The Role of Consumer Risk Perceptions and Attitudes in Cross Cultural Beef Consumption Changes

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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. Better understanding of the forces causing observed consumer reactions in light of beef food safety events is critical for policy makers and industry participants. 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. We use data from a total of 4,000 consumers in the U.S., Canada, Mexico and Japan to estimate a two-stage Probit/double-bounded Tobit modeling framework. Results reveal there are 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. Consumers from the four countries examined exhibited heterogeneous food safety perceptions and attitudes. Results suggest that food safety management strategies should vary across countries because of identified differences in food safety risk attitudes and risk perceptions.

Keywords: Cross-culture; risk attitude, risk perception, food safety, beef

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Food safety concerns have had dramatic impacts on food markets in general and cattle and beef markets in particular in recent years. Events that have been perceived to adversely affect food safety have resulted in complete loss of access to major markets for North American beef. Discovery of cattle infected with bovine spongiform encephalopathy (BSE) in North America in 2003 resulted in immediate, long lasting, and costly bans on animal and beef trade (Coffey et al.; Serecon). In addition to BSE, numerous other food safety concerns have been of considerable importance to the beef industry.

Periodic detection of *E. coli O157:H7, Salmonella, Campylobacter, Listeria*, and similar foodborne pathogens have been particularly noteworthy beef food safety concerns. The US Centers for Disease Control estimates that approximately 4 million foodborne bacterial illnesses occur annually in the US with 37% of those from *E. coli O157:H7, Salmonella, Campylobacter*, or *Listeria* (Meade et al.). Annually, more than 1200 deaths are associated with foodborne outbreaks from these four bacteria in the US (Meade et al.). Food safety events erode consumer confidence about beef food safety, which reduces demand for beef and cattle and may cause lower prices (Marsh, Schroeder, and Mintert). Furthermore, complete loss of market access may occur when a food safety event occurs such as loss of the Japanese export market for U.S. beef after the U.S. BSE discovery. A better understanding of cross cultural food safety risk perceptions, risk attitudes, and associated consumption behavior is needed as markets continue to globalize and become increasingly trade dependent.

Some consumers understand food safety risk is inherent in all food products or they simply are not very risk averse. Consumers in this category accurately assess the scientifically low level of risk present in food products and are willing to consume the product despite perceived low levels of risk. Evidence of this is that domestic beef demand in both Canada and the U.S. increased in 2004 following discovery of BSE infected cows in each of these countries (Agriculture and Agri-Food Canada; Kansas State University).

In contrast, some consumers react much differently to a food safety event and actually quit consuming the product if an actual or perceived food safety breach occurs (Pennings, Wansink, and Meulenberg). The dramatic beef demand decline that took place following the September 2001 discovery of a domestic dairy cow infected with BSE in Japan is an example of this phenomenon. Following the discovery, per capita Japanese beef consumption declined by more than 50% in just two months and about 1 in 4 Japanese consumers indicated that they eliminated beef from their diets (Peterson and Chen). This ultimately led to Japan enacting mandatory BSE testing for all bovines intended for human consumption. Although these examples refer to consumers by country of residence, reactions to food safety events vary across consumers within a country. Some consumers may stop eating beef in reaction to a BSE discovery, whereas, other consumers' demand for beef may not change at all. Therefore, developing an effective food safety supply chain management strategy and public policy requires understanding consumer perceptions and attitudes about beef food safety. Having a better understanding of food safety perceptions and attitudes makes it possible to better anticipate consumer behavior if a food safety event occurs.

The purpose of this study is to determine consumer attitudes and perceptions about beef food safety in Canada, U.S., Japan, and Mexico and quantify how perceptions and attitudes have affected beef consumption. Historically these countries were the four largest markets for North American beef. Food safety assurances are costly endeavors and food safety can never be guaranteed. However, the beef industry can potentially adopt a host of alternative production, processing, product handling and preparation, and product testing and surveillance activities that influence food product safety and/or consumer perceptions about beef food safety. Further, the industry can develop programs to inform consumers about food safety and the consumer's role in assuring beef products are safe. Determining the industry strategy and public policy options for managing beef food safety, especially during crises events such as discovery of BSE in North American cattle, requires in-depth knowledge about consumer perceptions and attitudes regarding beef food safety.

Risk Attitude and Perception Framework

Building upon the work of Pennings, Wansink, and Meulenberg and Lusk and Coble 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 purchase and consume a food product based upon the gain in utility anticipated 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 risk premium (π) that would leave a consumer indifferent between consuming and not consuming the risky food product can be derived from:

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

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

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

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 entire behavioral outcome space, which contains all possible behaviors of consumers, is driven by consumer risk attitudes and risk perceptions. This conceptualization has often been used to describe and explain behavior (Pennings and Van Ittersum). 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). However, in the case of food safety, the risk is not known with certainty nor is it easily estimable especially for food safety crises. Consumers, in other words, are unable to form a risk attitude, since they do not know the exact content of the risk, and they cannot form a risk perception either, as they are incapable of judging the likelihood (i.e., probability) of exposure to the risk content.

Since risk attitudes and risk perceptions span the entire behavioral outcome space, this space will increase in the case of a food safety breach. This increases the chances of what might be considered extreme, unpredictable, and undesirable behavior. Extreme, unpredictable, and undesirable behavior may become manifest as individual behavior, such as unwillingness to buy the product, or as collective behavior, such as banning sales of the product all together.

Equation (2) provides testable hypotheses regarding risky food choices: 1) more risk-averse individuals will be less likely to consume a food product perceived as risky, and 2) individuals that perceive a product as having more risk, will be less likely to consume the product. We use this framework to assess how risk aversion and risk perception affect how consumers react to information related to beef food safety. 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 information gathered regarding beef food safety in recent years. Beef food safety concerns have been met with widely divergent behavior by consumers in different countries making this evaluation across countries increasingly important. An empirical challenge may arise when testing the hypotheses since risk attitudes and risk perceptions are latent (unobservable) variables. Here, we test the reliability and validity of the risk

attitude and risk perception measures following the procedure outlined in Pennings and Garcia.[1] Risk attitude and risk perception are measured by a set of observable indicators that are subjected to confirmatory factor analysis to assess their psychometric properties. This procedure helps ensure that the empirical results are not driven by measurement error. Important public policy and beef supply chain management strategies can be gleaned from the effect risk aversion and risk perceptions have on beef consumption behavior. Furthermore, improved knowledge of how beef food safety risk aversion and perceptions differ across countries, and across consumers within a country can help formulate appropriate food safety policies and supply chain management strategies.

To further illustrate this point consider a situation where consumers are very risk averse regarding food safety and they perceive risk of consuming beef to be relatively high. In this situation consumers will take significant precautions before consuming a beef product and a food safety breach is likely to make them quit consuming the product all together. If a food safety crisis occurs (such as a case of BSE) regaining market access will require an aggressive approach to assure consumers that the risk has been eliminated. This will require a concerted effort on the part of regulators and industry participants to demonstrate an effective substantial change in procedures to enhance food safety, relative to consumers' perception of safety level prior to the food safety event (i.e., reassurance is not enough, a substantial change in process is likely required to restore consumer confidence). This type of consumer behavior led to mandated testing of all slaughter cattle for BSE following discovery of BSE in Japan's cattle herd.

Alternatively, consider the case where consumers may be less risk averse and perceive food safety risk of consuming beef to be very low. If a food safety event occurs,

such consumers will require reassurance in order to maintain demand, but if the event has a very low probability of being a significant and wide-spread health risk, consumers will not stop eating the product, unless the health risk threat of consuming the product substantially increases their risk perception. In such a case, the most effective policy is to demonstrate and inform consumers about the low level of risk present. This is the approach taken by the U.S. and Canada following discovery of BSE in each countries cattle herd. A testing procedure that demonstrates the low-level of presence of a potential food safety threat together with removing certain risk materials during beef processing has been sufficient to maintain consumer demand in this market environment.

Research Method

Data Collection Procedure

To collect information about consumer perceptions and attitudes regarding beef food safety, we conducted an on-line computer survey of consumers from households located in Canada, U.S., and Japan. The same survey was conducted via in-person interviews in Mexico. Mexican surveys were completed in-person because of limited computer access and/or use among the general population in Mexico. The survey instrument was designed to gain an understanding of consumer perceptions and attitudes about beef food safety. In addition, socio-demographic information about each respondent and how 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 consumer panel worldwide 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 overall came from a representative distribution of household income levels. The survey process was approved by the Institutional Review Board and participants were informed that their participation was voluntary and their responses anonymous.

A total of 4,005 respondents completed the survey across all four countries (Canada 1,002; U.S. 1,009; Japan 1,001; and Mexico 993). 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 U.S. 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 an average age ranging from 42 to 49 years old. The Mexican survey responses are more heavily skewed toward a younger population, with 67% of respondents being less than 35 years old and 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 over 18 years of age is less than 35 years old in Canada, the US, and Japan. In contrast, 43% of the adult population in Mexico is less than 35 years of age (US Census Bureau 2006).

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, consistent with their younger age distribution.

Income levels of respondents are also variable ranging from lower income levels ($22,500 or less) to upper income levels (more than $90,000).

Measuring Risk Attitudes & Risk Perceptions: A Confirmatory Factor Analytical Model

The two key variables in the conceptual model, risk attitude and risk perception, are unobservable, latent variables. To measure them in a reliable and valid manner we adhered to the iterative procedure recommended by Churchill and Pennings and Smidts. First, a pool of questions (i.e., indicators) was generated. The indicators were based on the literature. Care was taken to tap the domain of the indicators (i.e. risk in beef consumption) as closely as possible. Next, the indicators were tested for clarity and appropriateness in personally administered pre-tests. The resulting set of indicators was administered to consumers in the large-scale interview. Confirmatory factor analysis was used to assess the (psychometric) measurement quality of our constructs (Hair et al., Pennings and Garcia). The factor analytical model assumes that the observed variables are generated by a smaller number of latent variables (called factors). The relationship between the indicators and the latent variables (risk attitude and risk perception) can be represented by the following matrix equation:

$$x = \Lambda\ \kappa + \delta \tag{3}$$

where x is the $q\times1$ vector of the n sets of observed variables (i.e., indicators), κ is the $n\times1$ vector of underlying factors (e.g., risk attitude and risk perception), Λ is the $q\times n$ matrix of regression coefficients relating the indicators to the underlying factors, and δ

is the $q \times 1$ vector of error terms of the indicators. Because we wish to develop unidimensional risk attitude and risk perceptions constructs (e.g., scales), a construct is hypothesized to consist of a single factor. The overall fit of the model provides the necessary and sufficient information to determine whether a set of indicators describes risk attitude and risk perception.

All factor loadings (i.e., the regression coefficients in Λ in Equation (3)) were significant (minimum t-value was 4.60, $p < 0.001$) and greater than 0.4 for all risk attitude and risk perceptions factor models for all four countries. These findings support the convergent validity of the indicators (Anderson and Gerbing). The composite reliabilities for the constructs ranged from 0.56 to 0.92, indicating good reliabilities for the construct measurements (see Table 5). The average sum score of the indicators are used in subsequent analyses to measure risk attitude and risk perception.

Consumer Food Safety Knowledge and Information Sources

Developing effective supply chain management strategies that deal with food safety requires understanding what consumers know or perceive about beef food safety. Therefore, we asked a set of questions to inquire about the level of understanding of presence and probable impacts of potential beef food safety concerns. Table 2 summarizes responses to questions ascertaining the level of risk consumers perceive is associated with various food safety concerns (*E. coli O157:H7*, BSE, *Salmonella, Listeria, Campylobacter*) associated with beef products. Canadian and American respondents generally believe beef products are safe, though they perceive *E. coli O157:H7* as the highest risk with about 50% of respondents indicating *moderate risk* or

greater. About 60% of respondents in Canada and US 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 considerably more concerns about beef food safety than consumers in the other three countries. The high risk perceptions of Mexican respondents for food safety risks that have very low incidence rates (some infinitesimal) suggests Mexican consumers have a markedly higher concern about food safety than consumers in the three other countries. Exactly why Mexican consumers revealed greater beef food safety concerns is unclear, but perhaps they experience more food-safety related illnesses than consumers in the other countries.

Not unexpectedly, there exists a noticeable lack of knowledge among consumers about some beef food safety concerns. In particular, the most common response in Canada, US, and Japan was consumers *don't know* the risk levels associated with *Listeria, Campylobacter, and Staphylococcus aureus*. This could be because the incidence level of these foodborne pathogens is low and they receive little media attention so consumers are simply unfamiliar with these pathogens.

In addition to levels of concern about beef food safety, we inquired about the perceived probable health impact if a particular food safety issue occurred. Table 3 summarizes respondent expectations about the probable impact of a food safety occurrence for selected problems. Most respondents, generally 70% or more in each country, felt *E. coli O157:H7* and BSE would cause *major* or *serious illness* whereas 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, US 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, indicating they believe the likelihood of serious illness requiring hospital care for all of the specified food safety issues is substantially higher than did consumers in the other three countries.

Beef Food Safety Concerns and Reactions

Given concerns raised by at least some respondents about beef food safety and recent global beef food safety issues such as heavily publicized BSE events, we wanted to determine to what extent consumption habits might have changed because of food safety concerns. Table 4 summarizes respondent changes in beef consumption in response to changing food safety concerns. In Canada and the U.S. about 20% of consumers indicated that 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. Among consumers that reduced their beef consumption, the typical reduction was substantial, ranging from 20% to 60%. Roughly one-quarter of Canadian, U.S., and Japanese respondents reducing consumption virtually eliminated beef from their diet (80% or more reduction). This demonstrates that the beef industry has lost an important segment of its customer base because of food safety concerns. This is additional evidence that addressing food safety concerns within a supply chain management system are crucial to maintaining and expanding beef market share.

Given fundamental differences in risk perceptions and risk attitudes, and how this corresponds to effective food supply chain management; we sought to ascertain risk perceptions and attitudes of consumers in Canada, the U.S., Japan, and Mexico. This was accomplished by asking consumers a series of questions to build a set of risk attitude and risk perception scales (e.g. average sum score of indicators) using the confirmatory factor model outlined in Equation (3). 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, that they feel eating beef is worth the food safety risk (only about 25-30% indicated that they disagreed that eating beef was worth the risk). In contrast, a larger percentage of Japanese consumers have stronger held risk attitudes that eating beef is not worth the risk (e.g., 63% disagreed that eating beef was worth the risk). Mexican respondents, on average, held risk attitudes about beef food safety that tended to be similar to U.S. and Canadian consumers.

Summary statistics of the individual questions asked to ascertain risk perceptions are also provided in table 5. At least some consumers in each of the four countries surveyed perceive eating beef to be risky and at least some consumers in each country consider eating beef to not be risky at all. However, there are stark differences 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 responded with a score of 4 or lower indicating they disagree strongly that eating beef is risky (and they had an average score of less than 4 for each of the three questions). In contrast, only 42% of Japanese and 27% of Mexican respondents provided a ranking of 4 or lower for this question (and they had an average score of 5 or greater for five out of the six risk

perception questions by these two countries). Consumers in Canada and U.S. tend to have much stronger positive perceptions about beef food safety than Japanese and Mexican consumers.

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. Table 6 presents summary distributions of corresponding risk attitude and risk perception scales calculated as averages of responses to the sets of questions (e.g., the validated indicators in the confirmatory factor models). Figures 1 and 2 present the cumulative distributions of risk attitude and perception scales by respondent country. 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, American, or Mexican consumers. Japanese consumers have an average risk aversion score on a 1 to 10 scale of 6.6 compared to 4.8 to 5.0 for Canadian, U.S., and Mexican respondents. Food safety risk perceptions also differ across countries. Japanese and Mexican consumers perceive beef to have higher food safety risk (average Risk Perception scale of 5.2 and 5.6, respectively) than Canadian and American consumers (average Risk Perception scale of 3.3 and 3.7, respectively).

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 in recent years we estimated a two-stage model. In the first stage we model determinants of whether consumers lowered their consumption of beef over the last four years (table 4) as

the dependent variable. The second stage of the model estimates determinants of the percentage reduction in beef consumption for those survey respondents that indicated they had reduced consumption in the first stage.

The independent variables used as explanatory factors include demographic variables of gender, age, income, and education level (table 1). Of central interest are risk attitude and risk perception scales included as explanatory variables (table 6). The first stage is given by:

$$D_i = X_i^{'}\beta + \varepsilon_i \quad (4),$$

where D_i is a binary discrete variable ($D_i = 1$ if consumer *i* reduced beef consumption over the last four years, =0 otherwise), X_i is a vector of explanatory variables, β is a coefficient vector to be estimated, and ε is a random error $\varepsilon \sim N(0, \sigma_D^2)$.

In the second stage we model the percentage reduction in beef consumption for each consumer indicating a reduction in consumption as:

$$Q_i^* = Z_i^{'}\theta + \upsilon_i \quad (5),$$

where 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 $\upsilon \sim N(0, \sigma_Q^2)$. We actually observe Q_i as

$$Q_i = 0 \qquad iff \quad Q_i^* \le 0 \quad (6),$$

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

Furthermore, Q_i is censored between 0 and 100.

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 with $COV(\varepsilon, \upsilon) = \rho$. The model is estimated using maximum likelihood with a Probit model in the first stage and double-bounded Tobit model in the second stage.

Marginal effects of each independent variable are evaluated at sample means (denoted by $\overline{X}$ & $\overline{Z}$). For binary variables, in the first stage Probit model, the marginal effects are differences in predicted probabilities associated with changing the independent variable of interest set from 1 to 0. For example, the marginal effect of binary variable *j* is:

$$\begin{aligned} ME_j^D &= \text{Prob}[D=1 \mid \overline{X}, j=1] - \text{Prob}[D=1 \mid \overline{X}, j=0] \\ &= F(\overline{X}, j=1; \beta) - F(\overline{X}, j=0; \beta) \end{aligned} \quad (8),$$

where $F(\cdot)$ is the cumulative normal distribution (Greene, p. 668). For continuous variables (e.g., *Age*, *Education*, *Income*, *Risk Aversion*, and *Risk Perception*)[1], marginal effects are calculated at the sample means using the standard formula:

$$\frac{\partial E[D \mid \overline{X}]}{\partial \overline{X_k}} = \phi(\overline{X}'\beta)\beta_k \quad (9),$$

where $\phi(\cdot)$ is the standard normal density (Greene, p. 668).

For the second stage Tobit model, marginal effects for binary variables are calculated by taking the difference in the predicted values with the binary variable equal to 0 and 1 (see Greene, p. 764-766):

$$E[Q_i^* \mid Z_i] = F(\frac{Z_i\theta}{\sigma}) * (Z_i\theta + \sigma\lambda_i) \quad (10),$$

[1] We included the interaction between Risk Attitude and Risk Perception following Pennings and Wansink, and Lusk and Coble in the initial models estimated. However, the Canadian model did not converge and in the U.S., Japan, and Mexico models, the interaction terms were not jointly statistically significant so the interaction terms were not retained in the final models.

where $\lambda_i = \phi(\frac{Z_i\theta}{\sigma}) / F(\frac{Z_i\theta}{\sigma})$. Further, marginal effects for continuous variables are identified as:

$$\frac{\partial E[Q_i^* \mid \overline{Z}]}{\partial Z_k} = \theta_k * F(\frac{Z_i\theta}{\sigma}) \quad (11).$$

Results of the maximum likelihood estimation of the two-equation model are presented in table 7. Significance of the correlation coefficient in each model suggests employing a univariate framework would be insufficient. Not surprisingly, this indicates that unobserved factors increasing the probability a consumer reduced beef consumption during the past four years are highly correlated with the magnitude of reduction. Results for the first stage have strong similarities across countries in statistical significance of the explanatory variables, but noticeably different magnitudes of impact. For consumers in all four countries, the statistically significant ($p \leq 0.05$ level) factors related to whether the person reduced beef consumption are *Age*, *Risk Attitude*, and *Risk Perception* (and *Female* in the Canadian model only). Older consumers in all countries indicated that they were more likely to have reduced beef consumption in the last four years because of food safety concerns than younger respondents. Each additional 10 years of age increased the probability the consumer has reduced beef consumption because of food safety concerns by 3% (U.S.) to 7% (Canada). Each unit increase in the risk attitude scale increased the likelihood the consumer has reduced beef consumption because of food safety concerns by 2% in Canada, 4% in the U.S., 5% in Japan, and 8% in Mexico. Furthermore, each unit increase in the risk perception scale was associated with an 8% to 9% increase in probability that Canadian, American, and Mexican consumers have reduced beef

consumption in the last four years because of food safety concerns. In contrast, a unit increase in risk perception was associated with a 13% increase in the probability Japanese consumers reduced beef consumption.

Our findings that risk attitude and risk perception significantly affect consumption decisions are consistent with Pennings, Wansink, and Meulenberg as well as Lusk and Coble. Consistent with Lusk and Coble's conclusions that were based on a sample of U.S. students, we found marginal impacts of improving 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, Wansink, and Meulenberg.

Results from estimating the percentage reduction in beef consumption due to concerns about food safety reveal additional insights (table 7). Among consumers that have reduced beef consumption, older consumers reduced beef consumption more in each country in recent years because of food safety concerns. Each additional 10 years of age resulted in about a 2% to 5% reduction in beef consumption for those that reduced consumption. Risk attitude is an important determinant of the reduction in beef consumption with each unit increase in risk attitude having reduced beef consumption by approximately 2% to 3% in Canada, the U.S., and Japan and by 6% in Mexico. Risk perception is generally even more strongly associated with the percentage of beef consumption reduction with each unit increase in beef risk perception scale being associated with a roughly 5% (Mexico) to about 8% (Japan) reduction in beef

consumption. For each country, except Mexico, the marginal effect of risk perception on beef consumption decline is about two to three times the size of the risk attitude impact. 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, Mazzocchi, and Traill investigated how risk attitudes and perceptions affect European (UK, 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.

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 U.S. and Canada infected with BSE in 2003. When BSE was discovered in cattle in Japan in 2001, the resulting domestic beef demand decline was devastating to the industry and resulted in compulsory BSE testing of bovine destined for human consumption. In contrast, the 2003 and subsequent BSE discoveries in North America caused export market closures, but domestic beef demand did not decline and actually appeared to increase following these events. Casual observations of consumer reactions to such food safety events indicate markedly different risk behavior to similar events. 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 U.S., Canada, and Mexico, consumers in Japan are more risk averse with respect to beef food safety. Japanese consumers indicate less willingness to consume beef and disagree more that eating beef is worth the risk relative to consumers in North America. Furthermore, relative to consumers in the U.S. and Canada, Japanese and Mexican consumers perceive beef to be less safe and consider eating beef to involve greater food safety risk.

Twenty percent of U.S. and Canadian consumers indicate they reduced beef consumption in response to food safety concerns over the past four years. This compares to 55% of Japanese, and 31% of Mexican, consumers reporting beef consumption reductions traceable to food safety concerns. The differences in prevalence of beef consumption declines across country are directly related to divergence of beef food safety attitudes and perceptions. Likewise, the typical magnitude of decline in beef consumption is also directly associated with beef food safety risk attitudes and perceptions.

Different consumer attitudes and perceptions across countries suggest different public policy options in dealing with food safety events and varied industry supply chain management strategies to capture and maintain market share and even market access. In the U.S. and Canada demonstrating the low level of incidence and low probability of a food safety issue being present is a sufficient condition to maintain consumer demand. So, in the case of BSE in the U.S., testing for prevalence levels in the beef herd and removing risk materials from meat processing were sufficient industry and policy maker responses to the event. Removal of risk materials from beef food products,and very low incidence levels of BSE, were sufficient to maintain broad confidence in beef products among North American consumers.

In contrast, simply demonstrating low levels of BSE incidence in the cattle herd was not sufficient to regain Japanese consumers' confidence. 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 since Japanese consumers have a very low tolerance for even a very small probability that beef contributes to food safety problems.

Our findings have multiple implications for policy makers and industry decision makers. In particular, consumer risk attitudes and perceptions regarding food safety dominate demographic factors in influencing beef consumption behavior. Further, risk perceptions dominate risk attitudes of consumers in the U.S., Canada, and Japan. This suggests that educational efforts to improve understanding by these consumers of actual risk (rather than perceived risk) may effectively alter behavior. Conversely, Mexican consumers respond approximately the same to changes in risk attitude and perception suggesting educational efforts and removal of actual risk may be equally beneficial. Collectively, results suggest that effectiveness of alternative policies and industry investment decisions vary based upon targeted consumer markets. Future work could further evaluate this finding using alternative risky foods and further assess the viability of specific educational efforts and food safety enhancement investments targeting alternative consumers.

Footnotes

1. Reliability refers to the extent to which a variable or set of variables is consistent with what it is intended to measure. Validity refers to the extent to which a measure or set of measures correctly represents a concept (i.e., latent variable). Validity is concerned with how well the concept is defined by the measures (i.e., indicators), while reliability relates to the consistency of the measures.

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Table 1. Summary Statistics of Selected Demographic Variables of Survey Respondents

	Respondent Country			
Biographical Data	Canada	US	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 (No Bachelor's)	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%	

[a]Canada, I is less than $15,000; II $15,000-$34,999; III $35,000-$59,999; IV $60,000-$79,999; V $80,000 or more ($CN)
US, I is less than $22,500; II $22,500-$39,999; III $40,000-$59,999; IV $60,000-$89,999; V $90,000 or more ($US)
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 or more (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)

Table 2. Respondent Perception of Various Beef Food Safety Risks

	Respondent Country			
Food Safety Risk Perception	Canada	US	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. Expected Health Impact of Various Beef Food Safety Occurrences

Food Safety Occurrence	Respondent Country			
	Canada	US	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, in bed, 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, in bed, 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, in bed, 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, in bed, 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, in bed, 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, in bed, 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. Survey Respondent Trends in Beef Consumption Related to Food Safety Concerns

	Respondent Country			
Beef Consumption Habit	Canada	US	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 question)				
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%

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

	Respondent Country			
	Canada	US	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 0.05 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 U.S., 0.65 for Mexico, 0.56 for Japan and 0.69 for Canada. The reliabilities for risk perceptions are 0.93 for U.S., 0.80 for Mexico, 0.92 for Japan and 0.93 for Canada.

Table 6. Risk Attitude and Risk Perception Scale Distributions

	Respondent Country			
Risk Attribute	Canada	US	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

Table 7. Maximum Likelihood Estimates of Consumer Decisions to Reduce Beef Consumption and Quantity of Reduction, by Country

	Canada Respondents			US Respondents			Japan Respondents			Mexico Respondents		
	Coefficient	*p*-value	Marginal Effect	Coefficient	*p*-value	Marginal Effect	Coefficient	*p*-value	Marginal Effect	Coefficient	*p*-value	Marginal Effect
Stage 1: Reduced Beef Consumption Model (Probit)												
Intercept	-3.5556	0.0001		-2.8100	0.0001		-3.1308	0.0001		-2.8820	0.0001	
Female	0.2145	0.0381	0.0733	-0.0823	0.5312	-0.0300	0.0894	0.3235	0.0350	-0.1351	0.2009	-0.0535
Age	0.0210	0.0001	0.0072	0.0084	0.0190	0.0030	0.0110	0.0035	0.0043	0.0110	0.0013	0.0044
Education	0.1097	0.0408	0.0375	0.0584	0.2649	0.0213	0.1016	0.0221	0.0398	-0.0496	0.2115	-0.0197
Income	-0.0047	0.9087	-0.0016	-0.0492	0.1872	-0.0179	-0.0259	0.4583	-0.0102	0.0373	0.4626	0.0148
Risk Attitude	0.0649	0.0082	0.0222	0.1042	0.0001	0.0380	0.1245	0.0001	0.0488	0.2130	0.0001	0.0844
Risk Perception	0.2412	0.0001	0.0824	0.2560	0.0001	0.0933	0.3348	0.0001	0.1312	0.1978	0.0001	0.0783
McFadden's R-Square		0.18			0.21			0.19			0.09	
Stage 2: Quantity Reduction in Beef Consumption Model (Tobit)												
Intercept	-109.8903	0.0185		-155.8300	0.0001		-52.9643	0.0001		-101.8361	0.0001	
Female	10.9155	0.0365	6.7489	-3.6510	0.6201	-1.5074	-0.2563	0.9165	-0.2162	-3.2254	0.4754	-1.9452
Age	0.7306	0.0094	0.4515	0.5709	0.0042	0.2358	0.3848	0.0002	0.3246	0.3783	0.0085	0.2283
Education	4.5725	0.0884	2.8253	4.7047	0.1066	1.9432	0.8972	0.4626	0.7569	-1.9565	0.2469	-1.1804
Income	-3.3673	0.0697	-2.0807	-2.6194	0.2159	-1.0819	-2.2157	0.0151	-1.8693	0.5855	0.7837	0.3528
Risk Attitude	3.5535	0.0077	2.1957	5.6526	0.0001	2.3347	3.4558	0.0001	2.9155	9.4619	0.0001	5.7087
Risk Perception	10.9633	0.0001	6.7742	14.7025	0.0001	6.0726	8.9011	0.0001	7.5095	7.8523	0.0001	4.7376
Sigma	41.3920	0.0001		54.1031	0.0001		29.0045	0.0001		41.3981	0.0001	
Rho	0.8946	0.0001		0.9914	0.0001		0.8593	0.0001		0.9685	0.0001	
Log Likelihood	-1250			-1336			-2912			-1955		

Figure 1. Beef Food Safety Risk Attitude Cumulative Frequency Distributions, by Country

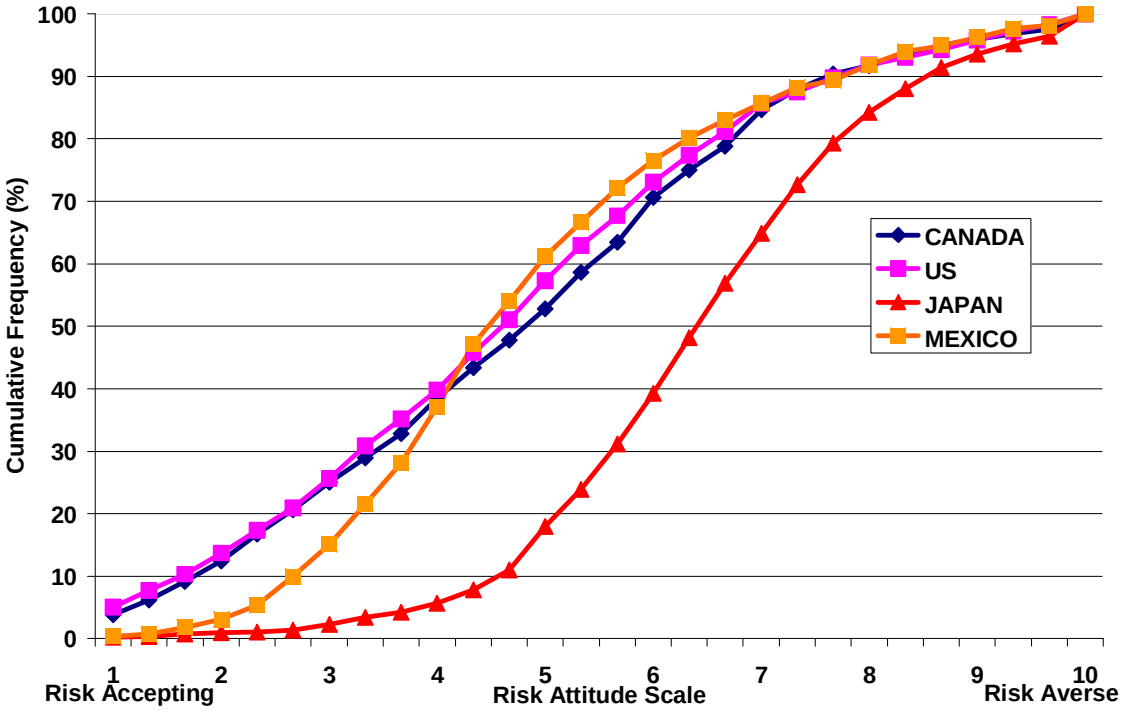

Figure 2. Beef Food Safety Risk Perception Cumulative Frequency Distributions, by Country