Consumers Valuations and Choice Processes of Food Safety Enhancement Attributes: An International Study of Beef Consumers

Glynn T. Tonsor
Assistant Professor, Dept. of Agricultural Economics
Michigan State University
213D Agriculture Hall
East Lansing, MI 48824-1039
Phone: (517) 353-9848
gtonsor@msu.edu

Ted C. Schroeder
Professor, Dept. of Agricultural Economics
Kansas State University
Manhattan, KS

Joost M.E. Pennings
Associate Professor, Dept. of Agricultural and Consumer Economics,
University of Illinois at Urbana-Champaign
AST Professor of Marketing & Decision Science,
Wageningen University, The Netherlands

and

James Mintert
Professor, Dept. of Agricultural Economics
Kansas State University
Manhattan, KS

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Abstract

Food safety concerns have had dramatic impacts on food and livestock markets in recent years. Here we examine consumer preferences for various beef food safety assurances. In particular, we evaluate the extent to which such preferences are heterogeneous within and across country-of-residence defined groups and examine the distributional nature of these preferences with respect to marginal improvements in food safety. We collected data from over 4,000 U.S., Canada, Japan, and Mexican consumers. Using mixed logit models we find that Japanese and Mexican consumers have WTP preferences that are nonlinear in the level of food safety risk reduction. Conversely, U.S .and Canadian consumers appear to possess linear preferences. These results suggest that optimal food safety investment strategies hinge critically upon consumer perception of actual food safety improvements, the distributional relationship describing the targeted consumer segment's tradeoff function between WTP premiums and risk reduction levels, and the cost structure of these investments.

Keywords: *consumer beef preference, food safety, investment decision, mixed logit, willingness-to-pay*

1. Introduction

Food safety is a growing global concern. Maintaining and gaining market access is increasingly requiring more substantial assurance and demonstration of food safety protocols by food production and processing industries. Food safety management and regulation is receiving more direct involvement by government regulatory and inspection agencies and has gained considerable attention of policy makers. Consumers are demanding increased food safety assurances as even very isolated food safety events have caused major market disruptions. Beef markets have been particularly adversely affected by food safety concerns in recent years. For example, discovery of a single beef cow in the U.S. infected with bovine spongiform encephalopathy (BSE) in 2003 caused immediate and long-lasting closure of virtually all U.S. beef export markets.[1] Regaining global market access has required major changes in animal age verification, costly alterations to beef processing, product losses, and careful segregation of meat products (Coffey et al., 2005). Furthermore, intensive inspections coupled with zero tolerance for a variety of food safety related concerns, have made maintaining market access, even with a host of added food safety protocols, regulations, and frequent audits, a major challenge.

Enhancing food safety requires increased food production, processing, and handling costs. Therefore, before large investments in food safety protocols, policies, and inspections are made, more information is needed regarding the probable return from these investments. That is, we need to know how concerned consumers are about beef food safety and how much they are willing to pay for an increase in food safety assurances in order to determine appropriate investments in food safety management and monitoring. The purpose of this study is to estimate consumer valuation for food safety enhancements in beef steak relative to the valuation of other

[1] A similar discovery a few months earlier in Canada caused a similar but economically even more dramatic impact because of the greater dependence of the Canadian industry on beef exports.

product attributes. This research focuses on increasing our understanding of similarities and differences in consumer perceptions and valuations for beef attributes in Canada, U.S., Japan, and Mexico. These four countries were, historically, the largest markets for North American beef. Furthermore, given the markedly different reactions in these countries to beef food safety events, they warrant more investigation regarding differences in preferences. The approach taken here provides an empirical examination of the extent of consumer heterogeneity in preferences within and across countries. Furthermore, the derived model is used to draw conclusions about the value of investments that could be made in enhancing food safety for beef destined for these four markets.

2. Previous Research

Several studies have investigated what consumers are willing to pay to avoid or obtain various food attributes (McCluskey et al., 2003; Grannis and Thilmany, 2002; Misra, Grotegut, and Clem, 1997; Misra, Huang, and Ott, 1991; Roosen, Lusk, and Fox, 2003; Burton et al., 2001; Lusk, Roosen, and Fox, 2003; Roosen, 2003; Alfnes, 2003; Tonsor et al., 2005). A few studies have focused on consumer willingness to pay for food safety assurances or risk reductions (Brown, Cranfield, and Henson, 2005; Goldberg and Roosen, 2005; McCluskey et al., 2005). Brown, Cranfield, and Henson (2005) employed an experimental auction to value Canadian consumers' willingness to pay for reductions in risk of becoming ill from exposure to *Campylobacter* from a chicken sandwich. Using Vickrey 2nd price auctions, the authors found consumer willingness to pay for lower *Campylobacter* risk to be decreasing functions of the individual's risk tolerance.

In a study among German consumers, Goldberg and Roosen (2005) used both contingent valuation and choice experiment methods to examine consumer willingness to pay for reductions in *Salmonellosis* and *Campylobacter* risk. Willingness to pay was highly convex in the level of each risk reduction. That is, WTP increased more than proportionally with risk reductions. McCluskey et al. (2005) examined Japanese consumer reluctance to exchange money for BSE-tested beef. Using choice contingent valuation methods the authors' findings suggested that representative Japanese consumers were willing to pay a 56% price premium for BSE-tested beef.

Each of these studies (Brown, Cranfield, and Henson, 2005; Goldberg and Roosen, 2005; McCluskey et al., 2005) contributes to our understanding of consumer perceptions of food safety risk in the meat industry. However, significant need to extend this work motivated our study. In particular, each of these prior studies assumed homogeneous preferences across consumers, analyzed a single country-of-residence based consumer group, and did not utilize data collection methodologies that would allow consumers to reveal tradeoffs between non-monetary product attributes and food safety. Each of these issues are addressed in this research. In particular, heterogeneous preferences are evaluated (utilizing mixed logit models), in a multinational study which allows for cross-country comparisons vital in understanding the international meat market complex. In addition, the employed choice experiment facilitates an evaluation of consumer willingness to trade food safety attributes for both monetary and non-monetary traits.

3. Research Design: Data Collection and Choice Experiment

This study uses a choice experiment to estimate WTP for beef steak attributes. Our sample, drawn from consumers in the U.S., Canada, Japan, and Mexico, represents a broader sample of consumers than in prior studies. Furthermore, we empirically compare Mexican consumer preferences for beef attributes with consumers from other countries. Given the growing importance of the Mexican market for Canadian and U.S. beef producers, this is an additional, timely contribution.

To collect information about consumer perceptions and preferences we conducted an on-line computer survey of consumers from households located in Canada (*N=1002*), the U.S. (*N*=1009), and Japan (*N=1001*). The same survey was conducted via in-person interviews in Mexico (*N=993*). The Mexico surveys were completed in-person because of limited computer access and/or use among the general population in Mexico.[2] The survey was translated into French (primarily for use in Quebec), Spanish (for Mexico), and Japanese to accommodate different respondent languages across countries.

The surveys were conducted through TNS NFO, a global market research company. TNS NFO has a vast consumer panel, with more than 5 million individuals worldwide in their data bank. For our surveys, TNS NFO targeted one adult per household who was familiar with shopping habits. Target respondents were older than 18 years of age and overall came from a representative distribution of household income levels. Ranking and choice questions were presented in randomized order across respondents to reduce question ordering biases. All surveys were completed between late February and early March 2006. Respondents were assured their answers would be anonymous and we were not supplied with information about specific respondent identities beyond socio-demographic data.

In addition to socio-demographic information about each respondent, meat consumption habits, perceptions of food safety risk present when consuming beef, and a multitude of other factors were collected. Each respondent also completed a choice experiment designed to

[2] A copy of the survey instrument is available upon request.

determine the amount consumers were willing to pay for various beef steak production, food safety, and product quality attributes. Combined, this information provides a comprehensive assessment of views and preferences of consumers from four different countries about beef products and attributes.

Choice experiments simulate real-life purchasing situations and permit multiple attributes to be evaluated, thus allowing researchers to estimate tradeoffs among different alternatives (Lusk, Roosen, and Fox, 2003). In this choice experiment, consumers were presented with a set of 21 simulated shopping scenarios, each of which involved choosing a preferred alternative from two beef strip loin steaks and a no purchase option.

Steaks were offered at four different price levels selected to be consistent with local retail prices. In addition to price, the steaks varied by country of origin, production practice, tenderness level, and food safety assurance (see table 1). An orthogonal fractional design (Kuhfeld, Tobias, and Garratt, 1994) was used to select scenarios in which steak prices are uncorrelated, and which allows for identification of own-price, cross-price, and alternative specific effects. This process also allows the choice experiment to be of reasonable size for survey participants. An example of choice scenario included in the choice experiment is:

Steak Attribute	**Option A**	**Option B**	**Option C**
Price ($/lb.)	$14.00	$11.00	Neither A nor B is preferred
Country of Origin	USA	Canada	
Production Practice	Natural	Natural	
Tenderness	Assured Tender	Uncertain	
Food Safety Assurance	Enhanced 80%	Enhanced 40%	
I choose …			

Though the choice experiments were hypothetical in that they did not include actual money or actual steak products, our instructions specifically stated "It is important that you make your selections like you would if you were actually facing these choices in your retail purchase decisions." This statement was included as part of a "cheap-talk" strategy at reducing hypothetical bias by informing survey participants of the concept prior to conducting the choice experiment (Lusk, 2003; Cummings and Taylor, 1999). Furthermore, given that our principal interest is differences in marginal willingness-to-pay amounts, we are less concerned with the hypothetical nature of our survey. This reassurance is based upon Lusk and Schroeder's (2004) research, which suggests that hypothetical willingness-to-pay for marginal changes in desirable attributes are not significantly different from non-hypothetical valuations. Descriptions included in the choice experiments of the specific product attributes were:

> *Country of Origin* refers to the country in which the cow was raised and includes Canada, Japan, Mexico, or USA.
>
> *Production Practice* is the method used to produce the cow where *Approved Standards* means the cow was raised using scientifically-determined safe and government-approved use of synthetic growth hormones and antibiotics (typical of cattle production methods used in USA and Canada); *Natural* is the same as typical except the cow was raised without the use of synthetic growth hormones or antibiotics.
>
> *Tenderness* refers to how tender the steak is to eat and includes *Assured Tender* which means the steak is guaranteed tender by testing the steak using a tenderness measuring instrument and *Uncertain* means there are no guarantees on tenderness level of the steak and the chances of being tender are the same as typical steaks you have purchased in the past.
>
> *Food Safety Assurance* refers the level of food safety assurance with the steak. *Typical* food safety means the steak meets current minimum government standards for food safety. *Enhanced 40%* means measures have been taken to reduce risks of illness associated with food safety from consuming the product by 40% relative to typical. *Enhanced 80%* means measures have been taken to reduce risks of illness associated with food safety from consuming the product by 80% relative to typical.

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 2. In Canada and Japan, male and female respondents were about equally split, whereas, in the U.S. and Mexico, females represent about 80% of respondents. Respondents in Canada, the U.S., and Japan had an average age ranging from 42 to 49 years old whereas Mexican respondents were younger, averaging 31 years of age. Although respondents in Mexico are younger than in the other three countries, this is consistent with Census data on age distributions across these four countries (US Census Bureau, 2006).

Mexican respondents tend to have lower education and income levels than respondents from the other three countries, consistent with their younger age distribution. More than 20% of Canadian and U.S. respondents are categorized in the upper income level, whereas about 12% of Japanese and 11% of Mexican respondents are from their respective highest income categories.

Nearly all respondents are at least occasional beef consumers, but there is a lot of variability in the frequency of consumption. For example, more than 60% of respondents in Canada, the U.S., and Mexico consume beef at least two to three times per week. This compares to just 30% of Japanese respondents consuming beef this often.

Developing effective supply chain management strategies and policies that deal with food safety requires sound understanding of what consumers know (or perceive) about food safety. Therefore, we asked a set of questions to inquire about the level of understanding of the presence, probable impacts of, and sources of information that consumers use as they assess beef food safety concerns. Table 2 includes a breakdown of responses to a question ascertaining the level of risk consumers perceive is associated with BSE food safety concerns. Canada and U.S. respondents generally believe beef products are safe, rating BSE as a *low* to *very low risk* (roughly 60%). In contrast, Japanese and Mexican respondents have considerably more concerns about beef food safety related to BSE risk with more than 50% of respondents from each country perceiving *high* or *very high risk*.

4. Research Method: Random Parameters Logit and WTP Analysis

A random parameters logit (RPL) model (also known as a mixed logit) was used to determine consumer willingness to pay for the various steak attributes of interest. The RPL model allows for random taste variation within the surveyed population, is free of the independence of irrelevant alternatives (IIA) assumption, and allows correlation in unobserved factors over time, thus eliminating three limitations of standard logit models (Train, 2003; Revelt and Train, 1998). Use of RPL models, rather than standard multinomial logit models, is relatively recent but increasing in popularity. In the context of our study, the RPL is appealing for a number of reasons. First, some of the steak alternatives presented in our choice experiment are similar, possibly making the IIA assumption overly restrictive. Secondly, a growing amount of research suggests consumers possess heterogeneous preferences, so employing a model that allows for and evaluates preference heterogeneity is appropriate (Lusk, Roosen, and Fox, 2003; Alfnes and Rickertsen, 2003; Alfnes, 2004; Tonsor et al., 2005).

Underlying the random parameters logit model is the consumer's random utility (*U*), in which the utility of option *j* for individual *i* in choice situation *t* is described by:

$$\mathrm{U}_{\mathrm{ijt}} = \mathrm{V}_{\mathrm{ijt}} + [\upsilon_{ij} + \varepsilon_{ijt}] \quad (1),$$

where V_{ijt} is the systematic portion of the utility function, υ_{ij} is an error term distributed normally over individuals and alternatives (but not choice situations), and ε_{ijt} is the stochastic error component i.i.d. over all individuals, alternatives, and choice situations. As noted by Alfnes (2004), this describes a panel data model where the cross-sectional element is individual *i* and the time-series component is the t choice situations. Important to note is that failure to utilize a panel data specification in this context would result in a mis-specified model. This arises from the perfect correlation of demographic variables across choice situations that would be ignored by assuming $\upsilon_{ij} = 0$ (as in the traditional multinomial logit).[3] The probability that subject i chooses option j in choice situation t is given by:

$$\mathrm{P}(\mathrm{U}_{\mathrm{ijt}} \geq \mathrm{U}_{\mathrm{ikt}}) = \mathrm{P}(\mathrm{V}_{\mathrm{ijt}} + \upsilon_{ij} + \varepsilon_{ijt} \geq \mathrm{V}_{\mathrm{ikt}} + \upsilon_{ik} + \varepsilon_{ikt}) \quad \forall\, \mathrm{k} \qquad (2).$$

Assuming the observable portion of utility is linear in parameters, we initially specify V_{ijt} as:

$$\begin{aligned} V_{ijt} &= \alpha_0 P_{jt} + \beta_1 Canada_{jt} + \beta_2 US_{jt} + \beta_3 Japan_{jt} + \beta_4 Mexico_{jt} + \beta_5 Natural_{jt} \\ &+ \beta_6 Tender_{jt} + \beta_7 FoodSafety40_{jt} + \beta_8 FoodSafety80_{jt} \quad \forall\, j = A, B \end{aligned} \qquad (3),$$

$$V_{ijt} = 0 \quad j = C \qquad (4),$$

where P_{jt} is the price of alternative j (A, B, or C) in choice situation t, $Canada_{jt}$, US_{jt}, $Japan_{jt}$, and $Mexico_{jt}$ are dummy variables equal to one if the beef steak is labeled as originating from Canada, the U.S., Japan, or Mexico, respectively (0 otherwise), $Natural_{jt}$, $Tender_{jt}$, $FoodSafety40_{jt}$, and $FoodSafety80_{jt}$ denote dummy variables equal to one if the alternative is labeled as being naturally produced, assured to be tender, has 40% enhanced food safety relative to standard practices, and has 80% enhanced food safety, respectively (0 otherwise), and α_0 and β_k (k=1, … ,8) are parameters to be estimated.

The model as specified in equations (3) – (4) fails to incorporate information about survey participants such as demographic variables or behavior observed from separate survey questions. Recent research (e.g., Nahuelhual, Loureiro, and Loomis, 2004) has demonstrated the

[3] Consequently, our model estimation procedures are carried out in LIMDEP (Greene, 2002) utilizing the program's panel data specification.

possible adverse implications of this omission. In essence, including individual specific information reduces possible omitted variable bias and allows us to determine if preference heterogeneity persists beyond typically observed factors. Furthermore, this results in derived willingness-to-pay estimates being functions of the included individual characteristics. This is more consistent with economic theory than classical WTP approaches that assume WTP is simply a function of product attributes (e.g., Lusk, Roosen, and Fox, 2003).

To incorporate observed individual characteristics, equation (3) is re-specified as:

$$\begin{aligned} V_{ijt} &= \alpha_0 P_{jt} + (\beta_1 + \boldsymbol{\gamma}'_{\mathbf{Canada}}\mathbf{Z_i}) * Canada_{jt} + (\beta_2 + \boldsymbol{\gamma}'_{US}\mathbf{Z_i}) * US_{jt} + (\beta_3 + \boldsymbol{\gamma}'_{Japan}\mathbf{Z_i}) * Japan_{jt} \\ &+ (\beta_4 + \boldsymbol{\gamma}'_{Mexico}\mathbf{Z_i}) * Mexico_{jt} + (\beta_5 + \boldsymbol{\gamma}'_{Natural}\mathbf{Z_i}) * Natural_{jt} + (\beta_6 + \boldsymbol{\gamma}'_{Tender}\mathbf{Z_i}) * Tender_{jt} \\ &+ (\beta_7 + \boldsymbol{\gamma}'_{FoodSafety40}\mathbf{Z_i}) * FoodSafety40_{jt} + (\beta_8 + \boldsymbol{\gamma}'_{FoodSafety80}\mathbf{Z_i}) * FoodSafety80_{jt} \quad \forall\, j = A, B \end{aligned} \qquad (5),$$

where the variables in equation (5) are defined as in equation (3),

$\mathbf{Z_i} = [\mathbf{Female_i}, \mathbf{Education_i}, \mathbf{Income_i}, \mathbf{Consume_i}, \mathbf{BSE\_Risk_i}]$ is a vector of individual *i*'s characteristics, $Female_i$, $Education_i$, $Income_i$, $Consume_i$, and BSE_Risk_i are demographic variables as defined in table 2, and α_0, β_k (*k*=1, ... ,8), and $\boldsymbol{\gamma}'_l$ (*l* = *Canada*, … , *FoodSafety80*) are parameters to be estimated.

Following Nahuelhual, Loureiro, and Loomis (2004), models defined by equation (5) are estimated with the steak attribute constants (β_k) allowed to vary randomly and with the price coefficient (α_0) fixed to keep it from varying within each population. The "population" from which the parameters are drawn from refers to either the sample of U.S., Canadian, Japanese, or Mexican participants. The normally distributed parameters can be more formally represented as:

$$B_{ik} = \overline{B}_k + \sigma_k * u_{ik} \qquad (6),$$

where $\overline{B}_k$ is the mean estimate of β_k across all individuals, σ_k is a diagonal matrix containing the standard deviations of $\overline{B}_k$, and u_{ik} is a vector of independent normal deviations for each individual within the population (e.g., within each country). If σ_k is not statistically different from zero, the estimate of $\overline{B}_k$ sufficiently describes the population's preferences implying preference homogeneity within a country. However, statistical significance of σ_k suggests significant preference heterogeneity for attribute *k*.[4]

Random parameters logit model estimated coefficients themselves have little interpretive value. However, relative combinations of select coefficients provide economically meaningful insights on consumer preferences. In particular, the willingness to pay for steak attributes can easily be calculated. Following Nahuelhual, Loureiro, and Loomis (2004) mean WTP for respondents from each country are calculated for each non-price attribute listed in equation (5) at the means of $\mathbf{Z}$ (denoted $\overline{\mathbf{Z}}$). For example, mean WTP for assurance of steak tenderness is given by:

$$Mean\,WTP_{Tender} = \frac{-(\beta_6 + [\frac{\sum_i \boldsymbol{\gamma}'_{Tender}\overline{\mathbf{Z}}}{N}])}{\alpha_0} \quad (7).$$

Not allowing the price coefficient (α_0) to vary randomly ensures a negative price coefficient for all respondents (Lusk, Roosen, and Fox, 2003) and ensures that willingness to pay estimates are normally distributed. To test if the estimated average WTP premiums are statistically different from zero, a Krinsky-Robb (1986) bootstrapping procedure was employed. More specifically, by utilizing the estimated parameter vector and covariance matrix, 1,000 WTP

[4] The resulting model contains 57 parameters to estimate. This estimation, while computationally cumbersome, is feasible given the large data set collected in this study.

estimates were generated from 1,000 randomly drawn parameter vectors. Given these 1,000 WTP estimates, 95% confidence intervals are constructed.

The Krinsky-Robb bootstrapped WTP estimates are further utilized to empirically test for differences in WTP preferences. In particular, a combinational technique suggested by Poe, Giraud, and Loomis (2005) was used to provide a simple nonparametric evaluation of differences in WTP distributions. The difference between two Krinsky-Robb bootstrapped WTP series is evaluated with this difference being calculated for all possible combinations of the two bootstrapped series. In other words, 1,000,000 differences (e.g., $WTP_a - WTP_b\ \forall a,b$; where $a = 1-1{,}000$ and $b = 1-1{,}000$) are calculated for each test. The proportion of simulated differences less than zero represents the probability that $WTP_a < WTP_b$. In other words, this proportion is analogous to a *p*-value associated with the one-sided test of $H_o : WTP_b > WTP_a$. This combinational approach is more precise than simply evaluating if the 95% confidence intervals previously mentioned overlap (Poe, Giraud, and Loomis, 2005).

5. Results

Prior to settling on the random utility model as specified in equations (4) – (6), a wide array of alternative model specifications were considered. While the multitude of model specification tests are not presented here for brevity; log likelihood tests consistently reject the hypothesis that preferences are jointly homogeneous (e.g. $\sigma_k = 0\ \forall k$) and the hypothesis that the consumer characteristic interaction terms are jointly insignificant (e.g $\boldsymbol{\gamma}_l' = 0\ \forall l$). Overall, model fit of the utilized models (table 3) was strong and consistent with other applications of random parameters logits (e.g., Lusk, Roosen, and Fox, 2003).

Estimated models (table 3) result in, as expected, a negative estimate for the fixed *Price* coefficient. Each of the eight standard deviation estimates of preferences for each steak attribute (σ_k) are statistically significant in all four consumer models. This result is consistent with the previously mention log-likelihood tests and suggests that consumer preferences for these steak attributes are statistically heterogeneous within each country. Preference heterogeneity persists even after accounting for consumer's socio-demographic status, beef consumption habits, and perceptions on BSE risk inherent in beef consumption.

By including interaction terms between steak attributes and individual characteristics we were able to account for consumers with different socio-demographic status, beef consumption habits, and perceptions on BSE risk inherent in beef consumption, having different marginal utilities with respect to the steak attributes being analyzed. A number of observed demographic effects shown by the interaction terms are noteworthy. First, many (ranging from 40% in the Mexican model to 70% in the Canadian model) of the interaction terms are statistically significant. For instance, females and consumers with lower frequencies of beef consumption in each of the four countries were more likely to choose the no steak purchase option.

Consumer willingness to pay estimates were simulated (see equation (7)) for the average consumer in each country. Table 4 presents results of these simulations of preferences for beef assured to be produced naturally, guaranteed to be tender, and possessing food safety risk reduction assurances of 40 and 80%, respectively. The typical U.S., Canadian, and Japanese consumer was not willing to pay a premium for *Naturally* produced beef whereas, representative Mexican consumers were willing to pay a small premium of $1.18/lb.

Strong preferences for steak tenderness were revealed for consumer in all four countries. Point estimates of mean WTP for tenderness assurance varied from about $3/lb for U.S.

consumers to approximately $11/lb for Japanese consumers. The average WTP by Japanese consumers may seem high relative to those of consumers in the other three countries. However, grain fed beef strip loin steak price in Japan is two to three times that of similar U.S. steak prices (note the differences in price ranges used in the choice experiments (table1)) (Clayton; Sakamoto). Therefore, the estimated premium for assured tender steak in Japan is similar in percentage to that of the other three countries. To further evaluate differences in WTP across countries, a nonparametric test of WTP differences was conducted and presented in table 5. These tests, combined with the point estimates in table 4, reveal the following relationships: $WTP_{Tender}^{US} \prec WTP_{Tender}^{Mexico} \approx WTP_{Tender}^{Canada} \prec WTP_{Tender}^{Japan}$. One test of homogeneous WTP for tenderness assurance was not rejected comparing Canadian and Mexican preferences.

An important objective of this study was to evaluate consumer preferences for alternative food safety assurances. Table 4 presents estimates of consumer willingness to pay for beef steaks that have different levels of food safety enhancements. Average WTP for 40% and 80% enhancements in food safety relative to standard practices are statistically positive for consumers in each of the four countries. Point estimates for average WTP for a 40% enhancement in food safety ranged from about $1/lb (Mexican consumers) to $3.70/lb (Canadian consumers). WTP for an 80% food safety enhancement ranged from about $4/lb for U.S. consumers to nearly $13/lb for Japanese consumers. Given relative prices of strip loin steak in the different countries, the premiums for enhanced food safety are similar in percentage terms across countries. Japanese consumers drastically reduced beef consumption following BSE discoveries (McCluskey et al. 2005; Peterson and Chen, 2005). Thus, Japanese consumers are willing to pay more for food safety assurances (McCluskey et al. 2005). Table 5 presents results of comparing WTP premiums for enhancements to food safety across countries. Representative Canadian consumers are willing to pay more for a 40% enhanced food safety than consumers in the other three countries. Conversely, with respect to an 80% enhancement in food safety, Japanese consumers are willing to pay more than typical consumers in the other three countries. All six pair-wise tests of equal premiums reveals a statistically significant (at the 0.05 level) ranking for the 80% enhanced food safety assurance of:

$$WTP^{US}_{FoodSafety80} \prec WTP^{Mexico}_{FoodSafety80} \prec WTP^{Canada}_{FoodSafety80} \prec WTP^{Japan}_{FoodSafety80}.$$

To further investigate consumer preferences regarding non-monetary tradeoffs, we compare consumer WTP for tenderness with each level of food safety enhancement assurance and evaluate the distribution of marginal preferences for incremental adjustments in food safety risk reduction. Table 6 presents results of corresponding nonparametric tests comparing WTP series to facilitate these evaluations.

The typical consumer in all four countries is willing to pay significantly more for assured tender steak than for a 40% enhancement in food safety. However, as food safety is enhanced further to 80%, consumers in the U.S. and Canada are statistically willing to pay more for the enhanced food safety than for tenderness assurances at the 0.05 significance level and Japanese consumers are marginally willing to pay more for the safety enhancement (0.055 significance level). On the other hand, Mexican consumers are statistically indifferent between the 80% enhanced food safety and tenderness assurances. From a demand stand point, if consumers deem that only partial success in food safety risk enhancement is achieved (as simulated here by 40% versus 80% enhancements), demand for beef may actually be strengthened more by improvements in tenderness than by what might be perceived as small improvements in food safety management. Conversely, if consumers view improvements in food safety to be more substantial (as in a 80% improvement rather than 40%), consumer beef demand would respond more to food safety improving investments then to assuring steak tenderness.

Table 6 also provides insight into the distribution of marginal utilities for the typical consumer in each country for food safety enhancements. In particular, we tested whether consumer WTP for an 80% enhancement in food safety was greater than twice the premium consumers would pay for a 40% enhancement. This test reveals whether WTP for food safety enhancements are convex, linear, or concave in the level of safety enhancement.

Representative Japanese and Mexican consumers are willing to pay an amount for 80% food safety enhancements that are significantly more than twice what they would pay for a 40% enhancement. That is, their preferences are convex in the level of food safety enhancement. Conversely, the typical U.S. and Canadian consumer have no statistical difference between WTP for 80% and twice the premium for 40% food safety enhancements, suggesting a linear WTP food safety enhancement relationship. These differences are illustrated in Figure 1 using smoothed functions of the WTP point estimates at 0%, 40%, and 80% food safety enhancements to reveal the relationships for each country. Figure 1 (along with table 4) also suggests that if constraints (e.g., state of technology, capital, etc.) are restricting such that only a 40% food safety enhancement is feasible, then investments targeting Canadian consumers may be most advisable. Conversely, if 80% enhancements in food safety are possible, investment targeting Japanese and then Canadian consumers may provide the most opportunity.

6. Managerial Implications

The value of investing in additional food safety assurances rests heavily on the preference structures of heterogeneous consumers being targeted, the relative amount and effectiveness of food safety enhancement consumers perceive by the investment, and the cost structure associated with implementing the proposed food safety enhancement procedures. Our analysis indicates U.S. and Canadian consumers have linear preferences for food safety enhancement whereas Japanese and Mexican consumers have convex preferences. These differences, especially when operating with incomplete information regarding the cost structure associated with food safety enhancement, are vital to note in making optimal food safety enhancement investment decisions.

Given differences in preference structures of targeted consumer groups identified in our research, the optimal decision regarding food safety enhancement will vary both across and within each country. Estimates of "food safety enhancement" costs are difficult to obtain as one would need, at the minimum, a thorough understanding of the procedures enacted to enhance food safety vertically throughout the supply chain and how effective targeted consumers would perceive such procedural changes. Future advancements on these and related critical issues will further enhance the contributions of this study. The general point is that the value of investing in additional food safety assurances rests heavily on the preference structures of heterogeneous consumers being targeted, the relative amount and effectiveness of food safety enhancement consumers perceive by the investment, and the cost structure associated with implementing the proposed food safety enhancement procedures.

7. Conclusion

Food safety concerns have had dramatic impacts on food and livestock markets in recent years. Furthermore, food safety assurances deemed to stabilize these markets and satisfy consumer demand are costly endeavors to implement. Despite this, relatively little research has examined consumer preferences for various beef food safety assurances. In particular, the literature is sparse in evaluating the extent to which such preferences are heterogeneous within and across country-of-residence defined groups and in examining the distributional nature of these preferences with respect to marginal improvements in food safety.

This article addresses these issues by examining an array of beef steak preferences among consumers in the U.S., Canada, Japan, and Mexico. Particular attention is devoted to evaluating how much representative consumers in each country are willing to pay for marginal improvements in food safety while also examining the extent of preference heterogeneity and allowing for non-monetary tradeoffs with food safety.

Representative Japanese and Mexican consumers have preferences that are nonlinear in the level of beef steak food safety enhancement. Conversely, typical U.S. and Canadian consumers appear to possess principally linear preferences. These findings suggest that optimal investment strategies hinge critically upon both consumer perception of actual food safety improvements and the distributional relationship describing the targeted consumer segment's tradeoff function between WTP premiums and risk reduction levels.

If consumers view proposed investments as only marginally improving food safety, the beef industry is better off investing in product eating characteristics such as improved tenderness. Conversely, if the targeted consumer group perceives food safety investments as significantly reducing the level of food safety risk, such investments become more viable options. Care should be taken to note that these comments are made in the absence of policy or other externality factors intervening. This is important given the public good debate and history of various methods of governmental regulation in issues pertaining to food safety.

Here, we discussed the results in terms of a representative consumer for each country. Such an analysis is helpful in understanding how consumers in different countries value food enhancement attributes in relation to other food attributes and will be helpful in developing country specific investments for the food industry. However, it is important to note that the results showed that within a country there is significant heterogeneity in consumer preferences regarding food safety assurance attributes. Further research may help identify observable factors driving this heterogeneity. Improved knowledge of factors motivating consumer behavior with respect to food safety would help policy makers (e.g., governments and industry) identify segment specific food safety activities which would be far more effective than a one size fits all strategy. Pennings and Garcia (2004) made a first attempt to profile segments of decision makers based upon their decision processes. Combining their methodology with that employed in our research increases our knowledge about heterogeneous preferences for food safety attributes.

Improved knowledge of the costs that will be incurred by the beef industry to provide additional food safety assurances could set the stage for valuable extensions of this research. An array of challenges exist in obtaining such information, which are further compounded by the fact that diverse consumer segments perceive alternative food safety risk to be of varying importance. Nonetheless, future work could seek to enhance the understanding of factors influencing the supply of additional food safety assurances utilizing the results presented here pertaining to consumer demand for these attributes.

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Table 1. Steak Product Attributes and Attribute Levels Evaluated in Choice Experiments

Product Attribute	Attribute Label
Country of Origin	Canada
	U.S.
	Japan
	Mexico
Production Practice	Approved Standards
	Natural
Tenderness	Uncertain
	Assured Tender
Food Safety Assurance	Typical
	Enhanced 40%
	Enhanced 80%
Price ($ U.S. / lb.)[a]	$5.00
	$8.00
	$11.00
	$14.00

[a] Prices were differed in each country to be consistent with local price ranges. Presented price options were: in Canada surveys (CAN $/lb) $5.50, $9.00, $12.50, and $16.00; in Mexico surveys (Mexican Pesos/kg) 120, 190, 260, 330; and in Japan surveys (Japanese yen/ 100 grams) 300, 600, 900, 1200.

Table 2. Demographic Variables and Summary Statistics of Choice Experiment Participants

Variable	Definition	U.S. Consumers (N =1009)	Canadian Consumers (N =1002)	Japanese Consumers (N =1001)	Mexican Consumers (N =993)
Gender	1 = Female; 0 = Male	0.83	0.52	0.49	0.80
Age	Average age in years	48.9	47.7	41.8	31.1
Education (Highest Level Completed)					
	1 = Less than High School Graduate	2.30%	1.70%	2.60%	31.01%
	2 = High School Graduate	19.50%	30.40%	32.70%	16.72%
	3 = Some College or Technical (No Bachelor's)	38.80%	40.20%	25.40%	17.92%
	4 = College Bachelor's Graduate	25.40%	17.00%	33.70%	25.98%
	5 = Post-College Graduate	13.80%	7.30%	2.90%	8.26%
	No Response	0.30%	3.40%	2.60%	0.10%
Household Income[a]					
	1 = lower	18.40%	10.20%	33.10%	35.70%
	2 = lower-middle	17.90%	23.10%	21.10%	39.00%
	3 = middle	14.60%	25.50%	21.20%	14.10%
	4 = middle-upper	22.20%	19.20%	12.20%	11.30%
	5 = upper	26.90%	22.10%	12.50%	0.00%
Beef Consumption Frequency (*Consume*)					
	1 = 4 or more times per week	17.74%	12.38%	3.10%	21.55%
	2 = 2-3 times per week	45.39%	47.80%	26.97%	45.62%
	3 = Once per week	20.32%	18.46%	29.37%	21.75%
	4 = 2-3 times per month	8.72%	9.98%	22.28%	7.45%
	5 = Once per month or less	5.35%	6.99%	16.08%	2.42%
	6 = Never	2.48%	4.39%	2.20%	1.21%
Perceived Risk of BSE ("Mad Cow") Related Diseases (*BSE_Risk*)					
	1 = Very High Risk	3.96%	4.99%	28.07%	38.77%
	2 = High Risk	8.13%	4.99%	24.88%	26.08%
	3 = Moderate Risk	18.33%	17.56%	18.58%	16.92%
	4 = Low Risk	24.08%	25.25%	12.39%	7.65%
	5 = Very Low Risk	36.17%	41.02%	8.19%	5.44%
	Don't Know	9.32%	6.19%	7.89%	5.14%

[a] The income groups have country specific ranges: *Canada* (Canadian Dollars): 1: ≤ \$15,000, 2: \$15,000-\$34,999, 3: \$35,000-\$59,999, 4: \$60,000-\$79,999, 5: ≥ \$80,000; *U.S.* (U.S. Dollars): 1: ≤ \$22,500, 2: \$22,500-\$39,999, 3: \$40,000-\$59,999, 4: \$60,000-\$89,999, 5: ≥ \$90,000; *Japan* (Japanese Yen): 1: ≤ 2,000,000, 2: 2,000,000-3,999,999, 3: 4,000,000-5,999,999, 4: 6,000,000-7,999,999, 5: ≥ 8,000,000; *Mexico* (Mexican Peso): 1: ≤ 4,000-6,000, 2: 7,000-21,000, 3: 22,000-54,000, 4: ≥ 55,000.

Table 3. Random Parameters Logit Estimates

Variable/Description	Parameter[a]	U.S. Consumers	Canadian Consumers	Japanese Consumers	Mexican Consumers
CANADA	Mean	0.8738*	2.6061*	0.9943*	0.4281
	Std Dev	2.9636*	2.7309*	2.8371*	2.2733*
U.S.	Mean	3.7294*	0.0226	-0.8651*	0.1660
	Std Dev	2.3536*	2.7506*	3.1761*	2.3629*
JAPAN	Mean	-1.1402*	-1.9656*	2.9157*	-0.3619
	Std Dev	3.2786*	3.4784*	3.2321*	2.5769*
MEXICO	Mean	-1.0254*	-1.8500*	-0.0183	1.1878*
	Std Dev	4.6322*	3.6745*	3.2288*	2.7055*
NATURAL	Mean	-0.9156*	-0.5324*	0.4007*	0.0681
	Std Dev	1.0689*	0.9312*	0.5449*	0.4308*
TENDER	Mean	1.3951*	1.2462*	0.8683*	0.5532*
	Std Dev	0.6824*	0.7729*	0.2986*	0.6311*
FOOD SAFETY 40	Mean	-0.0608	0.5006*	0.0953	-0.1293
	Std Dev	1.0151*	0.7460*	0.6176*	0.5325*
FOOD SAFETY 80	Mean	0.5425*	0.7823*	0.9204*	0.0916
	Std Dev	1.6277*	1.5289*	0.6635*	0.8699*
PRICE	Mean	-0.2948*	-0.1740*	-0.0544*	-0.0989*
*CANADA*FEMALE*	Mean	-0.9386*	-0.4566*	-0.5405*	-0.1854
*CANADA*EDUCATION*	Mean	0.3943*	0.3002*	0.0529	0.0390
*CANADA*INCOME*	Mean	0.0574	0.2695*	0.3539*	0.3846*
*CANADA*CONSUME*	Mean	-0.4903*	-0.6468*	-0.6743*	-0.1321*
*CANADA*BSE_RISK*	Mean	0.4088*	0.2445*	0.4637*	-0.0310
*U.S.*FEMALE*	Mean	-0.5996*	-0.5647*	-1.0784*	-0.1833
*U.S.*EDUCATION*	Mean	0.1093	0.3950*	-0.0714	-0.0221
*U.S.*INCOME*	Mean	-0.1484*	0.2683*	0.3447*	0.3471*
*U.S.*CONSUME*	Mean	-0.3061*	-0.5109*	-0.8609*	-0.1303*
*U.S.*BSE_RISK*	Mean	0.2996*	0.3250*	0.8205*	0.0715
*JAPAN*FEMALE*	Mean	-1.2626*	-1.1279*	0.1098	-0.0659
*JAPAN*EDUCATION*	Mean	0.9277*	0.5445*	0.1338	0.0134
*JAPAN*INCOME*	Mean	0.3082*	0.2722*	0.2551*	0.2567*
*JAPAN*CONSUME*	Mean	-0.6554*	-0.4169*	-0.4906*	-0.1594*
*JAPAN*BSE_RISK*	Mean	0.1868*	0.2695*	0.0386	-0.0225
*MEXICO*FEMALE*	Mean	-1.3665*	-0.6899*	-0.9480*	-0.4616*
*MEXICO*EDUCATION*	Mean	0.8763*	0.3656*	0.0909	0.0267
*MEXICO*INCOME*	Mean	0.4007*	0.2054*	0.3620*	0.3546*
*MEXICO*CONSUME*	Mean	-1.1078*	-0.4631*	-0.7121*	0.0210
*MEXICO*BSE_RISK*	Mean	-0.0704	0.2733*	0.5523*	0.1144*

[a] For normally distributed terms, parameters labeled as *Mean* and *StdDev* correspond to $\overline{B}_k$ and σ_k in equation (6), respectively. The *PRICE* and interaction terms are fixed (e.g., $\sigma = 0$).
[b] One asterisk indicates statistical significance at the 0.05 level.

Table 3. Random Parameters Logit Estimates (continued)

Variable/Description	Parameter	U.S. Consumers	Canadian Consumers	Japanese Consumers	Mexican Consumers
*NATURAL*FEMALE*	Mean	0.2064	0.1287	-0.2488*	0.2138*
*NATURAL*EDUCATION*	Mean	0.0744*	0.0731	-0.0188	-0.0140
*NATURAL*INCOME*	Mean	-0.0063	0.0225	-0.0675*	-0.0279
*NATURAL*CONSUME*	Mean	0.1893*	0.1049*	0.0325	-0.0104
*NATURAL*BSE_RISK*	Mean	0.0068	-0.0496	-0.0344	-0.0013
*TENDER*FEMALE*	Mean	-0.1303	0.1407	-0.0830	-0.1586*
*TENDER*EDUCATION*	Mean	-0.1514*	-0.1608*	-0.0781*	0.0231
*TENDER*INCOME*	Mean	-0.0016	0.0392	-0.0174	0.0336
*TENDER*CONSUME*	Mean	0.0737*	0.0605	0.0018	-0.0935*
*TENDER*BSE_RISK*	Mean	-0.0119	-0.0637*	0.0210	0.0442*
*FOOD SAFETY 40*FEMALE*	Mean	0.3153*	0.4689*	-0.0933	-0.0371
*FOOD SAFETY 40*EDUCATION*	Mean	0.0699	0.0811	-0.0534	0.0098
*FOOD SAFETY 40*INCOME*	Mean	0.0809*	0.0089	0.1293*	0.0585
*FOOD SAFETY 40*CONSUME*	Mean	0.0170	-0.0055	-0.0497	-0.0201
*FOOD SAFETY 40*BSE_RISK*	Mean	-0.0557	-0.0856*	0.0236	0.0677*
*FOOD SAFETY 80*FEMALE*	Mean	0.4047*	0.6761*	-0.0233	-0.0798
*FOOD SAFETY 80*EDUCATION*	Mean	0.0212	0.1785*	-0.1239*	0.0213
*FOOD SAFETY 80*INCOME*	Mean	0.2418*	0.0412	0.0549	0.1439*
*FOOD SAFETY 80*CONSUME*	Mean	-0.0005	-0.1428*	0.0339	-0.0323
*FOOD SAFETY 80*BSE_RISK*	Mean	-0.1422*	-0.0177	-0.0230	0.0739*
Log Likelihood		-14,066.83	-12,854.01	-12,777.66	-17,808.68
Pseudo R^2		0.39	0.42	0.43	0.22

[a] For normally distributed terms, parameters labeled as *Mean* and *StdDev* correspond to $\overline{B}_k$ and σ_k in equation (6), respectively. The *PRICE* and interaction terms are fixed (e.g., $\sigma = 0$).

[b] One asterisk indicates statistical significance at the 0.05 level.

Table 4. Willingness-to-Pay Estimates from Random Parameters Logit

Attribute:		U.S. Consumers	Canadian Consumers	Japanese Consumers	Mexican Consumers
NATURAL	*Upper 95% Confidence Interval*	$ 0.16	$ (0.09)	$ 2.64	$ 1.84
	Point Estimate	$ (0.10)	$ (0.58)	$ 1.20	$ 1.18
	Lower 95% Confidence Interval	$ (0.35)	$ (1.08)	$ (0.20)	$ 0.52
TENDER	*Upper 95% Confidence Interval*	$ 3.33	$ 5.41	$ 12.31	$ 5.22
	Point Estimate	$ 3.11	$ 4.97	$ 11.06	$ 4.52
	Lower 95% Confidence Interval	$ 2.89	$ 4.52	$ 9.70	$ 3.90
FOOD SAFETY 40	*Upper 95% Confidence Interval*	$ 2.00	$ 4.27	$ 3.65	$ 1.78
	Point Estimate	$ 1.71	$ 3.72	$ 1.88	$ 0.97
	Lower 95% Confidence Interval	$ 1.40	$ 3.17	$ 0.05	$ 0.18
FOOD SAFETY 80	*Upper 95% Confidence Interval*	$ 4.18	$ 8.32	$ 14.71	$ 5.82
	Point Estimate	$ 3.87	$ 7.73	$ 12.93	$ 4.78
	Lower 95% Confidence Interval	$ 3.52	$ 7.10	$ 11.02	$ 3.73

[a] All willingness-to-pay estimates are presented in U.S. Dollars/lb and were simulated following equation (7).
[b] Confidence intervals were derived using 1,000 repetitions of the Krinsky-Robb bootstrapping method.

Table 5. Willingness-to-Pay Hypotheses Tests Across Countries

H_o: WTP TENDER is Homogeneous Across Countries	CANADIAN WTP	JAPANESE WTP	MEXICAN WTP
U.S. WTP	0.0000	0.0000	0.0000
CANADIAN WTP	-----	0.0000	0.1524
JAPANESE WTP		-----	0.0000
H_o: WTP FOOD SAFETY 40 is Homogeneous Across Countries	CANADIAN WTP	JAPANESE WTP	MEXICAN WTP
U.S. WTP	0.0000	0.4171	0.0482
CANADIAN WTP	-----	0.0317	0.0000
JAPANESE WTP		-----	0.8066
H_o: WTP FOOD SAFETY 80 is Homogeneous Across Countries	CANADIAN WTP	JAPANESE WTP	MEXICAN WTP
U.S. WTP	0.0000	0.0000	0.0436
CANADIAN WTP	-----	0.0000	0.0000
JAPANESE WTP		-----	0.0000

[a] All willingness-to-pay estimates are presented in U.S. Dollars/lb and were simulated following equation (7).
[b] Table presents *p*-values determined using the nonparametric combinational method of Poe, Giraud, and Loomis to 1,000 Krinsky-Robb bootstrapped WTP estimates.

Table 6. Willingness-to-Pay Hypotheses Tests

Hypothesis Test:		U.S. Consumers	Canadian Consumers	Japanese Consumers	Mexican Consumers
Ho: WTP *TENDER* = WTP *FOOD SAFETY 40*	Difference in WTP Point Estimates	$ 1.40	$ 1.25	$ 9.18	$ 3.55
	p-value of Hypothesis Test	0.0000	0.0004	0.0000	0.0000
Ho: WTP *FOOD SAFETY 80 = WTP TENDER*	Difference in WTP Point Estimates	$ 0.76	$ 2.76	$ 1.87	$ 0.26
	p-value of Hypothesis Test	0.0001	0.0000	0.0548	0.3481
Ho: WTP *FOOD SAFETY 80 = 2*WTP FOOD SAFETY 40*	Difference in WTP Point Estimates	$ 0.45	$ 0.28	$ 9.18	$ 2.84
	p-value of Hypothesis Test	0.1019	0.3201	0.0001	0.0026

[a] All willingness-to-pay estimates are presented in U.S. Dollars/lb and were simulated following equation (7).
[b] Table presents *p*-values determined using the nonparametric combinational method of Poe, Giraud, and Loomis to 1,000 Krinsky-Robb bootstrapped WTP estimates.

Figure 1. Consumer WTP for Enhanced Food Safety