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Consumers' Willingness to Pay for Biotech Foods in China: A Contingent Valuation Approach

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Based on a large-scale survey, this study employs the contingent valuation method to estimate consumers' willingness to pay (WTP) for biotech foods in China and to account for the effects of respondents' characteristics on the likelihood of purchasing biotech foods and WTP. The survey, covering 1,100 consumers in 11 small-to-large cities (including Beijing and Shanghai) along China's eastern coast, was conducted in the fall of 2002. Although the survey covers eight different kinds of biotech foods, soybean oil made from imported biotech soybeans and insect-resistant biotech rice are the focus. A majority—about 60% or higher—of respondents were willing to purchase biotech foods without any price discounts. However, about 20% of them would only accept non-biotech foods. Price premiums that respondents were willing to pay for non-biotech foods averaged about 23-53% for non-biotech soybean oil and 42-74% for non-biotech rice. The lower bound WTP comes closer to the true value in light of hypothetical bias associated with the contingent valuation method.

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

Introduction

In January 2002, China introduced new regulations that require labeling of all foods containing biotech ingredients. The regulations also require costly testing and documentation of the safety of all biotech food ingredients. Since these regulations were hastily announced by the government, a number of issues concerning consumers remain unaddressed. Do the labeling regulations reflect the preferences of Chinese consumers? Will suppliers 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 processors in the domestic market and world agricultural trade.

There have been an increasing number of studies on consumer attitudes toward biotech foods in China (Environics International, 1999; Li, Curtis, McCluskey, & Wahl, 2003; Zhong, Marchant, Ding, & Lu, 2003; Hu & Chen, 2004; Ho & Vermeer, 2004; Curtis & Moeltner, 2006; Lin, Somwaru, Tuan, Huang, & Bai, 2006). 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, biotech feed for raising livestock and poultry, and the use of biotech ingredients in processed food production. Based on a large-scale consumer survey in 11 Chinese urban cities, for example, Lin et al. (2006) found that 46-67% of all respondents were supportive of biotech foods, depending on the kind of products. In contrast, 5-15% of urban consumers in this survey were opposed to biotech foods.

However, there are only a few studies available that address consumers' willingness to pay (WTP) for biotech foods in China (Li et al., 2003).[1] The survey in the Li et al. study is small-scaled and limited to consumers in Beijing. A major finding from that study is that consumers were more willing to pay premiums for biotech foods which provide them with direct nutritional or health benefits. In the case of *product*-enhancing biotech rice (that is, rice with an enhancement of its nutritional composition via biotechnology), which is a hypothetical product, that study found that 43.9% of respondents were willing to pay a premium for purchasing the product over the price of non-biotech rice and the mean WTP was 38.0%. Even though a somewhat smaller but positive mean WTP was also reported for biotech soybean oil, the result is ambiguous because no information was given to the respondents regarding the genetic trait

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.*

(either *product*-enhancing or *process*-enhancing) of this product. There is no assurance that all the respondents perceived the product to have the same genetic trait when they responded to the questionnaire. Consequently, survey results would likely be inconsistent across the respondents. In fact, it is conceivable that many respondents could perceive the biotech soybean oil, just like the biotech rice, to be of *product*-enhancing trait. The Li et al. study thus offers no direct evidence on the WTP of Chinese consumers for *process*-enhancing biotech products, such as soybean oil made from herbicide-tolerant soybeans.[2]

The main purposes of this paper are: 1) to understand consumers' WTP for selected biotech foods in China, 2) to use the contingent valuation method (e.g., Kanninen, 1993; Li et al., 2003; Chern, Rickertsen, Tsuboi, & Fu, 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. Our study differs from the Li et al. study by focusing the WTP analysis on soybean oil made from herbicide-tolerant biotech soybeans and on insect-resistant biotech rice. To our knowledge, our study is the first in its kind that addresses WTP for biotech products made from agronomic traits in China. Findings from our study are particularly significant because soybean oil made from herbicide-tolerant soybeans is the only kind of biotech soybean oil available in China's marketplaces, which requires biotech labeling, and insect-resistant biotech rice is a new technology on the verge of being approved by the government for commercialization.[2] Also, this study differs from Lin et al. (2006) in that the former focuses on the WTP that respondents indicated in the survey for soybean oil made from herbicide-tolerant biotech soybeans and insect-resistant rice, while the latter focuses on attitudes toward biotech foods for Chinese urban consumers in 11 cities and the estimation of the effects of various demographic and socio-economic characteristics on the likelihood of biotech food acceptance.

Previous Related Studies

The Li et al. (2003) study suggests that consumers in Beijing were willing to pay premiums for *product*-enhancing 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 ingredients. This section briefly reviews previous related studies, focusing on WTP-related 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, Ouchi, Grimsrud, and Wahl (2001) reported that these customers were willing to purchase noodles made from biotech wheat with a 60% price discount and tofu made from biotech soybeans with a 62% 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% of the respondents stated that they would purchase the biotech tofu with randomly assigned discount offers and 17% for biotech noodles. The remaining great majority of the respondents chose not to purchase biotech products even with price discounts. Consumer WTP biotech foods is 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. (2003) based on the contingent valuation method. This study uses data collected from 599 in-person interviews in August 2002 and the double-bounded

2. *Most biotech crops in the marketplace, including soybeans, corn, and cotton have process-enhancing traits (such as tolerance to herbicides and resistance to targeted insects) which have no direct benefit to consumers. Following the practice of the European Union (EU), Japan, and other countries, China has established a policy that requires labeling of food products with biotech content, which was to take effect on March 20, 2002. The requirement, however, was not strictly enforced until August 2003 when the government began to crack down on retailers that were violating the regulations. This less-than-strict enforcement of the labeling regulations could affect the accuracy of biotech labeling in China and consumers' WTP levels since the survey was conducted in the fall of 2002.*

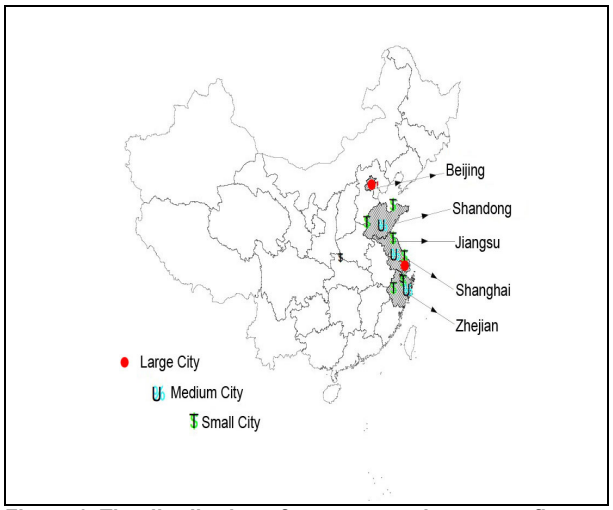

Figure 1. The distribution of survey samples across five provinces or municipalities in China.

dichotomous choice model to estimate the mean WTP. Consumers in Beijing were found to be willing to pay a premium of 38%, on average, for purchasing *product*-enhancing biotech rice over non-biotech rice, and a 16.3% premium for *product*-enhancing or *process*-enhancing biotech soybean oil. 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 product. Education, income, and the number of children in the household were found to be not statistically significant factors.

Using student survey data that were taken from December 2000 to March 2001, Chern et al. (2002) 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 double-bounded dichotomous choice model, WTP of non-biotech vegetable oil were estimated at: 1) 33-40% for Japan, 2) 17-21% for Taiwan, 3) 55-69% for Norway, and 4) 50-62% for the United States. The mean WTP varies because the base price for biotech foods was different 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 (2004) 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% price premium for purchasing non-biotech soybean oil, 37.42% premium for non-biotech tofu, and 108.4% 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

This study utilizes a survey of 1,100 consumers in 11 small-to-large cities (including Beijing and Shanghai) along China's eastern coast that was conducted by the Chinese National Bureau of Statistics through personal interviews at the households in the fall of 2002 (see Figure 1). 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. 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, 2003). A total of 1,005 usable sample data were collected—1) Beijing (200); 2) Shanghai (200); 3) Shandong province (200); 4) Jiansu province (205); and 5) Zhejiang province (200). The response rate is 91% (1,005/1,100) for the total sample and in each of the five provinces or municipalities (e.g., 200/220 in both Beijing and Shanghai).

Altogether, the survey resulted in 1,005 usable responses, of which 669 respondents indicated that they had heard about biotech foods (Bai, 2003). In general, the survey respondents are representative of the Chinese urban population in terms of demographic and socio-economic variables (Lin et al., 2006). Although the survey covers eight kinds of biotech foods, the analysis in this paper focuses on soybean oil made from imported biotech soybeans and insect-resistant biotech rice—two biotech products of agronomic traits.

The questionnaire for this large-scale survey was revised several times by analysts of the Center for Chinese Agricultural Policy (CCAP), Chinese Academy of Science (CAS) in Beijing, and USDA's Economic Research Service. The questionnaire was also pretested. 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 socioeconomic 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 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, 2003; Lin et al., 2006).[3] The sample is not representative of the entire Chinese population, however, 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 these excluded regions. However, a focus on coastal cities is appropriate since this population is the target market for most food processors and exporters.

Awareness of Biotech Foods

The survey found that about two-thirds of respondents had heard of biotech foods, around 10 percentage points lower than the level of awareness about biotechnology reported for the United States (International Food Information Council, 2004). Consumers who had never heard of biotech foods and those who had only heard of it on an *occasional* basis together accounted for 77% of all respondents. Only 23% of respondents indicated that they had *frequently* heard of biotech foods. Of the respondents who indicated that they had heard of biotech foods, time lengths of awareness averaged 2.65 years.

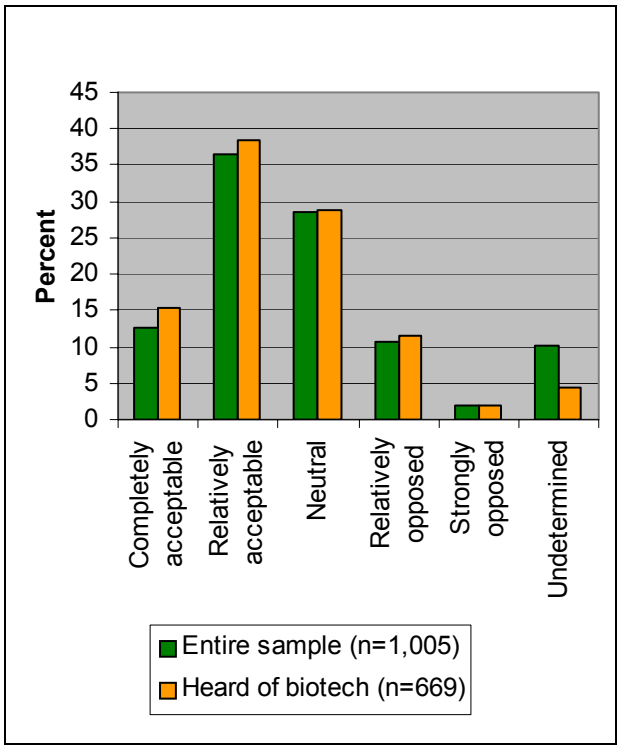

Figure 2. Consumer attitudes toward biotech soybean oil in China.

Biotech Food Acceptance

A majority of respondents were supportive of biotech foods, which is to say that they found biotech foods to be strongly or relatively acceptable. This pro-biotech group of consumers accounted for 46 to 67% of all respondents, depending on the kind of biotech foods. In contrast, 5 to 15% 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, 2003). 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, the survey data suggest that consumers who have heard of biotech foods tend to be slightly more supportive of biotech foods.

The consumer attitudes toward biotech foods reported above were expressed without any regard to the price differential between biotech and non-biotech foods. In the context of the price differential, the majority of respondents–ranging from 58.3 to 74.1%–were

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 decision-maker	57.51	0.49	0	1
Co-decision-maker	15.22	0.36	0	1
Little or no role	27.26	—	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	—	0	1
Occasionally	43.7	—	0	1
Frequently	22.9	—	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

willing to purchase biotech foods if their price (P_b) was the same as that for non-biotech foods (that is, P_b = no discount), depending on the kind of foods. The range was narrowed to 60.0-67.9% for soybean oil and rice (see Figure 3).[4] An even greater majority–ranging from 67.0 to 80.9%–were willing to purchase biotech foods if a 10% price discount (that is, P_b = 10% discount) was offered to them. In the case of output-enhancing biotech rice, about 6 to 10% more consumers were willing to purchase nutraceutical 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

4. *There are similarities between this finding and those in Li et al. (2003), which found that 73% to 80% of the respondents were willing to purchase biotech foods at the same price as the non-biotech foods. Also, 14.0% to 16.7% of the respondents were not willing to purchase biotech foods even with price discounts.*

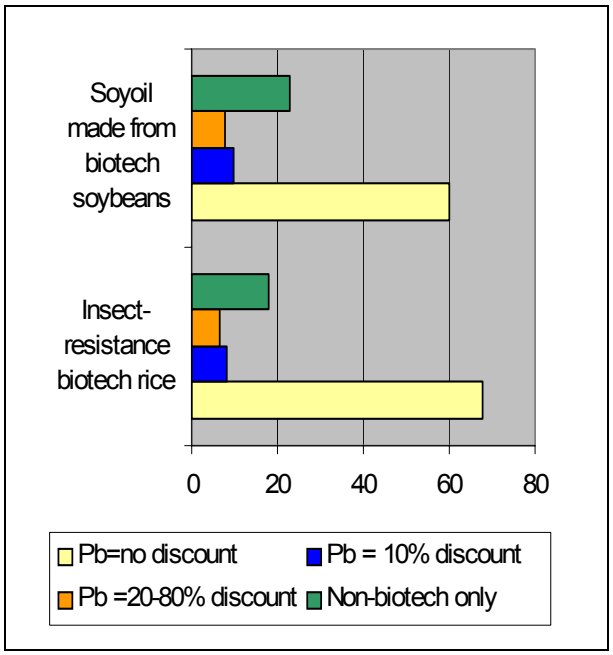

Figure 3. Price discounts needed to induce Chinese consumers to purchase biotech soyoil and rice.

significant, minority–about 20%–of 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 (see Figure 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. Results of chi-square tests, however, show that only differences in two variables—income (Y_{inc}) and non-consumption of soybean oil by the respondent's household (NO-SOYOIL)—are statistically significant between the two subgroups. The results are based on the Kruskal-Wallis test, but other methods show similar results which do not alter the outcomes of the chi-square test (Conover, 1980).

Table 2. Profile of survey respondents: Biotech soybean oil.

Variable	Consumers with 0% discount P_b	Consumers who accept non-biotech only	Chi-Square Test	
			χ^2-value	d.f.
GENDER	0.426	0.389	1.867	1
AGE	46.4	48.7	35.861	41
EDU	11.03	10.99	19.953	15
CITY	1.94	1.90	0.759	1
Y_{inc}	9,645	10,763	68.854**	67
NEWSFOOD	40.8	31.9	0.257	1
AWARENESS	1.75	1.78	2.279	1
NO-SOYOIL	9.95	25.0	3.863*	1

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)
Y_{inc}: 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 (%)

* *Statistically significant at 5% level.*
** *Statistically significant at 1% level.*

Contingent Valuation Method

Contingent valuation method (CVM) is an analytical tool commonly used to elicit the public's WTP (in terms of additional taxes) to protect non-marketed resources, such as recreation, wildlife, and environmental quality (e.g., Hanemann, Loomis, & Kanninen, 1991). 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, reflecting the fact that biotech products in question have "process-enhancing attribute"—including soybean oil made from herbicide-tolerant soybeans and insect-resistant biotech rice, which provide consumers with no direct nutritional or health benefits. 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 et al. (1991) 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:

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

$$P_r\{\text{No to BID}\} \leftrightarrow P_r\{\text{WTP} > \text{BID}\} \quad (1)$$

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 biotech foods. Both WTP and BID are expressed in terms of absolute values here and throughout this 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 to 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. a "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.[6] 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. 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:

$$P_r(\text{WTP} \leq \text{BID}) = \Phi(\alpha - \rho\text{BID} + \lambda' Z) \quad (2)$$

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

The probabilities of purchasing biotech foods for respondents that fall into the above three discrete outcome groups are as follow (McCluskey et al., 2003):

1. the "yes" group in the initial bid, $P_r(\text{WTP} \leq \text{BID}) = \Phi(\alpha - \rho B_0 + \lambda' \mathbf{Z})$,
2. the "no" and "yes" group, $P_r(B_0 < \text{WTP} \leq \text{BID}) = \Phi(\alpha - \rho\text{BID} + \lambda' \mathbf{Z}) - \Phi(\alpha - \rho B_0 + \lambda' \mathbf{Z})$, and
3. the "no" and "no" group, $P_r(\text{WTP} > \text{BID}) = 1 - \Phi(\alpha - \rho\text{BID} + \lambda' \mathbf{Z})$

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., 1991). 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.

6. The use of semi-double-bounded approach in implementing the CVM does impose restrictions on the WTP function, which in essence places an upper bound of zero price discounts for biotech foods. To the extent that some consumers were willing to pay premiums for whatever reasons—such as environmental benefits via the reduction in pesticide use from biotechnology of a process-enhancing attribute (e.g., Huang, Hu, Rozelle, & Pray, 2005), these restrictions would overstate the WTP.

Thus, the log likelihood function becomes:

$$L = \sum_i \{ID_i = 1 \ln \Phi(\alpha - \rho B_0 + \lambda' \mathbf{Z}) + ID_i = 2 \ln[\Phi(\alpha - \rho BID + \lambda' \mathbf{Z}) - \Phi(\alpha - \rho B_0 + \lambda' \mathbf{Z})] + ID_i = 3 \ln[1 - \Phi(\alpha - \rho BID + \lambda' \mathbf{Z})]\} \quad (3)$$

where I_k is an indicator function for the discrete outcome k, $D_i = j$ denotes the j^{th} alternative occurred, and i denotes the i^{th} individual. 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 et al., 1991; Qaim & De Janvry, 2003; McCluskey et al., 2001).

An alternative to the CVM is the experimental auction market (EAM) method, which can also be used to assess consumers' WTP for biotech versus conventional food products (Rousu, Huffman, et al., 2003; Rousu, Monchuk, et al., 2003; Rousu et al., 2004). Researchers design an experiment employing auctions to measure consumers' WTP through a bidding process for genetically modified products and others. The *bid* price is first placed on biotech products and then compared with a randomly selected *market-clearing* price from a probability distribution (e.g., uniform distribution) on a fixed interval to an upper limit. A participant who bids less than the market-clearing price does not "win" the auction. In contrast, a participant who bid more than the market-clearing price "wins" and purchases the food product at the market-clearing price.

Thus, both the CVM and EAM method require the respondent or auction participant to go through a similar bidding process. In the CVM, it is the bid price (in percent discount) offered to biotech foods, BID, that was randomly selected by researchers through the survey initially, and then the respondent determines whether to purchase the biotech food, depending on if the respondent's WTP is less than the bid price, as shown above. The *bid* price in the CVM is equivalent to the *market-clearing* price in the EAM method, both of which are the price to be paid by respondents who are willing to purchase biotech foods in the CVM as well as that for auction participants who win the auction in the EAM. Also, WTP in the CVM is equivalent to the *bid* price in the EAM method.

However, there are differences between the two approaches as well. First, the bidding process is reversed between these two approaches. The bid price (BID) is offered to the respondent first through the survey questionnaire in the CVM and then the respondent determines whether to purchase the biotech product based on the comparison between the WTP and bid price. In contrast, the *bid* price that the auction participant is willing to pay for the biotech product is determined first in the EAM method and then compared with the *market-clearing* price to determine whether he or she wins the auction. The WTP in the CVM is internal information to the respondent while the *bid* price in the EAM could be internal in sealed-bid auctions or external in open auctions. Second, the EAM method often requires payments of participation fees to induce participation, which could be costly if the scale of auction is large. Finally, the random selection of the market-clearing price in the EAM method and the initial bid in the CVM are important components of the design of experimental auctions or survey questionnaire, which could affect either successive bid prices for the former and mean WTP for the latter. Therefore, researchers should design their survey questionnaire so that the initial bid in the CVM is a good approximation of the true mean WTP and also their auction market experiments with a high probability of randomly selecting the market-clearing price being close to mean WTP.

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 $(\alpha + \lambda' \mathbf{Z})/ \rho$ based on a random utility framework in which it is postulated that a consumer is willing to purchase the biotech food when the utility of the purchase is at least as great as the purchase of the non-biotech food (Qaim & De Janvry, 2003; Chern et al., 2002; Chiang, 2004). 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.

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,

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
NOSOYOIL	1=not consuming soybean oil in the household

$$\partial\ (\text{WTP}) / \partial \mathbf{Z}_k = \lambda_k\ /\ \rho \qquad (4)$$

In the context of the dichotomous choice model specified in this study, a variable that has a coefficient with a negative sign means that 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 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:

$$P_{\text{r}}\,(\text{WTP} \leq \text{BID}) = \Phi\,(\alpha - \rho\text{BID} + \lambda' \mathbf{Z}) \qquad (5)$$

Definitions and measurement units for explanatory variables, BID and a vector **Z**, are presented in Table 3. BIDOIL and BIDRICE, both of which 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 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. Interactive terms between other variables (such as per capita disposable income) with the bid variable could be considered and tested to see if they are statistically significant.

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% level.*
** *Statistically significant at 5% level.*
*** *Statistically significant at 1% level.*

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% level.*
** *Statistically significant at 5% level.*
*** *Statistically significant at 1% level.*

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 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's urban cities than those living in larger cities and the employed.[7] This finding is consistent with what was found in an earlier study of consumer attitudes toward biotech foods in China (Lin et al., 2006). In contrast, consumers with a higher annual disposable 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 (Lin et al.), 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.

There potentially could be an errors-in-variables problem for the use of the awareness variable, AWARENESS, which equals 1 if the respondent has heard of biotech foods, and the NO-SOYOIL variable, which equals 1 if the respondent does not consume soybean oil in the household. In the case of AWARENESS, while access to mass media raises consumer awareness of biotech foods, media access also influences consumer attitudes toward these products and their WTP. As a result, the awareness variable in the conventional probit analysis becomes interdependent with the error term, which gives rise to biased and inconsistent estimates of the beta coefficient (Maddala, 1997). Similarly, the use of the NO-SOYOIL variable also raises the same kind of problem in that the respondent's taste and preference or health considerations might be the main driver for not consuming soybean oil, and if the subject elects not to consume soybean oil, there is no reason to expect he or she would be willing to accept edible oil made from biotech soybeans.

There are a couple of approaches to address this errors-in-variables problem. One method is the use of instrumental variable method or to endogenize the AWARENESS or NO-SOYOIL variable (Lin et al., 2006; Qiu, 2005). The upshot of this approach is to increase the beta coefficient of these variables and the mean WTP with fairly consistent results. In the case of the AWARENESS variable, access to mass media can be used as an instrumental variable or treated as an endogenous variable. As for the NO-SOYOIL variable, the choice of the instrumental variable is less clear, which might not be readily available from the survey in this study. The second approach is to conduct a follow-up survey of the respondents to determine whether their willingness to purchase biotech foods might have been altered if they had heard of biotech foods in the fall of 2002 when the survey was conducted.

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% to 52.6% in the case of soybean oil, depending on whether all 1,005 responses are included in the estimation of the dichotomous choice model. Based on the entire sample, mean WTP is calculated at 52.6%. 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, 2003). Second, mean WTP would likely be overstated because the feasible upper range for true WTP is 100% 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% 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%. This approach lowers mean WTP for soybean oil to 23.4%, which would come closer to the true WTP after taking into account hypothetical bias associated with CVM.

7. *The use of the SMALLCITY variable in the dichotomous choice model in this study, as opposed to midsize and large cities, is an approximation of the fixed effects for location of the respondents. Alternatively, fixed effects can be addressed by introducing city-specific dummies after selecting a base city as the benchmark for comparison.*

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

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 of 41.5% to 74.0%—the former leaves out the "no" and "no" group with bid prices offered for the biotech food being at 80% in the model estimation, while the latter includes the entire sample. Again, it is believed that the lower bound would come close to the true WTP after taking into account hypothetical bias associated with CVM. 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 a bid price of under 20%, mean WTP would be lowered to only 10.0% in the case of biotech soybean oil (see Table 6). Similarly, mean WTP would be lowered to 11.5% 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 variables other than the variable being considered (Greene, 1990). 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.

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% level.*
*** Statistically significant at 5% level.*
**** Statistically significant at 1% level.*

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 at the mean value (20.69%) would lead to a rise in the probability of purchasing biotech soybean oil in China by 11.65%. 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% 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. Consum-

ers who chose not to use soybean oil in cooking would have a 2.3% 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.

In the case of biotech soybean oil, respondents' preference in the choice of vegetable oil has the largest marginal effect on WTP. Consumers who chose not to consume biotech soybean oil were willing to pay a premium of 23.3% for purchasing non-biotech vegetable oil (see Table 8).[8] 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% 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% 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% lower premium for non-biotech rice than the employed. By the same token, residents in small cities were willing to pay a 14.6% 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% higher premium for non-biotech rice to avoid the consumption of biotech rice.[9]

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% level.*

*** Statistically significant at 5% level.*

**** Statistically significant at 1% level.*

Conclusions

A majority—about 60% 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% of respondents who would not accept biotech foods (with the exception of nutraceutical biotech rice) regardless of any price discounts. The remaining 20% 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 from 23.4% to 52.6% for non-biotech soybean oil and from 41.5% to 74.0% 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 bound for WTP to go beyond 100% 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% being offered to them in the bidding process. Excluding this subgroup significantly lowers the range of WTP. The lower bound WTP—23.4% for soybean oil made from herbicide-tolerant soybeans and 41.5% for insect-resistant biotech rice—appears to be more in the ballpark after taking into account hypothetical bias associated with CVM.

8. Another way of interpreting this finding is that consumers who chose not to consume biotech soybean oil required a 23.3% greater discount for purchasing biotech soybean oil.

9. The finding of our earlier study (Lin et al., 2006) 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.

The effects of consumer awareness of biotech foods on the probability of purchasing these foods and WTP could potentially be more accurately estimated if the awareness variable is endogenized. Many of the explanatory variables that affect consumer attitudes toward biotech foods also influence consumer awareness. A follow-up survey of the respondents would be useful in this regard to determine whether their willingness to purchase biotech foods might have been altered if they had heard of biotech foods in the fall of 2002 when the survey was conducted.

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., 2006). 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. 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 additional cost of identity preservation for 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 US 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. 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.[10] 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 and South American countries to China without incurring additional expenses in segregating biotech from non-biotech products.

Mean WTP 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, this prospect is tempered for a number of reasons. First, the earlier study by Chern et al. (2002) for Japan, Taiwan, Norway, and the United States suggests that respondents in their surveys were willing to pay premiums for avoiding the purchase of biotech foods. Second, environmental movement in China is still in its early stage, which would dampen consumers' willingness to pay such a premium for foods made from biotech products of input traits. Finally, uncertainty about biotechnology's longer-term effects on the environment (such as gene flow and development of resistance to insecticides by targeted insects) could partially offset the technology's positive benefits. As for biotech soybeans, the potential overstatement of WTP is even more limited because biotech soybean adopters' herbicide use, pound-by-pound, was actually higher than for non-adopters in the United States nationwide, although glyphosate is less toxic and persistent than other herbicides being replaced (Price et al., 2003).

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10. 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 as containing biotech ingredients because the cost of identity preservation would be incurred to maintain the non-biotech identity.

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