Identification of Consumer Segments and the Willingness-to-Pay Distribution: The Case of Non-Genetically Modified Vegetable Oil in the United States

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IDENTIFICATION OF CONSUMER SEGMENTS AND THE WILLINGNESS-TO-PAY DISTRIBUTION: THE CASE OF NON-GENETICALLY MODIFIED VEGETABLE OIL IN THE UNITED STATES

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This paper illustrates the importance of consumer segments for the estimation of the distribution of sample willingness to pay. We find evidence that those who prefer non-GM have a different marginal utility of income and that naïve pooling of consumer segments may yield a misleading recommendation for both agribusinesses and policy makers.

Keywords: Contingent Valuation, Genetically Modified, Stated Preference, Willingness to Pay.

JEL Classifications: Q13, D12.

The interest in the demand for food safety is growing as new production technologies are introduced. Consumers tend to perceive unknown or unfamiliar technologies to be unsafe (Slovic 1987). A negative perception can interact with dread and may help form negative attitudes, and once negative attitudes are formed, it is not easy to disabuse the public of unsubstantiated claims about new technologies. This is basically what happened to the food irradiation and genetic engineering technologies, especially in Europe (Grunert 2005). Considerable efforts have been made to document the public acceptance of genetically modified (GM) foods in Europe and the United States (Bredahl 2001; Scholderer and Frewer 2003; Frewer et al. 2004) and the willingness to pay for the presence or absence of GM attributes (Burton et al. 2001; Moon and Balasubramanian 2003; Grimsrud et al. 2004; Hu et al. 2004; Kaneko and Chern 2005).

Although there is some evidence that consumers split into segments with distinctive perception and attitudes (Baker and Burnham 2001; Ganiere, Chern, and Hahn 2006), information on segments has been used rarely in the estimation of willingness to pay (WTP). In fact, many researchers assume a common parametric distribution for the WTP. This treatment is unsatisfactory because each segment might have distinctive demand for food safety, which is determined by consumers' perception and attitude. If we pool the entire sample and estimate a single parametric model on the assumption of common marginal utility of income, then the distribution of non-GM premium will be distorted. In particular, the absolute value of marginal utility of income would be overestimated for the risk-conscious segment. This misrepresentation implies that the non-GM premium for the risk-conscious segment is underestimated, and, hence, the marketability of non-GM products is also underestimated. It is desirable that econometric models account for the presence of segments with different perception

and attitudes.

The objective of this paper is to illustrate the benefit of identifying consumer segments in estimating the demand for food safety. Specifically, we test the hypothesis of equal marginal utility of income (MUI) among different segments of consumers. We also compare the distributions of willingness to pay a non-GM premium from the models with and without the assumption of equal MUI. Our results indicate that the imposition of equal MUI assumption leads to a substantial difference in the WTP distributions and hence mean WTPs. The paper proceeds with the development of methodology, followed by the description of survey and data. We then present the results of econometric analysis and conclude with a discussion of our findings.

Economic Model

In order to elicit consumers' willingness to pay a premium for the non-GM alternative, we consider the paired choice between the non-GM and GM alternatives, rather than explicitly offering a premium in dollars or in percentages and asking the respondents a yes-no question. To analyze the paired choice between the non-GM and GM alternatives, we invoke the random utility maximization framework (Haab and McConnell 2002). Let y denote the income, x a vector of respondent i's characteristics, and P the posted price of the product. Then, consumer preferences are represented by the indirect utility function as follows:

$$U_i^j = \beta_0^j + \beta_1^{j'} x_i + \beta_2 (y_i - P_i^j) + \varepsilon_i^j,$$

where subscript i indexes respondent and j = NG or GM. We assume that the MUI is the same for the non-GM and GM alternatives so that there is no superscript on β_2. Respondent i

chooses the non-GM alternative if $U_i^{NG} > U_i^{GM}$. Let $\Delta U_i = U_i^{NG} - U_i^{GM}$. Then,

$\Delta U_i = \beta_0 + \beta_1' x_i - \beta_2 \Delta P_i + \varepsilon_i$, where $\beta_0 = \beta_0^{NG} - \beta_0^{GM}$, $\beta_1 = \beta_1^{NG} - \beta_1^{GM}$, $\Delta P_i = P_i^{NG} - P_i^{GM}$, and $\varepsilon_i = \varepsilon_i^{NG} - \varepsilon_i^{GM}$. We assume that ε_i are independently and identically distributed as normal with mean zero and variance σ^2. Then the probability of choosing the non-GM alternative is expressed as

$$\begin{aligned}\Pr(\text{Choose NG}) &= \Pr(\Delta U_i > 0) \\ &= \Pr\left(\frac{\varepsilon}{\sigma} < \frac{\beta_0 + \beta_1' x_i - \beta_2 \Delta P_i}{\sigma}\right) \\ &= \Phi(\beta_0^* + \beta_1^* x + \beta_2^* \Delta P_i),\end{aligned}$$

where $\beta_0^* = \beta_0 / \sigma$, $\beta_1^* = \beta_1 / \sigma$, and $\beta_2^* = -\beta_2 / \sigma$. For the present analysis, the parameters with asterisks are estimated and reported.[1] The expected non-GM premium has the following form:

$$E[WTP_i \mid x_i] = -(\beta_0^* + \beta_1^{*\prime} x_i) / \beta_2^*.$$

To relax the assumption of common MUI, we include the interaction terms ΔP^*NG and ΔP^*GM as additional regressors, where *NG* and *GM* are dummy variables that indicate that the respondent prefers the non-GM and GM alternatives, respectively. If $NG = GM = 0$, then the respondent feels that the non-GM and GM alternatives are equally good. No special change is required either in the estimation or in the computation of the willingness to pay in order to incorporate the slope dummies; only the formula for the expected non-GM premium is affected,

which is now expressed as

$$E[WTP_i \mid x_i] = -(\beta_0^* + \beta_1^{*\prime} x_i)/(\beta_2^* + \alpha_1 NG_i + \alpha_2 GM_i),$$

where α_1 and α_2 are coefficients on the slope dummies.

Survey and Data

The data are drawn from a U.S. national telephone survey that was conducted in 2003. Telephone interviews were conducted with the random-digit dialing method on 1,014 food shoppers of age 18 or older in the 48 states of the United States (excluding Alaska and Hawaii). The respondents answered questions about their knowledge, perception, and attitudes on genetically modified foods. They then participated in the stated preference (SP) experiments on the choice between non-GM and GM alternative food products (vegetable oil, cornflakes, and salmon).[2] The respondents were randomly asked either about vegetable oil and cornflakes or about salmon only. The size of the vegetable oil sample is 622, of which 481 provided responses usable to the econometric analysis. After the SP questions, the respondents answered questions about their socio-economic background.

The SP part is based on the paired choice between the non-GM and GM alternatives where the respondents are asked to consider the price and presence or absence of GM ingredients. The payment vehicle is the price difference between the two alternatives, and the respondents can show their willingness to pay the price difference by choosing the more expensive alternative or their unwillingness by choosing the other. There are two SP questions. The initial one is a screening question where we observe whether the respondents' willingness to pay a non-GM premium is negative, zero, or positive as the respondents choose between the non-GM and GM alternatives at the same price (i.e., no price difference). The answer choices are (1) non-GM,

(2) GM, (3) both are equally good or (4) neither non-GM nor GM. We include only those who chose (1), (2), or (3) in the analysis below.[3] For these respondents, we asked the same paired choice question, this time with a price difference.[4]

The price difference was distributed among the respondents according to the random design. For those who chose the non-GM or GM alternative, either the price of the forgone alternative was discounted or the price of the chosen alternative was raised. The rate of price discount was 10%, 30%, 50%, or 70% while the rate of price increase was 10%, 30%, or 50%. The respondent received one of the above 7 treatments randomly. The random distribution of treatments was facilitated by the software used for the computer-assisted telephone interviews. For those who indicated indifference between the non-GM and GM alternatives, we used the same randomization scheme of price discount and price increase, but with an additional piece of randomization: the half was treated as if they had chosen the non-GM alternative, and the other as if they had chosen the GM alternative. In the second SP choice question with a price difference, we allowed only two substantive choice options: (1) non-GM or (2) GM. The binary choice data obtained this way are used to estimate Probit models.

The sample composition is described in table 1, with descriptive statistics for key variables provided for subsamples and the entire sample. The non-GM segment indicates lower levels of objective and subjective knowledge but much higher level of risk perception. Consistent with House et al., the non-GM segment has a lower level of subjective knowledge.

Results

It is revealing to divide the sample into segments according to the initial screening question and study willingness-to-pay values for each segment. To sum up, we note that the

choice behavior of the non-GM segment is more or less dominated by perception and attitude variables, but those in the GM and indifference segments make their choice primarily on the basis of price. Table 2 presents the parameter estimates for alternative econometric models. The first three results are obtained by estimating a Probit model for each subsample. The Non-GM segment results indicate that the choice behavior of this segment is affected by risk perception and trust in the government. If the respondents are more risk-conscious, they tend to choose the non-GM alternative while they tend to choose the GM alternative if they trust the government more. A possible interpretation of this result is self-protection: consumers want to avoid risky products, but they need not take precautions if the government steps in to protect them. Another significant variable is age; older respondents tend to choose non-GM, other things being the same. While the non-GM segment's choice is influenced by perception and attitude variables, it is only marginally influenced by the price difference. This indicates that perception and attitude are more important factors than price consideration.

Figure 1 provides us with another glance at the price sensitivity of different segments. Panel (a) of figure 1 presents the responses to the second SP question of those who chose the non-GM and GM alternatives in the screening question. The right half of the panel indicates the proportions of non-GM and GM choice by the non-GM choosers at alternative price differences. As is evident, nearly 80% of non-GM choosers still choose the non-GM alternative at the largest price difference of $1.40. As the price difference increases from $0.20 to $1.40, the non-GM choosers appear to be quite unwilling to switch to the cheaper GM alternative. When this price-insensitive response pattern is linearly extrapolated, the distribution of non-GM premium should have a fat upper tail and many individuals in the extremely high value range. On the other hand, the GM choosers are more inclined to switch to the cheaper non-GM

alternative, as nearly 35% switched to the non-GM oil at the price difference of negative $1.40. Panel (b) of figure 1 presents the indifferent respondents' responses to the alternative price differences. Although the non-GM proportion is not monotonically decreasing, as it should be in theory, the indifferent respondents indicate a much higher sensitivity to price incentives with only 5% choosing the non-GM oil when it is $1.40 more expensive than the GM oil.

It is useful to identify segments and base the econometric analysis on the segments. Contingent valuation studies usually do not estimate an econometric model for different segments.[5] They usually estimate parametric econometric models using the entire sample, assuming that the MUI is the same for the entire sample. We provide a similar case of pooled estimation as model 1 in table 2.[6] The variables that attained significance in separate estimations are all significant in model 1. The MUI (i.e., coefficient for ΔP) is highly significant even though it was only marginally significant when the non-GM and GM subsamples were used separately. This significance is somewhat deceptive if we consider the fact that the non-GM choosers are quite insensitive to the price incentives, which is immediately apparent with a casual inspection of figure 1. To shed more light on the problem, we present in the last column of table 2 the parameter estimates for model 2, which relaxes the assumption of common MUI by including slope dummies. As is evident, variable $\Delta P*NG$ significantly affects the choice between the non-GM and GM alternatives, and the two-sided t-test rejects at the 5% level of significance the hypothesis that the non-GM segment has the same MUI as the indifferent respondents. The coefficient on $\Delta P*NG$ is positive, which means that the MUI for the non-GM segment is small in absolute value. This implies that the non-GM segment's choice behavior is affected so much by factors other than price, unlike the GM segment's or indifferent respondents'. On the other hand, the coefficient on $\Delta P*GM$ is not significant, which

implies that the GM choosers have the same MUI as the indifferent respondents.[7] Thus, the non-GM choosers stand out from the rest of the sample as they are unwilling to switch alternatives, given the price incentives.

Nonetheless, the results for model 1 as presented in table 2 look satisfactory at a glance. The estimated MUI is highly significant, which suggests that the respondents properly evaluated the trade-off between the price and the GM property. However, model 1 yields strikingly different willingness-to-pay estimates. Table 3 presents the estimated non-GM premiums that the respondents are willing to pay. The non-GM segment's premium from model 1 is much smaller than those from separate estimation and model 2. It is notable that the GM segment's and indifferent respondents' premiums from model 1 are not very different from the corresponding values from separate estimation or model 2; only the non-GM choosers' premium from model 1 stands out. Since the number of non-GM choosers is larger than that of GM choosers and indifferent respondents combined, model 1's low estimated premium for the non-GM segment leads to a low sample mean of respondents' estimated premiums, as indicated in the last column of table 3. All of these remarks about the model 1's results seem to be a blessing, however, when the researcher is solely interested in having the CV critics respect the estimated results since the parameter estimates are reasonably good in terms of statistical significance, and the sample mean of the respondents' non-GM premiums is smaller, which implies that the mean value may contain less of a potential hypothetical bias. In short, the estimation result for model 1 look good.

The good appearance is misleading, however. The problem is best illustrated by drawing histograms, or empirical distributions of non-GM premiums estimated by alternative models. Panel (a) of figure 2 is the distribution based on the separate estimation while panel (b)

is that based on model 1. As is obvious, the distribution in panel (a) is far more dispersed than that in panel (b). Moreover, panel (b) has a more clearly bimodal distribution than panel (a), with the upper tail truncated abruptly at around $3.00. This shape is mainly attributable to the assumption of common MUI. When the three respondent segments are pooled and the assumption of common MUI is imposed, the MUI (in absolute value) is overestimated for the non-GM segment while underestimated for the GM and indifference segments. Since the MUI appears in the denominator of the formula for the non-GM premium, the non-GM segment's premium is underestimated while the GM and indifference segments' are overestimated, which causes the premium distribution to shrink toward the middle. Hence, the distribution in panel (b) of figure 2 is clearly distorted. Panel (c) presents the premium distribution derived from model 2. Since the common MUI assumption is relaxed, there is no shrinkage found in panel (b). In fact, the distribution in panel (c) reproduces that in panel (a) with remarkable accuracy: high peaks around $0.00 and lower peaks from around $1.60 to around $5.60. With slope dummies in model 2, we predict that there are a significant number of respondents who have very high non-GM premiums while model 1 artificially truncates the premium distribution at a relatively low level.

The use of information on consumer segments in the estimation of willingness-to-pay distribution has important implications for both agribusiness firms and policy makers. Recommendations for agribusiness firms contemplating the marketing of non-GM products are quite different when it is based on model 1 or model 2. Model 1 results underestimate the potential of non-GM products as it fails to predict a potential niche market occupied by consumers with very high non-GM premiums, which model 2 successfully predicts. Implications for policy makers are also different between model 1 and model 2. The mean of

the respondents' estimated premiums is underestimated for model 1, but this mean value may be good for nothing: too low for the non-GM segment and too high for the rest. It is not appropriate to base the welfare calculus on the mean value obtained by sustaining an inappropriate hypothesis about respondents' preferences.

Conclusions

This paper estimated Probit models with alternative specifications, using different combinations of samples. The estimation results indicate that the demand for differentiated products should address the diversity of consumer preferences.

We used a stated preference survey with a screening question that allowed the researcher to identify segments of respondents according to their willingness to pay a premium for a non-GM product vis-à-vis the GM counterpart. The information on the identified segments was used in econometric analysis to derive the sample distribution of willingness to pay a non-GM premium. When a separate Probit model was estimated for each segment, the distribution of premium was somewhat bimodal and quite widespread with a large proportion of respondents in the very high price range and a cluster of respondents at around zero. However, when the segments are pooled with the assumption of common marginal utility of income, the distribution of premium was more clearly bimodal with the upper tail truncated at around $3.00. Another pooled-sample Probit model was estimated with the assumption of common marginal utility of income relaxed by including slope dummies. We found evidence that the respondents in the non-GM segment have a different marginal utility of income from the rest of the sample.

There are two interpretations for the above result. If the non-GM segment's response to the price incentives is genuine, it follows that the non-GM segment has an extremely large

non-GM premium. On the other hand, if the response is not genuine, the assumption of common marginal utility of income for the entire sample may be sustained. We generally cannot tell the difference just by examining the survey responses. One lesson to be learned from this study is that the identification of segments is extremely important as it has a direct implication on the distribution of welfare measure. In our application of GM food, we saw that the distribution of non-GM premium had a bimodal distribution. The screening question allowed us to obtain a bimodal distribution using only a simple Probit model and segment dummies. Without such information, econometrically more involved model must be used, and estimation would be more difficult (e.g., Hu et al. 2004).

Endnotes

[1] The asterisked parameters are scalar multiples of corresponding nonasterisked paremeters. Since the willingness-to-pay value can be expressed fully in terms of the asterisked parameters, and we are not particularly interested in the nonasterisked ones, we do not recover the latter from the former.

[2] In the present analysis, only the vegetable oil data are used.

[3] In usual contingent valuation surveys, the indifferent respondents (those who say no to the offered bid) may include the genuine zero bidders and the protest zero bidders (Strazzera et al.). In our case, we assume the genuine zero bidders are captured by the "indifference" option and the protest bidders by the "neither" option. We simply discard the "neither" option here, for the purpose of paper is to show the importance of identifying consumer segments.

[4] It may seem odd to ask another choice with price difference for "indifferent" respondents. Like Kriström (1997), many authors assume that indifferent respondents have exactly zero willingness to pay. However, this approach seems to be too restrictive. It is plausible that those consumers who are not well aware of their near-zero willingness-to-pay value may well choose the "indifference" option. This interpretation is similar to Wang's (1997) interpretation of "don't know" responses.

[5] The latent class model identifies latent classes and estimate class-specific parameters. The identification of classes is part of estimation process unlike the present case, where the identification precedes the econometric analysis.

[6] In our case, the second-question bids depend on the responses to the initial question, so the data set consisting only of the second responses is not a true random sample. For this reason, the intercept dummies NG and GM must be included in the econometric specification. Otherwise, model 1 is similar to the usual dichotomous-choice contingent valuation case.

[7] We note that the insignificance of the coefficient on $\Delta P^{*}GM$ may be due to the small size of the GM segment. Even so, the absolute value of the coefficient on $\Delta P^{*}GM$ is smaller than that of the coefficient on $\Delta P^{*}NG$.

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Table 1. Definition of Variables and Sample Means and Standard Deviations.

Variable	Definition	NG	GM	Indifferent	All
O_Know	Number of correct answers for 3 true or false questions	1.61[a]	1.63	1.87	1.70
	about GM foods. (Max=3; Min=0)	(1.00)[b]	(1.04)	(1.00)	(1.01)
S_know	1 if one is very well or somewhat informed about	0.56	0.61	0.64	0.60
	GM foods;0 otherwise.	(0.50)	(0.49)	(0.48)	(0.49)
Risky	1 if one perceives GM foods to be extremely or	0.61	0.49	0.30	0.49
	somewhat risky; 0 otherwise.	(0.49)	(0.50)	(0.46)	(0.50)
Govt	1 if one grades the government's food safety policies	0.47	0.57	0.65	0.54
	as excellent or good; 0 otherwise.	(0.50)	(0.50)	(0.48)	(0.50)
Kids	1 if one lives with children under the age 18;	0.44	0.41	0.45	0.44
	0 otherwise.	(0.50)	(0.50)	(0.50)	(0.50)
College	1 if one attains a bachelor's degree or higher;	0.41	0.24	0.40	0.39
	0 otherwise.	(0.49)	(0.43)	(0.49)	(0.49)
Age	One's age as of 2003.	45.05	45.41	45.01	45.07
		(15.44)	(16.22)	(16.14)	(15.75)
Male	1 if male; 0 if female.	0.27	0.27	0.33	0.29
		(0.44)	(0.45)	(0.47)	(0.45)
Income	One's income divided by 10,000.	7.43	6.20	6.91	7.11
		(7.23)	(5.76)	(5.10)	(6.39)
NG	1 if one chooses the non-GM oil in the initial choice;	1.00	0.00	0.00	0.53
	0 otherwise.	(0.00)	(0.00)	(0.00)	(0.50)
GM	1 if one chooses the GM oil in the initial choice;	0.00	1.00	0.00	0.11
	0 otherwise.	(0.00)	(0.00)	(0.00)	(0.31)
ΔP	Non-GM price minus GM price in the second choice.	N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A
z	1 if one chooses non-GM oil in the second SP question;	0.84	0.43	0.48	0.67
	0 if one chooses GM oil in the second SP question.	(0.36)	(0.50)	(0.50)	(0.47)
N	Number of respondents in the sample who chose	256	51	174	481
	the non-GM or GM oil or indicated indifference.	[229][c]	[47]	[154]	[430]

Sources: Primary survey data.

[a] Nonparenthesized numbers are sample mean values except those for variable *N*, which are the sample sizes.

[b] Parenthesized numbers are sample standard deviations.

[c] Numbers in brackets are numbers of respondents whose income is known.

Table 2. Probit Results for Paired Choice between Non-GM and GM for Consumer Segments

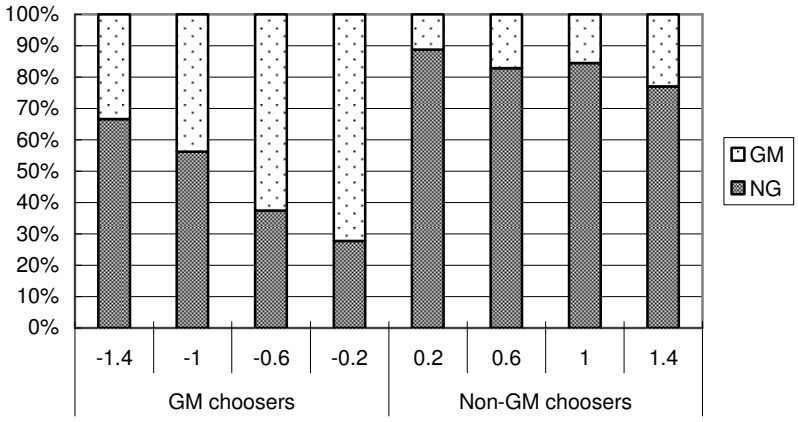
	Separate Estimation			Pooled Estimation	
Item	Non-GM	GM	Indifferent	Model 1	Model 2
Constant	0.34	-0.40	-0.14	-0.50	-0.50
	(0.44)	(0.79)	(0.57)	(0.31)	(0.32)
S_Know	0.09	0.01	0.06	0.07	0.08
	(0.21)	(0.40)	(0.23)	(0.14)	(0.14)
Risky	0.77***	-0.01	0.38	0.51***	0.51***
	(0.21)	(0.37)	(0.25)	(0.14)	(0.14)
Govt	-0.49**	-0.15	-0.43*	-0.37***	-0.38***
	(0.21)	(0.38)	(0.23)	(0.14)	(0.14)
Kids	0.20	-0.13	-0.04	0.07	0.08
	(0.21)	(0.39)	(0.26)	(0.15)	(0.15)
College	-0.16	-0.19	0.12	-0.02	-0.03
	(0.21)	(0.48)	(0.22)	(0.14)	(0.14)
Age	0.02**	-0.01	0.00	0.01**	0.01**
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)
Male	-0.04	0.32	-0.13	0.03	0.01
	(0.24)	(0.43)	(0.24)	(0.15)	(0.15)
NG				1.59***	1.23***
				(0.18)	(0.23)
GM				-0.78***	-0.69*
				(0.23)	(0.39)
ΔP	-0.41*	-0.95*	-0.99***	-0.84***	-1.01***
	(0.24)	(0.51)	(0.15)	(0.12)	(0.15)
ΔP*NG					0.63**
					(0.27)
ΔP*GM					0.31
					(0.51)
Log-likelihood	-95.21	-32.57	-89.89	-225.98	-223.19
N	256	51	174	481	481

Notes: Numbers in parentheses are estimated standard errors. Symbols ***, **, * indicate that the variable is significant at the 1%, 5%, and 10% levels, respectively.
[a] N is the number of respondents in each subsample.

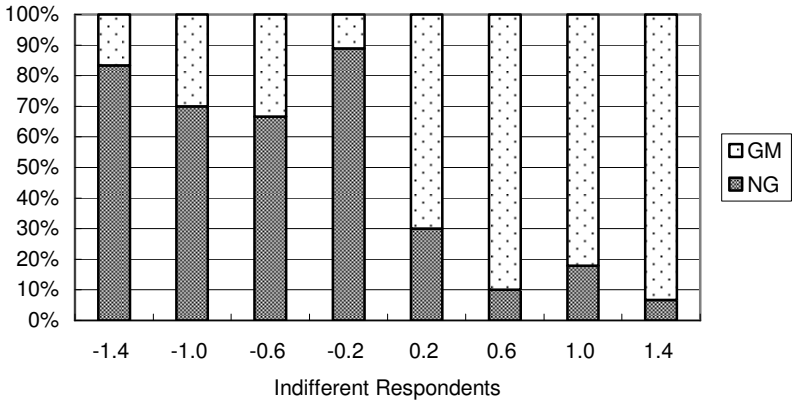
Table 3. Estimated Mean Non-GM Premiums

	Premium of Mean Respondent			Mean of Respondents' Premiums
Item	Non-GM	GM	Indifferent	All
Separate Samples				
Premium ($)	3.59	-0.83	-0.07	1.79
	(1.64)[a]	(0.22)	(0.11)	[2.15][b]
% Premium[c]	179.3%	-41.7%	-3.7%	89.4%
Pooled Sample				
Model 1				
Premium ($)	2.09	-0.85	-0.08	0.99
	(0.21)	(0.22)	(0.13)	[1.26]
% Premium	104.7%	-42.5%	-3.9%	49.6%
Model 2				
Premium ($)	3.62	-0.89	-0.08	1.80
	(1.72)	(0.30)	(0.11)	[2.08]
% Premium	181.1%	-44.3%	-3.8%	90.0%

[a] Numbers in parentheses are estimated standard errors.
[b] Numbers in brackets are sample standard deviations.
[c] The percentage premium is the share of premium in dollars to the base price of $2.00, which is used as the price for the non-GM and GM alternatives in the screening question.

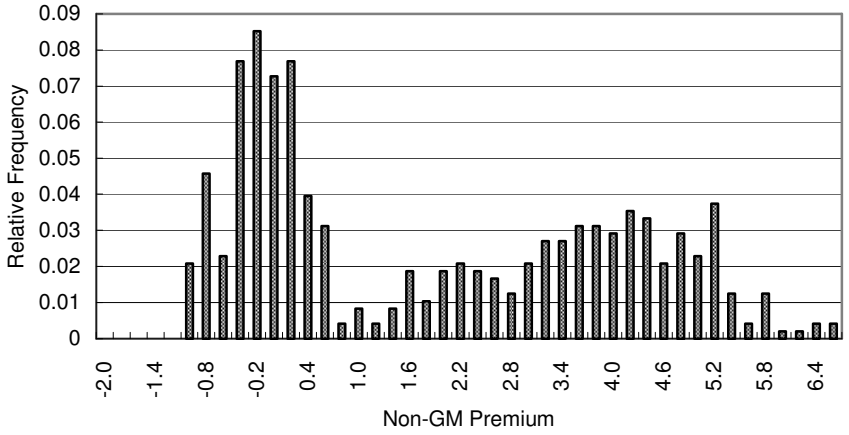


(a) Non-GM and GM Choosers

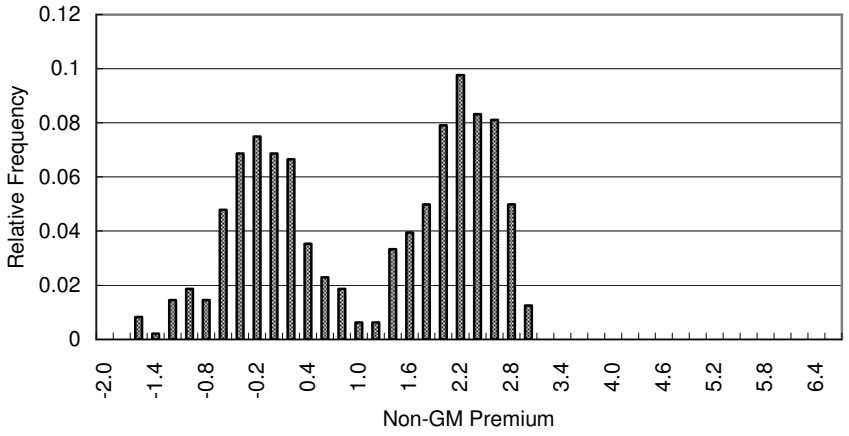


(b) Indifferent Respondents

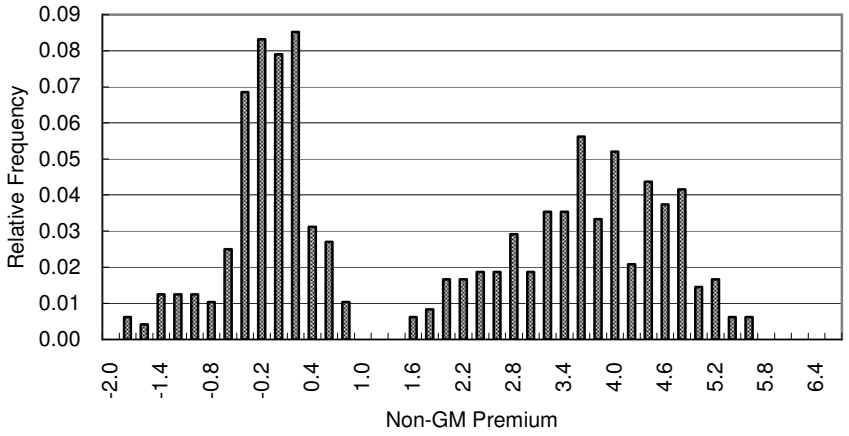
Figure 1. Response to paired choice question with price difference



(a) Separate Estimations



(b) Pooled Estimation without Slope Dummies



(c) Pooled Estimation with Slope Dummies

Figure 2. Distribution of Non-GM Premiums from Alternative Estimation Results