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Use of Spike Models in Measuring Consumers' Willingness to Pay for Non-GM Oil

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In this paper, Chinese consumers' preferences and their willingness to pay (WTP) for non–genetically modified (GM) vegetable oil were elicited by a payment card approach. In addition to the conventional model, spike models, which were originally developed to evaluate public goods, were adopted in this paper. These spike models recognize the possibility of zero WTP and provide opportunities to analyze two correlated decision stages: whether to pay a premium for non-GM oil and how much the premium is. Results show that consumers behaved consistently in the two decision stages and there is a premium associated with non-GM oil.

Key Words: Chinese consumers, non–genetically modified oil, spike models, willingness to pay

JEL Code: Q13, D12, C25

The introduction of genetically modified (GM) food into the market creates a significant amount of controversy. Concerns have been raised by different social entities regarding various aspects including human health, environment, ethics, and many others (Rousu et al. 2004). GM food and food produced through conventional agriculture are likely to coexist in the market for a foreseeable long period. One important issue is to know how consumers' view this dual market and how much they are willing to pay for non-GM products to avoid the uncertainties associated with GM food. China has one of the largest food demands in the world. Together with the United States, Canada, and Argentina, it contributes more than 95% of the world's GM food production (ISAAA). However, research on Chinese consumers' preferences and willingness to pay (WTP) for non-GM food is scarce. Using a recent survey data on Chinese consumers' WTP for non-GM vegetable oil, this study provides insights into the issue.

Although the Chinese government has recently begun to require mandatory labeling of GM products, the two types of products have not yet appeared in the market as competitors (Huang and Wang). The method of contingent valuation (CV) has been widely applied to welfare analysis of goods that are either nonmarketable or do not currently exist in the market, such as non-GM vegetable oil being studied in this paper. This study uses the payment card WTP elicitation approach, which may reduce the inconsistency associated with multiple-bounded WTP questions (McFadden 1994). In this paper, endogenous spike models are adopted to analyze Chinese consumers' preference and WTP for non-GM oil. The spike model had previously been applied only to public goods such as improvement of en-

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vironmental quality. This paper shows that the model can be used in the settings of private goods as well, and it provides an alternative way to explain consumers' WTP for non-GM vegetable oil. The strength of the model resides in its ability to allow consumers to exhibit true zero WTP for non-GM oil. The validity of the model is assessed in two different assumptions on the true WTP distribution (i.e., normal and Gumbel distributions). The spike model can also be used to explain what factors contribute to consumers' decisions to pay a premium for non-GM oil and what factors determine the amount they are willing to pay.

Theory

In a closed-ended WTP question, for any value that respondents have indicated or agreed to pay, their true WTP is assumed to be located above that value and below the next available value, if it exists (Hanemann and Kaninnen). This implies that when respondents refuse to pay any positive amount, their WTP is assumed to be between zero and the lowest value in the bidding range. Nevertheless, there are many possible reasons that respondents may not hold a positive value for the goods in question. For the case of vegetable oil, if respondents believe that GM and non-GM oil are identical in every aspect, they may not be willing to pay any additional amount for non-GM oil. On the other hand, given the uncertainties associated with GM food, especially those on human health, respondents who are not clear on these issues may hesitate to bid and in this case, a zero bid seems to be their best choice. Lastly, respondents may protest a WTP question. For GM oil, due to the controversies surrounding it, respondents may get irritated by any attempt to approach this topic—no matter if it is about GM oil or non-GM oil, their bid will always be zero.

Due to these reasons, treating nonpositive bids as an indication of a true WTP lying between zero and the lowest bid in the range will overestimate the true WTP (Werner 1999). An appropriate economic model should be designed to accommodate an appreciable proportion of zero WTP in a valuation study. McFadden and Leonard first used a model with the WTP distribution having a point mass at zero and subsequently provided a possibility of distinguishing a small positive or a zero WTP. Various researchers have specified models based on a similar approach in evaluating public goods (e.g., Kristrom; Hackl and Pruckner; Yoo and Kwak). This paper follows the terminology provided by Kristrom and refers to these types of models as spike models (with nontrivial density at zero). In a typical application of the spike models, respondents' WTP intentions are assessed by an open question that either precedes or follows the WTP question, in a form such as, "Given the situation presented to you, would you like to pay anything for the goods?" This gives the researcher *a priori* knowledge of which respondent has zero WTP. WTP analyses are then conducted based on answers to this question.

In addition to a simple stated WTP intention, McFadden (1994) and An and Ayala developed models that incorporate other household factors, such as demographic information, to explain the probability of why respondents would like to pay a nonzero amount. This type of model has recently been used in assessing WTP for improvement in environmental quality (Werner 1999, 2002). This is also in line with the two-step analysis of a sample selection problem: respondents first decide whether they would like to participate in the bidding, and if they are willing to pay something, they then decide how much to pay. A series of studies have followed these thoughts by using a conventional modeling approach with sample selections to situations of zero WTP in public good surveys (Haab; Strazzera et al. 2003a,b; Brox, Kumar, and Stollery). This approach treats the probability of whether to pay a nonzero amount as latent and makes it unnecessary to ask an open question of whether respondents are willing to pay a positive amount. This paper adopts the endogenous spike model specified by McFadden (1994) and An and Ayala.

Following the recommendation of the NOAA panel, closed-ended referendum CV (especially double-bounded CV), has been

dominating the literature. There are studies that compare various elicitation methods, including the payment card approach, and favor the double-bounded approach, mostly due to its efficiency (Hackl and Pruckner; Calia and Strazzera). However, the double-bounded approach is not without significant drawbacks. For example, Holmes and Kramer and Calia and Strazzera proved the existence of starting points bias.[1] Cooper, Hanemann, and Signorello and Aadland and Caplan focused on the inconsistency in responses to the question. These seem to recast on the acknowledgment raised by McFadden (1994), which states that responses to the double-bounded approach are internally inconsistent and are likely to produce worse results than an open-ended question. An additional potential difficulty associated with a double-bounded survey is that it requires a much larger sample size than an open-ended survey.

In light of these arguments, the payment card WTP elicitation method is used in this paper. The payment card approach goes beyond the open-ended and the bounded referendum approaches in that it provides several possible values for respondents to choose from. This approach avoids the inconsistency problems in a bounded referendum question by giving each respondent only one chance of expressing their WTP but at the same time also limits the reported WTP measures to a reasonable range. This is probably the reason why there is a renewed interest in the payment card approach in the evaluation literature (e.g., Brox, Kumar, and Stollery). It is true that the payment card approach may suffer from range and end point biases.[2] However, compared with a complex environmental good involving a large scale of possible impacts (McFadden 1986), it is less complicated to determine the potential range of the WTP for a private good, non-GM oil. In the next section, there is strong indication that payment card values used in the survey do cover the range of possible WTP for non-GM oil by Chinese consumers. Rowe, Schulze, and Breffle noted that in this case, the range and end point biases are minimal.

Survey and Data

The survey was implemented in Beijing, China beginning in the fall of 2002 and completed in early 2003. As the capital city of China, Beijing consistently attracts an amount of visitors from around China that is close to the number of its own permanent residents (13 million) (Beijing Statistical Yearbook). This large and greatly heterogeneous population in Beijing is useful for researchers to examine national-level food demand issues. A group of trained staff administered the survey through on-site interviews at various grocery marketplaces in Beijing. These include various retail and wholesale markets targeted at consumers at different levels of income and shopping preferences. In order to reduce the anchoring effect on genetic modification, introduction of the survey was worded as a general study on oil purchasing. A small token was awarded for each completed survey.

The survey has three sections and was designed to be completed in approximately 15 minutes. The first section is to evaluate consumers' general perceptions on general food safety issues, agricultural biotechnology, genetic modification, information acquisition and trust of sources of information, and attributes of vegetable oil. The second section contains the WTP question, asking how much *more* respondents would be willing to pay for non-GM oil with otherwise exactly the same quality as GM oil. Appendix 1 gives the payment cards used in the survey. Based on the average price of 30 Yuan (1 Yuan $\approx$ 0.12 USD) per 5-kg jug[3] for GM oil, the lowest nonzero amount respondents were allowed to bid *on top of* the regular price was one Yuan for non-GM oil and the high end was "39

[1] Hanemann and Kaninnen showed that careful design and intensive testing of the survey may significantly reduce the starting point bias.

[2] Range bias refers to the effect on evaluation results introduced by the range of the values given in payment cards while end point bias refers to effects possibly generated by various starting points of the payment card values.

[3] The 5-kg jug is the most common vegetable oil package on the Chinese market.

Table 1. Sample and Variables Descriptive Statistics Definition

Variable	Definition	Mean	SD
MALE	Male = 1; female = 0	0.5123	0.5003
MARRIED	Married = 1; unmarried = 0	0.7614	0.4266
AGE	Numerical value of years in age	37.8421	11.4958
EDU	Numerical value of years in school	14.4772	2.6322
INCOME	Numerical value of monthly household income before tax (in Chinese Yuan)	2,939.4737	2,150.1060
SHOPPER	Major grocery shopper = 1; otherwise = 0	0.6632	0.4730
SKNOW	1–5 Likert scale self-evaluated GM knowledge level	0.5912	0.4920
EXPERT	If issues on GM technology should be left to only to experts = 1; otherwise = 0	0.5912	0.4920
GMPLANT	1–5 Likert scale of "How risky are GM plant products to human health?"	0.2105	0.4080
GMANIML	1–5 Likert scale of "How risky are GM animal products to human health?"	0.2719	0.4453
TRUST	1–9 Likert scale of "How trustworthy is the government food safety regulation system?"	2.7158	1.1753
OKNOW	If all five GM-relative knowledge questions are answered correctly = 1; otherwise = 0	0.2579	0.4379
IMPPRI	1–5 Likert scale of "How important is price to choosing oil?"	0.4018	0.4907
IMPSEED	1–5 Likert scale of "How important is use of non-GM to choosing oil?"	0.3193	0.4666
IMPDOM	1–5 Likert scale of "How important is domestic site of production to choosing oil?"	0.2088	0.4068
PRICE	Numerical value of price premium reflected by payment cards (in Chinese Yuan)	9.5404	9.4064

Note: GM is genetically modified.

Yuan and above." Respondents could also bid nothing for non-GM oil in addition to 30 Yuan.[4] The last section of the survey gathered respondents' demographic characteristics.

Average shoppers were randomly intercepted for the survey and out of the 847 consumers who showed interest, 570 returned useable questionnaires. To verify the representativeness of the sample, descriptive statistics for key sample demographic variables (see Table 1) were compared to the 2002 Beijing Statistic Yearbook and no noteworthy differences were detected. A preliminary investigation of responses to the WTP question reveals that there were only four out of the 570 consumers who reported their WTP in the category "39 Yuan and above." It is therefore reasonable to believe that values showed in the payment cards in the survey covered the potential range of Chinese consumers' WTP for non-GM oil. Among these 570 respondents, 82 were not willing to pay any positive premium for non-GM oil. Given the lowest positive bid is 1 Yuan, the spike models can distinguish, by probabilities, individuals who were not willing

[4] This study uses a slightly different approach to elicit payment card values in that the payment cards differ from each other by only one Yuan rather than a larger interval (Brox, Kumar, and Stollery). Under this circumstance, an OLS analysis using payment card values as the dependent variable may also shed some lights to the question. However, since these values are not completely continuous, an OLS analysis of WTP generates only a crude measure.

to pay any premium for non-GM oil and those who would be willing to pay some positive amount between 0 and 1. A summary of variables used in this article with their corresponding definitions and descriptive statistics is also given in Table 1.

Model

Suggested by the random utility theory, given respondent i's characteristics vector X_{iq} and income Y_i, the utility of purchasing a GM oil product, represented by V_{i0}, can be written as

$$(1) \quad V_{i0} = \alpha_{i0} + \alpha_q X_{iq} + \alpha_Y Y_i + e_i$$

where α_0 is a constant; α_q and α_Y are unknown coefficients; and e_i is the stochastic portion of the utility. Assuming a random variable WTP_i represents respondent i's WTP for non-GM oil, the utility of purchasing non-GM oil V_{i1} is

$$(2) \quad V_{i1} = \alpha'_{i0} + \alpha'_q X_{iq} + \alpha_Y (Y_i - WTP_i) + e_i.$$

Following Haab and McConnell, the coefficient α_Y is maintained the same in these two states to ensure no "money illusion." Respondent i would be willing to pay WTP_i if the utility of purchasing GM or non-GM oil is exactly equal, $V_{i0} = V_{i1}$. If you equate expressions 1 and 2, you can obtain the expression for WTP_i. If $F(\cdot)$ can be used to specify the distribution function of the stochastic terms e_i in V_i, the probability of respondent i being willing to pay C_j (as given by a payment card) can be written as

$$(3) \quad \Pr(WTP_i \geq C_j) = 1 - F_i^j\left(\alpha_Y C_j - \sum \beta X_i\right)$$

where βX is the difference between the deterministic part of utilities in (1) and (2) excluding Y_i. If we define π_i as the probability of a respondent not willing to pay a positive amount, the unconditional probability for a respondent who was not willing to pay the lower end of the payment card values ($C_0 = 1$ Yuan) is

$$(4) \quad \Pr(WTP_i \geq C_0 = 0) = \pi_i 1 + (1 - \pi_i)(1 - F_i^0).$$

Similarly, the unconditional probabilities of respondent i being willing to pay a value between C_j and C_{j+1} and to pay the high end C_U are:

$$(5) \quad \Pr(C_{j+1} > WTP_i \geq C_j) = (1 - \pi_i)(F_i^j - F_i^{j+1}), \quad \text{and}$$

$$(6) \quad \Pr(WTP_i \geq C_U) = (1 - \pi_i)(F_i^U).$$

The corresponding log-likelihood can be written as

$$(7) \quad LL(\alpha, \beta) = \sum_{i=1}^{N} \left\{ d_0 \ln[\pi_i + (1 - \pi_i)(1 - F_i^0)] + \sum_{j=1}^{U-2} d_j \ln(F_i^j - F_i^{j+1}) + d_U \ln(F_i^U) + \sum_{j=1}^{U-2} (d_j + d_U) \ln(1 - \pi_i) \right\}$$

where d_0, d_j, and d_U equals one if respondent i was willing to pay 0, C_j, and C_U and equals zero otherwise. McFadden (1994) stated that under regular conditions (e.g., no empirical unidentification) the above log-likelihood function can be maximized and yield consistent estimates of the parameters.

It is necessary to specify the distribution of π and $F(\cdot)$ to give Equation (7) an explicit functional form. If Z_i is defined as a vector of covariates (Z_i need not be different from vector X_i), the probability of respondent i willing to pay zero premium for non-GM oil can be written as

$$(8) \quad \pi_i = \Phi\left(\sum \gamma Z\right)$$

where Φ is the standard normal distribution function. This can be substituted into the log-likelihood function and parameter γ's can be jointly estimated with other utility function parameters. In terms of the distribution for $F(\cdot)$, Haab noted that the final WTP estimation is not independent to the distribution one assumes on the WTP function (3). In order to represent this effect, both Gumbel and normal distributions are used for estimating the WTP

equation, while the normal distribution for π_i is maintained.[5]

The estimated WTP following the endogenous spike model is the probability π_i weighted average of the WTP function given in Equation (3):

$$(9)\quad E(WTP_i) = \pi_i WTP_i^0 + (1-\pi_i)G_i\left[1 - F_i\left(\alpha_Y C - \sum \beta X_i\right)\right]$$

where G_i is a function of the WTP function. Since given π_i, $WTP_i^0 = 0$, Equation (9) can be simplified as

$$(10)\quad E(WTP_i) = (1-\pi_i)G_i\left[1 - F_i\left(\alpha_Y C - \sum \beta X_i\right)\right].$$

Typically, researchers are interested in both the median and mean measures of the WTP (Hanemann and Kanninen). The median and mean WTP for normal specification of $F(\cdot)$ (a probit model) are

$$(11)\quad WTP_i^{P\text{-Median}} = (1-\pi_i)\frac{\sum \beta X_i}{\alpha_Y}, \quad \text{and}$$

$$(12)\quad WTP_i^{P\text{-Mean}} = (1-\pi_i)\int_0^{\infty}\left[1 - \Phi\left(\alpha_Y C - \sum \beta X_i\right)\right] dC.$$

For the Gumbel specification (a logit model), both median and mean have closed form and the median WTP is the same as in the probit specification:

$$(13)\quad WTP_i^{L\text{-Median}} = (1-\pi_i)\frac{\sum \beta X_i}{\alpha_Y}, \quad \text{and}$$

$$(14)\quad WTP_i^{L\text{-Mean}} = (1-\pi_i)\frac{\ln\left[1 + \exp\left(\sum \beta X_i\right)\right]}{\alpha_Y}.$$

If a spike model is not applied to recognize the possibility of zero WTP for some respondents, π_i will be zero, and Equations (11) through (14) reduce to standard formats under the binary logit and probit models.

Estimation Result

Given the previous discussion, three models are estimated in the paper: First is the conventional binary choice model that does not explicitly account for zero WTP. Variables representing the payment card value and other demographic and attitudinal information are all included in the WTP equation. The second model uses demographic and attitudinal variables to explain the endogenous participation probability while a constant and the payment card value variable are used in the WTP equation. This model is referred to as the spike WTP model. The third model recognizes the correlations between the two steps: whether to pay a positive amount for non-GM oil and if positive, how much the amount should be. Demographic and attitudinal variables are included in both stages to explain this decision process. Identical variables in both stages create natural correlation between the decision processes.[6] This model is thereafter named as spike WTP model with covariates. For each model, both probit and a logit specifications are used for the underlying distribution of WTP. Results of these three models are reported in Table 2 and Table 3 and discussed separately.

[5] Other types of distributions for the WTP function have been used in the literature, such as log-normal or log-logistic (see Hanemann and Kanninen for a review of these studies). These distributions restrict the estimated WTP to be positive. However, due to their significant mass at tails, they tend to overestimate the mean WTP. More importantly, in this study, since zero WTP is modeled, a logarithm cannot be applied (Hackl and Pruckner).

[6] We note that the two steps can be treated as a correlated decision and estimated using a bivariate distribution. This approach may generate more efficient parameter estimates. However, the focus of this study is not on assessing relative efficiencies of parameter estimation under various models, and the assumption of any bivariate distribution may be arbitrary as well.

Table 2. Coefficient Estimates for the Conventional and the Spike Model

	Conventional Model				Spike Model (without Covariates)			
	Probit		Logit		Probit		Logit	
Variable	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
					Participation equation			
SKNOW	0.2307***	0.0837	0.5182***	0.1818	0.6651	0.4627	0.6545	0.5287
EXPERT	−0.0224	0.1000	−0.0573	0.1496	−0.9958***	0.0405	−1.0081***	0.0353
GMPLANT	0.0181	0.1765	−0.0422	0.2653	−1.0476***	0.0754	−1.0396***	0.0675
GMANIML	0.3368*	0.1806	0.7067**	0.3166	0.8489***	0.2100	0.8558***	0.2192
TRUST	−0.0975**	0.0438	−0.1943*	0.0943	−1.5694**	0.7800	−1.5770*	0.8656
OKNOW	−0.0058	0.1139	0.0016	0.2683	−1.0543***	0.0841	−1.0523***	0.0866
IMPPRI	−0.4054***	0.0876	−0.8067***	0.1733	−1.0301***	0.0563	−1.0325***	0.0575
IMPSEED	−0.0959	0.1099	−0.0606	0.2088	−0.1200	0.3077	−0.1435	0.3790
IMPDOM	−0.0281	0.0735	−0.1230	0.1495	−1.0031***	0.0397	−1.0023***	0.0355
SHOPPER	−0.4483***	0.1265	−0.9899***	0.3063	−1.0461***	0.0725	−1.0549***	0.0810
MALE	0.0627	0.0877	0.1569	0.2287	−0.2295	0.5274	−0.2478	0.6189
MARRIED	0.4640***	0.1198	1.1069***	0.3073	1.0888*	0.5690	1.0679*	0.6640
AGE	−0.7161	0.4869	−1.2494	1.0919	−1.1424***	0.2003	−1.1505***	0.2329
EDU	−0.1324	0.1890	−0.1411	0.4294	−1.5889*	0.8128	−1.6187*	0.9474
					Willingness-to-pay equation			
CONSTANT	2.4726***	0.4119	4.3874***	0.8861	1.7477***	0.0501	3.3095	0.1189
PRICE	−0.0524***	0.0036	−0.1002***	0.0065	−0.0483***	0.0035	−0.0906***	0.0055
LL	−510.089		−489.164		−530.25		−509.917	

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

Conventional WTP Model

In Table 2, significant variables and their signs are consistent under the probit and logit specifications.[7] Given by the signs of variables SKNOW (subjective knowledge) and GMANIML (riskiness of GM animal products to human health), respondents who thought they were knowledgeable in terms of GM-related information and/or concerned about human health risk implications from GM ingredients in animal products were more likely to purchase non-GM oil. On the other hand, respondents who trusted the government's food safety regulation system (TRUST) were less likely to purchase non-GM oil. This result is consistent with expectation. The implications on human health from GM food tend to generate serious concerns from Chinese consumers on GM technology (Hu and Chen). However, if consumers trust the government food safety regulation system, then they know that all food, including GM oil, allowed to be sold in the market should pass the "safe-to-eat" criterion set by the government and in this case, there is no special gain of purchasing oil that is labeled as non-GM. Since non-GM oil products are usually associated with price premiums, if consumers are very price conscious, they will not be willing to purchase the higher-priced non-GM oil. Respondents who felt price was an important factor in making vegetable oil purchasing decisions (IMPPRI) were also less likely to pay a higher price for non-GM oil. A direct interpretation is that individuals who viewed price as an important factor were more price conscious, which is probably closely correlated with being more price sensitive.

Other variables indicate that respondents who were major grocery shoppers in their household (SHOPPER) were less likely to purchase non-GM oil; however, married individuals (MARRIED) were more likely to do so. Knowing the impact of demographic characteristics on consumers' purchasing intentions has potential important implications on retail store location or merchandise placement strategies (Hu). For example, given the finding in this analysis, retailers of non-GM oil should focus their selling effort in areas that feature family households rather than college communities or other areas concentrated by large numbers of single residents. In both specifications, the constant term is positive, indicating that holding other factors fixed, respondents were willing to purchase non-GM oil in general. Finally, the more expensive non-GM oil is, the less likely respondents were likely to purchase.

Spike WTP Model

In this model, only a constant term and price entered the WTP equation and all other variables were used to explain participation probability. Despite significant coefficients revealed in both stages, suggested by the log-likelihood function, the two specifications fit worse than their counterparts under the conventional WTP model. Respondents who believed that the decision of whether to introduce GM food into the market should be left only to experts (EXPERT) were less likely to pay anything more for non-GM oil than GM oil. Reflected by variables GMPLANT and GMANIML, respondents who had concerns on human health implications from GM plant products were less likely to pay a premium for non-GM oil, which is consistent with the conventional WTP model. Respondents who were concerned about the health implications from GM animal products were more likely to pay a premium. This result is somewhat surprising, since oil is a plant product and consumers who have concerns on GM oil are expected to be more willing to pay a higher price for non-GM oil. However, given the fact that oil products are actually free of GM protein due to processing (Health Canada), concerns on general GM plants may not be directly linked to purchasing probabilities for non-GM vegetable oil.

As in the conventional WTP model, re-

[7] It is noticeable that the estimated coefficients of the logit specification are systematically greater that those of the probit specification. This is because these two specifications have different normalization structures of the variance term, which directly affects the magnitude of the estimated coefficients (Louviere, Hensher, and Swait).

Table 3. Coefficient Estimates for the Spike Model with Covariates

	Probit		Logit	
Variable	Coefficient	SE	Coefficient	SE
Participation probability				
SKNOW	0.7235***	0.2089	0.5841**	0.2455
EXPERT	−0.4506	0.3701	−0.3355	0.3754
GMPLANT	−1.0920***	0.0668	−1.1137***	0.0711
GMANIMAL	0.7940***	0.1247	0.7834***	0.1225
TRUST	−1.2190***	0.1480	−1.4151***	0.2359
OKNOW	−1.0936***	0.0739	−1.134***	0.0847
IMPPRI	−1.0597***	0.0531	−1.0757***	0.0566
IMPSEED	0.0476	0.0902	−0.0283	0.0988
IMPDOM	−1.0059***	0.0417	−1.0073***	0.0405
SHOPPER	−0.9360***	0.0926	−0.9025***	0.0712
MALE	−0.3574	0.3754	−0.6603	0.4722
MARRIED	1.0905***	0.2726	0.8632**	0.3677
AGE	−1.1588***	0.1077	−1.2329***	0.1389
EDU	−1.4415***	0.3102	−1.7383***	0.4298
WTP equation				
SKNOW	0.2377**	0.0716	0.5387***	0.0911
EXPERT	−0.0227	0.0886	−0.0444	0.1856
GMPLANT	−0.0065	0.2192	−0.1164	0.0893
GMANIMAL	0.3567*	0.1980	0.8384***	0.1253
TRUST	−0.0970**	0.0437	−0.1993**	0.0925
OKNOW	−0.0081	0.0908	0.0232	0.1373
IMPPRI	−0.4035***	0.0827	−0.7830***	0.0931
IMPSEED	−0.1010	0.1236	−0.1159	0.1361
IMPDOM	−0.0217	0.1292	−0.0872	0.1111
SHOPPER	−0.4486***	0.0971	−0.9791***	0.1217
MALE	0.0663	0.0858	0.1874	0.1433
MARRIED	0.4749***	0.0764	1.0263***	0.1742
AGE	−0.7890***	0.1942	−0.9675***	0.0826
EDU	−0.1306	0.1462	−0.0629	0.4301
one	2.4823***	0.3046	4.2048***	0.6229
pcvalue	−0.0523***	0.0036	−0.1000***	0.0069
LL	−510.084		−489.189	

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

spondents who trust the government food safety regulation system were less likely to purchase non-GM oil. The impact of respondents' objective GM knowledge (OKNOW), however, was contradictory to that of respondents' subjective knowledge (SKNOW) found in the conventional WTP model. In both specifications, respondents who were truly knowledgeable (objective knowledge) were less likely to pay a higher price for non-GM oil. This contrast will be discussed in more detail when results of the third model are interpreted.

Respondents who thought price and the fact that the product was produced domestically were important factors for oil products (IMPPRI and IMPDOM) were less likely to pay a higher price for non-GM oil. Data revealed that those who viewed purchasing domestically produced oil as an important factor also were more likely to trust the government food safety regulation

system and thus might not be willing to pay a positive premium for non-GM oil. Impacts of demographic characteristics show that major grocery shoppers of a household, older people, and more educated respondents were less likely to pay a premium for non-GM oil; but married respondents were willing to pay a nonzero premium. The results imply that an obvious marketing plan for non-GM oil is to avoid locations with older and more educated residents. In the WTP equation, the constant term and the price coefficients have the same interpretation as in the first model.

Spike WTP Model with Covariates

Table 3 gives the result of the last model. Except for the constant terms and price, the same variables were included in both stages explaining the participation probability and WTP amount. This model is to capture the correlation between the two implicit decision stages. The probit and logit specifications under this model have almost the same model fit as those under the conventional WTP model. Significance of coefficients in the first stage is slightly different from the spike model without covariates. Coefficients of subjective knowledge (SKNOW) in the two specifications are now significantly positive and coefficients of variable EXPERT are no longer significant. All other significant coefficients are consistent with results in the spike model without covariates specifications and therefore share identical interpretation.

The significant and positive coefficients of SKNOW form a sharp contrast to the effects of OKNOW, which are negative. Hu and Chen pointed out that it is likely that what consumers' think (subjective knowledge) determines their purchase behavior rather than what they actually know (objective knowledge). A further analysis reveals that the absolute magnitude of variable OKNOW is not statistically different from that of SKNOW in the two model specifications. This in turn indicates that subjective knowledge might have played an equally important role as objective knowledge in determining respondents' decisions of whether to pay a positive premium for non-GM oil. It is however interesting to observe that this pattern was broken in the second stage where respondents determined how much premium they can accept for non-GM oil. The absolute magnitude of the coefficient of subjective knowledge is significantly greater than that associated with objective knowledge, suggesting that the effect of subjective knowledge was dominating in this stage of the decision. In general, the finding in this study is consistent with that in Hu and Chen. Any non-GM oil product promotion should pay close attention to the role of consumers' subjective knowledge level, as any strategy that increases the subjective knowledge may likely increase both sales (first stage) and profit (second stage). Interesting marketing strategies may also be created to take advantage of the potential conversion from consumers' objective knowledge to subjective knowledge.

Estimation results from the second decision stage are remarkably consistent with the first stage, as expected. In general, respondents who thought themselves knowledgeable, had concerns on human health implications from GM animal products, and were married were willing to pay more for non-GM oil than other respondents. Respondents who were trustful of the government food safety regulation system, price conscious, grocery shoppers, and who were older would pay less than others. Given these results, it is reasonable to say that respondents were consistent in terms of their decision of whether they wanted to pay a premium for non-GM oil and if they would, how much more they would pay. This also suggests that when the participation stage is ignored from the model, the result will not likely bias the interpretation of the direction of the impacts of various factors in consumers' purchase decision on non-GM oil. The argument for using a spike model resides in its more reasonable treatment of nonparticipation probabilities. The differences between these models can be more clearly compared in terms of their welfare implications.

WTP Measures

Equations (11) through (14) were used to calculate welfare measures based on estimated

Table 4. Estimated WTP Measures (Unit: Yuan)

	Mean	SD	Median	SD
Normal WTP distribution (probit model)				
Conventional	35.83	7.172	35.44	7.486
Spike	34.86	1.460	34.52	1.412
Spike with covariates	35.83	7.105	35.43	7.422
Gumbel WTP distribution (logit model)				
Conventional	36.18	8.309	35.76	8.647
Spike	34.50	1.476	34.13	1.458
Spike with covariates	35.13	8.167	35.72	8.476

coefficients obtained from the three models. Note that variables in vector X_i and probabilities π_i are defined over each individual respondent; therefore welfare measures are different for different individuals depending on their individual-specific factors incorporated in X_i and π_i. The sample enumeration approach was adopted in this analysis in that each respondent's WTP was calculated and the sample average (either mean or median) WTP was obtained from these individual WTP measures. The standard deviation then reflects how much the sampled respondents differed in their estimated WTP measures based on their individual characteristics. WTP measures were calculated for both the probit and logit specifications under each model. A Monte Carlo simulation described in Krinsky and Robb was used to account for variances associated with the estimated coefficients. For each individual, a total of 1,000 simulations were conducted and the results were averaged to obtain that individual's WTP measurement. For the mean WTP given under a probit specification (Equation 12), the integral was approximated by a 10-point Gaussian-quadrature. The mean and median WTP measures under each WTP specification in each model are reported in Table 4.

Overall, WTP measures in all situations are consistent. In general, these results imply that Chinese consumers were willing to pay an additional 4.1 to 6.2 Yuan to non-GM oil on top of the normal price of 30 Yuan/jug they would pay for GM oil. Standard deviations of all the WTP measures were relatively small compared with the sample mean or median, indicating that the sampled respondents were considerably similar in how much they were willing to pay for non-GM oil. There was no clear trend between predictions in the probit or logit specification of the underlying true WTP distribution. In addition, result did not seem to be affected by either calculating the mean or the median of the sampled respondents, as discovered in some other studies (e.g., Hu, Veeman, and Adamowicz). This suggests that the distribution of sampled respondents' WTP was quite symmetric.

In terms of the specific results of the three models, the estimated WTP in the conventional and the spike model with covariates were indistinguishable, however, the estimated WTP measured in the spike model were significantly less than those under the other two models. This manifests that by allowing true zero WTP in the spike model, one may reduce the magnitude of the estimated WTP. However, it is not clear why such a difference was not observed under the spike model with covariates. It is crucial to recognize this difference is for one consumer on average. If the total social welfare is to be calculated, this figure will have to be multiplied by the total number of potential consumers, the result of which may yield considerably different policy implications. Also noticeable is that the variances of WTP measures were significantly smaller in the spike model without covariates than in the other two models. Smaller variances may indicate that this model is able to predict WTPs with greater precision. Recall that the spike model without covariates has the least model fit among the three models. This offers an opportunity to compare models

based on different criteria. If better model fit is the goal of analysis, then the conventional WTP model and the spike model with covariates should be selected. However, if the goal is to achieve the most precise WTP measures, the spike model without covariates should be chosen because it also offers a reasonable treatment of responses that fall below the lowest payment card value.

Conclusion and Extensions

This paper examines Chinese consumers' preferences and WTP for non-GM vegetable oil. In addition to the conventional model, two spike models were adopted in order to capture the possibility that consumers may or may not truly wish to pay zero for non-GM oil when they do not want to pay for the minimum premium specified in the survey. In the spike models, two decision stages can be specified: first consumers decide whether they wish to pay nonzero amount and if they do, they decide how much they would be willing to pay. True WTP distribution was assumed to follow either a normal or a Gumbel distribution to account for the possibility that the estimated WTP was dependent on the distribution assumed. Results show that in addition to price, Chinese consumers' purchasing intentions for non-GM oil could be affected by both attitudinal and demographic factors. The three models generated consistent results. It is noteworthy that the combined effects of some variables may not necessarily be the same across the two decision stages, such as the relative importance of consumers' subjective and objective knowledge about GM technology.

In terms of predictions of Chinese consumers' willingness to pay for non-GM oil, although probit and logit WTP equation specifications yielded very similar WTP measures and these measures did not change according to whether the mean or the median of the sampled consumers WTP was maintained, results from the three models did show some differences. The average consumer's WTP for non-GM oil is around 4 to 6 Chinese Yuan. The spike model without the covariate structure predicted the least WTP measures as the theory suggests. Although standard deviations among sampled consumers' WTP measures were all relatively small to the mean/median WTP, measures from the spike model (without covariates) had the least variation among sampled consumers. On the other hand, results from the conventional and the spike model with covariates were quite similar.

There are possible extensions from this study. Haab suggested that the correlation between two stages of WTP could be modeled through a bivariate decision process. The dependence is then reflected by a parameter of correlation. This procedure shares a great similarity with demand analysis with sample selection bias. It may also be interesting to understand different behavioral reasons that constitute zero WTP. Are respondents indifferent to the product in questions, uncertain, or protesting? How to efficiently model and test for these various behavioral assumptions remains to be a challenging but interesting future research area. Such an analysis may benefit significantly from intensive follow-up questions in the survey.

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Appendix 1. Sample WTP Questions

Sample WTP Questions

Suppose you are shopping for vegetable oil in a grocery store. You found that there are only two brands of canola oil being sold: A 5-L jug of Brand A contains genetically modified ingredients, and a 5-L jug of Brand B does not.

Suppose these two brands have exactly the same flavor and nutritional values. The price of Brand A is 30 Yuan per jug. Due to the higher costs involved in producing and marketing oil with non-GM ingredients, price of Brand B may be higher than Brand A. Consider your situation, to the maximum, how much **MORE** would you be willing to pay for Brand B? Please pick one value in the following list (by a mark "X") that is the closest to the value you have in mind.

____ 0 Yuan	____ 1 Yuan	____ 2 Yuan	____ 3 Yuan
____ 4 Yuan	____ 5 Yuan	____ 6 Yuan	____ 7 Yuan
____ 8 Yuan	____ 9 Yuan	____ 10 Yuan	____ 11 Yuan
____ 12 Yuan	____ 13 Yuan	____ 14 Yuan	____ 15 Yuan
____ 16 Yuan	____ 17 Yuan	____ 18 Yuan	____ 19 Yuan
____ 20 Yuan	____ 21 Yuan	____ 22 Yuan	____ 23 Yuan
____ 24 Yuan	____ 25 Yuan	____ 26 Yuan	____ 27 Yuan
____ 28 Yuan	____ 29 Yuan	____ 30 Yuan	____ 31 Yuan
____ 32 Yuan	____ 33 Yuan	____ 34 Yuan	____ 35 Yuan
____ 36 Yuan	____ 37 Yuan	____ 38 Yuan	____ 39 Yuan

If the maximum price you are willing to pay for Brand B on top of the price of Brand A is higher than 39 Yuan, what would be the amount you are willing to pay? (Please indicate below)

_____ Yuan