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Consumer Food Safety Risk Perceptions and Attitudes: Impacts on Beef Consumption across Countries

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Consumer Food Safety Risk Perceptions and Attitudes: Impacts on Beef Consumption across Countries*

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Abstract

Beef food safety events have contributed to considerable market volatility, produced varied consumer reactions, created policy debates, sparked heated trade disputes, and generally contributed to beef industry frustrations. Utilizing data from a total of 4,005 consumers in the United States, Canada, Mexico and Japan in a Double-Hurdle modeling framework, we examine whether consumers altered their beef consumption behavior because of their risk aversion and risk perceptions stemming from information about beef food safety in recent years. Results reveal stark differences in risk perceptions and risk aversion regarding beef food safety across consumers in the four countries and that these differences are revealed through different beef consumption behavior. An improved understanding of food safety perceptions and attitudes will enable policy makers and agricultural industries to better anticipate consumers changing consumption behavior, if a food safety event occurs. Food safety management strategies vary across countries because of identified differences in food safety risk attitudes and risk perceptions.

KEYWORDS: risk attitude, risk perception, food safety, beef consumption

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1. Introduction

Food safety concerns have had dramatic impacts on food markets in general and beef markets in particular in recent years. However, consumers in different countries exhibit divergent responses to beef food safety events. For example, beef demand in Japan dropped substantially following discovery of a domestic cow infected with bovine spongiform encephalopathy (BSE) in 2001. Two years later, the United States lost access to the Japanese export market following a December 2003 BSE discovery in the United States. In contrast, beef demand in the United States increased in 2004 despite this discovery. How can such remarkably different consumer responses to a food safety issue be explained? We hypothesize that differing responses to perceived food safety hazards result, in part, from variation in risk perceptions and attitudes of consumers.

The objectives of this study are to 1) evaluate consumer attitudes and perceptions about beef food safety across different countries, and 2) quantify how perceptions and attitudes have affected changes in beef consumption over time. To accomplish these objectives, we illustrate a conceptual model showing how food safety risk attitudes and perceptions would be expected to affect food product consumption. We survey consumers in major markets for North American beef—the United States, Canada, Mexico, and Japan—to determine how beef consumption has changed over time and to measure consumer beef food safety attitudes and perceptions. We empirically determine whether consumer attitudes and perceptions about beef food safety affected beef consumption in recent years in light of beef food safety events.

Risk perceptions represent a person's views about the risk inherent in a particular situation. Perceptions about food safety risk are what the individual believes would be the amount of health risk, if any, they would face from consuming a food product. Risk attitudes are a person's overriding tendencies toward risk across different risky situations. Risk attitudes refer to how willing a person is to accept risk. Risk-averse people place a high premium on ventures that are assured safe, risk-neutral people are indifferent regarding choices with different levels of risk, and risk-seeking individuals pursue risky situations. By risk perception, we mean the risk that consumers believe to exist from eating a food product. By risk attitude, we mean the way consumers react to that perception (e.g. degree of risk aversion). In other words, risk aversion takes as given the risk that is perceived. Policymakers may be interested in the *actual* risk, of course, and we return to discussion of the validity of risk perceptions later in the paper, but the actual risk is not directly relevant for our estimation of consumer behaviors, because consumers react to the risk they *think* is present.

Consumer perceptions of beef food safety risk associated with BSE reveal diverse reactions. Setbon et al. (2005) determine that risk perception about BSE

among French consumers is related to emotion and value-based judgments. Levels of perceived risk associated with consuming beef during the BSE crisis in France is highly correlated with reduced beef consumption, suggesting consumers are choosing "a level of self-protection beyond public measures taken to reduce it" (Setbon et al., p. 823). Pennings et al. (2002) determine that differences in risk perceptions and attitudes about BSE contribute to disparate changes in beef consumption in the United States, Germany, and the Netherlands. U.S. consumers do not perceive that consuming beef presents high levels of risk despite BSE presence in the country. However, U.S. consumers who indicate they reduce beef consumption because of BSE concerns do so because they are risk averse. In contrast, risk perception and risk aversion both contribute to beef demand declines in Germany. Consumers in the Netherlands react in a similar manner to U.S. consumers in response to BSE, but those who reduce consumption do so primarily as a result of level of perceived risk rather than risk aversion.

The differences we observe in prior studies provide motivation for our study, which is the first to estimate, compare, and contrast how food safety risk perceptions and attitudes of American, Canadian, Japanese, and Mexican consumers impact beef consumption. A better understanding of cross-country food safety risk perceptions, risk attitudes, and associated effects on consumption is needed as markets continue to globalize and become more trade dependent and as the North American beef industry struggles to regain presence in Asian markets following BSE discoveries in Canada and the United States. Beef food safety concerns have been met with divergent behavior by consumers in different countries making this evaluation across countries valuable for several reasons. Important public policy and beef supply chain management strategies can be gleaned from understanding the effects risk aversion and risk perceptions have on beef consumption. Furthermore, improved knowledge of how beef food safety risk aversion and perceptions differ across countries, and across consumers, can help formulate food safety policies and supply chain management strategies.

Results reveal that Japanese are more risk averse toward beef food safety than U.S. and Canadian consumers. Also, Japanese and Mexican consumers perceive greater beef food safety hazards than do U.S. and Canadian consumers. Food safety perceptions and attitudes, and interaction between the two, contribute to reductions in beef consumption by at least some consumers in each of the four countries, with impacts most pronounced in Japan and Mexico. Furthermore, in the United States, Canada, and Japan, risk perceptions contribute more to beef consumption declines than do risk attitudes, whereas in Mexico the two have roughly equal impact. From policy and industry management perspectives, a beef food safety event in the United States and Canada can be dealt with by quickly containing the hazard and informing consumers about the low probability of adverse health effects associated with consuming the product. For Japanese

consumers, a beef food safety concern will require more comprehensive assurance that steps have been taken to eliminate a potential hazard.

The next section of this article provides a foundation for our work by summarizing past literature regarding food safety perceptions and attitudes. Then, we present a conceptual model illustrating how food safety perceptions and attitudes would be expected to affect consumer utility. Research methods and a summary of survey responses are provided next, followed by results of the empirical model demonstrating how risk attitudes and perceptions affect beef consumption. The final section presents conclusion and implications.

2. Previous Literature

A large body of literature demonstrates differences in risk perceptions and attitudes across countries and cultures. For example, the Chinese are less risk averse about financial decisions than Americans, with Polish and Germans in between these two (Weber and Hsee, 1998). The authors hypothesize that risk aversion differences are related to differing levels of collectivism in the four countries, suggesting cultural differences contribute to risk aversion variation. Weber et al. (1998) conclude that Chinese proverbs endorse more risk taking than American proverbs, reflecting risk taking differences between these cultures. Bontempo et al. (1997) determine that Asians (Hong Kong and Taiwan) perceive greater risk than American and Dutch respondents to lotteries having a small probability of large losses. If this translates to food safety perceptions, Asians might perceive greater food safety risk for a food safety hazard that has very small prevalence but potentially serious health consequences than would Americans. This is a particularly relevant for our study, which involves perceptions about beef food safety risk and how differing perceptions affect consumption by consumers in different countries.

A sizable literature base investigates consumer perceptions about food safety and related impacts. In surveys of United Kingdom residents, Sparks and Shepherd (1994) determine that, among a variety of food-related hazards including residues, environmental contaminants, food ingredients and preservatives, and others, microbiological contaminants are viewed as the most serious. Consumers perceive greater safety hazards exist for food product attributes about which they know less (e.g., new production technology) or about which they have no choice regarding exposure (Caswell and Joseph, 2006; Zepeda et al., 2003). Furthermore, food safety risk perceptions and attitudes are related to socioeconomic characteristics of consumers, trust in various sources of information, knowledge, previous family history of food safety events, and culture (Dosman et al., 2001; Lobb et al., 2006, 2007; Zepeda et al.).

Past research provides a foundation and launching point for our study. Differences in risk perceptions and attitudes are present among consumers in different countries. These differences lead to disparate actions in response to a food safety hazard.

3. Risk Attitudes and Perceptions: A Conceptual Model

Building on the work of Pennings et al. (2002) and Lusk and Coble (2005), we investigate how consumers vary in their attitudes about beef food safety risk, how they perceive beef food safety risk, and how attitudes and perceptions influence consumer reactions to food safety events. Assume an individual's von Neumann-Morgenstern utility depends upon wealth $U(W)$. Individuals determine whether to consume a food product based on the anticipated gain in utility from consuming the product. Utility associated with consuming a food product is uncertain because safety of food is not known with certainty. Thus, the consumer considers consuming the food product to entail some small, but uncertain, level of food safety risk. Consider the outcome from purchasing and consuming a food product as a random variable x with variance σ^2. Pratt's (1964) risk premium (π) that would leave a consumer indifferent between consuming and not consuming the risky food product can be derived from:

$$(1) \qquad E[U(W+x)] = U(W + E[x] - \pi)$$

The risk premium can be solved for by using Taylor series expansion around W to derive Pratt's approximation

$$(2) \qquad \pi = -\left(\frac{\sigma^2}{2}\right)\left[\frac{U''(W)}{U'(W)}\right]$$

where $\frac{-U''(W)}{U'(W)}$ is the Pratt-Arrow measure of absolute risk aversion which increases with increasing risk aversion. Equation (2) illustrates that the risk premium associated with consuming a food product with uncertain food safety risk is an increasing function of both risk aversion ($\frac{-U''(W)}{U'(W)}$, i.e., attitude) as well as the level of food safety risk present (i.e., risk perception, σ^2).

The behavioral outcome space, which contains all possible behaviors of consumers, is driven by consumer risk attitudes and risk perceptions. This conceptualization is often used to describe and explain behavior (Pennings and

Grossman, 2008). The risk content is often well understood (e.g., price fluctuations), and the likelihood of exposure to that risk content can be formulated as concrete probabilities. Commodity prices, for example, follow a random walk, as prices can go up or down with equal probability (Cargill and Rausser, 1975). However, food safety risk is not known with certainty nor is it easily estimable, especially during crises. Consumers form risk attitudes and perceptions in the midst of food safety concerns without complete information. If a food safety hazard arises, the risk can become sensationalized and spread throughout society (Grunert, 2002; Lobb, 2004). This increases the chances of what might be considered severe individual reactions, such as unwillingness to buy the product, or as collective behavior, such as banning sales of the product.

Equation (2) provides three testable hypotheses regarding risky food choices: 1) more risk-averse individuals will be less likely to consume a food product having a perceived risk, 2) individuals who perceive a product as having greater levels of food safety risk will be less likely to consume the product, and 3) the interaction between risk attitude and risk perception will affect consumption of a product having perceived food safety risk. We use this framework to assess how risk aversion and risk perception affect how consumers react to changes over time in beef food safety information. In particular, we test whether consumers from four different countries have altered their beef consumption habits because of risk aversion and risk perception stemming from beef food safety concerns.

4. Research Method

Data Collection

To collect information about consumer perceptions and attitudes regarding beef food safety, we conducted an online computer survey of consumers from households in Canada, the United States, and Japan. The same survey was conducted via in-person interviews in Mexico. Mexican surveys were completed in-person because of limited computer access among the general population in Mexico. The survey instrument is designed to gain an understanding of consumer perceptions and attitudes about beef food safety. In addition, socio-demographic information about each respondent and how their beef consumption habits have changed in recent years in response to food safety concerns were also collected.

The surveys were conducted through a subcontract with TNS NFO, a global market research company. TNS NFO has a vast, worldwide consumer panel with more than five million individuals in their data bank. For our surveys, TNS NFO targeted one adult per household who was familiar with the household's shopping habits. Target respondents were older than 18 years of age and came from a representative distribution of household income levels.

A total of 4,005 respondents completed the survey across all four countries. Summary data of selected demographic attributes of survey respondents are provided in Table 1. In Canada and Japan, male and female respondents are about equal, whereas in the United States and Mexico, females represent about 80% of respondents. Most respondents are 35 to 64 years of age in Canada, the U.S., and Japan, with the average age ranging from 42 to 49 years. The Mexican survey responses are more heavily skewed toward a younger population, with 67% of respondents being less than 35 years old and having an average age of 31. Though respondents in Mexico are younger than those from the other countries, this is consistent with Census data on age distributions across these four countries. Roughly one-quarter of the adult population is less than 35 years old in Canada, the United States, and Japan. In contrast, 43% of the adult population in Mexico is less than 35 years of age (U.S. Census Bureau, 2006).

Table 1. Summary Statistics of Selected Demographics of Respondents

	Respondent Country			
Biographical Data	Canada	U.S.	Japan	Mexico
Total Respondents	1002	1009	1001	993
Gender				
Male	48%	17%	51%	20%
Female	52%	83%	49%	80%
Age				
Under 25 years	3%	2%	9%	38%
25-34	15%	13%	20%	29%
35-44	22%	20%	25%	18%
45-54	23%	28%	30%	10%
55-64	27%	21%	16%	4%
Over 64	10%	16%	0%	2%
Average age (years)	47.7	48.9	41.8	31.1
Education Level				
Less than High School Graduate	2%	2%	3%	17%
High School Graduate	30%	19%	33%	17%
Some College or Technical	40%	39%	25%	18%
College Bachelor's Graduate	17%	25%	34%	26%
Post-College Graduate	7%	14%	3%	8%
No Response	3%	0%	3%	0%
Household Income Category[a]				
I lower	10%	18%	33%	36%
II lower-middle	23%	18%	21%	39%
III middle	26%	15%	21%	14%
IV middle-upper	19%	22%	12%	11%
V upper	22%	27%	13%	0%

[a]Canada, I is less than $15,000; II $15,000-$34,999; III $35,000-$59,999; IV $60,000-$79,999; V $80,000+ ($CN); the U.S., I is less than $22,500; II $22,500-$39,999; III $40,000-$59,999; IV $60,000-$89,999; V $90,000+ ($U.S.); Japan, I is less than 2,000,000; II 2,000,000-3,999,999; III 4,000,000-5,999,999, IV 6,000,000-7,999,999; V 8,000,000+ (Japanese Yen); Mexico, I is 4,000-6,000; II is 7,000-21,000; III 22,000-54,000; and IV is 55,000+ (Mexican pesos)

Respondent education levels (table 1) vary from less than high school to post-bachelor's graduate level. The majority of respondents in each country have at least some college education. Mexican respondents tend to have lower education levels than respondents from the other three countries, which is consistent with their younger age distribution. Income levels of respondents also vary, ranging from less than $22,500 annually to more than $90,000 annually.

Measuring Risk Attitudes and Risk Perceptions

An empirical challenge might arise when testing hypotheses provided by equation (2) because risk attitudes and risk perceptions are latent (unobservable) variables. To develop risk attitude and risk perception constructs in a reliable and valid manner, we adhered to the iterative procedure recommended by Churchill (1979) and Pennings and Smidts (2000). First, a set of questions based on the literature was generated for use in our surveys. Confirmatory factor analysis was then used with the resulting consumer responses to assess the psychometric quality of our constructs (Hair et al., 1995; Pennings and Garcia, 2001).

The analytical model underlying factor analysis assumes the observed indicators are generated by a smaller number of latent variables called factors. The *relationship* between the indicators and the latent variables can be represented by the following matrix equation:

$$(3) \qquad x = \Lambda\, \kappa + \delta$$

where x is the $q\times 1$ vector of the n sets of observed variables, κ is the $n\times 1$ vector of underlying factors, Λ is the $q\times n$ matrix of regression coefficients (e.g., factor loadings) relating the indicators to the underlying factors, and δ is the $q\times 1$ vector of error terms of the indicators. Equation (3) describes the relationship between the indicators and the latent constructs. Λ is estimated using a covariance structure modeling approach (e.g., Bollen, 1989). In this approached it is assumed that $E(\kappa) = E(\delta) = 0$, $E(\kappa\kappa') = \Phi$, and $E(\delta\delta') = \Psi$, a diagonal matrix. From these assumptions the co-variance matrix $\sum_{xx}$ of x can be written in terms of factor loadings, factor co-variances and the unique variances as:

$$(4) \qquad \sum_{xx} = \Lambda\Phi\Lambda' + \Psi$$

The idea of this modeling procedure is that all factors are to account for all correlations between the observed variables. Equation (4) is estimated utilizing the maximum likelihood framework (for a detailed description see Dillon and Goldstein, 1984). The overall fit of the confirmatory factor model provides the

necessary information to determine whether a set of indicators accurately describes risk attitude and risk perception.

All factor loadings (i.e., regression coefficients contained in Λ) were significant ($p < 0.001$) and greater than 0.4 for all risk attitude and risk perception factor models in each country.[1] These findings support the convergent validity of the indicators (Anderson and Gerbing, 1988). The composite reliabilities for the constructs ranged from 0.56 to 0.92, indicating good reliabilities for the construct measurements. Stated differently, this procedure collectively helps confirm that the observable indicators, or individual questions, load onto the latent constructs (i.e., risk attitude and risk perception indices) in a manner consistent with our specification. Furthermore, this procedure helps ensure that the empirical results are not driven by measurement error. The average sum score of the indicators are used in subsequent analyses to measure risk attitude and risk perception.

5. Consumer Food Safety Knowledge and Information Sources

Developing effective supply chain management strategies that deal with food safety requires understanding what consumers perceive about beef food safety. Therefore, we asked a set of questions to ascertain consumers' level of understanding of the presence and probable impacts of potential beef food safety concerns. Table 2 summarizes responses to questions regarding the level of risk consumers perceive is associated with beef product food safety concerns for *E. coli O157:H7*, BSE, *Salmonella*, *Listeria*, *Staphylococcus aureus*, and *Campylobacter*. Canadian and American respondents generally believe beef products are safe, though they perceive *E. coli O157:H7 h*as the highest risk with about 50% of respondents indicating *moderate risk* or greater. About 60% of respondents in Canada and the U.S. rated BSE as *low* or *very low risk*. Japanese respondents also generally perceived low risk levels, except for BSE, which more than 50% of respondents rated *high* or *very high risk*. Overall, Mexican respondents have greater concerns about beef food safety than consumers in the other three countries. The high risk perceptions of Mexican respondents for food safety hazards that have low incidence rates suggests Mexican consumers have a markedly higher concern about food safety than consumers in the three other countries. Why Mexican consumers revealed greater beef food safety concerns is unknown, but perhaps they experience more food safety-related illnesses than consumers in the other countries. In addition, food safety concerns could be influenced by external factors such as media and governmental announcements.

The lack of knowledge among consumers about some beef food safety concerns is noticeable. In particular, the most common response in Canada, the

[1] The full factor analyses can be obtained from the authors.

United States, and Japan is that consumers *don't know* the risk levels associated with *Listeria, Campylobacter, and Staphylococcus aureus* (table 2). This could be because the incidence level of these foodborne pathogens is low, and such pathogens generally receive little media attention, so consumers are simply unfamiliar with these pathogens.

In addition to levels of concern about beef food safety, we inquired what respondents would expect the likely impact on their health to be if they consumed a beef product having a specific food safety hazard. Table 3 summarizes respondent expectations about the probable impact of a food safety occurrence for selected potential hazards. Most respondents, generally 70% or more in each country, felt *E. coli O157:H7* and BSE would cause *major* or *serious illness.* A somewhat smaller, but still large, group (50% or more) felt the same way about *Salmonella*. Consistent with perceptions about risk levels of these food safety issues, respondents in Canada, the United States, and Japan generally did not know the likely impact of illness associated with *Listeria, Campylobacter*, or *Staphylococcus aureus*. Mexican consumers revealed that they have a higher level of concern about food safety issues in general. They believed the likelihood of serious illness requiring hospital care for all of the specified food safety issues was substantially higher than did consumers in the other three countries.

6. Beef Food Safety Concerns and Reactions

Respondent Risk Attitudes and Perceptions

Because some respondents raised concerns about beef food safety and recent global beef food safety issues, such as heavily publicized BSE events, we wanted to determine to what extent beef consumption habits might have changed because of food safety concerns. Table 4 summarizes respondents' changes in beef consumption in response to changing food safety concerns. In Canada and the United States, about 20% of consumers indicated they have reduced beef consumption because of food safety concerns in the past four years. This is in sharp contrast to Japan and Mexico, where 55% and 31% of respondents, respectively, indicated they have reduced beef consumption because of food safety concerns.[2] Among consumers who reduced their beef consumption, the typical reduction was substantial, ranging from 20% to 60%. Roughly one-quarter of Canadian, U.S., and Japanese respondents who reduced their consumption virtually eliminated beef from their diet with an 80% or more reduction. This

[2] Some survey respondents could have increased beef consumption in response to the consumer having reduced beef food safety concerns. We did not ask respondents about this possibility and as such we may have censored the sample. Our primary concern in this study was whether food safety concerns had contributed to reduced beef consumption.

demonstrates that the beef industry has lost an important segment of its customer base because of food safety concerns.

Table 2. Respondents' Perceptions of Various Beef Food Safety Risks

		Respondent Country			
Food Safety Risk Perception		Canada	U.S.	Japan	Mexico
E. coli O157:H7					
	Very High Risk	5.8%	5.9%	7.2%	35.7%
	High Risk	11.3%	12.8%	13.0%	23.5%
	Moderate Risk	29.9%	33.2%	23.5%	20.0%
	Low Risk	27.4%	25.8%	26.2%	4.3%
	Very Low Risk	17.0%	12.9%	13.3%	3.4%
	Don't Know	8.7%	9.4%	16.8%	13.1%
BSE ("Mad Cow") related diseases					
	Very High Risk	5.0%	4.0%	28.1%	38.8%
	High Risk	5.0%	8.1%	24.9%	26.1%
	Moderate Risk	17.6%	18.3%	18.6%	16.9%
	Low Risk	25.3%	24.1%	12.4%	7.7%
	Very Low Risk	41.0%	36.2%	8.2%	5.4%
	Don't Know	6.2%	9.3%	7.9%	5.1%
Salmonella					
	Very High Risk	2.5%	4.2%	5.4%	35.3%
	High Risk	7.2%	7.8%	12.4%	24.5%
	Moderate Risk	23.1%	25.2%	20.8%	19.1%
	Low Risk	27.3%	29.0%	27.4%	7.1%
	Very Low Risk	28.8%	21.5%	12.9%	4.2%
	Don't Know	11.2%	12.3%	21.2%	9.9%
Listeria					
	Very High Risk	1.2%	2.6%	3.7%	28.7%
	High Risk	2.5%	5.6%	7.7%	22.2%
	Moderate Risk	13.3%	16.6%	14.4%	19.1%
	Low Risk	18.4%	22.4%	20.1%	7.7%
	Very Low Risk	15.4%	16.0%	8.9%	4.3%
	Don't Know	49.3%	36.9%	45.3%	18.0%
Campylobacter					
	Very High Risk	1.1%	2.2%	3.7%	27.3%
	High Risk	2.4%	4.6%	7.1%	20.4%
	Moderate Risk	11.8%	13.2%	15.3%	17.8%
	Low Risk	17.0%	19.7%	20.5%	7.2%
	Very Low Risk	15.3%	13.5%	9.2%	4.4%
	Don't Know	52.5%	46.9%	44.3%	22.9%
Staphylococcus aureus					
	Very High Risk	1.7%	2.7%	5.4%	31.0%
	High Risk	3.5%	5.6%	9.1%	19.8%
	Moderate Risk	14.4%	16.3%	18.4%	18.2%
	Low Risk	18.2%	21.1%	23.7%	6.3%
	Very Low Risk	17.8%	15.6%	13.0%	4.4%
	Don't Know	44.5%	38.9%	30.5%	20.1%

Table 3. Respondents' Expected Health Impact from Consuming Beef with Various Beef Food Safety Hazards

	Respondent Country			
Food Safety Hazard	Canada	U.S.	Japan	Mexico
E. coli O157:H7				
Serious Illness (requires hospital care)	40.9%	38.5%	30.0%	40.3%
Major Illness (requires physician care)	31.1%	29.1%	40.8%	26.4%
Moderate Illness (vomit, no physician care)	14.9%	20.7%	13.0%	13.3%
Minor Illness (stomach ache, no physician care)	4.2%	2.9%	5.2%	3.5%
No adverse impact on health	1.0%	0.2%	1.8%	1.4%
Don't Know	7.9%	8.6%	9.3%	15.1%
BSE ("Mad Cow") related diseases				
Serious Illness (requires hospital care)	61.8%	68.7%	61.6%	52.5%
Major Illness (requires physician care)	18.9%	17.3%	17.7%	24.8%
Moderate Illness (vomit, no physician care)	4.0%	2.5%	3.2%	9.4%
Minor Illness (stomach ache, no physician care)	1.5%	0.9%	0.9%	3.9%
No adverse impact on health	2.1%	0.7%	3.6%	1.7%
Don't Know	11.8%	9.9%	13.0%	7.8%
Salmonella				
Serious Illness (requires hospital care)	18.0%	16.5%	15.7%	37.6%
Major Illness (requires physician care)	35.3%	38.6%	44.3%	30.4%
Moderate Illness (vomit, no physician care)	29.8%	30.8%	20.1%	14.2%
Minor Illness (stomach ache, no physician care)	4.8%	4.8%	5.6%	5.1%
No adverse impact on health	0.9%	0.6%	1.5%	1.3%
Don't Know	11.2%	8.8%	12.9%	11.4%
Listeria				
Serious Illness (requires hospital care)	7.1%	10.0%	6.7%	29.4%
Major Illness (requires physician care)	16.5%	23.9%	24.6%	28.7%
Moderate Illness (vomit, no physician care)	10.3%	14.4%	15.4%	12.9%
Minor Illness (stomach ache, no physician care)	3.4%	2.9%	4.9%	6.8%
No adverse impact on health	1.0%	0.2%	1.6%	1.8%
Don't Know	61.8%	48.7%	46.9%	20.4%
Campylobacter				
Serious Illness (requires hospital care)	6.7%	8.6%	7.0%	27.9%
Major Illness (requires physician care)	14.7%	18.1%	25.9%	25.3%
Moderate Illness (vomit, no physician care)	10.5%	12.0%	15.9%	11.6%
Minor Illness (stomach ache, no physician care)	3.7%	2.6%	5.2%	6.0%
No adverse impact on health	1.0%	0.5%	1.7%	2.7%
Don't Know	63.5%	58.2%	44.4%	26.5%
Staphylococcus aureus				
Serious Illness (requires hospital care)	12.3%	14.1%	12.8%	30.8%
Major Illness (requires physician care)	20.4%	25.6%	35.7%	24.4%
Moderate Illness (vomit, no physician care)	10.1%	14.1%	19.8%	12.2%
Minor Illness (stomach ache, no physician care)	4.6%	2.9%	4.9%	5.9%
No adverse impact on health	1.1%	0.7%	2.2%	2.5%
Don't Know	51.6%	42.7%	24.7%	24.2%

Table 4. Respondents' Beef Consumption Changes Related to Food Safety Concerns

		Respondent Country			
Beef Consumption Habit		Canada	U.S.	Japan	Mexico
Have lowered Beef Consumption Relative to Four Years Ago Because of Food Safety Concerns	Yes	19.6%	20.6%	55.0%	31.2%
	No	80.4%	79.4%	45.1%	68.8%
Approximate % of Beef Consumption Reduction (of those that responded "yes" to above)	Less than 20%	7.7%	10.1%	6.0%	11.6%
	20% - 39%	24.0%	26.9%	25.1%	30.7%
	40% - 59%	27.0%	22.6%	31.1%	28.7%
	60% - 79%	16.8%	18.3%	14.7%	13.2%
	80% or more	24.5%	22.1%	23.1%	15.8%

Given differences in beef consumption changes across countries in recent years, we sought to ascertain beef food safety risk perceptions and attitudes of consumers in Canada, the United States, Japan, and Mexico. This was accomplished by asking consumers a series of questions to build a set of risk attitude and risk perception scales using the confirmatory factor model outlined earlier. Summary responses to individual questions used to construct a risk attitude scale are reported in table 5.

Canadian and U.S. consumers indicate, on average, they feel eating beef is worth the food safety risk as only about 25-30% disagree that eating beef is worth the risk.[3] In contrast, a larger percentage of Japanese consumers hold stronger risk attitudes that eating beef is not worth the risk as 63% disagree that eating beef is worth the risk. Mexican respondents, on average, hold risk attitudes about beef food safety similar to those of U.S. and Canadian consumers.

Summary statistics of individual questions asked to ascertain risk perceptions are provided in table 5.[4] Some consumers in each of the four countries surveyed perceive eating beef to be risky, and some consumers in each country consider eating beef not to be risky at all. However, stark differences appear in beef food safety risk perceptions by country. For example, on a scale of 1 (strongly disagree) to 10 (strongly agree) that eating beef is risky, 75% of Canadian consumers respond with a score of 4 or lower, indicating they disagree

[3] Response of 7 or higher on a 10-point scale with 1=Strongly Agree to 10=Strongly Disagree.

[4] We use scales of 1 to 10 for measuring risk perceptions and attitudes primarily because of familiarity or comfort level most people in the general population have rating items on a 1 to 10 scale. A reviewer notes that a scale that has a neutral mid-point might be preferable.

strongly that eating beef is risky, and they have an average score of less than 4 for each of the three questions. In contrast, only 42% of Japanese and 27% of Mexican respondents provide a ranking of 4 or lower for this question, and they have an average score of 5 or greater for five out of the six risk perception questions. Consumers in Canada and the United States tend to have much more positive perceptions about beef food safety than Japanese and Mexican consumers.

Table 5. Means and Standard Deviations of Risk Attitude and Perception Individual Questions[a]

	Respondent Country			
	Canada	U.S.	Japan	Mexico
Risk Attitude Statements				
My willingness to accept food safety risk when eating beef, I am	4.47[b]	4.45[b]	5.70[c]	5.64[c]
(1= Very Willing, …, 10 = Not at all Willing)	(2.79)	(2.62)	(2.06)	(2.37)
I rarely think about food safety when eating beef.	5.05[b]	4.98[b]	6.75[c]	4.30[d]
(1= Strongly Agree, …, 10 = Strongly Disagree)	(3.08)	(2.98)	(2.32)	(2.58)
For me, eating beef is worth the risk.	5.29[b]	5.00[c]	7.34[d]	5.06[bc]
(1= Strongly Agree, …, 10 = Strongly Disagree)	(2.92)	(2.75)	(2.23)	(2.86)
Risk Perception Statements				
I consider eating beef	3.38[b]	3.68[b]	5.38[c]	5.45[c]
(1= Not at all Risky, …, 10 = Highly Risky)	(2.31)	(2.35)	(2.07)	(2.25)
When eating beef I am exposed to	3.31[b]	3.64[c]	5.27[d]	5.07[e]
(1= No Risk at all, …, 10 = Very High Risk)	(2.14)	(2.22)	(2.11)	(2.18)
Eating beef is risky	3.34[b]	3.72[c]	4.90[d]	6.38[e]
(1= Strongly Disagree, …, 10 = Strongly Agree)	(2.31)	(2.40)	(2.20)	(2.87)

[a] Standard deviations are reported in parentheses

[b, c, d, e] Means sharing the same superscript are not statistically different from each other at the 0.05 significance level.

Note. To examine the measurement quality of the risk attitude and risk perception scales confirmatory factor analysis has been performed (Pennings and Garcia). The construct reliabilities for risk attitudes are 0.72 for the U.S., 0.65 for Mexico, 0.56 for Japan and 0.69 for Canada. The reliabilities for risk perceptions are 0.93 for the United States, 0.80 for Mexico, 0.92 for Japan and 0.93 for Canada.

The set of risk perception and attitude questions were each averaged to form a scale for risk perception and a separate scale for risk attitude (following Pennings et al., 2002). Table 6 presents summary distributions of corresponding risk attitude and risk perception scales calculated as averages of responses to the

sets of questions. Figures 1 and 2 present cumulative distributions of risk attitude and perception scales by country. Pair-wise Chi-square tests reject ($p < 0.001$) the hypotheses of equality in risk attitude and risk perception distributions within each country as well as equality in each index distribution across the four countries. Larger risk attitude/risk perception scale values reflect higher levels of overall beef food safety risk aversion/perception. Japanese consumers have notably stronger risk aversion attitudes towards beef food safety than Canadian, U.S., or Mexican consumers. Japanese consumers have an average risk aversion score of 6.6 on a 1 to 10 scale compared with scores of 4.8 to 5.0 for Canadian, U.S., and Mexican consumers. Food safety risk perceptions also differ across countries. Japanese and Mexican consumers perceive beef to have higher food safety risk with average risk perception scores of 5.2 and 5.6, respectively. In contrast, Canadian and U.S. consumers have average risk perception scores of 3.3 and 3.7, respectively.

7. Impacts of Risk Attitudes and Perceptions on Consumption Behavior

To determine whether differences in risk attitudes and perceptions are related to stated changes in beef consumption by consumers in each of the four countries, we estimate a two-stage model. In particular, we employ a variation of Cragg's (1971) double-hurdle model allowing us to account for separate, but interdependent, decision making while avoiding bias that might be involved if the two decisions are naively assumed independent. To observe a reduction in beef consumption, two hurdles must be passed. The two equations estimated are:

$$D_i = X_i'\beta + \varepsilon_i \quad (5)$$

$$Q_i^* = Z_i'\theta + \upsilon_i \quad (6)$$

where

$$Q_i = 0 \quad iff \quad Q_i^* \le 0 \quad (7)$$

$$Q_i = Q_i^* \quad iff \quad Q_i^* > 0 \quad (8)$$

In the first equation (5), we model determinants of whether consumers lowered their consumption of beef over the last four years (table 4). Given the binary nature of this decision, a Probit model is utilized for this stage. Here $D_i = 1$ if consumer i reduced beef consumption over the last four years and $D_i = 0$

otherwise. Furthermore, X_i is a vector of explanatory variables, β is a coefficient vector to be estimated, and ε is a random error $\varepsilon \sim N(0, \sigma_D^2)$.

Figure 1. Beef Food Safety Risk Attitude Cumulative Frequency Distributions

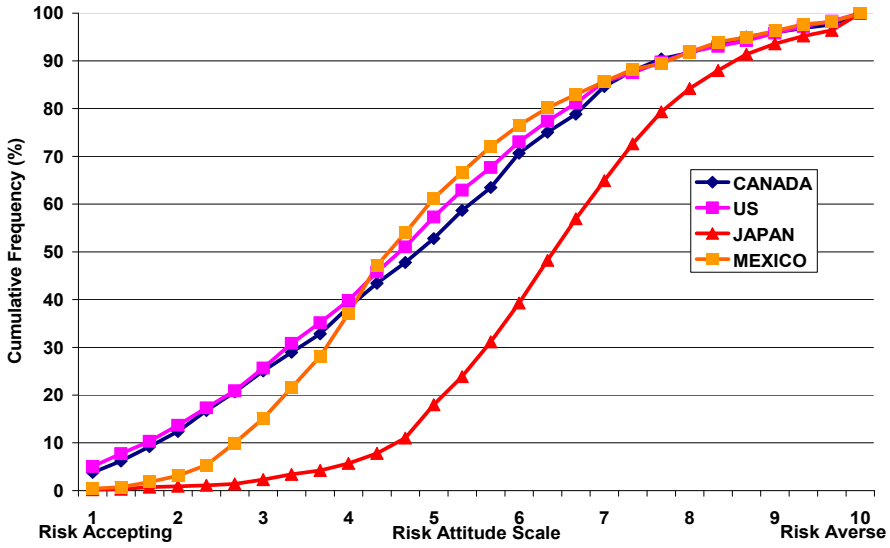

Figure 2. Beef Food Safety Risk Perception Cumulative Frequency Distributions

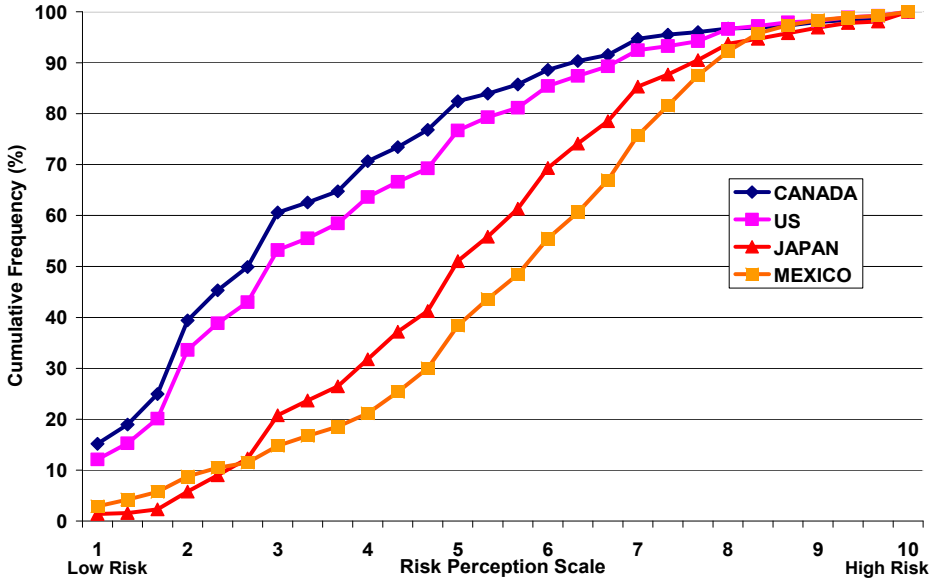

Table 6. Risk Attitude and Risk Perception Scale Distributions

	Respondent Country			
Risk Attribute	Canada	U.S.	Japan	Mexico
Risk Attitude				
Under 2.5 (Low Risk Aversion)	16.8%	17.3%	1.1%	5.3%
2.51 – 5.0	36.0%	39.9%	16.9%	55.9%
5.01 – 7.5	35.1%	30.2%	54.7%	27.0%
Over 7.50 (High Risk Aversion)	12.1%	12.5%	27.4%	11.8%
Average Risk Attitude Scale Value	4.9	4.8	6.6	5.0
Risk Perception				
Under 2.5 (Perceive Beef as Safe)	45.3%	38.9%	9.0%	10.5%
2.51 - 5.0	37.1%	37.9%	42.1%	27.9%
5.01 - 7.5	13.1%	16.6%	36.7%	43.2%
Over 7.50 (Perceive Beef as Unsafe)	4.5%	6.7%	12.3%	18.4%
Average Risk Perception Scale Value	3.3	3.7	5.2	5.6

The second equation (6) of the model estimates determinants of the percentage reduction in beef consumption for those survey respondents who indicated they had reduced consumption in the first stage (i.e., $D_i = 1$). Here, Q_i^* is a latent, unobserved variable representing optimal beef consumption reduction, Z_i is a vector of explanatory variables, θ is a coefficient vector to be estimated, and υ is a random error term $\upsilon \sim N(0, \sigma_Q^2)$. As shown in equations (7)-(8), we actually observe Q_i in a censored fashion. That is, Q_i is censored at 0 as only positive levels of reduction are observed by a subset of the consumers in our data.

Given that each of the two equations in the model have normally distributed errors, when jointly estimated, the model has a bivariate normal error covariance (e.g., $COV(\varepsilon, \upsilon) = \rho$). The independent variables (X_i and Z_i) used as explanatory factors include demographic variables of age, income, and education level (table 1). However, of central interest are risk attitude and risk perception scales. To determine whether differences in risk attitudes and perceptions are related to stated changes in beef consumption by consumers in each of the four countries, and to allow for nonlinear interactions, we incorporated risk attitudes and perceptions by interacting each index with country dummy variables as well as with each other. The resulting model is estimated using

maximum likelihood with a Probit model in the first stage and Tobit model in the second stage.

Marginal effects of each independent variable are frequently evaluated and convey more useful information than simple coefficient estimates. The first set of effects examined relate to the binary participation decision. Marginal effects derivations for Probit models are well documented:

$$(9) \qquad \frac{\partial E[D]}{\partial X_k} = \phi(X_k'\beta)\frac{\partial X_k'\beta}{\partial X_k}$$

Where $E[\cdot]$ denotes the expectations operator and $\phi(\cdot)$ is the standard normal density (Greene, 2003, p. 668).

As suggested by McDonald and Moffitt (1980), when estimating Tobit models we can decompose total or unconditional effects of an explanatory variable on the dependent variable in terms of the effects on the probability of participation and the conditional level of the dependent variable. This is useful in our assessing if, and how, differences in risk attitudes or risk perceptions influence beef consumption. In particular, this decomposition enables us to determine the impact of greater risk attitudes or perceptions on the probability that a consumer has recently reduced beef consumption *relative* to the impact on conditional levels of reduction.[5]

As implied by equation (9), the probability of observing a decline in beef consumption by an individual consumer is:

$$(10) \qquad \text{Prob}(Q_i > 0) = F(X_i'\beta)$$

Where $F(\cdot)$ is the cumulative normal distribution. Greene (p. 782) provides an expression for the conditional mean, which measures the average consumption reduction, given that a reduction is observed:

$$(11) \qquad E[Q_i \mid D_i = 1] = Z'\theta + \rho\sigma_Q\lambda_i$$

where $\lambda_i = \phi(Z_i\theta)/F(Z_i\theta)$. The unconditional mean of Q_i, which measures the overall average consumption reduction, is therefore:

$$(12) \qquad E[Q_i] = E[Q_i \mid D_i = 1] \times \text{Prob}(Q_i > 0)$$

[5] Newman, Henchion, and Matthews (2003) or Yen and Huang (1996) provide additional discussion of this decomposition.

While marginal effects are frequently presented, given the context of this multi-national research, elasticity estimates may be more informative and useful. We identify participation (e_k^P) elasticities by calculating the following expression for each individual:

$$(13) \qquad e_k^P = \left(\phi(X_k'\beta) \frac{\partial X_k'\beta}{\partial X_k} \right) \times \frac{X_k}{F(X_k'\beta)}$$

Utilizing and expanding on derivations provided in Greene (p. 783), conditional level (e_k^C) and unconditional level (e_k^U) elasticities are also identified using the following:

$$e_k^C = \frac{\partial E[Q_i \mid D_i = 1]}{\partial X_k} \times \frac{X_k}{E[Q_i \mid D_i = 1]} = \left(\frac{\partial Z'\theta}{\partial X_k} - \frac{\partial X'\beta}{\partial X_k} \times \rho\sigma_Q \delta_i(\alpha) \right) \times \frac{X_k}{\left(Z'\theta + \rho\sigma_Q \lambda \right)}$$

$$e_k^U = \frac{\partial E[Q_i]}{\partial X_k} \times \frac{X_k}{E[Q_i]}$$

$$= \left[\left(\frac{\partial Z'\theta}{\partial X_k} - \frac{\partial X'\beta}{\partial X_k} \times \rho\sigma_Q \delta_i(\alpha) \right) \times F(X_i'\beta) + \phi(X_k'\beta) \times \frac{\partial X_k'\beta}{\partial X_k} \times E[Q_i \mid D_i = 1] \right] \times \frac{X_k}{E[Q_i]}$$

where $\delta_i(\alpha) = \lambda_i^2 - \alpha\lambda_i$ and $\alpha = -X'\beta$.[6]

Results of the maximum likelihood estimation of the Double-Hurdle model are presented in table 7. The estimated correlation coefficient was not significantly different from zero. This suggests that employing an independent hurdle model may have been sufficient. However, since unobserved factors that affect the probability consumers reduced beef consumption during the past four years may be correlated with the magnitude of reduction, we maintain the Double-Hurdle specification over alternative, single equation approaches.[7]

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[6] Note from equation (12):

$$\frac{\partial E[Q_i]}{\partial X_k} = \left(\frac{\partial E[Q_i \mid D_i = 1]}{\partial X_k} \times F(X_i'\beta) \right) + \left(\frac{\partial F(X_i'\beta)}{\partial X_k} \times E[Q_i \mid D_i = 1] \right).$$

[7] Log likelihood ratio specification tests not shown for brevity strongly reject using a Tobit model and omitting the first hurdle or participation decision (Blundell and Meghir, 1987; Jones, 1989).

Demographic factors statistically significant in modeling the participation decision (stage 1) include education and age ($p \leq 0.05$) while income and age are significant determinants of the quantity of reduction decision (stage 2). Comparing the estimated risk attitude and risk perception coefficients in the participation equation with those in the consumption reduction equation reveals interesting findings. First, interactions between risk attitudes and risk perceptions are statistically significant in all four country groups in the quantity reduction decision, but these interaction terms are only significant for Canadian consumers in the binary participation equation.

Results from table 7 can be more readily interpreted by calculating elasticities (table 8). For example, a 1% increase in consumer age increases the probability by 0.69% that a respondent reduced beef consumption in recent years, the conditional level of consumption declines by 0.25%, and the unconditional level declines by 0.95%. In a relative sense, this indicates that the elasticity of reduction probability (0.69) accounts for approximately 73% (0.69/0.95) of the total unconditional level of consumption reduction associated with respondent age. Similar calculations reveal that differences in consumer education also impact the unconditional level of beef consumption reduction, primarily through probability effects. In contrast, approximately 63% of the impact resulting from a 1% increase in income manifest through changes in conditional level reductions. Furthermore, consumers with higher incomes have lower probabilities of having reduced beef consumption and, if they have reduced consumption, also have lower levels of reduction in consumption. This suggests the effect of increasing consumer age and education is concentrated primarily on changes in the probability of reducing beef consumption (stage 1), while the effect of increasing consumer income occurs through adjustments in conditional level reduction (stage 2).

Returning attention to the impact of risk attitudes and risk perceptions reveals additional insights. The probability that consumers reduced beef consumption and conditional and unconditional levels of reductions are more strongly associated with risk perception than risk attitude for consumers in the United States, Canada, and Japan. Elasticities of unconditional quantity reductions with respect to risk perceptions are about twice as large, ranging from 0.27% to 0.45%, as corresponding risk attitude elasticities, ranging from 0.15% to 0.21%, for consumers in the United States, Canada, and Japan. Mexican consumers have similar risk attitude and risk perception elasticities.[8]

[8] Calculation of elasticities with respect to covariates entering the model through interaction terms involving risk attitudes and risk perceptions incorporates both the direct effect of the coefficient on the covariate of interest and interaction effects of the covariate's interaction with other covariates. For other examples of the technique we use, see Lazaridis (2004) and Newman et al.

Table 7. Maximum Likelihood Estimates: Double-Hurdle Model of Beef Consumption Decisions

	Participation Decision	*Consumption Reduction*
Intercept	-3.2328	12.9884
	(0.0000)	(0.6525)
Education	0.0528	0.0973
	(0.0119)	(0.8956)
Income	-0.0230	-1.5868
	(0.2015)	(0.0068)
Age	0.1298	2.1913
	(0.0000)	(0.0200)
U.S.×Risk Attitude	0.1023	-1.7657
	(0.0005)	(0.2310)
U.S.×Risk Perception	0.2793	0.3360
	(0.0000)	(0.8824)
U.S.×Risk Attitude×Risk Perception	-0.0018	0.8624
	(0.7947)	(0.0003)
Canada×Risk Attitude	0.1471	-0.5629
	(0.0000)	(0.7104)
Canada×Risk Perception	0.3599	2.5430
	(0.0000)	(0.3096)
Canada×Risk Attitude×Risk Perception	-0.0216	0.5074
	(0.0020)	(0.0462)
Japan×Risk Attitude	0.1611	-1.1057
	(0.0000)	(0.5168)
Japan×Risk Perception	0.3684	2.3608
	(0.0000)	(0.3540)
Japan×Risk Attitude×Risk Perception	-0.0062	0.5126
	(0.4613)	(0.0079)
Mexico×Risk Attitude	0.2169	0.2829
	(0.0000)	(0.8799)
Mexico×Risk Perception	0.1948	-0.6291
	(0.0000)	(0.7114)
Mexico×Risk Attitude×Risk Perception	0.0003	0.6559
	(0.9605)	(0.0009)
Sigma	---	24.3986
	---	(0.0000)
Rho	0.3599	---
	(0.2986)	---
Log Likelihood	-7,607.5820	

Note: Estimated *p*-values are presented in parentheses.

Risk attitudes and risk perceptions among consumers in each of the four countries influence the probability that they reduced beef consumption more than the conditional level of reduction. In particular, the elasticity of probability of reducing beef consumption with respect to risk attitudes accounts for 73% (Mexico) to 100% (Japan) of the total elasticity of unconditional quantity reduction. Likewise, the elasticity of probability with respect to risk perceptions accounts for 71% (Canada) to 93% (Japan) of the total elasticity of unconditional quantity reduction. Collectively, this implies that the effect of risk attitudes and risk perceptions on household beef consumption is concentrated primarily in changes in the probability of consumption reduction, as opposed to adjustments in conditional level reduction. This distinction is particularly important to the beef industry in making future resource allocation decisions. For instance, it may be more beneficial for the industry to take steps towards maintaining its current consumer base (e.g., reducing the probability of reduction by currently high consuming individuals), as opposed to attempting to re-establish consumption by consumers who have reduced consumption over the past four years (e.g., reducing the conditional level of consumption reduction).

Our findings that risk attitude and risk perception significantly affect consumption decisions are consistent with Pennings et al. (2002) as well as Lusk and Coble. Consistent with Lusk and Coble's conclusions, which were based on a sample of U.S. students, we found marginal impacts of risk perceptions to dominate similar changes in risk attitudes (referred to as risk preferences by Lusk and Coble) among a broad sample of U.S., Canadian, and Japanese consumers. Furthermore, our analysis using a new set of nationalities provides support for heterogeneous impacts across country-of-residence groups consistent with the work of Hofstede (1980, 1983), Weber and Hsee, and Pennings et al. (2002). Thus, beef food safety risk perceptions are larger drivers of beef consumption declines in recent years than are risk attitudes. Prior research has not evaluated the impacts of risk perceptions and attitudes on decisions regarding the quantity of beef consumed. Lobb et al. (2006) investigated how risk attitudes and perceptions affect European (U.K., Italy, Germany, Netherlands, and France) consumer purchases of poultry. Risk attitudes had a greater impact on purchase decisions than risk perceptions. However, the importance of risk perceptions increased substantially in the event of a salmonella scare.

Table 8. Elasticity Estimates: Double-Hurdle Model of Beef Consumption

Variable	Statistic	Participation Decision	Conditional Consumption Reduction	Unconditional Consumption Reduction
Education	*Mean*	0.2036	0.0009	0.2046
	Interval[a]	(0.032, 0.490)	(-0.098, 0.043)	(-0.045, 0.530)
Income	*Mean*	-0.0836	-0.1411	-0.2247
	Interval	(-0.243, -0.007)	(-0.476, -0.012)	(-0.714, -0.020)
Age	*Mean*	0.6946	0.2527	0.9473
	Interval	(0.123, 1.622)	(-0.190, 0.689)	(-0.053, 2.288)
U.S.×Risk Attitude	*Mean*	0.1657	0.0435	0.2091
	Interval	(0, 1.052)	(-0.073, 0.434)	(0, 1.234)
U.S.×Risk Perception	*Mean*	0.3229	0.1234	0.4462
	Interval	(0, 1.769)	(0, 0.783)	(0, 2.453)
Canada×Risk Attitude	*Mean*	0.1375	0.0384	0.1759
	Interval	(0, 1.123)	(0, 0.293)	(0, 1.242)
Canada×Risk Perception	*Mean*	0.2628	0.1053	0.3681
	Interval	(0, 1.564)	(0, 0.629)	(0, 2.101)
Japan×Risk Attitude	*Mean*	0.1549	-0.0024	0.1525
	Interval	(0, 1.161)	(-0.206, 0.128)	(0, 1.230)
Japan×Risk Perception	*Mean*	0.2552	0.0184	0.2736
	Interval	(0, 1.469)	(-0.723, 0.573)	(-0.090, 1.957)
Mexico×Risk Attitude	*Mean*	0.3078	0.1152	0.4230
	Interval	(0, 1.829)	(0, 0.593)	(0, 2.305)
Mexico×Risk Perception	*Mean*	0.3106	0.0820	0.3926
	Interval	(0, 1.803)	(0, 0.448)	(0, 2.182)

Note: Effects evaluated for each individual in data sample.

[a] The effects were sorted in ascending order to identify displayed 95% confidence intervals. Ninety-five percent of the evaluated sample is estimated to have effects estimates within these boundary points.

8. Conclusions and Implications

Food safety concerns have created havoc in global beef markets in recent years. Most noteworthy in North America was loss of major export markets following discovery of cattle in the United States and Canada infected with BSE in 2003. Results from this study reveal consumer reactions to beef food safety events are heavily influenced by consumer food safety risk attitudes and risk perceptions. Relative to consumers in the United States, Canada, and Mexico, consumers in Japan are more risk averse with respect to beef food safety. Furthermore, relative to U.S. and Canadian consumers, Japanese and Mexican consumers perceive beef to be less safe and consider eating beef to involve greater food safety risk. Results in this study reveal that beef consumption changes over time are directly related to consumer beef food safety risk perceptions and attitudes.

Determining the most effective public policy options and industry supply chain management strategies regarding food safety depends on the nature of consumer concerns. Four potential situations could present problems regarding consumer beef food safety concerns: 1) consumers are risk averse, 2) consumers perceive high levels of risk and these perceptions are accurate, 3) consumers perceive low levels of risk when in fact the risks are high, or 4) consumers perceive high levels of risk when in fact the risk are low. These different scenarios suggest differing policy and supply chain management strategies.

Risk-averse consumers require high levels of food safety assurance, especially if a food safety event occurs. For example, simply demonstrating low levels of BSE incidence in the cattle herd is not sufficient to regain Japanese consumer confidence in beef. Our results indicate Japanese consumers are more risk averse regarding beef food safety, and they hold stronger adverse perceptions about food safety levels than U.S. or Canadian consumers. A concerted industry effort to ensure beef is free of any food safety concern is essential if beef is to regain market share because Japanese consumers have a very low tolerance for even a very small probability that beef contributes to food safety problems. Information reassuring consumers is going to have to be combined with a stringent, auditable set of changes in industry and government inspection standards to avoid huge sustained losses in consumer demand. In contrast, U.S. and Canadian consumers are generally less risk averse, meaning they will be satisfied by knowing the food safety risk is very low even in light of a BSE discovery. North American policy makers need to assure consumers they have assessed the level of food safety risk present and inform consumers of the low probability of a hazard.

The level of food safety risk consumers perceive to be present, relative to what is actually present, is critically important for economic as well as moral accountability. When food safety risks are high, regardless of whether consumers

perceive the risks to be high or low, the public policy strategy is to do what is necessary to reduce the risk. This may include significant regulation of industry as well as production and processing auditing and testing to reduce the level of risk present. Alternatively, if consumers perceive high levels of risk, regardless of the actual level of risk, our results indicate consumers will reduce product demand. If consumers inaccurately perceive high levels of risk, this indicates a need for policy makers and industry to demonstrate low levels of risk to reassure consumers the product is safe. Our future research aims to determine how to effectively reassure consumers of product safety when consumers perceive a product is less safe than it actually is.

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