Consumers' Willingness to Pay for Biotech Foods in China

William Lin, Agapi Somwaru, Francis Tuan
Economic Research Service
U.S. Department of Agriculture
Washington, D.C.
email:wwlin@ers.usda.gov
asomwaru@ers.usda.gov
ftuan@ers.usda.gov

and

Jikun Huang and Junfei Bai
Center for Chinese Agricultural Policy
Chinese Academy of Sciences
Beijing, China
email:jkhuang.ccap@igsnrr.ac.cn
junfei_bai@wsu.edu

Washington, D.C.
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Abstract

Based on a large-scale consumer survey, this study employs a semi-double-bounded dichotomous choice model to estimate the mean willingness to pay (WTP) for biotech foods in China. The study also accounts for the effects of respondents' characteristics on the probability of purchasing biotech foods and WTP. Analyses focus on biotech soybean oil and insect-resistant biotech rice.

Keywords: Biotech foods, willingness to pay, China, contingent valuation method, semi-double-bounded dichotomous choice model

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Introduction

In March 2002, China introduced new regulations that require labeling of all foods containing biotech ingredients. The regulations require costly testing and documentation of the safety of all biotech food ingredients. Uncertainty regarding the implementation of the regulations disrupted soybean imports for several months during 2002 and could affect corn and other commodities. China has also announced a strategy of positioning itself as an exporter of non-biotech agricultural commodities.

Do China's labeling regulations reflect the preferences of Chinese consumers? Will exporters of biotech products have difficulties selling in the China market? Do Chinese consumers value non-biotech foods enough to justify the higher cost of identity-preserved marketing? The answers to these questions have important implications for world agricultural trade, and depend largely on the evolution of Chinese consumer attitudes toward biotech foods and their willingness to pay (WTP) for non-biotech foods relative to the cost of identity preservation.[1]

There have been an increasing number of studies on consumer attitudes toward biotech foods in China (Environics International; Li *et al*.; Zhong *et al*.; and Lin *et al*.; Hu and Chen; Ho and Vermeer). Information obtained from these previous surveys suggested that the majority of Chinese consumers have favorable or neutral opinions about the use of biotechnology in crop production, livestock and poultry products fed with biotech feed grains, and the use of biotech

[1] For purposes of this study, WTP refers to price discounts (relative to non-biotech foods) that consumers are willing to accept for purchasing biotech foods, or price premiums (relative to biotech foods) that consumers are willing to pay for non-biotech foods.

ingredients in processed food production. Based on a large-scale consumer survey in 11 urban cities, for example, Lin *et al*. found that 46-67 percent of all respondents in China were supportive of biotech foods, depending on the kind of foods. In contrast, 5-15 percent of urban consumers were opposed to biotech foods. However, there are only few studies available that address consumers' WTP for non-biotech and biotech foods in China (Li *et al*.). Surveys for these studies are small-scale and tend to be city-specific (such as in Beijing). The support for biotech foods (in terms of consumer willingness to pay premiums) in some studies came about because they were asked about foods with *product-enhancing* traits (such as health or nutrition benefits) that are seen as beneficial to consumers.[2] Even though there have been an increasing number of studies that address consumers' WTP for non-biotech foods in Japan, Norway, Taiwan and the United States (Chern and Rickertsen; Kaneko and Chern; Chiang), it is not certain that results of WTP obtained from these countries are applicable to consumers' WTP for non-biotech foods in China.

The main purposes of this paper are: 1) to understand consumers' WTP for biotech foods in China, 2) to use the contingent valuation method (e.g., Kanninen, 1993; Li *et al.*, 2003; Chern and Rickertsen, 2002) to estimate mean WTP for non-biotech soybean oil and rice based on a large-scale survey in 11 Chinese urban cities, and 3) to estimate the effects of price discount offers and the respondents' characteristics (including demographic and socio-economic variables and awareness of biotech foods) on the probability of purchasing biotech foods and the latter's effects on WTP.

[2] Most biotech crops in the marketplace, including soybeans, corn, and cotton have *process-enhancing* traits (such as tolerance to herbicides and resistance to insects) which have no direct benefit to consumers.

A survey of 1,100 consumers in 11 small-to-large cities (including Beijing and Shanghai) along China's eastern coast was conducted by the Chinese National Bureau of Statistics through personal interviews in fall 2002. The samples were first stratified by demographic and socio-economic characteristics at the city level and then randomly selected within each of the sampled cities. Altogether, the survey resulted in 1,005 usable responses, of which 669 respondents indicated that they had heard about biotech foods (Bai). In general, the survey respondents are representative of the Chinese urban population in terms of demographic and socio-economic variables. The survey covers 8 kinds of biotech foods--1) insect-resistant fruits or vegetables, 2) delayed-ripening fruits or vegetables, 3) soybean oil made from herbicide-tolerant soybeans, 4) tofu made from herbicide-tolerant soybeans, 5) noodles made from insect-resistant wheat, 6) insect-resistant biotech rice, 7) neutraceutical biotech rice, and 8) livestock products fed with biotech corn. Analyses in this paper focus on soybean oil made from imported biotech soybeans and insect-resistant biotech rice.

Previous Related Studies

Information obtained from previous surveys suggested that Chinese consumers were willing to pay premiums for *product-enhancing* (or *output-trait*) biotech foods. In addition, consumers in some Asian countries were willing to pay premiums for avoiding the purchase of biotech foods (and hence purchasing non-biotech foods) made from *process-enhancing* (or *input-trait*) ingredients. This section briefly reviews previous related studies, focusing on surveys or studies that were conducted in China or other countries in Asia.

Using survey data collected from in-person interviews with 400 consumers at the Seikyou consumer cooperative in Matsumoto, Japan during June 2001, McCluskey *et al*. reported that

these customers were willing to purchase noodles made from biotech wheat with a 60-percent price discount and tofu made from biotech soybeans with a 62-percent price discount. Of the 400 respondents, only 16 indicated that they would be willing to purchase tofu made from biotech soybeans without a discount and only 12 said the same in the case of noodles made from biotech wheat. Only 15 percent of the respondents stated that they would purchase the biotech tofu with randomly assigned discount offers and 17 percent for biotech noodles. The remaining great majority of the respondents chose not to purchase biotech products even with price discounts. Consumer WTPs for biotech foods are estimated by the contingent valuation method, using the semi-double-bounded dichotomous choice model. Factors that contributed negatively to consumers' willingness to purchase biotech foods include: knowledge about biotech foods, views on the importance of biotech food labeling, family size, and views on the importance of food safety. In contrast, favorable attitudes toward the use of biotechnology and a higher price discount increase the likelihood of purchasing biotech foods.

A recent study of consumers' WTP for biotech rice and biotech soybean oil in Beijing, China was reported by Li *et al*. based on the contingent valuation method. This study uses data collected from 599 in-person interviews in August 2002 and the double-bounded dichotomous choice model to estimate the mean WTP. Consumers in Beijing were found to be willing to pay a premium of 38 percent for purchasing *product-enhancing* biotech rice over non-biotech rice, and a 16.3-percent premium for *product-enhancing* or *process-enhancing* biotech soybean oil. It is unclear how respondents in this survey had interpreted the genetic trait with the latter product and whether consistency in their interpretations had been maintained. In addition, this study does not address consumers' WTP for *input-trait* biotech rice. Favorable opinion about biotechnology contributed positively to the purchase of these biotech products and in the case of

biotech soybean oil, consumer knowledge of biotech foods also was a positive contributing factor. Higher price premiums or lower price discounts for biotech foods contributed positively to the likelihood of purchasing these biotech products. In the case of biotech rice, higher age reduced consumers' willingness to purchase this biotech product. Education, income, and children in the household were found to be not statistically significant factors.

Using student survey data that were taken during December 2000 to March 2001, Chern and Rickertsen conducted a study of willingness to pay premiums for non-biotech foods in four countries, with sample size in parentheses: Japan (103), Taiwan (213), Norway (126), and the United States (175). Based on the contingent valuation method, WTP of non-biotech vegetable oil were estimated at: 1) 33-40 percent for Japan, 2) 17-21 percent for Taiwan, 3) 55-69 percent for Norway, and 4) 50-62 percent for the United States. The mean WTP is measured as a range because the base price for biotech foods was varied in the design of offered prices in the survey. In Norway, age level, female gender and income contributed positively to WTP (in percent non-biotech premium) to avoid biotech alternatives, including soybean oil, biotech-fed salmon, and biotech salmon. In contrast, the more education the less price reductions for biotech foods are needed to induce the respondents' willingness to purchase biotech foods.

In February 2003, Chiang conducted a telephone survey of 1,013 consumers in Taiwan to estimate consumers' willingness to pay premiums to avoid biotech alternatives, including soybean oil, tofu, and salmon. Based on the contingent valuation method, a logit model was estimated through the maximum-likelihood approach. Results suggested that consumers in Taiwan were willing to pay a 21.19-percent price premium for purchasing non-biotech soybean oil, 37.42 percent premium for non-biotech tofu, and 108.4 percent premium for non-biotech-fed

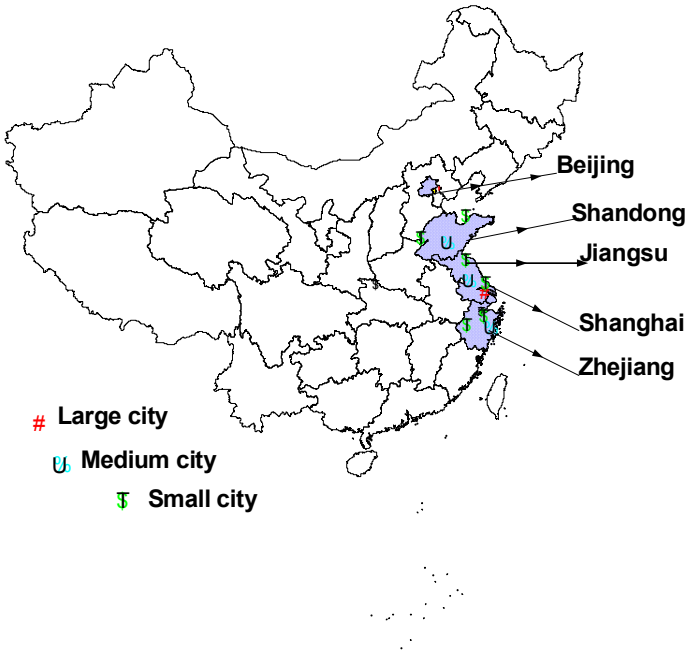
salmon. The range of price discounts that were randomly chosen in the second bid (for consumers who responded "no" to the first bid when the prices for biotech and non-biotech food products are the same) include: 5%, 10%, 20%, 30%, and 50%.

The Consumer Attitudes Survey

In fall 2002, a sample of 1,100 urban consumers was selected by using a combination of stratified and random samplings. First, all samples were taken from five provinces or municipalities along China's eastern coast--Beijing, Shandong, Jiangsu, Zhejiang, and Shanghai--where income, education, awareness of biotechnology, and population density are higher than in interior areas (fig.1). Consumer attitudes toward biotech foods in these five provinces can serve as an indicator of future trends in China's consumer preferences. Second, samples were stratified according to the size of the cities selected from each province. Large cities include Beijing and Shanghai, while medium cities include Jinan, Nanjing, and Ningbo. Small cities cover Dezhou, Weihai, Yancheng, Nantong, Shaoxing, and Jinhua. Third, survey samples in each city within an age limit (from 16 to 80) were randomly selected—55 for small cities, 110 for medium cities, and 220 for large cities (Bai).

The questionnaire for this large-scale survey was revised several times by analysts of the CCAP-CAS in Beijing, and the Economic Research Service. The questionnaire was also pre-tested. The survey was jointly conducted by the CCAP-CAS and China's National Bureau of Statistics through personal interviews at household sites. The questionnaire covers household demographic and socio-economic characteristics and the degree of awareness of, and attitudes toward, biotech foods. Respondents were asked about biotech products that are currently available in the market, including soybean oil made from imported biotech soybeans, delayed

Figure 1. The distribution of survey samples across five provinces or municipalities in China



ripening fruits or vegetables, and insect- or disease-resistant fruits or vegetables. The questionnaire characterizes others as potential biotech food products that could be introduced in the future.

Major socio-economic indicators for the 1,005 usable responses (including those who have never heard of biotech foods), shown in table 1, suggest that the respondents are generally representative of the entire population in the selected cities (Bai).[3] The sample is not representative of the entire Chinese population since it excludes the rural population (over 60%) and cities of central and western China, where income and education are lower and information is less abundant. Thus, our sample's awareness of biotechnology is likely to be higher than in

[3] Data used to verify that the sample is representative came from the 2003 China Statistical Yearbook and CCAP survey.

Table 1. Summary statistics for demographic and perception variables

Variable	Mean	Standard deviation	Minimum	Maximum
Gender	0.41	0.49	0 (female)	1 (male)
Age	46.55	12.47	16	80
Education (yrs)	11.08	2.94	1	18
Household size	2.98	0.76	1	7
Monthly per capita disposable income (rmb)	844.19	416.12	100	3003
Residing city: (%)				
Small city	30.3	0.46	0	1
Medium city	29.9	0.46	0	1
Large city	39.8	0.49	0	1
Occupation: (%)				
Government	3.18	0.42	0	1
State enterprises	19.10	0.42	0	1
Commercial	26.57	0.44	0	1
Unemployed	8.46	0.28	0	1
Retired &others	25.77	0.28	0	1
Role of food shopping: (%)				
Major decisionmaker	57.51	0.49	0	1
Co-decisionmaker	15.22	0.36	0	1
Little or no role	27.26	n.a.	0	1
Awareness of biotech foods: (%)				
Never heard of	33.4	0.46	0	1
Heard of (<3 yrs)	42.5	0.49	0	1
Heard of (>3 yrs)	24.1	0.43	0	1
Never heard of	33.4	n.a.	0	1
Occasionally	43.7	n.a.	0	1
Frequently	22.9	n.a.	0	1
Health condition: (%)				
Better than average	38.1	0.49	0	1
About the average	47.3	0.50	0	1
Worse than average	7.2	0.26	0	1

these excluded regions. However, a focus on coastal cities is appropriate since this population is the target market for most food exporters.

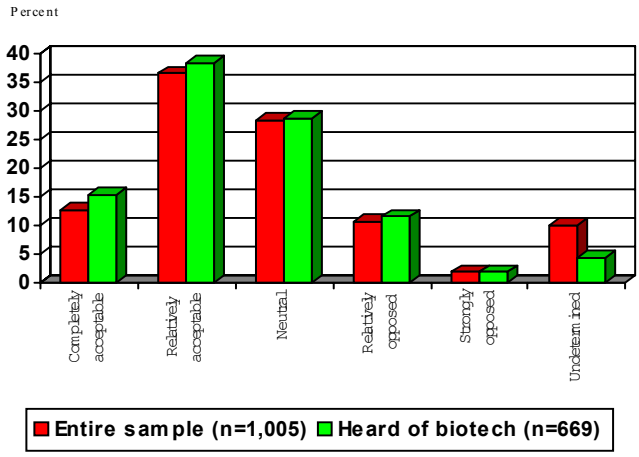
Awareness of Biotech Foods

The survey found that about two-thirds of respondents had heard of biotech foods, about 10 percentage points lower than the level of awareness about biotechnology reported for the United States (International Food Information Council). Consumers who had never heard of biotech foods and those who had only heard of it on an *occasional* basis, together accounted for 77 percent of all respondents. Only about 23 percent of respondents indicated that they had *frequently* heard of biotech foods. Of the respondents who indicated that they had heard of biotech foods, lengths of time of awareness averaged 2.65 years.

Biotech Food Acceptance

A majority of respondents were supportive of biotech foods, that is, they found biotech foods to be strongly or relatively acceptable. This pro-biotech group of consumers accounted for 46-67 percent of all respondents, depending on the kind of biotech foods. In contrast, 5-15 percent of respondents were strongly or relatively opposed to biotech foods. About a third of the consumers had either a neutral opinion or simply could not specify their attitudes toward biotech foods. Figure 2 shows the pattern of consumer attitudes toward biotech soybean oil in China, which is generally applicable to other biotech foods (Bai). Limiting survey samples to those who have heard of biotech foods significantly lowered the percent undetermined, which was then translated into more support for biotech foods. Relative to those who have never heard of biotech foods, survey data suggest that consumers who have heard of biotech foods tend to be

Figure 2. Consumer attitudes toward biotech soybean oil in China

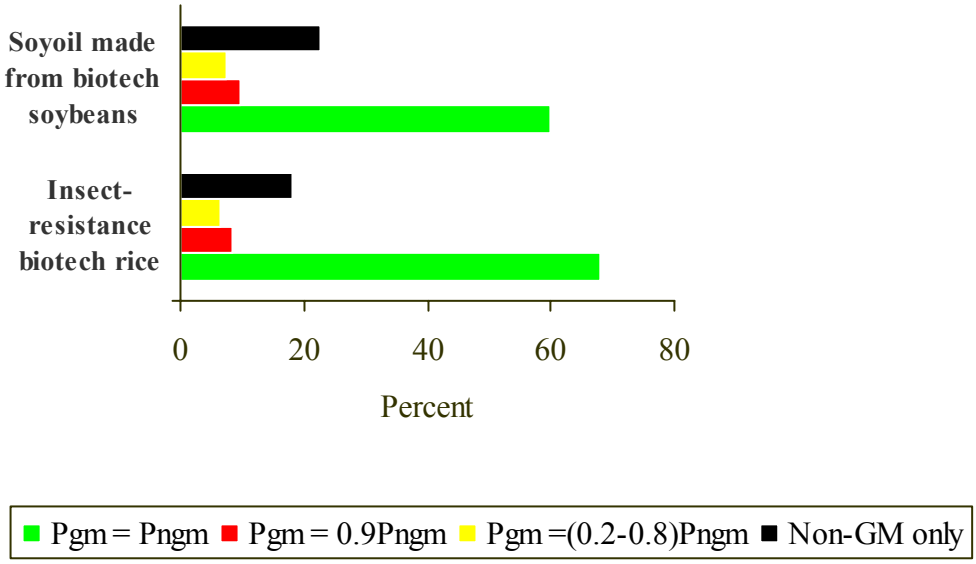


slightly more supportive of biotech foods.

The above consumer attitudes toward biotech foods were expressed without any regard for the price differential between biotech and non-biotech foods. The majority of respondents–58.3 to 74.1 percent–were willing to purchase biotech foods if their price was the same as that for non-biotech foods (that is, Pgm = Pngm), depending on the kind of foods. The range was narrowed to 60.0-67.9 percent for soybean oil and rice (fig. 3).[4] An even greater majority–67.0 to 80.9 percent–were willing to purchase biotech foods if a 10-percent price discount (that is, Pgm = 0.9 Pngm) was offered to them. In the case of output-enhancing biotech rice, about 6 to10 percent more consumers were willing to purchase neutraceutical biotech rice than input-trait biotech rice, depending on the price differential. In contrast, a smaller percentage was willing to purchase livestock products fed by biotech feeds. A small but significant minority–about 20 percent–of

[4] There are similarities between this finding and those in Li *et al*., which found that 73-80 percent of the respondents were willing to purchase biotech foods at the same price as the non-biotech foods. Also, 14.0-16.7 percent of the respondents were not willing to purchase biotech foods even with price discounts.

Figure 3. Chinese consumers' price discount needed to purchase biotech soyoil and rice



urban consumers were not willing to purchase biotech foods at any price. In the cases of biotech soybean oil and input-trait rice, the percentages were 22.7 and 18.0, respectively (fig. 3).

Table 2 shows the profile of survey respondents in the case of biotech soybean oil between the two subgroups: 1) respondents who were indifferent between biotech and non-biotech foods--they were willing to accept biotech soybean oil without any price discounts, and 2) respondents who purchased only non-biotech soybean oil and felt strongly that biotech and non-biotech products were not substitutable. Respondents in the second group tended to have more females, higher income, more information access from non-newspaper outlets, and use only non-soybean oil for household cooking.

Table 2. Profile of survey respondents: biotech soybean oil

Variable	Consumers with Pgm = Pngm	Consumers who accept non-GM only
Gender	0.426	0.389
Age	46.4	48.7
Edu	11.03	10.99
City	1.94	1.90
Yinc	9,645	10,763
Newsfood	40.8	31.9
Awareness	1.75	1.78
No-soyoil	9.95	25.0

Gender: female--0; male--1
Age : reported number of years
Edu : number of years receiving education
City : size of residing city (large=1; midsize=2; small=3)
Yinc : annual per capita disposable income (rmb)
Newsfood: media access through newspapers (%)
Awareness: Number of years that consumers, on average, have heard of biotech foods
No-soyoil : consumers who do not consume soybean oil (%)

Contingent Valuation Method

Contingent valuation method (CVM) is an analytical tool commonly used to elicit the public's WTP (in terms additional taxes) to protect nonmarketed resources, such as recreation, wildlife, and environmental quality (e.g., Hanemann, Loomis, and Kanninen). In recent years, CVM has been used to elicit consumers' WTP for non-biotech foods as some consumers have avoided the consumption of foods made from biotech ingredients. This section highlights the essence of the semi-double-bounded dichotomous choice model (McCluskey *et al*., 2001), which was used to implement the CVM in this study. Then, mean values of WTP are derived from the dichotomous choice model. Finally, marginal effects on WTP of demographic and socio-economic variables, as well as consumers' awareness of biotech foods, are discussed.

The Semi-Double-Bounded Dichotomous Choice Model

Hanemann, Loomis and Kanninen demonstrated that the double-bounded CVM approach can improve the statistical efficiency of dichotomous choice CVM. The survey questionnaire in this study was carefully designed to elicit consumers' bid prices through successive bids, starting with an initial bid where prices of biotech and non-biotech foods are assumed to be identical.[5] If consumers were willing to purchase biotech foods at no price discount, they would respond to the first bid by saying "yes". Otherwise, except in the case of neutraceutical biotech rice, they were asked if they would purchase biotech foods if a random price discount is offered to them. A set of price discounts was distributed randomly across respondents in the survey, which permits us to place both an upper and a lower bound on the respondent's unknown true WTP (Hanemann *et al*., 1991). The random price discounts are inclusive of all the possible values, including 10%, 20%, 30%, 40%, 60%, and 80%, which were selected on the basis of *a priori* information about the distribution of WTP from the survey. Finally, the survey questionnaire captures consumers who would accept only non-biotech foods regardless of price discounts.

This dichotomous choice model can be interpreted as a response consistent with maximizing a random utility model, which implies that:

$$\Pr\{\text{Yes to BID}\} \leftrightarrow \Pr\{\text{WTP} \leq \text{BID}\}$$

$$\Pr\{\text{No to BID}\} \leftrightarrow \Pr\{\text{WTP} > \text{BID}\}$$

where BID is the bid price (in percent price discount) offered to the respondent for purchasing biotech foods, and WTP is the respondent's minimum acceptable price discount for purchasing

[5] To mitigate initial bid bias, an optimal design of CVM's bidding process is to set the initial bid closer to mean WTP (Hanemann *et al*.). Since about two-thirds of the respondents indicated that they were willing to purchase biotech foods without a price discount, an initial bid of no price differential is assumed.

biotech foods. Both WTP and BID are expressed in terms of absolute values here and throughout the paper.

There are three discrete outcomes of the bidding process that are observable: 1) a "yes" to the initial bid (B_0)—WTP is equal or less than the initial bid, that is, no price discount, or $WTP \leq B_0 = 0$; 2) a "no" followed by a "yes" in the second bid—WTP lies between the initial bid and a random price discount in the second bid, that is, $0<WTP<BID$; and 3) "no" to both bids—WTP is greater than the random price discount in the second bid, that is, $WTP>BID$. Respondents who are indifferent between biotech and non-biotech foods fall into the first group. In other words, biotech and non-biotech foods are perfectly substitutable to these respondents. In the second group, respondents would accept biotech foods only if price discounts offered to them in the second bid exceed their minimum acceptable price discounts. Respondents in the third group are non-biotech consumers who would accept only non-biotech foods regardless of any price discounts given to biotech foods. In other words, these consumers regard biotech and non-biotech foods as not at all substitutable.

The qualitative dependent variable is expressed in terms of the probability of purchasing biotech foods to a bid amount. This model takes the form:

$$Pr\{WTP \leq BID\} = \Phi(\alpha - \rho BID + \lambda' Z)$$

where *WTP*: the minimum acceptable price discount (in percent terms) for biotech foods
BID : the bid price (in percent discount) offered to biotech foods,
Z : a set of observable characteristics for consumers,
Φ : a cumulative normal or logistic distribution function, and
α, ρ and λ : unknown parameters

The probabilities of purchasing biotech foods for respondents that fall into the above three discrete outcome groups are as follow:

1) the "yes" group in the initial bid, $Pr\{WTP \leq BID\} = \Phi(\alpha - \rho B_0 + \lambda' Z)$,

2) the "no" and "yes" group, $Pr\{B_0 < WTP \leq BID\} = \Phi(\alpha - \rho BID + \lambda' Z) - \Phi(\alpha - \rho B_0 + \lambda' Z)$, and

3) the "no" and "no" group, $Pr\{WTP > BID\} = 1 - \Phi(\alpha - \rho BID + \lambda' Z)$

The parameters are estimated using maximum likelihood method, which yields the choice probabilities by maximizing the log-likelihood function for the three discrete outcomes (Hanemann, Loomis and Kanninen; Qaim and De Janvry; McCluskey, Quchi, Grimsrud and Wahl).

Mean WTP

There are two alternative ways to compute the mean value of WTP. First, the mean WTP is estimated as the ratio of α / ρ by restricting the coefficients for all variables except the random bid to be zero in estimating the parameters (e.g., Hanemann *et al*., 1991; Li *et al*., 2003). Alternatively, the mean WTP can be computed as the ratio of $(\alpha + \lambda' Z)/ \rho$ (Qaim and De Janvry; Chern and Rickertsen; and Chiang). The latter approach is employed in this study in part because it accounts for the possibility that the respondents' characteristics can exert effects on the mean WTP.

As indicated earlier, consumers' decisions on whether or not to purchase biotech foods are modeled in a random utility framework. A consumer is willing to purchase the biotech food (alternative 1) when the utility of the purchase is at least as great as the purchase of non-biotech food (alternative 0), that is, if

$$U(1, P_0 - WTP; Z) \geq U(0, P_0; Z)$$

where 1 indicates the biotech food and 0 the conventional non-biotech alternative, P_0 is the consumer price of the non-biotech food, *WTP* is the minimum acceptable price discount for purchasing the biotech food, and Z are a set of observable characteristics of the consumer. In other words, a linear random utility model takes the form:

$$V_i = \alpha_i + \rho P_i + \lambda' Z + \varepsilon_i$$

where V_i is the deterministic part of the utility for alternative i and ε_i is the error term for the i_{th} alternative. Following the procedure by Chern and Rickertsen, the consumer is indifferent between purchasing biotech and non-biotech foods if:

$$\rho P_0 + \varepsilon_0 = \alpha_1 + \rho(P_0 - WTP) + \lambda' Z + \varepsilon_1$$

Assuming that $E(\varepsilon_0) = E(\varepsilon_1) = 0$, the mean WTP for the consumer to purchase the biotech food is:

$$E(WTP) = 1/\rho * (\alpha_1 + \lambda' Z)$$

Marginal Effects on WTP

The marginal effect of the Z variables on WTP in dollar terms can be calculated by taking the partial derivative of the above equation with respect to a per-unit change in the Z variables. That is,

$$\partial (WTP) / \partial Z_k = \lambda_k / \rho$$

In the context of the dichotomous choice model specified in this study, a variable that has a coefficient with a negative sign means that given the WTP being a negative number, a per-unit increase in the k_{th} variable would raise the minimum acceptable price discount for the biotech food. In other words, an increase in the k_{th} variable would lead to the consumer's willingness to

pay a higher premium for the non-biotech food. In contrast, a positive coefficient would indicate that a per-unit increase in the k_{th} variable would lower the minimum acceptable price discount for the biotech foods. That is, an increase in the k_{th} variable would lead to the consumer's willingness to pay a lower premium for the non-biotech food.

Estimated Model Results

In this study, the dichotomous choice model is estimated for consumers' willingness to purchase soybean oil made from herbicide-tolerant biotech soybeans and insect-resistant biotech rice in China:

$$\Pr \{WTP \leq BID\} = \Phi (\alpha - \rho BID + \lambda' Z)$$

Definitions and measurement units for explanatory variables, BID and a vector Z, are presented in table 3. BIDOIL and BIDRICE, both are negative numbers relative to the prices of non-biotech foods, are entered as raw input in absolute values for model estimation. Tables 4 and 5 show the estimated model results.

Price discounts offered to the respondent for purchasing biotech foods, BIDSOYOIL and BIDRICE, have expected negative sign and are highly statistically significant. Given these bid prices being negative numbers, a coefficient with a negative sign means that as price discounts offered to respondents for purchasing biotech foods increase, the respondents would be more willing to purchase biotech soybean oil and biotech rice. Alternatively, it means that consumers would be willing to pay higher premiums for purchasing non-biotech foods. Among respondents' demographic variables, gender is statistically significant in the case of soybean oil, but is not significant for biotech rice. Relative to females, male consumers were more willing to

Table 3. Definitions and measurement units of the explanatory variables

Variable	Definition and unit
BIDOIL	Ultimate bid prices (in percent discounts) offered for biotech soyoil
BIDRICE	Ultimate bid prices (in percent discounts) offered for biotech rice
GENDER	1=male 0=female
INCOME	Per capita annual disposable income (1,000 rmb)
UNEMPL	1=unemployed
SMALLCITY	1=residing in a small city
AWARENESS	1=have heard of biotech foods
BELINF	1=have trust in the accuracy of media information
NO-SOYOIL	1=not consuming soybean oil in the household

Table 4. Estimated dichotomous choice model results for biotech soyoil in China (sample size=1,005)

Variable	Coefficient	Standard error
Intercept	1.586	0.182***
BIDOIL	-2.711	0.154***
SMALLCITY	0.234	0.126*
UNEMPLOYMENT	0.373	0.217*
BELINF	0.157	0.112
AWARENESS	-0.106	0.107
INCOME	-0.029	0.011***
GENDER	0.193	0.108*
NO-SOYOIL	-0.631	0.145***

*,**,*** Statistically significant at 10%, 5%, and 1% level, respectively.

purchase biotech soybean oil in China's urban cities. Age and education are not statistically significant in the purchase of these products.

Residents of small cities and the unemployed were more willing to purchase biotech soybean oil and biotech rice in China' urban cities than those living in larger cities and the employed. This finding is consistent with what was found in an earlier study of consumer attitudes toward biotech foods in China (Lin *et al*.). In contrast, consumers with a higher annual disposable

Table 5. Estimated dichotomous choice model results for biotech rice in China (sample size=1,005)

Variable	Coefficient	Standard error
Intercept	1.507	0.172***
BIDRICE	-1.846	0.142***
SMALLCITY	0.269	0.121**
UNEMPLOYMENT	0.436	0.219**
BELINF	0.091	0.105
AWARENESS	-0.166	0.100*
INCOME	-0.027	0.010***
GENDER	0.121	0.102*

*,**,*** Statistically significant at 10%, 5%, and 1% level, respectively.

income were less willing to purchase these biotech foods, again consistent with previous findings.

Respondents who have heard of biotech foods are less inclined to purchase biotech rice than those who have no or little awareness. However, the impact of the awareness variable is not statistically significant in the case of biotech soybean oil. In our previous study of consumer attitude towards biotech foods, we found that consumers who have heard of biotech foods for more than three years show no difference in attitude from those who have never heard of biotech foods.

Mean WTP

According to the formula in the methodology section, mean WTP–average price premiums (in percent terms) that respondents are willing to pay for non-biotech foods relative to biotech foods–are computed for biotech soybean oil and biotech rice based on mean values of the Z

variables that reflect respondents' demographic and socio-economic variables, and their awareness of biotech foods.

Mean values of WTP are calculated to lie in the range from 23.4 percent to 52.6 percent in the case of soybean oil, depending on whether all 1005 responses are included in the estimation of the dichotomous choice model. Based on the entire sample, mean WTP is calculated at 52.6 percent. However, this mean WTP must be regarded as an upper bound. First, due to the *hypothetical* nature of the survey data, mean WTP elicited from the CVM reflects merely what is *stated* by the respondent, which is often larger than what is *revealed* in the marketplace (Lusk). Second, mean WTP would likely be overstated because the feasible upper range for true WTP is 100 percent rather than positive infinity for the "no" and "no" group in both the first and second bids. The CVM bidding process begins with a zero price discount being offered to the biotech food in this study, which sets the lower bound of true WTP from below at zero instead of negative infinity. However, a lack of similar restriction on the upper bound does not rule out the possibility that WTP could go beyond 100-percent for this group. The overstatement of WTP would be particularly pronounced for respondents to whom a random price discount of 80 was offered in the bidding process. An alternative is to leave out the "no" and "no" group if their bid prices were 80 percent, which lowers mean WTP for soybean oil to 23.4 percent.

By the same token, mean values of WTP in terms of average price premiums for non-biotech rice are estimated to lie in the range from 41.5 percent to 74.0 percent—the former leaves out the "no" and "no" group with bid prices offered for the biotech food being at 80 percent in the model estimation, while the latter includes the entire sample. Urban respondents apparently had the perception that they would be willing to pay higher price premiums for non-biotech rice to avoid

the consumption of biotech rice, if commercialized, because rice is a food grain. In contrast, soybean oil is a food product after crushing, which destroys much of the DNA sequence and thus even if biotech content is present in the product, the genetic material is not detectable using the lateral strip test--a qualitative test kit used in China for complying with biotech labeling regulations.

Mean WTP would be lowered if respondents with higher randomly offered bid prices were successively excluded from the sample in the estimation of model parameters. For example, if the sample is limited to the sub-sample with bid price of under 20 percent, mean WTP would be lowered to only 10.0 percent in the case of biotech soybean oil (table 6). Similarly, mean WTP would be lowered to 11.5 percent for this same sub-sample for biotech rice.

Marginal Effects

Two types of marginal effects of the respondents' characteristics and other regressors in the dichotomous choice model are discussed in this subsection: 1) marginal effects on the likelihood of purchasing biotech foods, and 2) marginal effects on mean WTP. The two types of marginal effects are actually interrelated as the marginal effect of one is a mirror image of the other.

Table 7 shows marginal effects of the explanatory variables on the probability of purchasing biotech foods in China. The marginal effects are the impacts of a per-unit change in each of the explanatory variables on the probability of purchasing biotech foods to a bid amount at mean values of the dependent and explanatory variables. These marginal effects are estimated from the difference in the predicted probability of purchasing biotech foods between two scenarios: 1) including the effects from all explanatory variables, and 2) including all explanatory

Table 6. Mean WTP for base scenario and various sub-samples by excluding respondents with higher bid prices

Item	Soybean oil	Biotech rice
Base scenario	23.4-52.6	41.5-74.0
Sub-sample with bid price (%)─		
Under 60	16.6	28.7
Under 40	16.5	22.3
Under 30	12.9	16.3
Under 20	10.0	11.5

Table 7. Marginal effects--Change in the probability of accepting biotech foods associated with explanatory variables

Explanatory variable	Biotech soybean oil	Input-trait biotech rice
BIDOIL or BIDRICE	-0.1165***	-0.0767***
SMALLCITY	0.0205*	0.0211**
UNEMPLOYMENT	0.0090*	0.0093**
BELINF	0.0280	0.0145
AWARENESS	-0.0163	-0.0222*
INCOME	-0.0700***	-0.0583***
GENDER	0.0227*	0.0128*
NO-SOYOIL	-0.0230***	--

*,**, *** Statistically significant at 10%, 5%, and 1% level, respectively.

variables other than the variable being considered (Greene). For qualitative variables, the marginal effects refer to incremental impacts on the probability of purchasing biotech foods to a bid amount if the value of the variable changes from zero to one.

The bid price (in percent discount) offered to respondents shows a negative coefficient in both the biotech soybean oil and biotech rice model. However, because the bid prices are discounts offered to respondents, the negative coefficient simply means that as the price discount offered increases, the probability of purchasing biotech foods becomes greater. For example, the -0.1165 marginal effect in the case of biotech soyoil means that an increase in the price

discounts offered to respondents of 20.69 percent (the mean value) would lead to a rise in the probability of purchasing biotech soybean oil in China by 11.65 percent. Respondents had higher probabilities of purchasing biotech foods if 1) they resided in small cities, 2) they were unemployed, 3) they had high trust in the accuracy of information from mass media, or 4) they were male. For example, residents in small cities had a 2.05-percent higher probability of purchasing biotech soybean oil than those living in larger cities. In contrast, respondents had lower probabilities of purchasing soybean oil if they had higher annual disposable income or did not use soybean oil for cooking in the household. Consumers who chose not to use soybean oil in cooking would have a 2.3-percent lower probability of purchasing biotech soybean oil than those who used soybean oil in household cooking.

Respondents with characteristics that contribute to lower probabilities of purchasing biotech foods would be willing to pay higher premiums for non-biotech foods. Among the characteristic variables included in the dichotomous choice model, key factors that have the largest marginal effects on WTP for biotech soybean oil and rice are consumers' preference in the choice of vegetable oil, size of the respondent's residing city, employment status, gender, and awareness of biotech foods.

Respondents' preference in the choice of vegetable oil has the largest marginal effect on WTP in the case of biotech soybean oil. Consumers who chose not to consume biotech soybean oil were willing to pay a premium of 23.3 percent for purchasing non-biotech vegetable oil (table 8).[6]

[6] Alternatively, this finding means that consumers who chose not to consume biotech soybean oil required a 23.3 percent greater discount for purchasing biotech soybean oil.

Table 8. Marginal effects--Change in the mean WTP associated with explanatory variables

Explanatory variable	Biotech soybean oil	Input-trait biotech rice
SMALLCITY	0.0863*	0.1457**
UNEMPLOYMENT	0.1376*	0.2362**
BELINF	0.0579	0.0493
AWARENESS	-0.0391	-0.0899*
INCOME	-0.0107***	-0.0146***
GENDER	0.0712*	0.0655*
NO-SOYOIL	-0.2328***	--

*,**, *** Statistically significant at 10%, 5%, and 1% level, respectively.

Some of these consumers purposely avoided biotech soybean oil because they preferred non-biotech vegetable oil for cooking. Hence, consumers' preference in the choice of vegetable oil played an important role in affecting consumers' willingness to pay for biotech foods. In contrast, residents in small cities were willing to pay an 8.6-percent lower premium for non-biotech soybean oil than those living in larger cities. By the same token, the unemployed were willing to pay a 13.8-percent lower premium than the employed.

In the case of biotech rice, unemployment had the largest marginal effect on consumer WTP in China. The unemployed were willing to pay a 23.6-percent lower premium for non-biotech rice than the employed. By the same token, residents in small cities were willing to pay a 14.6-percent lower premium for non-biotech rice than those living in larger cities. In contrast, respondents who have heard of biotech foods were willing to pay a 9.0-percent higher premium for non-biotech rice to avoid the consumption of biotech rice.

Conclusions

A majority—about 60 percent or higher—of respondents were willing to purchase biotech foods (including soybean oil and rice) surveyed in this study without any price discounts. To these consumers, biotech and non-biotech foods are perfectly substitutable. However, there were about 20 percent of respondents would not accept biotech foods (with the exception of neutraceutical biotech rice) regardless of any price discounts. The remaining 20 percent of respondents would purchase biotech foods only if price discounts were offered to them.

Results of the WTP analysis suggest that the price premiums that respondents were willing to pay for non-biotech foods averaged about 23.4-52.6 percent for non-biotech soybean oil and 41.5-74.0 percent for non-biotech rice. Respondents apparently were willing to pay higher premiums for non-biotech rice than non-biotech soybean oil in part because rice is a main food staple. Also, rice is consumed not in a highly processed form.

Mean WTP estimated from the entire sample would likely overstate the true WTP in part because of the *hypothetical* nature of the survey data used in the contingent valuation method and in part because the data potentially set the upper range for WTP to go beyond 100-percent discount, which deviates from reality. This potential overstatement of WTP particularly applies to the respondents who accepted only non-biotech foods at any price and with a price discount of 80 percent being offered to them in the bidding process. Excluding this subgroup significantly lowers the range of true WTP. The lower bound WTP appears to be more in the ballpark in light of the fact that a majority of respondents were willing to purchase biotech foods in the absence of any price discounts.

A finding of our earlier study is that if China's government would like to promote the acceptance of biotech foods, targeting the dissemination of information to consumers with the least exposure or awareness (less than three years familiarity) would be a more effective strategy to achieve the objective than a program across the board (Lin *et al*.). However, in the case of biotech rice, a higher awareness of biotech foods would lead to consumers' willingness to pay higher premiums for non-biotech rice to avoid biotech rice consumption.[7] This suggests that opportunities may arise for Chinese food manufacturers and retailers to voluntarily label their rice products as non-biotech if the premium exceeds the higher cost of producing and marketing non-biotech rice.

A high degree of acceptance of biotech foods by respondents has important implications for the decision by Chinese food manufacturers and retailers to use and label biotech foods, as well as for export of U.S. biotech products to China. Because a majority of China's consumers were not willing to pay premiums for non-biotech foods, this study's findings suggest that consumers' positive attitudes toward biotech foods would pave the way for many food manufacturers and retailers to use less costly biotech ingredients and label products accordingly.[8] This is especially true in the case of biotech soybean oil, where Chinese consumers were willing to pay only modest premiums for non-biotech soybean oil. This decision to label biotech products would, by and large, facilitate the export of China-approved biotech products (such as herbicide-tolerant soybeans) from the United States to China without incurring additional expenses in segregating biotech from non-biotech products.

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[7] The finding of our earlier study is obtained from a probit analysis of consumer attitudes toward biotech foods without any regard to the price differential between biotech and non-biotech foods. In contrast, findings from this study are obtained in the context of price differential. Also, awareness in this study covers those who have heard of biotech foods, regardless of the length of time.

[8] Even if consumers were willing to pay a small premium for non-biotech foods, food manufacturers and retailers may still choose to label their products because the cost of identity preservation would incur to maintain the non-biotech identity.

Mean willingness to pay for biotech rice may potentially be overstated in this study because some consumers could be willing to pay a premium for purchasing this food due to this new technology's effect on reducing pesticide use. However, the earlier study by Chern and Rickertsen for Japan, Taiwan, Norway, and the United States suggests that this prospect is limited—respondents in their surveys were willing to pay premiums for non-biotech foods. This same prospect is also limited for biotech soybeans because biotech soybean adopters' herbicide use, pound-by-pound, was actually higher than for nonadopters in the United States nationwide, although glyphosate is less toxic and persistent than other herbicides being replaced (Price *et at*.).

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