Willingness to Pay for Genetically Modified Food: Evidence from an Auction Experiment in Japan

This paper reports results from an experimental auction conducted in Japan. The auction experiment featured simultaneous bidding for the non-GM and GM products, combined with a stated choice question. We first estimated separately the hypothetical and nonhypothetical discounts on GM food for respondents to accept them. We then jointly estimated nonhypothetical and hypothetical GM discount functions to find little evidence of hypothetical bias for a common food product. We found that Japanese consumers required about 40% discount on the GM foods.

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Introduction

Consumer acceptance of food biotechnology has attracted considerable attention of applied economists in the past decade as the technology became commercial reality. Genetically modified (GM) foods were introduced to the market in 1996, and they have stirred heated debates in the U.S. export markets such as the European Union and Japan. The governments in these markets have already implemented labeling laws to restrict the development and distribution of GM foods, and they are considering making the laws even more stringent. These actions are justified by strong consumer opposition indicated by opinion polls and attitudinal surveys. The situation may not be particularly favorable for the developers and distributors of GM foods when the second-generation GM foods with direct consumer benefits are in the pipeline.

Consumer acceptance is the key to commercial success of GM foods. It is important to know how much premium on a non-GM food that consumers are willing to pay to avoid the GM alternative or how much discount is needed for consumers to accept a GM food. This information is valuable not only for farmers, food processors, and biotechnology firms but also for regulatory agencies. To obtain the required information, we need to employ a method of economic valuation. A popular choice is a survey-based stated preference method, such as contingent valuation or choice experiment, and many authors have applied these methods to study consumers' acceptance of GM foods (Burton, Rigby, Young, & James, 2001; Boccaletti & Moro, 2000; Chern, Rickertsen, Tsuboi, & Fu, 2003; Lusk, Roosen, and Fox, 2003; Lusk, 2004; McCluskey, Grimsrud, Ouchi, & Wahl, 2004; Moon & Balasubramanian, 2003; Li, McCluskey, & Wahl, 2004; Grimsrud, McCluskey, Loureiro, & Wahl, 2004). Survey-based methods may suffer from biases due to the hypothetical nature of the valuation questions, and there are many studies that report the evidence of hypothetical bias (Fox, Shogren, Hayes, & Kliebenstein, 1998; List & Shogren, 1998; Lusk & Fox, 2003). Nonetheless, there is no study that compares the hypothetical and nonhypothetical willingness to pay for non-GM or GM foods. We intend to provide a first attempt at examining the extent of hypothetical bias, if it exists at all, with regard to consumers' acceptance of GM foods.

In order to study the potential hypothetical bias, we need to have a nonhypothetical estimate of willingness to pay to serve as an anchor, in addition to the hypothetical counterpart. Since market-level data are unavailable, the only practical alternative is to use the experimental auction. A problem with the experimental auction is that the traditional method of experimental auction (one that uses the exchange format) does not serve our purpose. Suppose if we used the exchange format. We first endow the participants with the GM food and ask them to bid for exchanging the GM food with the non-GM food. Let B^{NG} and B^{GM} denote the true values of the non-GM and GM products to a participant, respectively. Since the exchange format elicits a bid for exchanging the two products, what we observe is only the difference $B^{NG} - B^{GM}$ and not B^{NG} and B^{GM} themselves. It is difficult to interpret the meaning of the difference $B^{NG} - B^{GM}$ if the absolute value of B^{NG} or B^{GM} differs among participants: the meaning of 5 dollars is different if it is compared against 10 dollars than if compared against 20 dollars. We need also elicit either B^{NG} or B^{GM}, if not both of them. To meet this challenge, we develop a format of experimental auction that requires the participants to submit bids for both the non-GM and GM foods simultaneously. By eliciting both B^{NG} and B^{GM}, we can obtain the required percentage discount on the GM food that can be easily compared against the corresponding value obtained from a hypothetical valuation question.

The knowledge of B^{NG} and B^{GM} incidentally provides an advantage of sorting out an issue in the empirical literature on consumer acceptance of GM foods: namely, the specification of the willingness-to-pay function. The literature has mixed results on how demographic variables behave as determinants of the willingness to pay. Baker and Burnham (2001) find that demographic variables are not significant determinants of the choice between non-GM and GM alternatives, but cognitive variables are. Moon and Balasubramanian (2003) find that demographic variables influence the choice but that they would become insignificant if they were included along with variables measuring the benefits and risks of GMOs (cognitive variables). This is because respondents' perception of benefits and risks are themselves influenced by demographic variables. On the other hand, Grimsrud et al. and Li, McCluskey, and Wahl find that demographic variables are generally significant even along with cognitive variables. In contrast, Huffman, Shogren, Rousu, and Tegene (2003) find none of their demographic variables are significant determinants of the non-GM premium (the food label was the only significant variable in their study). This inconsistency may be partly due to the difference in the elicitation mechanism and what is elicited in the study (e.g., willingness to pay or willingness to accept). Except for Huffman et al., researchers have used a variant of the exchange format. If the question is "Given the price of GM food, are you willing to pay a premium of *x* dollars on the non-GM food?" then we only know how much *more* the consumer is willing (or unwilling) to pay for the non-GM food; we still do not know the true values of the non-GM and GM foods. If we know B^{NG} and B^{GM}, then we can run a regression of B^{NG}, B^{GM}, and $B^{NG} - B^{GM}$ on demographic and cognitive variables. This is beneficial because we can study more complex behavioral patterns of the participants.

The objectives of this paper are to determine how Japanese consumers' willingness to pay for non-GM foods is influenced by demographic and cognitive variables and to determine the extent of potential hypothetical bias by comparing the non-GM premiums estimated by using experimental auction and contingent valuation. We elicit how much Japanese consumers are willing to pay for the non-GM and GM products by using experimental auction and find a possible reason why demographic variables are not always the determinants of the non-GM premium. Our results indicate that Japanese consumers' required GM discount is influenced by cognitive variables but not quite so by demographic variables and that there is little evidence that respondents exaggerate the GM discount (in percentage terms) they are willing to accept.

Procedure

We conducted an experiment in which GM and non-GM canola oil were involved. The choice of canola oil was made because it was the only available and acceptable choice. The purpose of the experiment was to measure the price difference that Japanese consumers were willing to sustain between the GM and non-GM alternatives when the alternatives were exactly the same in product attributes except for the use of GM and non-GM ingredients.[3] Since the auctioned products were displayed in front of the experimental subjects, they needed to appear exactly the same. One product we could manage to find that had both GM and non-GM varieties readily available in supermarkets and that looked the same was canola oil.

In three sessions, we also used GM and non-GM natto. Natto is fermented soybeans popularly consumed as a breakfast item in Japan. We added this product because, unlike oil, it is directly consumed and because the GM natto first hit the market just in time for our use in the experiment. We expected that the consumers have different levels of acceptance according to the way the GM ingredients are used in the foodstuffs, and the use of natto allowed us to examine if there was a categorical difference in acceptance between oil and natto.

We bought GM and non-GM canola oil of the same size (i.e., 1000 gram bottle) from supermarkets, peeled off the product labels, and pasted plain labels that said only the name of the products (namely, either GM or non-GM oil), their weight, and their GM status.[4] Similarly, we purchased 40 grams each of GM and non-GM natto packed in familiar white Styrofoam containers and replaced the product labels with plain labels. Although the products for display had plain labels, we guaranteed to the participants that they would purchase the products with the original labels prepared by the manufacturers.

The winner of the auction was determined by the second-price sealed-bid auction as well as the two-tier random mechanism. There were two trials in each auction. The participants simultaneously submit their bids for the GM and non-GM alternatives. The identification number of the participant who submitted the highest bid was announced along with the second highest bid for each product. Another trial was done by asking the participants to submit their bids once again. Then a straw was randomly drawn to determine which trial was binding (i.e., either first or second), and then another random draw of a straw was made to determine which product (i.e., either GM or non-GM) was binding in the chosen trial. A real transaction was made for only the binding product in the binding trial so that only one product was sold to only one participant in each experimental session.[5] The second-price auction was adopted because it is relatively easy to implement and because it is a weakly dominant strategy for the participants to reveal their true valuations (Vickrey, 1961; Milgrom & Weber, 1982). The use of random draws was made to control for the so-called wealth effect.

Each experimental session had two stages. At the first stage there were two trials of candy bar auctions, and at the second stage there were two trials of canola oil auction and, in select sessions, two trials of natto auction. The purpose of the first stage was to get participants acquainted with the mechanism of the second-price sealed-bid auction and random determination of binding trial and product. In each auction, participants bid for two products, but only one product was actually sold. At the beginning of the experiment, each respondent was given a small amount of "budget" with which bids were made.[6]

Once we collected all of the bids, we ran a regression of bid adjustment (i.e., second bid minus first bid) on the difference between the first announced price and the first bid (ΔP_j) and other control variables (X_{jk}):

$$\Delta Bid_j = \beta_{j0} + \beta_{j1}\Delta P_j + \sum_k \beta_{jk} X_{jk} + \varepsilon_j \tag{1}$$

The index *j* was used to indicate alternative products. The purpose of this regression was to test if the trial 2 bid was influenced by the announced price. If the announced price affected the participants' bids (i.e., affiliation was evident), then it was hard to claim that the trial 2 bid was an individual private value. If affiliation existed, Vickrey auction no longer elicited the participants' true values. In that case, it was recommended that the second bid be discarded. We included only the number of participants in the session and frequency of consumption as additional control variables. The number of participants measured the competitiveness of the session: on average, the more participants there were, the more aggressively one had to bid to win the auction.

Next, we ran regressions of B^{NG} , B^{GM} , and $B^{NG} - B^{GM}$ on demographic and cognitive variables (using earlier notations). About thirty percent of the participants submitted zero for the GM product, so we had to use a Tobit model for the regression of B^{GM} (lower censoring at zero) and hence for the regression of $B^{NG} - B^{GM}$ (upper censoring at B^{NG}). After removing inconsistent and unreasonable responses, we observed that no participants had submitted a zero bid for the non-GM product, so a linear regression was appropriate for B^{NG} . The models were specified as follows.

$$B^{NG} = \beta_0 + \beta_1 FAFH + \beta_2 AGE + \beta_3 EXPFAH + \beta_4 LAB + \beta_5 CANOLA + \varepsilon \tag{2}$$

$$B^{GM} = \beta_0 + \beta_1 NG + \beta_2 RISK + \beta_3 FAFH + \beta_4 EXPFAH + \beta_5 LAB + \beta_6 CANOLA + \varepsilon \tag{3}$$

$$\begin{aligned} B^{NG} - B^{GM} = {} & \beta_0 + \beta_1 NG + \beta_2 RISK + \beta_3 FAFH + \beta_4 AGE + \beta_5 EXPFAH + \beta_6 LAB \\ & + \beta_7 CANOLA + \varepsilon \end{aligned} \tag{4}$$

The variables common to all of the three models above were the frequency of dining out (FAFH), monthly food expenditure (EXPFAH), dummy for the location (LAB), and frequency of purchase (CANOLA). The dummy variables NG and RISK were added only to the GM bid model because these variables need not affect the non-GM bid because the non-GM product was a conventional product. The dummy variable NG equaled 1 if the individual submitted a higher bid for the non-GM alternative in the first trial of canola oil auction. This variable allowed some participants to have a nonpositive non-GM premium. Since it reflected the participant behavior, it had an aspect of dependent variable. We have more discussion on this variable below. The dummy variable RISK measured the participants' perception of risk to human health. The model for the non-GM bid additionally included age as an independent variable. This was not necessary, but it was a harmless control variable. Equation (4) contained all of the variables appearing in equations (2) and (3) as the left-hand side was the difference between the non-GM and GM bids. The definition of variables is given in Table 1.

Since the dummy variable NG reflected the process of self-selection, we estimated Probit models with NG being the dependent variable. In the first model, a full set of cognitive and demographic variables were included; in the second, only cognitive variables were included; and in the third, only demographic variables were used. The purpose of this analysis was to find the determinants of how one self-selected into the group that definitely preferred non-GM to GM food.

After the experimental auction, the participants were asked to make hypothetical purchase decisions under given price scenarios. Specifically, we provided the respondents a choice between GM and non-GM canola oil given the price scenarios. The price of GM oil was set at 250 yen, which was roughly the market price of GM canola oil. The price of the non-GM oil was set so that it would be 30, 50, 70, and 90% more expensive than the

GM oil. For the natto experiment, the base price of 30 yen was used, with the analogous scheme of price variations. The price scenarios were randomly distributed among the participants.

Once we collected hypothetical responses, we estimated the non-GM premiums. Since the question did not directly elicit the participants' willingness to accept a GM discount, we needed to invoke an econometric model to estimate the individual GM discount. We considered two models. The first was the minimum legal WTP model due to Harrison and Kriström (1995). According to this model, the respondent's choice was treated as simply agreeing to a legal contract. If the respondent chose the non-GM oil when the non-GM and GM prices were 325 yen and 250 yen, respectively, then the choice was taken to mean that the respondent were willing to pay a premium of 75 yen to the non-GM oil. If, under the same price scenario, the respondent chose the GM oil, then that choice would simply mean that the respondent were willing to pay a non-GM premium of zero. We included this approach to obtain a conservative estimate of non-GM premium.

The other approach was a standard Probit model. Let U^1 and U^0 be the utility functions for consuming the non-GM and GM alternatives. We assumed that the utility functions had a linear form: $U^1 = \beta_0^1 + \beta_1 P^1 + \boldsymbol{\beta}_2^{1\prime}\mathbf{x} + \varepsilon^1$ and $U^0 = \beta_0^0 + \beta_1 P^0 + \boldsymbol{\beta}_2^{0\prime}\mathbf{x} + \varepsilon^0$, where P^1 and P^0 indicated the non-GM and GM prices, respectively, and $\mathbf{x}$ was a vector of respondent characteristics (note that β_1 was the common price coefficient). The respondent would choose the non-GM alternative if and only if $U^1 > U^0$. This condition was alternatively expressed by the statement that $U > 0$, where $U = U^1 - U^0$. We assumed that the utility difference is a linear function such that $U = \beta_0 + \beta_1 \Delta P + \boldsymbol{\beta}_2{}'\mathbf{x} + \varepsilon$, where $\Delta P = P^1 - P^0$, $\beta_0 = \beta_0^1 - \beta_0^0$, $\boldsymbol{\beta}_2 = \boldsymbol{\beta}_2^1 - \boldsymbol{\beta}_2^0$, and $\varepsilon = \varepsilon^1 - \varepsilon^0$.[7] We also assumed that ε had a normal distribution. Since the non-GM premium was the maximum amount the respondent was willing to pay for the non-GM relative to the GM price, it was the price difference such that $U = 0$. However, since the utility was itself a random variable, we needed to take the expected value to remove randomness. Thus, the expected non-GM premium was

$$E[\text{Premium}] = -\frac{\beta_0 + \boldsymbol{\beta}_2{}'\mathbf{x}}{\beta_1}. \tag{5}$$

We included the segment dummy NG, monthly food expenditure, and frequency of purchase as covariates.

Now that we obtained unconditional and conditional (i.e., predicted) auction bids as well as hypothetical responses, we wished to compute the non-GM premiums in percentage terms. However, we encountered a problem with the formula for the percentage premium: the formula was given by $(B^{NG} - B^{GM}) / B^{GM}$, but the denominator was zero for many participants. Therefore, we could not take the sample mean of the percentage premiums defined by the above formula. Since no participant bid zero for the non-GM product, we replaced the denominator with B^{NG}. The resulting formula could be interpreted as the minimum discount on the GM product that one required in order to accept the GM product.

Since the percentage discounts from the Tobit and Probit models were estimated separately, it was impossible to test formally the equality between the two. To tackle this problem, we jointly estimated nonhypothetical and hypothetical GM discount equations, assuming that the errors had a bivariate normal distribution. As was mentioned above, the simple bid difference and price difference were inappropriate for direct comparison, so we used the percentage GM discounts as the dependent variables. We used only the canola oil data here because the sample size for the natto data was too small. We assumed that the percentage GM discounts were linear functions of the segment dummy NG, monthly food expenditure EXPFAH, and the purchase frequency CANOLA.

We let y and z denote, respectively, the observed GM discounts and hypothetical choice while we let y^* and z^* denote, respectively, the latent GM discounts and latent variable underlying the hypothetical choice. The GM discount from the auction was still assumed to follow a Tobit model. For simplicity, we suppressed the subscript indexing the individual.

$$
\begin{aligned}
&y = y^* \ \text{ if } B^{GM} > 0 \\
&y < y^* \ \text{ if } B^{GM} = 0 \\
&y^* = \mathbf{x}'\boldsymbol{\beta} + \varepsilon
\end{aligned}
\tag{6}
$$

When $B^{GM} = 0$, we merely observed the fact that $y < y^*$, and we did not know the true value of y^*. For the stated choice question, we merely observed a binary choice between the non-GM product ($z = 1$) and GM product ($z = 0$). The participant chose the non-GM alternative if the offered GM discount was less than or equal to the underlying GM discount. We wrote this mathematically as follows.

$$
\begin{aligned}
&z = 1 \ \text{ if } z^* \geq \frac{P^{NG} - P^{GM}}{P^{NG}} \\
&z = 0 \ \text{ otherwise} \\
&z^* = \mathbf{x}'\boldsymbol{\gamma} + \eta
\end{aligned}
\tag{7}
$$

We assumed that the error terms were distributed as bivariate normal: $(\varepsilon, \eta) \sim N(0, 0, \sigma_\varepsilon^2, \sigma_\eta^2, \rho)$.

To facilitate further exposition, we defined the following binary variable.

$$
d = \begin{cases} 1 & \text{if } B^{GM} = 0 \\ 0 & \text{if } B^{GM} > 0 \end{cases}
$$

Using the two binary variables, z and d, we could classify the participants' behavioral patterns into four categories. For each category, we obtained a distinct likelihood function. We would not suppress the subscript *i* for indexing individuals.

Case 1: $(d_i, z_i) = (0,1)$.

The participant submitted a positive value for the GM product in the auction and chose the non-GM product in the stated choice question. Since we observed the true nonhypothetical GM discount, we could use this information to write the bivariate normal distribution as a conditional distribution as follows.

$$
L_1 = \frac{1}{\sigma_\varepsilon} \phi\left(\frac{y_i - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma_\varepsilon} \right) \times \left[1 - \Phi\left(\frac{PD_i - \mathbf{x}_i'\boldsymbol{\gamma} - \rho\sigma_\eta (\frac{y_i - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma_\varepsilon})}{\sigma_\eta \sqrt{1-\rho^2}} \right) \right]
$$

The variable PD_i denoted the percentage GM discount offered in the stated choice question.

Case 2: $(d_i, z_i) = (0,0)$.

This case was the same as case 1, except that the hypothetical choice was GM instead of non-GM. The likelihood differs by only the second item in the product.

$$
L_2 = \frac{1}{\sigma_\varepsilon} \phi\left(\frac{y_i - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma_\varepsilon} \right) \times \left[\Phi\left(\frac{PD_i - \mathbf{x}_i'\boldsymbol{\gamma} - \rho\sigma_\eta (\frac{y_i - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma_\varepsilon})}{\sigma_\eta \sqrt{1-\rho^2}} \right) \right]
$$

Case 3: $(d_i, z_i) = (1,1)$.

The participant submitted zero for the GM product in the auction so that we only knew that the participant's true value was greater than $\frac{y_i - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma_\varepsilon}$. Since we did not know the true value, we could not get a closed-form expression of likelihood function for this case. The likelihood involves a double integral as follows.

$$
L_3 = \int_{\frac{y_i - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma_\varepsilon}}^{\infty} \int_{\frac{PD_i - \mathbf{x}_i'\boldsymbol{\gamma}}{\sigma_\eta}}^{\infty} \phi_2\left(\frac{\varepsilon}{\sigma_\varepsilon}, \frac{\eta}{\sigma_\eta}, \rho \right) \frac{d\varepsilon}{\sigma_\varepsilon} \frac{d\eta}{\sigma_\eta}
$$

Case 4: $(d_i, z_i) = (1, 0)$.

The likelihood for this case also involved a double integral as follows.

$$L_4 = \int_{\frac{y_i - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma_\varepsilon}}^{\infty} \int_{-\infty}^{\frac{PD_i - \mathbf{x}_i'\boldsymbol{\gamma}}{\sigma_\eta}} \phi_2\left(\frac{\varepsilon}{\sigma_\varepsilon}, \frac{\eta}{\sigma_\eta}, \rho\right) \frac{d\varepsilon}{\sigma_\varepsilon} \frac{d\eta}{\sigma_\eta}$$

Given the four likelihood functions for the above four cases, we could write the likelihood function for the entire sample as their product.

$$L = \prod_i L_1^{(1-d_i)z_i} L_2^{(1-d_i)(1-z_i)} L_3^{d_i z_i} L_4^{d_i(1-z_i)}.$$

We included the dummy variable NG for the self-selecting segment, food, oil purchase frequency. We assumed that the latent GM discount functions had the same functional form whether the decision was hypothetical or not. The hypotheses of interest were whether or not the slope coefficients on the latent GM discount functions were the same; whether or not the errors were uncorrelated; and whether or not the mean predicted value of GM discounts were equal.

All of the demographic and cognitive variables were obtained from the survey questionnaire administered at the end of each session.

Data

A total of 39 consumers were recruited on December 8, 2003, in front of a large supermarket to participate in the auction experiments in Tsukuba, a city that is one-hour drive from Tokyo. A sign board was placed throughout the day in front of the main entrance to the supermarket, and recruitment efforts were continued until an enough number of participants were assembled before each experimental session. There were a total of 6 sessions conducted on the same day and from 4 to 8 people participated in each of these sessions.

Another group of 28 consumers were recruited from the staff members of the University of Tokyo. An announcement of recruitment was distributed to the staff members that only said that the experiment was about consumer decision making. There were a total of three experimental sessions, one held in the evening of December 16, 2003 and two held in the evening of December 17, 2003. Eleven, eight, and nine people participated in the first, second, and third sessions, respectively. The data from the two groups were pooled for the econometric analysis whenever it was possible. Note that only the subjects in the Tokyo group participated in the natto experiment.

Table 1 summarizes key individual characteristics of the two groups of participants. A column is added to provide the comparable figures for the Japanese population.[8] The demographic characteristics of the two samples were similar, and where some differences were observed, the difference in recruitment could explain them. The Tsukuba group consisted of people of more diverse demographic background than the Tokyo group because the former was intercepted in front of a supermarket whereas the latter consisted of staff members of an academic department. The Tsukuba group contained more women and more married people because women and married people would be more likely to go to a supermarket for grocery shopping. The difference in the presence of kids could also be explained similarly.

Results

Table 2 presents the auction bids for the GM and non-GM canola oil and natto plus the observed premiums for non-GM oil and natto. Several facts were observed about the bidding behavior. First, both the mean and median bids for canola oil were invariably higher for Tsukuba than for Tokyo irrespective of GM status of the product. This was consistent with the finding of Lusk and Fox (2003), who reported higher bids among field experimental subjects, since Tsukuba was a field experiment while Tokyo was a lab experiment. Second, the mean and median premiums were smaller for Tsukuba than for Tokyo. This was an interesting result since field subjects were more willing to purchase the GM oil. This meant that the lab subjects submitted disproportionately low bids for the GM oil. It remained unclear whether this was a result specific to our study or a general pattern because we could not separate the effect of field-lab variation from that of sample variation. If it were confirmed in a larger-scale study with appropriate separation of the above confounding effect, it would have an important implication for similar valuation studies. Third, the percentage of zero bids was lower in the field setting, which lent further support to the hypothesis that the field subjects were more willing to make a purchase. Finally, it appeared that the mean bids declined from the first trial to the second. However, pooled-variance t-tests and Wilcoxon tests did not reject the null hypotheses that the mean bids were equal over trials.[9]

Table 3 exhibit the parameter estimates for the regression of bid adjustment on the observed price difference between the winning price and one's own bid. The consistent result was that the bid adjustment was highly correlated with the bid-announcement gap. This result was indicative of affiliation in that individual bids were influenced by the announcement. Since the announcement should not belong in the population regression function of bid values, and yet the second trial bids were affected by the announcement, it was advisable that the second trial bids be discarded when bid values were regressed on individual characteristics.

Table 4 presents the parameter estimates of bid regressions for canola oil. Column (i) is the result of the Tobit model for the GM bid. As can be seen, NG, EXPFAH, and LAB were significant, RISK was marginally significant, and FAFH and CANOLA were not significant. The significance of the intercept indicated that there were still some variations in the GM bid that were left unexplained. The interpretation of the coefficients was not straightforward for the Tobit model. The parameter estimates did not measure the marginal effects, which had to be computed separately, and the marginal effects of dummy variables (all but EXPFAH) were more involved. We did not present marginal effects because we were mainly interested in which variables were significant determinants. Column (ii) is the OLS regression of the non-GM bid. Here, no significant variable was observed except the control for age. Cooking oil was not subject to the labeling law in Japan, which meant that nonlabeled oil was most likely made of nonsegregated ingredients. Non-GM oil was not a typical product in Japan, but the regression result appeared to suggest that the participants regarded it as a typical product; if non-GM oil was the usual oil, it was expected that the bid was censored by the usual price, which was not observed and might differ among the participants. We also estimated the non-GM bid with exactly the same specification as the GM model (not reported), but the independent variables also failed to explain the variations in the non-GM bid. Column (iii) is the Tobit regression of the non-GM premium on all of the explanatory variables used in columns (i) and (ii). We included all of the variables because the dependent variable was the difference between the dependent variables in columns (i) and (ii). It was notable that the intercept, RISK, AGE, and LAB lost significance while NG, EXPFAH, and CANOLA increased their significance. It was not clear ex ante which variables would become significant when the difference was used as the dependent variable since the relevant standard error is the function of the variances of the relevant coefficients in the GM bid and non-GM bid functions and the covariance of those coefficients. Clearly, the non-GM premium is determined by the interaction between one's evaluation of the GM product and that of the non-GM product. This observation provides one reason why individual characteristic variables may be insignificant in a typical study since the dependent variable is often an equivalent of the bid difference in our case. Table 5 presents the parameter estimates for natto, and the same remarks apply to the interpretation of the results.

Table 6 exhibits the parameter estimates of the Probit models for the hypothetical responses. Here, the econometric specification was much more parsimonious than the previous Tobit and linear regressions for the estimation to be feasible. Except for the dummy variable NG for canola oil, the only significant variable was the price difference between the non-GM and GM alternatives. The respondents' hypothetical choice was affected by the price incentives in a reasonable and expected way: the more expensive the non-GM product was relative to the GM alternative, the less likely the respondent chose the non-GM alternative. The food expenditure variable was not significant here, even though it was significant in Tables 4 and 5. The estimated coefficients were used to compute the expected non-GM premium for each individual so that the premium would be a variable in its own right.

In the bid regressions and Probit models for hypothetical choice, the group dummy NG was an important variable. Since it reflected the participant behavior, it was of much interest to investigate what determined the variable NG. Table 7 presents three Probit models for the dependent variable NG. Column (i) includes the full set of cognitive and demographic variables, column (ii) includes only cognitive variables, and column (iii) includes only demographic variables. Column (ii) shows that cognitive variables RISK and GOV were significant by themselves, and column (iii) shows that demographic variables were not significant by themselves. If cognitive and demographic variables were used side by side, then cognitive variables would lose significance. Thus, we argue that the self-selection dummy NG is mainly determined by the individual's perception of risk to human health and confidence in the government.

Table 8 presents alternative estimates of non-GM premiums. Let us focus on the canola oil first. The mean non-GM premium was presented in absolute value. It was notable that the mean for canola oil based on the Probit model was much larger than the other corresponding values. However, it was not appropriate to compare the nonhypothetical and hypothetical non-GM premiums in absolute value since there was no base price (i.e., researcher-determined market value) for auction bids. To facilitate comparison, a row was added that presented the GM discounts in percentage terms.[10] According to this information, the discount from the Probit model was overestimated by the factor of 1.70 (2.25), as far as the unconditional (conditional) result was concerned. There appeared to be a hypothetical bias, based on this result. It was notable that the discount based on the legal minimum WTP model was much smaller, equal to 0.70 (0.93) times the unconditional (conditional) discount. There seemed no or little hypothetical bias from the latter result.

The results for natto in Table 8 were unexpected. Here, the percentage discounts from nonhypothetical bids were quite large. The conditional discount was actually larger than the Probit prediction. A possible reason was the negative perception about eating genetically modified soybeans, the effect that was negligible for canola oil since oil was not for direct consumption. There were some participants who were eager to try out the GM natto, which was a novel product in the retail market where all the other rival products were labeled as "not genetically modified," but the negative perception seemed to have more than offset the novelty effect. Since the closed-ended hypothetical choice question provided little room for expressing the negative perception by design, the hypothetical premiums were lower.

Although there appeared to exist a hypothetical bias according to the canola oil result in Table 8, there were two problems with the above comparison of GM discounts based on the Tobit and Probit maximum likelihood estimation. First, the latent regression functions were the differences in willingness to pay for non-GM and GM products. Since the differencing operation eliminated the absolute level, the comparison based on the difference was inappropriate. Second, the specifications of the regression functions were different. This was equivalent to assuming that the GM discount functions were different between the auction and the stated choice question. It was no surprise that the GM discounts looked quite different in Table 8. To address these problems, we estimated the nonhypothetical and hypothetical GM discounts jointly.

Table 9 presents the results of the joint estimation. Columns (i) and (ii) present the Tobit and Probit maximum likelihood estimation results. These estimates were obtained separately from each other, but they were based on the same specification. The intercept in column (i) was negative but that in column (ii) was positive. This was because the participants could bid a lower value for the non-GM product than for the GM product in the auction while the GM price was always lower than the non-GM price in the stated choice question. Otherwise the signs were the same for the other coefficients although the magnitudes were different. Column (iii) presents the joint estimation results with $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ allowed to differ from each other. By inspection, it was fairly obvious that the estimated coefficients in column (iii) were remarkably close to the corresponding values in columns (i) and (ii). However, the corresponding coefficient estimates within column (iii) appeared to differ in magnitude, and the correlation coefficient ρ was statistically indistinguishable from zero. The near-zero correlation coefficient did not necessarily imply that the participants changed behavior from the auction to the hypothetical question because of the difference in sign of the intercept terms.

In order to test the equality of coefficients within column (iii) with the likelihood ratio test, we estimated a restricted model. Column (iv) presents the joint estimation results when the restriction that the all the slope coefficients were equal between the nonhypothetical and hypothetical latent GM discount functions. The exclusion of the intercept terms was necessary because the difference in signs of the intercepts were imposed by the data collection process while the partial effects of the independent variables should not differ if the bias was absent. Notice that even though the coefficients of independent variables were restricted to be equal, we did allow the error variances to differ. The likelihood ratio test statistic was 3.022, which was smaller than the 5% critical value 7.815 for the chi-square distribution with 3 degrees of freedom. The p-value for the chi-square test was 0.388, which meant that the null hypothesis of equality could not be rejected at any conventional level of significance. The predicted mean GM discounts were 0.412 and 0.506, and the corresponding standard errors were 0.104 and 0.094 for the auction and the stated choice, respectively. The t-test of equality of the mean predicted GM discounts was performed. The t-ratio was 0.615 with the p-value of 0.538, which meant that the two GM discount estimates were statistically indistinguishable from each other.

We had to be careful in interpreting this result. First, the sample size was 50, which was fairly small, so that we could not expect a substantial statistical power; the hypothesis of equality may have been rejected had we obtained a larger sample. Second, even though there was no evidence of bias between the nonhypothetical and hypothetical elicitation formats, we could not attribute the absence of bias solely to the presence or absence of real financial incentives. The problem was that the auction adopted an open bidding format while the stated choice was a closed-ended paired choice, so we could not evaluate the ceteris-paribus effect of real financial incentives.

Nonetheless, based on our findings, we argue that there was little evidence of hypothetical bias. The stated choice question is obtained by sequentially changing two variables: (1) financial incentives (nonhypothetical or hypothetical) and (2) elicitation format (open-ended bidding or closed-ended paired choice). Starting from the nonhypothetical open-bidding auction, we would obtain the hypothetical auction by removing the real financial incentives, holding the elicitation format constant. Since the participants would not be required to make a payment for their bid in a hypothetical auction, there would be little incentive for them to submit a smaller value than if the auction were real. Neill, Cummings, Ganderton, Harrison, and McGuckin (1994) found that hypothetical values were significantly larger than the nonhypothetical values. Next, we would obtain the hypothetical paired choice by changing the elicitation format from open-bidding to dichotomous choice, holding the financial incentives fixed. Neill et al. (1994) again found the willingness-to-pay values from the two elicitation formats were statistically indistinguishable from each other. Unless there was a strategic reason to overbid, the open-ended format usually would obtain a smaller WTP value than the dichotomous-choice format (Bishop, Heberlein, & Turner, 1983; Kealy & Turner, 1993; Kriström, 1993). Thus, the above two variables should have had an effect such that the GM discount value from the stated-choice question was likely to be larger than that from the nonhypothetical auction. Since we found no evidence that the GM discounts were different between auction and stated choice question, it was highly unlikely that hypothetical bias was present.[11]

Conclusion

We conducted a series of experimental auctions to elicit Japanese consumers' willingness to accept (WTP) a discount on genetically modified canola oil and natto. The unconditional nonhypothetical GM discount was calculated by subtracting the bid for the genetically modified (GM) alternative from the bid for non-GM alternative. In terms of mean premium, the Japanese consumers indicated that they were willing to pay 94.31 yen over and above the GM price. The estimated percentage discount was 37% for canola oil and 44% for natto. In the absence of hypothetical bias, the Japanese consumers still required a large amount of discount on GM foods before accepting them. The percentage of zero bids was not excessive: about 70% of Japanese consumers were willing to pay a positive amount for the GM foods. This indicates that many Japanese consumers may be willing to accept GM foods so long as GM foods are sufficiently discounted.

The regressions of nonhypothetical bids indicated the possibility of obtaining insignificant variables on the bid difference even if the same variables were significant determinants of the non-GM and/or GM bids. This observation provided one possible explanation of inconsistency in the behavior of individual characteristic variables as determinants of non-GM premium or GM discount. The GM bid, the percentage discount, and hypothetical choice between the non-GM and GM alternatives were significantly explained by the self-selection dummy variable NG. This dummy variable was, in turn, explained significantly by cognitive variables but not by demographic variables, consistent with Baker and Burnham (2001). The NG variable suggested that there existed a group of consumers who definitely prefer non-GM foods and others who were more or less indifferent about the choice between non-GM and GM foods. The latter group represented only 20% of the entire sample, so the niche market for GM product may not be very large.

The hypothetical non-GM discounts were estimated by the legal minimum WTP and Probit models. The results for the natto experiment were somewhat counterintuitive, possibly due to the strong aversion among consumers toward directly consuming genetically modified soybeans. The results for the canola oil experiment were reasonable and consistent with the expectation. The legal minimum willingness-to-pay interpretation yielded discounts lower than the nonhypothetical discounts, and the Probit model yielded larger discounts (up to 1.70 times as much). Although there appeared to be a hypothetical bias, the nonhypothetical and hypothetical GM discounts were estimated separately with different econometric specifications, it was inappropriate to conclude the existence of hypothetical bias.

This above claim was supported by the results of the joint estimation of nonhypothetical and hypothetical data. By imposing the same functional form on the percentage GM discounts, the joint estimation revealed no evidence that the GM discounts were different between the auction experiment and the stated choice question. Once the GM discounts were expressed in terms of percentage of the true valuation of the non-GM product, the apparent disparity in Table 8 disappeared. Note, however, that we only made a within-sample comparison. We asked the stated choice question on the subjects after they participated in the experimental auction. It was conceivable that some subjects felt obliged to answer the stated choice question in a manner that was consistent with their bidding behavior. The between-group comparison is the best alternative in order to circumvent the above order effect.

Since the sample was small and nonrandom, the results from the current study should be viewed as such. First, the hypothesis tests based on a small sample may be inconclusive: failure to reject the null hypothesis may be as much the result of lack of statistical power as the result of genuine population property. Second, the results of the study could not be readily extended to the consumers living in the Tsukuba and Tokyo area, let alone the entire country. It should be noted, however, that we sampled the participants from the general public, food shoppers of 18 years of age or older, not from college students, so the GM discounts we obtained would be more credible than if student subjects were used. It is certainly helpful to conduct similar auction experiments at larger scales with more rigorously sampled consumers.

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Endnotes

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[3] We did not use deception in our experiment. We believe economic valuation studies should use true products and general public unless there are compelling reasons.
[4] We treat "nonlabeled" oil as GM oil because in all likelihood nonlabeled oil uses nonseregated ingredients. If segregated ingredients are used, the manufacturer should label its product as "non-GM." Oil is exempt from the mandatory labeling, meaning that even though GM ingredients are clearly used, the manufacturer is not required to label its oil product as GM.
[5] Ties were broken by random draws of straws.
[6] We endowed each participant 500 yen in six of the nine sessions and 1000 yen in the remaining sessions. For the sessions conducted in front of a supermarket, we distributed the voucher usable at the supermarket. The sessions conducted in a university classroom, we used real money.
[7] Note that the coefficients on the original utility functions need not be estimated. It suffices to estimate the coefficients on the utility difference in order to estimate the sample non-GM premium.
[8] The subjects used for the present study consist of food shoppers of 18 years of age or older. However, some of the figures for the Japanese population include Japanese people of 15 years of age or older (e.g., MARITAL) due to data availability. Thus, the population figures are not strictly comparable.
[9] The assumption of independence was clearly violated because each participants bid twice. We only intended these tests to be a benchmark result.
[10] The GM discount for the legal minimum WTP model is not precisely a GM discount. It should be interpreted as an alternative estimate of non-GM premium because the difference between non-GM premium and GM discount is more than merely reversing the sign for this model.
[11] We required the experimental subjects to participate in the Vickrey auction before answering a stated choice question, so it is possible that the subjects felt obliged to make a hypothetical choice consistent with their auction bids. We did not have a separate group of participants who did not participate in an auction but answered a stated choice question, it was impossible to test if the above order effect was significant.

Table 1

Definition and Sample Statistics of Individual Characteristics Variables.

Variable	Definition	All	Tsukuba	Tokyo	Japan
NG	1 if one submits higher bid for non-GM in the first canola trial; 0 otherwise.	0.813	0.821	0.800	
		(0.393)	(0.389)	(0.408)	
CANOLA	1 if canola oil is used regularly; 0 otherwise.	0.381	0.395	0.360	
		(0.490)	(0.495)	(0.490)	
NAT1	1 if one eats natto almost every day; 0 otherwise.	0.031		0.080	
		(0.175)		(0.277)	
NAT2	1 if one eats natto almost every day or one every few days;0 otherwise.	0.156		0.400	
		(0.366)		(0.500)	
GMUSE	1 if one knew whether or not the oil one usually uses is genetically modified; 0 otherwise.	0.540	0.590	0.458	
		(0.502)	(0.498)	(0.509)	
RISK	1 if GM foods are somewhat or extremely safe for human health;0 otherwise.	0.078	0.077	0.080	
		(0.270)	(0.270)	(0.277)	
GOV	1 if government regulations are excellent or good;0 otherwise.	0.109	0.103	0.120	
		(0.315)	(0.307)	(0.332)	
FAFH	1 if one never or rarely buy fast foods or prepared meals;0 otherwise.	0.328	0.410	0.200	
		(0.473)	(0.498)	(0.408)	
AGE	Age divided by 10.	4.832	4.916	4.696	4.829
		(1.320)	(1.393)	(1.210)	
FEMALE	1 if female; 0 if male.	0.778	0.872	0.625	0.510
		(0.419)	(0.339)	(0.495)	
MARITAL	1 if married; 0 otherwise.	0.651	0.692	0.583	0.600
		(0.481)	(0.468)	(0.504)	
COLLEGE	1 if bachelor's degree or higher; 0 otherwise.	0.548	0.447	0.708	0.490
		(0.502)	(0.504)	(0.464)	
SIZE	Household size.	2.902	2.973	2.792	3.230
		(1.193)	(1.280)	(1.062)	
KIDS	1 if living with kids 18 years of age or younger.0 otherwise.	0.349	0.395	0.280	0.280
		(0.481)	(0.495)	(0.458)	
LAB	1 if belonging in Tsukuba group. 0 otherwise.	0.391	0.000	1.000	
		(0.492)	(0.000)	(0.000)	
EXPFAH	Household expenditure on food at home in yen, divided by 10,000.	5.797	5.306	6.533	
		(4.113)	(3.417)	(4.968)	
N	Number of participants	64	39	25	

Sources: Primary survey data and the Japanese census survey conducted in 2000 by Japan's Ministry of Internal Affairs and Communication (http://www.stat.go.jp/english/index.htm).

Note: Numbers in parentheses are standard deviations.

Table 2
Sample Statistics of Auction Bids.

Item		Trial 1		Trial 2	
		Tsukuba	Tokyo	Tsukuba	Tokyo
GM oil	Mean	245.00	139.44	227.44	132
	Std. Dev.	184.32	118.26	153.97	100.5402
	Median	250.00	150.00	250.00	150
	% Zero	20.5%	32.0%	20.5%	32.0%
Non-GM oil	Mean	319.31	264.96	306.49	272
	Std. Dev.	153.97	111.19	121.95	88.97565
	Median	298.00	250.00	300.00	280
	% Zero	0.0%	0.0%	0.0%	0.0%
Premium	Mean	74.31	125.52	79.05	140
	Std. Dev.	84.15	142.93	76.69	142.7118
	Median	52.00	100.00	60.00	100
GM natto	Mean		21.00		19.08
	Std. Dev.		17.50		15.93
	Median		20.00		20.00
	% Zero		32.0%		32.0%
Non-GM natto	Mean		43.40		36.12
	Std. Dev.		22.68		11.80
	Median		40.00		35.00
	% Zero		0.0%		0.0%
Premium	Mean		22.40		17.04
	Std. Dev.		30.44		18.61
	Median		10.00		10.00
N[a]		39	25	39	25

[a] N is the number of participants.

Table 3
Impact of Announced Price on Bid Adjustment.

	Canola Oil				Natto			
Item	GM		Non-GM		GM		Non-GM	
Constant	-30.942		-68.205	*	9.974		97.191	***
	(32.102)		(37.444)		(9.017)		(23.328)	
ΔP	0.304	***	0.421	***	0.264	***	0.465	***
	(0.047)		(0.063)		(0.071)		(0.139)	
NUMBER	-2.399		2.518		-1.784	*	-12.033	***
	(4.128)		(4.743)		(1.014)		(2.598)	
CANOLA	29.008	**	14.723					
	(14.276)		(17.023)					
NAT1					12.204	***	10.894	
					(4.250)		(10.136)	
N	62		62		24		24	
R^2	0.446		0.468		0.452		0.529	
$\bar{R}^2$	0.418		0.441		0.374		0.461	

Note: The symbols ***, **, and * indicate that the coefficients are significant at the 1%, 5%, and 10% levels, respectively. Numbers in parentheses are estimated standard errors.

Table 4
Impact of Individual Characteristics on Auction Bids and Non-GM Premium for Canola Oil.

Item	(i) GM (Tobit)		(ii) Non-GM (OLS)		(iii) Premium (Tobit)	
Constant	398.620	***	58.109		-41.451	
	(74.728)		(65.742)		(60.953)	
NG	-155.756	**			175.569	***
	(65.037)				(36.938)	
RISK	185.625	*			0.542	
	(96.277)				(55.089)	
FAFH	14.534		-20.998		2.098	
	(52.881)		(33.798)		(30.899)	
AGE			57.726	***	-12.934	
			(12.710)		(11.444)	
EXPFAH	-15.613	**	-1.533		14.019	***
	(6.957)		(3.725)		(3.838)	
LAB	-102.642	**	-41.167		26.893	
	(50.139)		(31.950)		(28.384)	
CANOLA	19.793		-20.672		-57.305	**
	(49.806)		(31.402)		(28.705)	
Sigma	175.418	***			96.797	***
	(20.128)				(11.334)	
N	59		56		56	
Log-likelihood	-297.199				-258.783	
$\bar{R}^2$			0.245			

Note: The symbols ***, **, and * indicate that the coefficients are significant at the 1%, 5%, and 10% levels, respectively. Numbers in parentheses are estimated standard errors.

Table 5

Impact of Individual Characteristics on Auction Bids and Non-GM Premium for Natto.

Item	(i) GM (Tobit)		(ii) Non-GM (OLS)		(iii) Premium (Tobit)	
Constant	46.667	***	63.591	***	-5.754	
	(13.330)		(11.381)		(28.659)	
NG	-17.645				35.159	*
	(11.028)				(20.104)	
RISK	11.917				-15.876	
	(14.666)				(26.778)	
FAFH	-17.278		-22.930	*	-1.491	
	(10.568)		(11.841)		(20.463)	
COLLEGE			-21.245	*	-19.065	
			(10.470)		(17.949)	
EXPFAH	-2.190	**	-0.034		3.949	*
	(1.042)		(0.934)		(2.162)	
Sigma	18.662	***			33.684	***
	(3.586)				(6.357)	
N	24.000		24.000		24.000	
Log-likelihood	-75.904				-84.955	
$\overline{R}^2$			0.112			

Note: The symbols ***, **, and * indicate that the coefficients are significant at the 1%, 5%, and 10% levels, respectively. Numbers in parentheses are estimated standard errors.

Table 6

Impact of Individual Characteristics on Hypothetical Choice between Non-GM and GM.

Item	Canola Oil		Natto	
Constant	1.240		1.540	
	(0.910)		(1.578)	
NG	1.196	**	1.307	
	(0.554)		(0.984)	
EXPFAH	0.030		0.058	
	(0.071)		(0.092)	
CANOLA	-0.576			
	(0.481)			
NAT2			1.201	
			(0.748)	
PDIF	-0.009	**	-0.148	**
	(0.004)		(0.072)	
N	50		22	
Log-likelihood	-22.194		-8.444	
McFadden's R^2	0.195		0.386	

Note: The symbols ** and * indicate that the coefficients are significant at the 5% and 10% levels, respectively. Numbers in parentheses are estimated standard errors.

Table 7
Impact of Individual Characteristics on Self-Selection Dummy for Non-GM Segment.

Item	(i)		(ii)		(iii)
Constant	0.084		1.395	***	-0.428
	(0.998)		(0.361)		(0.873)
RISK	-1.068		-1.446	**	
	(0.716)		(0.604)		
GOV	-1.202	*	-1.121	**	
	(0.649)		(0.554)		
GMUSE	-0.485		-0.326		
	(0.533)		(0.415)		
AGE	0.206				0.197
	(0.194)				(0.160)
FEMALE	0.214				0.152
	(0.635)				(0.511)
COLLEGE	0.261				0.183
	(0.471)				(0.436)
KIDS	1.385	*			1.138
	(0.752)				(0.580)
EXPFAH	-0.031				-0.014
	(0.073)				(0.067)
N	55		63		55
Log-likelihood	-20.012		-26.302		-22.971
McFadden's R^2	0.233		0.143		0.119

Note: The symbols ** and * indicate that the coefficients are significant at the 5% and 10% levels, respectively. Numbers in parentheses are estimated standard errors.

Table 8
Sample Statistics of Alternative Non-GM Premiums.

	Canola Oil				Natto			
	Nonhypothetical		Hypothetical		Nonhypothetical		Hypothetical	
Item	Unconditional	Conditional [a]	Legal	Probit	Unconditional	Conditional	Legal	Probit
Mean Premium	94.31	102.47	101.88	243.62	22.40	27.43	10.56	23.35
Std. Dev.[b]	112.64	89.56	74.00	47.95	30.44	19.43	9.26	2.80
% Discount [c]	0.37	0.43	0.26	0.63	0.44	0.53	0.22	0.49
N	64	56	53	50	25	24	23	22

[a] The mean and percentage discount are the "unconditional" mean of the dependent variables.
[b] Estimated standard errors are provided for the Probit model.
[c] The GM discounts for the conditional nonhypothetical cases are "unconditional" means based on the Tobit maximum likelihood estimation of bid difference in percentage terms on the same set of variables as in Table 6 (regression results not reported). For the censored observations, the GM discount was 1.00 by definition, which means that the participants were not willing to accept the GM product. Therefore, the "conditional" mean from the Tobit estimation is interesting in this case. The "conditional" mean of the GM discounts are 0.36 and 0.45 for canola oil and natto, respectively. These estimates were remarkably close to the unconditional % discount figures reported above.

Table 9

Joint Estimation of Nonhypothetical and Hypothetical Non-GM Premiums.

	Separate Estimation				Joint Estimation			
	(i)		(ii)		(iii)		(iv)	
Item	Tobit		Probit		Unrestricted		Restricted	
Nonhypothetical								
Constant	-0.329	**			-0.330		-0.280	
	(0.163)				(0.436)		(0.342)	
NG	0.630	***			0.631		0.609	**
	(0.157)				(0.440)		(0.298)	
EXPFAH	0.049	***			0.049	**	0.046	**
	(0.016)				(0.020)		(0.018)	
CANOLA	-0.184	*			-0.185		-0.214	*
	(0.119)				(0.128)		(0.119)	
σ_ε	0.387	***			0.388	***	0.387	***
	(0.048)				(0.072)		(0.070)	
Hypothetical								
Constant			0.344	***	0.342	***	0.077	
			(0.101)		(0.132)		(0.209)	
NG			0.208		0.203			
			(0.129)		(0.157)			
EXPFAH			0.006		0.006			
			(0.013)		(0.024)			
CANOLA			-0.102		-0.106			
			(0.097)		(0.150)			
σ_η			0.174	**	0.168		0.474	*
			(0.083)		(0.106)		(0.272)	
ρ					0.191		0.145	
					(0.258)		(0.236)	
N	50		50		50		50	
Log-likelihood	-29.868		-22.149		-51.686		53.197	

Note: The symbols ** and * indicate that the coefficients are significant at the 5% and 10% levels, respectively. Numbers in parentheses are estimated standard errors.