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Consumer preferences for GM food and other attributes of the food system*

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While qualitative surveys regarding consumers' attitudes about gene technologies and their application to food production are plentiful, quantitative studies are less so. The present paper reports choice modelling methods to examine the conditions under which Australian consumers are willing to purchase genetically modified (GM) foods, if at all, and examines those preferences within the context of the food system as a whole. This allows us to compare consumer attitudes towards gene technology to consumer preferences for other features of the food they consume. The results of the choice modelling analysis suggest consumers require a discount on their weekly food bill before they will purchase GM food. Gene technology using animal as well as plant genes was found to be more objectionable to respondents than that using plant genes alone, especially among women. Age seems to affect the preferences for a certain type of food, with older people generally more accepting of the use of gene technology.

1. Introduction

Consumer groups have used their influence to convince governments that the potential risks to humans and the environment posed by goods containing genetically modified organisms (GMO) justifies stringent regulation even though the extent of those risks is as yet unknown. The aim of the analysis in the present paper is to add to knowledge about the concerns and preferences of consumers regarding foods produced using gene technology ('GM foods'). The measurement of the extent and nature of consumer concern to GM foods is of interest in itself but it is also important because the uncertainty over market reactions to GM foods is to some extent destabilising their development and production. As Owen *et al.* (2001) point out, '… uncertainty [over consumers' responses] undermines efficient production planning and hinders strategic development to position Australian exports for growth …' (p. vi).

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The Australian government is sufficiently convinced that GM foods differ from their conventional counterparts to design separate regulations governing their production and marketing in Australia. Through its food safety regulatory body, Australia New Zealand Food Authority (ANZFA) (now Food Standards Australia New Zealand (FSANZ)), the government agreed in November 2000 to specify mandatory labelling laws for all foods containing GMO if novel or modified DNA or protein is detectable in the final food product.

The analysis in the present paper focuses on a quantitative, choice modelling survey of Australian consumer attitudes to GM foods. It is hoped that, by identifying the (potential) discount needed to induce consumers to purchase GM foods, the results of the survey will assist in identifying an appropriate policy response.

2. 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, e.g., Hoban 1998; Norton *et al*. 1998; Yann Campbell Hoare Wheeler 1999; Mendenhall 2000; McGarry Wolf & Domegan 2000; Kelley 1995). 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. Ordinarily, however, food purchasing decisions are considered to be a result of constrained choice: consumers buy goods on the basis of the conditions under which it is offered. One would therefore expect the decision to accept or reject GM food to be based in part on factors such as the price relative to non-GM food, and any ethical and environmental factors associated with production of the food. In addition, individual characteristics of the consumer themselves may influence the decision about whether to buy GM food.

Choice modelling presents an attractive way of approaching the issue of foods produced using gene technology, because the choices are presented in context and explicitly highlight the trade-offs that often have to be made in actual decisions. In this sense, results are likely to be more reliable than contingent valuation willingness-to-pay (WTP)-type questions. An added benefit of the choice modelling framework is that concern about GM food can be compared with concern about other aspects of the food system: in the analysis that follows we compare attitudes regarding GM foods to concerns about the environment, food-borne illness and on-farm chemical use. There have been a relatively small number of papers that have applied this technique to GM foodstuffs (e.g., Burton *et al*. 2001; Owen *et al*. 2002; Burton and Pearse 2002; Donaghy *et al*. 2003).

Table 1 A simple choice set

Attributes	Option 1	Option 2
Technology	Conventional	GM
Weekly food bill	100% of current	80% of current

GM, genetically modified.

2.1 Choice modelling: theory

The central idea behind choice modelling is that individuals can choose between alternative options that are described by 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; Morrison *et al*. 1996; Adamowicz *et al*. 1998; Blamey *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. In selecting between these two options the respondent is essentially 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 option 1 is chosen if the welfare from its level of attributes is preferred to that generated by option 2. The model is then given empirical content by explicitly modelling the process by which welfare is generated. In its simplest form we can specify that

$$U_i = \beta_1 GM_i + \beta_2 PAY_i + \varepsilon \tag{1}$$

where U_i is the utility obtained from option i, GM is a dummy variable indicating the use of GM technology, PAY is the level 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 option 1 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 the error terms. McFadden (1973) shows that, assuming independent and identically distributed error terms following a Weibull distribution, the probability of choosing option j from N options can be expressed as:

(2)

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

Individual specific characteristics can be incorporated to explain choices; for example,

$$U_{ij} = \Sigma_k \beta_k X_{kj} + \Sigma_k \Sigma_m \alpha_{km} X_{kj} Z_{mi} + \varepsilon_j \tag{3}$$

where i identifies the individual, and Z_{mi} is the m'th characteristic (i.e., age, education, etc.) which may affect values. Not all of the interaction terms need to be included and one may have some prior beliefs or empirical evidence as to which attributes will be affected by which characteristics.

2.2 Partworths

The individual parameters generated by the choice model do not have a direct monetary interpretation: rather they signify the effect of that attribute on marginal utility (thus their signs and statistical significance are directly interpretable). However, the parameters can be combined to identify monetary values associated with changes in each attribute level, called a 'partworth' or implicit price.

Returning to the initial example of equation (1), a shift from conventional to GM technology, *ceteris paribus*, will change utility by an amount β_1. We can then evaluate the reduction in the amount the consumer has to pay that would just offset the decrease in utility arising from the new technology. This amount would formally represent the point where the individual would be indifferent between the original utility level, and the new technology with a reduced level of the food bill. The amount can be derived from:

$$\beta_2 PAY_1 + \varepsilon = \beta_1 * 1 + \beta_2 (PAY_1 + x) + \varepsilon \tag{4}$$

where x is the increase in payment that is to be identified. Equation (4) can be solved to identify x as:

$$x = -\beta_1/\beta_2. \tag{5}$$

Thus, the partworth, represented by x, is the (negative) coefficient on the attribute divided by the coefficient on the payment level. The partworth is associated with a unit increase in the attribute, and can be interpreted in the above example as the maximum that the respondent would be willing to pay to avoid consuming GM food.

2.3 A note on the 'willingness' to pay

Economic theory tells us that the maximum a person is willing to pay to consume a unit of a good is equal to the minimum amount that they would be willing to accept in order to abstain from consuming that good, ignoring any income effects. In empirical work, the WTP is quite frequently found to be much lower than the willingness to accept (WTA) (Knetsch and Sinden 1984) and thus these two measures of value cannot be assumed to be equivalent. The size of the disparity will depend on the size of the income effect and the degree of substitutability between the two goods being traded off. Shogren *et al*. (1994) have shown that while the WTA and WTP are usually equal for market goods, many non-market goods (such as reduced health risk) with no close substitutes show a significant difference between WTA and WTP. *Ex ante* the choice modelling framework does not impose a WTA or WTP framework, and in the same experiment may include increases or reductions in public goods. It provides baseline values for the attributes, and whether the values identified from the analysis are WTP or WTA will depend on the nature of the change from the baseline, and the sign of the valuation identified. Thus, if the baseline situation is conventional technology, and the alternative is GM, one would identify a WTA compensation for the introduction of GM if GM reduced welfare, but one would identify a WTP for the change if GM was introduced and consumers' welfare increased. In the present paper, the use of WTP or WTA interpretations will depend on the change in the attribute and the estimated valuation of that attribute.

3. An application of choice modelling: WA consumers' attitudes to GM food

The choice modelling framework was applied to a sample of consumers in Western Australia in the form of a survey encompassing elements of open-ended contingent valuation (CV) questions, scale-differentiated attitude statements, choice modelling questions and demographic data collection. By examining respondents' preferences, choices and attitudes towards GM foods, the survey adds to knowledge about the market potential and likely consumer response to GM crop development and production. In particular, the choice modelling component of the survey enriches our knowledge about consumer attitudes towards GM foods in the context of other attributes (including price) and the trade-offs made between those attributes when making purchase decisions.

One problem that has been identified with choice modelling (as well as with other non-market valuation techniques) is that of framing; that is, the survey process itself may give the topic at hand disproportionate weight. In order to remind respondents of the context in which the issue of GM food exists, information about other aspects of the food system were presented to respondents. 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, such as risk of food poisoning and on-farm chemical use. In order to reduce the complexity of the task faced by the respondent, only a relatively limited number of attributes can be included. Those used cover a diverse range of issues, relating to attributes of the good in production and consumption. As the debriefing questions indicated, the majority of the respondents thought that the main food issues of interest to them had been captured in the choice modelling experiment (section 5 below).

Before the main survey was sent out it was discussed with a small focus group (four people) and a pilot sample of 100 surveys were distributed in two suburbs of metropolitan Perth. The two suburbs had distinct socio-economic characteristics (a middle to upper income suburb where the median household weekly income is $A981, and lower-middle income area with median income $A635 per week) (ABS 2002). Since the responses to the survey led to only minor formatting changes, the responses from this stage of the survey formed part of the final sample and were incorporated in the econometric analysis.

The survey consisted of three main sections: an introductory letter and information about the survey, a choice modelling survey, and a set of debriefing and demographic questions. The choice modelling experiment followed a 'main effects' design leading to 28 choice sets, each containing three options or 'food baskets'. Each choice set contained one basket representing the status quo, defined as no change in the weekly food bill, level of chemical use, environmental risk or health risk and using conventional technology. The other two food baskets, B and C, were labelled according to the proportion of GM foods in that basket and contained different values of the other attributes, according to which choice set was generated. The 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 published literature as 'blocking' – see Bennett 1999). The additional set was discarded because it was judged to be dominated by the status quo.

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 3000; **1 in 5000**; 1 in 10,000
% of food basket C that is GM	30%, 60%, 80%, **0%**

Note: Attributes levels in **bold** define the status quo food basket; GM, genetically modified.

In addition to the choice sets each survey contained two open-ended WTP questions asking respondents to indicate how much they would be willing to pay per week to, first, reduce their risk of food poisoning and, second, to guarantee their food was free of GM. These came after the choice sets. These questions were designed to be simply supplementary to the choice modelling results and to provide a point of comparison between the explicitly stated WTP and the WTP (or the WTA in the case of GM foods) as implied by the results of the choice model. The final section of the questionnaire contained questions regarding socio-economic characteristics of the respondents (the results can be seen in Appendix 1), and a set of debriefing questions regarding the survey itself. A full copy of the survey is available from the authors on request.

Each option (or 'food basket') presented in the set consisted of five attributes, each taking a number of levels, as shown in table 2. The status quo levels of the attributes appear in bold text. All food attributes were described in detail in an introductory leaflet sent with the questionnaire. It was made clear in the information booklet that the attribute levels were independent. For example, risk of food-borne illness was related to conventional sources such as Salmonella, and it was made clear that it was unrelated to the use of plant and animal gene technology.

The weekly food bill was the payment vehicle, with this expressed as a percentage change in the food bill. The reason for this choice is the anticipated wide range of food expenditures within the sample. This makes it difficult to design changes in absolute food bills that will be relevant for low income, but not trivial for high-income households. Alternatively, economically significant changes in food bills for high-income households would be extreme for those on low incomes. The use of percentage changes overcomes this problem. The production technology was identified as having three 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 evidence found in previous attitude survey results that consumers are more concerned about gene technology involving animals than involving plants alone (Kelley 1995; Norton *et al*. 1998; IFIC 2002).

The level of on-farm chemical use was used as a proxy attribute representing 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 (zero years in the case of conventional technology, and varying time frames, including zero, as a possibility with the use of GM crops). The risk of contracting a 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. Currently, consumers are estimated to be exposed to a 1 in 5000 risk of food-borne illness from each meal event (ANZFA 1999).

4. Results

The main survey was administered by mail throughout Western Australia in October 2000. The survey was sent to 2080 randomly selected residents identified through 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).

Although 3268 completed choice sets were available for analysis, approximately 31 per cent of respondents were identified as 'lexicographic respondents' (i.e., those who would not choose food baskets B and C on principle). 'Lexicographic' 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.[1] If 'lexicographic' respondents are, by definition, those who choose the status quo regardless of the attribute levels of the other food baskets, then attempting to explain their choices on the basis of attribute levels (the basic

[1] This may overestimate the true number of 'lexiographic' respondents (i.e., those who will never choose GM foods regardless of the other attribute levels due to their selection being based on paradigms that do not contain the possibility for marginal tradeoffs of the attributes, e.g., based on ethical beliefs) since some of these may be willing to consume GM under a different set of circumstances than was presented to them in the survey.

premise of choice modelling) would produce biased estimates. The profile of those who always choose the 'default' basket A was examined based on their reasons for this strategy. The most common reason given for avoiding those food baskets containing GM foods was a fear of the unknown (many respondents actually used those exact words): the fact that these foods were, in the opinion of respondents, untested and presented unknown risks. Out of the lexicographic respondents, 73 per cent gave reasons that are unlikely to be offset by changes in the other attribute levels: 'fear of the unknown' (51 per cent) and 'Don't like the idea of GM' (22 per cent).

The authors therefore decided to exclude the 'lexicographic' respondents from the subsequent conditional logit analysis, leaving 2232 choice sets (those of the 68 per cent of respondents who did not choose food basket A every time) for analysis. A Hausman specification test that compares an estimator that is known to be consistent with an estimator that is efficient under the assumption being tested was employed at various stages of the analysis (including on the final model) to test the validity of removing the 'lexicographic' group (Hausman 1978; Statacorp 1999). These results indicated that the two groups of respondents were fundamentally different, and thus we are justified in separating them in the analysis.

A number of different model specifications were tried, although for reasons of space only the initial and final preferred models are reported here. The initial, most basic conditional logit model results are seen in table 3 below. 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

Table 3 Conditional logit results for 'non-lexicographic' subsample

	Log likelihood	–1740.35
	LR $\chi^2(10)$	1493.82
	Number of obs	2232
	Pseudo R^2	0.3003
		Coeff
Food bill (% change from current)		–0.026***
Health risk		0.159***
Environmental risk (years until gene transfer)	2 years	–1.299***
	5 years	–1.166***
	20 years	–0.634***
	50 years	–0.524***
Chemical use (% change from current)	–30%	0.940***
	+10%	–0.829***
Technology	GM(plants)	–0.531***
	GM(plants and animals)	–1.208***

*** indicates significance at the 1% level; GM, genetically modified.

the model with a series of dummy variables associated with each level (the baselines for these variables are zero risk of gene transfer, and zero change in chemical use), as a strong non-linear relationship is identified. The non-linearity can be seen most strongly in chemical use, where the welfare impact of a 10 per cent increase is similar in magnitude to a 30 per cent reduction.

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 10 000 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.

The negative coefficients on both GM variables imply that moving from conventional (baseline) 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.

Individual-specific characteristics can be incorporated into choice modelling to explain the utility gained from a certain option. As explained in section 2.1, personal characteristics can be included in the analysis by interacting them with the choice attribute variables.

During the exploratory phase of the data analysis, various demographic and socio-economic characteristics were tested for significance as explanators of choice.[2] Gender and age were the only socio-economic characteristics found to be significant determinants of attitudes towards GM technology. The other food attributes were not found to be significantly affected by any individual-specific variables. The log likelihood of the preferred model is –1682.28 and includes an extra seven parameters compared to the basic model in table 3. A chi-squared test (Greene 1997, p. 161) confirmed that the extended model is a significant improvement on the initial model (a test statistic of 116.14 compared to $\chi^2_{0.05,7} = 14.07$).

In addition, the choice modelling framework incorporated a feature which allowed the proportion of foods which contain GMO to be varied. That is, food basket C contained 30 per cent, 60 per cent or 80 per cent GM foods, depending on the version of the questionnaire that the respondent was

[2] Demographic information about the sample is summarised in Appendix 1.

Table 4 Preferred conditional logit model

	Log likelihood	−1682.278
	LR $\chi^2(17)$	1539.65
	Number of obs	2232
	Pseudo R^2	0.3139
		Coeff
Food bill (% change from current)		−0.026***
Health risk		0.162***
Environmental risk	2 years	−1.260***
(years until gene transfer)	5 years	−1.248***
	20 years	−0.810***
	50 years	−0.693***
Chemical use	−30%	0.736***
(% change from current)	+10%	−1.036***
Technology	GM(plants)	−0.812***
	GM(plants) ∗ age†	0.0099**
	GM(plants) ∗ male‡	0.273**
	GM(plants and animals)	−2.139***
	GM(plants and animals) ∗ age	0.0178***
	GM(plants and animals) ∗ male	0.661***
% GM	ASC(C)§ ∗ D30¶	0.267*
	ASC(C) ∗ D60	−0.021
	ASC(C) ∗ D80	−0.503***

*** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. † Age is a continuous variable measuring the age of the respondent. ‡ male is a dummy variable = 1 if respondent is male. § ASC(C) is an alternative specific dummy, = 1 if food basket C is under consideration. ¶ D30, D60 and D80 are dummy variables, = 1 if the percentage GM in food basket C is 30, 60 or 80, respectively. GM, genetically modified; ASC, alternative specific contrast.

given. The version was then included as an alternative specific constant (ASC) in the preferred model, and interacted with the proportion of GM food to see how preferences for basket C change as the proportion of foods containing GMO changes (a positive sign indicating that the modifier reduces the discount needed for a purchase to be induced). The results indicate that respondents do seem to differentiate between levels of GMO, although the design of the survey (with only changes in GM in the 3rd basket) may mean that these effects are confounded with a '3rd option' effect.[3] Because of the survey design (only food baskets B and C having GM) it is not possible to include an alternative specific constant for both basket B and C, as the technology dummies and the ASC would be perfectly collinear. Hence, parameters for the ASC and the technology dummies would no longer be independently identifiable.

[3] More complex representations are possible, with the percentage GM changing the marginal valuation of some or all of the attributes. Exploration of this indicated that the only attribute affected might be the environmental risk, but the results could not be given any consistent interpretation, e.g., reduced GM in basket C increases the negative valuation of environmental risks for that basket, although this result only held for some risk levels.

Table 5 Partworths (% change in food bill) associated with a unit increase in attribute levels

Attribute		Partworth
Risk		6.23
Environmental risk	2 years	–48.46
	5 years	–48.00
	20 years	–31.15
	50 years	–26.65
Chemical use	–30%	28.31
	+10%	–39.85

5. Estimates of partworths

As noted in section 2.2, monetary values of a unit change in an attribute level can be estimated by evaluating the ratio of the attribute coefficient to the coefficient on the monetary variable. Although the strict definition of a partworth as outlined in section 2.2 is normally represented by an absolute currency figure, our payment vehicle in the choice sets was defined as a percentage change in the weekly food bill and as such the numbers generated by our 'partworth' calculations are also in percentage terms (e.g., the percentage change in food bill that they would be WTP to achieve a change). For consistency we will refer to them as partworths even though they are not in dollar terms as is usual practice. It should be noted that the implication of using the percentage change in food bills is that we are assuming that the marginal utility from a percentage change in income is constant across all respondents as opposed to the more conventional assumption that the absolute marginal utility of income is constant across all respondents. The implication of our specification is that there is decreasing absolute marginal utility of income.

Table 5 shows the partworths for unit changes in non-technology attribute levels for the final model. Positive values are associated with changes that are seen as beneficial (i.e., the respondent is willing to pay a positive amount for a unit increase in this attribute), negative values with changes that reduce utility (i.e., the respondent requires compensation in form of a discount for a unit increase in this attribute and as such the value can be interpreted as a measure of WTA).

For chemical use, increased chemical use is viewed disproportionately negatively: respondents would be WTP a 28 per cent premium on weekly food bills if chemical use could be reduced by 30 per cent, but would be WTA a 40 per cent reduction in food bills to compensate for a 10 per cent increase in chemical use. Environmental risk is seen as having a very high impact on utility, particularly if the time frame to gene escape is short. The

Table 6 Partworths associated with gene technology in food (% change in food bill)

Age	Female	Male
GM (plants)		
15 years	–25.8***	–15.2
25 years	–21.9***	–11.4
35 years	–18.2**	–7.6
45 years	–14.4*	–3.8
55 years	–10.6	–0.0
65 years	–6.8	3.75
75 years	–2.9	7.56
GM (plants and animals)		
15 years	–72.6***	–47.0***
25 years	–65.8***	–40.2***
35 years	–58.9***	–33.3***
45 years	–52.0***	–26.5**
55 years	–45.2***	–19.6**
65 years	–38.3***	–12.7
75 years	–31.5***	–5.9

*** indicates significance at the 1% level, ** at the 5% level and * at the 10% level; GM, genetically modified.

respondents would be willing to pay approximately 6.2 per cent 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 partworths for the gene technology variables appeared to be affected by the gender and age of the respondent. The partworths for the technology variable are therefore reproduced separately from the other partworths, in table 6 below. As the partworths in table 6 show, men and women have different preferences towards gene technology in food. Both groups express predictable attitudes towards GM foods: the signs are all negative (except for the values that are insignificant), indicating that the use of GMO in food is seen as a 'bad' and that compensation in the form of a price discount would be needed (e.g., the average woman aged 35 years would require a reduction in food bill of 18 per cent to compensate for the introduction of plant gene technology). Foods containing GMO using animal genes are more dramatically resisted by consumers than foods modified using plant genes alone, a result also consistent with previous findings. The average woman aged 35 years is willing to accept this type of GM food only if a 59 per cent discount if offered.

Males seem to be less concerned with gene technology in food in general, and not at all significantly concerned about gene technology involving plants alone. The coefficient on the GM*Male attributes for both types of technology in table 4 are positive, indicating that a respondent being male will modify (i.e., soften) the negative response to GM foods by 0.273

Table 7 Changes in partworth associated with varying proportions of foods that contain GMO (% change in food bill).

Proportion of foods containing GMO	Partworth modifier
30%	10.3**
60%	–0.8
80%	–19.5*

* significant at the 5% level; ** significant at the 10% level; GMO, genetically modified organism.

(plants only) and 0.661 (plants and animals). While this indicates a less adverse stance than for females, the modifiers are not large enough to outweigh the GM partworth and hence the partworths for males as shown in table 6 are still negative overall. It can also be observed from the above partworths that older respondents are less concerned about gene technology than their younger counterparts (the coefficient on the GM*age variables in table 4 are moderators for every year that a respondent ages).

Table 7 reports the impacts of changing the level of GMO in food basket C. These values are estimated as the ratio of the relevant ASC coefficient and the payment coefficient in table 4, and indicate the implied value attributed to a change from 100 per cent GMO content to 30, 60 and 80 per cent.

The implication is that a basket with only 30 per cent of GM foods is an improvement on one with all foods containing GMO (at the 10 per cent level of significance). The interpretation, should one wish to accept that level of significance, would be that a woman aged 35 years would pay a premium of approximately 8 per cent to avoid a basket with 30 per cent GM foods (18.2 per cent from table 6, less 10.3 per cent from table 7), compared to an 18.2 per cent premium to void a basket with 100 per cent GM foods. There is no significant benefit attributed to a basket containing only 60 per cent of GM foods as compared with one containing 100 per cent GM foods. However, the negative and significant partworth associated with an 80 per cent GMO content means it is perceived to be significantly worse than an equivalent basket that contains all GM foods. Such a result may be evidence of 'third option' bias since the basket with less than 100 per cent of foods containing GM ingredients appeared always and only in the third column. Because of this, one needs to be wary of interpreting these modifiers as accurate measures of the value placed upon different percentages of GM food in the basket. What it does indicate is that respondents were able to distinguish between the different percentages of GM food in the baskets.

In view of the knowledge about the advantages and disadvantages of alternative forms of stated preference techniques, it is useful to compare the results of the choice modelling (CM) survey to the results of the open-ended CV question regarding GM foods (NB, the type of gene modification was not specified). For those identified as non-lexicographic respondents in the CM study who answered both the CV question and weekly expenditure question, the average willingness to pay (as generated by the CV study) to avoid GM foods is a 10.97 per cent increase in weekly food bills (the average dollar amount is $18.83 per week) which is less than the smallest significant partworth derived from the CM study.

Respondents were asked to state the amount they would be willing to pay to reduce their risk of contracting a food-borne illness by 50 per cent; that is from a 1 in 5000 to a 1 in 10 000 chance of illness. For the non-lexicographic respondent, the average WTP is $12.10 per week and for the lexicographic, $22.49. These averages imply that the group specifically concerned with GM food are more concerned about food safety risks than the others, however, the WTP of both groups are lower for reducing conventional food risks than for avoiding GM food. It is interesting to note that more than 46 per cent of the conventional respondents are equally as concerned about conventional food safety risks as GM foods: they are prepared to pay the same premium to avoid one risk as they are the other. Of those respondents, 50 per cent said they were not prepared to pay a premium to avoid either.

The results of the debriefing section of the questionnaire were also reviewed, since the conceptual difficulties and problems of choice modelling surveys have been well documented (see, e.g., Blamey *et al*. 1997). Approximately 73 per cent of respondents indicated the information provided to them about the survey and the issues presented therein did not confuse them, with almost 15 per cent expressing confusion and 12 per cent not sure (which may itself be an expression of confusion). More than 40 per cent of respondents who were confused by the options presented to them chose basket A always (i.e., treated the status quo as the default). One question in the survey asked respondents to indicate whether other food-related issues were more important to them than those mentioned in the survey. Only 24 per cent answered a definite yes, with just over half indicating that the survey had captured their concerns adequately.

The older respondents (those over 50) were no more likely than those under 50 to always choose basket A (34 per cent of respondents over 50 selected basket A, compared to 31 per cent of those under 50). They did, however, express a higher level of confusion with the options presented, with 33 per cent of those over 50 admitting they were confused compared to 21 per cent of all respondents.

6. Conclusions

The results of the present study show that most consumers will require some form of discount if they are to purchase GM foods although the size of this discount would depend to some extent on any effects (e.g., chemical, environmental) of the new technology and on the age and sex of the consumers themselves. It is also clear that, consistent with the findings of other research, Australians are more willing to accept gene technology as part of the food production process if animal genes are not included in that technology.

It seems that the size of the market for genetically modified foods will be constrained by the existence of a persistent, highly committed group of consumers who are averse to GM foods. These consumers appear to require an infeasible discount to consume these foods. Obviously the commitment of these people to avoiding GM foods would have to be tested in a market situation but it appears that a niche market for non-GM foods, even if such foods command a premium over GM foods, is potentially viable.

On a more optimistic note for GM food producers and marketers, about two thirds of the sample studied here are prepared to consume GM foods under certain conditions. Fully one-third of the sample indicated (when asked directly) that they would not be prepared to pay any premium to avoid GM foods. Whether one can place a great degree of confidence on this apparent indifference on the part of those consumers is not certain. It is clear however, that there is some degree of resistance in the market, even among those consumers who are theoretically willing to consume GM foods.

A few caveats of the study need to be kept in mind. First, the analysis is relevant only for those products that do not confer any direct benefit to the final consumer. It is likely that any products that can offer direct advantages in, say, taste or nutrition will be able to compete more favourably with non-GM foods and maybe even be able to command a premium. Second, some of the model results may be compromised by the acknowledged existence of a third option bias. Although encouraging signs exist about the ability of respondents to make distinctions between the proportions of GM foods in their shopping basket, the results themselves appear to be unreliable. Third, the relatively low response rate suggests caution in extrapolating the results to the population in general.

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Appendix 1

Socio-economic characteristics of respondents†

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 buying habits:	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%

† Percentages may not add correctly as a result of rounding.