Public Approval of Plant and Animal Biotechnology in Korea: An Ordered Probit Analysis

Ramu Govindasamy*
Benjamin Onyango
William Hallman
Ho-Min Jang
and
Venkata Puduri

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Ramu Govindasamy is Associate Professor Department of Agricultural, Food and Resource Economics and Associate Director of the Food Policy Institute, Benjamin Onyango is a Research Associate Food Policy Institute, William Hallman is Associate professor Department of Human Ecology and Associate Director Food policy Institute, Ho-Min Jang is Director Korean Institute of Bioscience and Biotechnology, and Venkata Puduri is a Post Doctoral Research Associate Department of Agricultural, Food and Resource Economics.

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Abstract:

This study analyzes predictors of Korean public acceptance of the use of biotechnology to create genetically modified food products. Results indicate that the consumers with above average knowledge of specific outcomes of genetic modification were more likely than those with inaccurate or no knowledge to approve use of plant or animal genetic modification for the creation of new food products. Young South Koreans consumers (ages 20 to 29 years old) were more likely than old consumers (ages 50 to 59) to approve use of biotechnology to create both plant and animal based foods.

Further, those Koreans in favor of GM labeling were less likely to approve the use of biotechnology for the creation of food products. The results also suggest that public trust and confidence on various institutions associated with biotechnology is critical for the future of the technology. There was some evidence of differential biotechnology approval among consumers of different residential areas, income levels and political affiliation. Thus, those in cities, those with incomes above 40 million Won, and of liberal political affiliation were found to be more approving of animal biotechnology.

Introduction

Science and industry are poised to bring consumers a wide variety of genetically modified (GM) products that have the potential for meeting basic food needs, as well as delivering a wide range of benefits. However, public perception of biotechnology and acceptance of its use in the production of food have been mixed in the U.S. and elsewhere (Hallman et al., 2002). Hoban (1998) reported broad support among consumers for biotechnology use in the production of food. However, some other studies report a more mixed reaction among the public in this issue. The supporters of biotechnology highlight the potentials benefits to society via reduction of hunger, prevention of malnutrition, cure of diseases, and promotion of health and quality of life. Opponents often view its use as an unnecessary interference with nature that has unknown and potentially disastrous interactions with human genetics and natural ecosystems.

Despite the enormous importance of the subject, only a handful of studies have systematically explored the issue more so for the larger part of the developing world. In a recent study, Moon and Balasubramanian (2001) found that consumer acceptance of biotechnology was significantly influenced not only by their perceptions of risks and benefits associated with GM products, but also by their moral and ethical views. In addition, consumers' views about corporations, knowledge of science, and trust in government had significant influence on their acceptance of biotechnology. Baker and Burnham (2001) found that consumers' cognitive variables were important determinants of their acceptance of food containing GM products, whereas the socio-economic variables were not significant. Some recent findings from studies on the Asian subcontinent indicate that Asian consumers generally hold positive attitudes towards GM more so for those foods that have product-enhancing attributes (Quan Li et al., 2002). This finding somehow contradicts results from studies done primarily in the U.S and the European

Union, bringing into picture the cultural, institutional and other differences that come into play in attempting to map out relevant factors driving acceptance across international borders. Scientific challenges notwithstanding, public acceptance of the use of biotechnology in food production remain a critical factor that will affect the global future of agricultural biotechnology.

This study analyzes the Korean public acceptance of the use of biotechnology related to the consumers' socio-economic attributes and other personal attributes. Specifically, this study analyzes and compares the effects of consumers' socio-economic and value characteristics on their approval of the use of biotechnology in (i) plants; and (ii) animals.

Using the Korean survey data collected between April and May 2003. This study implements an ordered probit model to estimate the relation between consumers' personal attributes and their approval of biotechnology. This analysis will contribute towards better understanding of public attitudes towards biotechnology and their willingness to accept GM food products. It will also help companies involved in the manufacturing and marketing of food in developing a profile of consumers most likely to accept GM food. Results of this study will help various institutions associated with food biotechnology better understand the concerns of the consumers. Information generated by this study will be useful in formulating appropriate private and public policies with regard to the use of genetic technologies in agricultural and food production.

Conceptual Framework

For each genetic process, assume that the consumer faces a choice between a approving genetic modification (A) and disapproving (D) product. Utilities derived from approval of the processes are given by U_A and U_D, respectively, which are not observable. The observable variables are process attributes a (a = A, D) and a vector of consumer characteristics (x). The utility of consumer i is postulated as follows:

$$U_{ai} = V_{ai} + \varepsilon_{ai} \qquad (1)$$

Where U_{ai} is the latent, unobserved utility for choice alternative a, V_{ai} is the explainable part of the latent utility that depends on the chosen process with attributes a and personal characteristics of consumer i, and ε_{ai} is the random or 'unexplainable' component of the latent utility associated with the choice of product attribute ***a*** and consumer i.

Consumer i's choice ordering between approval and disapproval of the genetic process to produce GM food products (i.e., between attributes A and D, respectively) is modeling in the following way: consumer i ranks a GM process in one of the three categories based on the indicator function:

$$Z_i = (V_{Ai} + \varepsilon_{Ai}) - (V_{Di} + \varepsilon_{Di}) = (\varepsilon_{Ai} - \varepsilon_{Di}) - (V_{Ai} - V_{Di}) \qquad (2)$$

Where Z_i can be interpreted as additional utility derived by consumer the i^{th} by choosing the to approve a genetic modification process over disapproval. Consumer expresses strong disapproval in the genetic modification process if Z_i is below some threshold value (e.g., μ_1), shows moderate disapproval if Z_i is above μ_1 but below another threshold value μ_2, and reveals approval in the process if Z_i is above μ_2. Formally, consumer i's choice ordering (denoted by Y_i where Y = 1 implies strong disapproval, Y = 2 implies moderate disapproval, and Y = 3 implies strong approval) can be expressed as follows:

$$Y_i = 1 \text{ if } Z_i < \mu_1,$$
$$Y_i = 2 \text{ if } \mu_1 < Z_i < \mu_2, \text{ and} \qquad (3)$$
$$Y_i = 3 \text{ if } Z_i > \mu_2,$$

Since part of the utility is random in nature, a researcher cannot perfectly predict the choice of a consumer. From the researchers' perspective, the problem is inherently stochastic, which naturally leads to formulating the ith consumer's choice problem in probability terms:

$$P(Y_i = 1 \mid \text{Choice Set}) = P[Z_i = (\varepsilon_{ai} - \varepsilon_{Di}) - (V_{Ai} - V_{Di}) < \mu_1)$$

$$P(Y_i = 2 \mid \text{Choice Set}) = P[\mu_1 < Z_i = (\varepsilon_{Ai} - \varepsilon_{Di}) - (V_{Ai} - V_{Di}) < \mu_2) \quad (4)$$

$$P(Y_i = 3 \mid \text{Choice Set}) = P[Z_i = (\varepsilon_{Ai} - \varepsilon_{Di}) - (V_{Ai} - V_{Di}) > \mu_2)$$

Under the assumption that the random term (ε_{Ai} - ε_{Di}) follows standard normal distribution, the above probabilistic model is the well-know ordered-probit model.

In empirical estimation, the indicator Z_i for the ith consumer is modeled as a function of his/her socioeconomic and value attributes and can be expressed as:

$$Z_i = \boldsymbol{\beta}'\mathbf{X} + \nu_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik} + \nu_i, \quad i = 1, 2, \ldots, n \quad (5)$$

where:

x_{ij} = jth attribute of the ith respondent;

$\boldsymbol{\beta} = (\beta_0, \beta_1, \ldots, \beta_k)$ = the parameter vector to be estimated; and

ν = random error or disturbance term.

In this setting, the probabilities of choice for Y_i = 1, 2, and 3 are given by:

$$P(Y_i = 1 \mid \text{Choice Set}) = \Phi(\mu_1 - \boldsymbol{\beta}'\mathbf{X}_i)$$

$$P(Y_i = 2 \mid \text{Choice Set}) = \Phi(\mu_2 - \boldsymbol{\beta}'\mathbf{X}_i) - \Phi[(\mu_1 - \boldsymbol{\beta}'\mathbf{X}_i)] \quad (6)$$

$$P(Y_i = 3 \mid \text{Choice Set}) = 1 - \Phi[(\mu_2 - \boldsymbol{\beta}'\mathbf{X}_i),$$

where Φ is the cumulative function of a standard normal distribution. In the above model, the μ's are unknown threshold parameters that separate the adjacent rankings or categories. In empirical estimation stage, both the β-vector and the μ's are estimated jointly using the maximum likelihood (ML) procedure[1].

The estimated β-coefficients of equation (5) do not directly represent the marginal effects of the independent variables on the probabilities of choice. The marginal effects are given by the following expression (assuming continuous explanatory variables):

$$\frac{\partial P(Y_i = 1)}{\partial X_j} = \phi(\mu_1 - \boldsymbol{\beta}'\mathbf{X})\beta_j$$

$$\frac{\partial P(Y_i = 2)}{\partial X_j} = \phi(\mu_1 - \boldsymbol{\beta}'\mathbf{X}) - \phi(\mu_2 - \boldsymbol{\beta}'\mathbf{X})\beta_j \qquad (7)$$

$$\frac{\partial P(Y_i = 3)}{\partial X_j} = \phi(\mu_2 - \boldsymbol{\beta}'\mathbf{X})\beta_j$$

where ϕ is the density function of standard normal variable. In the case where the explanatory variable is discrete or categorical in nature, the marginal effect of such a variable is obtained by evaluating the probabilities at alternative values of x_{ij}. The coefficient estimates are not equal to the marginal effects of the explanatory variables x on the probabilities. The marginal effects of the explanatory variables are calculated in the following manner:

$$\partial \text{Prob[cell j]} / \partial x_i = [f(\mu_{j-1} - \beta' x_i) - f(\mu_I - \beta' x_i)] \times \beta \qquad (8)$$

where $f(.)$ is the standard normal density. The marginal effects for the dummy variables are calculated as the difference between two resulting probabilities when the dummy variable equals its two values 0 and 1 (Nayga, Poghosyan, and Nichols, 2004).

[1] Actual estimation of the empirical model was performed using the software package LIMDEP (Econometric Software, 2002).

The following empirical model is used to estimate the relation between the probability that a will approve the use of biotechnology in food production and his/her personal attributes:

$$
\begin{aligned}
Z = {} & \beta_0 + \beta_1 MED\_CITY + \beta_2 RURAL + \beta_3 FEMALE + \beta_4 YOUNG + \beta_5 MID\_AGE1 + \\
& \beta_6 MID\_AGE2 + \beta_7 KNOW\_FDPRD + \beta_8 MIDSCORE + \beta_9 HISCORE + \\
& \beta_{10} KOREA\_GROWN + \beta_{11} GM\_NOWMART + \beta_{12} LABEL\_GM + \beta_{13} HIGH\_COL + \\
& \beta_{14} GRAD\_COL + \beta_{15} EMPLOY + \beta_{16} LIBERAL + \beta_{17} CENTRIST + \\
& \beta_{18} INCLT\_20MWON + \beta_{19} INC20\_30MWON + \beta_{20} INC30\_40MWON + \beta_{21} TRU\_FARMERS + \\
& \beta_{22} TRU\_GOV + \beta_{23} TRU\_ENVRON + \beta_{24} TRU\_SCI + \beta_{25} TRU\_INDUSTRY + \\
& \beta_{26} TRU\_MEDIA + \nu
\end{aligned} \qquad (9)
$$

The model explanatory variables are explained in table1.

Data Description and Summary Statistics

The data set used in this study was collected during a survey carried out in South Korea April 10, 2003 to May 9, 2003. The Food Policy Institute at Rutgers University developed the survey instrument originally used in South Korea. The Korean survey had in many instances identical questions similar to those for the U.S. survey on the same subject carried out in February to April 1, 2003. Most of the questions in the two surveys were similar with modifications made in consideration of cultural differences. The Korean Biosafety Clearing House (KBCH) commissioned Gallup Korea to conduct nationally based face-to-face interviews. A target sample was obtained through proportionate random sampling based on population by region. The survey group included adults from across South Korea ranging in age from 20 to 59 years. The sampling error was ± 3.1 percent with a statistical significance level of 95 percent. Interviewers attended an orientation covering the survey method, contents, and exercise in an effort to minimize non-sampling error. Control over the interviewers was exercised by distributing and collecting questionnaires each day. Interviewers approached subjects, briefly describing the study, and asked them to participate. The data was weighted using demographic variables just as the U. S data set, with exception of race/ethnicity using Korean National Census. Respondents were given a pen (worth $2 US) for answering the questionnaire. In total, 1054 complete face-to-face surveys were collected. However, after excluding the non-responses to specific questions relevant for this study, a total of 903 completed surveys were used for empirical analysis.

The survey collected information on public awareness and perceptions of food and food biotechnology and their willingness to accept and approve genetic modification to produce GM foods. Information was also collected on socioeconomic and value attributes of the consumers. In addition, the survey elicited respondents' views about scientists and companies involved in biotechnology research, as well as their confidence in the government's ability and willingness to protect public interest.

The dependent variable used in the two models is the respondents' approval of plant or genetic modification. For this study, the dependent variable was defined in the following manner. Each question had four possible answers, which included: Strongly approve, somewhat approve, somewhat disapprove, and strongly disapprove.

For each of the two questions an ordered dependent variable 0 was defined as follows: a respondent was considered (i) "approving of the genetic modification " if his /her response was strongly approve and approve (ii) 1"Disapprove of the genetic modification" if his /her response was Disapprove (iii) 2 "Strongly Disapprove of genetic modification " if his /her response was strongly disapprove. The independent variables used to explain public approval of use of plant or animal genes in creating genetically modified food include the socioeconomic and value attributes of the consumers. Most of these variables are defined as dummy or indicator variables.

The specific definitions of these variables are presented below while the summary statistics on these variables are presented in Table 1.

Age: Respondents are classified into four age groups as follows: (1) *YOUNG* (age 20-29 years 22%); (2) *MID_AGE1* (age between 30-39 years 49%); (3) *MID_AGE2* (age between 40-49 years 29%) and (4) *MATAGE* (age 50-59 years 15%). Only those between the ages of 20 and 59 were asked to participate in the survey thus skewing the age proportions of the sample relative to Census figures.

Income: Three different (annual) income levels are identified as follows:

(1) *INCLT_20MWon* (annual household income below 20 million Won); (2) *INC20_30 M Won* (income between 20 and 30 million Won; and (3) *INC30_40MWon* income between 30 and 40 million Won; (4) *INCAB_40MWon* income above 40 million Won. About 56 percent of the respondents belong to incomes group between 20 and 40 million Won with those below and above these group being of equal proportion (about 22%)

Gender: The dummy variable *FEMALE* is assigned a value of 1 if the respondent is male and 0 otherwise (i.e., male). The sample of respondents is almost evenly divided across gender.

Residence: Respondents were classified into three categories on the basis of where they lived: (1) *CITY* those who resided in large cities; (2) *MED_CITY*; those respondents who lived in medium cities;(3) *RURAL* those who lived in rural setting. About 49 % of the respondents lived in large cities, 40% lived in medium cities, and the remaining 11 % lived in the rural areas

Socio-political View: Respondents are classified on the basis of their self-reported socio-political views as follows: (1) *CONSERV* (self-described conservatives); (2) *LIBERAL* (self-described liberals); and (3) *CENTRIST* (those identifying themselves between liberals and conservatives). About 32 percent of the respondents identified themselves as conservatives, 24 percent as liberals and the remaining 44 percent as centrists.

Education: Based on their educational attainment, respondents are classified into three groups as follows: (1) *LTHIGHSC* if the respondent has less than high school education; (2) *HIGH_COL* if the respondent has high school or but less than some college education); and (3) *GRAD_COL* if the respondent has college or graduate education. The predominant group was those with high school and college education (58%), followed by those with graduate and above college education (31%), and a small proportion (11%) those with less than high school education.

Knowledge of Science: Survey-based studies on public perceptions of biotechnology have found evidence that respondents' knowledge of science (relating to biotechnology) is related to their acceptance of transgenic technology (Sheehy *et al*., 1998). To explore this issue, consumers' knowledge of science is included as an independent variable in the empirical model. To obtain an objective measure, survey participants were asked to correctly answer a set of 11 questions. These answers were evaluated and used to measure their basic understanding of science. Three different knowledge levels are identified as follows: (1) *LOWSCORE* (representing less than 5 correct responses); (2) *MIDSCORE* (6 to 8 correct responses); and (3) *HIGHSCORE* (9 or more correct responses). About 52 percent of the respondents fell into category 1, 39 percent into category 2 and 9 percent into category 3.

GM FOOD Labeling: a dummy variable *LABEL_GM* was assigned value of 1 if respondent thought that GM food should be labeled as such; 0 otherwise. 96 percent of the respondent was of the opinion that GM foods should be labeled.

Basic Knowledge about food production: a dummy variable BASIC_FP was assigned value of 1 if the respondent was above average (good to excellent); 0 otherwise (poor).

Importance of where food is produced: a dummy *KOREA_GR* was assigned if responded place importance of his/her food to be grown in Korea;0 otherwise. 85 % of the respondent placed importance in Korean produced foods.

Employment status: a dummy EMPLOY was assigned a value of 1 if the respondent was full time employed and in the military;0 otherwise. 58 % of the respondents were employed full time.

Awareness of GM Foods in Supermarkets: a dummy GM_NOWMA was assigned a value of 1 if the respondent was aware that GM foods are now in supermarket shelf; 0 otherwise. 52 % of the respondents were aware that GM foods are now in supermarkets.

Trust in Industry: The dummy variable *TRU_IND* was assigned a value of 1 if the individual somewhat or strongly agreed with the statement, "The Biotechnology industry will tell the truth, has the expertise to make a competent judgment, do what is right for society, and could be a useful source of information about GM food products," and 0 otherwise. Approximately 24 percent of the responses fell in category 1, while the remaining 76 percent fell in category 0.

Trust in Government: The dummy variable *TRU_GOV* was assigned a value of 1 if the individual somewhat or strongly agreed with the statement, "The Federal government will tell the truth, has the expertise to make a competent judgment, do what is right for society, and could be a useful source of information about GM food products," and 0 otherwise. Approximately 29 percent of the responses fell in category 1, while the remaining 71 percent fell in category 0.

Trust in Scientists: The dummy variable *TRU_SCI* was assigned a value of 1 if the individual somewhat or strongly agreed with the statement, "The scientists will tell the truth, have the expertise to make a competent judgment, do what is right for society, and could be a useful source of information about GM food products," and 0 otherwise. Approximately 72 percent of the responses fell in category 1, while the remaining 28 percent fell in category 0.

Trust in Farmers: The dummy variable *TRU_FARM* was assigned a value of 1 if the individual somewhat or strongly agreed with the statement, "The farmers will tell the truth, have the expertise to make a competent judgment, do what is right for society, and could be a useful source of information about GM food products," and 0 otherwise. Approximately 33 percent of the responses fell in category 1, while the remaining 67 percent fell in category 0.

Trust in Environmentalists: The dummy variable *TRU_ENV* was assigned a value of 1 if the individual somewhat or strongly agreed with the statement, "The environmentalists will tell the truth, have the expertise to make a competent judgment, do what is right for society, and could be a useful source of information about GM food products," and 0 otherwise. Approximately 83 percent of the responses fell in category 1, while the remaining 17 percent fell in category 0.

Trust the Media: The dummy variable *TRU_MEDIA* was assigned a value of 1 if the individual somewhat or strongly agreed with the statement, "The Media Professionals will tell the truth, have the expertise to make a competent judgment, do what is right for society, and could be a useful source of information about GM food products," and 0 otherwise. Approximately 60 percent of the responses fell in category 1 while the remaining 40 percent fell in category 0.

Model Estimation and Empirical Results

Two ordered probit models are estimated to explain genetic modification involving plant and animal genes. The estimated model coefficients with associated t-ratios, and the marginal effects of the explanatory variables along with their estimated t-ratios are reported in Tables 2 and 3. These tables also report the estimated values of unrestricted (i.e., full model) and restricted (i.e., all slope coefficients are zero) log likelihood functions, Chi-Square statistics of model significance, McFadden's R2 and model prediction success rates.

The results for the marginal effects of the ordered probit model estimation for approval of plant and animal based genetic modification are presented in Table 2 and 3. From table 2, the coefficients of *MED_CITY*, *RURAL*, *FEMALE*, *BASIC_FDPRD*, *KOREA_GROWN*, *GM_NOWMAR*, *HIGH_COL*, *GRAD_COL*, *EMPLOY*, *INC20-30MWON*, and *TRU_ENV*, are negatively related to the approval and significant at 10 or 5 percent level of significance while *YOUNG*, *MIDSCORE*, *HISCORE*, *LIBERAL*, *CENTRIST*, *TRU_SCI* and *TRU_MEDIA* are positively related to plant based genetic modification. The results show that city residents, male, those with less than high school education, employed part-time, and with income above 40million Won are more likely to approve genetic modification involving plant genes. Approving genetic modification involving plant genes also are, the young (20-29 years old compared to those in the 50-59 years category, those with average to high score in the scientific quiz, and are of liberal and centrist part affiliation compared to the conservative. Moreover, those who trust scientists and the media are likely to approve the plant based genetic modification. However, the statistically insignificant variables suggest that trust in government and industry and labeling of genetically modified food as such do not have significant influence on the approval of genetic modification involving plant genes.

The estimated unrestricted and restricted log likelihood functions along with the Chi-square statistic of model significance suggests that the model has significant explanatory power.

The model correctly predicts only 45 of the respondents and McFadden's R2 is 0.04. These results do not generate very strong confidence in these model results. Alternatively, there is not much divergence in opinion with respect to the public's approval of genetic modification involving plant genes.

Results for genetic modification involving animal based genes are reported in Table 3. The marginal effects coefficients of *MED_CITY, FEMALE, BASIC_FDPRD, KOREA_GROWN, GM_NOWMAR, LABEL_GM, GRAD_COL, INC20-30MWON, INC30_40MWON* and *TRU_ENV* are negative and significant and therefore will negatively influence approval. On the other the marginal effects coefficients of *YOUNG, MIDSCORE, HISCORE LIBERAL, CENTRIST, CENTRIST, TRU_FAMERS, TRU_SCI* and *TRU_MEDIA* are positive and therefore will influence positively the approval of genetic modification involving animal genes. The results suggest that residents in the large cities, male, those with less than average understanding of how food is produced, those who do not place much importance that the food they must Korean grown, and those who not opposed to GM labeling, those with incomes above 40 million Won will more than likely approve genetic modification involving animal genes. Similarly, those with less than high school education, and do not trust the environmentalist groups will also more than likely approve genetic modification involving animal genes.

Similar to the plant based genetic modification results, trust in government and biotech industry was insignificant suggesting that the views Koreans hold about these institutions do not influence their opinions about animal based genetic modification. The estimated likelihood functions (restricted and unrestricted) and Chi-Square statistics indicate significant explanatory power for the estimated model. However, the McFadden's R^2 is rather low 0.04 while the correct prediction was 48 percent.

Conclusions

The results of this study have important implications for the agricultural industry. Consumer expectations and demands will drive the successful placement of the genetically modified food products in the market. This study may serve as an outreach tool to reach the potential consumers. The findings of this study will also aid industry develop strategies capable of better anticipating, and perhaps bring about, changes in market demand relative to product innovation.

The results of all the models showed that consumers with above average knowledge of specific outcomes of genetic modification were more likely than those with inaccurate or no knowledge to approve of the use of genetic modification for the creation of plant- and animal-based foods products. Industry should therefore invest in educational campaigns targeting those segments of the population with inaccurate or no knowledge of genetic modification. Additionally, for those in the industry involved in the South Korean export market a promising finding from this study was that South Korean consumers ages 20 to 29 years old were more likely than consumers ages 50 to 59 to approve of using GM to create both plant- and animal-based foods.

Results also indicated that those who felt labeling to be necessary were less likely to approve of the use of GM technology for the creation of food products than those who didn't feel it necessary. It is therefore reasonable to assume that enacting a policy that requires the labeling of GM food products would cause a decrease in demand via a leftward shift of the demand curve. Despite this fact, it would be prudent of policymakers to consider the potential welfare effects associated with this shift in demand prior to the creation of a GM labeling policy.

The results also indicate that consumers' trust and confidence in institutions associated with biotechnology is critically important for wide acceptance of food biotechnology. For example the results show those who trust their farmers and the media are more likely to prove of Plant DNA as opposed to trusting the environmentalists or scientists. The results may reflect the agenda nature being championed by institution in question thus less approval by those trusting the scientists and environmentalists. This may be due to the fact these consumers are often more concerned about environmental issues and the use of biotechnology is sometimes viewed as potentially dangerous for the environment as told by the media or environmentalists.

This finding has important implications the Korean policy-makers. Especially important is the issue of public trust and confidence on various institutions associated with biotechnology, for lack of such trust may seriously undermine the potential of this technology to benefit the society.

The results also show that, those who with college and above education are less approving of the technology. Less approving were also those who are aware that GM foods are now in the market and those preferring their food to be Korean grown. Similarly the females compared to males were less likely to approve of this technology. The Koreans who trusted their scientist were more approving of the animal based genetic modification. Our results further found some evidence of differential GM approval among consumers of different residential areas, income levels and political affiliation. With those in the cities, incomes with above 40 million won, coming from a liberal party leanings being more approving of animal GM.

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Table 1: Descriptive statistics of Variables

Variable	Description	Mean	Std. Dev.
CITY	1=if respondent resides in large city;0=otherwise	0.49	0.50
MED_CITY	1=if respondent resides in Medium city;0=otherwise	0.40	0.49
RURAL*	1=if respondent resides in rural area;0=otherwise	0.11	0.31
FEMALE	1=if respondent is female;0=otherwise	0.49	0.50
YOUNG	1=if respondent age is between 20-29 years;0 otherwise	0.22	0.42
MID_AGE1	1=if respondent age is between 30-39 years;0 otherwise	0.34	0.47
MID_AGE2	1=if respondent age is between 40-49 years;0 otherwise	0.29	0.46
MATAGE*	1=if respondent age is between 50-59 years;0 otherwise	0.15	0.35
BASIC_FP	1=if basic understanding of how food is produced is good; 0 otherwise	0.63	0.48
LOWSCORE*	1=correctly answered 5 out of 11 questions;0=otherwise	0.52	0.50
MIDSCORE	1=correctly answered 6-8 out of 11 questions in the biological science;0 otherwise.	0.39	0.49
HISCORE	1=correctly answered more than 8 out of 11 questions in the biological science;0 otherwise	0.09	0.29
KOREA_GR	1=if respondents will strongly like his food to be produced in Korea;0 =otherwise	0.85	0.35
GM_NOWMA	1=if respondent is aware that GM food is now in supermarkets;0=otherwise	0.52	0.50
LABEL_GM	1=if respondent will prefer GM food to labeled as such;0=otherwise	0.96	0.18
LTHIGHSC*	1=if respondent education is below highschool;0=otherwise	0.11	0.32
HIGH_COL	1=if respondent level of education is high school and college; 0 =otherwise	0.58	0.49
GRAD_COL	1=if respondent level of education is college degree and above; 0 =otherwise	0.31	0.46
EMPLOY	1=if full time employed;0=otherwise	0.58	0.49
LIBERAL	1=identifies himself as liberal;0=otherwise	0.24	0.43
CONSERV*	1=identifies himself asconservative;0=otherwise	0.32	0.47
CENTRIST	1=identifies himself as in-between liberal and conservativel;0=otherwise	0.44	0.50
INCLT_20	1=income range les than 20 million won;0=otherwise	0.21	0.41
INC20_30	=Income range 20-30 million won;0=otherwise	0.28	0.45
INC30_40	1=income range 30-40 million won;0=otherwise	0.28	0.45
INCAB_40*	1=is in income range above 40 million won;0=otherwise	0.23	0.42
TRU_FARM	1 = responded can trust Farmers (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.33	0.47

TRU_GOV	1 = that responded can trust Government (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.29	0.45
TRU_ENV	1 = that responded can trust Environmentalist (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.83	0.37
TRU_SCI	1 = that responded can trust scientists (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.72	0.45
TRU_IND	1 = that responded can trust industry (tell truth, provide useful information, has expertise, and protect society) on GM Issues.	0.24	0.43
TRU_MEDIA	1 = that responded can trust the media professionals (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.60	0.49
Note: Asterisk implies that the variable was dropped during estimation to avoid dummy variable trap.			

Table 2: Approval of Genetic Modification Involving Plant Genes: Ordered Probit Model Estimates

Variable	Estimated Marginal effects and t-ratios					
	Strongly Approve		Disapprove		Strongly Disapprove	
	Marginal Effect	t-ratio	Marginal Effect	t-ratio	Marginal Effect	t-ratio
Constant	0.000	0.000	-	-	-	-
MED_CITY	-0.038*	-2.21	0.003	1.08	0.034	0.35
RURAL	-0.041*	-2.44	0.002	0.85	0.039	0.40
FEMALE	-0.081*	-4.48	0.008	1.53	0.073	0.80
YOUNG (20-29 years)	0.163*	12.29	-0.033*	-8.16	-0.129	-1.24
MID_AGE1 (30-39 years)	0.022	1.39	-0.002*	-3.02	-0.019	-0.19
MID_AGE2 (40-49 years)	0.005	0.30	0.000	-0.34	-0.004	-0.04
Basic Food production	-0.045*	-2.62	0.005	1.33	0.040	0.43
MIDSCORE	0.074*	5.25	-0.009*	-6.23	-0.065	-0.63
HISCORE	0.070*	4.71	-0.012*	-27.93	-0.058	-0.58
KOREA_GROWN	-0.086*	-4.68	0.015*	2.21	0.071	0.83
GM_NOWMA	-0.044*	-2.55	0.005	1.23	0.039	0.42
LABEL_GM	-0.013	-0.81	0.002	0.62	0.012	0.12
HIGH_COL	-0.030**	-1.77	0.003	1.04	0.027	0.28
GRAD_COL	-0.074*	-4.13	0.005	1.07	0.069	0.73
EMPLOY_FULL TIME	-0.061*	-3.45	0.007	1.50	0.054	0.58
LIBERAL	0.069*	4.70	-0.010*	-12.55	-0.059	-0.58
CENTRIST	0.055*	3.77	-0.006*	-7.83	-0.049	-0.48
INCLT_20 MIILION WON	0.012	0.79	-0.001	-1.14	-0.011	-0.11
INC20_30 MIILION WON	-0.054*	-3.13	0.004	1.05	0.051	0.53
INC30_40 MIILION WON	-0.014	-0.88	0.001	0.62	0.013	0.13
TRU_FARMERS	0.050*	3.39	-0.006*	-18.24	-0.044	-0.43
TRU_GOVERNMENT	0.001	0.07	0.000	-0.07	-0.001	-0.01
TRU_ENVIRONMENTALIST	-0.079*	-4.33	0.013*	2.07	0.066	0.75
TRU_SCIENTISTS	0.095*	7.55	-0.004	-1.15	-0.091	-0.83
TRU_INDUSTRY	-0.021	-1.27	0.002	0.78	0.019	0.20
TRU_MEDIA	0.028**	1.86	-0.003*	-13.12	-0.026	-0.25
LL Function						
Restricted LL	-943.98					
Chi-Square	-985.02					
DF	82.07					
Prediction Sucess	26					
* α=. 05, **α=. 10		45%				

Table 3: Approval of Genetic Modification Involving Animal Genes: Ordered Probit Model Estimates

Variable	**Estimated Marginal effects and t-ratios**					
	Strongly Approve		**Disapprove**		**Strongly Disapprove**	
	Marginal Effect	**t-ratio**	**Marginal Effect**	**t-ratio**	**Marginal Effect**	**t-ratio**
Constant	0.00	0.00	-	-	-	-
MED_CITY	-0.041*	-2.60	-0.015*	-5.32	0.057	0.51
RURAL	-0.006	-0.42	-0.002	-0.46	0.008	0.07
FEMALE	-0.070*	-3.93	-0.024*	-20.73	0.094	0.86
YOUNG (20-29 years)	0.053*	4.79	0.014*	2.20	-0.068	-0.59
MID_AGE1 (30-39 years)	-0.018	-1.24	-0.007	-1.65	0.025	0.22
MID_AGE2 (40-49 years)	-0.006	-0.44	-0.002	-0.49	0.008	0.07
Basic Food production	-0.048*	-2.90	-0.015*	-8.22	0.063	0.58
MIDSCORE	0.028*	2.30	0.009	1.55	-0.037	-0.32
HISCORE	0.091*	8.95	0.016*	2.13	-0.107	-0.93
KOREA_GROWN	-0.071*	-3.87	-0.016*	-30.31	0.086	0.82
GM_NOWMA	-0.067*	-3.82	-0.023*	-19.35	0.090	0.83
LABEL_GM	-0.026**	-1.70	-0.007*	-2.87	0.034	0.31
HIGH_COL	-0.024	-1.58	-0.008*	-2.38	0.032	0.28
GRAD_COL	-0.065*	-3.79	-0.027*	-12.02	0.092	0.83
EMPLOY_FULL TIME	-0.022	-1.47	-0.007*	-2.12	0.029	0.26
LIBERAL	0.033*	2.79	0.010**	1.71	-0.044	-0.38
CENTRIST	0.053*	4.97	0.017*	2.42	-0.070	-0.60
INCLT_20 MIILION WON	-0.023	-1.57	-0.009*	-2.24	0.032	0.28
INC20_30 MIILION WON	-0.060*	-3.58	-0.026*	-9.98	0.086	0.77
INC30_40 MIILION WON	-0.028**	-1.88	-0.011*	-2.96	0.039	0.35
TRU_FARMERS	0.033*	2.78	0.010**	1.73	-0.043	-0.38
TRU_GOVERNMENT	0.012	0.94	0.004	0.78	-0.016	-0.14
TRU_ENVIRONMENTALIST	-0.077*	-4.13	-0.017*	-18.90	0.094	0.90
TRU_SCIENTISTS	0.070*	8.32	0.031*	3.44	-0.101	-0.85
TRU_INDUSTRY	0.011	0.87	0.004	0.74	-0.015	-0.13
TRU_MEDIA	0.049*	4.74	0.018*	2.48	-0.068	-0.58
LL Function	-943.98					
Restricted LL	-985.02					
Chi-Square	82.07					
DF	26					
Prediction Success		48%				
* α=. 05, ** α=. 10						