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Consumer attitudes to GM foods: some preliminary results from Western Australia

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Abstract

Numerous qualitative studies have examined consumer attitudes towards genetically modified foods. This research adds to those studies by using choice modelling methods to examine the extent to which Western Australian consumers are willing to pay to avoid GM foods, if at all. The questionnaire asked respondents to choose between hypothetical baskets of foods with different attributes before asking them explicit "willingness to pay" questions. The fieldwork on which this paper is based has only recently been completed, and so the results are preliminary. However they appear statistically robust and consistent with previous findings. The presentation will include an outline of the survey and a summary of results.

Keywords: genetically modified food, consumer attitudes, choice modelling

[1] Sallie James gratefully acknowledges financial assistance from the ARC and Agriculture, WA.

Introduction

The emergence of food safety issues relating to genetically modified organisms (GMOs) raises a number of important conceptual and practical issues at the academic, regulatory and commercial levels. The broader project of which the analysis in this paper forms a part will address regulatory issues relevant to food safety, risk analysis, consumer attitudes towards risk and trade ramifications of gene technologies.

Food safety decisions made by private companies and government organisations are based on risk assessments which provide the scientific evidence for determining and controlling threats to food safety and quality. However consumers may differ from scientists in their assessment of risk and may consider attributes other than food safety such as taste, price and ethical and environmental attributes when purchasing food. These differences in attitudes have a major impact on the regulation, production and marketing of foods to meet the requirements of consumers in international markets. Thus, quantifying the value of food safety and quality attributes is a key factor in private and public decision making regarding the types of food products offered in the market and the regulations enforced.

A survey was conducted in October 2000 in Western Australia to determine what the attitudes of consumers to foods produced using gene technology might be. The survey used choice modelling techniques based on a conditional logit model, with additional information collected on attitudes and background demographic information. The results of this survey will be reported in the second section of the paper. It is hoped that, by identifying consumers' willingness to pay to avoid GM foods, the results of the survey can assist in identifying the appropriate policy response.

Section 1: Choice modelling and willingness to pay

Numerous qualitative surveys have been administered in Australia and abroad in order to gauge public opinion on genetic engineering and foods containing ingredients modified by those technologies (see, for example, Kelley, 1995; Hoban, 1998; Norton *et al.*, 1998; Yann Campbell Hoare Wheeler, 1999; Wolf and Domegan, 2000 and Mendenhall, 2000). However, many of these identify only qualitative attitudes, such as a rating of consumers' 'concern' about the technology, or whether they would be willing to purchase it. Such views will normally be conditional upon the circumstances within which GM food becomes available. Is rejection of GM food independent of the level of price discount that might be available? Are environmental or ethical concerns about GM production techniques non-negotiable, or could they be offset by potential alternative environmental benefits from GM crops? As with all consumer behaviour, the observed outcomes will be the result of constrained choice. Contingent valuation (CV) as applied to environmental goods has long recognised this problem, and has lead to an emphasis on alternative uses of resources that may be committed to conservation, and the 'scope' of the good being considered in relation to the wider environment.

Choice modelling is a particularly attractive way of approaching this issue, in that the choices presented explicitly highlight the trade-offs that often have to be made in actual decisions. More specifically, the technique allows a single issue of interest to be broken down into the range of elements that it comprises, thereby allowing the trade-offs between these components to be analysed.

Choice modelling: theory

The central idea behind choice modelling is that individuals can choose between alternative options that contain a number of attributes with different levels. Respondents are not asked to report how much they prefer alternatives, nor even how much they value individual changes in an attribute; they are merely asked to identify which of a number of options they prefer. Formally, it is based within the framework of Random Utility Theory, and there have been extensive applications in marketing and environmental valuation (e.g. Bennett, 1999; Blamey *et al.*, 1998; Morrison *et al.*, 1996; Hansen and Schmidt, 1999; Adamowicz, *et al.*,1998).

To motivate the discussion, consider a simple case where there are two attributes in each option: the form of technology used to produce food (Conventional or GM) and the level of the weekly food bill for the individual. If only two options are provided, the choice set could be as illustrated in Table 1.

Table 1: A simple choice set

Attributes	Option1	Option 2
Technology	Conventional	GM
Weekly food bill	100% of current	80% of current

In selecting between these two the respondent is asked to compare the reduced food bill with the change in technology.

Choice modelling formally represents the choice process as a comparison between the welfare, or utility, gained from each option, such that Option1 is chosen if the welfare from its level of attributes is preferred to that generated by Option 2. At that level, it is tautological: the respondents choose the option they prefer. The model is given empirical content by explicitly modelling the process by which welfare is generated. In its simplest form we can specify that

$$U_i=\beta_1 GM_i + \beta_2 PAY_i + \varepsilon \qquad (1)$$

where U_i is the utility obtained from option i, GM is a dummy variable indicating the use of GM technology and PAY are the levels of expenditure, and the β_i are parameters that are to be estimated. ε is an unobservable component of utility, namely something which is known to the respondent, but which the analyst cannot identify.

Formally, the respondent will choose option1 if $U_1>U_2$. The task of the statistical analysis is then to identify estimates of the parameters (β_i) so that the predicted choices, made on the basis of a comparison of the utilities predicted for each option using equation (1), match as closely as possible the actual choices revealed in the survey. Hence in this example one might expect that β_1 would be negative, so that the presence of GM will reduce the probability that the option will be chosen, while β_2 will also be negative: options with higher payment levels will be less likely to be chosen.

The model is implemented by choosing a particular distribution of disturbances. Testing the properties of the error process can lead to significant efficiency gains, and added insight into the choice process. Greene (1997) shows that, assuming independent and identically distributed error terms, the probability of choosing option j from N options can be expressed as:

$$\text{Prob}(Y = j) = \frac{\exp\left[\sum_{k=1}^{K} \beta_k X_{kj}\right]}{\sum_{n=1}^{N} \exp\left[\sum_{k} \beta_k X_{kn}\right]} \qquad (2)$$

where X_k (k=1,..,K) denotes the choice attributes.

This leads to the conditional logit model, which generates the probability of choosing an option conditional upon the values of the exogenous variables (the attribute levels). One implication of the conditional logit model is the assumption of independence of irrelevant alternatives, which asserts that the relative probabilities of two options being chosen are independent of the remaining probabilities.

Partworths

An important aspect of the interpretation of the outcomes from choice models is the notion of a 'partworth', or implicit price. The individual parameters generated by the model do not have a direct interpretation, other than in their signs or statistical significance. However, the parameters can be combined to identify monetary values associated with changes in each attributes level.

If one returns to the initial example of equation 1:

$$U_i = \beta_1 GM_i + \beta_2 PAY_i + \varepsilon \qquad (1)$$

A shift from conventional to GM technology, *ceteris paribus*, will change utility by an amount $\beta_{1.}$ The question can then be posed: what reduction in the amount the consumer has to pay would just offset the decrease in utility arising from the new technology? If this amount could be identified, then formally the individual would be indifferent between the original position, and the new technology with a reduced level of the food bill. The amount can be derived from:

$$\beta_2 PAY_1 + \varepsilon = \beta_1 {*} 1 + \beta_2 (PAY_1 + x) + \varepsilon \quad (3)$$

where x is the increase in payment that is to be identified.

This can be solved to identify x as:

$$x = -\beta_1/\beta_2 \quad (4)$$

i.e. the (negative) parameter on the attribute divided by the parameter on the payment level. x is the partworth associated with a unit increase in the attribute, and can be interpreted here as the maximum that the respondent would be willing to pay to avoid consuming GM food.

Section 2: An application of choice modelling : WA Consumers' attitudes to GM food

One problem that has been identified with choice modelling is that of framing: that is, the survey process itself may give the topic unwarranted prominence. In order to remind respondents of the context in which the issue of GM food exists, various other food related attributes were presented in each choice set. Not only does this give an appropriate frame to the issue of GM foods, it also allows us to compare the concern associated with gene technology to other food related issues.

Each option (or "food basket") presented consisted of five attributes, each taking a number of levels. The details of the attributes and levels are reported in Table 2.

Table 2: Attributes and levels

Attribute	Level
Weekly food bill (% change from current)	-50, -40, -30, -20, -10, 0, 10, 20, 30, 40, 50
Production technology	Conventional, GM (plants), GM (plants and animals)
Level of on-farm chemical use (% change from current)	-30, 0, 10
Environmental risk (years until gene transfer)	0, 2, 5, 20, 50
Health risk (chance of contracting food poisoning)	1 in 3,000, 1 in 5,000, 1 in 10,000

The weekly food bill is the payment vehicle. The production technology was identified as having 3 possible levels: "conventional", where no gene technologies are used in food production, gene modification using plant genes and gene modification using plant and animal genes. The two types of gene modification were introduced in order to explore further the inferences made in previous attitude surveys that consumers are more concerned about gene technology involving animals that involving plants alone.

The level of on-farm chemical use is used as a proxy for the intensity and potential environmental impact of agriculture and was allowed to increase or decease with the use of GM crops. Likewise, the "environmental risk" attribute was included to explore the possibility of "gene escape" into the environment. This risk was presented to respondents as the years before this happens (including the possibility of zero risk in the case of conventional technology and as a possibility with the use of GM crops).

The risk of food related illness was used to remind respondents that food, whether conventional or produced with the aid of gene technologies, presents some risk of food poisoning. All food attributes were described in detail in an introductory leaflet in the survey. It was made clear in the information booklet that the attribute levels were independent. For example, the use of plant and animal gene technology bears no relationship to the chance of contracting a food-borne illness. A full copy of the survey is available from the authors on request.

The experiment followed a 'main effects' design leading to 28 choice sets, each containing three food baskets, as shown in Appendix 1. Each choice set contained one basket representing the status quo defined as no change in the weekly food bill, chemical use, environmental risk, health risk and using conventional technology.

The resulting 28 choice sets were split in to three subsets, with each respondent randomly allocated one set of nine choice sets to complete (a process sometimes referred to in the literature as 'blocking' – see Bennett, 1999) and the additional set discarded because it was judged to be dominated by the status quo. In addition to the choice sets each survey contained two conventional willingness to pay questions asking respondents to indicate how much they would be willing to pay per week to reduce their risk of food poisoning and to guarantee their food was free of GM ingredients. These questions were designed to be simply supplementary to the choice modelling results and to provide a point of comparison between the stated WTP and the WTP as revealed by the choice model. The final section of the questionnaire contained questions regarding socio-economic characteristics of the respondents, and a set of de-briefing questions regarding the survey itself.

The survey was administered by mail throughout Western Australia in October 2000. The survey was sent to 2080 randomly selected residents identified thought the white pages and respondents were asked to return the questionnaire by mail using the reply paid envelope provided. Over 370 questionnaires were returned over a one-month period (a response rate of approximately 18 per cent).

Preliminary results

The analysis of the results obtained from the survey is still in the initial stages, but some results are presented here. A conditional logit model was run using data from all of those respondents that were not identified as "protest respondents" i.e. those who would not choose Food Baskets B and C on principle.[2] Protest respondents were deemed to be all of those respondents who chose Food Basket A (the status quo) in every choice set, regardless of the levels of the attributes contained in the other baskets. This may overestimate the true number of protest respondents (i.e. those who will never choose GM foods regardless of the other attribute levels due to ethical beliefs) since some of these may be willing to consumer GM

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[2] A similar model was run for all respondents: the partworth results are reported in Table 3

under a different set of circumstances than was presented to them in the survey. Protest responses will be clarified by further analysis of the debriefing questions. The results below are for those respondents (population equal to 68%) who did not choose Food Basket A at least once, giving 2264 choices to be analysed.

Table 3: Conditional logit results for 'non-protest' sub-sample

		Coeff	Standard Error	Z
Food Bill (% change from current)		-0.026	0.002	15.33
Health Risk		0.159	0.014	11.55
Environmental Risk	2 years	-1.300	0.157	8.27
(years until gene transfer)	5 years	-1.166	0.136	8.60
	20 years	-0.634	0.120	5.28
	50 years	-0.524	0.141	3.71
Chemical use	-30%	0.940	0.115	8.17
(% change from current)	+10%	-0.829	0.124	6.71
Technology	GM - plants	-0.531	0.151	3.52
	GM - plants and animals	-1.208	0.161	7.52
Log Likelihood	-1740.35			
LR $\chi^2(10)$	1493.82			
Pseudo R^2	0.3003			

Some initial estimation results indicated that although health risk, environmental risk and the measure of chemical use are cardinal variables, both environmental risk and chemical use are more appropriately included in the model with a series of dummy variables associated with each level, as a strong non-linear relationship is identified. The baseline for these variables are zero risk of gene transfer, and zero change in chemical use.

The health risk variable, which relates to food safety risk from food poisoning, was coded differently from the other variables with values of 3, 5 and 10 corresponding to a 1 in 3000, 1 in 5000 and 1 in 10000 risk of contracting a food-borne illness. Therefore, a unit increase in the health risk variable (as coded) implies a reduction in food risk.

The signs of the coefficients conform to a priori expectations. Higher food bills and increased risk of health risks both reduce utility, and hence reduce the probability of an option being selected. The risk of gene transfer into the broader environment is seen to reduce utility, but as the time frame at which this occurs increases, this effect is moderated. The progression of coefficient values shows a clear non-linearity. Reduced chemical use is favoured, while increased use reduces the probability of an option being chosen. Note that the value attached to a 10% increase use is equivalent (in magnitude) to a 30% reduction: again a strong non-linearity in response.

The negative coefficients on both GM variables imply that moving from conventional to GM technology reduces utility, and that there is a difference between the two types of technology: respondents are more than two times more concerned about GM technology that involves animal genes being used in food products.

Estimates of partworths

Monetary values of a unit change in an attribute levels can be estimated by the ratio of the attribute coefficient to the coefficient on the monetary variable (the food bill in this example). Table 4 shows the partworths for unit changes in attribute levels for the model of the non-protesters, and for all respondents. Positive values are associated with changes that are seen as beneficial, negative values with changes that reduce utility.

Table 4: Partworths for non-protest and full samples.

		Non-protest sample	Full sample
Risk		6.1	5.8
Environmental Risk	2 years	-49.9	-49.0
	5 years	-44.8	-39.0
	20 years	-24.3	-21.8
	50 years	-20.2	-13.3
Chemical use	-30%	36.2	37.3
	+10%	-31.9	-31.5
Technology	GM - plants	-20.4	-68.8
	GM - plants and animals	-46.5	-95.3

Since the food bill is defined as a percentage change, the valuations are in terms of percentage change in the weekly household food bill. Thus, for the average non-protesting respondent[3], food bills will have to drop by more than 20% before food produced using gene technology would be purchased. Foods containing GM ingredients based on animal genes are more dramatically resisted by consumers: food bills have to fall by 47% before they are considered.

For chemical use, a relatively high valuation is placed on a reduction in chemical use: respondents would be prepared for food bills to be some 36% higher if chemical use could be reduced by 30%, and would require an almost equivalent reduction in food bills if chemical use were to be increased by 10%. Environmental risk is seen as having a very high impact on utility, particularly if the time frame to gene escape is short.

The non-protesting respondents would be willing to pay 6.11% of their weekly food bill for a reduction in the probability of a major health incident from 1 in 3000 to 1 in 4000, and so on.

The survey asked an open-ended contingent valuation (CV) question regarding willingness to pay to improve the safety of their food and this result can be compared to a similar open-ended question regarding GM foods. Just under half of all respondents (i.e. 148 out of 373) indicated in the CV questions that they would be willing to pay no more to improve food safety from conventional food risks such as food poisoning than they would pay to ensure their weekly food basket was free of GM ingredients.

The results of the choice modelling survey can be compared to the results of the stated WTP question regarding GM foods. For those respondents who answered both the CV question and weekly expenditure question, the average willingness to pay to avoid GM foods is a 77.6% increase in food bills for the non-protesters. This is a substantial figure and much higher than that generated by the choice modeling framework.

[3] The partworths for the sample as a whole can be interpreted in a similar fashion.

Other information was collected in the final section of the questionnaire[4], including a survey eliciting respondents' attitudes to technology and ethical related questions. The results are shown in Table 4:

Table 5: Attitude survey results

Statement	Mean (all)	Mean (non-protesters)	Mean (protesters)
The genetic engineering of plants is completely acceptable	**3.47**	**2.97**	**4.60**
The genetic engineering of animals is completely acceptable	**3.98**	**3.67**	**4.66**
There should be consultation with consumers before the release of genetically modified foods	**1.64**	**1.76**	**1.38**
The benefits of genetic engineering outweigh the risks	**3.75**	**3.37**	**4.58**
Even if it brings no immediate benefits, scientific research should be supported	**2.21**	**1.95**	**2.80**
It is important to me to buy goods that are environmentally friendly	**1.72**	**1.80**	**1.54**
Human beings have the right to use nature as they wish	**3.98**	**3.87**	**4.23**
The information provided by industry and business to the public about risks of technology is honest and reliable	**4.21**	**4.05**	**4.58**
I am very well informed about gene technology	**3.74**	**3.86**	**3.47**

Scale: 1= strongly agree, 2=agree, 3=undecided, 4=disagree, 5 = strongly disagree

As can be seen from Table 5, there were not many large differences between the attitudes of the protesting respondents compared to the non-protesting respondents. The results suggest respondents feel most strongly that consumers should be consulted before genetically modified foods are released and that the information provided by industry and business regarding risks of technology is unreliable.

The authors found it useful to analyse the results of the debriefing section of the questionnaire, since the conceptual difficulties and problems of choice modelling surveys have been well documented. More than 40% of respondents who were confused by the options presented to them chose Basket A always (i.e. treated the status quo as the default). As Table 6 shows, approximately 73% of respondents indicated the information provided to them about the survey and the issues presented therein did not confuse them, with almost 15% expressing confusion and 12% not sure (which may itself be an expression of confusion). One question of the survey asked respondents to indicate whether other food-related issues were more important to them than those not mentioned in the survey. Only 24% answered a

[4] A summary of socio-economic data of the sample is shown in Appendix 2

definite yes, with just over half indicating that the survey had captured their concerns adequately.

Table 6: Debriefing results

Question	Yes	No	Maybe
Information confusing? (%)	14.7	72.9	12.4
Options confusing? (%)	20.8	66.2	13
Other food issues more important? (%)	23.8	51	26
Needed more information? (%)	39.5	37.5	23

To explore the profile of those more likely to choose the "default" basket A, the authors examined the profile of the protest respondents. They found that the elderly (those over 50) were no more likely than those under 50 to choose basket A (34% of respondents over 50 protested, compared to 31% of those under 50). They did, however express a higher level of confusion with the options presented, with 33% of those over 50 admitting they were confused compared to 21% of all respondents.

Similarly, those respondents who claimed they buy organic food at least "sometimes", expressed a stated willingness to pay to avoid GM foods of $86.80, compared to $48.77 for all respondents.

Section 3: Conclusions

This paper has provided an overview of an approach to identifying the values consumers may have with regard to GM foods. Choice modelling brings with it a number of advantages, not least the possibility of embedding the issue of interest within a broader context. In this case the specific concern of GMOs has been located and examined within the broader framework of consumer attitudes to the food production system. Given that the survey has only recently been completed, the results presented must be regarded as preliminary although they appear statistically robust and are consistent with previous qualitative findings with respect to consumer attitudes to GM food. Moreover, this work is indicative of the type of analysis that can be conducted using choice modelling techniques. In the final version of this paper it is anticipated that the analysis will be extended in the following manner:

- the choice modelling analysis will be extended to include the effect of personal characteristics,
- a more detailed analysis of the open ended CV data will be undertaken,
- a further analysis of the protest votes from those whose responses indicate that they may be deemed ethical or philosophical objectors to GM technology. This analysis will include an examination of the reasons given by those who always chose Food Basket A.
- further investigation into those respondents indicating they were confused by the information and/or options presented: are those respondents who admit they were confused more random in their answers to the choice modelling part of the survey?

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Appendix 1: Example of a choice set

1. Suppose the following three alternative food baskets were available to you.
(Please tick box A, B or C underneath the table to show your preference for either food basket).

	Food Basket Current situation **A**	**Food Basket** All foods contain GM ingredients **B**	**Food Basket** 30% of foods contain GM ingredients **C**
Change in your weekly food bill	No change	Reduced by 10%	Reduced by 50%
Conventional or GM technology	Conventional	GM using genes from plants only	GM using genes from plants and animals
The level of on-farm chemical use	Current level	Current level	Increased by 10%
Years until gene transfer	No risk	50 years	No risk
Level of health risk	1 in 5,000 chance of illness	1 in 3,000 chance of illness	1 in 3,000 chance of illness
(Which food basket do you prefer?)	**A** ☐	**B** ☐	**C** ☐

Appendix 2: Socio-economic characteristics of respondents[5]

Gender:	Male	45%
	Female	55%
Age:	11-20	0.27%
	21-30	8%
	31-40	21%
	41-50	31%
	51-60	21%
	61-70	12%
	70+	8%
Education :	<10	27%
	12	18%
	Cert/dip	22%
	Tert	33%
	Other (p/grad)	2%
Income:	0-10K	3%
	10-30K	18%
	30-50K	31%
	50-70K	17%
	70-90K	11%
	90K+	20%
Mean shopping bill:		$163.50
Organic food Purchasers:	Never	9%
	Rarely	21%
	Sometimes	48%
	Often	20%
	Always	2%
Occupation:	Homemaker	13%
	Student	2%
	Employee	39%
	Retired	19%
	Self-employed	25%
	Seeking work	2%
Heard of GM food:	No	25%
	Yes	75%
Children under 5:	Yes	17%
Children 6-16:	Yes	23%

[5] Percentages may not add correctly due to rounding.