Consumer Acceptance of GMO: Survey Results from Japan, Norway, Taiwan, and the United States*

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The objective of this paper is to estimate the consumer willingness to pay (WTP) for genetically modified (GM) foods in Japan, Norway, Taiwan, and the U.S. There are notable differences in the attitudes and perception of GM foods across countries. Americans are more willing to consume GM foods than Norwegians, Japanese and Taiwanese. A majority of respondents in all surveys supports mandatory labeling of GM foods. The students in the U.S., Japan, Norway, and Taiwan are willing to pay premiums of 50-62%, 33-40%, 55-69%, and 17-21%, respectively, for non-GM vegetable oil. The WTP values for avoiding the GM alternatives indicate that the average Norwegian consumer demands price reductions of 55%, 54%, and 67% for GM soybean oil, GM-fed salmon, and GM salmon as compared with the conventional alternatives.

***Keywords**: GMO, Consumer Acceptance, WTP*

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* An earlier version of the paper was presented at the 2nd World Congress of Environmental and Resource Economics, Monterey, California, June 24-27, 2002. The authors would like to thank Arild Skogmo, Frode Alfnes, and Dadi Kristofersson for help with the Norwegian surveys, and Naoya Kaneko, Hsin-Yi Chen, Lewis Horner and the Center for Survey Research of The Ohio State University for assistance and funding support for the U.S. survey. Furthermore, we are grateful for the collaboration with Nobuhiro Tsuboi of the University of Tsukuba in Japan and Tsu-Tan Fu of Academia Sinica in Taiwan who conducted the student surveys used in this paper.

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本文文稿作業之執行由吳珮瑛編輯負責。

農業經濟叢刊（Taiwanese Agricultural Economic Review），7:1(2001)，1-28。
中國農村經濟學會出版

I. Introduction

It seems odd that goods produced with a more advanced technology are less desirable to the consumer. The genetically modified (GM) foods appear to fall into this category, at least for some consumers. Genetically modified organisms (GMOs) have been developed from advanced biotechnology to achieve certain desirable traits in agricultural production such as weed and pest resistance. Unfortunately, without direct tangible benefits to the consumer, the foods produced with GMO ingredients may be perceived as being inferior to their non-GM counterparts. There have been concerns about the consumer's acceptance of GM foods in many countries of the world such as those in the European Union (EU) and Japan, as no food manufacturers have dared to test the markets with specifically labeled GM foods under the mandatory labeling regulations.

In order to understand the factors affecting the consumer acceptance of GM foods and to estimate the willingness to pay (WTP) for any premium associated with non-GM products, we have been conducting a multi-country survey project. Specifically, since 2000, a joint research project has been undertaken to conduct a multi-country analysis on consumer attitudes toward GM foods and on eliciting the consumer's WTP for GM vs. non-GM foods in Japan, Norway, Taiwan, and the United States. In 2001, we conducted a uniform student survey in the four countries and a mail survey of residents in Columbus, Ohio, using exactly the same questionnaire. Most recently in April-May 2002, we completed two pilot national telephone surveys using a revised uniform questionnaire in Norway and the U.S.

Since the first commercialization of GM grain corps in 1996, the adoption of Roundup Ready soybeans and Bt corn has increased rapidly in the U.S. (Darr, 2001; Darr and Chern, 2002). However, over this short time period, the use of these GM products has been controversial in the EU, Japan and other countries. In 1997, the EU imposed mandatory labeling of GM foods with a 1% tolerance level, while Japan followed suit in 2001 with a 5% GM content limit. The debates on the consumer acceptance and labeling regulations have attracted much interest among economists to investigate the consumer attitudes toward GMOs and GM foods. There were several consumer surveys conducted in the U.S. (Hoban, 1999; Hallman and Metcalfe, 2001; Moon and Balasubramanian, 2001; and Mendenhall and Evenson, 2002), Europe (Boccaletti and Moro, 2000 for Italy; Burton, Ridby and Young, 2001 for the UK; Spetsidis and Schamel, 2001 for Germany; and Verdurme, et al., 2001 for Belgium), and Japan (Macer and Ng, 2000; Ng, et al., 2000). Most of these studies were descriptive in nature and few of them dealt with the estimation of the WTP for GM foods. Moon and Balasubramanian (2001) estimated the WTP for breakfast cereals made of non-GM ingredients in the U.S. and the UK. Boccaletti and Moro (2000) also attempted to quantify the WTP for generic GM products with different hypothetical attributes in Italy, and Burton et al. (2001) calculated the WTP for such products in the UK. Our study attempts to extend these previous works to design a survey instrument for eliciting the WTP for different GM foods used in the four countries participating in this joint project.

The main objective of this paper is to present the results from a student survey conducted in four countries and another national telephone survey conducted in Norway and the U.S. For the reminder of the paper, we will first provide a brief discussion of the GM food regulations in various countries. We

will then present the student surveys and the estimated WTP for vegetable oil in the four countries. The survey results from the two pilot surveys in Norway and the U.S. will be discussed, but only the preliminary results on the estimated WTP for GM soybean oil, salmon fed with GM soybeans, and GM salmon in Norway are available at this time.

II. Consumer Concerns and Labeling

There is a substantial resistance to GM crops in Europe and other parts of the world. Consumer organizations have expressed concerns regarding antibiotic resistant marker genes, potential allergic reactions, ethical and religious concerns, and the lack of consumer choice due to inadequate labeling (Franks, 1999).

Most national labeling systems are still under development and different countries have taken different approaches. As noted earlier, the EU has imposed mandatory labeling systems. In the EU a number of directives set the framework for the labeling systems in the member states. Directive 90/220 from 1990 establishes requirements for labeling GM crop varieties for seeds, the Novel Food Regulation 258/97 from 1997 sets a 1% tolerance level for whole and processed foods, and Regulation 1139/98 from 1998 covers GM varieties of corn and soybeans that were released before Regulation 258/97 was adopted. However, the EU directives and regulations do not come into effect until the member states enact them as national laws. Some member states also want to go beyond the base requirements. For example, Austria's prefers a ban on GM foods (Phillips and Mc Neill, 2000). Norway is a member of the European Economic Space and is in many cases bound by EU’s directives and regulations. However, Norway has adopted somewhat stricter requirements than those established in EU’s Novel

Food Regulation. One major difference is that labeling is mandatory even if GM foods do not differ from their conventional counterparts (The Norwegian Biotechnology Advisory Board, 2002). Due to consumer opposition, none of the major Norwegian food retailers sell GM foods.

In the United States, the government made a decision on May 3, 2000 to reject a mandatory biofood labeling on the ground that from a health and safety standpoint, these foods do not differ from their conventional counterparts. Since GM foods, such as GM soybeans, are nutritionally equivalent to the conventional ones, Food and Drug Administration (FDA) policy does not require labeling of GM foods (Vogt and Parish, 1999). So far, there has not been notable consumer opposition to GM foods in grocery stores, however, some consumer groups have strongly supported the consumer's right to know.

The new system of labeling GM foods in Japan that has been in effect since April 1, 2001 has several provisions. First, the provision on voluntary labeling applies to foods made from non-GM crops segregated throughout the production and distribution stages. Those foods can be labeled as "Not genetically modified." Second, mandatory labeling applies to the following two categories: (1) foods made from crops not segregated from GM crops, for which they are required to be labeled as "Not segregated from GM product," (2) foods made from GM crops, in which case, they have to be labeled as "Genetically modified" or "Genetically modified (soybean) segregated."

In Taiwan, there has been increasing concerns over GM foods expressed by the public. According to a press report (Taipei Journal, September 29, 2000), the results of testing conducted by the Taipei-based Environmental Quality Protection Foundation (EQPF) indicate that 11 out of 14 soybean and potato products popular in Taiwan contained GM ingredients. This is, of course, not surprising because

Taiwan imports most of its soybeans from the U.S. The Taiwan government has closely monitored the development of GM food labeling regulation in Japan. Following the Japanese GM food labeling law, the Bureau of Food Sanitation in Taiwan enacted a new law for GM food labeling regulation in 2001. Specifically, the new regulation stipulates that foods containing more than 5% of GM ingredients, such as soybeans and corn, must be labeled as “GMOs-contained.” The new regulation will be enforced beginning January 1, 2003.

III. Student Survey Comparison

Our student survey questionnaire contained five sections. First, respondent’s awareness and knowledge of GM food were investigated. Next, we explored respondent’s attitudes and perceptions of GM food, such as willingness to consume, environmental concern, and religious and ethical concerns associated with GM food products. Then we asked the respondents about their attitudes toward GM food labeling, as well as type of labeling system they would support. Another section was on contingent valuation, where respondents were elicited about their willingness to consume certain GM food products versus their traditional counterparts, given different price scenarios. Based on the market prices of the products, we designed three price scenarios for all GM and non-GM products. The food products included vegetable oil, salmon, and tofu. The last section of the survey contained the demographic information. The results for selected questions related to knowledge, attitudes toward GM foods and labeling, perception, and willingness to consume foods with alternative GM attributes will be reported later. The responses to these questions provide the basis for constructing the independent variables used in the econometric model for

estimating the WTP for a premium of non-GM foods.

The U.S. student survey was conducted at The Ohio State University while the survey in Norway was conducted at the Agricultural University of Norway. The same questionnaire was also used in the surveys conducted at University of Tsukuba (Japan) and National Taiwan University (Taiwan). These student surveys were taken during December 2000 to March 2001. Attempts were made to use the upper level classes for juniors and seniors taken by different majors in various colleges. Note that the original questionnaire was developed in English and later translated into Norwegian, Japanese, and Chinese.

Table 1 shows the sample sizes and descriptive statistics (in %) for selected questions. Results show that even though U.S. students had a higher percentage of being not informed about the GMOs or GM foods, they outperformed Japanese students in the two "true or false" questions related to specific knowledge on GMOs. It is interesting that Japanese students were much more conservative and perhaps more honest, as 94% and 69% of the respondents indicated "don't know" to the two true-false questions. Perception of the health risk of GM foods varied from country to country. While only 6% of U.S. students ranked GM foods as "very risky," the percentages were higher in Norway (11%), Japan (10%) and Taiwan (17%). The acceptance toward GM foods varied greatly between Norway and the United States. Despite the low awareness of biotechnology, more than 80% of U.S. students were at least "somewhat willing" to consume GM foods. By comparison, a majority of Norwegian students (56%) were not "very willing" or would avoid consuming GM foods despite of their high awareness of GM technology. The difference in the attitude on the willingness to consume GM foods was very dramatic between Japan and Taiwan. While there was only 17% of Japanese students who were "somewhat" or "very willing" to consume GM foods, the figure was 79% for Taiwanese students.

Table 1. Sample Mean Statistics in Terms of Percentage Distribution for Each Question from Student Surveys, 2001

Question	Alternative	Norway	U.S.	Japan	Taiwan
Sample Size		126	175	103	213
Before this survey, how well were you informed about GM foods or organisms?	Very well	1%	8%	20%	2%
	Somewhat	88	68	77	94
	Not informed	11	24	3	4
Non-genetically modified soybeans do not contain genes while genetically modified soybeans do.	True	6	3	0	5
	False	85	63	6	85
	Don't know	9	34	94	10
By eating GM foods, a person's genes could be altered.	True	6	5	16	13
	False	70	78	15	62
	Don't know	24	17	69	25
How safe or risky of GM foods to human health?	Very risky	11	6	10	17
	Neither	44	55	50	49
	Very safe	45	32	26	18
	Don’t know	0	7	14	16
How willing to consume foods with GM ingredients?	Very willing	10	38	4	19
	Somewhat	34	44	13	60
	Not very	38	14	63	20
	Would avoid	18	4	20	1
How willing to consume GM foods if they reduce the amount of pesticides applied to crops?	Very willing	23	54	10	64
	Somewhat	41	37	33	27
	Not very	26	6	43	9
	Would avoid	10	3	14	0
How important to label GM foods?	Very	84	49	60	79
	Somewhat	13	29	21	19
	Not very	3	22	19	2
What type of labeling would you support?	Mandatory for GM and non-GM	48	39	30	67
	Mandatory for GM	48	37	52	27
	Voluntary	3	20	17	4
	Don’t support any	1	4	1	2

It is important to note that the willingness to consume GM foods increases notably if the GM foods contain specific benefits to the consumer such as reduction of the amount of pesticides applied to crops. In all four countries, student respondents would with a large margin support a mandatory labeling system.

Based on the data from the contingent valuation (CV) portion of the student survey questionnaire, we also estimate the WTP for a premium for non-GM foods. The methodology is based on a random utility model described later in this paper and also in Chen and Chern (2002). We first estimate a logit model in which the decision on buying a GM food is a function of many attitude, perception, knowledge, and demographic variables as well as the price difference between GM and non-GM product. From the estimated logit model, we can calculate the expected WTP premium for a non-GM product by respondents. The average WTP can then be computed by taking an average from the entire sample. Since there are many missing data for tofu and salmon, perhaps due to the unfamiliarity of the products, the results of the logit model are not very satisfactory. Only the results for vegetable oil are presented in Table 2. These results show that students in all four countries are willing to pay a high premium for non-GM vegetable oil, ranging from 17-21% in Taiwan to 55-69% in Norway. Note that there is a range of WTPs in each country. This is due to the design of offered prices in the survey. Specifically, we varied the base price (i.e., for GM foods). When the percentage of premium is computed using the estimated average of WTP as a percentage of the base price, the highest and lowest base prices yield the ranges presented in Table 2.

Table 2. Estimated WTP for Premiums of Non-GM Vegetable Oil

Item	Norway	U.S.	Japan	Taiwan
Reference Size	Liter	32 Fl oz	Standard	600 grams
WTP in Local Currency	NOK13.7	$1.13	88 Yen	NT$ 15
WTP in US$	$1.51	$1.13	$0.88	$0.45
Percentage of Premium (%)	55~69%	50~62%	33~40%	17~21%

IV. The Public Surveys and Analysis

Two telephone surveys were conducted during March and April 2002 in Norway and the U.S. We asked similar questions, however, the surveys were conducted in different languages creating some differences regarding the exact wording of questions. Some questions from the original English questionnaire were also omitted from the Norwegian survey. For example, adjectives like “extremely” were toned down in the Norwegian translation and questions concerning “race” or “religion” (Norway is 95% white and protestant) were omitted. We have used the U.S. wordings of the alternatives and questions in the tables presented later. There are many advantages of doing a telephone survey. One is that the alternative choices of several questions can be randomly selected for each interview. The interviewers were trained to answer questions to the respondents and thus the quality of the responses should be higher than a typical mail survey.

The nationwide U.S. survey consisted of 250 respondents aged 18 and over. The survey was conducted by telephone with the random digit dialing method. This pilot survey was funded and conducted by the Center for Survey Research

(CSR) of The Ohio State University. As noted earlier, we based our experience from the student surveys as well a mail survey conducted in Columbus, Ohio in 2001 to revise the survey instrument for this public survey. One important innovation in the revised questionnaire is that we do not assume a priori that GM foods are inferior to their conventional counterparts. Also, we design the WTP questions with sequential closed-ended questions (Carson and Mitchell, 1995). We went through many rounds of revision. Among them was a pretest by a group of graduate students. The final version was given to the CSR for conversion to a telephone interview format. The CSR also conducted another pretest and the feedbacks were used to change some of the questions and wordings. The U.S. survey was conducted within a three-week period in April 2002, with a mix of day times and evenings. Average age of the U.S. survey respondents was 47 while 77% were females. Note that in the U.S. survey, we required the respondents as a food shopper in the household. There were 4.3% of the respondents who were vegetarians.

The Norwegian survey was conducted by Skogmo (2002) and the Norwegian results from the public survey are based on his results. In the Norwegian survey, 100 respondents aged 18 and over living in Oslo (the capital) and 100 respondents living in Nordland (a county without any major cities in the Northern part of Norway) were randomly selected from the phone book and interviewed. The phonebook covers about 97% of Norwegian households. The sample consists of 46% male and 54% female respondents. The average age of the respondents was 49 years or about four years above the national average for the age group 20 to 80 years. The high mean age was partly a result of 40% of the interviews being conducted during daytime when many retired people answered the phone. Furthermore, four out of five calls were rejected pointing to a potential self-selection problem with less participation among people with valuable time.

1. Comparison of Results

The results in Table 3 show that about 45% of the respondents considered themselves “not informed” and about 45% considered themselves “somewhat informed ” about GM foods or organisms. A somewhat larger percentage of Americans (14.1%) than Norwegians (8.0%) claimed to be “very well informed.” These figures differ substantially from the student surveys discussed above, as a majority of student respondents (ranging from 94% in Taiwan to 68% in the U.S.) considered themselves “somewhat informed.”

Table 3. Consumer Information and Knowledge, Percentage Distribution for Each Question

Question	Alternative	Norway	U.S.
Before this survey, how well were you informed about GM foods or organisms?	Very well	8.0%	14.1%
	Somewhat	45.0	41.0
	Not informed	47.0	44.9
Non-genetically modified soybeans do not contain genes while genetically modified soybeans do.	True	16.0	23.4
	False	37.5	43.8
	Don't know	46.5	32.8
By eating GM foods, a person's genes could be altered.	True	28.0	22.3
	False	36.0	61.3
	Don't know	36.0	16.4

The high proportions of “not informed” respondents correspond well with the proportion of correct answers to our two knowledge statements. Only 37.5% of Norwegian and 43.8% of American respondents thought it was false that “Non-genetically modified soybeans do not contain genes while genetically modified soybeans do” while 36.0% of Norwegians and 61.3% of Americans believed it was

false that "By eating GM foods, a person's genes could be altered." As expected, a larger share of younger respondents answered correctly and also more students in the student surveys answered correctly. The results in Table 4 show that a majority of Norwegians (59.5%) and close to half of Americans (48.9%) believed that GM foods were risky to human health while 23.5% of Norwegians and 20.7% of Americans thought they were safe. A third of the Norwegians considered them extremely risky.

Less than a third of Norwegian (30.5%) and 43.0% of American respondents claimed that they were willing to consume foods produced with GM ingredients. The American resistance is unexpected given that about 70% of the foods on the retail food store shelves are said to contain some form of GMO ingredient in the U.S. (Kinsey, 2001). A larger proportion of the Norwegian than the U.S. respondents were either "extremely unwilling" (45.5%) or more surprisingly "extremely willing" (13.0%) to consume GM foods.

The opposition against GM foods was reduced when some benefits associated with them were explicitly mentioned in the questions suggesting that GM foods can grow in popularity when consumers become aware of the potential benefits. Benefits offered in our questions are reduced use of pesticides, improved nutritional qualities, or lower price. Close to 40% of Norwegians and around 70% of Americans were willing to consume GM foods conditional on those benefits. When we asked which of these potential benefits was the most important, about 65% of the Norwegian and 55% of the American respondents answered reduced use of pesticides and below 10% answered reduced price. More than half of Norwegians found reduced price to be "extremely unimportant" for their decision to buy or not to buy GM foods. The insensitivity to price may be caused by the hypothetical nature of the choice (i.e., no real goods or payments) as

discussed in much of the experimental economics literature (e.g., List and Shogren, 1998). In the student surveys, especially the Japanese and Norwegian students were less willing to accept similar trade-offs than the respondents in the public survey.

We also asked about some potential sources of concern. More than 80% of Norwegians and 40% of Americans were "extremely unwilling" to purchase GM foods if it posed a risk of causing allergic reaction for some people. Only 10.0% of Norwegians and 25.0% of Americans were willing to take such a risk. Ethical and religious concerns were important for 29.5% of Norwegians and 36.3% of Americans while such concerns were "extremely unimportant" for as much as 62.5% of Norwegians and 28.9% of Americans.

A majority of Norwegian (98.5%) and American (87.1%) consumers demanded labeling. These results are in line with the results in the Eurobarometer (2001) where 94.6% of the 16,029 respondents in the 15 member states of EU wanted to have the right to choose between GM and non-GM foods. Support for labeling was reduced when the respondents were reminded that labeling may increase food prices, however, 55% of Norwegians supported labeling even if prices are increased by 5% or more. The insensitivity to price may again be partly explained by the hypothetical nature of the question.

The results indicate more favorable attitudes to GM foods in the U.S. than in Norway; however, the opinions in the U.S. are also quite mixed. This general conclusion is consistent with Priest (2000) who found that the U.S. increasingly resembles Europe in having significant amounts of reservation towards biotechnology.

It is interesting to examine whether or not the knowledge about GMOs has any effect on the attitude and perception toward GM foods. Figures 1-2 present the distributions of the responses to the following questions in the U.S. public survey:

1: How risky would you say GM foods are in terms of human health?

2: How willing are you to consume foods produced with GM ingredients?

by answer of　“true, false, or don't know,” to the following “false” statement:

“Non-GM soybeans do not contain genes while genetically modified soybeans do.”

These figures show that the knowledge does matter. For those who evaluated the statement correctly, they tend to consider GM foods less risky to human health than those who did not do it correctly. Also, those who were more knowledgeable about GMOs would be more willing to consume GM foods than those less knowledgeable. These results suggest that it is important to educate the public about GMOs with accurate scientific information in order to increase the consumer acceptance of GM foods.

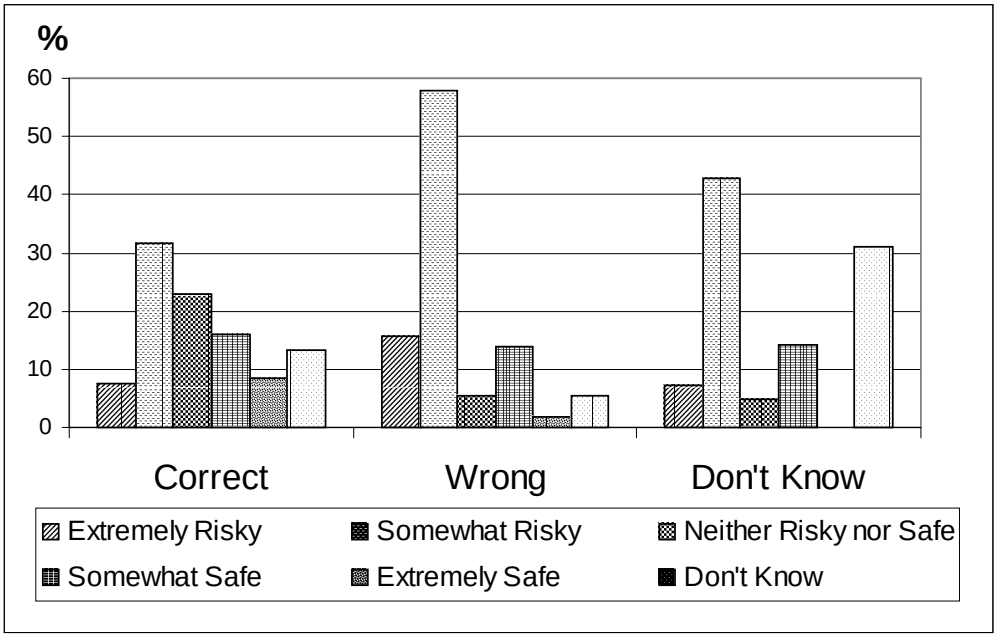

Figure 1. Distribution of Responses to the Question “How risky would you say GM foods are in terms of risk for human health?” by Answer (True, False or Don’t Know) to the statement “Non-GM soybeans do not contain genes while genetically modified soybeans do” from the U.S. Public Survey

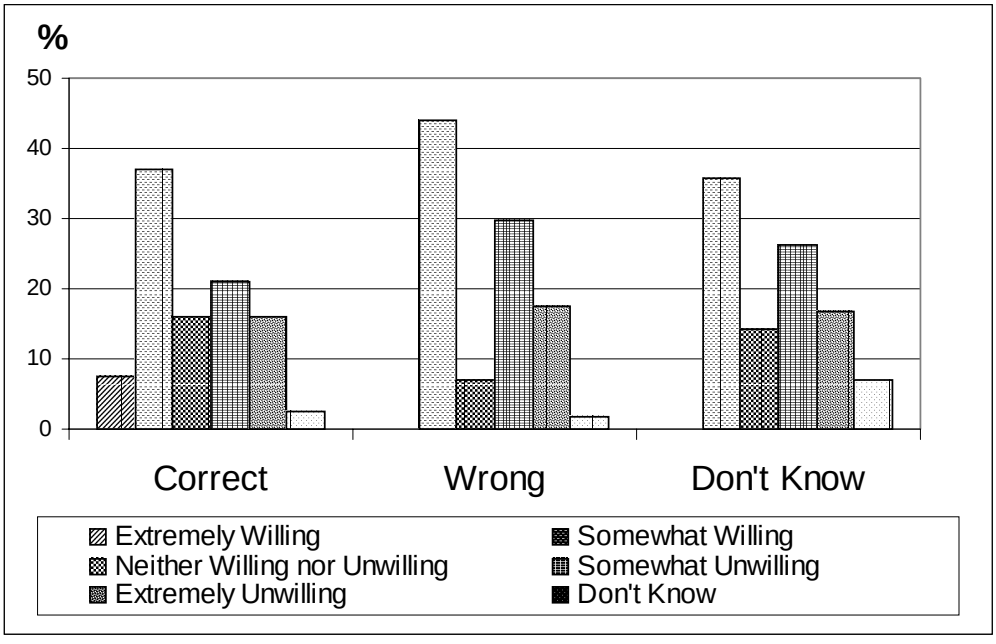

Figure 2. Distribution of Responses to the Question "How willing are you to consume foods produced with GM ingredients?" by Answer (True, False or Don't Know) to the statement "Non-GM soybeans do not contain genes while genetically modified soybeans do" from the U.S. Public Survey

2. Estimation of WTP

We next investigate the willingness to pay (WTP) for different types of soybean oil (non-GM and GM) and salmon (non-GM, GM fed, and GM). GM foods are not sold in Norway but GM soybean oil is commonly sold in the U.S. Salmon can potentially be fed by GM soybeans (GM-fed salmon) and a GM salmon is developed by the Canadian company *Genesis*. The GM salmon grows faster than wild salmon (but not necessarily faster than farmed salmon) and the feeding costs are lower (Aftenposten, September 9, 2001). None of the GM salmon are yet for sale. Nevertheless, there is a considerable interest for

consumers' acceptance and WTP for various types of salmon in the aquaculture sector.

To calculate WTP we use a stated choice method (SCM), which is based upon buyers' hypothetical choice for GM food purchases. We use a simple design developed for the telephone survey and the only attributes included are prices of GM versus non-GM implying that attributes like reduced use of pesticides or improved nutritional values are not considered.

A disadvantage of the SCM (and other stated preference methods) is that peoples' behavior in a hypothetical setting may not fully reflect actual behavior, i.e., the respondents may not act on their stated choices. However, given that none of the GM qualities of salmon are available, we could not use experimental auctions or other incentive compatible techniques.

We have two alternatives of soybean oil and three alternatives of salmon. The choice experiment consisted of two steps and each step consists of one binary choice for soybean oil and two binary choices for salmon. In step one, we asked the respondents if they would choose (i) non-GM or GM-fed salmon, (ii) non-GM or GM salmon, and (iii) non-GM or GM soybean oil given identical prices for each of the two choices. The base prices we used reflected prices found for the non-GM products in stores. The percentage distributions of the respondents' choices are shown in Table 5. More than 80% of Norwegians chose the non-GM alternative for each of the three choices. For the American respondents, 45.1% chose non-GM soybean oil, 59.2% chose non-GM salmon (over GM fed), and 68.9% chose non-GM salmon (over GM salmon). Not for any of the choices did more than 10% of the respondents prefer a GM product but in the U.S. close to a quarter of the respondents were very indifferent between the GM and non-GM alternatives.

Table 5. Stated Choices at Identical Prices, Percentage Distribution for Each Choice

Choices	Country	First Choice					
		Non GM	GM	GM Fed	Indifferent	None	Don't Know
Salmon: Non GM/GM fed	Norway	81.8		1.0	8.6	8.1	0.5
	U.S.	59.2		6.5	24.9	8.3	1.2
Salmon: Non GM /GM	Norway	86.4	1.0		4.0	7.6	1.0
	U.S.	68.9	3.6		21.0	5.4	1.2
Soybean oil: Non GM / GM	Norway	85.4	2.5		7.0	4.5	0.5
	U.S.	45.1	8.7		24.9	19.1	2.3

In step two, each respondent was given the same choices as in step one but offered price reductions for the commodity he/she did not choose. The price reductions were in the interval 5% to 50% for GM soybean oil and GM-fed salmon and 10% to 60% for GM salmon. Respondents that were indifferent between some alternatives in step one were randomly offered reduced price for one of the alternatives.

Following Ben-Akiva and Lerman (1985) and Haab and McConnell (2002), we specify a random utility model that is linear in parameters:

$$V_{in} = \beta_{i0} + \beta_1 p_{in} + \beta_{i2} x_{n2} + ... + \beta_{ik} x_{nk} + \varepsilon_{in}, \quad (1)$$

where V_{in} is respondent n's utility of choosing alternative i, p_{in} is the price offered to respondent n for alternative i, x_{n2} ... x_{nk} are the individual specific characteristics (for example gender or education) of respondent n, and the error terms ε_{in} are assumed to be independently, identically, and extreme value (Gumble)

distributed. The estimated parameters, except the utility of money (β_1), are allowed to vary across the alternatives allowing the personal characteristics to have non-constant effects for the alternatives and thereby an impact on the choices made. For identification, the parameters of the first equation (except β_1) are normalized to zero. Letting the scale parameter μ = 1, the probability of choosing alternative *i* for respondent *n* is estimated by the logit model:

$$\pi_n(i) = \frac{e^{V_{in}}}{\sum_j e^{V_{jn}}}. \tag{2}$$

For soybean oil we use a binary (*i*=1 is non GM and *i*=2 is GM) and for salmon a multinomial (*i*=1 is non-GM, *i*=2 is GM-fed, and *i*=3 is GM) logit model.

The estimated parameters can be combined to identify monetary values associated with changes in each attribute and characteristic level. Since the utility of the non-GM alternative (*i*=1) is $V_{1n} = \beta_1 p_{1n} + \varepsilon_{1n}$, the WTP_{in} for the GM alternatives (*i*=2, 3) can be calculated from the expression:

$$\beta_1 p_{1n} + \varepsilon_{1n} = \beta_{i0} + \beta_1 \left(p_{in} + WTP_{in} \right) + \beta_{i2} x_{n2} + ... + \beta_{ik} x_{nk} + \varepsilon_{in}. \tag{3}$$

Assuming that $E(\varepsilon_{1n}) = E(\varepsilon_{2n}) = E(\varepsilon_{3n}) = 0$, the average consumer's willingness to pay for each alternative is

$$\overline{WTP_i} = -\frac{1}{\beta_1}\left(\beta_{i0} + \beta_{i2}\overline{x_2} + ... + \beta_{ik}\overline{x_k} \right), \tag{4}$$

where $\overline{x}_k$ denotes the mean value of the individual specific characteristic *k*. The marginal change in WTP for alternative *i* associated with a change in characteristic *k* is

$$\frac{\partial WTP_i}{\partial x_k} = -\frac{\beta_{ik}}{\beta_1}. \tag{5}$$

Using Norwegian data (we will estimate similar models using the U.S. data later) and the LIMDEP program version 7, we estimate models using different sets of characteristics; however, the average consumer's WTP for each alternative is reasonably robust for choice of variables. The WTP estimates are based on a model including alternative specific *prices* (in NOK), *age* (calculated as the age of the respondent, divided by 10 and centered by subtracting the mean of the sample), *gender* (-1 if female and 1 if male), *education* (educational level on a scale from 1 to 6), and *income* (the log of household income on a scale from 1 to 11). For estimation, the choices of indifferent respondents are weighted with a half on each of the two indifferent alternatives.

The average Norwegian consumer's WTP to avoid the various GM alternatives are shown in Table 6. The amounts may be interpreted as the amounts that we would have to reduce the price of the non-GM alternative to let the average consumer be equally well off. The price of non-GM soybean oil was NOK 40 and the price of GM soybean oil has to be reduced with NOK 22.13 to NOK 17.87 per liter to make the average Norwegian consumer equally well off. In a similar way, the price of GM-fed salmon has to be reduced with NOK 43.42 and GM salmon with NOK 53.96 from the base price of NOK 80. This corresponds to price reductions of 55%, 54%, and 67% for GM soybean oil, GM-fed salmon, and GM salmon. All the estimated values are significantly different from zero at the 5% level of significance. As expected, the required reduction in price is larger for GM salmon than for the other GM alternatives. There is a distinction between direct and indirect GM consumption and there is also a difference between plant and animal genes.

Table 6. WTP Values to Avoid GM Alternatives, Norway (Standard errors in the parentheses)

	Alternative		
	GM soybean oil	GM-fed salmon	GM salmon
Mean, NOK	22.13 (2.84)	43.42 (5.06)	53.96 (5.23)
Mean, US$[a]	2.77	5.43	6.75
Percentage reduction	55%	54%	67%

[a] The exchange rate is set to NOK 8.00 per US$.

Table 7. Marginal WTP Values Measured in NOK to Avoid GM Alternatives, Norway (Standard errors in parentheses)

Variable	Alternative		
	GM soybean oil	GM-fed salmon	GM salmon
Age	1.88 (0.78)	3.52 (1.80)	3.54 (1.94)
Gender	-4.48 (1.31)	-9.32 (3.06)	-11.72 (3.39)
Education	-2.87 (0.93)	-5.29 (2.27)	-5.85 (2.45)
Income	1.05 (0.47)	3.71 (1.19)	3.03 (1.25)

The marginal WTP values reported in Table 7 show how much a change in one of the individual specific characteristics will affect the WTP to avoid the different GM alternatives. It is reassuring that the effects of the characteristics are consistent across the various GM alternatives. The age effects are always positive and significant for GM soybean oil and GM-fed salmon. If the age of the respondent increase by 10 years, then the respondent demand an extra price reduction of NOK 1.88, 3.52, and 3.54 for GM soybean oil, GM-fed salmon, and GM salmon, respectively. The gender effects are always negative and significant. Females are coded as –1 and males as 1 implying that female consumers demand

price reductions of NOK 4.48, 9.32, and 11.72 as compared with the average Norwegian consumer for GM soybean oil, GM-fed salmon, and GM salmon, respectively. The effect of education is always negative and significant. The more education the less price reductions are needed. If the educational level (from one to six) increases by one, then the respondent requires NOK 2.87, 5.29, and 5.85 less compensation for consuming GM soybean oil, GM-fed salmon, and GM salmon. The effect of income is always positive and significant implying that respondents with higher incomes demand larger price reductions. Since the log of income is used as a variable, there is always a positive and significant but decreasing effect of income, and the estimates reported are for changes from mean income. If the mean household income increases with one class (or NOK 100,000), then the respondent demands an additional price reduction of NOK 1.05, 3.71, and 3.03 for GM soybean oil, GM-fed salmon, and GM salmon, respectively.

The reported WTP figures are quite substantial indicating a strong opposition against GM foods in Norway. Given the potential hypothetical bias mentioned above they must be interpreted as upper bounds. However, we may note that the reported WTP values are identically and inversely related to the estimated price parameter, β_1, implying that any hypothetical bias affects the levels of the WTP and not the relative price effects between the GM and GM-fed salmon.

V. Conclusions

This paper presents survey results and analyses from a joint research project to conduct a multi-country study on the consumer acceptance of GM foods. The results indicate more favorable attitudes to GM foods in the U.S. than Norway for students as well as ordinary consumers. However, the opinions in the U.S. are

also quite mixed and only 43% of the American respondents in the public survey claimed that they are willing to consume foods produced with GM ingredients. Japanese students are also more skeptical towards GM foods than Taiwanese students. The opposition against GM foods is reduced when some benefits associated with them are introduced into the questions suggesting that GM foods have a potential to become more popular. Reduced use of pesticides and improved nutritional qualities are perceived as more important potential benefits than reduced price. Health concerns are apparently more important than ethical or religious concerns in explaining the negative attitudes towards GM foods. The support for mandatory labeling is overwhelming in the student as well as public surveys.

The survey results also show that the respondents more knowledgeable about GMOs tend to consider GM foods as less risky to human health and are more willing to consume GM foods than those who are less knowledgeable. Therefore, it is important to educate the public about GMOs in order to increase the consumer acceptance of GM foods.

There is a substantial WTP to avoid GM alternatives. The students in all four countries are willing to pay premiums ranging around 60% in Norway to about 20% in Taiwan for non-GM vegetable oil. In the public survey, 80% of the Norwegian respondents chose the non-GM alternatives in each case and for the American respondents 45% chose non-GM soybean oil, 59% non-GM salmon over GM-fed salmon and 69% chose non-GM salmon over GM salmon. These figures indicate that there are differences between direct and indirect GM consumption and between animal and plant genes.

The WTP for avoiding the GM alternatives indicates that the average Norwegian consumer demands price reductions of 55%, 54%, and 67% for GM

soybean oil, GM-fed salmon, and GM salmon as compared with the conventional alternatives. For GM soybean oil, the estimated WTP from the public survey is very close to that obtained from the student survey. These high values may, at least to some extent, be due to the hypothetical nature of the choices without any real payments.

Future research will focus on estimating identical models for the U.S. and Norway for more systematic testing in the differences in WTP to avoid GM foods in Europe and the U.S. The public surveys reported in this paper were pilot surveys. Similar pilot surveys will be soon conducted in Taiwan and Japan. We also plan to revise and improve our survey instrument, conduct a larger national sample, and expand the project to cover more countries.

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消費者對基因改造有機品之接受度：日本、挪威、台灣與美國之調查結果

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本篇文章的目的是評估日本、挪威、台灣與美國消費者，對基因改造（genetically modified，GM）食品的願付金額（willingness to pay，WTP)。這些國家對 GM 食品的態度與認知程度有顯著的差異。相較於挪威人、日本人與台灣人，美國人消費 GM 食品的意願較高。由四個國家的調查結果發現，大多數的受訪者支持 GM 食品需有強制性之說明。而美國、日本、挪威與台灣的學生分別願意支付 50-62%、33-40%、55-69%與 17-21%的額外費用，以購買非 GM 植物油。此外，為避免 GM 替代品的 WTP 評估結果顯示，對於挪威消費者而言，平均對 GM 大豆沙拉油、餵食 GM 飼料之鮭魚與 GM 鮭魚等產品之需求價格，分別要比傳統的替代品低 55%、54%與 67%。

關鍵詞：基因改造有機品、消費者接受度、願付金額

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