A multi-country assessment of consumer attitudes of genetically modified foods and the implications for new labeling system

by

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and

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Abstract: This paper estimates the willingness to pay (WTP) for non-genetically modified (GM) vegetable oil and tofu in Korea by using contingent valuation (CV) method and compares this WTP with Japan, Norway, Taiwan and the U.S. It also recovers the distribution of WTP by using a bootstrapping approach to provide a better measure of consumer's WTP on non-GM foods. Especially, we pay attention to the different characteristics of vegetable oil and tofu; vegetable oil made from GM soybeans doesn't have genetically altered protein, but tofu made from GM soybean has genetically altered protein. For this reason, vegetable oil made from GM soybeans is excluded from mandatory GM labeling system in Korea. Therefore, in this paper, the potential differences between WTP for non-GM vegetable oil and non-GM tofu are also investigated in order to evaluate the questions regarding the relevance of the introduction of new labeling system in Korea.

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1. Introduction

Since the growth of biotechnology in the late 20th century, agricultural sectors have been largely influenced by genetically modified (GM) crops. According to the USDA data in 2002, about 75% of the planted corns in the U.S. were GM crops. And 34% of soybeans and 71% of cottons were genetically modified organisms (GMOs). While GM crops may provide a new way of releasing people from starvation, they might have some potential danger for human health and environment (Kwon, 2002). By this reason, GMOs have accepted in many parts of the world, but at the same time farmers are frustrated by the uncertainty involved in the marketing of GM crops.

Uncertainties associated with consumer acceptance for GM foods have been increased in many countries, especially in Europe and East Asia countries such as Korea and Japan (Chern et al., 2002). Meanwhile, in other countries such as the U.S., these uncertainties seem to be taken relatively less by consumers. These potential differentials in consumer attitude for GM products might be closed related to a policy influencing the production, consumption and marketing of GM products. Thus, it is a useful analysis to examine consumers' attitudes and willingness to pay (WTP) for GM foods in a multi-country setting.

In many agricultural importing countries, the imposition of a mandatory labeling of GM

foods has intensified the debates on the application of GM technology in agricultural production. GM mandatory labeling is applied differently by the characteristics of products. For instance, vegetable oil and tofu, made from GM soybeans, will have different characteristics; while vegetable oil made from GM soybeans doesn't have genetically altered protein, tofu made from GM soybeans has genetically altered protein. This observation leads some countries (e.g., Korea) to impose different labeling rules for vegetable oil and tofu from GM soybeans. Vegetable oil made from GM soybeans is excluded from mandatory GM labeling, but tofu made from GM soybeans is a subject to be labeled. The labeling system of European Union (EU) had been similar to that of Korea. But, according to their new labeling system started in October 2003, GM products even without GM altered protein or DNA must be labeled.

Recently, a lot of efforts have been devoted to the investigation of consumers' attitudes and WTP. Chen and Chern (2002) estimated WTP for non-GM foods in the U.S. using data from public survey. Kwon (2002) also estimated WTP for non-GM foods in Korea using public survey data. Using data from a student survey, Chern et al. (2002) estimated WTP for non-GM vegetable oil and non-GM salmon in Japan, Taiwan, Norway and the U.S. and analyzed the difference of consumer acceptance for GMOs among these countries. However, for all of these studies, a potential difference of consumer's WTP for GM products with different characteristics (e.g., with or without genetically altered protein or DNA) has not been a focus of their analysis.

The objective of this paper is as follows. First, this paper estimates WTP for non-GM foods by using contingent valuation (CV) method from student survey in Korea and compares the result with other four countries with reference to the paper written by Chern et al. (2002). While a student sample cannot be viewed as representative of consumers, but for more consistent comparison with Chern's study, we conducted a student survey using the same survey questionnaire used in their study. Secondly, we investigate potential WTP differentials between GM products with genetically altered protein or DNA and without these characteristics (e.g., GM vegetable oil and GM tofu). The policy implication of this investigation is straightforward: this paper can provide an empirical answer to the following question regarding the relevance of the introduction of new labeling system in Korea: Do consumers require new labeling for GM processed food in which genetically altered protein or DNA doesn't remain? Lastly, using a bootstrapping approach, this paper recovers the distribution of WTP. This allows us to construct bootstrap confidence intervals of WTP, providing a better measure of consumer's WTP for non-GM foods.

This paper is structured as follows. Section 2 compares results of student survey in five countries. Section 3 estimates WTP for non-GM tofu and non-GM vegetable oil from a student survey in Korea and compares it with other four countries. Section 4 analyzes the distribution of WTP for non-GM tofu and non-GM vegetable oil by using a bootstrapping approach to generate

a better measure of consumer's WTP for these two GM products with different characteristics. Section 5 summarizes and concludes the paper.

2. Comparison of Student Survey results

In other to compare consumer's attitudes and WTP for GM foods among countries more accurately and effectively, a student survey was conducted using the same questionnaire obtained from Chern's study (2002).[1] This questionnaire was translated into Korean. We also added a few questions to analyze a potential difference of WTP between non-GM vegetable oil and non-GM tofu. Before we asked these questions, different characteristics between these two products were explained explicitly in the questionnaire to provide correct information. And based on the market prices of products, we designed ten scenarios for non-GM vegetable oil and five scenarios for non-GM tofu in order to elicit WTP for these products. Then, lastly, we asked respondents questions regarding whether they agree to introduce a new labeling rule for GM processed food in which genetically altered protein or DNA does not remain. The student survey was conducted at Seoul National University. Table 1 shows sample size and the distribution of the sample classified by age, grade, college and sex.

Table 2 shows the survey results for selected questions. They show that before the survey,

[1] Chern et al.. 2002. "Consumer Acceptance and Willingness to Pay for Genetically Modified vegetable oil and salmon: A Multiple-Country Assessment." *AgBioForum*, 5(3), 105-112

higher percentage of Korean students didn't have information about GMOs or GM foods than other Asian countries' students. But the percentage was lower compare to U.S. students and almost equal to Norwegian students. For two true-false questions in the survey about specific knowledge on GMOs, the results were similar to those of the same questions in each country except Japan: 94% and 69% of Japanese students answered "don't know" to these two questions. It is possible that Japanese students were more conservative and perhaps misrepresented their familiarity with the subject matter asked in the preceding questions (Chern et al., 2002).

For the question about health risk of GM foods, the answers were varied from country to country. Relatively higher percentage of Norwegian (45%) and US (32%) students ranked GM foods as "very safe" than Asian students; Korea (12%), Japan (26%) and Taiwan (18%). Korean and Japanese students had relatively low acceptance level of GM foods. More than 80% of these two countries' students were "not very" or "would avoid" to consume GM foods. On the contrary, about 80% of U.S. and Taiwanese students were "very willing" or "somewhat willing" to consume GM foods. It is interest that while relatively low percentage of Taiwanese students ranked GM foods as "very safe", almost 80% of them were willing to consume GM foods. These results suggest that Korean and Japanese students had more negative attitude to GM foods than American and Taiwanese students.

It is important to note that, in all five countries, the percentage of respondents at least

"somewhat willing" to consume GM foods increased, if these foods reduced pesticide uses. This means that consumers' willingness to consume GM foods is found to be increasing if the GM foods contain benefits to the consumers. In all five countries, GM food labeling was viewed as an important policy instrument. All five countries would support a mandatory labeling system. In this study, we added the following question: "Do consumers require labeling for GM processed food in which genetically altered protein doesn't remain?" This is an important question in Korea because currently, over 99% of imported GM soybean is used to produce vegetable oil and about 80% of vegetable oil is made from GM soybeans. The survey result shows that 91.2% of respondents answered "yes" to label GM foods even if GM protein doesn't remain in the processed food. This suggests a new labeling system reflecting consumer's attitude on GM foods in Korea.

3. Willingness to Pay for Non-GM foods

In the environmental economics literature, consumer willingness to pay for non-market goods, such as water quality improvement (Carson and Mitchell, 1981) or air pollution control (Loehman and De, 1982), has been estimated by using the contingent valuation (CV) methods. Consumer willingness to pay for food safety, such as reduced food-borne risks (Hammitt, 1986), has also been evaluated by using CV. There are several economic tools to value non-market goods, but CV is a widely-used, appropriate choice for measuring food safety (Buzby, et al.,

1995).

In this study, we employ a CV approach to estimate the WTP for non-GM food products. The CV scenario in our survey questionnaire contains the dichotomous choice questions. Food products used in the survey include vegetable oil and tofu. And the survey was conducted on the assumption that GM foods were cheaper than non-GM foods. Therefore, in the dichotomous choice questions, we specified GM foods were cheaper than non-GM foods. The levels of price discount for GM food products were ranged from 10% to 90% for tofu and from 5% to 50% for vegetable oil. There were five price scenarios for tofu and ten price scenarios for vegetable oil.

Table 3 and table 4 show the results of willingness to consume non-GM tofu and vegetable oil. For non-GM tofu, despite of its lower price, it is found that 60.4% of respondents were not willing to consume GM tofu. As the percentage of price discount for GM tofu was getting larger, the percentage of respondents who were willing to consume non-GM tofu is found to be decreased. For non-GM vegetable oil, the results indicate that 60.9% of respondents were willing to consume non-GM vegetable oil even though it is cheaper than its non-GM counterpart.

Next, we investigate potential differentials in willingness to consume GM products when GM product of interest has different characteristics compare to other GM products. Recall that vegetable oil and tofu made from GM soybeans have different characteristics; vegetable oil

made from GM soybeans doesn't have genetically altered protein, but tofu made from GM soybeans has genetically altered protein. In order to control for a possible bias related to the order of WTP questions on two different GM products, we designed two different types of survey questionnaire (type I and type II) depending on the order of WTP questions. Whereas we asked first the willingness to consume non-GM vegetable oil in type I, the willingness to consume non-GM tofu is questioned first in type II. Before we asked willingness to consume each product, the information about the characteristics of each product is provided explicitly in the survey. Table 5 shows survey responses on the willingness to consume non-GM tofu and non-GM vegetable oil by the type (i.e., the order of WTP questions). The results suggest that the willingness to consume non-GM vegetable oil was different by the type, but it was the same for non-GM tofu. It is plausible that students responded with negative attitude for GMOs in type I questionnaire, but in type II, respondents answered the question with recognition of the different characteristic of two products.

Using the data from the student survey, we estimated the expected values of WTP for non-GM tofu and non-GM vegetable oil. The methodology was based on a random utility model. Following Haab and McConnell (2002), we specify a respondent's utility which is linear in parameters as follows:

$$U_{ij} = \alpha_i Z_j + \beta_i (Y_j - P_{ij}) + \varepsilon_{ij}, \qquad (1)$$

where i is the dichotomous choice ($i = 0$ is GM and $i = 1$ is non-GM), Y_j is the income of respondent j, Z_j is a vector of respondent characteristics and attributes of the choice, P_{ij} is price of alternative (e.g., GM or non-GM food) i, and the error term ε_{ij}. On the assumption that the marginal utility of income for non-GM food and GM food are identical, the probability of choosing non-GM food can be expressed as:

$$\Pr[non-GM] = \Pr[\alpha Z_j - \beta(\Delta P) + \varepsilon_j > 0], \quad (2)$$

where $\alpha = (\alpha_1 - \alpha_0)$, $\Delta P = (P_{1j} - P_{0j})$ and $\varepsilon_j = (\varepsilon_{1j} - \varepsilon_{0j})$. And equation (2) can be rewritten as:

$$\Pr[non-GM] = \Pr[\varepsilon < (\alpha Z_j - \beta \Delta P)]. \quad (3)$$

Assuming that the error term has a logistic distribution, we denote the probability of choosing the non-GM food as:

$$\Pr[non-GM] = [1 + \exp(-(\alpha Z / \sigma - \beta \Delta P / \sigma))]^{-1}. \quad (4)$$

From the estimated logistic model, we can calculate the expected value of WTP for a non-GM food by estimation of the parameter α and β. The WTP for non-GM food can be defined as:

$$\alpha_1 Z_j + \beta(Y_j - WTP_{1j}) + \varepsilon_{1j} = \alpha_0 Z_j + \beta(Y_j - WTP_{0j}) + \varepsilon_{0j}. \quad (5)$$

Rearranging terms in (5), we have

$$WTP_{1j} - WTP_{0j} = \frac{1}{\beta}(\alpha Z_j + \varepsilon_j). \quad (6)$$

From equation (6), we can derive the expected value of WTP for non-GM food:

$$E[WTP_{1j} - WTP_{0j} \mid \alpha, \beta, Z_j] = \alpha Z_j / \beta , \quad (7)$$

Table 6 shows the estimated WTP for vegetable oil and tofu in Korea.[2] These results indicate that Korean students were willing to pay 54.2% price premium for non-GM vegetable oil and 81.2% for non-GM tofu. It is noticeable that the WTP for non-GM tofu was higher than non-GM vegetable oil. While we found no significant differences in price premium for non-GM tofu by the type, the WTP premiums for non-GM vegetable oil were estimated to be different by the type. For non-GM vegetable oil, the results suggest that the respondents were willing to pay a price premium of 56.9% in type I and 52.4% in type II. This reflects that the respondents had negative attitude for the consumption of GMOs and they recognized the different characteristics of these two processed products, especially in the type II questionnaire where the willingness to consume non-GM tofu is questioned first.

Table 7 shows WTP for non-GM vegetable oil in five countries. These results indicate that students in all five countries were willing to pay a price premium for non-GM vegetable oil. However, it is interesting to note that the WTP premium for non-GM vegetable oil was quite different between Korea and Japan, while their attitude representing a willingness to consume GM foods was very similar; more than 80% of student respondents in these two countries chose “not very” or “would avoid” to consume GM food. It might be possible that Japanese students

[2] South Korean won to US dollar exchange rate used in this study is 1,200.

are more reluctant in paying price premiums for non-GM food than Korean students. On the other hand, it is shown the U.S. students were willing to pay a high premium for non-GM vegetable oil, while high percentage of them was willing to buy GM foods.[3]

4. The bootstrap distribution of WTP

Bootstrapping is a nonparametric approach of statistical inference based on resampling (Fox, 2002). Bootstrapping is based on the idea that the sampling distribution of interest may be recovered by generating a large number of new samples from the original sample. The essential idea of the bootstrap is as follows: Suppose that for a sample of N observations $\{X_1, X_2, \cdots, X_n\}$, we wish to estimate the sampling distribution of the log mean. We proceed to draw a large number of resamples of size N from the original sample randomly with replacement. For each resample, which has the same number of observations as the original sample, we calculate the log mean. The bootstrap sampling distribution of the log mean is then obtained as a frequency distribution of the resulting logarithmic means of resamples.

In this study, we drew thousand resamples of size 200 from the original sample randomly with replacement. And for each resample, we calculated the WTP for non-GM tofu and non-GM vegetable oil. To obtain the expected WTP from these resamples, we removed 17 outliers from a

[3] Following Chern et al. (2002), this is because vegetable oil is an inexpensive food in the US, and the WTP elicited from the CV survey may be inflated. And they also noted that the US students are not as sensitive to price variations as those in other countries.

thousand WTP which were calculated from each resample.[4] Table 8 shows the estimated WTP for non-GM foods by using bootstrapping approach. This result indicates that Korean students were willing to pay 61.4% price premium for non-GM vegetable oil and 84.1% for non-GM tofu. This result is somewhat different from the previous result. However, note that this implies that respondents were willing to pay more price premiums for non-GM tofu than for non-GM vegetable oil. And the standard deviation of WTP for non-GM vegetable oil is larger than that of non-GM tofu. This contributes to a smaller variation of WTP for non-GM tofu: 95% bootstrap confidence intervals were ranged from 8.8% to 114% for non-GM vegetable oil and from 49% to 119% for non-GM tofu. Table 9 also shows upper and lower bounds of WTP for non-GM vegetable oil and non-GM tofu based on 95% bootstrap confidence intervals. In Figure 1, the bootstrap sample distributions of WTP for non-GM tofu and non-GM vegetable oil are depicted. As is shown, the mean WTP of non-GM vegetable oil is smaller while the variance of WTP for non-GM vegetable oil is larger than that of non-GM tofu. Consistent with our previous discussion on respondent attitudes, this reflects that WTP of GM products varies significantly depending on product characteristics.

5. Concluding remarks

[4] We used the WTP which ranged from $0 to $8.33.

This paper conducted student survey in Korea to analyze consumer's attitudes for GM foods. Using contingent valuation method, we also estimated WTP for non-GM vegetable oil and non-GM tofu. A multi-country assessment of consumer's attitudes for GMOs and the WTP for non-GM vegetable oil has been done using with reference to the paper written by Chern et al. (2002). Furthermore, this paper recovers sample distribution of WTP by using a bootstrapping approach to provide a better measure of consumer's WTP on non-GM foods.

The findings of this paper are summarized as follows. First, student survey shows that a high percentage of Asian respondents including Korean students were well informed about GMOs. But relatively low percentage of Asian students ranked GM foods as "very safe". Especially, Korean and Japanese students had relatively negative attitude to GM foods. Student respondents in all five countries (Korea, Japan, Taiwan, U.S., and Norway) viewed GM food labeling as an important policy measure. Second, Korean students were willing to pay price premium of 54.2% for non-GM vegetable oil and 81.2% for non-GM tofu. It is noteworthy that the WTP for non-GM tofu was estimated higher than that of non-GM vegetable oil. This is because that these two processed foods have different characteristics; vegetable oil made from GM corns doesn't have genetically modified protein, but tofu made from GM soybeans has genetically modified protein. Comparing with other countries, the WTP for non-GM vegetable oil in Korea (54.2%) was similar to the U.S. (50-62%) and Norway (55-69%). In other Asian

countries, the WTP for non-GM vegetable oil were relatively low, ranging from 17-21% in Taiwan to 33-40% in Japan. Third, our results indicate that the distributions of WTP for non-GM vegetable oil and non-GM tofu are different. The bootstrap confidence intervals of WTP were ranged from 8.8% to 114% for non-GM vegetable oil and from 49% to 119% for non-GM tofu. That is, the variation of WTP for non-GM tofu is smaller than that of non-GM vegetable oil. This might be due to the different characteristics of two products. Overall, our results indicate that consumers have negative attitude to GM food in Korea. Finally, the survey result also indicates that 91.2% of respondents answered "yes" to label GM foods even if GM protein doesn't remain in processed food (e.g., vegetable oil). Given that over 99% of imported GM soybean is used to produce vegetable oil and about 80% of vegetable oil was made from GM soybeans in Korea, this result is in favor of the introduction of new labeling system.

This study can be expanded in several ways. First, more reliable WTP estimates for non-GM food can be obtained if one uses data from large public survey. Compared to analysis based on a student survey, this will provide a basis for consistent and reliable WTP comparison between countries. Second, noting the presence of time lag between our survey (winter of 2003) and other countries survey (2001??), it would be desirable to conduct consumer survey at the same time period for comparison purpose.

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Table 1.Sample size and the distribution of sample by age, grade, and sex

		Male	Female	Total
Total		133	59	192
Age	Under 20	42	27	69
	20 – 24	53	28	81
	Over 25	38	4	42
Grade	Freshman	32	18	50
	Sophomore	20	9	29
	Junior	30	17	47
	Senior	31	8	39
	Graduate Student	20	7	27
college	Agriculture	96	37	133
	Non-Agriculture	40	19	59

Table 2. Knowledge and attitudes toward GM foods (unit: %)

Question	Alternative	Korea	Japan	Taiwan	U.S.	Norway
Sample Size		**192**	**103**	**213**	**175**	**126**
Before this survey, how well were you informed about GM foods or organisms?	Very well	7	20	2	8	1
	Somewhat	81	77	94	68	88
	Not informed	12	3	4	24	11
Non-genetically modified soybeans do not contain genes while genetically modified soybeans do.	True	4	0	5	3	6
	False	73	6	85	63	85
	Don't know	23	94	10	34	9
By eating GM foods, a person's genes could be altered.	True	7	16	13	5	6
	False	57	15	62	78	70
	Don't know	36	69	25	17	24
How safe or risky of GM foods to human health?	Very risky	7	10	17	6	11
	Neither	64	50	49	55	44
	Very safe	12	26	18	32	45
	Don't know	17	17	16	7	0
How willing to consume foods with GM ingredients?	Very willing	4	4	19	38	10
	Somewhat	14	13	60	44	34
	Not very	55	63	20	14	38
	Would avoid	27	20	1	4	18
How willing to consume GM foods if they reduce the amount of pesticides applied to crop?	Very willing	11	10	64	54	23
	Somewhat	40	33	27	37	41
	Not very	39	43	9	6	26
	Would avoid	10	14	0	3	10
How important to label GM foods?	Very	83	60	79	49	84
	Somewhat	16	21	19	29	13
	Not very	1	19	2	22	3
What type of labeling would you support?	Mandatory for GM and non-GM	63	30	67	39	48
	Mandatory for GM	34	52	27	37	48
	Voluntary	2	17	4	20	3
	Don't support any	1	1	2	4	1

Source: Chern, W.S. et al. 2002. Consumer Acceptance and Willingness to Pay for Genetically Modified vegetable oil and salmon: A Multiple-Country Assessment. AgBioForum, 5(3), 105-112, Student survey in Korea, 2003.

Table 3. Willingness to consume non-GM tofu

Price discount in GM tofu	Willingness to consume		Total
	Yes	No	
10%	31 (77.5%)	9 (22.5%)	40
30%	31 (79.5%)	8 (20.5%)	39
50%	19 (54.3%)	16 (45.7%)	35
70%	17 (42.5%)	23 (57.5%)	40
90%	18 (47.4%)	20 (52.6%)	38
Total	116 (60.4%)	76 (39.6%)	192

Table 4. Willingness to consume non-GM vegetable oil

Price discount in GM vegetable oil	Willingness to consume		Total
	Yes	No	
5%	14 (70.0%)	6 (30.0%)	20
10%	12 (60.0%)	8 (40.0%)	20
15%	16 (84.2%)	3 (15.8%)	19
20%	15 (75.0%)	5 (25.0%)	20
25%	13 (76.5%)	4 (23.5%)	17
30%	9 (50.0%)	9 (50.0%)	18
35%	7 (36.8%)	13 (63.2%)	20
40%	9 (45.0%)	11 (55.0%)	20
45%	15 (78.9%)	4 (21.1%)	19
50%	7 (36.8%)	12 (63.2%)	19
Total	117 (60.9%)	75 (39.1%)	192

Table 5. Willingness to consume non-GM vegetable oil and non-GM tofu by the type (the order of questions)

Type	Willingness to consume non-GM vegetable oil		Willingness to consume non-GM tofu	
	Yes	No	Yes	No
I	64 (66.7%)	32 (33.3%)	58 (60.4%)	38 (39.6%)
II	53 (55.2%)	43 (44.8%)	58 (60.4%)	38 (39.6%)
Total	117 (60.9%)	75 (39.1%)	116 (60.4%)	76 (39.6%)

Table 6. Estimated WTP for non-GM vegetable oil and non-GM tofu by the type

Item	Total		Type I		Type II	
	Oil	Tofu	Oil	Tofu	Oil	Tofu
Mean WTP	$1.35	$1.35	$1.42	$1.35	$1.31	$1.37
Percentage of premium	(54.2%)	(81.2%)	(56.9%)	(81.3%)	(52.4%)	(82.3%)

Table 7. Estimated WTP for non-GM vegetable oil in five countries

Item	Korea	Japan	Taiwan	US	Norway
Reference size	0.9Liter	standard	600g	32fl oz.	Liter
Mean WTP	₩1,625	¥88	NT$15	$1.13	NOK13.7
Mean WTP in US$	1.35	0.88	0.45	1.13	1.51
Percentage of premium	54.2	33-40	17-21	50-62	55-69

Source: Chern, W.S. et al. 2002. Consumer Acceptance and Willingness to Pay for Genetically Modified vegetable oil and salmon: A Multiple-Country Assessment. AgBioForum, 5(3), 105-112, and Students survey in Korea, 2003.

Table 8. Estimated WTP for non-GM vegetable oil and non-GM tofu by bootstrapping

Item	Base price	WTP	Percentage of price premium	Standard deviation of WTP
Vegetable oil	$2.50	$1.54	**61.4%**	**$0.67**
Tofu	$1.67	$1.40	**84.1%**	**$0.30**

Table 9. Upper and lower bound of WTP fon non-GM vegetable oil and non-GM tofu on 95% bootstrap confidence intervals

Item	Upper bound	Lower bound	Percentage of upper bound	Percentage of lower bound
Vegetable oil	$2.85	$0.22	**114%**	**8.8%**
Tofu	$1.96	$0.82	**119%**	**49.0%**

Figure 1. Bootstrap sample distributions of WTP for non-GM vegetable oil and non-GM tofu.