Consumer Valuation of the Second Generation of Genetically Modified (GM) Foods with Benefits Disclosure

by

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Abstract

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Employing contingent valuation method (CVM), the study explores whether or not consumers' risk/benefit beliefs and knowledge about GM foods affect their behavior as measured by willingness to pay (WTP) a premium for GM beef with benefits. The results demonstrate that risk/benefit perceptions play a significant role to elicit WTP for GM beef with benefits

Genetic modification (GM) offers the potential for production of foods and feed crops with improved characteristics, such as more nutritious components, improved resistance to disease and pests, better taste, and so on. GM foods are foods containing ingredients from plant and animal organisms produced using scientific techniques that involves taking genes from one species and inserting them in another species to transfer a desired trait or characteristic[1]. GM crops offer opportunities for farmers to lower production cost, increase crop production, and increase profits by using inputs more efficiently. Additionally, GM crops provide other potential benefits, such as improving environmental quality by using less pesticide and herbicide, enhanced food quality and safety, and by mitigating world food shortages.

However, despite the benefits, some consumers view biotechnology as a risky process, and have a greater interest in assuring food safety. Consumers with unfavorable attitudes toward GM products may expect to have the right to know whether or not products are produced using biotechnology. Consumer concerns regarding biotechnology are believed to stem from potential unknown effects due to the modifications of genes and nutritional contents of food. In addition, concerns of environmental quality from contamination of organic crops and/or herbicide resistant weeds and morality are other factors to influence consumer attitude of GM foods.

Consumer acceptance of GM foods has been mixed due to differences in perceived risk and benefit of these foods. Acceptance of GM products is associated with

[1]FDA and USDA suggest using "bioengineered" or "biotech" to describe foods produced using biotechnology. However, the terms "genetically modified (GM) and "genetically engineered" are commonly used in academic publications. In this paper, the terms "biotechnology", "biotech", "genetically modified", and "genetically engineered" are used interchangeably. The terms refer to all modern techniques in cellular and molecular biology used to alter the genetic composition of foods or food ingredients, including in *vitro* nucleic acid, recombinant DNA, genetic modification, and genetic engineering.

the consumers' risk/benefit beliefs about biotechnology. When consumers perceive benefits to themselves and society, they are expected to have more a favorable attitude toward GM foods, relative to consumers who perceive no benefit. On the other hand, if consumers perceive GM foods as a health risk, and risky to the environment, they would possess a less favorable attitude to those foods. In this regard, consumers' risk/benefit beliefs of GM foods are expected to play a significant role in shaping their behavior of GM foods. In analyzing consumer behavior of GM foods, however, a problem researchers confront is that U.S. consumers' actual behavior of GM foods can't be fully observed. A main reason is that consumers are not provided much opportunity to reveal their preference due to restricted products experience from unavailability of many GM foods and voluntary labeling policy. Instead, researchers rely on consumers' self reported behavior, or intention to behave. In psychology, consumers' conscious decision is intention, and most behavioral scientists agree that the consumers' intention is the best predictor for their behavior. The objective of this study is to explore whether or not consumers' risk/benefit beliefs and knowledge about GM foods affect their behavior as measured by willingness to pay (WTP) a premium for GM foods with benefits disclosure.

Literature Review

Several studies elicited public perceptions of biotechnology. Grobe et al. (1999) studied consumer risk perception associated with recombinant Bovine growth hormone (rbGH), which is a food-related biotechnology used in milk production. The study indicated diverse consumer profiles across risk perception categories. In addition, the study showed that consumers who engaged in a self-protective action were strongly correlated with environmentalist concerns. Hoban (1999) discovered that consumers from

different areas of the world, including the U.S. and France, have quite diverse perceptions and understanding toward biotechnology. The study concluded that consumer perceptions about biotech products vary significantly depending on type of information, government credibility, and cultural preferences. According to Harrison and Han (2005), as beliefs regarding potential adverse effects of GM crops on wildlife and the environment increase, the less likely consumers are to support FDA's current labeling policy. The study suggests that consumer beliefs are significant determinants of consumer attitude toward the current labeling policy.

A number of studies have also estimated WTP for GM and non-GM food products. An initial effort to estimate WTP for GM free product is reported in Fox et al. (1994). The study demonstrated once consumers who had a strong negative bias against bST prior to the experiment received balanced scientific explanation of the product, about 70% of them expressed a willingness to buy the product at zero or small discount. Stefano and Daniele (2000) showed that income and information about biotechnology are significant determinants affecting WTP for GM foods. Their analysis indicated that when consumers are given correct information, they are more likely to pay higher prices to benefit from quality improvements. In addition, the study suggested that consumers' WTP should be different depending upon degrees of risk type and risk avoidance. A study by Lusk et al. (2001) showed that students had more receptive of GM foods and strong willingness to consume them. Seventy percent of students were unwilling to pay a premium for non-GM corn chips, but 20% of participants were willing to pay at least $0.25/oz for non-GM corn chips. The study found that students who often consume GM corn chips have less concerns of the perceived risk associated with GM foods. Moon and

Balasubramanian (2001) assumed that consumers' WTP premium for non-GM foods can be investigated by examining subjective risk and perceptions about biotechnology. The study revealed that strong health risk perceptions for both US and UK consumers increases the probability to pay a premium for non-GM foods. On the other hand, as they are aware of benefits about biotechnology, they are less likely to pay a premium for non-GM foods. An impact of information of GM products on WTP is investigated by Tamara et al. (2003). Their results showed that when positive-biased information regarding GM products is provided, WTP for GM products increased. The study also suggested that the effect of biased information on acceptability and WTP for GM products depend upon product type. Loureiro and Bugbee (2005) estimated consumers' WTP for enhanced GM tomato. Their analysis suggested that consumes pay the highest premiums for modification which increase the tomato flavor or enhance the nutritional value. The study pointed that attitudinal variables (such as feeling about GM modification) play a statistically significant role in explaining consumer acceptance and WTP for different modifications.

The present study is different from previous studies in three ways. First, most of the literature has dealt with consumer WTP for non-GM foods. The first generation of GM foods offers benefits primarily for producers and the environment. However, second generation of GM foods providing benefits to consumers is just around corner. To date, few quantitative studies have examined linkages between a consumer's risk/benefit beliefs about GM foods, with benefits disclosure, and WTP for those foods. Second, the study utilizes a series of diagnostic measures to appraise internal consistency of theoretical concepts, such as belief, attitude, and intention. Third, contingent valuation

method (CVM) for the study is used to elicit consumers' WTP a premium for GM foods. To prevent hypothetical bias stemming from hypothetical nature of questions presented to respondents, two widely used approaches for correcting them, which are a follow-up certainty question with some adjustment and cheap talk, are employed. (Cummings and Taylor,1999; List, 2001; Lusk, 2003; Aadland and Caplan, 2003; Champ et al., 1997; Champ and Bishop, 2001; and Poe et al., 2002). To our best knowledge, none of the studies has used both methods at the same time.

The GM product chosen for the study is beef containing less fat and lower cholesterol compared to usual beef. Given that beef is a staple food, it is assumed that normal consumers are familiar with the conventional food.

A Theoretical Framework

When analyzing consumer intentions, an important question is what factors cause intention development. The presumption is that beliefs are key elements in forming attitudes, intentions, and eventually influencing behavior. Beliefs represent the base set of information that a consumer has about an object or concept (Fishbein and Ajzen, 1975). Thus, these beliefs describe all thoughts that a consumer has about GM foods in association with various attributes, and beliefs play an important role in forming attitude mediating intention (Moon and Balasubramanian, 2004; Bredahl, 2001; and Grove and Douthitt, 1995).

According to Fishbein's multi-attribute model, a person's attitude toward any object is a function of his/her beliefs about the object and the implicit evaluative responses (or aspects) associated with those beliefs (Fishbein, 1963). Engel, Blackwell, and Kollat (1978) defined attitude as "a learned predisposition to respond consistently in

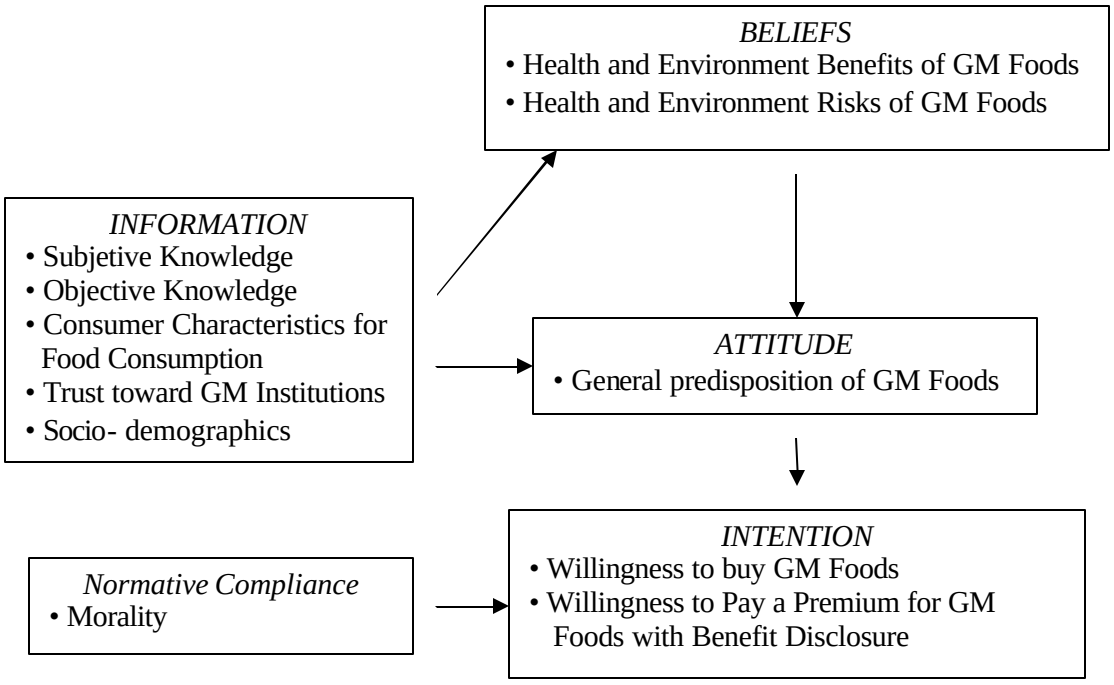
a favorable manner with respect to a given alternative" (p.388). Thus, attitude refers to consumers' favorable or unfavorable evaluation of GM foods, and attitude formation is closely related to consumer evaluation of GM foods. A consumer's attitude toward GM foods, following Fishbein's theory, is a function of the strength with which a consumer holds beliefs (i.e., his/her subjective probability that GM foods are related to specific attributes) and of his/her positive or negative evaluation of each attribute. The strength of belief associated with a given attribute is multiplied by the consumers' positive or negative evaluation of the attributes involved. The belief effects are then summed across all attributes. Algebraically, it is hypothesized that $A = \sum_{i=1}^{N} B_i a_i$, where A = consumer's total attitude toward GM foods, B_i = the consumers' belief regarding attribute 'i', a_i = the evaluative aspect of B_i, and N = the number of beliefs. Beliefs and their evaluative aspects are acquired via a consumer survey. Intention indicating a certain amount of affect toward an object is defined as "the subjective probability that beliefs and attitudes will be acted upon" (p.388, Engel, Blackwell, and Kollat, 1978). While attitude is viewed as a general predisposition that does not predispose the person to perform any specific behavior, intention is related to a specific behavior.

Past studies demonstrated that consumer beliefs not only have a major mediating effect in shaping their attitude, but also beliefs are influenced by socio-demographic characteristics (for example, Moon and Balasubramanian, 2004; Grove, Douthitt, and Zepeda, 1999; and Lin, 1995). In addition, a few previous studies suggest that various socio-demographic factors influence information acquisition, consequently attitude and behavior (for example, Nayga, 1996; Florkowski et al., 1994; and Ippolito and Mathios, 1990). Thus, based on attitude theory and previous studies, we hypothesize that attitude is

affected by both the information available to consumers and consumers' beliefs about GM foods. To accomplish the objectives of the study, the choice process model by Engel, Blackwell, and Kollat (1978) is used as a conceptual basis for our model specification.

The theoretical framework for the analysis is presented in Figure 1. It shows a consumer's cognitive process for WTP for GM foods. A consumers' WTP regarding GM foods is determined by his/her intention viewed as the determinant of the behavior. Figure 1 depicts a basic framework for how consumers' WTP a premium for GM foods is affected by various types of information, which have a direct effect on consumer attitude

Figure1. A theoretical model of explaining willingness to pay a premium for GM foods.



Adapted from Engel et al. , 1978

and an indirect effect via the belief system. In addition, Figure 1 shows a recursive (or sequential) linkage between beliefs, attitudes, and intention. Beliefs comprise 2 factors, benefits and risks perceptions of GM foods regarding the health and environment. For attitude toward GM foods, consumers' general predisposition with respect to them is

explored. Consumers' perceived morality about GM foods reveals personal norms. It is assumed that perceived morality directly influences consumer intention to pay a premium for GM foods. Finally, a consumer's WTP a premium for GM foods is hypothesized to be a function of attitude.

Empirical model

It is assumed in the study that there are two reasons for a large number of zero values on WTP a premium for GM foods: i) consumers are not willing to pay a premium for GM foods (nonparticipation in the market); and ii) consumers do not pay a premium for GM foods at current income level (corner solution). Tobit model developed by Tobin (1958) assumes that zero observation is attributable to only economic factors, such as prices and income levels (corner solution) (Jensen, 1995; and Newman, 2003). In addition, tobit model supposes that the decision to participate in the market is the same as the decision about the amount of the premium to pay. This implies that any variable that increases the probability of nonzero value must also increase the conditional mean of the positive values. This strong restriction may not be appropriate for WTP a premium for GM beef.

Double hurdle model developed by Cragg (1971) allows the variables to affect the participation and the quantitative premium decisions separately. Double-hurdle model generalizes the tobit model in that even though consumers may have positive reception toward GM foods with direct benefits, impediments to pay a premium for those foods, due to foods safety and environmental concerns as well as budget constraint, may prohibit WTP a premium. This recognition leads to the modeling of consumer behavior in two stages: i) first, based on hindrances to buy GM foods and pay a premium, consumers

decide whether or not to buy GM foods and pay a premium for GM beef; and ii) second, according to the intensity of the desire for the GM foods, the consumers decide on how much to pay a premium for GM beef. As economic theory provides little guidance as to which variable should appear in the first and second hurdle, the approach followed has been to include the same set of variables in both decisions.

The double hurdle model is specified as follows:

$$
\begin{aligned}
d_i &= \mathbf{z_i}'\gamma + \eta_i \\
y_i^* &= \mathbf{x_i}'\beta + \varepsilon_i \\
y_i &= y_i^* \text{ if } d_i > 0 \\
y_i &= 0 \text{ if } d_i \le 0
\end{aligned}
\tag{1}
$$

where y_i^* represents the optimal premium level of i^{th} consumer for GM beef, and it can be interpreted as the solution to a utility maximization problem. y_i^*, can take on negative values, but values of y_i^* less than zero are unobserved. y_i is the i^{th} consumer's observed premium for GM beef that he/she is willing to pay, and y_i is censored at zero. d_i represents the decision (participation) of whether to buy GM foods and pay a premium. It is assumed that only the sign of d_i as a latent indicator is observed, and y_i^* is observed only when d_i is positive. $\mathbf{z_i}$ is vectors of explanatory variables in decision stage. The error terms, η_i and ε_i, are independently and normally distributed with zero means and constant variances $(1, \sigma^2)$. y_i^*, in terms of willingness to buy GM foods, is rated on 5-point Likert scales, strongly disagree-strongly agree scale. We formed a summated rating scale, by summing respondents' scores on 5 items, and obtained average score ranging from a low of 1 to a high of 5. To make sure if respondents tend to take similar position on the other items, the data value of a variable with negative direction is reversed (i.e. go

from negative to positive). Then, 'agree' and 'strongly agree' responses are treated as 'yes' to willing to buy GM foods. $\mathbf{x}_i$ is a vector of explanatory variables including information, beliefs, attitude, and normative compliance explained in the theoretical model.

It is assumed that latent constructs, such as information, beliefs, attitude, normative compliance, and intention, are not observable and directly measured. Instead, these latent variables can be observed via other direct observable proxy indicators. To measure each latent variable, multiple indicators that measure the same concept into a single variable are summated, and the average score of the variables is used as a replacement variable. This summated scale provides a specific advantage. It offers a means of overcoming to some extent the measurement error in the estimation process occurring from abstract or theoretical concepts, thus increases the reliability (Hair et al., 1998). Because the construct reliability is a closer approximation of reliability, it is preferred over Chronbach's alpha. If construct reliability value is higher than 0.6, it means that construct reliability is good with high internal consistency (Fornell and Bookstein, 1982). Most of multi-item scales demonstrate a relatively high degree of the internal consistencies ranging from 0.75 to 0.94.

In the tobit model, the variables ($\mathbf{x}_i$) and parameters (β) describes the decision of whether to buy a GM foods and pay a premium, and of how much to pay. In the double hurdle model different sets of variables ($\mathbf{z}_i, \mathbf{x}_i$) and parameters ($\gamma, \beta$) explain the two decisions.

The log likelihood function for an equation (1) is

$$\ln L = \sum_{y_i>0} -\frac{1}{2}[\log(2\pi) + \log\sigma^2 + \frac{(y_i - \mathbf{x}_i'\beta)^2}{\sigma^2}] + \sum_{y_i=0} \ln(1-\Phi(\mathbf{z}_i\gamma)) + \sum_{y_i>0} (\log\Phi_i(\mathbf{z}_i\gamma) - \log\Phi_i(\frac{\mathbf{x}_i\beta}{\sigma})) \quad (2)$$

Specification test employing a likelihood ratio statistic for the tobit model and the double hurdle model is performed to decide which model is more consistent with the fundamental consumer behavior for GM beef.

Data and Questionnaire

The data analyzed in this study were collected in a random, national, mail survey of 3,999 households conducted in July 2005. Each of the 3,999 people was mailed a survey package. The packet with a postage-paid return envelope includes a letter which briefly explains the purpose of the survey, encourages their participation, and provides background information about the genetic modification. A reminder letter and a follow-up questionnaire were sent to non-respondents three weeks after the initial mailings.

A representative sample is always concerns to a researcher. Thus, to truly represent current U.S. population distribution, the sample was stratified by four geographic regions according to the U.S. census bureau in 2000.; Northeast, Midwest, South, and West, The number of questionnaire sent to each region is as follows; Northeast 799 (19.0%), Midwest 920 (22.9%), South 1,400 (35.6%), and West 880 (22.5%). Of the 3,999 survey mailed, 490 were returned, yielding overall response rate of 12.3%. After discarding the incomplete or otherwise unusable surveys, there were 393 usable responses for a response rate of about 10%. The willingness to pay a premium was

elicited with an open-ended question as part of a mail survey. The study used 80% as cutoff certainty values.

Results

The profiles of respondents based on the survey results are presented in the table 1. As shown in the table 1, our sample has lower percentage of females and is relatively older. The significant difference between the sample and U.S. census is the level of education attained, which is not unusual for a mail survey. However, it seems that U.S. population is decently represented by the survey sample. In addition, summary statistics and data description are provided in the table 2. The independent variables included subjective and objective knowledge of GM foods, trust on GM institutions, risk/benefit perceptions, and etc. Table 3 presents the results for the tobit and the double hurdle model for GM beef containing less fat and lower cholesterol. The tobit results appear in the first column, the probit results for the yes/no willingness to buy and WTP appear in the second column, and the truncated normal estimations for the nonzero paying premium decisions are in the third column. The second and third columns represent the alternate two-step WTP decision process. In the tobit model, both the decision of whether to be willing to buy GM foods and to be willing to pay a premium, and how much to pay a premium are captured in the b parameters. On the other hand, in the double hurdle model the participation in the market is embodied in q, and b embodies the second decision of how much to pay a premium.

The first test was whether to accept the null hypothesis that $q=b/\sigma$. As the tobit model is nested regarding the double hurdle model, the null hypothesis can be used to test the tobit specification against double hurdle. If the restriction is valid and it is not

imposed, the estimates are inefficient but the results are still statistically correct. If the restriction is not valid and tobit is used, parameter estimates are incorrect and inferences can be misleading (Haines et al., 1988). If the null hypothesis is accepted, the tobit special case is accepted and tobit estimation can be used to investigate quantity premium for GM beef. The null hypothesis is tested using a likelihood ratio statistic, $\lambda = -2[\ln L_{Tobit} - (\ln L_{Probit} + \ln L_{Truncated})]$. The null hypothesis is rejected at the 0.05 level ($\chi^2_{df=22}$ is 33.92) for GM beef. That is, the decision to buy GM foods and pay a premium for GM beef, and the quantity premium decision are based on the different decision-making structure for GM beef. Therefore, given the results from the likelihood ratio test, the remaining discussion of the study focuses on the estimated coefficients from the double hurdle model for GM beef.

Using estimated parameters from the double hurdle model for GM beef, mean WTP is calculated. Mean WTP for GM beef is 15.86%, which suggests that consumers are aware of substantial benefits from GM beef. That is, consumers having more interest in heath are more likely to pay a high premium for GM beef.

The results of the double hurdle estimation for GM beef are displayed in the table 3. It is assumed that while consumers' subjective knowledge of GM foods is based on their perceptions, or beliefs, objective knowledge is found on their correct information on it. Thus, different influences of knowledge variables are expected, and it is hypothesized that consumers' subjective knowledge has more strong impact on WTP than objective knowledge. In addition, it is hypothesized that as respondents have more proper information about GM foods, they feel more positive, thereby are more likely to pay a premium. However, the results in table 3 show no significant impact on it. It is found that

benefits of GM foods to the health and environment have a significantly positive impact on the market participation, but no significant effects on premium level. As expected, if consumers have a positive attitude about GM foods, the probability of their participating in the market and paying a premium increases. However, surprisingly, the risk variable and morality turned out to be insignificant.

In general, it is believed that U.S. consumers have little knowledge about GM foods. For example, our survey results indicate that only 13% of respondents give correct answers to five questions. Thus, to deal with lack of knowledge, consumers are more likely to rely on GM institutions that provide information about GM foods. Accordingly, it is hypothesized that as consumers have a high degree of trust on GM institutions, they are more likely to participate in the market. The results suggest that trust toward GM institutions has a strong influence on decision of whether to buy GM foods and to pay a premium for GM beefs, but the premium level paid is insignificantly and inversely related to trust. The results also indicate that consumers' market participation is positively associated with frequency of purchasing organic foods.

While consumers in South relative to Midwest are more likely to decide to participate in the market, consumers residing in Northeast and West tend to pay a higher premium significantly on GM beef than do consumers located in Midwest. It is assumed that consumers who reside in urban area have a greater exposure to information and media concerning for GM foods compared to non-urban consumers. Thus, it is hypothesized that the participation in the market is positively influenced by the urbanization. The results show that the consumers in urban area are less likely to participate in the market, but they pay a greater premium once they decide to participate

in the market. Consumer groups between age 18 and 34 are less likely to purchase GM foods and to pay a premium for GM beef, and apt to pay a lower premium. In addition, consumer group less than income $24,999 have a tendency to pay a premium at higher percentage once they are in the market.

The table 3 presents that the tobit model tends to pick up more of yes/no decision, and its inability to explain the quantitative premium to pay. Another important finding is that the tobit model understates the impact of explanatory variables on a premium level paid. For example, the level of premium paying consumers in Northeast and urban is about 4.5 times and 18times the level estimated by the tobit model in absolute value, respectively. In addition, it is found that several estimated parameters in the premium percentage of the double hurdle have different signs with those from the tobit model. These conflicting results may be caused by the invalid restriction of the tobit model that the decision to participate in the market is the same as the decision about how much to pay a premium. Thus, if the restriction of the tobit model for GM beef is imposed, this would produce biased estimates, as well as miss the true behavioral patterns, eventually resulting in incorrect conclusions.

Conclusions

This study conducted a national survey to investigate the effects of consumers' risk/benefit beliefs on the level of a premium for GM beef with less fat and lower cholesterol. To prevent the overestimation problem in CVM, cheap talk and certainty scale methods are used together. In addition, for the internal reliability of a scale, multiple items for each theoretical concept are composed of. One big contribution of the present study is that all of the perceived benefits and risks of GM foods currently debated

in the market place are employed in this survey applying for national consumers for analysis.

The chi-squared specification test indicates that the double hurdle model is a superior fit for GM beef. Rejection of the tobit model for GM beef suggests that the decision 'to buy GM foods' and 'to pay a premium' for GM beef is separate from 'the premium level' decision. The results provide a possible interpretation that zero premiums of GM beef may be occurred not only corner solution but also due to the health and environmental concerns and morality because consumer believe that gene transfer of GM animal is more radical than GM plants.

Consumers' decision on participating in the market and the level of a premium paid were hypothesized to be related to their beliefs toward GM foods. The study found that the qualitative factors, such as benefits of GM foods on the health and environment, trust on GM institutions, and positive evaluation of GM foods, are significant, positive influence on the willingness to buy GM foods and to pay a premium. However, unexpectedly, the results show that risks of GM food and morality have expected signs but insignificant impact on the participation in the market, and insignificant impact on a level of premium paid for GM beef. A reasonable explanation of these results is that to some extent beneficial attributes of GM foods could mitigate consumers' risk perceptions (Moon and Balasubramanian, 2003; and Bech-Larsen and Grunert, 2000).

Interestingly, consumes living in Northeast region tend to pay a higher premium for GM beef. This suggests that consumers residing in Northeast have different information source and different lifestyle, and they have more concerns about food nutrition. Socio-demographic characteristics and regional and locational differences are

included to examine the significance of their effects on the levels of a premium for GM beef. However, the study shows that many of socio-demographic variables are not statistically significant, which is consistent with a previous study (Baker and Burnham, 2001; and Huffman et al., 2003).

A limitation of the present study is that most respondents have either some college, or higher level of education. Less educated consumers may show different decisions on participation in the market and premium percentage paid for GM foods relative to the highest educated consumers. In addition, low response rate due to complexity of questionnaire may lead to nonresponse bias. For example, consumers responding to the survey are more likely to be interested in GM foods relative to nonrespondents, and thus more sensitive to the risks and benefits of GM foods relative to the general population. This may lead to an upward bias in the estimates of consumer intention toward decision on the participation in the market and premium percentage they pay.

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Table1. Stratification Categories and Descriptive Statistics of Sample and U.S. Population[a]

Characteristic	Sample Number	Sample (%)	U.S. Census (%)
Gender			
Male	233	59.4	49.1
Female	159	40.6	50.9
Age(years)			
18 - 24	3	0.8	9.8
25 - 34	39	10.0	13.8
35 - 44	55	14.1	15.6
45 - 54	96	24.6	13.9
55 - 59	70	17.9	5.2
60 - 64	37	9.5	4.0
65 or older	90	23.1	12.3
Income			
Under $15,000	25	7.0	15.9
$15,000 - $24,999	31	8.7	13.3
$25,000 - $34,999	44	12.3	12.4
$35,000 - $49,999	58	16.2	15.4
$50,000 - $74,999	84	23.5	18.4
$75,000 - $99,999	58	16.3	10.8
$100,000 and over	57	16.0	13.8
Race			
White	344	88.4	80.7
Non-White	45	11.6	19.3
Marital Status			
Married	267	68.5	58.9
Single	123	31.5	41.1
Education			
Less than high school	12	3.1	15.9
High school (or equivalency)	57	14.7	32.1
Technical or some college	94	24.3	17.0
Associate degree	33	8.5	8.3
Bachelor degree	96	24.7	17.7
Advanced degree	96	24.7	9.0
Living Area			
Rural area	98	25.2	21.0
Urban area[b]	291	74.8	79.0
Regions			
Northeast	63	16.0	19.0
Midwest	98	25.0	22.9
South	138	35.1	35.6
West	94	23.9	22.5

[a] Data in the fourth column obtained from the *Statistical Abstract of the United States* (U.S. Census Bureau: 2000 and 2003).

[b] Included suburban area.

Table 2. Summary Statistics and Variable Definitions

Variable	Description	Mean	Std. Dev.
Sub_Knowledge[a]	Subjective knowledge of GM foods	4.142	2.490
Obj_Knowledge[b]	Objective knowledge of GM foods	2.641	1.644
Benefits[c]	Benefits of GM foods on the health and environment	3.191	0.635
Risks[d]	Risks of GM foods on the health and environment	3.114	0.674
Morality[e]	Morality issue of GM foods	3.019	0.881
Acceptance[f]	General predisposition of GM foods	2.774	0.776
Trust[g]	Trust on GM institutions	2.802	0.784
Food_Label	Frequency of reading food label (1=never, 5=all of the time)	3.929	1.027
Org_Food	Frequency of purchasing organic foods (1=never, 5=all of the time)	2.571	0.891
Northeast	Northeast (1= if residence is in the Northeast; 0 otherwise)	0.160	
South	South (1= if residence is in the South; 0 otherwise)	0.351	
West	West (1= if residence is in the West; 0 otherwise)	0.239	
Rural	Rural (1= if residence is in the rural area; 0 otherwise)	0.252	
Urban	Urban (1= if residence is in the urban area; 0 otherwise)	0.231	
Gender	Gender (1= male)	0.594	
Married	Married (1= married; 0 otherwise)	0.685	
Age18_34	1= age group between 18 and 34; 0 otherwise	0.108	
Age35_59	1= age group between 35 and 59; 0 otherwise	0.567	
White	1= white; 0 otherwise	0.884	
More_College	1= more than college; 0 otherwise	0.822	
Inc_less $24,999	1= income group less than $24,999; 0 otherwise	0.157	
Inc_more $75,000	1= income group more than $75,000; 0 otherwise	0.322	

[a]Subjective knowledge of GM is measured by consumer's self reporting. Respondents are asked how knowledgeable they are about GM foods on 1 through 10 scales.

[b]Objective knowledge of GM is rated on five true-false items. The five items are added together to create an objective knowledge scale which ranges from 0 to 5, where 0 represents a respondent who does not answer any of five questions correctly, and 5 represents a respondent who answers all five questions correctly. Don't know responses are coded as wrong responses.

[cd]Benefits and risks associated with GM foods consist of 5 items on the health and 5 items on the environment. The items are assessed on 5-point Likert scales, strongly disagree-strongly agree scale. Then, we formed a summated rating scale, by summing respondents' scores on all 10 items, and obtained average score ranging from a low of 1 to a high of 5.

[ef]Respondents were asked to rate on a scale of 1 to 5 (with 1 corresponding to strongly disagree and 5 corresponding to strongly agree) their level of morality and acceptance of GM foods with 5 items, respectively. In calculating the index, the responses to the first and third question in acceptance of GM foods were inverted so that a low number corresponded to less acceptance of those foods and a high number corresponded to more acceptance, to be consistent with other items. The answers to all five items were then summed and averaged for each respondent to generate the morality and acceptance variables.

[g]Trust on GM institutions is measured on 5 scales, where 1 indicates no trust at all and 5 represents a very high degree of trust, ranging from 1 to 5.

Table 3. Estimated Tobit and Double Hurdle Model of GM Beef with Benefit Disclosure

Variable	Tobit		Probit		Truncated	
	Coefficient (Std. Err.)	Marginal Probs. (Std. Err.)	Coefficient (Std. Err.)	Marginal Probs. (Std. Err.)	Coefficient (Std. Err.)	Marginal Probs. (Std. Err.)
Constant	-154.845 (63.505)		-6.201(2.033)		-127.441(135.041)	
Sub_Knowledge	-2.201(1.957)	-0.289 (0.247)	-0.037(0.064)	-0.003 (0.006)	-1.733 (3.986)	-0.523 (1.191)
Obj_Knowledge	-0.016 (2.833)	-0.002 (0.371)	0.042 (0.098)	0.004 (0.009)	-2.192 (6.364)	-0.662 (1.942)
Benefits	20.605 (8.958)**	2.702 (1.154)**	0.501(0.293)*	0.045 (0.028)	13.347 (18.101)	4.028 (5.545)
Risks	-7.541(7.952)	-0.989 (1.048)	-0.134 (0.275)	-0.012 (0.025)	8.477 (16.150)	2.559 (4.880)
Morality	-13.778 (7.780)*	-1.807 (0.963)	-0.315 (0.234)	-0.028 (0.020)	-0.552 (26.879)	-0.167 (8.112)
Acceptance	25.543 (8.831)***	3.349 (1.099) ***	1.024 (0.287)***	0.092 (0.033)***	34.939 (21.235)*	10.545 (5.659)*
Trust	12.892 (6.300)**	1.690 (0.791)**	0.434 (0.208)**	0.039 (0.019)**	-21.391(18.434)	-6.456 (5.065)
Food_Label	-1.757 (4.051)	-0.230 (0.528)	-0.140 (0.143)	-0.013 (0.013)	-4.881 (11.714)	-1.473 (3.483)
Org_Food	10.267 (5.452)*	1.346 (0.703)*	0.516 (0.191)***	0.047 (0.020)**	-4.473 (10.343)	-1.350 (3.164)
Northeast	16.881(11.692)	2.433 (1.836)	0.618 (0.380)	0.079 (0.064)	76.056 (37.959)**	45.528 (28.169)
South	16.282 (9.280)*	2.240 (1.346)*	0.646 (0.306)**	0.072 (0.044)	1.406 (24.483)	0.425 (7.425)
West	10.598 (10.433)	1.461(1.516)	0.244 (0.343)	0.025 (0.040)	57.448 (27.100)**	27.447(15.674)*
Rural	-2.444 (8.414)	-0.318 (1.083)	-0.120 (0.278)	-0.010 (0.023)	18.414 (19.285)	6.291 (7.296)
Urban	-3.924 (9.018)	-0.506 (1.148)	-0.115 (0.298)	-0.010 (0.025)	53.131 (25.375)**	23.991(12.478)*
Gender	-4.653 (8.056)	-0.615 (1.069)	-0.128 (0.259)	-0.012 (0.025)	-27.815 (24.726)	-10.028 (10.279)
Married	-12.816 (7.700)*	-1.746 (1.079)	-0.328 (0.260)	-0.033 (0.029)	-10.912 (18.325)	-3.496 (6.189)
Age18_34	-28.417 (14.807)*	-3.171(1.386)**	-0.862 (0.477)*	-0.046 (0.019)**	-53.452 (47.142)	-9.557 (4.767)**
Age35_59	-5.481(7.634)	-0.725 (1.020)	-0.220 (0.261)	-0.021(0.026)	8.820 (16.250)	2.611 (4.593)
White	-10.521(11.346)	-1.477 (1.690)	-0.138 (0.380)	-0.014 (0.041)	10.516 (32.092)	2.849 (7.816)
More_College	0.634 (11.643)	0.083 (1.517)	-0.151(0.391)	-0.015 (0.041)	25.385 (34.278)	5.981 (6.424)
Inc_less $24,999	-0.400 (12.047)	-0.052 (1.572)	-0.715 (0.453)	-0.043 (0.021)**	125.392 (38.608)***	96.949 (27.922)***
Inc_more $75,000	-5.713 (7.701)	-0.739 (0.978)	-0.054 (0.253)	-0.005 (0.022)	-28.333 (21.522))	-8.423 (6.239)
sigma	32.689 (3.673)***				22.792(4.826)***	

*,**,***, indicates estimated coefficient is significant at the 0.10, 0.05, and 0.01 level, respectively. Log-L for Probit=-81.790, Log-L for Truncated =-180.940, and Log-L for Tobit =-284.751