Effects of Information on Consumer Risk Perception and Willingness to Pay for Non-Genetically Modified Corn Oil

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Abstract

This study examines the effects of scientific information about the safety of genetically modified corn oil on Japanese consumers' risk perception and on their willingness-to-pay. Practical results show that the information affects only the variance component of risk perception.

Keywords: Genetically Modified, Contingent Valuation, Willingness to Pay, Risk Perception

JEL Classification: D12, D11, C35, D81

Introduction

Whereas the production of genetically modified (GM) crops in the United States (US) has increased rapidly in recent years, in Japan, which is one of the US's largest export markets for farm products, the tendency is that consumers avoid buying GM foods (Tokyo 2000; STAFF 2003). Especially for GM foods with mandatory labeling, Japanese food manufacturers have not produced the GM-labeled foods in anticipation of consumers' opposition to them. Therefore, there is no opportunity for people to see that GM-labeled foods are already on retail shelves in Japan. If most consumers also want to avoid buying the other GM foods, not subject to mandatory labeling under the current system, it is predicted that the range of items subject to labeling will be extended, and such foods will then be excluded from markets. It is therefore important for the US exporters to know the preference structure of Japanese consumers regarding GM foods without mandatory labeling, when designing their market strategy.

Such a demand analysis is definitely useful for the Japanese government also. If consumers value non-GM foods more than GM foods, and without mandatory labeling for those, a welfare loss will arise because of this asymmetric information. And if so, Japanese policy makers need to know the willingness-to-pay (WTP) of consumers for the non-GM foods, which are now generally unobservable in markets, in order to compare the cost with the benefit of labeling. Since some nonmarket valuation techniques, such as contingent valuation (CV), choice experiments, and experimental auctions, enable us to elicit the WTP, the studies to measure WTP for the non-GM foods using these techniques are carried out in many regions and countries (Lusk et al. 2004b).

On the other hand, the Japanese government is making efforts to provide scientific information about the safety of GM foods for consumers, in order to remove their fear of health risks arising from the GM foods. If, by this dissemination of information, Japanese consumers become indifferent between GM foods and non-GM foods, then any information problem in markets should not occur, and the remaining issue will only be the cost-benefit analysis about this information approach. Accordingly, the importance here is to measure the effect of information on WTP. If, by this information approach, consumers' WTP for non-GM foods is reduced, then the discussion about the cost-benefit of this approach will be meaningful. However, if the consumers' WTP does not change, this information approach will not bring any economic benefits to the people. In this case, we can suggest focusing only on the cost-benefit of labeling.

At the same time, the analysis of the effect of information on WTP must be useful for the US exporters also. By this analysis, they can foresee the consumption trends for GM foods of Japan in the near future. They can also simulate the effect when they themselves provide the information to Japanese consumers.

Several studies have analyzed the effect of information on WTP for non-GM foods. Rousu et al. (2004) examined how consumer behavior towards a GM food changed when negative information about GM foods from environmental groups was introduced. They found not only that negative information supplied by environmental groups could reduce consumer demand for GM foods, but also that information provided by a neutral third party group gave less weight to the negative information. Jaeger et al. (2004) investigated how information about benefits of GM foods affected willingness to accept (WTA) to give up a non-GM food and consume a GM food. They found that when information about health and environmental benefits was provided, the WTA was reduced. Li, McCluskey, and Wahl (2004) examined the effect of scientific information about GM-corn-fed beef on WTP for it, and found that when the scientific information was provided, the WTP increased. These findings are consistent on the point that when positive information about GM foods is provided, the valuation of non-GM foods is reduced. However, we can not generalize this finding to consumers in other countries, because all these studies used samples of the US consumers. Lusk et al. (2004a) compared the effects of positive information on WTA for a GM food, among the US, England, and France, and found that the US and English consumers' WTA was reduced by the positive information, but French consumers' WTA was unaffected by the positive information. This result suggests that there is a possibility that the effect of information on Japanese consumers' WTP is also different from that on the US consumers' WTP.

Although the WTP measure is an essential component for analyzing the consumer's behavior in terms of economics, we have to note that there is also another risk measure. Some studies regarding food safety focus on the consumer's qualitative risk perception, not the WTP measure (Grobe, Douthitt, and Zepeda 1999; Dosman, Adamowicz, and Hrudey 2001; Hayes, Fox, and Shogren 2002; Roosen, Hansen, and Thiele 2004). Intuitively, it is expected that risk perception and WTP are correlated positively. However theoretically, as demonstrated in this study, the WTP does not necessarily increase as the risk perception increases. Therefore, it is possible that information does not affect WTP, even though it affects risk perception. This means that, in order to evaluate the effect of information on the consumer's preference, it is not sufficient to only investigate the effect on WTP. As I described above, several studies have analyzed the effect of information on WTP for non-GM foods (Tegene et al. 2003; Jaeger et al. 2004; Noussair, Robin, and Ruffieux 2004; Li, McCluskey, and Wahl 2004; Lusk et al. 2004a; Rousu et al. 2004), but to my knowledge, no study has as of yet analyzed the effects on WTP and on risk perception comprehensively.

In this study, I will examine whether the dissemination, by the Japanese government, of the scientific information about the safety of GM corn oil has a significant impact on Japanese consumers' risk perception of the GM food or their WTP to avoid it. At present, Japanese food manufacturers are not obliged to label oils produced from GM crops as "genetically modified." This is because introduced genes or the proteins produced by the genes are resolved, removed, or changed during the process of purification. However, in the EU, new labeling rules, which include the labeling of such GM foods, have been applied since April 2004, and taking this into consideration, it is highly probable that extending the range of items subject to labeling will also be discussed in Japan soon.

To evaluate the effects of information on risk perception and on WTP, I conducted a CV survey regarding GM corn oil in Japan in February 2002. In this survey, I used a between-subject design, in which some respondents were provided with the information about the safety of GM corn oil, while the other respondents were not provided with it. Using this survey data, I jointly estimated risk perception function with an information variable as an argument and WTP function with risk perception variables as arguments. In this article, I will show the estimation results, and then examine whether the coefficient of each variable is significant.

Theoretical Framework

To explain the WTP to avoid a health risk theoretically, several studies have employed a state dependent utility model (Hayes et al. 1995; Lin and Milon 1995; Lusk et al. 2004a). In this model, risk perception can be represented by a Bernoulli distribution with two outcomes: a good state of health and a bad state of health. Ordinarily, it is assumed that, when an individual consumes non-GM foods, a good state of health occurs with probability 1, and also, when an individual consumes GM foods, a good state of health occurs with probability α, which is greater than 0 and less than 1, and a bad state occurs with probability $1 - \alpha$. This assumption, however, may be unrealistic. Consumers will consider the most probable bad state of health (for example, how many days I have to stay in bed) as a health risk, rather than consider the probability of a fixed bad state of health (for example, what is the probability that I have to stay in bed for a week). Based on this idea, the distribution of health risk needs to be extended to a probability distribution with three or more events.

"The most probable bad state" implies a mean component of the perceived health risk. On the other hand, consumers will have different perceptions of the most probable bad state. One consumer may assume that a bad state occurs, but another consumer may predict that the same bad state occurs with a lower degree of confidence. The latter risk must be regarded as greater than the former risk. This is a variance component of the perceived health risk. To my knowledge, no study regarding food safety has so far evaluated this measure.

On the basis of the above discussion, in this section, I will develop a theoretical model to explain the relationship amongst information, mean component of risk (how dangerous), variance component of risk (how uncertain), and WTP, assuming that a level of health damage follows a continuous probability distribution. First, I will define the WTP to avoid a risk in the framework of the expected utility theory. I assume that an individual consumes a risky food, q, and a composite good, x, which is used as the numeraire. I also denote the bad influence of q on human health by r. Here, r is a random variable with non-negative support, finite mean, μ, and variance, σ^2. Hereinafter, I call it health risk. Following the expected utility theory, the individual's utility maximization problem is represented as

$$\max_{x,q} \quad \mathrm{E}\left[U\left(x, q, r\right)\right], \qquad \mathrm{s.\,t.} \quad x + pq = y, \tag{1}$$

where $U(\cdot)$ is the utility function, E is the expectation operator for r, p is the price of q, and y is money income. By solving this maximization problem, a demand function of q, $q(p, y)$, is derived, and then, the expected indirect utility function is represented by $\mathrm{E}\left[V\left(p, y, r\right)\right]$, where $V(\cdot)$ is an indirect utility function.

Here, consider the state where q is not risky, that is $\mathrm{Prob}(r = 0) = 1$. Then, an individual's (expected) utility is represented by $V(p, y, 0)$, and also, the change of utility, which is caused by the change from the state where q is risky to the state where q is not risky, is represented as

$$\Delta V = V(p, y, 0) - \mathrm{E}\left[V\left(p, y, r\right)\right]. \tag{2}$$

As a measure of this utility difference, we often use the WTP measure. It is defined as

$$V(p + WTP, y, 0) = \mathrm{E}\left[V\left(p, y, r\right)\right]. \tag{3}$$

This WTP is often called option price.[1] Substituting equation (3) into equation (2) yields:

(4) $$\Delta V = V(p, y, 0) - V(p + WTP, y, 0).$$

Assuming that $\partial V/\partial p < 0$, we can see from equation (4) that this WTP is a sign-preserving measure of the underlying utility change.

Next, I will investigate the relationship between WTP and risk perception. Here, I assume that $\partial V/\partial r < 0$, and $\partial^2 V/\partial r^2 < 0$. The latter inequality means that an individual is risk averse. I also assume that σ is not a function of μ. The second order Taylor expansion of $V(p, y, r)$, around μ, yields:

(5) $$V(p, y, r) \approx V(p, y, \mu) + \left.\frac{\partial V}{\partial r}\right|_{r=\mu}(r - \mu) + \frac{1}{2}\left.\frac{\partial^2 V}{\partial r^2}\right|_{r=\mu}(r - \mu)^2.$$

Then, the expected indirect utility function is approximated as

(6) $$\mathrm{E}\left[V(p, y, r)\right] \approx V(p, y, \mu) + \frac{\sigma^2}{2}\left.\frac{\partial^2 V}{\partial r^2}\right|_{r=\mu}.$$

Substituting equation (6) into equation (3), and totally differentiating it with respect to μ and WTP yields:

(7) $$\frac{dWTP}{d\mu} = \frac{\left.\frac{\partial V}{\partial r}\right|_{r=\mu} + \frac{\sigma^2}{2}\left.\frac{\partial^3 V}{\partial r^3}\right|_{r=\mu}}{\frac{\partial V}{\partial p}}.$$

Since $\partial V/\partial r < 0$, and $\partial V/\partial p < 0$, if $\partial^3 V/\partial r^3 \leq 0$, then the sign of $dWTP/d\mu$ is positive. On the contrary, if $\partial^3 V/\partial r^3 > 0$, then the sign of $dWTP/d\mu$ is undetermined. This means that the WTP does not necessarily increase as the mean component increases. Since positive $\partial^3 V/\partial r^3$ represents the decrease of the degree of risk aversion, in the case that the degree of risk aversion decreases as r increases, it is possible that the WTP decreases as the mean component increases.

On the other hand, totally differentiating it with respect to σ and WTP yields:

(8) $$\frac{dWTP}{d\sigma} = \frac{\sigma\left.\frac{\partial^2 V}{\partial r^2}\right|_{r=\mu}}{\frac{\partial V}{\partial p}}.$$

Since $\partial^2 V/\partial r^2 < 0$, and $\partial V/\partial p < 0$, the sign of $dWTP/d\sigma$ is positive. This means that the WTP increases as the variance component increases. However, we have to note that this result depends on the approximation of V as represented by equation (5). If we expand V in Taylor series up to the third order, and assume that the third moment of r is a function of σ, the sign of $dWTP/d\sigma$ is undetermined in general.

Finally, I will investigate the relationship between information and WTP. In this model, I employ the definition of Lusk et al. (2004a) for an information variable about a risky food: a positive value indicates favorable information and a negative value indicates unfavorable information, and then denote it as I. Also, I assume that μ and σ are the functions of I, where $\partial\mu/\partial I < 0$, and $\partial\sigma/\partial I^2 < 0$. Then, substituting equation (6) into equation (3), and totally differentiating it with respect to I and WTP yields:

$$\frac{dWTP}{dI} = \frac{\dfrac{\partial\mu}{\partial I}\left(\dfrac{\partial V}{\partial r}\Big|_{r=\mu} + \dfrac{\sigma^2}{2}\dfrac{\partial^3 V}{\partial r^3}\Big|_{r=\mu}\right) + 2\sigma I \dfrac{\partial^2 V}{\partial r^2}\Big|_{r=\mu}\dfrac{\partial\sigma}{\partial I^2}}{\dfrac{\partial V}{\partial p}}. \tag{9}$$

Since the right side of this equation has the term of $\partial^3 V/\partial r^3$, the sign of $dWTP/dI$ is undetermined in general, as well as $dWTP/d\mu$. Also, even though the sign of the inside of the parenthesis on the right side is negative, the sign of $dWTP/dI$ is undetermined in the region of $I < 0$. This means that, in the case that an individual possesses unfavorable information, the WTP does not necessarily increase along with increasing negative information (decreasing I), because the mean component increases, while the variance component decreases.

These results are different from those obtained by Lusk et al. (2004a). They derived the negative relationship between information and WTA, using the state dependent utility model. However, as I showed here, this negative relationship does not hold within the more general framework of the expected utility theory. Also, according to Lusk et al. (2004a), consumers' WTA increases as more unfavorable information is provided. However, when variance component of risk decreases with the increase of the negative information, there is a possibility that WTP

(WTA) decreases as more unfavorable information is provided.

To summarize this section, even though the information affects the mean or the variance component, it does not necessarily affect the WTP. Accordingly, in order to evaluate these relationships, it is essential to analyze them practically.

Contingent Valuation Survey

Object of Evaluation

In this CV survey, I asked respondents how much they would be willing to pay in order to avoid the health risk of GM corn oil. There are two main reasons for choosing corn oil. First, it is found that corn is one of the most important trade commodities for both the US and Japan. The corn export value in the US, in 2004, is the second largest compared to that of soybeans in the US agricultural commodities, and Japan is the country that imports the most corn from the US. At present, the oils made from GM ingredients do not have to be labeled as "genetically modified," because introduced genes or the proteins produced by the genes are resolved, removed, or changed during the process of purification. However, considering that the EU has introduced a new labeling system for such GM oils, or that many Japanese consumers still have a strong opposition to GM foods, it is highly probable that the mandatory labeling of GM oils will be discussed in the near future.

Second, it is found that GM corn (Bt corn) is well-known as an insecticidal plant, which causes an unfavorable impression of GM foods on people. As described later, there is no scientific evidence to support that Bt corn is harmful to human health, but many Japanese consumers still think that eating an insecticidal plant is dangerous to human health. Such attitudes are understandable without scientific information, and on the contrary, it is predicted that consumer attitudes to such GM foods will change with this information. Therefore, using Bt corn as an object of evaluation is effective in investigating the effects of the information. Several studies have examined Japanese consumers' attitudes to GM foods, such as vegetable oil (Chern et al. 2002), noodles (McCluskey et al. 2003), and canola oil (Kaneko and Chern 2004), but no study has as of yet measured the WTP premium for non-GM corn oil.

Survey Outline

Most of the studies analyzing the effect of information on WTP have conducted an experimental auction, using a within-subject design (Jaeger et al. 2004; Noussair, Robin, and Ruffieux 2004; Lusk et al. 2004a). Although experimental auctions have the advantage of reducing hypothetical bias, the usable sample size is usually limited to 100 or less. Also, within-subject design does not require a homogeneity test between groups, but it may cause the effects of order, fatigue, or boredom. From these viewpoints, I conducted a CV survey, using a between-subject design.

In this survey, two types of questionnaires were designed: one in which the information about the safety of Bt corn oil was provided, and the other in which the information was not provided. First, based on the booklet that the Japanese government has distributed to the public (MAFF 2002), I explain the reasons why Bt corn is harmless to human health. Bt corn is a corn genetically engineered to contain the gene of *Bacillus thuringiensis*, which produces an insecticidal protein. Although, at first sight, eating a plant with insecticidal properties seems to be risky to human health, in the scientific sense, there is no evidence to support it. Rather, the safety of the corn is often argued for on the basis of scientific evidence. This entails the following two differences in the digestive systems of humans and insects. One is that the inside of the human stomach is acid, whereas the inside of the digestive systems of insects is alkaline. Bt protein is not fully digested in the alkaline environment, and then the insecticidal peptide survives in the digestive tract, but in the acid environment, it is fully digested, and then the insecticidal activity is lost. The other is that the human intestinal cells do not have receptors for Bt protein, whereas the insect intestinal cells have these receptors. In the insect body, the insecticidal peptide is connected to the receptors in the intestinal cells, and then the cells are destroyed, but in the human body, such a situation does not occur, even though Bt protein was not fully digested in the stomach. This is because there is no receptor to receive it. At present, Bt corn has been approved for commercial use in many countries.

On the basis of the above, in one of two questionnaires, I attached the following explanations (in italics) to the questions about risk perceptions of GM corn and GM corn oil.

> **Question about risk perception of GM corn**
>
> *The body structures are different between humans and insects. Even if we eat this GM corn, the protein included in the corn, which kills insects, is resolved in our stomachs, and it is not taken into our bodies via the intestines. Therefore, this GM corn is generally considered to be harmless to human health.* How dangerous do you think it is eating this GM corn?
>
> **Question about risk perception of GM corn oil**
>
> At present, GM corn and the processed foods, in which the GM corn is the main ingredient, must be labeled as "genetically modified," but oil made from GM corn does not have to be labeled. *The reason is that the introduced genes or the proteins produced by these genes are resolved, removed, or changed in the process of purification, and as a result of that, the traces of the GM corn disappear.* How dangerous do you think it is eating this GM corn oil?

The survey was conducted at the entrance of a supermarket in Kusatsu-city, Shiga-prefecture, Japan, in February 2002. The respondents were divided randomly into two groups: the group that was provided with the information about the safety of GM corn (informed group), and the group that was not provided with it (uninformed group), and they then filled out the corresponding questionnaire. Finally, I recruited 200 respondents for each group. I also gave the respondents two boxes of facial tissue as a reward for answering.

Risk Perception

As described in the previous subsection, in this survey, I asked questions about the risk perceptions of GM corn and GM corn oil. Then, I provided four answers to these questions: (1) think it safe, (2) think it a little dangerous, (3) think it very dangerous, and (4) do not know well. According to the idea described in the second section, these answers relate to such probability distributions as shown in figure 1. The answer (1) is represented by a distribution in which the mean is close to 0, the answer (3) is represented by a distribution in which the mean is relatively large, and the answer (2) is represented by a distribution in which the mean is in the middle between the means of (1) and (3). The answer (4) is represented by an uniform distribution. On the basis of these images, in this analysis, I assume that the means and the variances of these 4 distributions are related as shown in table 1.

Willingness to Pay

Respondents were first showed a bottle of the corn oil actually sold at 600 yen per 900 g in market, and were asked how much of price increase they would be willing to pay for a bottle of non-GM corn oil. As described in earlier in this section, at present, the oils made from GM ingredients do not have to be labeled as "genetically modified," and therefore, we do not have any way to know whether and how much of GM ingredients were used in the real oil product. Although, by simple calculation, it is predicted that about 40 percent of the ingredients in the corn oil product will be GM corn, in this questionnaire, to avoid any bias caused by using such inaccurately calculated data, I provided respondents only with the information that we do not know whether GM ingredients are used in the corn oil product that is actually sold in market.[2] Also, in this survey, I used open-ended elicitation format.

Model

In this section, I will construct a trivariate model, in which dependent variables are the mean and the variance components of health risk, as well as the WTP. First, I will build a model of risk perception. Based on the assumptions shown in table 1, the mean variable takes one of the three ordered values: 0 (μ_0), 1 (μ_1), and 2 (μ_2), and the variance variable takes one of the two values: 0 (σ_0), and 1 (σ_1). Therefore, in my model, the mean and the variance functions are respectively modeled as ordered probability models. The mean function is represented as

$$r_m^* = \boldsymbol{\beta}'_m \boldsymbol{x}_m + \varepsilon_m, \tag{10}$$

$$r_m = \begin{cases} 0, & \text{if} \quad r_m^* < 0 \\ 1, & \text{if} \quad 0 \leq r_m^* < \eta \\ 2, & \text{if} \quad r_m^* \geq \eta \end{cases}, \tag{11}$$

where r_m is the mean variable of health risk, r_m^* is the latent variable of r_m, $\boldsymbol{x}_m$ is the vector of personal attributes related to the mean component of perceived health risk, $\boldsymbol{\beta}_m$ is the coefficient vector of $\boldsymbol{x}_m$, η is the threshold parameter between $r_m = 0$ and $r_m = 1$, and ε_m is the stochastic error term which follows the standard normal distribution. Similarly, the variance function is represented as

$$r_v^* = \boldsymbol{\beta}'_v \boldsymbol{x}_v + \varepsilon_v, \tag{12}$$

$$r_v = \begin{cases} 0, & \text{if} \quad r_v^* < 0 \\ 1, & \text{if} \quad r_v^* \geq 0 \end{cases}, \tag{13}$$

where r_v is the variance variable of health risk, r_v^* is the latent variable of r_v, $\boldsymbol{x}_v$ is the vector of personal attributes related to the variance component of perceived health risk, $\boldsymbol{\beta}_v$ is the coefficient vector of $\boldsymbol{x}_v$, and ε_v is the stochastic error term which follows the standard normal distribution.

On the other hand, since the WTP is elicited by using open-ended format in this survey, the WTP function is represented by a linear regression model:

$$WTP = \boldsymbol{\beta}_w' \boldsymbol{x}_w + \alpha_m r_m^* + \alpha_v r_v^* + \varepsilon_w, \tag{14}$$

where WTP is the WTP premium for non-GM corn oil, $\boldsymbol{x}_w$ is the vector of personal attributes related to the WTP, $\boldsymbol{\beta}_w$ is the coefficient vector of $\boldsymbol{x}_w$, α_m and α_v are the coefficient vectors of r_m^* and r_v^* respectively, and ε_w is the stochastic error term which follows a normal distribution with a mean of zero and a variance of γ_w^2. Information variable is included in $\boldsymbol{x}_m$ and $\boldsymbol{x}_v$, but it is not included in $\boldsymbol{x}_w$. If $WTP > 0$, then we can also specify the WTP function as

$$\ln WTP = \boldsymbol{\beta}_w' \boldsymbol{x}_w + \alpha_m r_m^* + \alpha_v r_v^* + \varepsilon_w. \tag{15}$$

This specification means that the WTP follows a log-normal distribution. As I described in the second section, the WTP does not necessarily increase as the mean or the variance component of risk increases. In the next section, I will evaluate these relationships by testing the significance of α_m and α_v.

Also, since the identical person answers both questions about risk perception and WTP, it is possible that three error terms, ε_m, ε_v and ε_w, are mutually correlated by a common but unobservable factor included in each error term. Under this hypothesis, the covariance matrix for ε_m, ε_v, and ε_w is represented as

$$\Sigma = \begin{bmatrix} 1 & \rho_{mv} & \rho_{mw}\gamma_w \\ \rho_{mv} & 1 & \rho_{vw}\gamma_w \\ \rho_{mw}\gamma_w & \rho_{vw}\gamma_w & \gamma_w^2 \end{bmatrix}, \tag{16}$$

where ρ_{ij} is the correlation coefficient between ε_i and ε_j $(i,\ j = m,\ v,\ w$, and $i \neq j)$.

Since the dependent variables in equations (10) and (12), r_m^* and r_v^*, appear on the right side of equation (14) or (15), this model is a simultaneous equations model. In this study, I will estimate the parameters using a full information maximum likelihood approach. The likelihood function is derived in the Appendix. If each component of risk does not affect the WTP, and all the correlation coefficients between any two error terms are zero, these three equations can be estimated separately.

Results

Data

Table 2 shows the definitions of candidate independent variables examined in this study, and the sample means and standard deviations of the informed and the uninformed groups. The 201 respondents answered the questions of risk perception, WTP, and the questions corresponding to the candidate independent variables. Also, the last column in table 2 shows p-values of the Mantel extension test for trend (Mantel 1963). All the p-values are much greater than 5 %, and therefore, the hypothesis that the relative frequencies of each category of a variable are equal, between the informed and the uninformed groups, is not rejected.

Since only 9 (4%) of the respondents, who answered all the related questions, stated zero WTP, in this analysis, I removed them from the sample. By this sample selection, the following two advantages in estimation are achieved. One is that the complexity of the optimization calculation is reduced. If we include the observations with zero WTP in the sample, we have to extend the linear model of WTP into a censored regression model. Then, trivariate normal density functions appear in the likelihood function, and therefore, the optimization calculation will become more complicated. The other is that we can examine not only a linear specification represented by equation (14), but also a semi-log specification represented by equation (15) for the WTP function.

Trend Test for Risk Perception

Before estimating the model described in the previous section, I performed some tests to determine the relationship among information, risk perception, and WTP, using only these three variables. First, I performed the Mantel extension test for trend in order to determine the relationship between information and risk perception.

Table 3 shows the results of the Mantel tests. Also, figure 2 compares the histograms of the mean and the variance components between the informed and the uninformed groups. For both the components of GM corn risk, the hypothesis of the equality of distributions is rejected at the 1% level. Since the relative frequencies of μ_0 and σ_0 are larger, and those of μ_1, μ_2, and σ_1 are smaller in the informed group, this result means that when the scientific information is provided, the perceived health risk of GM corn decreases. On the other hand, for the variance component of the perceived risk of GM corn oil, the hypothesis of the equality of distributions is rejected at the 10% level, but for the mean component of this, the null hypothesis is not rejected even at the 20% level. Although the changes in the relative frequencies of the mean or the variance levels are similar to those in the case of GM corn, statistically, it is found that only the variance component of risk perception of GM corn oil decreases.

Equality Test for Mean and Median WTP

Table 4 shows the sample mean and median of the WTP, as well as their confidence intervals, in the informed and the uninformed groups. The confidence intervals are constructed using the nonparametrtic percentile bootstrap method. For the entire sample, even though the median is selected, the WTP accounts for about 40 % of the base price. This is very similar to the average premium for non-GM foods across the 22 studies, reported by Lusk et al. (2004b).

On the other hand, contrary to intuitive expectations, we can see that the WTP in the informed group is larger than that in the uninformed group. This result is theoretically possible, as I showed in the second section in this article. The question rather, is whether this difference is significant. Therefore, I tested whether the mean or the median WTPs were equal between the informed and the uninformed groups in the following manner. First, I derived the distribution for the difference between the mean or the median WTPs in the informed and the uninformed groups, using the nonparametic bootstrap method, and then, I constructed the 95% confidence intervals. Second, by applying the duality between confidence intervals and hypothesis tests, when 0 was not included in the 95% confidence interval, we rejected the hypothesis that there is no difference between the two WTPs at the 5% level.

The calculated 95% confidence intervals are shown in rows 3-4 in table 5. We see from this table that the difference of the mean or the median WTPs between the informed and the uninformed groups is not significant. Therefore, from this result, it is found that there is no relationship between the information and the WTP. Moreover, I tested whether the mean or the median WTPs were equal between the μ_0 and μ_1, μ_1 and μ_2, or σ_0 and σ_1. The calculated 95% confidence intervals are shown in rows 5-10 in table 5. Similar to the results above, it is found that there is no relationship between the mean or the variance component and the WTP. This result, also, is theoretically possible, as I showed in the second section.

Model Estimation

Next, I will show the estimation results of the model described in the previous section. First of all, in order to evaluate which of the two specifications (linear and semi-log specifications) of the WTP function is supported statistically, I performed the PE test developed by MacKinnon et al. (1983). Table 6 shows the regression results for the PE tests. We can see from the p-values presented in the last row that the semi-log specification is not rejected against the linear specification at the 5% level, whereas the linear specification is rejected against the semi-log specification at the 5% level. From this result, I selected the semi-log specification for the WTP function.

In the simultaneous model described in the previous section, the parameters are not identified, unless at least one variable in $\boldsymbol{x}_m$ is not included in $\boldsymbol{x}_w$ and another variable in $\boldsymbol{x}_v$ is not included in $\boldsymbol{x}_w$. In this analysis, I first estimated the WTP function using ordinary least squares, and then excluded the variable of GM for which p-value was the largest in the estimated model, from $\boldsymbol{x}_w$, so as to satisfy this condition for identification. The first column of table 7 shows the estimation result of this simultaneous equations model (Model 1). We can see from this table that neither of the coefficients of the mean and the variance variables in the WTP function (α_m and α_v) is significant, even at the 20% level. This is consistent with the results of the nonparametric tests in the previous subsection. Accordingly, from these results, it is concluded that Japanese consumers' risk perception of GM corn oil does not affect their WTP to avoid it, and therefore, even if the scientific information affects the mean or the variance component of risk perception, it does not affect the WTP. Also, we can see that none of the correlation coefficients between error terms are significant, even at the 20% level. This result shows that there are no unobserved factors that affect both risk perception and WTP. Hence, the three equations can be estimated separately.

I finally selected the model shown in the second column of table 7 (Model 2), based on minimizing the AIC. In this table, we can see that the coefficients of the information variables are both negative in the mean and the variance functions. However, whereas the coefficient of the information variable of the variance function is significant at the 10% level, that of the mean function is not significant at the 10% level. This is consistent with the results of the Mantel tests. Accordingly, it is concluded that when the scientific information is provided, the variance component of risk perception decreases, but the mean component does not necessarily decrease.

Lastly, consider the signs of coefficients of the other important demographic variables. (1) The sign of CORN variable included in the mean function is positive. This means that the better consumers know the insecticidal corn, the safer they think the oil made from it will be. Since, in the Japanese mass media, only the risky aspects of GM foods are usually featured, people who do not know about it well tend to think it is dangerous. (2) Whereas the sign of BUY variable included in the mean function is negative, the sign of that in the WTP function is positive. This means that the more frequently consumers buy corn oil, the more dangerous they think that the GM corn oil is, but the less their WTP is. It is possible that people who frequently buy corn oil have strong concerns for the health risks due to GM corn oil, compared to people who do not buy it, and therefore, that they think it is more dangerous. On the other hand, at first sight, the relationship in the WTP function seems to be inconsistent with that in the mean function, but it is considered that this is due to an income effect. Since the expenditure on corn oil, of people who frequently buy it, is larger than that of people who do not buy it, in cases where the income effect is large, such a phenomenon can occur. (3) The signs of LABEL variables included in the mean and the WTP functions are both negative. This means that the better consumers know the labeling system for GM foods in Japan, combined with the more confidence in which they estimate how dangerous GM corn oil is, and also, the less their WTP is. It is considered that people who know the labeling system well have strong concerns for the effects of food ingredients. Therefore, they may be able to estimate the health damage from GM foods with a greater confidence.

Conclusion and Discussion

In this article, I examined whether the scientific information provided by the Japanese government about the safety of GM corn oil affected Japanese consumers' risk perception or their WTP, in both theory and practice. First, in my theoretical analysis, I found that the WTP did not necessarily increase as the mean or the variance component increased, within the general framework of the expected utility theory. This finding implies that, even if the mean or the variance component is reduced by the scientific information, the WTP is not necessarily reduced. Lusk et al. (2004a) derived the negative relationship between information and WTA, using the state dependent utility model, but their theoretical result was inconsistent to one of their empirical results: French consumers' WTA is unaffected by positive information. However, my finding supports this empirical result.

Second, in my empirical analysis, I found that the dissemination, by the Japanese government, of the scientific information about the safety of GM corn oil significantly reduced the variance component of Japanese consumers' risk perception, but it did not reduce the mean component and the WTP. This finding implies that it is highly probable that the current information dissemination efforts will not bring any economic benefits to Japanese consumers. Also, I found that Japanese consumers' WTP premium for non-GM corn oil accounted for about 40 % of the price of the corn oil sold in market. This finding implies that when the mandatory labeling rule of GM foods is applied to corn oil, Japanese consumers will choose non-GM corn oil, as long as the price increase in non-GM corn oil is less than 40 %. Moreover, based on these two findings, it is predicted that, even if the scientific information about GM foods has been widely disseminated in Japan, Japanese consumers will not change such a behavior.

On the other hand, the finding that only the variance component of risk perception is reduced when the scientific information is provided gives us a new perspective to evaluate the relationship among information, risk perception, and economic behavior. As I described in the second section, such a phenomenon is possible, but we have to notice that this theoretical model is developed within a static framework. Between the time that people obtain positive information about a risky food and the time that they actually buy the food, there may be a dynamic process in order to determine the WTP: (1) realizing what they did not know before (variance is reduced), (2) becoming aware that something is safe that they thought to be dangerous before (mean is reduced), (3) starting to actually buy the food (WTP is reduced). On the basis of this idea, the result in this study is interpreted as meaning that people are still at the first stage. Since scientific information about GM foods has not yet been widely disseminated in Japan, and respondents in this survey answered the questions right after they received the information, it is predicted that this interpretation will be valid. However, naturally, this is only a hypothesis. It is an interesting further issue to analyze such dynamic effects of information.

Footnotes

1. Hayes et al. (1995) define the option price as $U(y - WTP) = \mathrm{E}U$. Since, in this survey, I asked how much of price increase consumers would be willing to pay for non-GM corn oil, here, I define it as the form of the WTP premium per risky food, q.

2. 89 percent of the corn in Japan is imported from the US (MAFF 2003), and 45 percent of the corn planted acreage in the US is used for GM varieties (USDA 2004). This value of 40 percent is obtained by multiplying these percentages.

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Appendix

Likelihood Function

The reduced form of this model is derived from equations (10), (12), and (14). It is represented as

$$r_m^* = \boldsymbol{\beta}_m' \boldsymbol{x}_m + \varepsilon_m, \tag{17}$$

$$r_v^* = \boldsymbol{\beta}_v' \boldsymbol{x}_v + \varepsilon_v, \tag{18}$$

$$WTP = \boldsymbol{\beta}_w' \boldsymbol{x}_w + \alpha_m \boldsymbol{\beta}_m' \boldsymbol{x}_m + \alpha_v \boldsymbol{\beta}_v' \boldsymbol{x}_v + \alpha_m \varepsilon_m + \alpha_v \varepsilon_v + \varepsilon_w. \tag{19}$$

Let $\varepsilon_{w'}$ denote the new error term, $\alpha_m \varepsilon_m + \alpha_v \varepsilon_v + \varepsilon_w$. Then, the transformation of variables into the reduced form error terms is represented as

$$\begin{bmatrix} \varepsilon_m \\ \varepsilon_v \\ \varepsilon_{w'} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ \alpha_m & \alpha_v & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_m \\ \varepsilon_v \\ \varepsilon_w \end{bmatrix} \equiv \mathrm{A} \begin{bmatrix} \varepsilon_m \\ \varepsilon_v \\ \varepsilon_w \end{bmatrix}. \tag{20}$$

Since the vector, $[\varepsilon_m, \varepsilon_v, \varepsilon_{w'}]$, is a linear function of $[\varepsilon_m, \varepsilon_v, \varepsilon_w]$, and the matrix, A, has full rank, $[\varepsilon_m, \varepsilon_v, \varepsilon_{w'}]$ follows a trivariate normal distribution with zero mean vector and the covariance matrix, $\mathrm{A}\,\Sigma\,\mathrm{A}'$ (Greene 2003, p. 873). The covariance matrix is represented as

$$\mathrm{A}\,\Sigma\,\mathrm{A}' = \begin{bmatrix} 1 & \rho_{mv} & \omega_{mw} \\ \rho_{mv} & 1 & \omega_{vw} \\ \omega_{mw} & \omega_{vw} & \omega_w \end{bmatrix}, \tag{21}$$

where

$$\omega_{mw} = \alpha_m + \alpha_v \rho_{mv} \gamma_w + \rho_{mw} \gamma_w, \tag{22}$$

$$\omega_{vw} = \alpha_v + \alpha_m \rho_{mv} \gamma_w + \rho_{vw} \gamma_w, \tag{23}$$

$$\omega_w = \alpha_m^2 + \alpha_v^2 + \gamma_w^2 + 2\alpha_m \alpha_v \rho_{mv} \gamma_w + 2\alpha_m \rho_{mw} \gamma_w + 2\alpha_v \rho_{vw} \gamma_w. \tag{24}$$

Since r_m and r_v are both discrete variables, while WTP is a continuous variable, the likelihood when $r_m = m$, $r_v = v$, and $WTP = w$ is represented by $f(WTP = w)\,\mathrm{Prob}(r_m = r,\ r_v = v\ |WTP = w)$, where f is a marginal density function of WTP. Letting $L(m, v, w)$ denote the likelihood when $r_m = m$, $r_v = v$, and $WTP = w$, the likelihoods of the combinations among r_m, r_v, and WTP are represented as

$$\begin{aligned} L(0,\ 0,\ w) = {} & \frac{1}{\gamma_w} \phi\left(\frac{w - \boldsymbol{\beta}_w' \boldsymbol{x}_w}{\gamma_w}\right) \\ & \times \Phi_b \left[\frac{-\boldsymbol{\beta}_m' \boldsymbol{x}_m - \frac{\omega_{mw}}{\omega_w}\left(w - \boldsymbol{\beta}_w' \boldsymbol{x}_w\right)}{\sqrt{1 - \frac{\omega_{mw}^2}{\omega_w}}}, \frac{-\boldsymbol{\beta}_v' \boldsymbol{x}_v - \frac{\omega_{vw}}{\omega_w}\left(w - \boldsymbol{\beta}_w' \boldsymbol{x}_w\right)}{\sqrt{1 - \frac{\omega_{vw}^2}{\omega_w}}} \right], \end{aligned} \tag{25}$$

$$(26)\quad L(1,\ 0,\ w) = \frac{1}{\gamma_w}\phi\left(\frac{w-\boldsymbol{\beta}_w'\boldsymbol{x}_w}{\gamma_w}\right) \times \left\{ \Phi_b\left[\frac{\eta-\boldsymbol{\beta}_m'\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}}, \frac{-\boldsymbol{\beta}_v'\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right] - \Phi_b\left[\frac{-\boldsymbol{\beta}_m'\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}}, \frac{-\boldsymbol{\beta}_v'\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right]\right\},$$

$$(27)\quad L(2,\ 0,\ w) = \frac{1}{\gamma_w}\phi\left(\frac{w-\boldsymbol{\beta}_w'\boldsymbol{x}_w}{\gamma_w}\right) \times \left\{ \Phi_u\left[\frac{-\boldsymbol{\beta}_v'\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right] - \Phi_b\left[\frac{\eta-\boldsymbol{\beta}_m'\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}}, \frac{-\boldsymbol{\beta}_v'\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right]\right\},$$

$$(28)\quad L(0,\ 1,\ w) = \frac{1}{\gamma_w}\phi\left(\frac{w-\boldsymbol{\beta}_w'\boldsymbol{x}_w}{\gamma_w}\right) \times \left\{ \Phi_u\left[\frac{-\boldsymbol{\beta}_m'\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}}\right] - \Phi_b\left[\frac{-\boldsymbol{\beta}_m'\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}}, \frac{-\boldsymbol{\beta}_v'\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}_w'\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right]\right\},$$

$$(29)\quad L\,(1,\ 1,\ w) = \frac{1}{\gamma_w}\phi\left(\frac{w-\boldsymbol{\beta}'_w\boldsymbol{x}_w}{\gamma_w}\right)$$

$$\times\left\{\Phi_u\left[\frac{\eta-\boldsymbol{\beta}'_m\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}}\right]-\Phi_u\left[\frac{-\boldsymbol{\beta}'_m\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}}\right]\right.$$

$$-\Phi_b\left[\frac{\eta-\boldsymbol{\beta}'_m\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}},\frac{-\boldsymbol{\beta}'_v\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right]$$

$$\left.+\Phi_b\left[\frac{-\boldsymbol{\beta}'_m\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}},\frac{-\boldsymbol{\beta}'_v\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right]\right\},$$

$$(30)\quad L\,(2,\ 1,\ w) = \frac{1}{\gamma_w}\phi\left(\frac{w-\boldsymbol{\beta}'_w\boldsymbol{x}_w}{\gamma_w}\right)$$

$$\times\left\{1-\Phi_u\left[\frac{-\boldsymbol{\beta}'_v\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right]-\Phi_u\left[\frac{\eta-\boldsymbol{\beta}'_m\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}}\right]\right.$$

$$\left.+\Phi_b\left[\frac{\eta-\boldsymbol{\beta}'_m\boldsymbol{x}_m-\frac{\omega_{mw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{mw}^2}{\omega_w}}},\frac{-\boldsymbol{\beta}'_v\boldsymbol{x}_v-\frac{\omega_{vw}}{\omega_w}\left(w-\boldsymbol{\beta}'_w\boldsymbol{x}_w\right)}{\sqrt{1-\frac{\omega_{vw}^2}{\omega_w}}}\right]\right\},$$

where ϕ is the univariate standard normal density function, Φ_u is the univariate standard normal distribution function, and Φ_b is the bivariate standard normal distribution function with the correlation coefficient represented by

$$(31)\qquad \frac{\rho_{mv}\omega_w-\omega_{mw}\omega_{vw}}{\sqrt{\omega_w-\omega_{mw}^2}\sqrt{\omega_w-\omega_{vw}^2}}.$$

The parameters are estimated by maximizing the (log) likelihood function, which consists of these likelihoods.

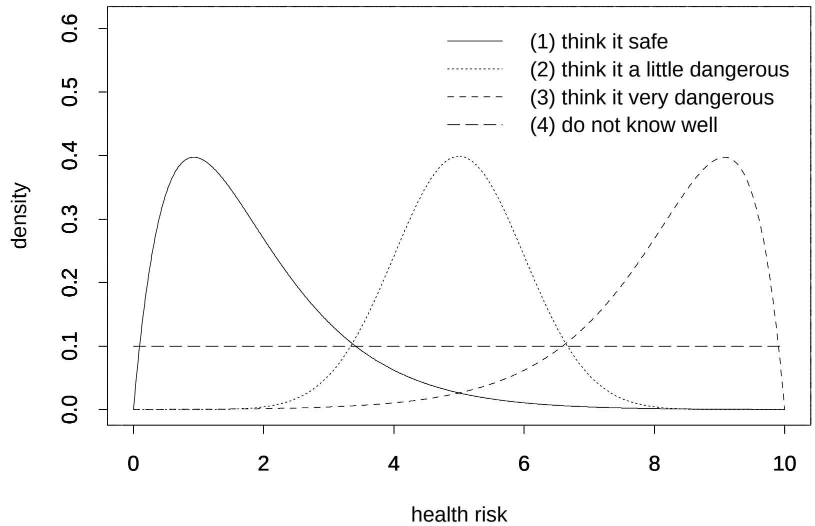
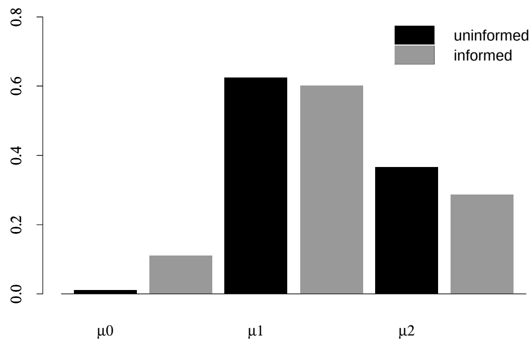
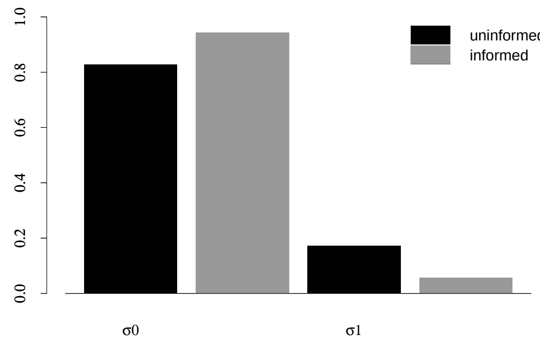


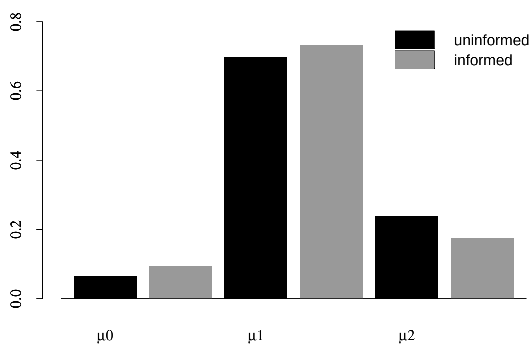
Figure 1. Images of Probability Distributions Corresponding to Answers of Risk Perception



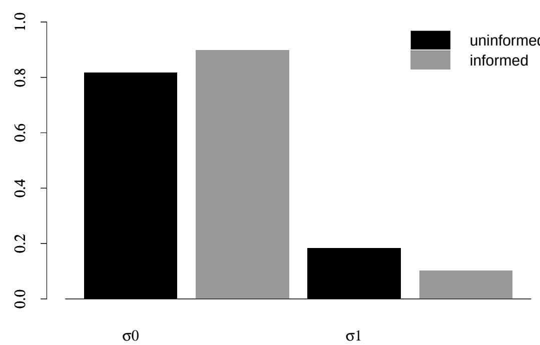
(a) GM Corn (Mean)



(b) GM Corn (Variance)



(c) GM Corn Oil (Mean)



(d) GM Corn Oil (Variance)

Figure 2. Histograms of Risk Perceptions

Table 1. Moments of Probability Distributions Corresponding to Answers of Risk Perception

Answer	Mean[a]	Standard Deviation[b]
(1) think it safe	μ_0	σ_0
(2) think it a little dangerous	μ_1	σ_0
(3) think it very dangerous	μ_2	σ_0
(4) do not know well	μ_1	σ_1

[a] $\mu_0 < \mu_1 < \mu_2$.

[b] $\sigma_0 < \sigma_1$.

Table 2. Variable Definitions and Descriptive Statistics

Variable	Definition	Mean (Standard Deviation) Uninformed	Informed	p-value[a]
INFO	1=informed group;	-	-	-
	0=uninformed group			
GM	Knowledge of GM techniques	2.043	2.120	0.481
	1=know well;	(0.566)	(0.589)	
	2=know somewhat;			
	3=do not know			
CORN	Knowledge of insecticidal corn	1.817	1.824	0.787
	1=know well;	(0.761)	(0.718)	
	2=know somewhat;			
	3=do not know			
LABEL	Knowledge of labeling system	2.022	2.102	0.403
	1=know well;	(0.655)	(0.652)	
	2=know somewhat;			
	3=do not know			
BUY	Purchase frequency of corn oil	2.194	2.157	0.502
	1=buy frequently;	(0.395)	(0.364)	
	2=buy sometimes;			
	3=do not buy			
GENDER	1=female;	0.710	0.722	0.844
	0=male	(0.454)	(0.448)	
AGE	Age in decades	3.731	3.713	0.894
		(1.329)	(1.218)	
JOB	1=office worker or official;	0.742	0.787	0.452
	0 otherwise	(0.438)	(0.409)	
CHILD	1=with children of age 12 or younger;	0.452	0.500	0.495
	0 otherwise	(0.498)	(0.500)	

[a] The p-value of Mantel test statistic for trend between the informed and the uninformed groups.

Table 3. Results of Mantel Tests for Trend between Informed and Uninformed Groups

	GM Corn		GM Corn Oil	
	Test Statistic	p-value	Test Statistic	p-value
Mean Component	6.943	0.008	1.076	0.300
Variance Component	6.922	0.009	2.717	0.099

Table 4. Estimated Mean and Median WTPs

	Uninformed	Informed	Entire Sample
Mean WTP (yen)	373	406	391
	(309, 439)[a]	(345, 470)	(343, 429)
Median WTP (yen)	200	300	250
	(175, 300)	(200, 400)	(200, 300)

[a] The 95% confidence interval constructed using the nonparametrtic percentile bootstrap method.

Table 5. Test Results of Equality of WTPs

Hypothesis of Equality of WTPs	95% Confidence Interval of the Difference		Test Result
	Lower Limit	Upper Limit	
Informed and Uninformed (Mean)	−122.1	58.0	not rejected
Informed and Uninformed (Median)	−200.0	100.0	not rejected
μ_0 and μ_1 (Mean)	−324.7	29.8	not rejected
μ_0 and μ_1 (Median)	−600.0	100.0	not rejected
μ_1 and μ_2 (Mean)	−103.4	121.1	not rejected
μ_1 and μ_2 (Median)	−100.0	200.6	not rejected
σ_0 and σ_1 (Mean)	−92.2	156.6	not rejected
σ_0 and σ_1 (Median)	−100.0	450.0	not rejected

Table 6. Regression Results for PE test

Variable	Linear Model			Semi-log Model		
	Coefficient	t-value	p-value	Coefficient	t-value	p-value
Intercept	1950.760	2.722	0.007	7.470	5.382	0.000
GM	293.032	2.386	0.018	0.443	1.446	0.150
CORN	−246.773	−2.082	0.039	−0.103	−0.581	0.562
LABEL	201.542	1.730	0.085	−0.196	−1.652	0.100
BUY	−177.952	−1.416	0.159	0.300	1.557	0.121
GENDER	−137.533	−1.738	0.084	−0.114	−0.607	0.545
AGE	−6.870	−0.307	0.759	0.039	0.587	0.558
JOB	−187.326	−2.591	0.010	−0.718	−1.936	0.054
CHILD	−165.387	−2.147	0.033	−0.368	−1.474	0.142
Difference in Prediction[a]	3416.990	2.369	0.019	−0.016	−1.714	0.088

[a] In the linear model, this variable means the difference between the prediction of $\ln WTP$ under the semi-log model and the logarithm of that of WTP under the linear model, and in the semi-log model, it means the difference between the prediction of WTP under the linear model and the exponential of that of $\ln WTP$ under the semi-log model.

Table 7. Estimation Results of Trivariate Models

Variable	Model 1			Model 2		
	Coefficient	t-ratio	p-value	Coefficient	t-ratio	p-value
Mean Function ($\boldsymbol{\beta}_m$)						
Intercept	0.531	0.504	0.614			
INFO	−0.305	−1.222	0.222	−0.275	−1.568	0.117
GM	0.130	0.624	0.532			
CORN	0.316	1.768	0.077	0.385	3.254	0.001
LABEL	−0.048	−0.261	0.794			
BUY	−0.452	−1.782	0.075	−0.310	−1.707	0.088
GENDER	0.657	2.421	0.015	0.700	3.621	0.000
AGE	0.107	1.111	0.266	0.141	1.852	0.064
JOB	0.539	1.980	0.048	0.612	2.995	0.003
CHILD	0.247	1.071	0.284	0.304	1.654	0.098
η	2.445	8.988	0.000	2.439	14.068	0.000
Variance Function ($\boldsymbol{\beta}_v$)						
Intercept	0.276	0.216	0.829			
INFO	−0.388	−1.166	0.244	−0.384	−1.752	0.080
GM	0.020	0.070	0.944			
CORN	−0.212	−0.754	0.451			
LABEL	−0.236	−1.118	0.264	−0.435	−5.958	0.000
BUY	−0.289	−0.602	0.547			
GENDER	−0.091	−0.191	0.848			
AGE	0.074	0.443	0.658			
JOB	0.157	0.314	0.754			
CHILD	−0.185	−0.504	0.614			
WTP Function ($\boldsymbol{\beta}_w$)						
Intercept	5.414	5.807	0.000	5.309	11.541	0.000
CORN	0.173	0.237	0.813			
LABEL	−0.253	−0.970	0.332	−0.180	−1.688	0.093
BUY	0.160	0.343	0.732	0.302	1.635	0.104
GENDER	0.164	0.158	0.874			
AGE	0.044	0.375	0.708			
JOB	−0.047	−0.072	0.943			
CHILD	−0.008	−0.014	0.989			
α_m	−0.191	−0.137	0.891			
α_v	−0.074	−0.067	0.947			
γ_w	0.994	9.361	0.000			
ρ_{mv}	0.122	0.073	0.942			
ρ_{mw}	0.171	0.120	0.905			
ρ_{vw}	−0.239	−0.247	0.805			
Log-likelihood	−495.891			−502.598		
AIC	1061.781			1033.196		