

Consumer Response to Genetically Modified Food Products in Japan

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Abstract

In Japan, a large U.S. export market, there has been growing public opposition against genetically modified (GM) foods. We estimate willingness to pay for GM-free food product and analyze factors that induce Japanese consumers to choose GM-free food products. The results suggest that Seikyou (consumer cooperative) customers in Japan are willing to purchase GM noodles with a 60% discount and GM tofu with a 62% discount. Finally, we analyze factors that affect self-reported risk perceptions associated with GM foods.

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Introduction

Biotechnology has been touted as the future of agriculture. However, the business leaders, producers, and scientists involved in biotech did not foresee how controversial genetically modified (GM) foods would be, particularly for export markets such as Japan. A better understanding of consumer attitudes and behavior toward genetically modified food products in these export markets is essential for designing market strategies.

In Japan, thirty-four local self-governing bodies are engaged in research and development of GM products (Asahi Shinbun 2001). However, most of their products will not be marketed in Japan because of the growing public opposition against GM foods. Reflecting this trend, U.S. export orders for soybeans and corn that are not genetically modified have increased even at premium prices. In the United States in 1999, premiums of 8 to 15 cents per bushel were offered for non-GM corn, and premiums of 5 to 35 cents per bushel were offered for non-GM soybeans at the farm level. In response, some Japanese food companies and farmers have switched to non-GM ingredients and seeds. For instance, Asahi and Kirin, the two Japanese leading beer companies, will switch entirely to non-GM ingredients, and soybean farmers who do not use GM seeds are enjoying a huge demand for their beans (Tolbert 2000).

Labeling policy of GM foods is rapidly evolving worldwide. Japan's new system of labeling GM foods went into effect on April 1, 2001. Foods made from GM crops are now required to be labeled as "genetically modified." Foods made from non-GM crops, which have been identity preserved, can be voluntarily labeled as "not genetically modified." Finally, there is a mandatory labeling requirement for foods that have not been identity preserved. They must be labeled as "not segregated from GM product." In fact, while few products carry labels as

“genetically modified”, many products claim to be free of genetically modified organisms (GMOs) or “GMO-free” (Shimano Mainichi Shinbun 2001). GM status labels provide consumers not only information, but they present the opportunity to choose. McCluskey (2000) argues that the appropriate labeling policy for GM foods depends on the size of the market and willingness to pay for GMO-free foods relative to the costs of identity preservation.

The heated debate over labeling issues in Japan reflects increasing consumer concern about food safety including effects on human health and the environment. Several consumer groups, who are against genetic modification of food, insist on mandatory labeling of GM food products. These groups campaigned against GM products as being not adequately tested for safety. Some school lunch programs are trying to serve foods that are GMO-free to the extent possible. Even so, the Japanese Ministry of Agriculture has been trying to convince consumers that GM products are safe to eat.

In this study, we estimate consumers’ willingness to pay for GM-free food products and analyze consumers’ choices and risk perception associated with GM foods. The paper is organized as follows: In the following section, we review the literature on consumer preferences and attitudes towards GM foods. We then discuss the Japanese survey data that is utilized in this study. Next, we discuss three empirical analyses. First, we use a semi-double-bounded logit model to estimate the mean willingness to pay for GM foods. Second, we use a multinomial logit model to analyze factors that affect whether consumers choose GM food products. Third, we use a multinomial logit model to analyze factors that affect the level of risk perception. Finally, we close with some concluding remarks.

Previous Studies

In recent years, the issue of GMO labeling has received considerable attention. However, there are only a few studies that analyze consumer willingness to pay (WTP) for food products that contain GM ingredients. Lusk *et al.* (2001) estimates willingness to pay for corn chips made without genetically modified ingredients. In their experimental study, junior and senior-level agricultural economics students at Kansas State University indicate their maximum WTP by exchanging a bag of GM corn chips for a bag of GM-free corn chips. They find that an individual who is very concerned about GM foods would be 50% more likely to be willing to pay a premium to exchange GM chips for non-GM chips than an individual with little concern for GM foods. However, their results indicate that 70% of all participants state that they are not willing to pay a premium for non-GM chips. The average bid to exchange GM chips for non-GM chips is \$0.07/oz. Still, 20% of participants are willing to pay at least \$0.25/oz. for the exchange, and 2% offer bids of \$0.50/oz., suggesting that there may be a potential niche market in the United States for GM-free food products.

A small number of survey studies assess consumer perceptions about food safety and biotechnology in developed societies including the United States and Japan. Jussaume and Judson (1992) examine the effect of characteristics on consumer attitudes towards food safety. They use mail surveys in Seattle and Kobe, Japan, to examine differences between consumers in the two countries. Their findings indicate that residents of Kobe are significantly more concerned about food safety than residents in Seattle. For both countries, they find that households with children under the age of 18, who belong to consumer cooperatives, and with relatively high incomes are more likely to care about food safety issues.

Hoban (1999) studies consumer awareness and acceptance of biotechnology and willingness to purchase GM foods using a telephone survey conducted in Japan and the United States in 1995 and 1998. Despite the recent controversy over GMOs, he finds increasing acceptance of biotechnology used for food production by Japanese and U.S. consumers from 1995 to 1998, and increasing numbers of consumers who are willing to buy GM foods in both countries. He concludes that the use of biotechnology does not negatively affect consumers' willingness to purchase those foods. However, he insists that consumer awareness and understanding of biotechnology is relatively still low in Japan compared with the United States.

Consumer attitudes towards biotechnology have been changing since Hoban's study as more information has been provided to public primarily by media. Macer and Chen Ng (2000) report that support for biotechnology and genetic engineering in Japan is decreasing, especially for agricultural applications. They use a mail survey that spans the years 1991, 1993, 1997 and 2000 and find that Japanese interest in science and biotechnology increases from 30% in 1991 to 47% in 2000. From the 2000 survey, 97% of respondents are familiar with the term "biotechnology", which implies that awareness of biotechnology has increased significantly among the Japanese public. Also from the 2000 survey, only 31% are likely to support GM foods, and only 20% say they are willing to buy GM fruits. Macer and Chen Ng conclude that although the majority of Japanese consumers are optimistic about biotechnology, there are increasingly negative views towards its application for agriculture.

Data

The survey used in this study was pre-tested with Japanese subjects in Nagano and Matsumoto, Japan, and conducted at the Seikyou consumer cooperative, a grocery store-like setting, in

Matsumoto, Japan during June 2001. The survey data was collected with in-person interviews. By collecting data from consumers at the same time and place where actual purchase decisions are made, we hoped to better elicit consumers' true preferences about the products. Respondents were selected randomly with the criterion that the interviewer was to solicit every third customer who came in the survey area. Every respondent was given a gift certificate (worth approximately \$12 in Japanese Yen) as an incentive to participate in the survey. Even with this participation incentive, the turndown rate was about 50%.

In total, 400 consumers were surveyed. The majority of respondents are the primary food shoppers of the household (77%) and female (78%). Sixty-seven percent of those shoppers shop for groceries daily or between two and five times a week. The respondents' average age is 46 years, and 54% of all respondents have children under the age of 18 years old living in their household. The average household income as a whole family ranges between 5,100,000 yen (U.S.\$42,011) and 7,600,000 yen (U.S.\$62,604)¹ for the 2000 fiscal year, and their average education included some years of college. Summary statistics and variable descriptions are presented in Table 1.

As in all surveys, sample representativeness is of concern. The potential bias of greatest concern in this study is the population choice bias, in which the population chosen does not adequately correspond to the population that will purchase genetically modified food products. Consumer cooperatives usually focus on offering “safe foods” as a marketing strategy and target members who are more willing to purchase safe foods (Jussaume 1998). In Japan, the consumer cooperative, especially Seikyou, has significant power in the marketplace. Since most shoppers at Seikyou are members of the consumer cooperative, we expect that they have stronger concerns

about food safety than consumers who shop other grocery stores. Another potential bias is that Matsumoto is an agricultural area. Residents of Matsumoto may be more closely associated with agricultural production and have more knowledge about the production processes and their safeness. We suspect that agricultural residents are less sensitive to GM products. Given the preceding concerns, we acknowledge that the extent to which the findings can be fully generalized to broader populations is uncertain.

The survey responses include information regarding respondents' attitudes about imported products, the environment, food safety, their familiarity with and perceptions about GM food products, and socio-demographic information. Information about environmental and food safety attitudes is based on trade-off situations between environmental quality and economic growth and between food safety and food prices. (The actual questions used to elicit consumers' environmental attitudes and food safety concerns are presented in the Appendix.) Eliciting these attitudes from trade-off scenarios is an effective way of ensuring that survey information was informative as well as useful in an empirical modeling context. For example, without the tradeoff, most respondents will say that they value the environment highly. The lack of variation in response can lead to statistical insignificance of the effect of the environmental variable, and in the extreme if all responses are uniform, the effect is statistically unidentifiable

Regarding environmental and food safety attitudes, 65% of the customers assign more importance to preserving the environment than economic growth, and 74% placed more importance on food safety issues than price. Variable definitions and summary statistics for the questions related to consumers' environmental and food safety attitudes and perceptions about genetically modified foods are presented in Table 2.

Finally, contingent valuation questions regarding willingness to pay for tofu containing genetically modified soybeans and noodles made from genetically modified wheat were asked using a dichotomous choice format. Not surprisingly, of the 400 respondents only 16 and 12 said that they would be willing to purchase the genetically modified tofu and noodles without a discount, respectively. Further, only 15% (for tofu) and 17% (for noodles) of consumers state that they would purchase the GM tofu and noodles with the randomly assigned discount offers. The rest of the respondents state they would not purchase GM products even with the discounts.

Empirical Analysis

The empirical analyses associated with this research is divided into three sections: consumer willingness to pay methodology and estimation results, analysis of factors affecting consumer choice of GM products, and analysis of factors affecting perception of risk associated with GM products.

Consumer Willingness to Pay Estimation Methodology

The contingent valuation method (CVM) has become a standard approach to elicit people's willingness to pay (WTP) through dichotomous choice, market-type questioning format with a direct survey such as via telephone, mail, and in-person questionnaire (Kanninen 1993). In the dichotomous choice CVM, each respondent is asked whether or not he/she would be willing to pay a particular price for a particular good in a hypothetical market, letting him/her answer with "yes" or "no" along with the dollar "bid" amounts offered to each individual. The hypothetical market for the good in question must be as close as possible to a real market in order to reveal people's true preferences if an actual market existed (Pearce and Kerry 1990). Food products used in our study, noodles and tofu, are appropriate to be examined since they are

frequently consumed food products by the most Japanese population: 310 out of 400 respondents (78%) said they consumed tofu daily or more than once a week.

There are two types of bidding procedures used in the CVM: the single-bounded and double-bounded dichotomous choice with the double-bounded model gaining popularity (Kanninen 1993). The single-bounded model approach finds the bid amount as a threshold by asking only one dichotomous choice (Hanemann *at el.* 1991). The statistical efficiency of this conventional approach can be improved by use of the double-bounded model, which engages in two bids. Respondents are asked if they were willing to pay the initial dollar bid amount. Given a second follow-up bid amount, higher or lower according to the response to the first bid, they are asked again to choose a product they choose. In the double-bounded model, there are four possible outcomes: “yes” to both bids; “no” to both bids; a “yes” followed by a “no”; and a “no” followed by a “yes”.

In order to elicit consumer preferences and willingness to pay for GM food products, we build on the double-bounded logit model and develop a “semi-double-bounded” logit model, which is more applicable to examine outcomes of our survey. Each participant is presented with an initial bid of no discount for the GM food products. If the individual responds “yes”, meaning that he/she is willing to purchase the GM food product at no discount, then no follow-up question is asked because of the nature of the product. The type of genetic modification associated with the products in question is a *process attribute*, which reduces costs—as opposed to a *product-enhancing* attribute. The one example of a product with a product-enhancing attribute is the Flavr Savr Tomato. Proponents claim that the GM products with process attributes are identical to GM-free products. Opponents view genetic modification as a negative attribute. Therefore, it would not make economic sense to pay a premium for these GM products

with only cost-reducing attributes. On the other hand, if the individual responds “no”, meaning that he/she is not willing to purchase the GM food products without a discount, then, he/she is presented with a second bid which includes some positive discount for the GM food products. Therefore, in our semi-double-bounded model, there are three possible outcomes, instead of the four possible outcomes in the standards double-bounded model. They are: (a) “no” to both bids, (b) a “no” followed by a “yes”, and (c) a “yes”.

The bids in our model are based on price differentials. The initial bid (B_0) is zero, implying there is no price difference between GM and GM-free food products. The second bid (B_H) is only given to those individuals who answer that they will not buy GM food products at equal prices. The second bid takes the form of random percentage discount. In the context of the survey outcomes, two “no” responses mean that the person is not willing to purchase the GM-product even with a discount. This means that he/she has a high WTP for GM-free food products. By the same logic, a person who answers with a “no” followed by a “yes” has an intermediate WTP for GM-free food products. Finally, a person who answers “yes” to the first question is not willing to pay any premium for GM-free food products. With this bid information, we estimate how much of a relative discount Japanese consumers will require to purchase GM food products. We interpret these results as consumers’ willingness to pay for GM-free foods.

The sequence of questions isolates the range in which the respondents’ true WTP lies, placing it into one of the following three intervals: $(-\infty, B_0]$, $(B_0, B_H]$, or $(B_H, +\infty)$. The second bid, in conjunction with the response to the initial preference decision, allows both an upper and a lower bound to be placed on the respondent’s unobservable true WTP. Therefore, the following discrete outcomes of the bidding process are observable:

$$(1) \quad D = \begin{cases} 1 & WTP \leq B_0 \\ 2 & B_0 < WTP \leq B_H \\ 3 & B_H < WTP, \end{cases}$$

where WTP denotes the individual's WTP (or bid function) for the particular GM-free food product. Respondents who indicate the lowest WTP for GM-free foods fall into the first group. Those who fall into the second group indicate intermediate WTP for GM-free foods. Finally, those who indicate the highest WTP for GM-free fall into the third group. The WTP function is represented as:

$$(2) \quad WTP = \alpha - \rho B + \lambda' \mathbf{z} + \varepsilon$$

where B is the bid amount each consumer faces, \mathbf{z} is a column vector of observable characteristics of the individual, ε is a random variable accounting for unobservable characteristics, and α , ρ , and λ are unknown parameters to be estimated. Assuming linearity in \mathbf{z} and ε and letting $\varepsilon \sim G(0, \sigma^2)$, where $G(0, \sigma^2)$ denotes a cumulative distribution function with mean zero and variance σ^2 , the choice probabilities can be characterized as²:

$$(3) \quad \text{prob}(D = j) = \begin{cases} G(\tilde{\alpha} - \tilde{\rho}B_0 + \tilde{\lambda}'\mathbf{z}) \\ G(\tilde{\alpha} - \tilde{\rho}B_H + \tilde{\lambda}'\mathbf{z}) - G(\tilde{\alpha} - \tilde{\rho}B_0 + \tilde{\lambda}'\mathbf{z}) \\ 1 - G(\tilde{\alpha} - \tilde{\rho}B_H + \tilde{\lambda}'\mathbf{z}) \end{cases} \text{ for } j = \begin{cases} 1 \\ 2 \\ 3 \end{cases}$$

Thus, the log likelihood function becomes:

$$(4) \quad L = \sum_i \left\{ \begin{array}{l} I_{D_i=1} \ln G(\tilde{\alpha} - \tilde{\rho}B_{0i} + \tilde{\lambda}'z_i) + I_{D_i=2} \ln [G(\tilde{\alpha} - \tilde{\rho}B_{Hi} + \tilde{\lambda}'z_i) - G(\tilde{\alpha} - \tilde{\rho}B_{0i} + \tilde{\lambda}'z_i)] \\ + I_{D_i=3} \ln [1 - G(\tilde{\alpha} - \tilde{\rho}B_{Hi} + \tilde{\lambda}'z_i)] \end{array} \right\}$$

where I_K is an indicator function for the event K , $D_i = j$ denotes that the j^{th} alternative occurred, and i denotes individual i . In the empirical implementation of the model, we define $G(\cdot)$ to be the standard logistic distribution with mean zero and standard deviation $\sigma = \pi / \sqrt{3}$.

WTP Estimation Results

We estimate the parameters in the log likelihood function given in (4) with the restriction that $\lambda = 0$ (Hanemann *et al*, 1991). From the parameter estimates we can calculate the empirical mean WTP for each of the GM-free by $\hat{\alpha} / \hat{\rho}$. Our results indicate that Seikyuu members are willing to pay a 60% premium for GM-free noodles over GM noodles and a 62% premium for GM-free tofu over GM tofu. As explained above, these WTP results are premiums consumers would be willing to pay for GM-free food products relative to GM food products. The high premiums are reasonable given how relatively few people indicated their willingness to purchase GM foods either at the equal prices or discounted prices.

It is also important to analyze factors that affect the choice of GM food products. In the next section, we analyze what personal characteristics and perceptions about biotechnology impact consumers' decisions to purchase of GM food products.

Estimation and Results: Effects on Consumers' Choices

The discrete choice of either GM or GM-free food products is modeled within a multinomial logit framework. The theoretical foundations of the (unordered) multinomial logit model lie in the random utility model approach (Mittelhammer *et al*. 2000). The i^{th} consumer's

utility derived from the selection of tofu/noodles of type j (GM and GM-free) can be represented as for noodles:

$$(5) \quad U_{ij}^{noodles} = \beta_{0j} + \beta_{1j}FoodSafety_i + \beta_{2j}Knowledge_i + \beta_{3j}Perception_i + \beta_{4j}Label_i + \beta_{5j}FamilySize_i + \beta_{6j}NoodleDiscount_i + \varepsilon_{ij},$$

and for tofu:

$$(6) \quad U_{ij}^{tofu} = \gamma_{0j} + \gamma_{1j}FoodSafety_i + \gamma_{2j}Knowledge_i + \gamma_{3j}Perception_i + \gamma_{4j}Label_i + \gamma_{5j}FamilySize_i + \gamma_{6j}Shopper_i + \gamma_{7j}Gender_i + \gamma_{8j}TofuDiscount_i + \varepsilon_{ij}.$$

where U_{ij} denotes the utility level that the i^{th} consumer receives if he or she chooses the j^{th} alternative (either GM or GM-free foods). The explanatory variables include individual specific characteristics, which may affect utility derived from consuming GM foods. *FoodSafety* represents food safety attitudes, *Knowledge* is the respondent's self-reported knowledge about biotechnology, *Perception* represents the respondent's attitudes about the use of biotechnology, *Label* is the respondent's assessment of the importance of labeling GM food products, *FamilySize* is the number of people in the respondent's household, *NoodleDiscount* and *TofuDiscount* are the respective amounts of discount, *Shopper* indicates whether the respondent is the main shopper, and *Gender* indicates that the respondent is female. Finally, ε_{ij} is the residual error term, which captures errors in perception and in the overall representation of the level of utility. Notice that the utility from choosing the j^{th} alternative is not observable, but the consumer's choice is observable.

Other explanatory variables are excluded because they are statistically insignificant. For example, unexpectedly, age and presence of children under the age of 18 in the household do not

have significant impact on choice for either of GM food products. This may imply that concern about GM food cuts across age groups and family composition. Toyama (2001) finds age differences are not a significant factor affecting knowledge and attitudes about food biotechnology, in her consumer survey conducted in Kumamoto, Japan. Additionally, income and education are excluded from our analysis. Jussaume and Lorie (1998) do not include age, income and education variables in their model of concerns about food safety in Japan due to the low levels significance of these variables.

We use the method of maximum likelihood to estimate [5] and [6]. The results are presented in Table 3. In addition, the marginal effects of the explanatory variables on the probability of choosing GM noodles and tofu are presented in Table 4. We find that the variables have similar effects on consumer choice for both GM food products. The results of the marginal effect analysis indicate that self-reported knowledge about biotechnology, views on labeling GM ingredients, and family size have a negative effect on probability of choosing GM noodles and tofu. If a respondent reports him/herself to be knowledgeable about genetic modification in food production, it is less likely that he/she will buy GM food products. Similarly, if the respondent thinks it is important for food with genetically modified ingredients to be labeled, he/she will less likely to be willing to buy GM foods. As family size increases, willingness to buy GM foods diminishes. This result supports Toyama (2001) findings that Japanese households with children and older than forty-six years old show more concern about food safety.

Being female negatively affects the likelihood of choosing GM foods. Toyama (2001) obtains similar results that females have more negative feeling toward food biotechnology. The probability of choosing GM food products increases when a respondent perceives the use of

biotechnology for agricultural production positively. Similarly, strong food safety attitudes decrease the likelihood that the consumer will choose GM foods. When an individual places high importance on lower food prices rather than safe food, the probability of choosing GM foods will increase by 57% and 51% for GM noodles and tofu, respectively. Finally, as expected, a higher discount increases the likelihood of choosing GM food products.

One would expect for consumers' perception of risk associated with GM foods to affect the choice GM food products. The use of biotechnology in agriculture has created concern about possible risks to human, animal, and plant health and life, and to the environment (Caswell 2000). A lot has been written about the perceived and real risks and benefits associated with GM foods. Bredahl (2001) points out that risk perceptions determine how consumers perceive benefits and costs associated with the use of genetic modification in food production and also affect their purchase intentions of GM foods.

Estimation and Results: Effects on Perceived Risks Associated with GM Food Products

We find that 42% of respondents perceive low level of risk associated with GM foods, 33% perceive high level of risk, and 32% answer they do not associate any risk or do not know. We use the following multinomial logit model to analyze factors that affect the level of risk perceptions:

$$(6) \quad Risk_{ij} = \beta_{0j} + \beta_{1j} Environment_i + \beta_{2j} Knowledge_i + \beta_{3j} Perception_i + \beta_{4j} Import_i + \beta_{5j} Gender_i + \beta_{6j} WTPnoodle + \beta_{7j} WTPtofu + \varepsilon_{ij}$$

where $Risk_{ij}$ denotes the type of perceived risk ($j =$ high risk; low risk; or no risk/“don't know”) that consumer i reported, $Import$ denotes that the respondent prefers domestic foods to imported foods, and $WTPnoodle$ and $WTPtofu$ denote the individual's WTP (or bid function) for the

respective GM-free food product. We present the results in Table 5, and the marginal effects of those variables on the level of risk are presented in Table 6. Other socio-demographic variables have been excluded since they are not statistically significant.

The model estimates the effect of the explanatory variables on the probability of perceiving the high level of risk more precisely than for low level of risk. We find that concern about the environment increases the probability of perceiving high levels of risk. Respondents with greater environmental values have perceived risk associated with GM foods that is 21% higher. On the other hand, environmental concerns have a negative, although not statistically significant, effect on the probability of perceiving low or no risk or “don’t know”. Similarly, high respondent reported knowledge about biotechnology positively affects the probability of perceiving high risk, while the probability of low and no risk or “don’t know” are negatively related with the self-reported level of knowledge. This implies that the consumers who perceive themselves as more knowledgeable also perceive more risk. Being female makes one more likely to perceive that there are high levels of risk associated with consuming GM foods. WTP for GM-free noodles and tofu strongly affects the probability of having a high level of perceived risk.

When a respondent prefers domestic foods to imported foods, the probability of high perceived risk increases. Most Japanese consumers prefer domestic foods even though they did not associate with any risk or they did not care about risks. Toyama (2001) finds that 44% of 309 Japanese consumers try to avoid imported foods because of food safety or GM food concerns. The same study also shows that 61% of respondents try to avoid imported foods, but they sometimes buy imported foods without knowing it. In general, Japanese consumers have tendency to choose domestically produced foods at all levels of risk perceptions.

Conclusions

A better understanding of Japanese consumers' attitudes and behavior toward genetically modified food products will be essential for designing market strategies for Japan. In this study, we consider factors that induce certain consumers to choose GM-free food products and their willingness to pay for these products. From the results, we conclude that most consumers will require a significant discount to purchase GM food products.

This study underscores the importance and complexity of the interactions between consumer attitudes, socio-demographic realities, relative prices, and the ultimate actual value of GM food products to consumers, which leads to the realized effects on prices of labeling for agricultural producers.

Our study analyzes Japanese consumers' WTP for GM food products. To estimate consumer WTP, we develop a semi-double-bounded logit model. Although the double-bounded dichotomous choice model is commonly used for estimating WTP, the semi-double-bounded model better suits the case of a product with a cost-reducing attribute. The results suggest that Seikyou consumers are willing to purchase GM noodles with a 60% discount and GM tofu with a 62% discount. Alternatively, these discounts can be expressed as 60% and 62% WTP premiums for GM-free noodles and tofu.

We use a multinomial logit model to estimate factors affecting the choice of GM food products. We find that consumers who are less concerned about food safety, less knowledgeable about biotechnology, more positive about the use of biotechnology in food production, and less concerned about labeling of GM foods are more willing to choose GM food products when they are offered more discounts on GM foods. Also, female consumers with larger families are more willing to pay for GM foods.

We use a second multinomial logit model to analyze risk perceptions associated with GM foods. The results show that concern about environment, self-reported knowledge about biotechnology, less favorable perceptions about the use of biotechnology in foods, WTP for GM-free foods, and preferences for domestic foods increase individual perception of risk associated with GM foods.

Although our findings may overestimate the attitudes and preferences compared with the general Japanese population, this study should be useful for marketers who want to sell food products in Japan. Risks associated with GM foods and negative feelings toward the use of biotechnology for agriculture may be the key barriers to Japanese consumers preventing them from choosing GM foods. Producers and the government will need to convince people of the safety of consuming GM foods.

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Table 1: Summary Statistics for the Demographic Variables

Variable	Description	Frequency	Mean	Std. Dev.
Age	Age of the consumer	≤ 30 years = 12 % 30 to 50 = 50% 50 to 70 = 32% >70 years = 5%	45.63	13.88
Gender	1 if female, 0 if male		0.78	0.42
Shopper	1 if main shopper 0 otherwise		0.76	0.43
Education	1 = compulsory school 2 = HS diploma 3 = 2-year college 4 = 4-year degree 5 = Adv./Prof. degree 6 = N/A	= 3.75% = 42.5% = 19.5% = 17.25% = 13.5% = 3.5%	2.94	1.16
Children	1 if children <18 in the household 0 otherwise		0.54	0.5
Total Children	Number of children in the household	0 = 46.5% 1 = 22.25% 2 = 23.25% 3 = 7.75% >3 = 0.25%	0.93	1.01
Income (000)	1 = <2,500 yen 2 = 2,510-5,000 yen 3 = 5,010-7,500 yen 4 = 7,510-10,000 yen 5 = >10,010 yen 6 = N/A	1 = 3.75% 2 = 22.25% 3 = 26% 4 = 15.75% 5 = 11.5% 6 = 20.75%	6.35	2.5

Table 2: Summary Statistics for Consumer Information and Perception Variables

Variable	Description	Scaled Values	Mean	Std. Dev.
Environment	Importance of environmental sensitivity vs. economic growth	(1,10)	6.53	1.88
Food Safety	Importance of food safety versus price	(1,10)	3.15	1.94
Risk of GMO	No risk, some risk, or high risk	(0, 1, 2)	1.07	0.76
Perception	Favorable opinion toward Use of Biotech	(0, 1)	0.12	0.32
Knowledge about Biotechnology	Self-Reported knowledgeable about biotech	(0, 1)	0.82	0.39
Labeling GMO	Views about the Importance of labeling GM foods	(0, 1)	0.98	0.13
Import	Preference of domestic vs. imported food products	(0, 1)	0.92	0.28

Table 3: Multinomial Logit Model Results (P-values are in parentheses), Dependent Variable, Z=choice of GM food

Variables	Estimated Coefficients	
	Noodle with GM Wheat	Tofu with GM Soybeans
Constant	0.2903 (0.8253)	-1.8360 (0.1198)
Food Safety	0.4726 (0.0000)	0.4925 (0.0000)
Knowledge about Biotech	-0.7603 (0.0371)	-0.7733 (0.0340)
Perception	2.1244 (0.0000)	2.3077 (0.0000)
Labeling GMO	-3.4178 (0.0080)	-1.6213 (0.1176)
Shopper		1.4040 (0.0217)
Family Size	-0.1965 (0.1062)	-0.2849 (0.0796)
Gender		-1.4493 (0.0133)
Noodle Discount	3.3921 (0.0002)	
Tofu Discount		3.7504 (0.0001)

n=400

Chi-square (GM noodles, GM tofu) =112.8598, 109.4555

DF (GM noodles, GM tofu) =7, 9

Table 4: Multinomial Logit Marginal Effects (P-values are in parentheses)

Variables	Noodle with GM Wheat	Tofu with GM Soybeans
Constant	0.3484 (0.8261)	-0.1896 (0.1083)
Food Safety	0.5673 (0.0000)	0.5084 (0.0000)
Knowledge about Biotech	-0.9128 (0.0367)	-0.7984 (0.0348)
Use of Biotech	0.2550 (0.0000)	0.2383 (0.0000)
Labeling GMO	-0.4103 (0.0111)	-0.1674 (0.1257)
Shopper		0.1450 (0.0186)
Family Size	-0.2359 (0.1021)	-0.2941 (0.0752)
Gender		-0.1496 (0.0117)
Noodle Discount	0.4072 (0.0002)	
Tofu Discount		0.3872 (0.0000)

n=400

**Table 5: Probability of Perceiving Different Level of Risk with GM Foods
Multinomial Logit Model Results (P-values are in parentheses)**

Variables	Estimated Coefficients	
	Low Level Risk	High Level Risk
Constant	-0.5414 (0.4339)	-2.2444 (0.0048)
Environment	0.1369 (0.0543)	0.2588 (0.0013)
Knowledge about Biotech	0.6186 (0.0474)	1.0639 (0.0080)
Use of Biotechnology	-0.4768 (0.2181)	-0.6259 (0.2359)
Imported Foods	-0.5831 (0.2296)	-0.3855 (0.4271)
Gender	0.5888 (0.0467)	0.9805 (0.0066)
WTP GM Noodle	-0.1638 (0.6232)	-1.1941 (0.0116)
WTP GM Tofu	-0.1803 (0.5960)	-1.3961 (0.0072)

n=400
Chi-square=81.3844
DF=14

**Table 6: Probability of Perceiving Different Level of Risk with GM Foods
Multinomial Logit Marginal Effects (P-values are in parentheses)**

Variables	No Risk/Don't Know	Low Risk	High Risk
Constant	0.9411 (0.5205)	0.1770 (0.2948)	-0.2711 (0.0001)
Environment	-0.1697 (0.3434)	-0.4607 (0.8048)	0.2158 (0.0047)
Knowledge about Biotech	-0.7433 (0.3420)	-0.7123 (0.9389)	0.8145 (0.1547)
Use of Biotech	0.5299 (0.3805)	-0.1974 (0.8261)	-0.3325 (0.6578)
Imported Foods	0.5640 (0.0000)	-0.7356 (0.0000)	0.1717 (0.0016)
Gender	-0.7004 (0.2920)	-0.2598 (0.9736)	0.7263 (0.1361)
WTP GM Noodles	0.3987 (0.4207)	0.1206 (0.1640)	-0.1604 (0.0175)
WTP GM Tofu	0.4570 (0.3980)	0.1433 (0.1360)	-0.1890 (0.0120)

n=400

Table 7: WTP Premium for GM Noodles and Tofu (%) with Confidence Intervals

	$\tilde{\alpha}$	$\tilde{\rho}$	WTP Point Estimate	95% Confidence Interval
Estimates from Semi- Double- Bounded Model for Noodles	2.7607	4.5714	$\tilde{\alpha} / \tilde{\rho} = 0.6039$	$(0.4619, 0.7459)^1$
Estimates from Semi- Double- Bounded for Tofu	2.8599	4.5597	$\tilde{\alpha} / \tilde{\rho} = 0.6272$	$(0.4611, 0.7933)$

¹ This confident interval was calculated using the delta-method, which approximates the asymptotic variance of the ratio of two random variables as (see Kanninen, 1993):

$$a\sigma^2\left(\frac{-\alpha}{\rho}\right) \cong \frac{1}{\rho^2} \left[\left(\frac{a}{\rho}\right)^2 \sigma^2(\alpha) - 2\left(\frac{\alpha}{\rho}\right) \text{cov}(\alpha\rho) + \sigma^2(\rho) \right].$$

APPENDIX A

QUESTIONS USED TO ELICIT FOOD SAFETY AND ENVIRONMENTAL ATTITUDES

Where would you place yourself on a scale from 1 to 10, **if economic growth at all costs is a 1 and saving the environment at all costs is a 10.** (CIRCLE JUST ONE)

1 2 3 4 5 6 7 8 9 10

When you are purchasing food, how important are lower **food safety** risks versus **lower cost food** on a scale of 1 to 10, where **1 means lower food safety risk is all important** and **10 means lower food prices are all important?** (CIRCLE JUST ONE)

1 2 3 4 5 6 7 8 9 10

QUESTIONS ABOUT GMO KNOWLEDGE AND ATTITUDES

How knowledgeable are you about biotechnology and genetically modified (GM) foods?

1. Very knowledgeable
2. Somewhat knowledgeable
3. Not informed

Overall, how do you feel about the use of biotechnology in foods?

1. Very positive
2. Somewhat positive
3. Neutral
4. Somewhat negative
5. Very negative
6. Don't know

How much risk, if any, do you associate with genetically modified foods?

1. High level risk
2. Low level risk
3. No risk
4. Don't know

How important is it to you for foods with genetically modified ingredients to be labeled?

1. Very important
2. Somewhat important
3. Not very important

Do you prefer domestic to imported food products?

1. Yes
2. No

QUESTIONS RELATED TO WILLINGNESS TO PAY

A U.S. university is developing a genetically engineered wheat. Would be willing to purchase noodles made with this wheat if they are offered at the same price as noodles without genetically engineered wheat?

Yes (skip to tofu questions)
No

Would you be willing to purchase these noodles if they were offered at a price that is **[INSERT RANDOM DISCOUNT]** less than noodles without genetically engineered wheat?

Yes
No

Would you be willing to purchase tofu made with genetically modified soy beans if it were offered at the same price as tofu with GMO-free soy beans?

Yes (skip to demographic questions)
No

Would you be willing to purchase genetically modified tofu if it were offered at a price that is **[INSERT RANDOM DISCOUNT]** less than noodles without genetically engineered soy beans?

Yes
No

Endnotes

¹In order to obtain a high response rate, respondents were asked to place themselves in income intervals, rather than state their exact income amount. Survey respondents are typically reluctant to divulge incomes information. The exchange rate used is \$1=121.398 yen.

²The condition of linearity on z is a simplifying assumption widely used in RUM (random utility models). This assumption implies that consumer's willingness to pay of c dollars is generally represented as:

$U(0, x_0, m) \leq U(1, x_1, m - c)$, $\Pr\{WTP \geq c\} = \Pr\{V_0 + \varepsilon_0 \leq V_1 + \varepsilon_1\} = \Pr\{\varepsilon_0 - \varepsilon_1 \leq V_1 - V_0\}$, where $V_1 - V_0 = \alpha + \beta c$.