Using Stated Preference and Prior Purchase Intention in the Estimation of Willingness to Pay a Premium for Genetically Modified Foods

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ABSTRACT

This study provides an appropriate analytical approach using stated preference analysis and the contingent valuation method to investigate consumers' willingness to pay a premium for genetically modified (GM) foods together with their prior purchase intentions. Although most analyses treat consumers' attitudes and willingness to pay as separate issues, we introduce the idea of prior purchase intention to analyze these two issues as a whole. To achieve this purpose, a modeling technique invoking the multinomial logistic model and the accelerated failure time model is presented. Based on the data collected from an essential double-bounded design, our empirical results suggest that Taiwanese consumers are willing to pay a premium of about 11 NT dollars (7% of the given average market price of 150 NT dollars for the non-GM salmon) to avoid GM-soybean-fed salmon. In addition, the results of this study provide evidence that our stated-preference double-bounded design has a better-off statistical efficiency than the single-bounded one. [EconLit Citations: C510, D120, Q110]. © 2011 Wiley Periodicals, Inc.

1. INTRODUCTION

The contingent valuation (CV) method proposed by Hanemann (1984) has been commonly used to assess the willingness to pay (WTP) values of nonmarket goods, such as for the purposes of environmental quality or health promotion (Olsen & Smith, 2001; Zhai & Ikeda, 2006), and it has also been applied to food demand issues in accordance with the value attached by consumers to reducing the chronic risks associated with food consumption (Chern, Rickertsen, Tsuboi, & Fu, 2002; Kuchler, Ralston, & Tomerlin, 2000). Similar to the CV method used to evaluate consumers' WTP, the stated-preference approach compares a specific product with a few competing alternatives that differ in terms of the values or certain key characteristics (Bateman, 2002).

As in other countries, genetically modified (GM) foods have a prominent, yet controversial, presence in Taiwan. The Department of Health has conducted several large-scale surveys to understand consumers' perceptions of GM products and their basic knowledge of biogenetic technology. Consumers in Taiwan are to varying degrees concerned with the safety issue that arises from the use of biotechnology in food production. However, there are few studies available that address Taiwanese consumers' WTP for biotech foods, which is a popular way of examining consumers' attitudes toward GM foods (Bukenya & Wright, 2007; Curtis & Moeltner, 2007; Spence & Townsend, 2006). The multicountry survey of Japan, Norway, Taiwan, and the United States in Chern et al. (2002) was a small-scale study limited only to student subjects. To arrive at a better representation of Taiwanese consumers and a thorough understanding of their attitudes, we conducted a nationwide survey in Taiwan in 2003. However, as a feature of the

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survey design, the objective was to estimate a premium that consumers were willing to pay to avoid GM foods.

Conventional analyses have attempted to consider the willingness to pay a premium (WTPP) on the basis of assuming that the purpose in paying it was to avoid the possible risk that would arise as a result of purchasing a risky new product or service. The common practice has been to separate the analysis of consumers' attitudes toward the risky new product or service from the estimation of the consumers' willingness to pay a premium. However, one would expect that consumers with extreme preferences toward risk could express an unreasonable WTPP. In our study of GM foods, extreme preference consumers may consist of protesters (or nonsupporters) who do not purchase or consume a certain kind of food no matter it is non-GM or GM, and extreme opponents of GM foods. To identify consumers with extreme preferences in this study, respondents were asked their purchase intentions (PI) toward GM and non-GM foods before the elicitation of their WTPP. Hence, such prior PI could be safely assumed to be independent of the price. Based on the responses to the questions associated with prior PI, we did find a group of extreme opponents of GM foods who preferred only non-GM products and were extremely unwilling to purchase GM alternatives. Somewhat surprisingly, we also found a small group of consumers who were extremely opposed to non-GM foods and preferred only GM alternatives, and were extremely unwilling to purchase non-GM products. In addition, there was a group of protesters who simply had no interest in purchasing either product regardless of the price.

In general, it is believed that WTPP is possibly overestimated if there is a considerably large proportion of extreme non-GM food lovers, and underestimated if there are too many extreme GM food lovers.[1] Hence, the WTPP estimate would likely be biased if the consumers' prior PI were not taken into account. On the other hand, by screening out those extreme opponents and protesters, and paying attention only to those who are ambivalent toward both GM and non-GM products, the information collected through the survey would be more suitable for use in the WTPP estimation. The corresponding premium distribution could also be appropriately considered over a range of both positive and negative values, where a positive premium indicates the possible risks involved in purchasing GM alternatives and a negative premium represents a reversed preference.

Accordingly, the central focus of this study is to present a statistical model that properly incorporates consumers' attitudes into the estimation of WTPP. To jointly model a consumer's attitude and his or her WTPP, we adopt the multinomial logistic model and the accelerated failure time model to analyze a consumer's attitude together with his or her WTPP. This modeling technique is particularly appealing because it can be utilized in both single- and double-bounded design settings of CV surveys. At the same time, the gain in efficiency associated with a double-bounded model, however, may be considerable. Moreover, by introducing the screening procedure in terms of prior PI, we are able to filter out those noneligible subjects such as extreme opponents and protesters, which helps us to further improve the accuracy of our estimation.

The remainder of the article is organized as follows. Section 2 briefly reviews two articles leading to our questionnaire design. Section 3 describes our questionnaire design. In Section 4, we discuss the idea of prior PI and the role it plays in the study. Section 5 elucidates our statistical model, and the empirical results are presented in Section 6. We conclude with a summary of our findings.

[1] Fu, Chuang, and Chen (2004) used the same data of this study to estimate the WTP for avoiding GM-soybean-fed salmon. They found the risk premium for non-GM salmon to be 49% of the market price. However, in their WTP estimation they focused only on those respondents who chose non-GM salmon given the same prices for GM and non-GM salmons. In addition, the sample might include those extreme non-GM foods lovers and extreme opponents of GM foods as well. Therefore, their estimated WTP was subject to bias and overestimation problems, which also indicated a need for developing proper ways to screen out samples with extreme preference.

2. LITERATURE REVIEW

Li, McCluskey, and Wahl (2004) used the stated-preference approach and the CV method for GM food. In their study, consumers were first asked whether they were willing to pay the same price, B_I, for GM-corn-fed beef as that for non-GM-corn-fed beef. If a respondent's answer to the question was No (Yes), a follow-up question was asked at the second bid, B_L (B_H), with a percentage price markdown (markup) of the initial bid, B_I, on the GM-corn-fed beef relative to the non-GM-corn-fed beef. The price markdown or markup was randomly set at one of five levels: 10%, 20%, 25%, 50%, and 100%. The standard double-bounded logit model was then used to examine the outcomes of their survey. However, because the initial bid, B_I, was a fixed value equal to the average market price of non-GM-fed beef rather than a randomly assigned bid value conventionally used in a standard double-bounded design, the nonrandomness of B_I might have made the fitting of a double-bounded CV model inappropriate.

Kaneko and Chern (2005) designed a questionnaire similar to Li et al.'s (2004) with more options for a consumer to select his or her preferred goods. They first requested respondents to choose, at the market price of the non-GM food at the survey time, a preference from (1) non-GM, (2) GM alternative, (3) Indifferent, or (4) Neither. A subsequent question was presented that was conditional on the first answer except for the "Neither" response. If the non-GM (GM) was chosen, the price of the GM (non-GM) would be randomly discounted by 5, 10, 20, 30, or 50%. If a respondent appeared to be indifferent between these two products, the follow-up price adjustment would be a random markdown on the GM alternative or the non-GM product. In such an instance, the respondent was then asked whether he or she was still indifferent or whether he or she would choose the cheaper product. They related the WTPP to the difference in the utilities of purchasing the non-GM food and the GM alternative.

Inclusion of the indifference option in the CV question by Kaneko and Chern (2005) was an interesting idea. The indifference option provides a consumer with an alternate choice so that he or she is not forced to give a dichotomous response when he or she truly has no preference between the two products. Despite recognizing the problematic interpretation that could be overcome by including the indifference option, they also inappropriately regarded their survey design as a double-bounded one. Specifically, their design, in terms of data structure, yields only right- and left-censored observations, as opposed to interval-censored observations obtained from a standard double-bounded design (Alberini, 1995; Hanemann, Loomis, & Kanninen, 1991). Therefore, their design should be considered as a special type of single-bounded design, or a stated-preference single-bounded CV model. We may think that the first question in their questionnaire design states a consumer's preference, and the follow-up question provides the actual CV information to measure the respondent's WTPP to avoid the GM alternative.

The possibility of estimation bias due to protesters, however, did not receive much attention in the studies of Li et al. (2004) and Kaneko and Chern (2005). Kaneko and Chern asserted that the study of WTP should focus on the "optimizers," i.e., those consumers who would change their choice when they faced a substantial price markdown. Their argument was conceptually correct, but they failed to provide a convincing screening procedure to separate protesters from "optimizers." In their study, Kaneko and Chern (2005) attempted to utilize the Neither option in their initial CV question in the hope of separating protesters from optimizers. However, we believe that their procedure is only of limited help in filtering out those protesters. Although responding does not necessarily mean that the subject does not like the GM and the non-GM products at all, it may simply indicate that the subject thinks that the asking price is too high for either product. Therefore, an alternative screening procedure is required. On the other hand, in some cases, respondents may choose the non-GM (GM) products regardless of how much the price is discounted in comparison with the GM (non-GM) alternative. This behavior directly contradicts the hypothesis that most consumers would change their choices when faced with a substantial price markdown. To reduce the impact arising from protesters and respondents with extreme preference, we assume that the WTPP can be reliably measured only if a respondent is willing to consume GM and non-GM foods ambivalently, and subsequently provide a solution to estimate the WTPP unbiasedly through the use of a prior purchase intention in this study.

3. THE STATED-PREFERENCE DOUBLE-BOUNDED CONTINGENT VALUATION METHOD

To understand Taiwanese consumers' knowledge, attitudes, and risk premium in relation to GM foods, the Center for Survey Research, Academia Sinica, conducted an island-wide representative telephone survey in 2003. We designed a questionnaire to elicit data to be used in the stated-preference double-bounded CV framework. The questionnaire had three parts. The first part explored a consumer's personal background knowledge, understanding, and perception regarding GM foods. Consumers' attitudes toward GM and non-GM foods were also investigated. The second part consisted of a series of CV questions involving vegetable oil, tofu (soybean curd), and salmon. The final part was concerned with the socioeconomics, demographics, and other profiles of the respondent.

As an illustration, we present only the case of GM-soybean-fed salmon in this article. Similar to Kaneko and Chern (2005), the second part of the survey first asked a preference question regarding GM and non-GM: "Given that the otherwise identical GM-soybean-fed and non-GM salmon is sold at an identical price of 150 NT dollars per 600 grams, which of the following four options would you select, (1) Non-GM, (2) GM alternative, (3) Indifferent, or (4) Neither?"

Except for the Neither response, two subsequent follow-up questions were presented that were conditional on the previous answers, with a modified bid price adjustment strategy. For example, when the non-GM (GM) was chosen in the initial preference question, we would randomly mark down (mark up) the GM price or mark up (mark down) the non-GM price in the first follow-up question. When a respondent was indifferent between the two alternatives, then he or she randomly received one bid option among the preceding bid options of marking down (marking up) the GM price or marking up (marking down) the non-GM price. The percentage of the bid price markdown or markup by 10, 30, or 50% was also randomly assigned. This CV scenario was implemented in both follow-up questions. The percentage of the bid price change (mark up or mark down) in asking the second follow-up question was one half of the previously assigned one.

Although our survey design was similar to that of Kaneko and Chern (2005) both in the initial preference and the first follow-up questions, our design in addition included the second follow-up question. Through the use of two follow-up questions, we generated interval-censored data and accrued the usual efficiency benefits as in the standard double-bounded CV model. Thus, our model could be regarded as a stated-preference double-bounded CV model. In addition, our questionnaire design differed from most other surveys in the literature on the price adjustments of follow-up questions. That is, the conventional markdown scenario was paired with an additional markup scenario. Just as in Kaneko and Chern (2005), if a respondent chose the non-GM product in the initial preference question, the GM price would be reduced by a randomly assigned percentage, whereas the non-GM price would be reduced similarly if the GM alternative was chosen. Differing from the study of Kaneko and Chern (2005), when a respondent chose non-GM (GM) products in our survey, we also allowed a non-GM (GM) price markup (by a randomly assigned percentage) as a bid price option that the respondent could choose. Such a price markup would yield the same price difference as that from a price markdown. Because we aim to study the amount of the premium that a consumer is willing to pay, the price difference between the two alternatives is the key to a respondent's decision. Therefore, a markup scenario would serve as a good vehicle for this purpose just as a markdown one does.

In the case where Indifferent was chosen in the initial preference question, in which the prices of non-GM and GM were both 150 NT dollars, the price markup and markdown adjustments in the follow-up questions would still be valid. Detailed explanation is given in Appendix A.

Figure 1 illustrates our survey process regarding the WTPP elicitation when non-GM, GM or Indifferent are the responses to the initial preference question, respectively. We explain the bidding flow and resulting WTPP censored ranges designed for individuals responding to one of three initial preferences with change amounting to 50% of the bid price in Appendix B.

According to our survey design scheme, there are 16 possible responses: Cases 1(1) to 1(4) are the four responses associated with the initial preference of non-GM, Cases 2(1) to 2(4) are

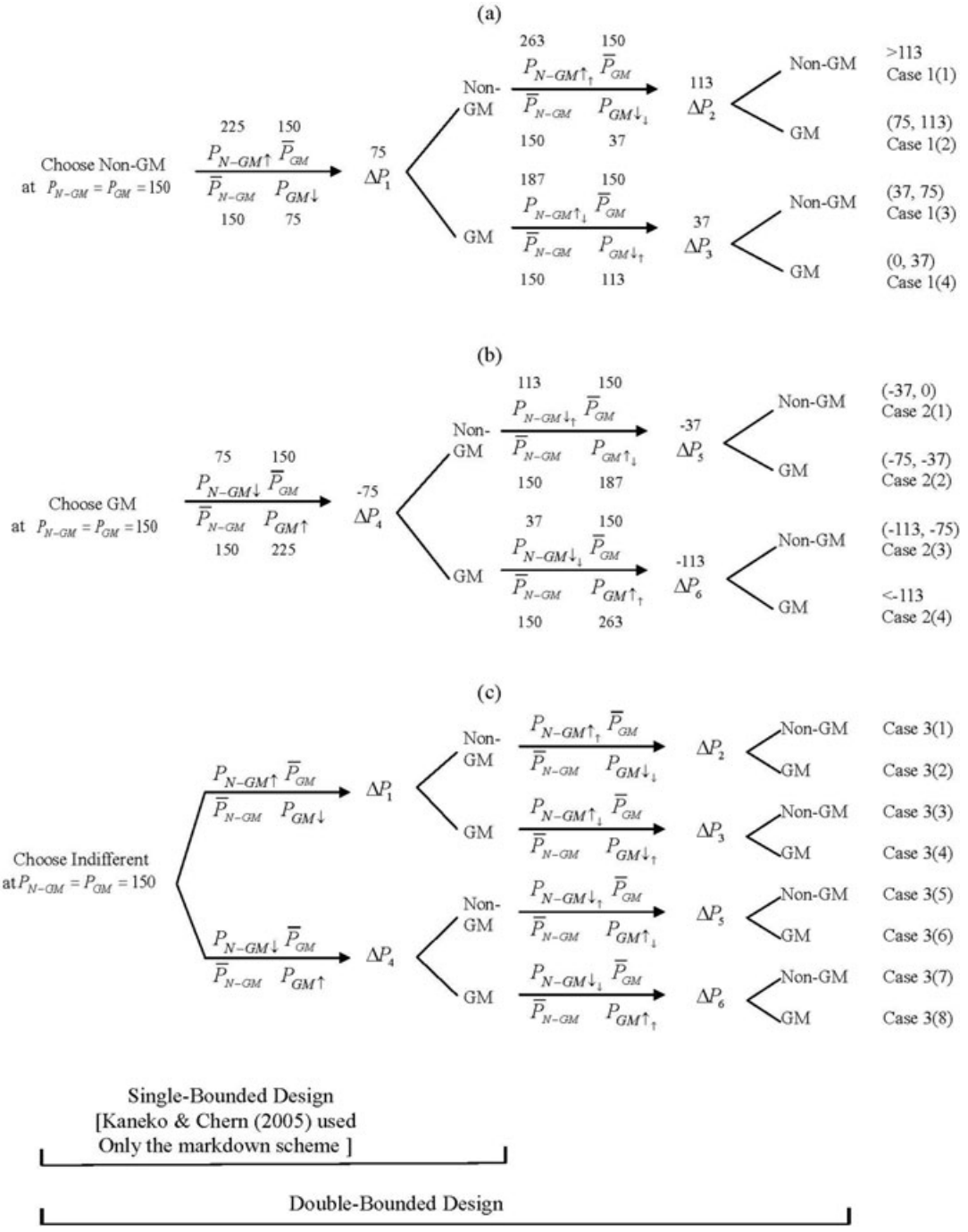

Figure 1 The Bidding Flow of a Stated-Preference Double-Bounded Survey for the Willingness to Pay a Premium.

TABLE 1. Designed Censored Ranges of Different Cases in the Bidding Flow.

Cases	Initial preference	Responses to the (first, second) follow-up questions	WTPP censored ranges at price change of 50%	30%	10%
Case 1(1)	Non-GM	(non-GM, non-GM)	>113	>67	>22
Case 3(1)	Indifferent				
Case 1(2)	Non-GM	(non-GM, GM)	(75, 113)	(45, 67)	(15, 22)
Case 3(2)	Indifferent				
Case 1(3)	Non-GM	(GM, non-GM)	(37, 75)	(22, 45)	(8, 15)
Case 3(3)	Indifferent				
Case 1(4)	Non-GM	(GM, GM)	(0, 37)	(0, 22)	(0, 8)
Case 3(4)	Indifferent				
Case 2(1)	GM	(non-GM, non-GM)	(−37, 0)	(−22, 0)	(−8, 0)
Case 3(5)	Indifferent				
Case 2(2)	GM	(non-GM, GM)	(−75, −37)	(−45, −22)	(−15, −8)
Case 3(6)	Indifferent				
Case 2(3)	GM	(GM, non-GM)	(−113, −75)	(−67, −45)	(−22, −15)
Case 3(7)	Indifferent				
Case 2(4)	GM	(GM, GM)	<−113	<−67	<−22
Case 3(8)	Indifferent				

the four responses associated with the initial preference of GM, and Cases 3(1) to 3(8) are the eight responses associated with the initial preference of Indifferent. Within each response, there are three possible percentage price changes (50%, 30%, and 10%). Table 1 shows the initial and follow-up responses for all the cases and their corresponding censored ranges. For example, when a subject exhibits an initial preference for Indifferent and consecutively chooses GM and non-GM in response to the same two follow-up questions that are given to individuals with an initial preference for non-GM products, this subject is classified as in Case 3(3) and his or her WTPP censored ranges would be (37, 75), (22, 45), or (8, 15) conditional on 50%, 30%, and 10% of the price change he or she receives, respectively. Note that the single-bounded design in Kaneko and Chern (2005) consisted only of the first half of the bidding flow, as indicated in Figure 1. In WTP elicitation studies, a double-bounded design with interval-censored data is widely known to have higher efficiency in estimating the mean and median of the WTP (Alberini, 1995; Hanemann et al., 1991). As for the WTPP, our truly double-bounded design will also be seen to share this same property in a later section of this article.

4. PRIOR PURCHASE INTENTION

One of the most crucial differences between our study and previous studies is the introduction of consumers' prior purchase intentions. This study not only evaluates consumers' willingness to pay a premium, but it also performs an analysis of the consumers' prior PI with regard to GM and non-GM foods. By specifying proper PI groups, a screening procedure can be imposed to filter out those protesters, with no prior PI toward both GM and non-GM foods, as well as those extremely opposed to GM or non-GM foods.

Two questions may serve as good vehicles for us to perform the analysis of consumers' prior PI in this study. The first is, "Under ordinary circumstances, what is the likelihood of your purchasing "Salmon fed with non-GM soybean derivatives?" The response item is one of (1) *Extremely Likely,* (2) *Likely,* (3) *Not Sure,* (4) *Unlikely,* and (5) *Extremely Unlikely*. The second question is exactly the same as the first one except that non-GM is replaced by GM. We assume that it is impossible for a respondent to purchase the specific food if he or she chooses (5) *Extremely Unlikely*. In the other cases, the respondent is considered to be a potential buyer of the corresponding food. Unlike the CV questions, these two questions are more informative in that they reflect a respondent's prior PI in the absence of price information. By using these two

questions, respondents can be classified into four intention groups: subjects having no interest in either the GM or the non-GM products (denoted by G = 0), extreme opponents of the GM product intending to purchase only the non-GM product (denoted by G = 1), extreme opponents of the non-GM product intending to purchase only the GM alternative (denoted by G = 2), and subjects ambivalent toward both products and willing to purchase either the GM or the non-GM product (denoted by G = 3). The group with G = 0 is indeed the group consisting of subjects with no prior PI toward either the GM or the non-GM products regardless of the price, and is the true group of protesters compared to the Neither group specified in Kaneko and Chern (2005). Because the group contains no information on WTPP, we will focus only on the other three intention groups instead.

5. THE STATISTICAL MODEL

In this study, we propose an analytical scheme that uses the stated preference analysis and the CV method to investigate a consumer's WTPP to avoid GM foods together with his or her PI. We incorporate the multinomial logistic model with the accelerated failure time model to evaluate potential predictors for the individual's prior PI and the relevant WTPP, respectively. The basic framework of this analysis is to model WTPP. Without incorporating the consumers' prior PI, the evaluation of WTPP may be misleading. For example, the mean WTPP for non-GM food lovers may be an unreasonably large value. By excluding those subjects whose intentions are relatively extreme, our model subsequently concentrates on subjects willing to purchase either GM or non-GM products. The prior PI analysis utilizes the multinomial logistic model with the third group as the baseline, which formulates

$$\ln \frac{P(G=1|s)}{P(G=3|s)} = \alpha' s, \tag{1}$$

and

$$\ln \frac{P(G=2|s)}{P(G=3|s)} = \beta' s. \tag{2}$$

where s denotes a set of observable personal attributes, such as gender, age, and other socioeconomic variables.

To quantify the WTPP to avoid the risk of consuming GM foods, it is legitimate to base the analysis only on those who are ambivalent toward both GM and non-GM foods, i.e., the group with G = 3. Conditional upon this group, we implement the accelerated failure time (AFT) model to illustrate the willingness of these respondents to pay a premium (Kalbfleisch & Prentice, 2002). The model may be expressed as

$$\ln(\text{WTPP}|x;\, G=3) = \theta' x + \sigma\varepsilon, \tag{3}$$

where x and ε are observable traits and the unobservable stochastic component of a respondent, respectively. As the model indicates, it is also referred to as a log location-scale model. However, what makes the model useful is that the stochastic component is usually assumed to be a log-generalized gamma random variable with shape parameter q and density function

$$f(\varepsilon|q) = \frac{|q|}{\Gamma(q^{-2})}(q^{-2})^{q^{-2}}\exp[q^{-2}(q\varepsilon - e^{q\varepsilon})],\ -\infty < \varepsilon < \infty. \tag{4}$$

Previous studies on the WTP often adopted a symmetric distribution, such as a Gaussian or logistic distribution, for the stochastic component. The choice of a symmetric distribution probably oversimplifies the real scenarios in practice. The generalized gamma family includes many commonly used distributions as its special cases such as the Weibull ($q = 1$), exponential

($q = \sigma = 1$), gamma ($\sigma = 1, q > 0$), and lognormal ($q = 0$) distributions (Kalbfleisch & Prentice, 2002). The use of the log-generalized gamma distribution provides us with much flexibility in data analysis.

Under the AFT model specification in Equation 3, the mean lnWTPP and the mean WTPP are given by

$$E(\ln \text{WTPP}|x; G = 3) = \theta' x + \sigma \left[\frac{1}{q}(\psi\left(\frac{1}{q^2}\right) + \ln q^2)\right], \quad \text{if } q \neq 0, \tag{5}$$

and

$$E(\text{WTPP}|x; G = 3) = e^{\theta' x} \cdot \frac{1}{\Gamma(q^2)}(q^2)^{\sigma/q}\Gamma\left(q^{-2} + \frac{\sigma}{q}\right), \quad \text{if } q > \frac{-1}{\sigma}, q \neq 0. \tag{6}$$

where $\psi(\cdot)$ is the digamma function, the logarithmic derivative of the gamma function.

Based on the stated-preference double-bounded survey, we observe respondents' purchase intentions and relevant censored ranges for WTPP. Theoretically, $P(\text{WTPP}_i = \infty|x_i; G_i = 1) = P(\text{WTPP}_i = -\infty|x_i; G_i = 2) = 1$. Hence, to analyze prior PI and WTPP, the full likelihood function is

$$L = \prod_{i\in\Gamma_1} P(G_i = 1|s_i) \prod_{i\in\Gamma_2} P(G_i = 2|s_i) \prod_{i\in\Gamma_3} P(WTPP_i \in (L_i, U_i)|x_i; G_i = 3)P(G_i = 3|s_i) \tag{7}$$

where Γ_j is the set of observations that belong to the j^{th} intention group, and (L_i, U_i) is the observed WTPP censored range from the i^{th} respondent. Because

$$\begin{aligned} P(\text{WTPP}_i \in (L_i, U_i)|x_i; G_i = 3) &= P(\ln(L_i) < \ln(\text{WTPP}_i) < \ln(U_i)|x_i; G_i = 3) \\ &= P(\ln(L_i) < \theta' x_i + \sigma\varepsilon_i < \ln(U_i)|x_i; G_i = 3) \\ &= P\left(\frac{\ln(L_i) - \theta' x_i}{\sigma} < \varepsilon_i < \frac{\ln(U_i) - \theta' x_i}{\sigma}|x_i; G_i = 3\right), \end{aligned} \tag{8}$$

The log-likelihood function can be explicitly written as

$$\begin{aligned} \ln L = &\sum_{i\in\Gamma_1} \ln\left(\frac{e^{\alpha' s_i}}{1 + e^{\alpha' s_i} + e^{\beta' s_i}}\right) + \sum_{i\in\Gamma_2} \ln\left(\frac{e^{\beta' s_i}}{1 + e^{\alpha' s_i} + e^{\beta' s_i}}\right) \\ &+ \sum_{i\in\Gamma_3}\left[\ln P\left(\frac{\ln(L_i) - \theta' x_i}{\sigma} < \varepsilon_i < \frac{\ln(U_i) - \theta' x_i}{\sigma}\right) + \ln\left(\frac{1}{1 + e^{\alpha' s_i} + e^{\beta' s_i}}\right)\right]. \end{aligned} \tag{9}$$

It can be further decomposed into a sum of two independent parts of log-likelihood functions. The former is the log-likelihood function of the multinomial logistic model,

$$\sum_{i\in\Gamma_1} \ln\left(\frac{e^{\alpha' s_i}}{1 + e^{\alpha' s_i} + e^{\beta' s_i}}\right) + \sum_{i\in\Gamma_2} \ln\left(\frac{e^{\beta' s_i}}{1 + e^{\alpha' s_i} + e^{\beta' s_i}}\right) + \sum_{i\in\Gamma_3} \ln\left(\frac{1}{1 + e^{\alpha' s_i} + e^{\beta' s_i}}\right), \tag{10}$$

and the latter is the log-likelihood function of the AFT model,

$$\sum_{i\in\Gamma_3}\left[\ln P\left(\frac{\ln(L_i) - \theta' x_i}{\sigma} < \varepsilon_i < \frac{\ln(U_i) - \theta' x_i}{\sigma}\right)\right]. \tag{11}$$

TABLE 2. Variable Definitions and Summary Statistics.

Variable	Description	Sample mean and proportion
RISK	Binary response 1: If one thinks GM food is extremely/somewhat risky to human health. 0: Otherwise	0.326
EDU	Binary response 1: High school and above. 0: Otherwise	0.329
AGE	Age of the respondent	43.431 (12.209)

Note. Sample size $n = 334$. The number in the parentheses is the standard deviation.

This enables us to estimate the parameters of each sub-log-likelihood function separately. The estimation procedures can be performed using the SAS statistical package version 9.1, which is equipped with built-in modules to analyze both the multinomial logistic model and the AFT model with errors of the generalized gamma distribution. However, some data adjustment is necessary before proceeding with the data analysis. Equation 3 represents the essential framework for modeling the WTPP. For some cases in this study, the censored intervals may be less than zero, and consequently the log function is undefined. Therefore, a modified AFT model is given by

$$\ln((\text{WTPP} + C)|x; G = 3) = \theta' x + \sigma\varepsilon, \tag{12}$$

where C is a positive number such that $\ln(\text{WTPP} + C)$ is well-defined. Implicitly, in Equation 12 we impose a lower bound of the WTPP at $-C$. Although the price of the GM alternative can be greater than that of the non-GM food in our study, a huge difference in prices is unreasonable. Thus, this practice makes our estimation not only feasible, but also conceptually sensible. We set the value of C to be 150, the average market price for the non-GM salmon. However, a sensitivity analysis indicates that an arbitrary choice of C within a reasonable range does not seriously affect the results of our WTPP analysis.

6. EMPIRICAL RESULTS

A telephone survey was administrated in August 2003 using a computer-assisted telephone interview (CATI) system. A stratified systematic sampling method was used to select the households to be interviewed, and 1,004 respondents completed the interview. About one third of the households were randomly assigned to answer CV questions associated with salmon, and the rest of them were randomly assigned to answer questions on either tofu or vegetable oil.

Table 2 displays the definitions and sample descriptive statistics of the key variables that were found to be statistically significant in our final model for salmon. Among the 334 respondents, 32.9% were high-school educated or above, and 50% were over the age of 42. In addition, 32.6% of the respondents believed that GM foods were detrimental to human health. It seems that Taiwanese consumers are more "adventurous" in the sense that they do not hold negative or suspicious attitudes toward GM products and are probably more willing to purchase them.

As far as prior PI is concerned, 58 subjects were classified into intention Group 1 (non-GM only), 8 into Group 2 (GM only), and 268 subjects were classified into Group 3. Not surprisingly, the number of respondents in Group 2 was the minimum among the three and Group 3 was the maximum. Preliminary estimates of the WTPP distribution, though not presented here, were also computed using the Turnbull estimator, a nonparametric distribution analysis technique that requires no distribution assumption (Hanemann & Kanninen, 1998; Turnbull, 1976). The estimated mean WTPP was found to be unreasonably high for Group 1 and extremely low for Group 2. This finding confirms our conjecture that the mean WTPP would

TABLE 3. Estimated Parametric Model.

Parameter (Covariate)	Estimate	Standard error	Asy. $\chi^2(1)$	*P*-value
		Multinomial logistic model		
α_0 (Intercept)	−3.508	0.654	28.763	<0.001
α_1 (RISK)	1.480	0.313	22.361	<0.001
α_2 (EDU)	0.676	0.311	4.711	0.029
α_3 (AGE)	0.024	0.012	3.974	0.046
β_0 (Intercept)	−3.511	0.358	95.786	<0.001
		AFT model		
θ_0 (Intercept)	4.966	0.133	1403.735	<0.001
θ_1 (RISK)	0.257	0.083	9.675	0.002
θ_2 (AGE)	0.006	0.003	4.927	0.026
σ	0.428	0.056	57.984	<0.001
q	1.439	0.271	28.300	<0.001
−2Log-likelihood	1411.378 (350.067 + 1061.311)			
AIC	1431.378			
		AFT model (Use only single-bounded response)		
θ_0 (Intercept)	4.966	0.144	1191.691	<0.001
θ_1 (RISK)	0.296	0.091	10.487	0.001
θ_2 (AGE)	0.008	0.003	7.379	0.007
σ	0.329	0.097	11.543	<0.001
q	1.941	0.855	5.151	0.023

possibly be overestimated or underestimated if these extreme respondents were to account for a considerable proportion in a study. Therefore, the exclusion of these two groups was justified.

As for the CV part of the survey, most of the 268 respondents included in the WTPP analysis chose to consume non-GM salmon in response to the initial question when both GM and non-GM products were sold at the same price of 150 NT dollars. Meanwhile, about 15% of the respondents could not explicitly express their preferences between these two. Without the Indifference option, when being forced to choose between the GM and the non-GM options, these respondents would be very likely to choose not to answer this question. As a result, they would be excluded from the analysis. Thus, inclusion of the Indifference options considerably increases the sample size used in the analysis.

Table 3 presents our best-fitting parametric model based on the minimum AIC criteria. The top panel of the table shows the parameter estimates of the multinomial logistic model. To avoid getting unstable estimates due to the insufficient observations for Group 2, we retained only the intercept term β_0 in $\ln[P(G = 2|s)/P(G = 3|s)]$. The results indicated that subjective risk perception regarding GM products (RISK), education level (EDU), and age (AGE) were three factors related to a respondent's prior PI. Positive estimates of α_1, α_2, and α_3 suggest that subjects who were older, more highly educated, or who had higher risk perception toward the GM product tended to purchase only the non-GM product.

Parameter estimates of the AFT model are presented in the middle panel of Table 3. For those who were willing to purchase either the GM or the non-GM products, the estimates indicated that they would pay a higher premium if they were older, or had higher risk perception toward the GM product. Although gender and education level are generally considered to be significant variables in WTP studies, neither was significant in this study. Data analysis found that both gender and EDU were significantly associated with RISK and AGE, and were therefore not included in the final model.

We may also interpret the relative effects of the significant covariates using quantities $\exp(\theta_l)$ for corresponding parameter estimates. For instance, the covariate RISK has the greatest relative effect in the sense that the mean WTPP for a consumer with high risk perception was 1.3 0(= exp(0.26)) times that for one with low risk perception.

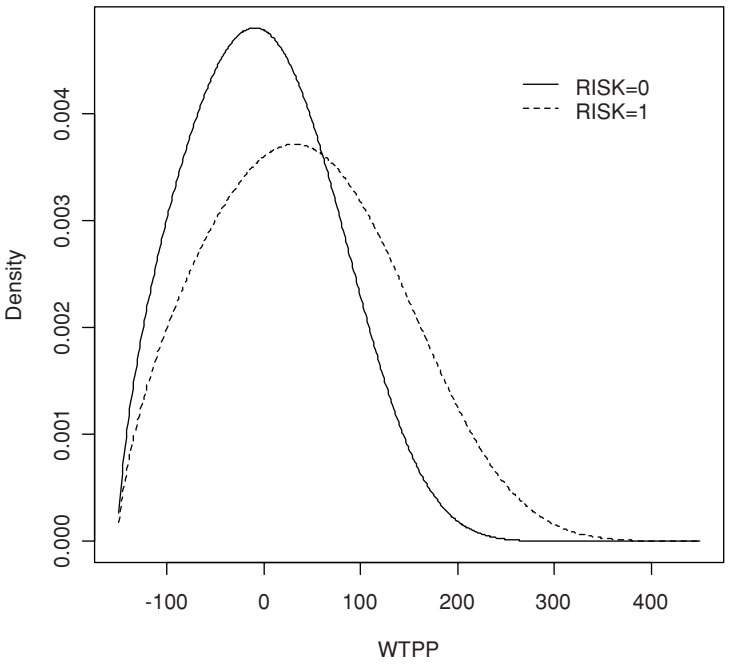

Figure 2 RISK-Stratified Density Functions of the Willingness to Pay a Premium for Age = 43.43 Estimated by the Accelerated Failure Time (AFT) Model.

In addition, we note that the Wald test of the hypothesis $q = 0$ against $q \neq 0$ was highly significant. A positive estimate of the shape parameter q indicated that the data were not normally distributed. Figure 2 plots the probability density functions of the WTPP stratified by RISK for subjects of the average age 43.43. It is evident from the figure that the shape of the density function is positively skewed rather than symmetrical. Because the most popular normality assumption can only lead to a symmetric distribution of WTPP, the adoption of a log-generalized gamma distribution in this case greatly enhances the accuracy of the model estimation.

Lacking a formal goodness-of-fit criterion, we examined the adequacy of the model fit by visually comparing the survival curves obtained from the nonparametric Turnbull estimator and the parametric AFT model. Note that the nonparametric Turnbull estimates, or empirical distribution estimates adjusted for interval-censored data, were obtained directly from the data without imposing any model assumptions. Hence, any fitted parametric model close enough to the Turnbull estimates can be deemed a favorably acceptable model for the data. Figure 3 displays two sets of estimated survival curves stratified by RISK for those who were about 43 years old, where smooth curves represent the parametric model fits, and step functions are the estimated Turnbull curves. Because both survival curves in each stratum are close to each other, the parametric AFT model appears to fit the WTPP data satisfactorily.

To substantiate our claim that the double-bounded design was more efficient than single-bounded designs, the AFT model was also fitted using only single-bounded responses, namely, information obtained from the initial question and the first follow-up question. As shown in the bottom panel of Table 3, most standard errors inflate, particularly σ and q. This result confirmed that our modified double-bounded design shared the same good property as the conventional double-bounded design.

Using the parameter estimates provided in Table 3, we can estimate the mean and the median of WTPP for several subsamples as shown in Table 4. The overall mean WTPP for the complete

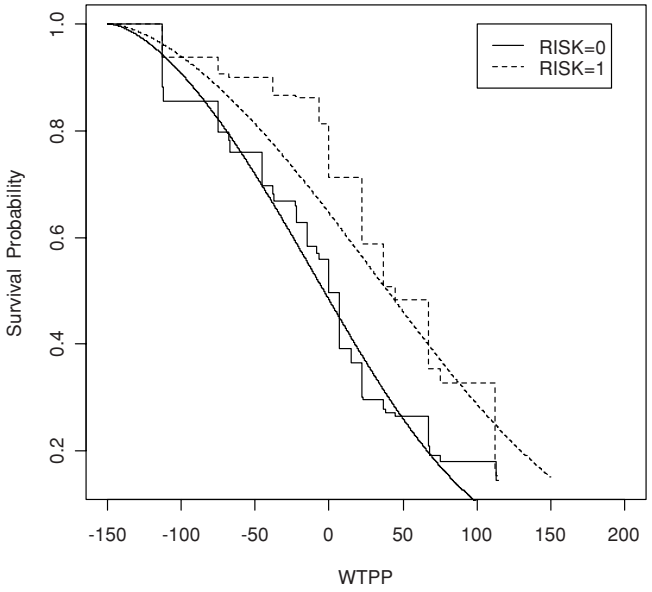

Figure 3 RISK-Stratified Survival Curves of the Willingness to Pay a Premium for Age = 43.43: A Comparison Between Turnbull Estimates (Step Functions) and Estimates Obtained From the Accelerated Failure Time (AFT) Model (Smooth Curves).

TABLE 4. Estimated Mean and Median Willingness to Pay a Premium.

	Sample size	Mean	Median
Overall	268	10.59	7.20
Low risk perception (RISK = 0)	195	0.52	−3.16
High risk perception (RISK = 1)	73	44.64	39.88

sample was 10.59 NT dollars, which was about 7% of the average market price for non-GM soybean-fed salmon. Evidently, a subject with higher risk perception regarding GM was willing to pay a higher premium. On the contrary, subjects with lower risk perception regarding GM generally had a negative premium for avoiding GM soybean-fed salmon, which may be interpreted as a positive willingness to pay a risk premium for the GM alternative.

7. CONCLUDING REMARKS

The stated-preference double-bounded CV method is facilitated by our proposed model, and overcomes the disadvantages that appeared in previous related studies. By giving rise to a higher statistical efficiency through the use of the stated-preference contingent valuation method, this study provides a useful strategy in statistical analyses for both the consumer's purchase intention toward GM foods and his/her willingness to pay a premium. This approach allows us to analyze the patterns of PI and to incorporate the appropriate information from respondents into the WTPP model simultaneously. In particular, the inclusion of prior PI considerably reduces the bias in the estimation of WTPP.

In general, the proposed model can be applied to surveys for various kinds of commodities with a single-bounded or double-bounded design. However, some caution must be exercised. First, this method is applicable provided that researchers are able to classify respondents into proper intention groups based on a collection of prior information unrelated to the willingness to pay. Second, as a common restriction for all stated-preference approaches, an identical

price for competing products is offered to the customers. Hence, the WTPs of the competing products cannot be estimated, and that is why we circumvent this difficulty by focusing on the price difference as the risk premium.

As for the salmon survey data that were analyzed using the proposed model, risk perception, education level, and age were identified as significant factors that might have some impacts on Taiwanese consumers' prior PI. Taiwanese consumers would prefer to purchase non-GM salmon and would be willing to pay a higher premium if they are older, or if they consider GM-soybean-fed salmon to be risky to human health. This real example also demonstrates that the stated-preference double-bounded CV survey has a better-off statistical efficiency than the single-bounded one.

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APPENDIX A

Detailed Explanation for the Validity of Follow-Up Price Adjustments When Indifferent Is Chosen in the Initial Preference Question

Suppose a respondent chose Indifferent in the initial preference question, which indicated no difference in his or her preference toward non-GM and GM products at the price of 150 NT dollars. By assuming his or her choice would depend upon the price difference between these

two alternatives, four kinds of price difference scenarios could be designed in the follow-up questions. Supposing such a price difference was 45 NT dollars (a 30% price change), then in the first follow-up question, we could mark up (mark down) the price of non-GM or mark up (mark down) the price of GM by 45 NT dollars while holding the other price unchanged. If the response to the first follow-up question was GM or non-GM, then we could apply such a price adjustment again (but with one-half of the first price change, 23 NT dollars) in the second follow-up question. On the other hand, if the respondent answered Indifferent again to the first follow-up question, then the respondent would be regarded as an irrational subject or a person who was insensitive to price. This is because the Indifferent response in the preference question represented no special preference between the GM and non-GM alternatives, whereas the Indifferent response to the first follow-up question with a price difference implied some special preference toward the alternative with a lower price. The preferences implied by these two subsequent responses thus contradicted each other, and we then deleted such subjects from the entire analysis.

APPENDIX B

Detailed Explanation of Bidding Flow in Figure 1

Figure 1(a) presents the bidding flow for an individual with an initial preference for non-GM who is randomly assigned to respond to the scenario where the percentage of the bid change is 50%. The price adjustment in the first follow-up question is designed to be either increasing the non-GM price (the price markup scenario), denoted by $P_{N-GM}\uparrow$, or reducing the GM price (the price markdown scenario), denoted by $P_{GM}\downarrow$, by 50% (that is, 75 NT dollars) while holding the price of the other product unchanged, as denoted by $\bar{P}_{GM}$ or $\bar{P}_{N-GM}$, respectively. Correspondingly, the price difference between these two products, defined as $P_{N-GM} - P_{GM}$, is $\Delta P_1 = 75 (= 225 - 150 = 150 - 75)$. Supposing that the respondent chooses non-GM in response to the first follow-up question, we may infer that this respondent has a risk premium of more than ΔP_1. Conditional on this response, the price adjustment in the second follow-up question is either increasing the non-GM price ($P_{N-GM}\uparrow_\uparrow$) (the price markup scenario) or reducing the GM price ($P_{GM}\downarrow_\downarrow$) (the price markdown scenario) once more by one half of ΔP_1 (that is, 38 NT dollars). After the second-time price change, the price difference becomes $\Delta P_2 = 113 (= 263 - 150 = 150 - 37)$. If the respondent still chooses non-GM in response to the second follow-up question, as shown in Case 1(1), then his or her premium could be greater than 113 with the censored range being denoted by >113. Otherwise, if GM is chosen, as shown in Case 1(2), the respondent's WTPP is somewhere between 75 and 113, and the corresponding interval-censored premium is denoted by (75, 113).

Similar ways of marking up prices and marking down prices are applied to the case where the response to the first follow-up question is GM. Such a choice of GM implies that this respondent has a risk premium of less than $\Delta P_1 (= 75)$. Again, in the second follow-up question, we will mark up the price of GM ($P_{GM}\downarrow_\uparrow$) or mark down the price of non-GM ($P_{N-GM}\uparrow_\downarrow$) by one-half of the ΔP_1. That is, the respondent will be asked to make choices either between $P_{N-GM} = 187$ and $P_{GM} = 150$ or between $P_{N-GM} = 150$ an$P_{GM} = 113$, which implies a price difference of $\Delta P_3 (= 187 - 150 = 150 - 113 = 37)$. If the response to such a second follow-up question is non-GM, as in Case 1(3) in Figure 1(a), then the WTPP of that respondent lies between 37 and 75. Otherwise, if the response is GM, as in Case 1(4), then the WTPP is less than 37.

Figure 1(b) presents the bidding flow for an individual whose response to the initial preference question is GM. Such an individual is also randomly assigned to respond to the scenario where the percentage of the bid change is 50%. By using the same price markup and markdown scenarios, one can easily identify the price differences $P_{N-GM} - P_{GM}$ such as ΔP_4, ΔP_5 and ΔP_6 to be -75, -37 and -113, respectively. Then, the corresponding censored ranges of WTPP for Case 2(1), Case 2(2), Case 2(3), and Case 2(4) are $(-37, 0)$, $(-75, -37)$, $(-113, -75)$ and <-113, respectively.

The bidding flow for those who respond as Indifferent in the initial preference question is shown in Figure 1(c). It is designed to include the bidding flows of both Figures 1(a) and 1(b). These respondents will be randomly assigned one of the above-mentioned scenarios in the follow-up questions. Consequently, the values of the price differences ($\Delta P_1, \ldots, \Delta P_6$) are the same as those in Figures 1(a) and 1(b). Furthermore, the censored ranges of Cases 3(1) to 3(4) are the same as those of Cases 1(1) to 1(4), just as those of Cases 3(5) to 3(8) are the same as those of Cases 2(1) to 2(4).

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