Consumer acceptance and willingness to pay for genetically modified rice in China

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Abstract

Over the past decade public perception of GM food in China has become increasingly contentious. Concerns have emerged with regard to public health, environmental safety, and economic impacts. This paper utilizes a survey conducted in 2013 to evaluate China's urban consumers' acceptance and willingness to pay (WTP) for genetically modified rice. The survey was conducted in thirteen of the main rice consuming provinces of China. Responses from 994 consumers are used to estimate WTP for GM rice relative to non-GM rice. A double bounded dichotomous choice contingent valuation method is used to estimate consumers' WTP for GM rice products. The effect of socio-demographic characteristics of consumers on acceptance and WTP is also reported. The survey design includes different information treatments for GM rice: no specific rice trait information, environmental/producer trait information (Bt rice), consumer health trait information (Golden rice) and stacked environmental/producer plus consumer health traits information. For the three specific rice trait information treatments, the risks and benefits information were reordered for the half of the respondents. The main result of the study is that a majority of Chinese urban consumers require a large discount to be willing to pay for GM rice regardless of rice trait and information treatment. Compared to previous studies, Chinese consumers' WTP and attitudes on GM rice have become more negative.

Keywords: GM rice, China urban consumers, willingness to pay, double bounded dichotomous choice model

JEL Classification: D12

I. INTRODUCTION

Rice is a key staple food in China and much of Asia. Approximately three billion people depend on rice as a basic source of food (Redoña et al. 2004). China is the largest rice producing and consuming country, however, it continues to face a gap between national supply and demand. According to Rosegrant's estimation, "the cereal production in China must keep rising to about 40% to meet the needs of demand of the national population in 2020" (Rosegrant et al. 2001). Challenged by water and land resource constraints, the government of China is seeking to improve productivity and boost output through new technologies such as genetically modified rice.

Chinese agriculture is characterized by small farms, with fragmentation of land ownership. The average size of farms is decreasing throughout the country, and the number of small-size holdings has increased significantly (Tan et al.2006). Due to intensive cultivation and a decline is the rural labor force, pesticides and herbicides use is excessive, threatening the future sustainability of agriculture (Liu et al.2006; Huang et al. 2005). Non-GM rice cultivation patterns have resulted in negative consequences to the ecosystem and to production costs. China has to rely on rising productivity and more environmentally friendly rice variety to face the gap between national demand and supply.

To increase yield production, reduce water pollution and efficiently allocate land resources, the Chinese government has attached great attention to biotechnology improvements. The National Program for Long-and Medium-Term Scientific and Technological Development 2006-2020 (PRC. State Council, 2006), includes the development of new GM crops as one of the 16 major projects. Current funding of ￥24 billion ($375 million) is designated for GM rice research (Lakhan.et al. 2006). By 2009 the production area for *Bt* (bacillus thuringiensis) cotton nationwide had reached 3.8 million hectares, 70% of total area of cotton production (Huang et al 2002). Lower costs and marginally higher yields of *Bt* cotton have resulted in large net profit gains in China of more than ￥59 billion (Jiang et.al., 2011). GM soybean imports have become increasingly important source of vegetable oil and protein feed (Tan et. al. 2013).

On October 22, 2009, China's Ministry of Agriculture issued two biosafety certificates for commercial production of *Bt* rice lines Huahui No.1 and Shanyu 63 in Hubei province. A CAS (Chinese Academy of Sciences) trial research indicated that the two new varieties of GM rice can lower input costs, reduce labor intensity, reduce the need for insecticides and their harmful effects on beneficial insects (Huang et al..2010). It is reported that based on the field data in Hunan and Fujian provinces that *Bt* Xianyou 63 could save up to 60% of pesticide input application per hectare and release nine working days of pesticide application (Huang et al., 2005).

The controversy of whether GM rice should be commercialized in China has become important. At present bio-technology is primarily used for industry. Because of government indecision, biosafety regulations, consumer resistance and trade concerns, the current policy from the Ministry Agriculture of PRC is that *Bt* rice is forbidden to be commercialized.

Chinese consumers' acceptance of GM rice has been found to be easily influenced by the social environment (Zhong et al. 2003). The Chinese Center for Disease Control (China CDC) in Hunan province found that dozens of children were used in 2008 as test subjects for the vitamin A enhancing GM Golden rice. Parents of theses however were not provided informed consent. This news story was widely distributed and resulted in a large public outcry towards GMO food.

This study measures the current attitudes and wiliness to pay for *Bt* and Golden rice by China's urban consumers. The study also includes a comparison of results with previous studies of Chinese consumers' WTP and attitudes. The paper is organized as follows. The next section provide a review of related literature, followed by the research methods and results. We close with a summary and conclusions.

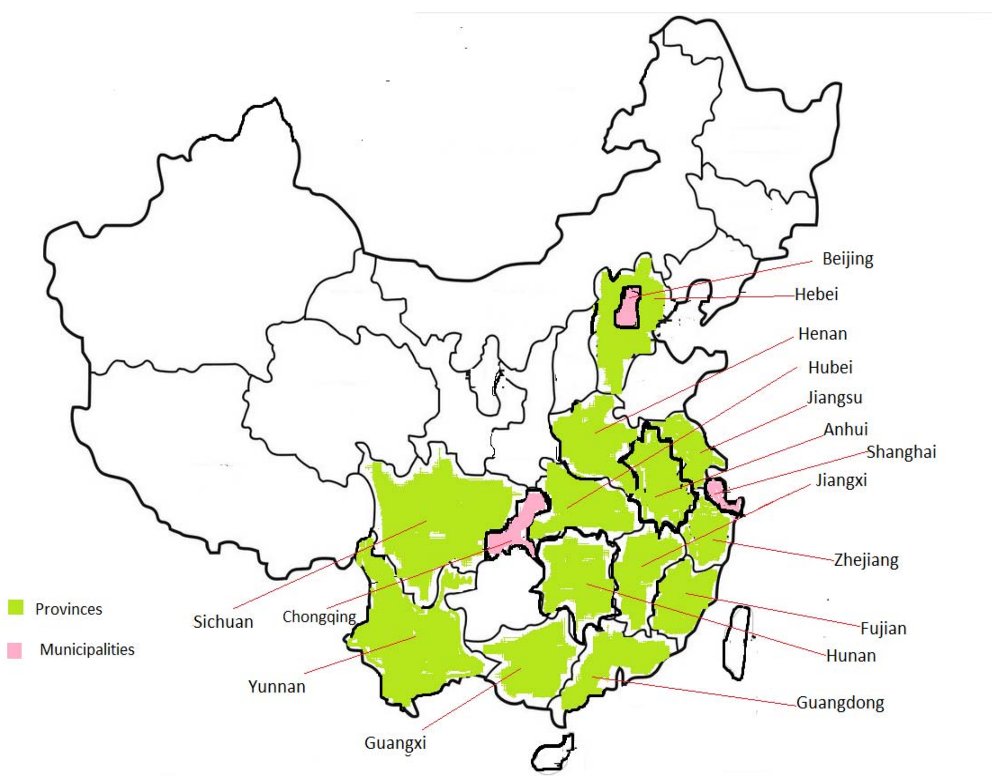
II. Related studies

Li, Curtis, McCluskey, and Wahl (2003) estimated the WTP for bio-technology in Beijing, China. They concluded that Chinese consumers, on average, were willing to pay a 38% premium for GM rice over the non-GM alternatives and product-enhancing bio-technology would be more likely to gain a price premium of 43.9%. Zhong et al. (2003) stated that Chinese people know little about GM food, but regardless of their knowledge, forty percent will buy GM food. In a more recent study Ho et al (2006) demonstrated that most Chinese consumers lack the most basic understanding of bio-technology and its potential risks. The majority of the respondents (60%) were either unwilling to consume GM food or were neutral about the idea. Huang et al. (2010) stated that for 60% or higher of respondents, GM and non-GM foods are perfectly substitutable, 20% of the respondents would not buy any GM food and only 20% would buy it with a price discount. Lin et al. (2006) found that the acceptance towards GM rice is relatively high. De Steur et al. (2010) did a hypothetical experimental auction about folate enhanced rice in Shanxi province, and found female consumers would pay a premium of 33.7% for folate nutrient enhanced GM rice. However, the literature over time has discerned less favorable acceptance and increased knowledge on GM rice. Fu et al (2012) found that the consumer acceptance of GM food has declined from 80% of 2005 to 40% in 2010 (Fu et.al, 2012).

III. SURVEY DESIGN AND METHOD OF ANALYSIS

The survey sample for this study was selected to cover thirteen major rice consuming provinces (55 cities) and three municipalities in China. After pretests we trained students at China Agricultural University in Beijing to conduct the survey during the summer 2013 break (July 1st to July 22nd) trip to their home cities. 35 student enumerators were selected based on their hometown location. To ensure sample quality, each enumerator was responsible for surveying only 30 respondents; in total this survey included a total sample of 1050 respondents. After review, 994 respondents were determined as containing valid data.

Figure 1 The distribution of survey sample across provinces in China



In this study we estimate the WTP of Chinese consumers for GM rice using non-GM rice price as a reference. The respondents' were asked objective and subjective prior knowledge questions and acceptance of GM soyoil, livestock products fed GM maize, pest resistant GM rice, and health enhance GM rice. Information treatments that provided science-based descriptions of *Bt* and Golden rice and potential benefits and risks associated with each GM trait were cross elicited with the order for which benefits and risks are presented to the respondents. Finally, we collected information on socio-economic variables that are hypothesized to influence consumer acceptance.

A hypothetical contingent valuation method is used in the form of double-bounded dichotomous choice to estimate the WTP. To test for and calibrate hypothetical bias we provide half of the sample with a cheap talk script. A 1*2 +3*2*2 factorial design was used to test the information effect, calibration effect and ordering /formatting effect as discussed above. Four different information treatments were applied to test the information effect on consumers' valuations toward GM rice: 1) no information or neutral information treatment, 2) health information treatment of Golden rice, 3) environmental information treatment, and 4) combined (stacked) health and environmental information treatment. For the combined environmental health information treatment, the hypothetical rice product which contains both attributes from *Bt* and Golden rice was presented, with benefits and risks. Two ordering/formatting treatments were used on the three specific rice trait information treatments with two tailed characteristics to test the information format effect.

A reference price question is asked after the information and cheap talk treatment. This reference price question offers a reference price of 5 Yuan/ kg for non-GM rice and elicited the basic preferences of the consumers. There are four options for the reference price question which: 1) they prefer to buy GM rice, 2) they prefer to buy non-GM rice, 3) they have an indifferent preference for GM rice and non-GM rice, and 4) they choose not to buy rice. This question operates as a filter, which eliminates respondents who never purchase rice and then segregates those who do purchase rice into two groups. Those who prefer to purchase non-GM rice were presented with a lower price DBDC question set. Those who are indifferent between equally priced GM rice and non-GM rice or who prefer GM rice are then presented with upper price DBDC question set.

The survey ends with a pair of double bounded dichotomous choice (DBDC) question sections (lower first bound price or higher first bound price) to obtain the WTP related to different GM rice products. Each participant is presented with two bids. The first bid is contingent upon the respondent's answer to their choice between non-GM and GM rice priced equally at 5 Yuan/kg. If the response to the reference question is prefer GM or indifferent, then the first bid price for GM rice is randomly assigned in the range of 5.25 Yuan/kg to 7.5 Yuan/kg with intervals of 0.25 Yuan/kg. If the response to the reference question is prefer non-GM then the first bid price for GM rice is randomly assigned in the range of 2.5 Yuan/kg to 4.75/Yuan/kg with intervals of 0.25 Yuan/kg. The level of the second bid is conditional on the answer of the first bid. A "No" response to this first question will have the premium halved and a "yes" response will have the premium doubled.

Double Bounded Dichotomous Choice Model

Based on the empirical estimation framework by Lopez-Feldman et al., (2012) the analytical model of the double bounded model follows. We define the first bid value as $B_{i.}$ If the respondent agrees to purchase the product at the first bid and answers "yes", the second bid (B_{i2})

sets a bid value higher than the first bid ($B_i < B_{i2}$) , and if the answer is "no" then the second bid is at a lower value($B_i > B_{i2}$). Here we specify the second bid with a higher value than the first bid as B_{i2}^h, and with lower value as B_{i2}^l. Using this mechanism, there are four, discrete obsdervable outcomes of the price bidding process for GM rice:

1. "yes, yes", a yes to the initial bid and a yes to the second bid
2. "yes no", a yes to the initial bid and a no to the second bid
3. "no yes", a no to the initial bid and a yes to the second bid
4. "no, no", a no to the initial bid and a no to the second bid

We define the likelihood of the four outcomes as: P^{yy}, P^{yn}, P^{ny}, P^{nn}. According to the assumption for the principle of bidding, consumers will choose the bid which is most likely their ideal willingness to pay to maximize their utilities. When a subject's WTP is higher than the bid, it is expected that the individual will answer yes. Therefore if we define the willingness to pay for a certain respondent *i* as $WTP_{i.}$, we note the probability of observing a positive / negative response for the first bound question at given values as:

$$Pr\text{ (Answer1=1)} = Pr\ (WTP_{i.} > B_{i,}) \quad (1)$$

$$Pr\text{ (Answer1=0)} = Pr\ (WTP_{i.} < B_{i,}) \quad (2)$$

where B_i is the bid price offered to the respondent for purchasing biotech rice, and $WTP_{i.}$ is the respondents' acceptable price for purchasing biotech rice. Answer1 is a binary valued indicator for the response "yes" for the first bounded question.

The likelihood functions of the four outcomes (P^{yy}, P^{yn}, P^{nn}, P^{ny}) for the double bounded question set are generated from (1) and (2). Under the first situation, when the respondent answers " yes" for the first bound question, and "yes" for the second bound question, then $B_i < B_{i2}^h$.

$$P^{yy}(B_i, B_{i2}^h) = Pr(B_i < WTP_{i.} \text{ and } B_{i2}^h \leq WTP_{i.} = Pr(B_{i2}^h \leq WTP_{i.})$$

(3)

Under the second condition, where a "yes" is followed by a "no", we have $B_i < B_{i2}^h$

$$P^{yn}(B_i, B_{i2}^h) = Pr(B_i \leq WTP_{i.} < B_{i2}^h)$$

(4)

Under the third condition, where a "no is followed by a "no", we have $B_{i2}^l < B_i$,

$$P^{nn}(B_i, B_{i2}^l) = Pr(B_i > WTP_{i.} \text{ and } B_{i2}^l \geq WTP_i) = Pr(B_{i2}^l \geq WTP_{i.})$$

(5)

Finally, under the fourth condition, where a "no" is followed by a "yes", we have $B_{i2}^l < B_{i.}$

$$P^{ny}(B_i, B_{i2}^l) = Pr(B_{i2}^l \leq WTP_{i.} < B_i)$$

(6)

If we model the WTP for an individual with relevant information and characteristics, we can model the willingness to pay as follows: $WTP_i = \alpha + X_i\beta + \mu_i, \quad \mu_i \sim N(0, \sigma^2)$ where the parameters β, α, σ^2 are a $K*1$ vector and two scalars, X_i is a $1*K$ vector of explanatory variables. The total sample size is n, and the error term is μ. We can modify the above likelihood functions as:

$$P^{yy}(B_i, B_{i2}^h) = Pr(B_{i2}^h \leq WTP_{i.}) = 1 - \phi\left(\frac{Xi'\beta - Bi2h}{\sigma}\right)$$

(7)

$$P^{yn}(B_i, B_{i2}^h) = Pr(B_i \leq WTP_{i.} < B_{i2}^h) = \phi\left(\frac{Xi'\beta - Bi2h}{\sigma}\right) - \phi\left(\frac{Xi'\beta - Bi}{\sigma}\right)$$

(8)

$$P^{nn}(B_i, B_{i2}^l) = Pr(B_{i2}^l \geq WTP_{i.}) = \phi\left(\frac{Xi'\beta - Bi2l}{\sigma}\right)$$

(9)

$$P^{ny}(B_i, B_{i2}^l) = Pr(B_{i2}^l \leq WTP_{i.} < B_i) = \phi\left(\frac{Xi'\beta - Bi}{\sigma}\right) - \phi\left(\frac{Xi'\beta - Bi2l}{\sigma}\right)$$

(10)

where $\phi(x)$ is the standard cumulative normal distribution function.

Given a sample with n respondents, where $B_{i,}$ B_{i2}^{l}, B_{i2}^{h} are the bids used for the ith respondent. Based on the above functions (7) to (10) , we can then define the log-likelihood function as follows.

$$lnL(\Theta)=\sum_{i=1}^{N}[\,D_i^{yy}\,ln(1-\phi\,(\frac{Xi'\beta-Bi2h}{\sigma}))+D_i^{yn}\,ln\,(\phi\,(\frac{Xi'\beta-Bi2h}{\sigma})-\phi\,(\frac{Xi'\beta-Bi}{\sigma}))$$
$$+\;D_i^{nn}\,ln\,(\phi\,(\frac{Xi'\beta-Bi2l}{\sigma}))+\;D_i^{ny}\,ln\,(\;\phi\,(\frac{Xi'\beta-Bi}{\sigma})-\phi\,(\frac{Xi'\beta-Bi2l}{\sigma}))$$

(11)

where D_i^{yy}, D_i^{yn}, D_i^{nn} ,D_i^{ny} are indicator variables as dummies that take the value of 1 or 0 depending on the related outcomes for each individual.

IV. RESULTS

Summary statistics of the socio-demographic variables are presented in Table 1. Respondents identified as federal employees, company employees and individual business owners were classified as salaried; all others were classified as non-salaried. Based on the record of the Sixth National Census of Population in China (2011), our sample is representative with respect to education, household size, and age. Our sample is also representative of the current Chinese rice consumers because it covers the major rice production and consumption area along Yangzi River, east coast, and Pearl River Delta.

Table 1 also summarizes demographic and socioeconomics characteristics of the two sub samples based on the respondents' answers to the reference question. A total of 725 participants indicated a preference for non-GM rice in the reference question, while 254 indicated indifference or a preference for GM rice.

The two sub-samples are significantly different in terms of household size, acceptance of GM products, GM related terms awareness and governmental administrative division.

Participants who preferred non-GM had a larger household size and were more likely to live in a capital city. This sub-sample also had lower acceptance for GM products and was less aware of the term 'GMO'.

Multinomial logistic regression and marginal effects of the reference questions

A multinomial logistic regression model was estimated to test forsignificant differences among the four choice responses to the reference question. The dependent and independent variables are described in Table 2. The estimated regression coefficients are provided in Table 3, using the response of 'prefer GM rice' as a base.. For this model, there were three replicates of the predictor variables representing the three models that were estimated: "Non-GM rice vs. GM rice", "Indifferent vs. GM rice" and "Neither vs.GM rice".

The estimated coefficients are not easily interpreted quantitatively due to the nature of multinomial logistic model. However a positive coefficient represents higher probability to choose the alternative rice product over GM rice, and a negative coefficient means a lessening probability to choose GM rice compared to relative product for a marginal increase in the related dependent variable

Table 1 Summary statistics for socioeconomic characteristics

Variables	Categories and units	Total sample (n=994)		Lower starting prices (n=725)		Higher starting prices (n=254)	
		Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Age		37.7	12.2	37.9	12.2	36.6	11.9
Household size *		3.5	1.2	3.5	1.2	3.3	1.2
Income level	1,000 Yuan	7.26	7.84	7.04	6.95	7.88	9.98
Meals containing rice per day		2.2	0.6	2.2	0.6	2.1	0.6
Objective knowledge accuracy		0.36	0.16	0.357	0.164	0.364	0.164
GM soybean oil acceptance*		0.64	0.48	0.58	0.49	0.86	0.35
GM corn fed livestock acceptance*		0.65	0.48	0.5	0.5	0.86	0.35
Acceptance of GM pest resistance rice*		0.57	0.5	0.59	0.49	0.8	0.4
Acceptance of health enhanced GM rice*		0.67	0.47	0.61	0.49	0.88	0.33
Heard of term “Hybridization”		0.79	0.41	0.79	0.4	0.78	0.41
Heard of term “Gene”		0.86	0.36	0.85	0.35	0.84	0.36
Heard of term “Biotechnology”		0.69	0.46	0.7	0.46	0.67	0.47
Heard of term “GMO”*		0.86	0.35	0.87	0.33	0.83	0.37
Prior knowledge		2.73	0.9	2.7	0.87	2.79	0.93
Gender	Male	51.11%		50.48%		53.54%	
	Female	49.52%		49.52%		46.46%	
Have Bachelor’s degree or not?	Yes	47.69%		49.10%		43.70%	
	No	52.31%		50.90%		56.30%	
Working status	With salary	58.15%		58.21%		59.45%	
	Without salary	41.85%		41.79%		40.55%	
Governmental Administrative divisions	Capital city*	17.61%		19.86%		11.81%	
	Secondary city*	22.84%		20.69%		27.56%	
	Town	41.95%		42.48%		42.13%	
	Village	17.61%		16.97%		18.50%	
Frequency of purchasing rice	More than once	27.57%		26.76%		30.31%	
	Once per month	43.86%		45.24%		40.94%	
	Less than once	28.57%		28.00%		28.74%	
Current household rice stock(kg)	Less than 5kg	24.95%		25.52%		22.83%	
	5kg or10 kg	37.42%		37.66%		37.01%	
	More than 10kg	37.63%		36.82%		40.16%	
*Statistically significant at 5% level between two sub-samples.							

Table 2 Descriptions of multinomial logit model variables

Variables	Sub factors	Description
Dependent variable	Non-GM rice, GM rice, Indifferent, Neither	Indifferent: between GM and Non GM rice, Neither: do not purchase any rice product
Age	Continuous variable	
Male	Binary variable	Whether the gender of the respondent is male or not
Bachelor's degree	Binary variable	1 = bachelor's degree or higher, 0 = less than bachelor's degree
Household size	Continuous variable	The house hold number
Salary Status	Binary variable	1= salaried income, 0 = no salary
Meals	Continuous variable	Number of Meals including rice per day
Income	Continuous variable	The median value was chosen of every categorical option and divided by 1000
Objective knowledge accuracy	Continuous variable	The accuracy rate of six objective knowledge true/false questions
Cheap talk	Binary variable	1= cheap talk script, 0= no cheap talk
Information treatments	No specific trait information Health trait br (Golden rice) information, benefits first then risks Health trait rb (Golden rice) information, risks first then benefits Environment trait br (Bt rice) information, benefits first then risks Environment trait rb (Bt rice) information, risks first then benefits Stacked br health+environment information, benefits first then risks Stacked rb health+environment information, risks first then benefits	Information and order treatment code
City size	Large population , median population ,small population	Variable City was recorded by urban population density
Administrative divisions	Capital city, Secondary city, town, village	Governmental administrative divisions
Media source	Binary variable	Whether the respondent think that food related information from TV or Newspaper media were more reliable.

Table 3 Multinomial regression results to the reference question responses.

Reference question	Coef.	P	Coef.	P	Coef.	P
Rice preferences	Prefer non GM rice		Indifferent		Neither	
Male	-0.36	0.13	-0.25	0.37	-0.54	0.39
Age	0.015	0.142	0.001	0.918	-0.012	0.657
Bachelor's degree	0.512	**0.04	0.14	0.63	0.55	0.42
Household size	0.05	0.59	-0.25	**0.04	-0.72	***0.01
Salary status	0.34	0.15	0.52	0.06	-0.48	0.45
Meals	0.11	0.60	0.11	0.63	-0.27	0.60
Income continuous	0.000	0.28	0.00	0.98	0.00	0.72
True false accuracy	-0.44	0.54	-0.46	0.59	-3.14	0.13
Cheap talk	0.30	0.21	0.06	0.83	0.46	0.45
Information and order (No information base)						
Health trait br	0.86	*0.08	0.58	0.29	-0.27	0.83
Health trait rb	-0.03	0.94	-0.26	0.59	-1.15	0.35
Environmental br	0.25	0.56	0.21	0.68	0.78	0.40
Environmental rb	0.72	0.13	0.62	0.24	0.55	2.56
Stacked trait br	-0.10	0.81	-0.08	0.86	-0.62	0.55
Stacked trait rb	0.08	0.84	0.04	0.94	-13.61	0.98
City size (Middle base)						
Large	-1.00	***0.01	-1.28	***0.00	-1.56	**0.05
Small	-0.96	***0.00	-1.28	***0.00	-2.99	***0.01
Administrative division(Capital city base)						
Second level city	-0.97	**0.03	-0.11	0.83	1.13	0.38
Town	-0.99	**0.02	-0.56	0.26	-0.54	0.70
Village	-0.93	*0.06	-0.22	0.71	1.34	0.34
Media sources	-0.43	*0.07	-0.18	0.52	-0.32	0.61

***statistically significant at 1% level, ** at 5% level, * at 10% level

To better interpret the the Table 3 coefficients, marginal changes in probabilities were computed for the four outcomes with all continuous variables set at their mean values[1]. MERS (marginal effect at representative values) were computed to obtain the overall effect of the factor variables and illustrate intuitively meaningful results. These estimates are presented in Table 4.

[1] age=37.6, household number=3.5, monthly income=7261.6 Yuan, true false question set accuracy =36%

Based on the results from Table 4 we can interpret the marginal probability of each outcome over different variables. These marginal effects represent changes in probabilities of selecting outcomes. Respondents who had a bachelors degree were 7.46% more likely to choose “Non-GM rice” and 3.4% less likely to choose “GM rice” among all the alternative options.. Having a bachelor’s degree also decreased the probability of choosing “Indifferent” by 4 %(p-value < 0.10). The administration of the cheap talk script applied increased the probability of choosing “non-GM rice” 4.5% (p-value < 0.10. Compared to those who had the no specific trait information treatment, respondents who had “Health br” treatment are 8.77% more likely to choose “non-GM rice”, 5.4% less likely to choose “GM rice” (p-value < 0.10)at, and 2.4%, 1% less likely to choose “Indifferent” and “Neither” insignificantly.

Compared to respondents who lived in a middle-sized city, people who lived in either large or small population density city were more likely to choose “GM rice” over the other three alternatives. Respondents who lived in a capital city are significantly more likely to choose “conventional rice” and those who lived in town are 6% significantly more likely to choose “GM rice”. Respondents who thought TV and newspaper media sources offered more reliable food information were significantly less likely to pick “non-GM rice” by 5.7% and more likely to pick other outcomes on the response scale. In conclusion, respondents who lived in a capital city, had a bachelor’s degree, had a health related information formatted in benefit risk order treatment are more likely to choose non-GM rice; respondents who lived in a small city or town, do not have a bachelor’s degree and had “no information” treatment are more likely to choose GM rice over other alternative rice products regardless of price difference.

Table 3 MERs of the four outcomes

	Non-GM rice	GM rice	Indifferent	Neither

Variables	MER	P>z	MER	P>z	MER	P>z	MER	P>z
Male	-3.45%	0.22	2.62%	0.15	1.06%	0.66	-0.23%	0.70
Bachelor's degree	7.46%	***0.01	-3.39%	*0.07	-4.23%	*0.09	0.16%	0.82
Salary status	0.71%	0.80	-2.87%	0.13	3.02%	0.21	-0.86%	0.20
Cheap talk	4.47%	*0.10	-1.94%	0.28	-2.78%	0.23	0.25%	0.68
Information and order (no information as base)								
health order1	8.77%	**0.08	-5.36%	*0.09	-2.43%	0.58	-0.98%	0.37
health order2	3.12%	0.55	0.73%	0.84	-2.84%	0.51	-1.01%	0.35
Environment order1	1.34%	0.80	-2.04%	0.56	-0.37%	0.93	1.08%	0.51
Environment order2	5.36%	0.29	-4.85%	0.13	-0.36%	0.94	-0.15%	0.90
combine order1	-0.49%	0.93	0.93%	0.80	0.18%	0.97	-0.62%	0.59
combine order2	2.23%	0.67	-0.51%	0.89	-0.16%	0.97	-1.55%	0.11
City size(middle as base)								
large	-1.21%	0.76	7.11%	**0.03	-5.16%	0.13	-0.74%	0.39
small	0.04%	1.0	6.85%	***0.01	-5.38%	*0.07	-1.50%	**0.03
Administrative divisions(capital city as base)								
second level city	-16.26%	***0.0	4.90%	*0.06	9.83%	***0.01	1.53%	* 0.09
town	-9.92%	***0.01	5.95%	***0.01	3.86%	0.26	0.11%	0.79
village	-14.21%	***0.00	4.78%	0.12	7.52%	*0.09	1.91%	0.14
Media source	-5.73%	**0.04	2.93%	* 0.10	2.77%	0.24	0.03%	0.96

***statistically significant at 1% level, ** at 5% level, * at 1 percent level.

Double bounded dichotomous choice model and WTP

Based on the answer to the reference question, the sample was divided into three sub samples. 725 respondents who chose non-GM rice were assigned lower starting prices in the double bounded questions set; those respondents who preferred GM rice and those who were indifferent were grouped together as 254 observations to a higher starting prices double bounded questions set; the 15 respondents who showed no preference in purchasing rice products were excluded from the WTP estimation. The double bounded elicited module in STATA was applied to obtain the DBDC parameter estimates (Lopez-Feldman, 2012). Table 5 summarizs the additional variables' description for the double bounded analysis included as the DBDC but not the multinomial logit.

Lower starting prices DBDC and WTPs

Each respondent who preferred non-GM rice for the reference question was assigned to the lower starting price double bounded dichotomous question set. Ten starting prices from 2.5 Yuan/kg to 4.75 Yuan/kg with a 0.25 Yuan/kg interval were randomly assigned to the 725 participants. Based on the response on the first bound question, a follow-up dichotomous question was then provided with the secondary price set as either double or half the premium (here we defined the premium as the price difference between the starting point price and the reference price of 5Yuan/kg). The proportion of positive answers declined as first bound prices increased, which indicated that individuals were sensitive to the bid amount. Regardless of the difference in starting prices, 72.5% respondents chose "no" to buy GM rice at the first bid questions. Table 6 summarizes the lower starting price DBDC model estimation.

Table 4 Variable description of DBDC model

Original categories	Variable label	Description
Information and order treatment combination	EO1	Environmental information benefit risk order
	EO2	Environmental information risk benefit order
	HO1	Health information benefit risk order
	HO2	Health information formatted in order2
	CO1	Aggregated information formatted in order1
	CO2	Aggregated information formatted in order2
Meals	Meals	Number of meals with rice per day
Administrative division	VL1	Respondents reside in capital cities
	VL2	Respondents reside in secondary cities
	VL3	Respondents reside in towns
	VL4	Respondents reside in villages
Rice purchase frequency(rp)	Once/month	Respondents who purchase rice once a month
	< once	Purchase rice less than once a month
	> once	Purchase rice more than once a month
Rice stock	<5kg	Current house rice stock less than 5 kg
	5kg-10kg	5kg<Current house rice stock<10kg
	>10kg	Current house rice stock more than 10kg
Heard of Terms	terms_1	Heard of term: hybridization or not
	terms_2	Heard of term: Gene or not
	terms_3	Heard of term: biotechnology or not
	terms_4	Heard of term: Genetically modified food or not
Subjective knowledge(GMPK)	Gm good	Subjectively considered GM knowledge at good level
	Gm neutral	Subjectively considered GM knowledge at normal level
	Gm poor	Subjectively considered GM knowledge at poor level
Golden rice case	golden	Have heard the 2012 golden rice case in Hainan
Acceptance of GM products	ac1	Acceptance rate of GM soybean over 50%
	ac2	Acceptance rate of GM feed livestock over 50%
	ac3	Acceptance rate of GM pest resistant rice over 50%
	ac4	Acceptance rate of GM health enhanced rice over 50%
Objective knowledge accuracy	TF accuracy	The accuracy ratio for six true false questions

Keeping other variables at their mean value, having a bachelor's or higher degree decreased the willingness to pay by 0.56 Yuan. A one unit increase in household number decreased WTP by 0.24 Yuan. A one unit increase in meals with rice per day decreased the WTP for GM rice by 0.48 Yuan. A thousand Yuan increase of a respondent's monthly salary significantly decreased the WTP for GM rice by 7 Fen. Purchasing rice on a monthly basis decreased the WTP for GM rice by 0.8 Yuan. Respondents whose household rice stock is less than 5 kg had a 1 Yuan lower WTP than respondents from households with other stock levels.The awareness of hybrid technology and bio-technology also negatively affected the WTP in a by decreasing the price of GM rice 1.4 Yuan and 1 Yuan, respectively. Subjects who stated their understanding of GM rice as good or normal were willing to pay less for GM rice by 0.86 Yuan and 0.76 Yuan. Not surprisingly, the acceptance of GM related products had a positive impact on the WTP of GM rice. Relative to Bt rice, a one unit increase of acceptance for GM soybean oil, GM corn-fed livestock and GM health enhanced rice increased the WTP of GM rice by 0.7 Yuan, 1.2 Yuan and 1 Yuan, respectively.

Table 5 DBDC model for lower starting price sub-sample

Variables	Coef.	P	Variables	Coef.	P	Variables	Coef.	P
EO1	0.03	0.96	VL1	-0.42	0.47	terms_2	0.16	0.76
EO2	-0.17	0.74	VL2	-0.80	0.11	terms_3***	-0.99	0.01
HO1	-0.34	0.51	VL3	-0.10	0.82	terms_4	-0.30	0.55
HO2	-0.58	0.27	VL4	omitted		Gm good*	-0.86	0.09
CO1	-0.06	0.92	Large City	-0.62	0.14	Gm neutral*	-0.75	0.08
CO2	-0.44	0.40	Small City	0.15	0.68	Gm poor	omitted	
Cheap talk	0.30	0.28	Middle city	omitted		golden	-0.58	0.14
male	0.08	0.80	Once a month**	-0.78	0.03	ac1**	0.74	0.05
age	0.01	0.44	<once	-0.36	0.38	ac2***	1.21	0.00
Bachelor's degree*	-0.56	0.01	>once	omitted		ac3	0.44	0.21
Household size*	-0.24	0.06	<5kg**	-0.99	0.02	ac4***	1.09	0.00
Salary status	-0.25	0.38	5kg-10kg	-0.50	0.14	Media	-0.16	0.56
Income ***	-0.07	0.00	>10kg	omitted		TF accuracy	-0.26	0.76
Meals*	-0.48	0.06	terms_1***	-1.36	0.00	_con	2.857	

***statistically significant at 1% level, ** at 5% level, * at 1% level.

Table 7 presents a summary of the WTP estimates among information treatments. With every variable set at their mean value, the mean WTP for GM rice by this particular group is 1.60 Yuan/kg, which is a 68% discount from non-GM rice price at 5 Yuan/kg. The WTP for respondents who received the neutral no specific trait information treatment was 1.83 Yuan/kg which was significantly higher than the mean WTP and other information treatments.

Table 6 Mean WTP for GM rice by respondents who preferred non-GM rice.

WTP	Yuan/kg	Std.Err
Mean	1.60	0.37
No specific trait information	1.83	0.51
Health trait nformation	0.91	0.73
Environmental trait information	1.69	0.72
Stacked trait information	1.33	0.73
Order benefits risks	1.46	1.04
Order risks benefits	0.64	1.04
With cheap talk	1.45	0.40
Without cheap talk	0.76	0.39

Consumers who were provided with health related information registered the lowest WTP among the information treatments at 0.91 Yuan/kg, not significantly different from 0. A low WTP result was also obtained for the stacked event rice trait information and order formatting. The mean WTP under different information treatments provided the following WTP rank of No specific trait information> environmental trait information> stacked trait information>health information. With respect to benefits and risk information ordering, respondents were WTP a much higher amount when informed of benefits followed by risks than vice versa. Indeed when risks were presented first, respondents had a very low WTP for GM rice of 0.64 Yuan/kg, not significantly different from zero. Cheap talk was tested as the calibration method. The results suggest that hypothetical bias for this sample who prefer non-GM rice lowers the WTP estimate for GM rice. The WTP estimate was almost twice higher for the respondents provided the cheap talk script. This result suggests that the respondents in this particular group had a significantly large hypothetical bias against GM rice.

The effects of the variables presented in Table 6 on the WTP provide additional insights. Treating the respondent as one who purchases rice once a month, leaving all other independent variable values as their mean values, the WTP is 1.28 Yuan/kg, 20% lower than the Mean WTP. Respondents whose current rice stock was less than five kilogram offered a WTP of 1.05 Yuan/kg for GM rice. Compared to those who had no awareness of hybrid technology and biotechnology, respondents who had heard of these terms were willing to pay much less for a kilogram of GM rice, 1.33 Yuan/kg vs.2.68 Yuan/kg; and 1.31 Yuan/kg vs.2.30 Yuan/kg, respectively. Respondents who indicated a high acceptance of GM soybean, GM corn fed livestock, and health enhanced rice, were WTP more for GM rice. The WTP estimates for GM rice were: 1.92, 2.10, and 2.04, respectively, exceeding the mean WTP for the total sample. Consumers with less than a bachelor's degree were WTP more for GM rice than those who had a bachelor's or higher degree, (1.87 Yuan/kg vs.1.33 Yuan/kg) however, it was only significantly differently at the 90% level. Respondents who had more intensive rice diets were WTP less for GM rice. Respondents who subjectively considered themselves with good and normal knowledge on GM rice were willing to pay significantly less than those who considered themselves less knowledgeable. Finally, respondents with higher incomes were WTP significantly less for GM rice.

Higher starting prices DBDC and WTPs

The same DBDC analysis was conducted for the sub-sample who responded to the reference question as having preferred GM rice or were indifferent to GM and non-GM rice at a price of 5 Yuan/kg. This sub-sample of 254 respondents were randomly assigned to 10 higher starting prices for the first bound ranging from 5.25 Yuan/kg to 7.5 Yuan/kg with a 0.25 Yuan/kg interval. We use the same variables to estimate the effect of explanatory variables on WTP estimates.

Table 7 Higher starting prices DBDC model

Variable	Coef.	P>z	Variable	Coef.	P>z	Variable	Coef.	P>z
EO1	0.18	0.76	Bachelor's degree	0.38	0.39	terms_4	-0.54	0.38
EO2	0.28	0.66	Household size	0.08	0.60	Gm good	-0.11	0.85
HO1	-0.86	0.20	Salary status**	-0.73	0.05	Gm neutral	0.62	0.23
HO2	0.20	0.74	Income ***	0.05	0.00	Golden**	0.87	0.02
CO1	0.78	0.18	Meals	0.43	0.14	ac1	0.56	0.34
CO2	-0.17	0.78	Rice purchase	-0.18	0.42	ac2	0.30	0.62
Cheap talk	-0.30	0.38	Rice stock	-0.10	0.68	ac3	-0.14	0.78
male	-0.23	0.49	TF accuracy**	2.47	0.02	ac4	0.16	0.79
Age*	0.03	0.05	terms_1	0.10	0.82	Media *	-0.61	0.07
terms_3	0.35	0.44	terms_2	-0.22	0.74	_cons	2.349	

From the table 8, relatively few variables were determined to be statistically significantly. Age of the respondent was associated with a higher WTP, one unit increase in age would lead the WTP increase by 3 Fen. A one unit (1000 Yuan) increase in income would also increase the WTP by 5 Fen/kg. Holding other variables at their mean values, respondents who were salaried were WTP 0.73 Yuan/kg less than those who did not. Objective knowledge was associated with a significantly higher WTP. The difference between 100% accurate rate and 0% accurate rate was 2.47 Yuan/kg. Surprisingly the awareness of 2012 Golden rice experimental event was associated with a significantly higher WTP by 0.87 Yuan/kg. Respondents who were aware of the school children Golden rice experimental study were WTP 6.16 Yuan/kg compared to 5.29 Yuan/kg by those who were not aware of this scandal.

Table 8 Mean WTP for GM rice by respondents who preferred or were indifferent to GM rice

WTP	Yuan/kg	Std.Err
Mean	5.72	0.168
No specific trait information	5.62	0.418
Health trait Information	4.96	0.804
Environmental trait information	6.07	0.750
Stacked trait information	6.23	0.733
Order Benefits risks	5.72	1.143
Order Risks benefits	5.92	1.138
With cheap talk	5.55	0.252
Without cheap talk	5.85	0.227

The mean WTP for GM rice by the upper price bound sub-sample was 14.4% higher than for non-GM rice. The WTP ranked by information treatment was: Stacked trait information > Environmental trait information > No specific trait information > Health trait related information. In this higher starting prices DBDC group, respondents were WTP more for environmental trait GM rice than for the health trait GM rice. The ordering effect of benefits and risks had no significant effect even though surprisingly, the WTP when risks were ordered first was slightly higher than the WTP when benefits were ordered first. Also the calibration using the cheap talk script showed no significant difference in WTP, although there was a slight bias to a higher WTP by those respondents who were not administered the cheap talk script.

V. SUMMARY AND CONCLUSION

This paper provides an assessment of Chinese consumer attitudes and WTP for GM rice based on a survey of 994 urban consumers in the summer of 2013. The survey collected socio-demographic information and used a reference question to create sub-samples of respondents according to their preference for GM rice relative to non-GM rice at a reference price of 5 Yuan/kg. A large majority, 73% of the sample, preferred non-GM compared to GM rice. The mean WTP estimate for GM rice by this sub-group suggested that a discount of 68% was required to make GM rice competitive. The remainder of the sample responded to the reference question as either preferring GM rice to non-GM rice (9%) or indifferent (17%). The mean WTP for those who preferred or were indifferent to GM rice suggested a WTP premium for GM rice of 14.4%.

Socio-demographic variables that significantly lowered the WTP estimate for GM rice by those who preferred non-GM rice included education level, household size, income level, rice intensity of the diet, small household inventory of rice stocks, awareness of terminology 'hybridization' and 'biotechnology' and the respondent's subjective knowledge of GM rice. A higher WTP was associated with respondents who were more likely to accept GM soyoil, livestock fed GM maize, and health-enhanced GM rice.

For the respondents who preferred GM rice or were indifferent, their willingness to pay for GM rice was negatively associated with having a salaried job and trusting TV, radio and print media as a more reliable source of information on food. WTP by this group was significantly higher with the repondent's age, income, objective knowledge of genetic and biotech facts and awareness of the Golden rice scandal.

Compared to a similar study by Lin et al. (2007) our results showed a much lower acceptance rate for GM rice. The results suggest that the government of China is facing an increasingly difficult barrier by consumers for the commercialization of GM rice. The results suggest the importance of providing science-based objective information to improve the knowledge of Chinese consumers. Respondents who thought they were more knowledgeable about GM rice are associated with a significantly lower WTP for GM rice. If the China government is to be successful in its campaign to boost rice productivity through biotechnology, then it will not only have to provide more science-based information but also change entrenched negative attitudes and opinions with regard to GM rice.

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