*Journal of Agricultural and Applied Economics*, 38,1(April 2006):201–211


# Consumers' Valuation of GMO Segregation Programs in Japan

**Shigeru Matsumoto**

The contingent valuation method was used to elicit Japanese consumers' willingness-to-pay for genetically modified organism (GMO) segregation programs. The results revealed that most consumers pay nonnegligible premiums for products produced under strict GMO-segregation programs. However, we found that the premium did not vary by the threshold level of GMO content in the product. We further found that a government certification did not increase the premium for GMO-segregation programs. Therefore, an additional mandatory regulation to reduce GMO contaminations would not be worthwhile because such a regulation would incur substantial enforcement costs.

*Key Words:* contingent valuation method, genetically modified organism segregation, willingness-to-pay

**JEL Classifications:** D12, M31, Q13, Q18

Consumers with heterogeneous preferences demand products of varying quality. Firms then attempt to attract customers to their products by informing them about the quality of the products. Although voluntary information disclosures by firms contribute to the segmentation of products in the market, the refined requests of the heterogeneous consumers are often not met. When the sale of a specific product causes welfare loss to some consumers, they demand that the government segregate the unwanted product. The segregation policy, in turn, incurs regulatory costs and may result in welfare loss for other consumers. Therefore, it is important to examine whether the segregation policy is worthwhile. This article studies the segregation policy for genetically modified organisms (GMOs) in Japan.

Japan is a major export market for the U.S. agricultural industry. For instance, in the year 2000, the U.S. exported 3,608,478 metric tons of soybean and 15,532,633 metric tons of corn to Japan. These export volumes correspond to 4.78% of the total U.S. soybean production and 6.13% of the total U.S. corn production.[1] Because U.S. agribusiness is greatly affected by Japanese agricultural policies, these policies are the key focus area of the U.S. government during trade negotiations. Among the many controversial agricultural policy problems between the two countries, the regulation of GMOs has now become the most serious.

The Japanese government introduced the policy of mandatory labeling of genetically modified foods on April 1, 2001. According to this new law, food companies should place

Shigeru Matsumoto is associate professor, Department of Economics, Kansai University, Osaka, Japan.

The author is grateful to two anonymous referees for their valuable feedback on an earlier draft of this paper. This article benefited from the valuable comments and suggestions of Charles Jones, Mark Metcalfe, Yoshiaki Kaoru, and Keiji Takeuchi. This research received financial support from the Kansai University Special Research Fund, 2002.

[1] U.S. production data are based on FAOSTAT (www.fao.org/). Import data are sourced from Trade Statistics of the Ministry of Finance, Japan (www.customs.go.jp/).

a GM label on the product if the proportion of GMOs in the product is more than 5% of its total weight. Thus, Japanese consumers now have access to GMO-labeling information while shopping. Despite this, consumer groups in Japan are still aggressively campaigning against GMOs (Seikatsu Club Group). They state that the current segregation policy on GMOs is too lenient and insist that the government should lower the threshold level of GMO content.[2] Furthermore, several consumer groups have examined products without any GM labeling (No! GMO Campaign). On discovering that the product contains GMOs, they disclose the name of the food company. The disclosure strategy exerts huge pressure on the food companies because this could easily result in loss of customers. To reduce the possibility of GMO mixing, the companies have started adopting voluntary segregation programs.

Several studies have examined the consumer acceptance of GMOs. Most of these studies, however, asked consumers to directly compare GM products with GM-free products. Consumers were then asked whether they would prefer to buy GM-free products at a premium or GM products at a discount. Although such willingness-to-pay (WTP) and willingness-to-accept (WTA) studies are useful for general GMO debates, they are not applicable to the imminent regulatory problem faced by policymakers and food companies in anti-GMO countries.[3] Consumer groups are likely to demand further GMO segregation. However, the segregation program involves substantial implementation costs because a large volume of food is imported from abroad. Therefore, the more relevant issues that should be examined are the need for a GMO-segregation program and the authority to be held responsible for such GMO-segregation programs.[4] We address these two issues in this article.

We elicited the consumers' WTP for the various GMO-segregation programs. Under a segregation policy, the threshold level of GMO content, beyond which a product is considered to be genetically modified, is specified. We examined how the consumers' WTP changes with the threshold level. If the consumers' WTP are sensitive to the threshold level, a stricter segregation policy could be formulated. Otherwise, the policy would be redundant.

To enforce mandatory segregation programs, the government should be actively involved in enforcement activities. Such activities incur nonnegligible costs. Because private companies have already instituted voluntary segregation programs, we must evaluate whether government certification for such GMO-segregation programs is necessary. To address this issue, we explore two scenarios in this article. In the first scenario, we asked consumers to indicate the WTP for a GM-free product with government certification. In the second scenario, we asked consumers to indicate WTP for a GM-free product produced under a voluntary segregation program by a private company. We compare consumer WTP across these two scenarios and discuss whether government certification for a GMO-segregation program is essential.

In the following section, we provide a literature review on the consumer acceptance of GMOs. In the third section, the data collection process and corresponding descriptive statistics are reported. In the fourth section, the empirical model is specified. We have employed a double-bounded dichotomous-choice contingent valuation (DBDC-CV) model. The results of the consumer WTP for GMO-segregation programs are presented in the fifth section. The final section presents the conclusions.

[2] The threshold level in the European Union is 1%.

[3] The exceptions are Noussair, Stéphane, and Ruffieux, and Rousu et al.) They examined the effect of threshold-level GMO content on the consumers' product selection. However, they did not pay attention to the voluntary GMO-segregation programs followed by private companies. We have addressed this in our article.

[4] Marubeni, one of the largest general trading companies in Japan, collaborated with Archer Daniels Midland, and introduced a unique management system to provide GMO-free crops to Japanese consumers. See Marubeni Corporation.

## Literature Review

Consumer acceptance of GMOs has recently attracted the attention of many economists. Over the past few years, a number of studies have been conducted on this topic. Several common findings have been reported in the foregoing studies. In this section, we briefly summarize the findings before specifying the purpose of our own research.

Foregoing studies examined the relationship between consumers' acceptance of GMOs and consumers' characteristics. Most studies found that consumers' acceptance of GMOs was poorly explained by sociodemographic variables (see Burton et al., for example).[5] In contrast, they found that subjective risk perception toward GMOs and background knowledge of biotechnology largely influenced the consumers' acceptance of GMOs.

Consumers' acceptance of GMOs varies widely across countries. Moon and Balasubramanian examined the WTP for breakfast cereals made from GMO-free foods in the United States and the United Kingdom. They found that consumers in the United Kingdom were significantly more willing to pay a premium for GMO-free cereal than those in the United States. Lusk et al. (2004a) conducted a laboratory auction experiment in the United States and in the European Union (EU). They found that the median level of compensation demanded by the English and French consumers to consume a GM cookie was twice that demanded by the U.S. consumers. McCluskey et al. conducted a CV survey in Japan. They found that many Japanese consumers were highly reluctant to purchase GM noodles. According to their findings, the discount required to induce most Japanese consumers to purchase GM noodles is above 50%. Li et al. examined the consumers' WTP for GM soybean and rice in Beijing, China. They showed that, unlike European and Japanese consumers, the Chinese consumers had displayed a very positive approach toward GM foods. Chern et al. conducted a survey on genetically modified vegetable oil, tofu, and salmon in the United States, Norway, Japan, and Taiwan. Their results revealed that there was a notable difference in the consumers' attitude toward GM foods across the four countries.

Consumers' acceptance of genetically modified technology also varies across different types of food. When consumers were asked to evaluate GM foods directly, they revealed a strong resistance to GM foods. In contrast, when asked to evaluate GMOs in processed foods, their resistance was mitigated. Lusk et al. (2004b) recently conducted a meta-analysis of genetically modified food-evaluation studies. They reported that consumers assigned the lowest values to GM meat products and the highest value to GM oil, in foregoing studies.

The use of GM technologies that do not provide tangible benefits to the consumer reduces the acceptability of the food. Hence, the producer must reduce the price of the so-called "first-generation" GM food, relative to the traditional non-GM food. In contrast, the so-called "second-generation" GM food has been developed to provide benefits to the consumer. Thus, it is expected that the second-generation GM foods enjoy greater consumer acceptability. West et al. studied the Canadian consumers' valuation of GM products that would enhance functional health properties. They found that most Canadian consumers were reluctant to purchase GM products even after evaluating the benefits of the functional properties associated with the products.

Although the foregoing studies reported valuable findings, these studies assumed that a complete segregation of GMOs was feasible. In a trade-oriented country like Japan, this assumption is slightly inappropriate. Furthermore, no research has compared consumer benefits under government regulation and under a private company's voluntary program in the GMO-segregation procedure. In this study, we asked consumers to evaluate various GMO-segregation programs. We will compare the consumers' WTP for these segregation programs.

[5] The exception is gender. Females, in general, are more concerned with GMOs.

## Survey Design and Data

The GM product used in this study is a potato snack product made with genetically modified potato. Potato snack products sold in Japan are diverse in terms of flavors and shapes. At a typical grocery store, consumers would find barbecue, curry, pizza, seaweed, shrimp, or wasabi flavors. Some of these products are molded into french fry or checkered shapes rather than usual potato-chip shapes. To begin this survey, we presented potato snack samples shaped like french fries to each subject.

Unlike GM soybean production or GM corn production, GM potato production is not very popular in the United States. In the year 2000, the production area of GM potatoes accounted for only 3% of the total potato production area. Monsanto Corporation, which developed the GM potato, has discontinued the sale of GM potato seeds since March 2001. Therefore, Japanese snack food companies assumed that the possibility of GM potato mixing was very limited. However, contrary to their expectations, it has been reported that since the enforcement of the new labeling law, many potato snacks without any GMO labeling contained GM potatoes. For example, House Foods, a leading food company in Japan, spent 400 million yen to recall their snacks that contained genetically modified potatoes, which the company was not licensed to sell in Japan. After a series of such incidents, GMO mixing has grown into a highly sensitive issue for many snack companies.

The survey discussed in this study was conducted at two stores: a grocery store and a bookstore. Both stores are located in Suita-shi, a suburb of Osaka, the second largest city in Japan. The data was collected between 10:00 am and 5:00 pm on December 8 and December 15, 2002. The subjects were individually and randomly recruited at the store entrance. As a reward for participation in the survey, every subject was given either a minidisk or batteries (an equivalent of 400 yen). In all, 252 subjects were interviewed. All partially completed survey forms were removed from the data set, which reduced the number of subjects to 219.

Variable definitions and summary statistics used in the analysis are presented in Table 1. We asked the subjects to list their income, family size, gender, age, and education level. We conducted the survey in a residential area where most residents are young couples with children because they are major buyers of potato snacks. The descriptive statistics show that subjects' age is well distributed in the relevant range. In the year 2000, the annual income of the average household in Japan was 6.199 million yen, whereas the average number of persons in a household was 2.76. Statistics listed in Table 1 reveal that the household income of subjects participating in our study was higher than the national average. Similarly, the number of persons in each household was also larger than the national average.

We divided the subjects into four groups to elicit their WTP for GMO segregation under different scenarios. Table 1 shows that Group 2 had the highest number of young subjects. The difference in age affects other data characteristics.

Consumption pattern may influence the WTP for GMO segregation. To take the consumption pattern into consideration, we asked subjects the consumption frequency of similar potato snacks.

A subject who considers GMO information to be important may spend more money to avoid GMO intake. We classified the product information into eight categories: volume, expiration date, ingredients, allergy, food additive, growing-district cultivation belt, calories, and transgenic. We then asked the subject to rank these categories. In Table 1, *Importance* indicates the consumer's ranking of GM-labeling information among these categories.

Hoban (1996, 1997) and Macer showed that the acceptance of biotechnologies was higher among people who have more knowledge of science. We included four questions to determine the changes in WTP with the level of a consumer's knowledge of science. First, the subject was asked to specify the number of years for which the Japanese scholars had been successively awarded the Nobel Prize for chemistry. Although this question does not di-

**Table 1.** Variable Definitions and Summary Statistics

| Variable | Definitions | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|---|
| *Income* | Annual household income level[a] | 1.86 | 1.72 | 1.89 | 1.94 |
| | | (0.79)[b] | (0.79) | (0.80) | (0.81) |
| *Family Size* | Number of people in the household | 3.12 | 2.15 | 3.38 | 3.00 |
| | | (1.31) | (1.41) | (1.31) | (1.19) |
| *Female* | 1 is female; 0 is male | 0.65 | 0.72 | 0.59 | 0.79 |
| | | (0.48) | (0.45) | (0.50) | (0.41) |
| *Age* | 1 is younger than 30, 2 is 30–40, | 2.16 | 2.00 | 2.34 | 2.33 |
| | 3 is 40–50, and 4 is older than 50 | (1.01) | (1.16) | (0.77) | (1.06) |
| *College* | Dummy variable, 1 is bachelor's | 0.42 | 0.21 | 0.54 | 0.31 |
| | degree; 0 is otherwise | (0.50) | (0.41) | (0.50) | (0.47) |
| *Frequency* | 1, eat snack at least 3 times | 0.44 | 0.38 | 0.59 | 0.46 |
| | per month; 0, otherwise | (0.50) | (0.49) | (0.50) | (0.50) |
| *Importance* | Respondent's subjective ranking | 4.21 | 4.34 | 4.38 | 4.00 |
| | of labeling information | (2.06) | (2.01) | (1.95) | (1.85) |
| *News* | Science news-related knowledge | 0.42 | 0.36 | 0.28 | 0.29 |
| | | (0.50) | (0.48) | (0.45) | (0.46) |
| *Biotech* | Biotech-related knowledge | 0.11 | 0.02 | 0.08 | 0.15 |
| | | (0.31) | (0.14) | (0.28) | (0.36) |
| *Diet* | Dietary knowledge | 1.07 | 1.21 | 1.00 | 1.17 |
| | | (0.73) | (1.43) | (0.80) | (0.78) |
| *N* | Number of subjects in each group | 57 | 53 | 61 | 48 |

[a] 1 is less than 6,000,000 yen; 2 is 6,000,000–8,000,000 yen; and 3 is more than 8,000,000 yen.
[b] Numbers in parentheses indicate standard deviations.

rectly check the level of science knowledge, it measures a subject's accessibility to science-related news. The second question pertained to biotechnology. We asked the subjects whether they were familiar with the term "traditional breeding" and asked them to explain it. A subject was considered to be a knowledgeable consumer if the response explained the fact that traditional breeding has been used for developing new products. Based on this biotechnology question, *Biotech* is used as a dummy variable. The last two questions pertained to general diet knowledge. We asked the subjects to indicate the recommended level of daily sodium intake as well as the three major nutrients. Subjects were asked to choose the right answer to each question from three alternatives. In Table 1, *Diet* indicates the number of correct answers to these two questions.

After handing a preprepared sample potato snack to the subject, the interviewer divulged the following information:

> Since April 2001, foods made from GMOs have been required to be labeled as "genetically modified" by the national law. However, when GMOs do not account for 5% or more of the total weight of the product, labeling is not required. Certainly, food companies put a lot of effort into the segregation of GMOs. But, such effort needs nonnegligible expenses.

To further segregate GM-free foods from GM foods, companies have to incur additional production costs. The government then needs to engage in comprehensive regulatory activities. Therefore, a policymaker must carefully decide on the threshold level of GMO content under a segregation policy. To address this issue, we varied the threshold level across three groups. The interviewer asked the following question to the subjects in Group 1, Group 2, and Group 3:

> Assume that the potato snack is priced at 120 yen. Now, suppose the government strengthens the labeling regulation and then guarantees

**Table 2.** Percentage of Subjects Whose Response Was "Yes" to the First Dichotomous-Choice Questions ($a/b = c\%$)

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Guarantor | Government | Government | Government | Company |
| *Threshold level* | 0% | 1% | 2% | 0% |
| *N* | 57 | 53 | 61 | 48 |
| First *Bid* ($B_1$) | | | | |
| 20 yen | 13/19 = 68.4% | 16/20 = 80.0% | 14/25 = 56.0% | 14/20 = 70.0% |
| 30 yen | 14/20 = 70.0% | 10/16 = 62.5% | 11/16 = 68.8% | 9/15 = 60.0% |
| 40 yen | 8/18 = 44.4% | 9/17 = 52.9% | 7/20 = 35.0% | 8/16 = 50.0% |

[a] Number of subjects whose response was "Yes."
[b] Number of subjects.
[c] Percentage of subjects who responded "Yes."

> Group 1: complete prevention of GMO mixing
> Group 2: reduction of GMO mixing to less than 1%
> Group 3: reduction of GMO mixing to less than 2%
>
> in the product without any GMO label. Would you purchase the potato snack under the new segregation policy if the price increases by $B_1$ yen? Please note that the prices of potato snacks produced by other food companies would increase in a similar fashion once the policy is introduced.

By comparing responses across the three groups, we can show the changes in consumers' WTP with a change in the threshold level of GMO content. Because the typical Japanese consumer prefers GM-free products, we expect that the WTP increases with the reduction of the threshold level.[6]

Consumers who are against the use of GMOs can purchase the product from the company that guarantees to sell only GM-free products.[7] By doing so, they can effectively prevent the intake of GMOs. However, if the consumers find additional benefits in mandatory GMO regulation enforced by the government, they will demand government certification for the segregation program. To examine the changes in consumer responses with the availability of government certification, we asked a different question to the subjects in Group 4. Specifically, the interviewer asked the following question:

> Group 4: Assume that the potato snack is priced at 120 yen. Now, suppose that a well-known food company promises to use the foods grown in a specific area, enters into exclusive contracts with specific farmers, and engages in zero-tolerance programs. Then, the company guarantees complete prevention of GMO mixing in the product. Would you purchase the potato snack produced by this company if the price increases by $B_1$ yen?

A discrepancy will be observed in the WTP between Group 4 and the remaining three groups, only if the consumers find additional benefits in government certification. By comparing the WTP of Group 4 with that of the remaining three groups, we will examine whether the consumers find additional benefit in mandatory regulation.

Table 2 shows the percentage of subjects who responded "yes" to the first dichotomous choice question. We compare the consumer response across bids. The lowest response rate was observed against the highest bid (40 yen). However, the percentage of subjects who responded positively in Group 3 increased from 56.0% to 68.8% as the bid increased from 20

[6] We examined the prices of similar potato snacks at grocery stores. The prices ranged between 100 yen and 150 yen. Because the stores were located near the university, we asked 21 students about their WTP for the GM-free product. The WTP of 20 students was below 160 yen; hence, we set the maximum price at 170 yen.

[7] For example, the Seikatsu Club Group and Daichi-No-Kai deal with a producer who exclusively produces GMO-free products.

**Table 3.** Percentage of Subjects Who Responded "Yes" to the Second Dichotomous Choice Questions ($a/b = c\%$)

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Guarantor | Government | Government | Government | Company |
| *Threshold level* | 0% | 1% | 2% | 0% |
| *N* | 57 | 53 | 61% | 48 |
| Second *Bid* ($B_2$) | | | | |
| 10 yen | 4/6 = 66.7% | 4/4 = 100.0% | 8/11 = 72.7% | 4/6 = 66.7% |
| 20 yen | 5/6 = 83.3% | 6/6 = 100.0% | 5/5 = 100.0% | 6/6 = 100.0% |
| 30 yen | 15/23 = 65.2% | 12/24 = 50.0% | 19/27 = 70.4% | 14/21 = 66.7% |
| 40 yen | 8/14 = 57.1% | 5/10 = 50.0% | 4/11 = 36.4% | 4/8 = 50.0% |
| 50 yen | 2/8 = 25.0% | 5/9 = 55.6% | 0/7 = 0.0% | 3/7 = 42.9% |

[a] Number of subjects whose response was "Yes."
[b] Number of subjects.
[c] Percentage of subjects who responded "Yes."

yen to 30 yen. This shows that the consumer response did not change with the bid in a systematic way.

Next, we compare consumer responses across groups. To examine the effect of the threshold level, we compared the percentage of subjects who responded positively in Group 1, Group 2, and Group 3. Using chi-square tests, we tested the hypothesis that the frequencies of positive responses were identical across the three groups. We failed to reject the hypothesis at all three bid levels ($P = 0.232$ at 20 yen, $P = 0.883$ at 30 yen, and $P = 0.546$ at 40 yen).

To examine the effects of the mandatory regulation, we compared the percentage of positive responses between Group 1 and Group 4. We tested the hypothesis that the frequencies of "yes" were identical across the two groups. Again, we failed to reject the hypothesis at all three bid levels ($P = 0.915$ at 20 yen, $P = 0.537$ at 30 yen, and $P = 0.746$ at 40 yen).

Follow-up questions were asked according to the consumer's response to the first question. If the subject's answer to the first question was "yes," they were subsequently asked whether they would purchase the potato snack under a new segregation program if the price increased by $B_{2Y}$ yen, where $B_{2Y} = B_1 + 10$. Conversely, if the subject's answer to the foregoing questions was "no," they were asked whether they would purchase the potato snack under a new segregation program if the price increased by $B_{2N}$ yen, where $B_{2N} = B_1 - 10$.

Table 3 shows the percentage of subjects whose response was "yes" to the second dichotomous choice question. The range of the second bid is wider than that of the first. However, the basic statistics are similar to that of Table 2.

## Model Specification

Assume that a consumer $i$ has a true WTP for GMO segregation, $WTP_i^*$. Denoting the determinant of WTP as a vector, $\mathbf{X}_i$, and assuming a linear functional form for the WTP equation, $WTP_i^*$ can be specified as

$$(1) \qquad WTP_i^* = \mathbf{X}_i'\boldsymbol{\beta} + \varepsilon_i$$

where $\boldsymbol{\beta}$ is a vector of coefficients, and $\varepsilon_i$ is an independently and identically distributed normal error with zero mean and variance $\sigma^2$. In our DBDC-CV, there are four possible outcomes: (1) both answers are "yes" (yes-yes); (2) a "yes" followed by a "no" (yes-no); (3) a "no" followed by a "yes" (no-yes); and (4) both answers are "no" (no-no). Let us define $I^{yy}$, $I^{yn}$, $I^{ny}$, and $I^{nn}$ as indicator functions for these four outcomes. The log-likelihood function is then defined as:

**Table 4.** Willingness-to-Pay for GM Food Segregation[a]

| | SBDC Model | | DBDC Model | |
|---|---|---|---|---|
| | Coefficient | SD | Coefficient | SD |
| *Constant* | 1.048** | (0.534) | 1.171*** | (0.427) |
| *Income* | −0.123 | (0.121) | −0.133 | (0.106) |
| *Family Size* | 0.033 | (0.078) | 0.044 | (0.066) |
| *Female* | 0.346 | (0.214) | 0.301 | (0.202) |
| *Age* | 0.176 | (0.107) | 0.175* | (0.090) |
| *College* | 0.066 | (0.209) | −0.049 | (0.193) |
| *Frequency* | −0.154 | (0.187) | −0.119 | (0.165) |
| *Importance* | −0.028 | (0.048) | −0.013 | (0.043) |
| *News* | −0.343* | (0.192) | −0.344* | (0.177) |
| *Biotech* | −0.098 | (0.328) | −0.109 | (0.289) |
| *Diet* | 0.055 | (0.102) | 0.003 | (0.104) |
| *Threshold Level* | −0.163 | (0.124) | −0.117 | (0.111) |
| *No Mandatory Regulation* | −0.312 | (0.252) | −0.283 | (0.225) |
| *Bid* | −0.035*** | (0.013) | −0.050*** | (0.005) |
| Log-likelihood | −135.238 | | −278.862 | |
| *N* | 219 | | 219 | |

[a] GM is genetically modified; DBDC is double-bounded dichotomous-choice.
*** Indicates statistical significance at the 1% level.
** Indicates statistical significance at the 5% level.
* Indicates statistical significance at the 10% level.

$$
\begin{aligned}
(2)\quad \log L = \sum_{i=1}^{N} [ & I_i^{yy} \ln\{1 - \Phi[(B_i^{2y} - \mathbf{X}_i'\boldsymbol{\beta})/\sigma]\} \\
& + I_i^{yn} \ln\{\Phi[(B_i^{2y} - \mathbf{X}_i'\boldsymbol{\beta})/\sigma] \\
& \qquad - \Phi[(B_i^{1} - \mathbf{X}_i'\boldsymbol{\beta})/\sigma]\} \\
& + I_i^{ny} \ln\{\Phi[(B_i^{1} - \mathbf{X}_i'\boldsymbol{\beta})/\sigma] \\
& \qquad - \Phi[(B_i^{2n} - \mathbf{X}_i'\boldsymbol{\beta})/\sigma]\} \\
& + I_i^{nn} \ln\{\Phi[B_i^{2n} - \mathbf{X}_i'\boldsymbol{\beta})/\sigma]\}],
\end{aligned}
$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function.

In the assessment of the consumer WTP, we use the sociodemographic variables defined in Table 2 and the bid information. We also examine the effect of the threshold-level change and the availability of government certification.

## Results

In this study, we employed the DBDC-elicitation method. Follow-up questions used in the DBDC format allow a researcher to narrow the confidence interval. This particular feature makes the DBDC elicitation method the most popular method in CV studies. However, several studies have criticized the DBDC elicitation method because the use of follow-up questions produces a bias (see Bateman et al., for example). Yoo and Yang correctly summarized the argument and stated that the distribution of underlying preferences implied by the answers to the first question may not be the same as that implied by the responses to the first and second questions. Although several studies have dealt with the problem, the validity of the DBDC model is still a controversy (see Hanemann, Loomis, and Kanninen, Cameron and Quiggin, McFadden). In consideration of the current controversy, we report the result for a single-bounded dichotomous choice (SBDC) probit model, using only the responses to the first bid, and the result for the DBDC probit model using the responses to both the first and second bids.

Table 4 presents the basic results. Most parameter signs are consistent across the SBDC and DBDC models, with the exception of *College*. However, the parameter for this variable is not statistically significant. Sociodemographic variables are not statistically signifi-

cant, with the exception of *Age*. Older consumers pay a larger premium for products produced under strict segregation programs.

A consumer's subjective evaluation of GMO-labeling information does not influence his or her WTP. For instance, in this survey, subjects who answered that GMO information was important, did not necessarily state that they would pay a premium for GMO segregation. A consumer's accessibility to science-related news also influenced the results. The results show that a consumer who is likely to access science-related news pays less money for GMO segregation. On the other hand, neither biotech knowledge nor diet knowledge can explain the difference in the WTP.

In Table 4, *Threshold Level* indicates the threshold level of GMO content: 0%, 1%, and 2%. The minus parameter sign for the variable implies that the WTP decreases as the threshold level of GMO content increases; therefore, we obtained the expected sign. However, the parameter is not statistically significant. In Table 4, *No Mandatory Regulation* is the dummy variable for Group 4, which was asked to specify its WTP for a private company's voluntary segregation program. The minus sign of this variable shows that the consumer WTP under mandatory regulation with government certification is larger than that under the private company's voluntary program. The consumers thus found an additional benefit in government certification. However, the parameter is not statistically significant.[8]

In Table 4, *Bid* indicates the rate of bid for the potato snack price: $Bid = (B_i/120)/100$. Therefore, it specifies the premium for products produced under strict GMO-segregation programs. The parameter for *Bid* is negatively significant, which indicates that the consumers pay premiums. Based on the results of the SBDC model, the mean WTP for the complete GMO-segregation program is 46.27 yen under government regulation. This is approximately 38.56% of the price of the potato snack. However, when the DBDC model is used, the mean WTP declined to 34.37 yen, which is 28.64% of the price of the potato snack.

Lusk et al. (2004b) calculated the average premium for non-GM foods in their meta-analysis. They reported that the average premium across all the foregoing studies was 44%. When one outlier is eliminated from the samples, the average premium decreases to 29%. Thus, the estimated WTP in this study is approximately equal to the average of the foregoing studies.

## Conclusions

Foregoing studies have estimated the premiums for GM-free products. Hence, in this article, we estimated the consumer WTP for GM-segregation programs. Based on the results, the mean consumer WTP for complete GMO segregation is 28.64% of the product price. This implied that Japanese consumers greatly valued GMO-segregation programs.

Rousu et al. conducted an experimental auction in the United States. They compared mean consumer bids for GM-free products with that of products for which the GM-threshold was set either at 1% or 5%. They then demonstrated that consumers were willing to pay a large premium to avoid GM contamination in an uncontaminated product. However, they also found that consumers would not greatly value a 1% GM-tolerance level over a 5% level. In this study, we conducted a contingent valuation survey on Japanese consumers. These consumers were more familiar with GM-segregation programs than U.S. consumers because the GM-labeling program has been in effect since April 1, 2001. We obtained the empirical evidence that supports the finding by Rousu et al. Thus, we can conclude that Japanese consumers would not pay a premium for the reduction in GM-tolerance level.

In Japan, many food companies engage in

[8] This experiment is hypothetical. A large number of articles show that individuals act differently in hypothetical experiments compared with nonhypothetical experiments. However, Lusk and Schroeder argued that researchers are able to compare marginal differences in WTP as long as the overall hypothetical bias is constant. The primary focus of this article is the marginal difference in WTP for different threshold levels and the availability of government certification. We thank the referee for information in this regard.

voluntary GMO-segregation programs to reduce GMO contamination. Consumers who are against the use of GMO products can purchase the product from such companies. In this study, we examined whether consumers derive additional benefits on account of mandatory regulation. We found that, on an average, a consumer perceives an approximately 28% to 38% benefit in using GM-free products, irrespective of whether it has government certification.

Interestingly, the reduction of threshold level and government certification do not affect consumer WTP. Therefore, additional mandatory regulation to reduce GMO contaminations might not be worthwhile because such a regulation would incur substantial enforcement costs.

*[Received May 2004; Accepted November 2005.]*

## References

Bateman, I.J., I.H. Landford, A.P. Jones, and G.N. Kerr. "Bound and Path Effects in Double and Triple Bounded Dichotomous Choice Contingent Valuation." *Resource and Energy Economics* 23,3(July 2001):191–213.

Burton, M., D. Rigby, T. Young, and S. James. "Consumer Attitude to Genetically Modified Organisms in Food in the UK." *European Review of Agricultural Economics* 28,4(2001): 479–98.

Chern, W. S., K. Rickertsen, N. Tsuboi, and T. T. Fu. "Consumer Acceptance and Willingness to Pay for Genetically Modified Vegetable Oil and Salmon: A Multiple-Country Assessment." *AgBio Forum* 5,3 (2003).

Daichi-No-Kai. Internet site: www.daichi.or.jp/cgi/index.pl (Accessed April 21, 2004).

Hanemann, M., J. Loomis, and B. Kanninen. "Statistical Efficiency of Double-Bounded Choice Contingent Valuation." *American Journal of Agricultural Economics* 73(1991):1255–63.

Hoban, J.T. "How Japanese Consumers View Biotechnology." *Food Technology* 50,7(July 1996): 85–88.

———. "Consumer Acceptance of Biotechnology: An International Perspective." *Nature Biotechnology* 15,3(March 1997):232–34.

Li, Q., K.R. Curtis, J.J. McCuskey, and T.I. Wahl. "Consumer Attitude Toward Genetically Modified Foods in Beijing, China." *AgBio Forum* 5,4 (2003).

Lusk, J.L., and T.C. Schroeder. "Are Choice Experiments Incentive Compatible? A Test with Quality Differentiated Beef Steaks." *American Journal of Agricultural Economics* 86,2(May 2004):467–82.

Lusk, J.L., L.O. House, C. Valli, S.R. Jaeger, M. Moore, B. Morrow, and W.B. Traill. "Heterogeneity in Consumer Preferences as Impetus for Non Tariff Trade Barriers: Experimental Evidence of Demand for Genetically Modified Food in the United States and European Union." Working paper, Department of Agricultural Economics, Purdue University, 2004a.

Lusk, J.L., M. Jamal, L. Kurlander, M. Roucan, and L. Taulman. "A Meta Analysis of Genetically Modified Food Valuation Studies." Working paper, Department of Agricultural Economics, Purdue University, 2004b.

Macer, D. "Japanese Attitudes to Genetic Technology: National and International Comparisons. Public and Academic Support for the Use of Government-funded Genetic Screening in Japan." *Human Genome Research and Society.* N. Fujiki and D. Macer, eds., pp. 120–37, Christchurch: Eubios Ethics Institute, 1992.

Marubeni Corporation. *Marubeni Group Journal: M-Spirit No. 11.* Internet site: www.marubeni.co.jp/usful/word/11.html (Accessed September 2002).

McCluskey, J.J., K.M. Grimsrud, H. Ouchi, and T.I Wahl. "Consumer Response to Genetically Modified Food Products in Japan." *Agricultural and Resource Economics Review* 32,2(2004): 222–31.

McFadden, D. "Contingent Valuation and Social Choice." *American Journal of Agricultural Economics* 76(1994):689–708.

Moon, W., and S.K. Balasubramanian. "Public Perceptions and Willingness-to-Pay A Premium for Non-GM Foods in the United States and United Kingdom." *AgBio Forum* 4,3/4(2001).

No! GMO Campaign. Internet site: www.no-gmo.org/ (Accessed April 20, 2004).

Noussair, C., R. Stéphane, and B. Ruffieux. "Do Consumers Really Refuse To Buy Genetically Modified Food?" *The Economic Journal* 114(January 2004):102–20.

Rousu, M., W.E. Huffman, J.F. Shogren, and A. Tegene. "Are United States Consumers Tolerant of Genetically Modified Foods?" *Review of Agricultural Economics* 26(February 2004):19–31.

Seikatsu Club Group. Internet site: www.seikatsuclub.coop/ (Accessed April 20, 2004).

West., G.E., C. Gendron, B. Laurue, and R. Lambert. "Consumers' Valuation of Functional Properties of Foods: Results from a Canada-wide Survey." *Canadian Journal of Agricultural Economics* 50(December 2002):541–58.

Yoo, S.H., and H.H. Yang. "Application of Sample Selection Model to Double-Bounded Dichotomous Choice Contingent Studies." *Environmental and Resource Economics* 20(October 2001):147–63.