Paper Title:

Disaggregating consumer demands for organic and genetically modified foods using the Choice Modelling technique.

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Issues concerning consumer demands for genetically modified and organic food remain highly topical in Australia. It is unclear how consumers perceive issues associated with food production such as food safety, environmental impacts or animal welfare. It is also unclear how consumers might value potential changes in those issues. This paper reports on research using the choice modelling technique to estimate and compare consumer demand for genetically modified and organic foods. The case study considers commodities including tomatoes, milk and beef. The results provide some indication of the contribution of associated factors with consumer choices, as well as exploring consumer values for higher food safety standards. The results are of relevance to the current policy debate regarding the introduction of GM foods to Australia.

Key words: Genetically modified, organic, demand, choice modelling

1.0 Introduction

The agriculture sector in Australia has undergone significant and rapid change in the last 40 years (Cavaye 1999). Farmers have had to contend with environmentally conscious consumers and increasing competition. New trends are emerging in food production systems in response to consumer demand and production supply pressures, and societies' desire to control and reduce some of the externalities resulting from agriculture. In middle and high income countries the public's concerns about food quality and availability are being replaced with food safety, environmental quality, ethics and health concerns (Antle and Wagenet 1995, Kohl, 2000).

Some agricultural production involves externalities. There may also be public good aspects of food production and distribution that are unattractive for private enterprise to supply. In both instances the responsibility of providing public goods, limiting the extent of externalities resulting from agriculture and providing a framework in which rights can be specified and enforced, rests with governments. As demands for regulatory accountabilities have increased, governments are increasingly required to use risk assessment and benefit cost analysis to evaluate whether existing or proposed food and fibre regulations enhance public welfare (Caswell 1998). Estimating the consumer value for all food and fibre attributes (including those not reflected in markets) is a key determinate in assessing the net social benefit of introducing regulatory controls to the production of food and fibre in Australia.

It is also important in evaluating where governments should provide public goods, and how property rights and resources should be allocated between competing groups. Many of these issues are reflected in the debate surrounding genetically modified (GM) and organic foods. Concerns regarding GM foods relate to potential spillover effects on human health and the environment. There may also be spillover effects between GM and organic farmers. Organic food production may also involve some externality impacts. There are public good aspects involved with food safety, food labelling, information provision, research and environmental factors.

To measure the full cost of food production requires estimates of both use and non-use benefits and costs associated with the production of agricultural goods. Use values generated by assets involve direct contact with the resource. They include direct contact uses such as recreation and indirect uses such as the provision of good quality water from a protected catchment. Non-use values are generated without direct contact. For instance, people may value the biodiversity supplied by an environment without wanting to experience it directly (Bennett 1999).

The development of food biotechnology industries has to date involved scientists and regulators much more than economists. More recently though, there has been growing recognition that to address food safety issues and other uncertainties, expertise from other disciplines needs to be considered (Appell 2001). A number of economic techniques have emerged that are capable of valuing public good attributes of food and risks associated with their production. One of these techniques is termed Choice Modelling (CM). To date the CM technique has been successful in environmental valuation[1] but has had only limited application in estimating consumers' values for items such as food safety and ethical farming practices.

Cost benefit analysis and other tools can be used in evaluating options involving risks associated with introducing genetically modified (GM) crops in Australia in the absence of perfect knowledge. Releasing GM crops may result in unforseen irreversible ecological outcomes. Similarly halting the development of this technology may result in significant opportunity costs to current and future generations. This dilemma of choosing between economically disruptive precautionary measures now or risking unfavourable ecological outcomes in the future currently faces policy makers in Australia.

This paper reports the preliminary findings of a CM experiment to indicate consumer's willingness to pay for similar agricultural commodities produced from organic, conventional and genetically modified production systems. Each system, whilst providing consumers with commodities of similar use values, is differentiated by environmental, food safety and ethical characteristics. These non-use attributes maybe important influences on consumers purchase decisions and government policy directions.

The paper is structured as follows. In section 2 the growth of organic and GM agriculture in Australia is described and the conflicting land use issues confronting these industries discussed. In section 3 the key attributes associated with food are identified and a description given on how economists are able to deal with some of the uncertainty surrounding these attributes. In section 4 non-market valuation techniques are reviewed and in sections 5, 6 and 7 an application of CM to food production in Queensland is described. Finally the results of the experiment are reported in section 8 and conclusions made in section 9.

2.0 Organic agriculture and the biotechnology revolution

The Australian organic industry has undergone recent and rapid expansion. In 1990 the industry was worth $28 million (Lyons and Lawrence 2000). In 1998 Carson (1998) estimated Australia's organic food sales to be 2% of domestic food sales, having an annual retail value of $90 to $100 million with potential export sales of $30 million. In 2000 the Australian organic industry had an annual gross value of $200 million, with $40 million of product exported (Kinnear 2000).

Organic agriculture may be associated with several externalities. These include dryland salinity, soil erosion, declining water quality, removal of remnant vegetation and resulting biodiversity declines. For example some broadacre organic grain enterprises rely on traditional tillage techniques (rather than chemicals) to control weeds during a fallow period. In the event of rainfall the lack of ground cover can result in significant soil erosion.

The introduction of biotechnology to agriculture promises to revolutionise food production systems. Currently in Australia only genetically modified cotton and

[1] There have been extensive applications of CM in the marketing and environmental valuation literature. See Rolfe et al. 2000, Bennett 1999, Hansen and Schmidt 1999 and Adamowicz, et al. 1998.

carnations are approved for commercial cultivation (Thomas et al. 2000). GM foods currently available in the Australian market place include foods derived from soybeans, canola, corn, potato, sugar beet and cotton. The majority of these foods are derived from GM crops grown overseas (ANZFA 2000). There are a number of other GM crops being trialed under license in Australia.

There appears to be a number of benefits and opportunities available to society through the responsible use of GM crops. A review of the literature suggests the major benefits of biotechnology can be grouped under an agronomic, humanitarian, phytoremediation, pharmaceutical or environmental theme.

Agronomic benefits of GM crops include increased yields and reduced pesticide costs, improved disease resistance, enhanced crop adaptation to adverse climates (dry, saline, or cold), enhanced durability of crops during harvest and transport and considerable savings in labour through reduced herbicide and insecticide application (Ballenger 2001; Whitman 2000;Xue and Tisdell 2000; and Pinstup-Anderson 2001).

The humanitarian potential of GM crops within developing and newly industrialised countries may improve the quality of life for millions of people faced with food shortages, address nutrient depleted soils, reduce infectious disease and improve nutritionally inadequate diets. Proponents of GM foods in developing nations argue the technology has the potential to improve the nutrient content of foods, enable the development of edible vaccines and eliminate micronutrient malnutrition in developing countries (Whitman 2000; Pinstup-Anderson 2001).

Biotechnology in the pharmaceutical sector has enabled the development of DNA vaccines, protein engineering medicine, monoclonal antibodies, antisense RNA drugs and the production of insulin (Xue and Tisdell 2000). Heavy industry in developed and developing economies also stands to benefit from the use of GM organisms in cleaning up industrial pollution (ie phytoremediation). Biological transformation reactors created by biotechnology absorb pollutants or wastes and decompose them into materials of low or no toxicity (Xue and Tisdell 2000). In the US extremely radiation-resistant bacterium, Deinococcus radiodrums, are being genetically engineered with biodegredation genes to render them suitable for the treatment of mixed wastes at nuclear production facilities (Wackett 2000)

Observed environmental benefits resulting from the introduction of GM biotechnology in the US include reduced use of herbicides and insecticides and an increased use of lower risk chemicals in replace of higher risk alternatives. For example the use of Glyphosate has significantly increased with the introduction of Roundup Ready cotton and soybeans. Glyphosate has a half life in the environment considerably shorter than its competitors (Marra 2001).

The potential risks associated with genetically modified organisms (GMOs) can be summarised into two main categories. The first is where GMOs have some potential impact on human and animal health, while the second (and perhaps most controversial) is where GMOs impact on the environment.

Currently in Australia many food ingredients from GM soybean, canola, corn, potato, sugar beet and cotton oil have been approved for food use (Dean 2000). There is no evidence that genetically modified foods are causing health problems in humans (Feldmann et al 2000). However, there are lingering fears in the public and scientific arena that as yet unspecified effects may cause health problems in humans in the future.

Some commentators have raised possibilities that GM foods may pose a health risk to consumers through potential allergenicity and carcinogenicity, alterations in nutritional qualities of foods, and the development and accidental release of antibiotic resistant microbes and toxins (Uzogara 2000; Brown 2001; Nemecek 2001; WHO 2000). There have also been concerns that animals fed on GM grain could develop a build-up of antibiotic resistance. However, little scientific evidence has been found for any of these risks. Different gene transfer techniques and quality assurance procedures have been introduced to minimise those risks further (Feldmann et al 2000).

Given the power of biotechnology to produce combinations of genes not found in nature, Krimsby & Wruberl (1996) and Rissler & Mellon (1996) in Altieri (2000) list some of the most serious ecological risks posed by the commercial-scale use of transgenic crops as:

- Reduced crop genetic diversity by simplifying cropping systems and promoting genetic erosion;
- Potential transfer of genes from herbicide resistant crops (HRC's) to wild or semi-domesticated relatives, thus creating super weeds;
- HRC volunteers becoming weeds in subsequent crops;
- Reduced agro-biodiversity in time and space;
- Vector mediated horizontal gene transfer and recombination to create new pathogenic bacteria;
- Vector recombination to generate new virulent strains of virus, especially in transgenic plants engineered or viral resistance with viral genes;
- Development of insect resistance to Bt toxin;
- The untargeted elimination of beneficial insects and soil biota from the massive use of Bt toxin in GMO crops.

There are an increasing number of farmers growing GM crops hoping to achieve the production increases and cost savings proponents of the technology suggest. Donaghy and Rolfe (2000) summarise the arguments that there is potential for significant spillover effects to be borne by organic growers resulting from the continued adoption of genetically modified agricultural production systems. These include:

- The threat of accidental contamination of organic produce with GM crops through hybridisation among distinct plant species;
- The unintended removal of beneficial insects from integrated pest management systems;
- The introduction of "terminator technology" and the patenting of genetic information and plant variety rights;
- Lost opportunities to capitalise on price premiums being paid for GE-free crops; and

- The loss of Bt pesticide sprays as a convenient means of controlling insects organically.

There are tradeoffs involved in the development of both biotechnology and organic crops in Australia. Given the substantial consumer concerns over GMOs and other food safety issues, and the current levels of government regulation and investment of public funds, the debate over where those tradeoffs should be set is likely to intensify. There is already growing interest from economists in these questions (eg Caswell 1998, Feldmann et al 2000).

While the production gains from using GM crops are relatively easy to assess through market mechanisms, the net social value of other impacts are more difficult to quantify. CM provides a mechanism to assess whether governments and markets have properly considered and valued all consumer demands associated with the broad scale application of GM technologies in Australia. Through CM regulators can estimate and value the loss of utility society would incur in the advent of spillover effects from growing GM crops on the environment and neighbouring growers, including organic growers. Similarly CM allows estimates of consumer values for food safety to be made particularly in light of the potential food safety and health impacts associated with the ingestion of GM and organic foods.

Governments are currently making choices relevant to these issues. For example the Australian government is responsible for the provision of adequate food safety standards, food labelling, the allocation of research funds and the development of risk assessment frameworks for new GM crop trials. This commitment involves an allocation of resources and tradeoffs. Determining how efficient the given choices are requires estimates of program costs, the opportunity cost associated with investing in a program, community values for the choices in question and the development of appropriate strategies for dealing with risk and uncertainty. Understanding these interactions will better enable governments to broker compromises between GM proponents, community and organic agriculture stakeholders.

3.0 Identifying the issues to be considered

A number of studies in Australia and abroad have examined consumer attitudes towards genetically modified foods, environmentally friendly foods and foods produced using ethically acceptable production systems (eg. Kelley 1995, Norton et al., 1998, Yann Campbell Hoare Wheeler, 1999, Mendenhall, 2000). The majority of these studies have generated qualitative data and have been unable to produce any estimates of non-use values associated with food production.

Ness and Gerhardy (1994) investigated (using a quantitative method) consumer preferences for multiple attribute food products using an application of conjoint analysis to freshness and quality attributes of eggs in the United Kingdom. Rolfe (1999) expanded this work through a CM study that sought to identify the reasons why consumers purchased free range eggs in preference to eggs produced from battery hens and to estimate values consumers placed on eggs produced organically. Similar CM exercises have been undertaken where stated choices for environmentally friendly and conventional consumer items were compared with market related data (Blamey et al 1999).

More recently Baker and Burnham (2001) have used conjoint analysis to determine the extent to which the GMO content of food products influences American consumer preferences and explored the relationship between consumer characteristics and their preferences for GMO food products. In Australia James and Burton (2001) have used Choice Modelling to test whether or not consumers are willing to pay a premium on their weekly food bill to avoid GM food. Results of the analysis suggest that consumers are willing to pay a premium on their weekly food bill to avoid GM food and that this premium is higher than the marginal WTP to avoid conventional health risks from food poisoning. The study also found that gene technology using animal as well as plant genes was found to be more objectionable to respondents than using plant genes alone.

The work of Rolfe (1999), Blamey et al. (1999), Baker and Burnham (2001) and James and Burton (2001) has demonstrated the usefulness of the CM and conjoint analysis techniques in estimating consumer surplus values for environmental, animal welfare and food safety attributes. This study extends the use of CM to Queensland's horticulture, dairy and beef industries, producing estimates of consumers' willingness to pay for food safety, animal welfare and environmental attributes of tomatoes, milk and beef.

Food safety, animal welfare and environmental attributes maybe important influences on consumer purchasing patterns particularly when consumers are confronted with the option of choosing a GM, organic or conventionally grown product. By estimating and incorporating these public good values into traditional benefit cost analysis, the net benefits to the Australian public from both biotechnology and organic cropping options can be more fully considered.

4.0 A review of non-market valuation techniques

Responding to demand for dollar estimates of non-market values, especially those associated with environmental impacts, economists developed an array of techniques classified as "revealed preference" or "stated preference" methods (Bennett 1999).

Revealed preference techniques for estimating non-market values rely on the use of information from markets that are specifically related to the non-marketed value under consideration. The travel cost method and hedonic pricing are examples of revealed preference techniques[2]. Revealed preference techniques can be limited in their usefulness due to their retrospective nature and inability to value changes that have not been experienced. In addition they can not be used in the absence of a related well functioning market (Morrison et al. 1996). For example the Australian food market does not differentiate products according to food safety attributes because of high standards set by government regulation. This makes it difficult to isolate out price premiums for food safety.

Stated preference techniques rely on participants' responses to questions regarding willingness to pay or willingness to accept hypothetical situations. The attraction of stated preference techniques comes from their ability to estimate the full array of use and non-use environmental benefits and costs through an ex ante application. The

[2] Bennett (1996) and Fraser and Spencer (1998) provide applications of these two techniques.

most commonly applied stated preference technique has been the contingent valuation method (CVM).

In response to concerns of bias associated with CVM applications economists developed the Choice Modelling technique. CM has been developed from marketing, tourism, transportation and environmental fields (see McFadden, 1974, Louviere and Hensher, 1982, Bennett, 1999, Blamey, et al. 2000). CM allows economists to estimate respondents' marginal rates of substitution between alternative attributes and willingness to pay to move from the "status quo" bundle of attribute levels to other alternatives that correspond with policy outcomes of interest to communities and the government (Bennett 1999).

In a CM experiment respondents are asked to choose only one option from each of several sets of multiple resource use options. Each choice is between a constant "status quo" and "proposed" alternatives. The groupings of "status quo" and proposed alternatives are known as choice sets. The proposed alternatives in each choice set are differentiated by the condition of the environment described to respondents and the financial burden they impose. The descriptors of the environment and the financial impost involved are known as the attributes of the alternatives (Bennett 1999). Variation across the proposed alternatives in the choice sets is achieved by assigning different levels to the attributes.

CM relies on the application of random utility theory (RUT) to describe choice as a function of attribute levels. RUT states that consumers seek to maximise their utility when making choices. The probability that a given alternative will be chosen (P) is assumed to be a function of the utility derived from the alternative in question (V) and each of the other alternatives in the choice set. The alternative offering the highest expected utility has the highest choice probability. The most commonly used statistical model in estimating this relationship is the multinomial logit model (MNL) (Blamey et al 2000). MNL regression models generally take the following form:

$$P_{i\,j} = \frac{\exp(\lambda\, V_{ij})}{\Sigma \exp(\lambda V_{ih})} \qquad (1)$$

where P_{ij} represents the probability that individual i will make choices j from all h in choice sets C, and λ represents a scale parameter commonly normalised to 1 for any data set (Loch et al 2001). MNL models generate from a CM experiment conditional indirect utility functions that take the form:

$$V_{ij} = \lambda\,(ß + ß_1 Z_1 + ß_2 Z_2 + \ldots\ ß_n Z_n + ß_a S_1 + ß_b S_2 + \ldots\ ß_m S_j\,) \qquad (2)$$

where V_{ij} is the observable utility, ß is the constant term, and $ß_{1\ to}\,ß_n$ and $ß_{a\ to}\,ß_m$ are the vector of coefficients attached to the vector of attributes (Z) and socio-economic characteristics (S) that influence utility. The constant term ß can be partitioned into alternate specific constants (ASCs) that are unique for each of the alternatives that are considered in the choice sets. ASCs capture the influence on choice of unobserved attributes relative to specific alternatives (Rolfe et al 2000).

The use of MNL models is dependent on a condition known as the independence from irrelevant alternatives (IIA). This states that the probability of a particular alternative being selected is independent of the other alternatives, and can be tested by dropping an alternative from the choice sets and comparing parameter vectors for significant differences (Rolfe et al 2000).

Implicit Prices are calculated using the following formula:

$$\text{Implicit Price} = -(\beta_{\text{non-marketed attribute}} / \beta_{\text{monetary attribute}}) \qquad (3)$$

By observing and modelling how people change their preferred option in response to the changes in the levels of the attributes, it is possible to determine peoples willingness to give up some amount of an attribute in order to achieve more of another. By including a monetary payment vehicle ($'s) in the attributes, it is also possible to estimate the amount that people are willing to pay to achieve more of an attribute. This is called a part worth or implicit price estimate and can be estimated for each of the non-monetary attributes used in the choice sets (Bennett 1999).

CM can also be used to infer the amount people are willing to pay to move from the "status quo" bundle of attribute levels to specifically defined bundles of attribute levels that correspond with policy outcomes that are of interest. In other words the value of a change from the status quo to a specific alternative can be derived. These estimates in turn are suitable for inclusion as value estimates in the benefit cost analysis of relevant policy alternatives (Bennett 1999).

5.0 Applying CM to food production in Queensland

Three CM experiments were designed to assess values Queensland consumers might hold for organic, GM and conventionally produced foods. One experiment each for milk, steak and tomatoes were run concurrently in a single survey. In each case consumers were asked to choose between an organic, GM and conventionally farmed alternative based on the attributes of each. The logic of combining the experiments into a single survey was that respondents were less likely to be fatigued by a variety of choice profiles. This allows more choice profiles to be offered. There were also likely to be some framing advantages when respondents were likely to be explicitly aware of the variety of alternate goods.

Results of focus group[3] sessions and a review of the literature indicated that Australian consumers where influenced by a large number of attributes. Using the focus groups these were diluted down to 7 key product attributes:

- food safety;
- animal welfare;
- environmental impacts;
- location of production;
- beef tenderness;
- appearance;
- freshness.

[3] Zikmund (2000), Bennett (1997) and Krueger (1988) define focus group interviews as an unstructured, free flowing discussion with a small group of people. Ideally the group will comprise an interviewer or moderator and six to ten participants.

The payment vehicle used in the experiment was the purchase price of each product if bought at a supermarket. A range of levels for each attribute was used to construct choice profiles for each product. An example of one of the choice sets used in each CM experiment is attached as appendix 1. The questionnaire comprised 12 choice sets (four for each of the three experiments) with three options per choice set. The options included purchasing either the conventional good (status quo option), GM good or organic good. Within this experiment icons were used to label each attribute.

An experimental design[4] was used to construct 16 different versions of each survey that best represented the tradeoffs consumers encounter when purchasing conventional, organic or GM products. The same design was used for each experiment. For example the impact on environment attribute was split into 8 levels so that each choice set included one of those eight levels of environmental impact. The other attributes varied across four levels. Table 1 presents the pool of attributes and levels used in each of the three experiments.

Table 1 Attributes and levels used in each of the three CM experiments

CM Experiment	Attribute	Conventionally farmed Levels	GM Levels	Organic Levels
Milk	Location of milk production	Current Standard	Local, Regional, Elsewhere in Qld, Other states	Local, Regional, Elsewhere in Qld, Other states
	Risk to human health (% change)	Current Standard	0,-5,-10,-15	0,5,10,15
	Impact on the environment from production (% change)	Current Standard	-20,-15,-10,-5,0,5,10, 15	-20,-15,-10,-5,0,5,10,15
	Animal welfare (% change)	Current Standard	-15,-10,-5,0	0,5,10,15
	Price ($/2 litres)	2.50	1,1.50,2,2.50	2.75,3,3.50,4
Tomatoes	Appearance of tomato (% change)	Current Standard	0,5,10,20	-15,-10,-5,0
	Risk to human health (% change)	Current Standard	0,-5,-10,-15	0,5,10,15
	Impact on the environment from production (% change)	Current Standard	-20,-15,-10,-5,0,5,10, 15	-20,-15,-10,-5,0,5,10,15
	Freshness of the tomato (% change)	Current Standard	-15,-10,-5,0	0,5,10,15
	Price ($/kg of tomatoes)	2	1,1.25,1.50,1.75	2.25,2.50,2.75,3
Steak	Tenderness (% change)	Current Standard	0,5,10,20	-15,-10,-5,0
	Risk to human health (% change)	Current Standard	0,-5,-10,-15	0,5,10,15
	Impact on the environment from production (% change)	Current Standard	-20,-15,-10,-5,0,5,10, 15	-20,-15,-10,-5,0,5,10,15
	Animal welfare (% change)	Current Standard	-15,-10,-5,0	0,5,10,15
	Price ($/kg of steak)	8	4,5,6,7	9,10,11,12

6.0 Framing

Crucial to the success of a CM experiment is the relevance of information provided to respondents regarding the issues being tested. Respondents must be made aware that the good under consideration is embedded in an array of substitute and

[4] A fractional factorial experimental design was used to assign attribute levels to the alternatives. The resultant alternatives were assigned to 16 blocks such that each respondent was only presented with the alternatives that comprise one block of the fractional factorial.

complementary goods. An appropriate frame makes respondents aware of competing demands for public funds whilst reminding them of their own financial constraints (Bennett 1999).

Focus groups were used to estimate the frame of reference existing in respondents minds relating to organic and GM foods prior to being provided with any information. Based on this information a three page explanatory brochure was prepared and attached to the questionnaire. Respondents were asked to read the brochure prior to completing the questionnaire.

The brochure contained basic explanatory notes regarding biotechnology, GMOs, cloning, a brief description of GM crops currently grown in Australia and a summary of the major benefits and risks associated with GMOs. The brochure also defined organic agriculture, the magnitude of the industry and a brief explanation of some of the land use conflicts confronting the two industries eg the potential for genetic contamination of organic produce.

A second round of focus group discussions was held to test the draft questionnaire and explanatory brochure. These discussions confirmed participants' preference for the use of icons to label attributes and the combination of percentage changes and words to represent changes to attributes. For example an improvement in the freshness of tomatoes (10% fresher than current standards) associated with GMOs was written as "10% fresher" in the choice set.

The use of "% changes" was chosen as the preferred method for describing levels due to the difficulty experienced in framing attributes such as risk to human health, impact on the environment and animal welfare. Many of these attributes were a combination of a number of factors with different measurement units. The % change approach improved the consistency with which attributes were described across the three experiments.

In addition to the explanatory notes mentioned above no other information was provided to respondents. Several follow-up questions were included in the survey to test that respondents understood the choice they were making and to uncover the reasons for their answer. This also allowed researchers to ascertain whether respondents who were confused, or felt that survey was biased, had a particular preference for one of the choice options.

7.0 Sampling structure and technique

The survey was administered to 240 Rockhampton residents using a drop off and pick up sampling method with respondents having 7 days to complete the survey. Market researchers were contracted to undertake the surveys in December 2001. 208 of the 240 surveys dropped off were returned giving an 87% response rate. Of the returned surveys 203 were analysed giving an effective response rate of 82%.

8.0 Results

The data was analysed utilising MNL models. Because the choices involved labelled alternatives, this had to be modelled explicitly in the MNL format. The models did not allow the Hausman Independence of Irrelevant Alternative (IIA) test to be performed for model violations. Because there was little reason to suggest respondents may have used a nested decision structure to make choices, it was thought appropriate to continue to use the MNL models.

For the steak and tomato experiments the environmental attribute was split into positive and negative ranges, and a significant attribute calculated for each[5]. Part-worths with confidence intervals were calculated for each to facilitate comparisons. Splitting the environmental attribute into positive and negative ranges was to enabled comparisons to be made of peoples' WTP for environmental improvements when the condition of the environment is below current standards or above current standards.

Several non-attribute variables were collected in the survey to help explain respondents' choices to the options chosen. Table 3 describes the non-attribute variables included in the analysis.

Table 2 Non-attribute variable definitions

Variable	Definition
ASC	Alternative-specific constant taking on a value of 1 for either the organic or GM option in the choice sets, and 0 for the base.
Bias	Dummy variable taking on a value of 1 for respondents that thought the information provided in the survey was biased in favour of the environment; otherwise 2.
Confused	Dummy variable taking on a value of 1 if respondents thought the information or options presented in the survey was confusing; otherwise 2.
Unrealistic	Dummy variable indicating whether or not respondents found the survey believable. A value of 1 was used if respondents thought the options were unrealistic; otherwise 2.
Q1	Dummy variable measuring how strongly respondents ranked the environment against 5 other socio-economic concerns. If environment was ranked either first or second in importance it was given a value of 1; otherwise 0.
Q2	Five-point Likert scale indicating frequency with which respondents purchased organic products. A value of 1 corresponded with "never purchased organic" and 5 "frequently purchased organic".
Q4	Dummy variable indicating how much experience respondents have had with food production. A value of 1 was used if respondents had experience in food production (owned or worked on farms, regularly grew vegetables at home or studied agriculture or related topic); otherwise 0.
Income	Respondents income on a sliding scale of 1 (under $6,239) to 8 ($104,000 +)
Sex	Dummy variable indicating gender. A value of 1 indicated a female respondent and 2 male.
Donate	Dummy variable taking on a value of 1 for respondents that had donated to any environmental organisation; otherwise 2.
Membership	Dummy variable taking on a value 1 for respondents that held a membership to any animal welfare organisation, otherwise 2.
Age	Age of respondent.

9.1 Steak results

The results of the MNL model for the Steak CM experiment are contained in Table 3. There is a significant negative ASC for the GM alternative, indicating there are a

[5] The –20, -15, -10 and –5 levels were coded in for environment negative, while the 5,10 and 15 levels were coded into environment positive.

number of other factors which reduce the probability of choice compared to organic and conventionally produced steak. The *biased*, *confused* and *unrealistic* attributes were not significant in the model indicating that respondents found it easy to complete the choice sets.

Tenderness was found to be significant for organic steak (where levels were negative) suggesting that an increase in tenderness is positively associated with choice. For the GM option (where all the *tenderness* levels were positive) *tenderness* was not found to be significant. The results suggest that consumers rate improved *tenderness* as an important attribute when levels drop below current standards, but are indifferent to levels above current standards.

Similarly the *animal welfare* attribute was found to be significant for GM beef (where levels were negative), suggesting that an improvement in *animal welfare* is positively associated with choice (ie consumers are concerned about animal welfare issues when purchasing GM steak). In contrast consumers are indifferent to any improvements to *animal welfare* from current standards when purchasing organic beef.

Table 3 Results of the MNL Model for Steak

Variables	coeff.	s. error
ASCGM	-1.1803**	0.5896
Price	0.3430*	0.0734
GM Tender	0.3941	0.0244
GM Health	0.0062	0.7986
Environment positive	0.0317**	0.0161
Environment negative	0.0521***	0.0143
GM Animal Welfare	0.0462**	0.0235
GM Question 1	-0.9775***	0.3718
GM Question 4	0.4778*	0.2741
GM Age	-0.0368***	0.0095
ASC Organic	1.3407	1.0868
Organic Tender	0.0528***	0.0173
Organic Health	0.0278	0.0172
Organic Animal Welfare	-0.0077	0.0171
Organic Question 1	0.4084*	0.2145
Organic Question 2	0.2261**	0.1080
Organic Question 4	0.4812**	0.1949
Organic Unrealistic	0.4161*	0.2524
Organic Donate	-0.5177**	0.2047
Organic Member	-0.8317*	0.4641
Organic Income	0.0000*	0.0000
Model Statistics		
Log L	-804.1842	
Adj Rho-square	0.3251	
Chi-squared [19]	146.3765	

Notes: *** Significance at the 1% level, ** Significance at the 5% level, * Significance at the 10% level.

A significant positive relationship was found for both the *environmental positive* and *environmental negative* attributes indicating that improvements to the environment from both positive and negative levels are positively associated with choice. Implicit prices for the *environment* (positive and negative), *animal welfare* (GM only) and beef *tenderness* (organic only) attributes are reported in table 4. These part-worths provide the value of each 1% increase in the attributes.

Table 4 Implicit Prices for Steak Attributes

Variable	Value of a one unit improvement (A$)	Confidence Intervals Lower (A$)	Upper ($A)
Environment Positive	$0.09	$0.05	$0.11
Environment Negative	$0.15	$0.13	$0.22
GM Animal Welfare	$0.13	$0.05	$0.12
Organic Tenderness	$0.15	$0.14	$0.19

The larger coefficient for the *environment negative* attribute shows that consumers place a higher value on reducing impacts to the environment when the environmental impacts are larger than what would normally result from conventional grazing systems. The *environment positive* attribute shows that even when environmental impacts resulting from the production of steak are less than current levels, consumers are still willing to pay $0.09/kg for each unit reduction in environmental impacts. Because the confidence intervals do not overlap, there is a significant difference between *environment positive* and *environment negative*.

Analysis of the non-attribute variables included in the model suggests that consumers who donate to *environmental organisations* or hold a membership with an *animal welfare organisation* are more likely to choose organic steak in preference to the status quo (conventionally produced steak) or the GM option.

Consumers that chose GM steak in preference to either organic or the status quo option rate *unemployment, defence, education, health* and *crime prevention* higher than *environmental issues*. Conversely consumers that chose the organic option rate *environmental issues* higher than *defence, education, health* and *crime prevention*. People who have some *experience with agriculture* are more likely to choose either GM or organic over conventionally produced steak.

9.2 Tomato results

The results of the MNL model for the tomato CM experiment are contained in Table 5. Similar coding and model structure used in the steak experiment was applied to the tomato experiment. Model fits are slightly lower than for the steak experiment.

The results for the tomato experiment are not as clear as the steak results. Again there is a significant negative *ASC* value for the GM option suggesting there are a number of other influences reducing the probability of choice for GM options compared to the organic and status quo option. Similarly the positive *ASC* value for the organic option suggests there are a number other factors increasing the probability of an organic tomato being chosen in preference to the GM or conventional alternatives.

The risks on *human health* attribute is significant (positive coefficient) for GM tomatoes (where the levels were negative), suggesting that consumers are valuing reductions in health risk when choosing their options. When purchasing organic tomatoes (where health levels were positive) consumers are not concerned about health issues. This suggests that decreases in health risk are less important than increases in health risk.

Similarly the *freshness* of GM tomatoes was found to be significant, suggesting that an improvement in the *freshness* of tomatoes is positively associated with choice (ie *freshness* is an important attribute to consumers when purchasing GM tomatoes). In contrast, consumers remained indifferent to any improvements in *freshness* when purchasing organic tomatoes.

Table 5 Results of the MNL model for Tomatoes

Variables	coeff.	s. error
ASCGM	-2.4789***	0.5821
Price	-0.8191***	0.2589
GM Appearance	0.0387	0.0249
GM Health	0.06732***	0.0260
Environment positive	0.01327	0.0148
Environment negative	0.0747***	0.0136
GM Freshness	0.0410*	0.0244
GM Biased	-1.2410**	0.4885
GM Occupation	0.2365**	0.1020
GM Income	0.0000*	0.0000
Organic Appearance	0.0071	0.0153
Organic Health	-0.0028	0.0155
Organic Fresh	0.0199	0.0155
Organic Question 2	0.441***	0.0852
Organic Sex	-0.3262**	0.1617
Organic Donate	-0.5403***	0.1468
Organic Income	0.0000***	0.0000
Model Statistics		
Log L	-786.6064	
Adj Rho-square	0.2677	

Notes: *** Significance at the 1% level, ** Significance at the 5% level, * Significance at the 10% level.

Unlike the steak results only one of the split *environment* variables (negative) had a significant positive relationship. The result demonstrates that consumers are concerned with environmental impacts associated with tomato production only when the impacts are worse than what would normally result from conventional tomato growing practices. Implicit prices for the *environment* (negative), *health* (GM only) and *freshness* (GM only) attributes are reported in table 6.

Table 6 Implicit Prices for Tomato Attributes

Variable	Value of a one unit improvement (A$)	Confidence Intervals Lower (A$)	Upper (A$)
Environment Negative	$0.02	-$0.02	$0.07
GM Freshness	$0.05	-$0.02	$0.14
GM Health	$0.08	$0.02	$0.22

The *organic sex* variable for tomatoes was significant and positive suggesting that females are more likely to purchase organic tomatoes than males. The organic *question 2* variable was also significant and positive indicating that consumers choosing the organic option are more likely to have purchased organic food products previously.

9.3 Milk results

The results of the MNL model for the milk CM experiment are contained in Table 7. A different model to that used in the steak and tomato experiments was used, where the environment attribute in this analysis was not split. A robust model could not be generated for this option because the location of production attribute was identified in separate levels for modelling purposes.

Table 7 Results of the MNL model for Milk

Variables	coeff.	s. error
ASCGM	-4.1251***	0.6640
Price	-0.6474***	0.2112
Region	-0.8436***	0.2672
Elsewhere in Qld	-1.3381***	0.2978
Interstate	-0.8786***	0.2745
GM Health	0.1146***	0.0317
Environment	0.0585***	0.0097
GM Animal Welfare	0.0046	0.0289
GM Biased	0.4565**	0.2010
GM Confused	0.9245***	0.2134
GM Unrealistic	1.0987***	0.1932
GM Question 2	-0.4142**	0.1781
ASC Organic	-5.3335***	0.5280
Organic Health	-0.0435*	0.0241
Organic Animal Welfare	-0.0327	0.0233
Organic Biased	1.2266***	0.0150
Organic Confused	1.1804***	0.1665
Organic Unreal	1.3047***	0.1588
Organic Income	-0.0000*	0.0000
Model Statistics		
Log L	-878.8898	
Adj Rho-square	0.61516	
Chi-squared [17]	460.8626	

Notes: *** Significance at the 1% level, ** Significance at the 5% level, * Significance at the 10% level.

The *ASC* values for both the organic and GM options were negative, suggesting that there are a number of other factors reducing the probability of consumers choosing GM or organic milk over the conventional product. Purchasing *locally produced* milk was found to be preferable to milk produced *elsewhere in the region*, *elsewhere in the state* or from *interstate* supplies[6]. The part-worth estimates for these attributes (Table 8) reveal that if *locally* produced milk is not available consumers do not differentiate much between milk produced elsewhere in Queensland or from interstate sources. These results suggest the presence of social existence values[7] where Rockhampton consumers are willing to pay a premium for their milk in order to protect local jobs and the viability of the local industry.

Animal welfare was not found to be significant for either organic or GM milk options suggesting that Rockhampton consumers are comfortable with current industry standards.

The *health* attribute was found to be significant for GM milk (where levels were negative) suggesting that a reduction in health risks is positively associated with choice (ie consumers are concerned about health risks when purchasing GM milk). In contrast improvements in *health* risk are negatively correlated with choices for organic milk. This may be the result of an interaction with either of the *confused*, *biased* or *unrealistic* variables.

The *environment* attribute was also found to be highly significant when purchasing milk. The mean willingness to pay per household to avoid a 1% increase in environmental impacts resulting from milk production was $0.09/carton.

Table 8 Implicit Prices for Milk Attributes

Variable	Value of a one unit improvement (A$)	Confidence Intervals Lower (A$)	Upper (A$)
		Per 2 Litre Carton	
Produced in Region	-$1.30	-$4.54	$-0.54
Produced Elsewhere in Qld	-$2.07	-$6.00	$-0.89
Produced Interstate	-$1.36	$-4.09	$-0.56
		Per 1% Improvement	
GM Health	$0.18	$0.08	$0.045
Environment	$0.09	$0.05	$0.22
Organic Health	-$0.07	-$0.19	$0.00

Respondents were asked at the end of the CM questions to indicate whether or not the questions were *biased*, *confusing* or *unrealistic*. Responses to these questions were included in the analysis and demonstrate that consumers who chose conventional milk options were more likely to have found the survey *confusing*, *biased* or *unrealistic*. The conventional production option appears to have been a default for these respondents. Further modelling and analysis is required to identify where these issues may be concentrated and thus avoided in future surveys.

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[6] Locally produced milk was the status quo with a default value of 0.
[7] Blamey et al (2000) report similar results from a CM experiment valuing remnant vegetation in Central Queensland.

The results demonstrate that Rockhampton consumers in the sample survey hold similar part worth values for the human health attribute for tomatoes and milk ie \$0.09/kilogram of tomatoes and \$0.09/litre of milk for each 1% reduction in risk to human health. A comparison of the environmental part-worths across the three experiments suggests that Rockhampton consumers value reducing the environmental consequences of tomato production much less than for milk and steak production.

10.0 Conclusions

The CM experiments reported in this paper provide an analysis of some non-use values associated with the production of steak, tomatoes and milk. Consumer demands vary according to the levels of the different attributes and the production system employed (ie organic, conventional or GM). When purchasing these products consumers typically make trade-offs between a number of environmental, economic, ethical and social considerations. This research has attempted to quantify these interrelationships using the CM technique.

Initial conclusions suggest that consumers are concerned about the environmental consequences of agriculture, and place a significant value on reducing these impacts, particularly if these impacts were to increase to levels greater than what is currently experienced. Interestingly consumers expressed a WTP to reduce the environmental impacts of grazing to levels below the status quo. Further work is needed to explore these issues further.

Food safety issues were found to be significant for tomatoes and milk, and only in cases when the risk of illness from consuming one of these products falls below current standards. The results support the argument that consumers are satisfied with current food safety standards for both these products. The presence of the negative part-worth estimate for the organic health attribute may suggest the interaction of this and another variable within the model. Further modelling is required to explore this value further.

Animal welfare issues were found to be significant for steak, but only when animal welfare standards fall below the current status quo. Consumers remained indifferent to improvements in animal welfare levels above current standards. The results suggest that current industry standards and regulations governing the humane treatment of dairy and beef animals are adequately addressing consumer expectations regarding animal welfare issues.

The location of production attribute was significant for milk suggesting that consumers are willing to pay a premium on milk prices in order to support local jobs and the viability of the local industry. Consumers remained indifferent between milk produced regionally, elsewhere in Queensland or interstate. The results suggest that Rockhampton consumers support dairy deregulation as long as the local dairy industry is not lost during the current adjustment process.

These results demonstrate that significantly different values are held by Rockhampton consumers for organic and GM goods. Respondents WTP in order to avoid worsening environmental impacts provides some justification for a precautionary approach when considering high-risk environmental activities. Similarly the part worth estimates for GM health impacts support the governments food labelling, GM testing and other and public safety initiatives.

There are several caveats that should be noted with these results. The results only apply to steak, tomatoes, and milk and it is unclear whether values can be extrapolated to other foods. Surveys have only been collected in Rockhampton, and it is yet to be determined if the same values are held by a wider population. The model reported in this paper has not been tested for IIA conditions due to the relatively small size of the data sets. Further work using an expanded data set and a detailed analysis of the data set is required before more general conclusions can be drawn.

There are private and public good advantages in disaggregating consumer demand for food products. Understanding the values consumers place on individual attributes will enable food producers to tailor their products to changing consumer demands (private good benefits). Identifying the significant non-use values associated with food production will also enhance the relevance of government policy, particularly those addressing agricultural spillover effects (public good attributes). Unfortunately the economies of scale associated with many rural businesses prevent firms undertaking this type of research directly. Opportunities for Australian research and development corporations, and government agencies, to sponsor similar studies to the CM research reported in this paper should be identified and encouraged. These studies will contribute to the development of new products, targeted marketing strategies and improved government policies from the perspective of the producer, retailer and government.

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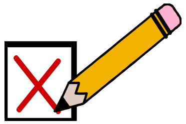
Appendix 1 Example Choice Sets

Question 8: Purchasing Steak

If y … urchasing 1kg of steak which of the following three options would you choose? Please choose the option you prefer most by ticking **ONE** box.

Important issues to consider when purchasing steak

How mu … ll each alternative cost 	**Tenderness** 	**Risk to human health** 	**Impact on the environment from production** 	**Animal welfare** 	I would choose 
Conventional					
$8/kg	Current standard	Current standard	Current standard	Current standard	☐
GM					
$6/kg	**10% increase**	**15% more risk**	**5% worse**	**No change**	☐
Organic					
$12/kg	**15% decrease**	**No change**	**5% better**	**10% better**	☐

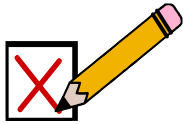
Question 9: Purchasing Steak

If you were purchasing 1kg of steak which of the following three options would you choose? Please choose the option you prefer most by ticking **ONE** box.

Important issues to consider when purchasing steak





How much will each alternative cost	**Tenderness**	**Risk to human health**	**Impact on the environment from production**	**Animal welfare**	I would choose
Conventional					
$8/kg	Current standard	Current standard	Current standard	Current standard	☐
GM					
$7/kg	**No change**	**No change**	**15% worse**	**No change**	☐
Organic					
$10/kg	**No change**	**15% less risk**	**20% worse**	**15% better**	☐

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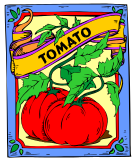
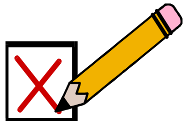
Question 13: Purchasing Tomatoes

If you were purchasing tomatoes which of the following three options would you choose? Please choose the option you prefer most by ticking **ONE** box.

Important issues to consider when purchasing tomatoes

How much will each alternative cost 	**Appearance of tomato** 	**Risk to human health** 	**Impact on the environment from production** 	**Freshness of the tomato** 	I would choose 
Conventional					
$2/kg	Current standard	Current standard	Current standard	Current standard	☐
GM					
$1.75/kg	**10% better**	**15% more risk**	**10% better**	**10% less fresh**	☐
Organic					
$2.50/kg	**5% worse**	**5% less risk**	**10% better**	**5% fresher**	☐

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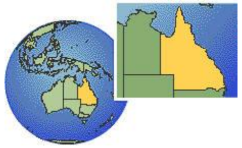
Question 14: Purchasing Milk

If you were purchasing a 2 litre carton of milk which of the following three options would you choose? Please choose the option you would prefer most by ticking **ONE** box.

Important issues to consider when purchasing milk

How much will each alternative cost

Location of milk production

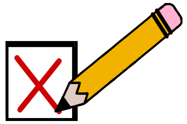


Risk to human health

Impact on the environment from production

Animal welfare

I would choose



	How much will each alternative cost	Location of milk production	Risk to human health	Impact on the environment from production	Animal welfare	I would choose
Conventional	$2.50 for 2 litres	Produced locally	Current standard	Current standard	Current standard	☐
GM	**$1 for 2 litres**	**Produced locally**	**10% more risk**	**No change**	**15% worse**	☐
Organic	**$2.75 for 2 litres**	**Produced in region**	**10% less risk**	**20% worse**	**10% better**	☐

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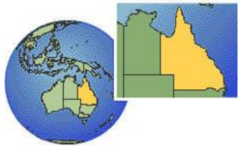
Question 15: Purchasing Milk

If you were purchasing a 2 litre carton of milk which of the following three options would you choose? Please choose the option you would prefer most by ticking **ONE** box.

Important issues to consider when purchasing milk

How much will each alternative cost

Location of milk production

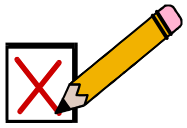


Risk to human health

Impact on the environment from production

Animal welfare

I would choose



	Cost	Location of milk production	Risk to human health	Impact on the environment from production	Animal welfare	I would choose
Conventional	$2.50 for 2 litres	Produced locally	Current standard	Current standard	Current standard	☐
GM	$2 for 2 litres	Produced locally	No change	20% worse	10% worse	☐
Organic	$3.50 for 2 litres	Produced in region	No change	No change	15% better	☐