.180		-0.275	*

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

(Continued)

Table 5.5 Continued

	Alberta		Ontario	
Interaction between the knowledge extent of BSE news and BSE events				
BSE news *BSE1	0.108	**	-0.235	
BSE news *BSE2	-0.299		-0.085	***
BSE news *BSE3	-0.015		0.207	*
Interaction between BSE risk to the family and BSE events				
risk *BSE1	0.225		0.276	
risk *BSE2	0.096	***	0.163	***
risk *BSE3	-0.228		-0.207	
Interaction between BSE & vCJD concern and BSE events				
disease*BSE1	0.060		-0.069	***
disease*BSE2	0.106		-0.385	
disease*BSE3	0.108		0.046	**
Interaction between BSE impact on beef safety confidence and BSE events				
impact*BSE1	-0.163		-0.315	
impact*BSE2	0.040		0.050	***
impact*BSE3	0.073		0.168	

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

Table 5. 6 Marginal Effects from Negative Binomial Regression on Monthly Beef Units Purchased: Interaction Terms between the Food Opinions Survey Responses and BSE Events

	Alberta		Ontario	
Interaction between worry trait and BSE events				
worry trait index*BSE1	0.046		0.064	
worry trait index*BSE2	-0.118	**	-0.011	
worry trait index*BSE3	-0.043		0.027	
Interaction between food attitudes and BSE events				
optimism index *BSE1	-0.180		-0.157	
optimism index *BSE2	0.036		0.235	***
optimism index *BSE3	0.034		0.188	***
pessimism index*BSE1	-0.222	*	0.025	
pessimism index*BSE2	0.166		0.068	
pessimism index*BSE3	0.073		0.034	
Interaction between general trust and BSE events				
don't trust *BSE1	0.001		-0.053	
not sure of trust*BSE1	0.030		-0.063	
don't trust*BSE2	-0.052		0.024	
not sure of trust*BSE2	-0.031		0.026	
don't trust*BSE3	0.125	***	0.012	
not sure of trust*BSE3	0.000		-0.018	

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

(Continued)

Table 5.6 Continued

	Alberta		Ontario	
Interaction between confidence of beef and BSE events				
confidence in the safety of beef *BSE1	-0.020		0.164	**
confidence in the safety of beef *BSE2	-0.184	**	-0.122	
confidence in the safety of beef *BSE3	0.019		-0.154	***
Interaction between the trust index and BSE events				
manufacturers index 1*BSE1	0.036		0.089	
manufacturers index 2*BSE1	-0.131		-0.119	
manufacturers index 1*BSE2	-0.159	*	0.006	
manufacturers index 2*BSE2	0.280	**	-0.009	
manufacturers index 1*BSE3	-0.065		-0.002	
manufacturers index 2*BSE3	-0.069		0.007	
government index 1*BSE1	0.020		0.030	
government index 2*BSE1	-0.030		-0.022	
government index 1*BSE2	-0.071		0.051	
government index 2*BSE2	0.100		-0.015	
government index 1*BSE3	-0.057		0.029	
government index 2*BSE3	0.134	**	-0.087	*
Interaction between feed index and BSE events				
feed index *BSE1	-0.121		0.072	
feed index *BSE2	0.096		0.026	
feed index *BSE3	0.004		-0.214	***

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

(Continued)

Table 5.6 Continued

	Alberta		Ontario	
BSE news *BSE1	0.065		-0.093	**
BSE news *BSE2	-0.215	***	-0.065	
BSE news *BSE3	-0.027		0.042	*
Interaction between BSE risk to the family and BSE events				
risk *BSE1	0.047		0.090	*
risk *BSE2	0.125	*	0.031	
risk *BSE3	-0.175	***	-0.160	***
Interaction between BSE & vCJD concern and BSE events				
disease*BSE1	0.078		-0.023	
disease*BSE2	0.035		-0.125	***
disease*BSE3	0.022		0.066	***
Interaction between BSE impact on beef safety confidence and BSE events				
impact*BSE1	-0.009		-0.206	***
impact*BSE2	-0.051		0.031	
impact*BSE3	0.052		0.127	***

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

Table 5. 7 Regression Results on Monthly Beef Expenditures: Interaction Terms between the Food Opinions Survey Responses and BSE Events

	Alberta		Ontario	
Interaction between worry trait and BSE events				
worry trait index*BSE1	147		108	
worry trait index*BSE2	21		-24	
worry trait index*BSE3	66		75	**
Interaction between food attitudes and BSE events				
optimism index *BSE1	-320		-244	*
optimism index *BSE2	0		193	
optimism index *BSE3	0		29	
pessimism index*BSE1	-484	**	15	
pessimism index*BSE2	4		-70	
pessimism index*BSE3	-101		-127	*
Interaction between general trust and BSE events				
don't trust *BSE1	-215	**	-19	
not sure of trust*BSE1	15		-85	
don't trust*BSE2	184	*	107	
not sure of trust*BSE2	37		57	
don't trust*BSE3	185	***	-48	
not sure of trust*BSE3	10		-58	

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

(Continued)

Table 5.7 Continued

	Alberta		Ontario	
Interaction between confidence of beef and BSE events				
confidence in the safety of beef *BSE1	-80		113	
confidence in the safety of beef *BSE2	25		129	
confidence in the safety of beef *BSE3	161	**	-149	**
Interaction between the trust index and BSE events				
manufacturers index 1*BSE1	-25		-33	
manufacturers index 2*BSE1	-82		-56	
manufacturers index 1*BSE2	-175		-124	
manufacturers index 2*BSE2	148		204	
manufacturers index 1*BSE3	1		-52	
manufacturers index 2*BSE3	-79		-31	
government index 1*BSE1	-202		29	
government index 2*BSE1	154		18	
government index 1*BSE2	-104		169	*
government index 2*BSE2	258		-373	***
government index 1*BSE3	41		69	
government index 2*BSE3	80		-6	
Interaction between feed index and BSE events				
feed index *BSE1	-346	**	154	
feed index *BSE2	-37		205	**
feed index *BSE3	41		-221	***

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

(Continued)

Table 5.7 Continued

	Alberta		Ontario	
Interaction between the knowledge extent of BSE news and BSE events				
BSE news *BSE1	246	**	-131	*
BSE news *BSE2	10		-15	
BSE news *BSE3	12		101	***
Interaction between BSE risk to the family and BSE events				
risk *BSE1	-116		4	
risk *BSE2	168		95	
risk *BSE3	-223	***	-144	***
Interaction between BSE & vCJD concern and BSE events				
disease*BSE1	277	**	-95	
disease*BSE2	40		-273	***
disease*BSE3	80		103	**
Interaction between BSE impact on beef safety confidence and BSE events				
impact*BSE1	-57		-156	**
impact*BSE2	78		-91	
impact*BSE3	107	*	90	**

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

Interaction between Egg Purchases Variables and BSE Events

The determinants of consumers' reaction to BSE events might be associated with consumer preferences on value-added foods with health and nutrition attributes. In Alberta, consumers who purchased value-added eggs reacted significantly more negatively to the second and third BSE events in beef participation and the units of beef purchased, although the magnitudes were modest. In Ontario, consumers who purchased value-added eggs reacted significantly more negatively to the third event in beef expenditures, although the magnitude was also modest.

As one of the hypotheses of the study, we want to test whether the relationship between food safety concerns and consumer behavior towards other food attributes such as health and nutrition exists. The egg purchase data appeared to be an interesting proxy of revealed willingness-to-pay for health attributes in products other than meat, and it

served as a proxy of awareness and concern for farm-level production practices. The results show that consumers who purchased value-added product responded more strongly to BSE than those purchased conventional products. The responses appear stronger especially after the second and the third BSE events. The correlated behavior between BSE and health concerns exists.

Table 5. 8 Marginal Effects from Logit Regression on Beef Participation: Interaction Terms between Value-added Egg Purchases and BSE Events

	Alberta		Ontario	
Interactions between egg and BSE events				
valueegg*BSE1	0.001		-0.007	
valueegg*BSE2	-0.018	**	0.013	**
valueegg*BSE3	-0.009	**	0.001	

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

Table 5. 9 Marginal Effects from Negative Binomial Regression on Monthly Beef Units Purchased: Interaction Terms between Value-added Egg Purchases and BSE Events

	Alberta		Ontario
Interactions between egg and BSE events			
valueegg*BSE1	<0.001		-0.002
valueegg*BSE2	-0.007	*	0.003
valueegg*BSE3	-0.004	**	0.001

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

Table 5. 10 Negative Binomial Regression Results on Monthly Beef Expenditures: Interaction Terms between Value-added Egg Purchases and BSE Events

	Alberta		Ontario	
Interactions between egg and BSE events				
valueegg*BSE1	-2		2	
valueegg*BSE2	1		-2	
valueegg*BSE3	-1		-3	*

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

Explanatory Variables Affecting Beef Purchases in General

Besides the BSE interaction variables, some variables such as seasonality, dummy variables for BSE events, and others also affect consumers' beef purchases. This section includes the discussion of all the general variables.

The independent variables that explain general beef consumption show that household size is predictably positively associated with the number of beef purchases in terms of units and beef expenditures in Ontario. 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.

Beef consumption significantly increased at .05 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. Higher concerns about animal welfare were negatively associated with the number of beef units purchased in Ontario. The opposite, unexpected result occurred in Alberta. Higher concerns about animal disease were negatively associated with the number of beef units purchased in both provinces.

Table 5. 11 Marginal Effects from Logit Regression on Beef Purchase Participation: Independent Variables that Explain General Beef Participation

	Alberta		Ontario	
January	0.159		0.499	***
February	0.153		0.468	***
March	0.296	**	0.435	***
April	0.103		0.287	**
May	0.373	**	0.233	
June	0.233		0.131	
July	-0.163		-0.062	
September	0.055		0.171	
October	-0.017		0.286	**
November	0.217		0.342	***
December	-0.427	***	0.091	
Household size	0.052		0.146	**
Age 35-44	0.198		0.734	**
Age 45-54	0.277		0.985	***
Age 55-64	0.173		0.271	
Age 65+	0.318		0.336	
< High school	-0.740	**	0.097	
High school	0.362		0.160	
Some college	0.216		0.439	***
College	-0.091		0.376	**

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

(Continued)

Table 5.11 Continued

	Alberta		Ontario
Some university	-0.483		0.186
Trust in scientists	0.020		-0.328
Trust in consumer organizations	-0.180		-0.279
Trust in media sources	0.115		0.202
Animal welfare concern	0.624	***	0.061
Animal disease concern	-0.098		-0.063
Retailer index1	-0.076		0.187
Retailer index2	0.285		0.060
Farmer index1	0.006		-0.095
Farmer index2	-0.127		0.011
BSE event 1, t+0	1.351		-1.057
BSE event 1, t+1	1.144		-1.446
BSE event 1, t+2	1.602		-0.566
BSE event 1, t+3	1.493		-0.552
BSE event 1, t+4	1.037		-0.738
BSE event 2, t+0	-0.578		-0.429
BSE event 2, t+1	-0.336		-0.498
BSE event 2, t+2	-0.406		-0.867
BSE event 2, t+3	0.361		-0.342
BSE event 2, t+4	-1.105		-0.724
BSE event 3	-0.335		0.98907

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

Table 5. 12 Marginal Effects from Negative Binomial Regression on Monthly Beef Units Purchased: Independent Variables that Explain General Beef Consumption

	Alberta		Ontario	
January	0.005		0.236	***
February	-0.012		0.158	***
March	0.076		0.196	***
April	0.010		0.100	*
May	0.133	**	0.094	
June	0.045		0.068	
July	-0.114	*	-0.006	
September	-0.067		0.071	
October	-0.079		0.088	
November	0.055		0.158	***
December	-0.256	***	-0.018	
Household size	0.040		0.051	**
Age 35-44	0.298	*	0.243	**
Age 45-54	0.435	**	0.183	
Age 55-64	0.396	**	0.149	
Age 65+	0.546	***	0.245	**
< High school	-0.287	**	0.001	
High school	0.327	***	0.087	
Some college	0.108		0.225	***
College	-0.076		0.136	**

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

(Continued)

Table 5.12 Continued

	Alberta		Ontario	
Some university	-0.288	**	0.055	
Trust in scientists	0.083		0.090	
Trust in consumer organizations	-0.054		0.104	*
Trust in media sources	0.049		0.036	
Animal welfare concern	0.429	***	-0.207	***
Animal disease concern	-0.196	***	-0.111	**
Retailer index1	-0.126	*	0.347	***
Retailer index2	0.257	***	-0.345	***
Farmer index1	-0.019		-0.271	***
Farmer index2	-0.071		0.025	
BSE event 1, t+0	1.207	*	-0.020	
BSE event 1, t+1	1.134		-0.025	
BSE event 1, t+2	1.492	**	0.165	
BSE event 1, t+3	1.553	**	0.238	
BSE event 1, t+4	1.111		0.143	
BSE event 2, t+0	-0.033		-0.332	
BSE event 2, t+1	0.122		-0.349	
BSE event 2, t+2	0.083		-0.444	
BSE event 2, t+3	0.422		-0.223	
BSE event 2, t+4	-0.166		-0.245	
BSE event 3	0.086		0.411	

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

Table 5. 13 Regression Results on Monthly Beef Expenditures: Independent Variables that Explain General Beef Consumption

	Alberta		Ontario	
January	-208	*	45	
February	-258	**	46	
March	-58		97	
April	-85		86	
May	200	*	-2	
June	48		35	
July	-69		35	
September	-91		65	
October	-156		63	
November	-88		12	
December	-486	***	-9	
Household size	137	***	143	***
Age 35-44	548	**	283	
Age 45-54	632	**	542	***
Age 55-64	497	*	351	*
Age 65+	696	**	360	*
< High school	-348		203	*
High school	270		267	**
Some college	-83		347	***
College	-123		346	***

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

(Continued)

Table 5.13 Continued

	Alberta		Ontario	
Some university	-379		83	
Trust in scientists	11		-308	
Trust in consumer organizations	234		-43	
Trust in media sources	-109		7	
Animal welfare concern	130		53	
Animal disease concern	88		-30	
Retailer index1	-49		57	
Retailer index2	236		65	
Farmer index1	-169		-71	
Farmer index2	6		77	
BSE event 1, t+0	2948	**	1000	
BSE event 1, t+1	2850	**	899	
BSE event 1, t+2	3049	**	675	
BSE event 1, t+3	3442	**	876	
BSE event 1, t+4	2756	*	1038	
BSE event 2, t+0	-1442		103	
BSE event 2, t+1	-1076		-150	
BSE event 2, t+2	-1379		-124	
BSE event 2, t+3	-976		-222	
BSE event 2, t+4	-1676		76	
BSE event 3	-782		1172	**

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

Part Two: Meat Purchases and the Food Opinions Survey

This section focuses on the results from the four provinces where egg purchase data were not available: the Maritimes, Quebec, Manitoba/Saskatchewan (abbreviated in tables as Man/Sask), and British Columbia (abbreviated in tables as BC). The analysis is based on the regression of the merged data sets including meat purchase from 2002 to 2008 and the Food Opinions Survey in 2008. Similar to Part One, the results are categorized into three groups based on the specific hypotheses: interaction terms between demographic variables and BSE events; interaction terms between some survey questions and BSE events and the independent variables explaining general beef consumption. As with Part One, for each section three regression results are discussed for each province. Random effects logit answers the question of whether beef purchases stopped or not after BSE events, random effect negative binomial models explain how BSE affected the units of beef purchased, and random effects linear regression gives information on how beef expenditures were affected by BSE events.

Table 5. 14 Tables Key in Part Two

		Measures of Beef Purchases		
Explanatory Variables		Participation	Units Purchased	Expenditures
Interaction Terms	Demographic Variables and BSE Events	Table 5.15	Table 5.16	Table 5.17
	Food Opinions Survey and BSE Events	Table 5.18	Table 5.19	Table 5.20
Affecting Beef Purchases in General		Table 5.21	Table 5.22	Table 5.23

Qualitatively similar results from all three measures of beef purchases were obtained in all provinces. Detailed regression results for the three measures are reported in Tables 5.15-5.23 in which variables are categorized by the main hypotheses.

Interaction between Demographic Variables and BSE Events

Based on the research questions, a set of testable hypotheses was the strength of interaction between BSE responses and demographic variables. Similar results of the interaction terms were observed across all three measures. For instance, compared to households that don't have children, the probability of beef purchases and the units of beef purchases were both significantly increased for households with children in the

Maritimes. However, the impact on households with children varied across the provinces. Taking the number of beef units purchased as an example, for households with children, a significant negative effect after the first BSE event was found in Quebec but a significant positive impact was found in the Maritimes after the first BSE event. Compared with urban residents, rural residents reduced beef consumption in terms of units and expenditures after the first and/or third BSE events in 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 5. 15 Marginal Effects from logit Regression on Beef Participation: Interaction Terms between Demographic Variables and BSE Events

	Maritimes	Quebec	Man/Sask	BC
Interaction between have children and BSE events				
have Children *BSE1	-0.120	-0.547	-0.439	0.221
have Children *BSE2	1.363***	0.326	0.157	-0.086
have Children *BSE3	-0.389	-0.005	0.247*	0.183
Interaction between income and BSE events				
income < $20K *BSE1	-0.435	0.358	-0.328	0.927
income $20-$30K *BSE1	-0.753	0.069	-0.372	0.281
income $30-$40K *BSE1	-0.146	1.393*	-0.320	0.003
income $40-$50K *BSE1	1.351	25.434	-0.136	0.650
income $50-$70K *BSE1	0.537	-0.535	0.201	-0.141
income < $20K *BSE2	-0.176	-0.486	0.526	-1.331**
income $20-$30K *BSE2	-0.567	-1.293	-0.415	0.012
income $30-$40K *BSE2	0.716	1.375	0.624*	-0.423
income $40-$50K *BSE2	-0.490	-0.011	0.387	0.096
income $50-$70K *BSE2	-0.945*	0.087	-0.225	-0.363
income < $20K *BSE3	-0.526*	-1.057***	-0.313	-0.689**
income $20-$30K *BSE3	-0.045	-0.710**	0.029	-0.705***
income $30-$40K *BSE3	0.343	-0.938**	0.027	0.057
income $40-$50K *BSE3	-0.730***	-0.471	0.135	0.063
income $50-$70K *BSE3	0.132	-0.328*	-0.039	-0.201
Interaction between resident areas and BSE events				
rural*BSE1	0.980	-0.543	0.156	0.352
rural*BSE2	-0.251	-1.138**	-0.203	0.089
rural*BSE3	0.292	-0.309	0.016	0.619***

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

Table 5. 16 Marginal Effects from Negative Binomial Regression on Monthly Beef Units Purchased: Interaction Terms Between Demographic Variables and BSE Events

	Maritimes		Quebec		Man/Sask		BC	
Interaction between have children and BSE events								
have Children *BSE1	0.279		-0.423	***	-0.101		0.071	
have Children *BSE2	0.384	*	0.043		0.002		-0.013	
have Children *BSE3	-0.057		0.007		0.070		0.005	
Interaction between income and BSE events								
income < $20K *BSE1	0.013		-0.152		0.154		0.268	
income $20-$30K *BSE1	-0.344		0.020		0.003		0.124	
income $30-$40K *BSE1	-0.056		0.416	*	0.021		0.069	
income $40-$50K *BSE1	0.127		0.309		0.110		0.303	*
income $50-$70K *BSE1	0.389	*	0.017		0.249	*	0.038	
income < $20K *BSE2	-0.131		-0.120		0.352		-0.684	**
income $20-$30K *BSE2	-0.467	**	-0.417		-0.278		0.022	
income $30-$40K *BSE2	-0.017		0.116		0.270		-0.112	
income $40-$50K *BSE2	-0.199		0.140		0.173		0.141	
income $50-$70K *BSE2	-0.500	***	-0.019		-0.201		-0.039	
income < $20K *BSE3	-0.320	***	-0.190		-0.213	*	-0.123	
income $20-$30K *BSE3	-0.143		-0.226	**	0.075		-0.189	*
income $30-$40K *BSE3	-0.072		-0.164		0.088		0.112	
income $40-$50K *BSE3	-0.357	***	0.136		0.056		0.213	***
income $50-$70K *BSE3	-0.198	**	0.125	*	-0.029		-0.063	
Interaction between resident areas and BSE events								
rural*BSE1	0.230		-0.330	**	0.132		0.215	*
rural*BSE2	0.137		-0.095		-0.089		-0.112	
rural*BSE3	0.101		-0.208	**	0.039		0.288	***

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

Table 5. 17 Regression Results on Monthly Beef Expenditures: Interaction Terms between Demographic Variables and BSE Events

	Maritimes		Quebec		Man/Sask		BC	
Interaction between have children and BSE events								
have Children *BSE1	259		-82		-65		174	
have Children *BSE2	34		-291		69		-150	
have Children *BSE3	-230	*	-31		55		101	
Interaction between income and BSE events								
income < $20K *BSE1	295		-362		74		176	
income $20-$30K *BSE1	-477		-180		-203		489	
income $30-$40K *BSE1	175		39		-337		34	
income $40-$50K *BSE1	600		822	**	-180		924	***
income $50-$70K *BSE1	566	*	-304		-205		313	
income < $20K *BSE2	-406		373		393		-464	
income $20-$30K *BSE2	-699	**	-956	*	145		-386	
income $30-$40K *BSE2	-260		-87		427	*	27	
income $40-$50K *BSE2	-382		-475		184		-21	
income $50-$70K *BSE2	-816	***	7		11		-70	
income < $20K *BSE3	-416	**	-510	***	-330	**	-383	**
income $20-$30K *BSE3	-257		-206		36		-200	
income $30-$40K *BSE3	-188		71		45		-19	
income $40-$50K *BSE3	-542	***	-72		4		-41	
income $50-$70K *BSE3	-357	**	103		49		-60	
Interaction between resident areas and BSE events								
rural*BSE1	366		-875	***	127		359	*
rural*BSE2	175		-368		-162		-90	
rural*BSE3	177	*	-396	***	77		307	***

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

Interaction between the Food Opinions Survey Responses and BSE Events

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

Households with higher optimism about food product safety purchased more beef units after the third BSE event in the Maritimes and Manitoba / Saskatchewan. 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 Quebec only.

Similarly to Part One, consumer trust in food system decision makers significantly affected BSE responses in some provinces. Trust that manufacturers are knowledgeable in food safety, identified by manufacturers index1 in the regression, 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. A consistent conclusion emerged from all three beef purchase criteria. Meanwhile, and as expected, trust in the government to be honest about food safety, identified by government index 2 in the regression, contributed to higher beef unit purchases in most provinces 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 Manitoba / Saskatchewan and British Columbia. 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 BSE news purchased fewer beef units when BSE occurred in most provinces. For consumers in Quebec and Manitoba / Saskatchewan, unexpected significant impacts were found, higher perceived BSE risk to the family led to more beef units purchased and greater beef expenditures after BSE events.

Table 5. 18 Marginal Effects from Logit Regression on Beef Participation: Interaction Terms between the Food Opinions Survey Responses and BSE Events

	Maritimes	Quebec	Man/Sask	BC
Interaction between worry trait and BSE events				
worry trait index*BSE1	0.343	0.109	-0.028	0.004
worry trait index*BSE2	-0.108	-0.546 ***	0.243 **	0.121
worry trait index*BSE3	-0.102	-0.094	0.120 **	-0.206***
Interaction between food attitudes and BSE events				
optimism index *BSE1	-0.159	-0.144	-0.392	-0.080
optimism index *BSE2	-0.049	0.228	0.010	-0.250
optimism index *BSE3	0.174	-0.307	0.338 ***	0.002
pessimism index*BSE1	-0.405	-0.182	-0.194	0.350
pessimism index*BSE2	0.567 **	-0.167	-0.269	-0.028
pessimism index*BSE3	0.252 *	-0.257	-0.065	0.272**
Interaction between general trust and BSE events				
don't trust *BSE1	0.128	0.241	-0.252 *	0.113
not sure of trust*BSE1	-0.302	-0.307	-0.010	-0.309
don't trust*BSE2	-0.273	-0.264	-0.020	-0.001
not sure of trust*BSE2	-0.143	0.096	-0.435 **	0.045
don't trust*BSE3	-0.091	-0.078	-0.020	0.119
not sure of trust*BSE3	-0.073	-0.127	0.243 ***	0.056
Interaction between confidence of beef and BSE events				
confidence in the safety of beef *BSE1	-0.545	0.298	0.033	0.089
confidence in the safety of beef *BSE2	0.235	-0.023	0.034	0.088
confidence in the safety of beef *BSE3	0.287 *	-0.146	-0.020	0.069
Interaction between the trust index and BSE events				
manufacturers index 1*BSE1	0.101	0.021	-0.016	-0.068
manufacturers index 2*BSE1	-0.162	0.363	0.341	0.091
manufacturers index 1*BSE2	0.049	-0.425	-0.297 *	0.180
manufacturers index 2*BSE2	0.216	-0.119	0.202	0.216
manufacturers index 1*BSE3	0.142	-0.395 ***	-0.219 ***	-0.282***
manufacturers index 2*BSE3	-0.419 **	0.538 ***	-0.018	0.306**
government index 1*BSE1	0.139	-0.014	0.224	-0.021
government index 2*BSE1	0.311	-0.110	0.142	0.054
government index 1*BSE2	-0.241	-0.264	-0.057	0.020
government index 2*BSE2	-0.025	0.056	-0.117	0.017
government index 1*BSE3	0.024	0.632 ***	-0.041	-0.165*
government index 2*BSE3	0.421 **	-0.721 ***	0.312 ***	0.241*

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

(Continued)

Table 5.18 Continued

	Maritimes	Quebec	Man/Sask	BC
Interaction between feed index and BSE events				
feed index *BSE1	0.192	-0.875***	-0.079	-0.163
feed index *BSE2	-0.212	0.796***	-0.131	-0.227
feed index *BSE3	-0.050	0.269**	0.132	0.053
Interaction between the knowledge extent of BSE news and BSE events				
BSE news *BSE1	0.300	0.439*	-0.061	0.280
BSE news *BSE2	-0.171	-0.070	0.163	0.141
BSE news *BSE3	-0.130*	0.175*	-0.087*	-0.009
Interaction between BSE risk to the family and BSE events				
risk *BSE1	-0.081	-0.067	0.533***	-0.564**
risk *BSE2	-0.082	0.626***	0.142	0.142
risk *BSE3	-0.040	0.075	0.104	0.069
Interaction between BSE & vCJD concern and BSE events				
disease*BSE1	0.121	-0.208	-0.138	0.053
disease*BSE2	0.426**	0.181	-0.033	0.112
disease*BSE3	0.033	-0.111	0.051	-0.137
Interaction between BSE impact on beef safety confidence and BSE events				
impact*BSE1	-0.265	0.352	-0.149	0.057
impact*BSE2	0.246	-0.400*	-0.114	-0.005
impact*BSE3	0.087	-0.003	-0.064	0.013

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

Table 5. 19 Marginal Effects from Negative Binomial Regression on Monthly Beef Units Purchased: Interaction Terms between the Food Opinions Survey Responses and BSE Events

	Maritimes	Quebec	Man/Sask	BC
Interaction between worry trait and BSE events				
worry trait index*BSE1	0.033	0.082	0.028	0.019
worry trait index*BSE2	0.006	-0.136**	0.129**	0.146**
worry trait index*BSE3	0.014	0.010	0.074***	-0.061*
Interaction between food attitudes and BSE events				
optimism index *BSE1	0.038	-0.240*	-0.133	-0.110
optimism index *BSE2	0.049	-0.013	0.041	-0.308**
optimism index *BSE3	0.115**	-0.109	0.215***	-0.091
pessimism index*BSE1	-0.096	-0.109	-0.153	-0.112
pessimism index*BSE2	0.071	0.014	-0.124	-0.092
pessimism index*BSE3	0.090*	-0.120**	0.042	0.076
Interaction between general trust and BSE events				
don't trust *BSE1	0.066	0.160**	-0.213***	-0.086
not sure of trust*BSE1	-0.068	-0.125	-0.059	-0.103
don't trust*BSE2	-0.046	-0.028	0.025	-0.088
not sure of trust*BSE2	-0.021	-0.117	-0.266**	-0.054
don't trust*BSE3	-0.071**	-0.044	-0.046	0.038
not sure of trust*BSE3	0.000	-0.140***	0.164***	0.027
Interaction between confidence of beef and BSE events				
confidence in the safety of beef *BSE1	-0.120	0.113	-0.127	0.008
confidence in the safety of beef *BSE2	0.134	-0.046	0.025	0.070
confidence in the safety of beef *BSE3	0.038	-0.079*	-0.072	0.024
Interaction between the trust index and BSE events				
manufacturers index 1*BSE1	0.033	0.079	0.051	-0.126
manufacturers index 2*BSE1	-0.074	-0.037	0.175	0.110
manufacturers index 1*BSE2	-0.076	-0.092	-0.193**	0.163*
manufacturers index 2*BSE2	-0.022	-0.098	0.131	0.038
manufacturers index 1*BSE3	-0.040	-0.097*	-0.160***	-0.064
manufacturers index 2*BSE3	0.017	0.322***	-0.007	0.111
government index 1*BSE1	0.158	-0.030	0.168**	-0.025
government index 2*BSE1	-0.070	0.062	0.039	0.198
government index 1*BSE2	0.024	-0.188**	0.030	-0.080
government index 2*BSE2	0.079	0.074	-0.040	0.116
government index 1*BSE3	0.047	0.129***	0.010	-0.124***
government index 2*BSE3	0.006	-0.262***	0.194***	0.172***

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

(Continued)

Table 5.19 Continued

	Maritimes	Quebec	Man/Sask	BC
Interaction between feed index and BSE events				
feed index *BSE1	0.121	-0.265***	-0.007	-0.024
feed index *BSE2	0.095	0.169*	-0.010	0.020
feed index *BSE3	0.009	0.075*	0.011	-0.042
Interaction between the knowledge extent of BSE news and BSE events				
BSE news *BSE1	0.008	0.072	-0.091*	0.090
BSE news *BSE2	-0.132**	-0.008	0.034	0.063
BSE news *BSE3	-0.078***	0.118***	-0.021	0.010
Interaction between BSE risk to the family and BSE events				
risk *BSE1	0.031	-0.050	0.217***	-0.014
risk *BSE2	0.011	0.145**	0.031	0.091
risk *BSE3	0.005	0.039	0.021	0.034
Interaction between BSE & vCJD concern and BSE events				
disease*BSE1	-0.129	-0.014	-0.122*	-0.011
disease*BSE2	0.093	0.050	0.003	-0.066
disease*BSE3	0.027	-0.023	0.038	-0.040
Interaction between BSE impact on beef safety confidence and BSE events				
impact*BSE1	-0.051	0.171***	-0.047	0.031
impact*BSE2	-0.013	-0.144**	-0.046	-0.027
impact*BSE3	0.001	-0.034	-0.020	0.017

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

Table 5. 20 Regression Results on Monthly Beef Expenditures: Interaction Terms between the Food Opinions Survey Responses and BSE Events

	Maritimes	Quebec	Man/Sask	BC
Interaction between worry trait and BSE events				
worry trait index*BSE1	-35	-70	61	-17
worry trait index*BSE2	1	-106	101	73
worry trait index*BSE3	-7	-82*	39	-175***
Interaction between food attitudes and BSE events				
optimism index *BSE1	130	-393	-37	-256
optimism index *BSE2	217	-817***	35	-430**
optimism index *BSE3	60	-592***	259***	-358***
pessimism index*BSE1	-215	-129	75	-103
pessimism index*BSE2	61	-339	-115	-193
pessimism index*BSE3	10	-285***	63	127
Interaction between general trust and BSE events				
don't trust *BSE1	199	432***	-218**	46
not sure of trust*BSE1	31	-129	-111	28
don't trust*BSE2	65	213*	30	-48
not sure of trust*BSE2	8	-282*	-104	-204
don't trust*BSE3	38	178***	-3	127**
not sure of trust*BSE3	81	-85	24	-152*
Interaction between confidence of beef and BSE events				
confidence in the safety of beef *BSE1	-151	315*	94	158
confidence in the safety of beef *BSE2	129	-22	18	121
confidence in the safety of beef *BSE3	73	104	-92*	145**
Interaction between the trust index and BSE events				
manufacturers index 1*BSE1	-41	28	-27	-25
manufacturers index 2*BSE1	-14	312	116	285
manufacturers index 1*BSE2	-223 *	-71	-224**	138
manufacturers index 2*BSE2	-280	265	162	-39
manufacturers index 1*BSE3	-100	-88	-74	-159**
manufacturers index 2*BSE3	-82	777***	-36	465***
government index 1*BSE1	-14	203	151	-102
government index 2*BSE1	-195	-3	219	270
government index 1*BSE2	156	-291*	67	-276**
government index 2*BSE2	308	432*	-51	314*
government index 1*BSE3	88	239***	-60	-133***
government index 2*BSE3	134	-275***	188***	290***

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

(Continued)

Table 5.20 Continued

	Maritimes	Quebec	Man/Sask	BC
Interaction between feed index and BSE events				
feed index *BSE1	64	10	-135	112
feed index *BSE2	253**	293*	47	148
feed index *BSE3	63	237***	43	96
Interaction between the knowledge extent of BSE news and BSE events				
BSE news *BSE1	50	19	-76	248**
BSE news *BSE2	-167**	-79	23	-24
BSE news *BSE3	-47	-11	22	64
Interaction between BSE risk to the family and BSE events				
risk *BSE1	85	26	210**	-155
risk *BSE2	-46	203*	-23	15
risk *BSE3	-34	296***	-20	70
Interaction between BSE & vCJD concern and BSE events				
disease*BSE1	-242**	-85	8	-111
disease*BSE2	8	70	-41	-55
disease*BSE3	-28	-224***	63	58
Interaction between BSE impact on beef safety confidence and BSE events				
impact*BSE1	-77	179	24	90
impact*BSE2	21	-211*	16	-41
impact*BSE3	24	-77	-28	-65

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

Explanatory Variables Affecting Beef Consumption in General

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. 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.

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 Manitoba / Saskatchewan. Higher concerns about animal disease were negatively associated with the number of beef units purchased in Quebec.

Table 5. 21 Marginal Effects from Logit Regression on Beef Participation: Independent Variables that Explain General Beef Participation

	Maritimes	Quebec	Man/Sask	BC
January	0.492***	0.141	0.535***	-0.074
February	0.052	-0.312	0.257**	0.095
March	0.189	-0.374*	0.227*	0.078
April	0.016	-0.123	0.140	-0.129
May	0.272	-0.330	0.305**	-0.232
June	0.334*	-0.200	0.072	0.035
July	0.127	-0.195	-0.090	-0.169
September	0.133	0.098	0.027	-0.205
October	0.302*	-0.069	0.133	0.038
November	0.239	-0.206	0.197	-0.013
December	-0.194	-0.264	-0.117	-0.363**
Household size	0.292***	0.415***	-0.095	0.054
Age 35-44	-0.138	0.168	0.498	-0.525
Age 45-54	0.517	-0.202	0.379	-0.612
Age 55-64	0.371	0.035	0.420	-0.774
Age 65+	0.685	-0.046	0.437	-0.937
< High school	-0.371	0.528*	-0.518***	0.947***
High school	0.013	0.956***	-0.402***	-0.027
Some college	-0.232	-0.304	-0.083	0.352*
College	-0.021	-0.156	-0.127	0.469**
Some university	-0.348	0.674***	-0.445**	0.040
Trust in scientists	-0.035	-0.197	0.011	0.195
Trust in consumer organizations	-0.296	-0.240**	-0.014	-0.227
Trust in media sources	0.253	-0.048	-0.010	-0.017
Animal welfare concern	0.014	-0.072	-0.108	0.060
Animal disease concern	-0.049	-0.179	0.134	0.040
Retailer index1	-0.603***	0.354*	0.091	0.166
Retailer index2	0.394	0.038	-0.354**	0.068
Farmer index1	0.173	-0.498***	-0.320**	-0.004
Farmer index2	-0.186	-0.177	0.006	-0.416
BSE event 1, t+0	-0.391	1.773	0.286	-0.788
BSE event 1, t+1	-0.642	0.742	0.728	-1.143
BSE event 1, t+2	-0.494	1.326	0.587	-0.229
BSE event 1, t+3	0.793	1.014	1.357	-0.569
BSE event 1, t+4	0.278	1.460	0.594	-0.985

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

(Continued)

Table 5.21 Continued

	Maritimes	Quebec	Man/Sask	BC
BSE event 2, t+0	-2.310	-0.474	0.335	-0.745
BSE event 2, t+1	-2.019	0.115	0.732	-1.548
BSE event 2, t+2	-1.852	0.331	0.552	-1.626
BSE event 2, t+3	-2.259	0.513	1.153	-0.870
BSE event 2, t+4	-2.467	-0.397	0.624	-1.574
BSE event 3	-2.447**	2.066	-1.759**	-0.488

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

Table 5. 22 Marginal Effects from Negative Binomial Regression on Monthly Beef Units Purchased: Independent Variables that Explain General Beef Consumption

	Maritimes	Quebec	Man/Sask	BC
January	0.159***	0.043	0.152***	0.011
February	-0.054	-0.085	0.048	0.039
March	0.057	0.016	-0.004	0.065
April	-0.068	0.051	0.027	-0.083
May	0.043	0.029	0.157***	-0.090
June	0.135**	0.049	0.009	0.012
July	-0.025	-0.059	-0.017	-0.051
September	0.033	0.054	0.010	-0.067
October	0.021	-0.023	0.032	-0.004
November	0.016	-0.050	0.013	0.033
December	-0.095	-0.161**	-0.191***	-0.155**
Household size	-0.030	0.127***	0.014	0.060*
Age 35-44	0.270	0.212	-0.169	-0.547
Age 45-54	0.379	0.421	-0.397*	-0.716
Age 55-64	0.413*	0.271	-0.259	-0.735
Age 65+	0.526**	0.332	-0.229	-0.704
< High school	-0.236***	0.492***	-0.258***	0.604***
High school	-0.031	0.423***	-0.195***	0.269***
Some college	-0.282***	-0.100	0.019	0.340***
College	-0.098	-0.044	-0.032	0.342***
Some university	-0.224**	0.178**	-0.066	0.240***
Trust in scientists	-0.161*	0.167**	-0.081	-0.033
Trust in consumer organizations	-0.118	0.052	0.122**	-0.171**
Trust in media sources	0.178***	-0.071	0.003	0.115**
Animal welfare concern	0.072	0.006	0.072	0.111*
Animal disease concern	-0.036	-0.118**	-0.024	-0.010
Retailer index1	-0.260***	-0.007	-0.147***	0.012
Retailer index2	0.038	0.024	0.010	0.055
Farmer index1	-0.060	-0.254***	0.137**	-0.168**
Farmer index2	0.300***	-0.016	-0.309***	-0.013
BSE event 1, t+0	0.036	1.069	0.354	-0.010
BSE event 1, t+1	-0.078	0.787	0.583	-0.101
BSE event 1, t+2	0.292	0.926	0.526	0.150
BSE event 1, t+3	0.135	0.999	0.968	0.177
BSE event 1, t+4	-0.029	0.875	0.600	-0.098

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

(Continued)

Table 5.22 Continued

	Maritimes	Quebec	Man/Sask	BC
BSE event 2, t+0	-1.205*	0.597	-0.230	0.032
BSE event 2, t+1	-1.145*	0.808	-0.041	-0.143
BSE event 2, t+2	-1.047	0.634	-0.097	-0.330
BSE event 2, t+3	-1.064	0.807	0.066	0.059
BSE event 2, t+4	-1.133*	0.570	-0.171	-0.167
BSE event 3	-0.847**	0.496	-0.966***	0.173

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

Table 5. 23 Regression Results on Monthly Beef Expenditures: Independent Variables that Explain General Beef Consumption

	Maritimes	Quebec	Man/Sask	BC
January	68	-18	116	-120
February	-167*	-219	-30	-117
March	20	2	-59	28
April	-117	0	86	-168
May	-17	58	427***	-127
June	349***	205	145	8
July	-67	44	53	104
September	8	136	76	-166
October	-70	-75	10	-58
November	-41	-53	-46	-161
December	-80	-193	-123	-215*
Household size	233***	179***	99***	128**
Age 35-44	305	509	-107	170
Age 45-54	874**	771**	-152	88
Age 55-64	707*	573*	-97	222
Age 65+	845**	600*	-45	95
< High school	-44	1761***	-236**	809***
High school	110	939***	-100	745***
Some college	63	524***	167	625***
College	-50	458***	-67	833***
Some university	-29	221*	-67	552***
Trust in scientists	73	-254***	95	384***
Trust in consumer organizations	-122	-386***	-51	-162
Trust in media sources	179*	203***	-3	-114
Animal welfare concern	-72	57	-172**	83
Animal disease concern	7	-265***	133	-228**
Retailer index1	-155	126***	133	73
Retailer index2	112	-151**	-202*	16
Farmer index1	67	-3	-108	79
Farmer index2	-105	-516***	5	-307*
BSE event 1, t+0	1324	-749	-1688	-1737
BSE event 1, t+1	999	-1379	-1138	-1880
BSE event 1, t+2	1967	-1166	-1152	-1472
BSE event 1, t+3	1793	-979	-712	-1384
BSE event 1, t+4	1335	-1294	-1329	-1776

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

(Continued)

Table 5.23 Continued

	Maritimes	Quebec	Man/Sask	BC
BSE event 2, t+0	-1500	2378	-303	1241
BSE event 2, t+1	-1363	2783	-20	1233
BSE event 2, t+2	-1285	2156	-110	662
BSE event 2, t+3	-1300	2485	-54	1497
BSE event 2, t+4	-1291	2188	-524	923
BSE event 3	-405	936	-1198**	-724

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

Eighteen regressions results are included in this section and they are grouped in two parts based on the data availability of each province. Three measures of beef purchases in terms of purchase participation, beef units purchased and expenditures based on the integration of three data sources: meat purchases, egg purchases and the Food Opinions Survey in Alberta and Ontario are involved in Part one. Each of the regression results are categorized by four main hypotheses is Part one. Three measures of beef purchases based on the integration of two data sources: meat purchases and the Food Opinions Survey in the other four provinces are included in Part two. Each of the regression results are categorized by three main hypotheses in this part. In all regions of Canada, results regarding purchase participation, beef units purchased and expenditures were substantially similar. The purpose of estimating three models was to identify potential confounding effects of lower beef prices following BSE events. For example, if behavior changed only due to lower beef prices, one might see an increase in participation and units purchased, but not in beef expenditures. In this case, however, all three models returned the same qualitative results, increasing the confidence that confounding price effects were muted.

Chapter Six

Conclusions

This study relates concerns of nutrition and food opinions to recurring food safety events in the context of three BSE events in Canada. Previous literature has paid little attention to recurrence of food safety events in shaping individual response to food risks. The dynamic relationship between consumer behavior and BSE outbreaks was examined in this study. More than that, this study extends previous research by providing a systematic account of the determinants of the relationship between recurring BSE events and nutrition and food safety concerns in six provinces of Canada. This study show that the recurrence of food safety events may lead to consumer behavior changes toward a food product.

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, with consumers in eastern Canada reacting most negatively to BSE. 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. The positive responses to the first BSE outbreaks appeared in a previous study also (Maynard and Wang, 2011), in which Homescan meat purchases from 2002 to 2005 in Canada were evaluated. This study extended the previous study by enlarging the time periods to 2008, adding two more data sets: egg purchases and the Food Opinions Survey conducted in 2008, both of which contained households that had been members of the meat purchase panel. Meanwhile, different econometric models were applied in this study. Significant negative impacts on beef consumption occurred after the second and third events in the Maritimes and Manitoba / Saskatchewan only, whereas significant negative reactions to the second and third BSE events were discovered in all provinces in the previous study. The positive reaction to the first BSE outbreak was possibly induced by the transparent and proactive responses from the Canadian government. Consumers might be sympathetic toward Canada's struggling ranchers and the conclusion about the first event was treated as a trade issue instead of a food safety issue (Boyd and Jardine, 2007; Maynard and Wang, 2011). The first BSE event occurred in Alberta, and the positive reaction was also strongest in Alberta; this

may suggest that this unusual positive reaction largely comes from the support for the ranchers in Alberta. However, the sympathy from consumers may not be repeated after recurrences of BSE events (Maynard and Wang, 2011). The fear of food safety might affect consumer behavior towards beef products and this was identified by this study and the previous study.

Households' level of trust that manufacturers have sufficient knowledge to control food safety affecting consumers' beef purchases but impacts differ across 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 Quebec. 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). Consumers mainly rely on institutions to guarantee the safety of food products because of the complexity of the food product chain and limited knowledge about food products (Lang and Hallman, 2005). Previous literature already concluded that trust is an important factor in the analysis of consumer behavior towards food risks. This study distinguishes trust in the industry decision makers into their knowledge to control food safety and their ability to take good care of food safety.

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 most provinces, optimism about food products correlated with more positive BSE impacts. Similarly, in most provinces, consumers with high worry trait values were more likely to reduce beef purchases in response to BSE. While many parameters were of the expected sign, there were also several instances of unexpected but statistically significant parameters.

Consumers who purchased value-added eggs reacted significantly more negatively to the second and third BSE events, as did those who reported increasing food safety concerns in the opinions survey. Their negative responses to BSE were stronger than those of consumers who purchased conventional products. The egg purchase data served as a proxy of awareness and concern for farm-level production practices and the

willingness-to-pay for health and nutrition attributes in this study. The results showed that a relationship exists between concern for health and nutrition attributes and food safety. Industry decision makers can incorporate this information into their decisions and strategies when facing a difficult situation such as food safety events.

The results send important messages to beef producers about consumer reaction to BSE events. Taking household beef consumption as measured by expenditures in British Columbia as an example, the interaction terms between trusts in the government appear in Table 5.20. Beef expenditures were measured in cents, so the parameter estimates suggest that the degree of consumer trust in the government to be honest about food safety increased by one unit when the third BSE occurred prompted household of British Columbia to spend $2.9 more per month on beef. According to the Canadian Census of Population, in 2006 the total household number in British Columbia was 1,642,715, the aggregate impacts of trusts in the government is honest about food safety could prompt the beef expenditures increased by $4,763,873.5 per month (assume the number of household would not change). Therefore, the results can serve as the indicator of beef consumption for beef producers in Canada.

Five issues are likely to generate discussion. First, conflicting evidence of Canadian BSE impacts exist by using different data and different models. The rich sources of new information about consumer food opinions and non-meat purchase behavior of the same households have meaningful benefits. The integration of actual purchase data with survey data 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 coverage of the analysis demonstrates modest but interesting results in which consumer reaction to BSE vary regionally. Third, the general correspondence between the survey responses and actual purchase behavior spanning several years indicates that consumer behavior is persistent over time. It is an encouraging sign of construct validity in the survey instrument and it also reduces the concern of endogeneity of the survey which is performed at the end of data collection of beef purchase. Finally, it was interesting to see the correspondence between concern of health and nutrition and food safety concern. It sends important information to industry decision makers. The beef industry may benefit from incorporating this information.

One of the primary motivations for pursuing this study was that limited consumer character tics appeared significantly reacted to BSE discoveries in Canada from previous study. This study extends the previous one by enlarging the time periods and more data sources which can be helpful to identify individual heterogeneity and the application of panel random effects models which also targets on controlling the unobserved and constant aspects of households.

The integration of actual purchase data with survey data and egg purchases may provide more accurate explanation on consumer behavior, in which "what you think" or "what else you do" may be the key to explaining individual choices. Primary findings may extend to other food safety and animal health crises, especially those with ambiguous human health impacts. 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. It suggests the guarantee of the institution is honest about food safety will be very important to retrieve consumer confidence of food product. Policy makers need to pay more attention to the issue of the traceability system of food products. The identification of informational context is a logical next step in future food safety research.

Appendices

Appendix 1
Example of Meat Purchase Data

hhid	region	hhsize	kid	age	income	educ	year	month	day	foodtype	exp	units
33000007	6	1	9	3	5	6	2	3	6	15	934	1
33000007	6	1	9	3	5	6	2	4	29	34	428	1

hhid=household ID;

region 6 = British Columbia; hhsize 1= the household size is single member;

kid 9 = no children under 18 in the household;

age 3 = household head age is from 45 to 54 years old;

income 5 = household income is range from $50,000 to $69,999;

educ 6 = household head is with university graduate;

year 2 = 2002; month 3 = March; day 6 = date is 6;

foodtype 15 = poultry; exp 934= expenditure is 934 in cents; units 1= one unit purchased.

Appendix 2
Example of Egg Purchase Data

hhid	UPC	Unit 02/02/2002	Unit 01/01/2005
33000024	5731609263	0	0
33000024	6038367416	0	0

hhid=household ID; UPC 5731609263 indicates conventional egg;

UPC 6038367416 indicates conventional egg;

The unit of conventional egg purchased on 02/02/2002 is zero by 33000024;

Appendix 3
The Food Opinions Survey

Please have the Head of the Household who does the majority of the grocery shopping complete the survey.

General Trust

1. Generally speaking, would you say that most people can be trusted?

1=People can be trusted

2=Can't be too careful in dealing with people

3=Don't know

How much do you trust each of the following groups of people?

Cannot be trusted at all - 1

Somewhat untrustworthy - 2

Slightly untrustworthy - 3

Somewhat trustworthy - 4

Can be trusted a lot - 5

Don't know - 6

2. People in your family

3. People in your neighborhood

4. People you work or go to school with

5. Doctors or nurses

6. Scientists

7. Consumer Organizations

8. Environmental organizations

9. Media sources

10. Strangers

11. How often do you lend money to your friends?

Never - 1

Infrequently - 2

Moderately often - 3

Frequently - 4

Regularly - 5

Prefer not to say - 6

Please indicate to what extent you find the following statements characteristic of yourself.

Not at all typical - 1

2 - 2

Somewhat typical - 3

4 - 4

Very typical - 5

12. Many situations make me worry

13. I know I shouldn't worry about things, but I just cannot help it

14. I notice that I have been worrying about things

Food Attitudes

5-point scale ranging from 1(strongly disagree) to 5 (strongly agree).

15. I am optimistic about the safety of food products.

16. I am confident that food products are safe.

17. I am satisfied with the safety of food products.

18. Generally, food products are safe.

19. I worry about the safety of food.

20. I feel uncomfortable regarding the safety of food.

21. As a result of the occurrence of food safety incidents, I am suspicious about certain food products.

Perceived safety of meat

Please indicate how much confidence you, generally, have in the safety of the following product groups. Give your answer on a scale from 1 ("No confidence at all") to 5 ("Complete confidence").

22. Beef

23. Chicken / poultry

Attitudes towards eating beef

24. Do you, or does any member of your household, eat beef?

1=Yes

2=No – skip to 'Trust in Food Industry' section (Q31)

25. When eating beef, my household is exposed to …

Answer on a scale from 1 (“Very little risk”) to 5 (“A great deal of risk”).

26. Members of my household accept the risks of eating beef

Answer on a scale from 1 (“Strongly disagree”) to 5 (“Strongly agree”).

27. Members of my household think eating beef is risky

Answer on a scale from 1 (“Strongly disagree”) to 5 (“Strongly agree”).

28. For members of my household, eating beef is…

Answer on a scale from 1 (“Not risky”) to 5 (“Risky”).

29. For members of my household, eating beef is worth the risk

Answer on a scale from 1 (“Strongly disagree”) to 5 (“Strongly agree”).

30. My household is … the risk of eating beef

Answer on a scale from 1 (“Not willing to accept”) to 5 (“Willing to accept”).

Trust in food industry

Answer on a scale from 1 (“Strongly disagree”) to 5 (“Strongly agree”).

Manufacturers

31. Manufacturers have the competence to control the safety of food

32. Manufacturers have sufficient knowledge to guarantee the safety of food products

33. Manufacturers are honest about the safety of food

34. Manufacturers are sufficiently open about the safety of food

35. Manufacturers take good care of the safety of our food

36. Manufacturers give special attention to the safety of food

Retailers

37. Retailers have the competence to control the safety of food

38. Retailers have sufficient knowledge to guarantee the safety of food products

39. Retailers are honest about the safety of food

40. Retailers are sufficiently open about the safety of food

41. Retailers take good care of the safety of our food

42. Retailers give special attention to the safety of food

Government

43. The government has the competence to control the safety of food

44. The government has sufficient knowledge to guarantee the safety of food products

45. The government has honest about the safety of food

46. The government has sufficiently open about the safety of food

47. The government takes good care of the safety of our food

48. The government gives special attention to the safety of food

Farmers

49. Farmers have the competence to control the safety of food

50. Farmers have sufficient knowledge to guarantee the safety of food products

51. Farmers are honest about the safety of food

52. Farmers are sufficiently open about the safety of food

53. Farmers take good care of the safety of our food

54. Farmers give special attention to the safety of food

Animal production related concerns

55. To what extent are you concerned about the following issues?

Answer on a scale from 1 ("Not at all concerned") to 5 ("Very concerned").

55. The feed given to livestock

56. Conditions in which food animals are raised

57. Genetically modified animal feeds

58. Animal diseases

59. BSE (mad cow disease) and Creutzfeldt Jakob Disease (vCJD)

60. The origin of products/ animals

61. Antibiotics in meat

Recall of media coverage on BSE (mad cow disease)

62. Have you seen, heard, or read about BSE (mad cow disease)?"

1=Yes

2= No – end survey

63. To what extent have you seen, heard, or read any news messages in the media about BSE (mad cow disease) over the past five years?

Answer on a scale from 1 ("Very few messages") to 5 ("Many messages")

64. If a Canadian cow is found with BSE (mad cow disease) the risk to my family is:

Answer on a scale from 1 ("Very low") to 5 ("Very high").

65. If you have any awareness of a BSE (mad cow disease) incident in Canada over the past five years, where did you get your information from? Please scan all that apply.

(1=selected; 0=not selected)

Friends and family

Newspapers

Magazines

Radio

TV

Internet

Other

Don’t know/Don’t Recall

66. If you have any awareness of a BSE (mad cow disease) incident in Canada over the past five years, has this had any impact on your confidence in the safety of beef products?

1=A very small impact

2=Some impact

3=Moderate impact

4=Large impact

5=A very large impact

6=Don’t know

Appendix 4
Index of the Food Opinions Survey Variables

Name of Index	Survey Questions
worry trait index	Many situations make me worry I know I shouldn't worry about things, but I just cannot help it I notice that I have been worrying about things
optimism index	I am optimistic about the safety of food products I am confident that food products are safe I am satisfied with the safety of food products Generally, food products are safe
pessimism index	I worry about the safety of food I feel uncomfortable regarding the safety of food As a result of the occurrence of food safety incidents, I am suspicious about certain food products.
manufacturers index1	Manufacturers have the competence to control the safety of food Manufacturers have sufficient knowledge to guarantee the safety of food products

(Continued)

Appendix 4 Continued

manufacturers index2	Manufacturers are honest about the safety of food Manufacturers are sufficiently open about the safety of food Manufacturers take good care of the safety of our food Manufacturers give special attention to the safety of food
retailers index1	Retailers have the competence to control the safety of food Retailers have sufficient knowledge to guarantee the safety of food products
retailers index2	Retailers are honest about the safety of food Retailers are sufficiently open about the safety of food Retailers take good care of the safety of our food Retailers give special attention to the safety of food
government index1	The government have the competence to control the safety of food The government have sufficient knowledge to guarantee the safety of food products
government index2	The government are honest about the safety of food The government are sufficiently open about the safety of food The government take good care of the safety of our food The government give special attention to the safety of food

(Continued)

Appendix 4 Continued

farmers index1	Farmers have the competence to control the safety of food Farmers have sufficient knowledge to guarantee the safety of food products
farmers index2	Farmers are honest about the safety of food Farmers are sufficiently open about the safety of food Farmers take good care of the safety of our food Farmers give special attention to the safety of food
feed index	The feed given to livestock Genetically modified animal feeds Antibiotics in meat

Appendix 5
Definitions of the Variables

Variables	Full Name of Variables	Definition
jan	January	Monthly dummy variables with Aug
feb	February	excluded as the base
mar	March	
apr	April	
may	May	
jun	June	
jul	July	
sep	September	
oct	October	
nov	November	
dec	December	
Household Demographics Variables		
hhsize	Household size	
age2	Household Head Age 35-44	Age dummy variables with <35 excluded
age3	Household Head Age 45-54	as the base
age4	Household Head Age 55-64	
age5	Household Head Age 65+	
hheduc1	HHE< High school	Education dummy variables with
hheduc2	HHE=High school	university graduates excluded as the base,
hheduc3	HHE=Some college	HHE=household head Educ
hheduc4	HHE=College	
hheduc5	HHE=Some university	

(Continued)

Appendix 5 Continued

The Food Opinions Survey

tsc	trust in scientists	Trust of the specific groups of people
tcoc	trust in consumer organizations	
tmc	trust in media sources	
chicken	confidence in poultry safety	Dummy variables with beef excluded as the base
q56	animal welfare	Livestock raised conditions concern
q58	animal diseases	Animal diseases concern
rindex1	retailers index 1	Trust in the retailers is knowledgeable in food safety
rindex2	retailers index 2	Trust in the retailers is honest on food safety
findex1	farmers index 1	Trust in the farmers is knowledgeable in food safety
findex2	farmers index 2	Trust in the farmers is honest on food safety

BSE Dummy Variables

bse10	BSE event 1, t+0	The 1st BSE event dummy variables separately the occurrence month (t=0) and 4 subsequent months
bse11	BSE event 1, t+1	
bse12	BSE event 1, t+2	
bse13	BSE event 1, t+3	
bse14	BSE event 1, t+4	
bse20	BSE event 2, t+0	The 2nd BSE event dummy variables separately the occurrence month (t=0) and 4 subsequent months
bse21	BSE event 2, t+1	
bse22	BSE event 2, t+2	
bse23	BSE event 2, t+3	
bse24	BSE event 2, t+4	
bse3	BSE event 3	The 3rd BSE event combined all remaining events during the study period

(Continued)

Appendix 5 Continued

Interaction Variables: Egg and BSE		
valueegg1	valueadded egg*BSE1	Value added egg dummy variables with conventional eggs as the base
valueegg2	valueadded egg*BSE2	
valueegg3	valueadded egg*BSE3	
Interaction Variables: Survey and BSE		
wtindex1	worry trait index *BSE1	worry trait index= Household worry characteristics
wtindex2	worry trait index *BSE2	
wtindex3	worry trait index *BSE3	
opindex1	optimism index *BSE1	Food attitudes: optimism of food safety
opindex2	optimism index *BSE2	
opindex3	optimism index *BSE3	
peindex1	pessimism index*BSE1	
peindex2	pessimism index*BSE2	
peindex3	pessimism index*BSE3	
gt21	don't trust *BSE1	
gt31	not sure of trust*BSE1	
gt22	don't trust*BSE2	
gt32	not sure of trust*BSE2	
gt23	don't trust*BSE3	
gt33	not sure of trust*BSE3	
beef1	confidence in beef safety *BSE1	
beef2	confidence in beef safety *BSE2	
beef3	confidence in beef safety*BSE3	
mindex11	manufacturers index 1*BSE1	
mindex21	manufacturers index 2*BSE1	
mindex12	manufacturers index 1*BSE2	
mindex22	manufacturers index 2*BSE2	
mindex13	manufacturers index 1*BSE3	
mindex23	manufacturers index 2*BSE3	

(Continued)

Appendix 5 Continued

gindex11	government index 1*BSE1	gindex1= Household trust in the government is knowledgeable in food safety
gindex21	government index 2*BSE1	
gindex12	government index 1*BSE2	
gindex22	government index 2*BSE2	gindex2= Household trust in the government is honest on food safety
gindex13	government index 1*BSE3	
gindex23	government index 2*BSE3	
feedindex1	feed index *BSE1	Household concern of the feed given to livestock
feedindex2	feed index *BSE2	
feedindex3	feed index *BSE3	
q591	BSE and vCJD concern*BSE1	Household concern of BSE and vCJD
q592	BSE and vCJD concern *BSE2	
q593	BSE and vCJD concern*BSE3	
q63c1	BSE news *BSE1	
q63c2	BSE news *BSE2	
q63c3	BSE news *BSE3	
q64c1	risk *BSE1	
q64c2	risk *BSE2	
q64c3	risk *BSE3	
q113cc1	impact *BSE1	
q113cc2	impact *BSE2	
q113cc3	impact *BSE3	
Interaction Variables: Demographics and BSE		
havekids1	family with kids *BSE1	Child presence with no child excluded as the base
havekids2	family with kids *BSE2	
havekids3	family with kids *BSE3	

(Continued)

Appendix 5 Continued

income11	Income < $20K *BSE1	5 income categories with the $70,000+ excluded as the base
income21	Income $20-$30K *BSE1	
income31	Income $30-$40K *BSE1	
income41	Income $40-$50K *BSE1	
income51	Income $50-$70K *BSE1	
income12	Income < $20K *BSE2	
income22	Income $20-$30K *BSE2	
income32	Income $30-$40K *BSE2	
income42	Income $40-$50K *BSE2	
income52	Income $50-$70K *BSE2	
income13	Income < $20K *BSE3	
income23	Income $20-$30K *BSE3	
income33	Income $30-$40K *BSE3	
income43	Income $40-$50K *BSE3	
income53	Income $50-$70K *BSE3	
regionr1	rural*BSE1	Household location dummy variables with urban as the base
regionr2	rural*BSE2	
regionr3	rural*BSE3	

Appendix 6
Stata Code

Alberta and Ontario

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

xtlogit has_x1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3 valueegg1 valueegg2 valueegg3, re i(hid)

mfx

Regression two: Panel Negative binomial model is used for units purchased count data

xtnbreg sumq1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42

income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3 valueegg1 valueegg2 valueegg3, re i(hid)

mfx

Regression three: Random effect linear regression model for continues expenditure data

xtreg sumx1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3 valueegg1 valueegg2 valueegg3, re i(hid)

Maritimes, Quebec, Manitoba/Saskatchewan and British Columbia

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

xtlogit has_x1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42

income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3, re i(hid)

mfx

Regression two: Panel Negative binomial model is used for units purchased count data

xtnbreg sumq1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3, re i(hid)

mfx

Regression three: Random effect linear regression model for continues expenditure data

xtreg sumx1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3, re i(hid)

Correlation between random effects and explanatory variables

Alberta and Ontario

Fixed effects linear approximation of the logistic dependent variable

xtreg has_x1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3 valueegg1 valueegg2 valueegg3, fe i(hid)

linear approximation of the negative binomial dependent variable

xtreg sumq1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3 valueegg1 valueegg2 valueegg3, fe i(hid)

the unit of beef purchased linear approximation of beef expenditures

xtreg sumx1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3 valueegg1 valueegg2 valueegg3, fe i(hid)

Maritimes, Quebec, Manitoba/Saskatchewan and British Columbia

Fixed effects linear approximation of the logistic dependent variable

xtreg has_x1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3, fe i(hid)

linear approximation of the negative binomial dependent variable

xtreg sumq1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3

wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3, fe i(hid)

the unit of beef purchased linear approximation of beef expenditures

xtreg sumx1 jan feb mar apr may jun jul sep oct nov dec hhsize age2 age3 age4 age5 hheduc1 hheduc2 hheduc3 hheduc4 hheduc5 tsc tcoc tmc q56 q58 rindex1 rindex2 findex1 findex2 bse10 bse11 bse12 bse13 bse14 bse20 bse21 bse22 bse23 bse24 bse3 wtindex1 wtindex2 wtindex3 opindex1 opindex2 opindex3 peindex1 peindex2 peindex3 gt21 gt31 gt22 gt32 gt23 gt33 beef1 beef2 beef3 mindex11 mindex21 mindex12 mindex22 mindex13 mindex23 gindex11 gindex21 gindex12 gindex22 gindex13 gindex23 feedindex1 feedindex2 feedindex3 q63c1 q63c2 q63c3 q64c1 q64c2 q64c3 q591 q592 q593 q113cc1 q113cc2 q113cc3 havekids1 havekids2 havekids3 income11 income21 income31 income41 income51 income12 income22 income32 income42 income52 income13 income23 income33 income43 income53 regionr1 regionr2 regionr3, fe i(hid)

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