Demand for Genetically Modified Food:

Theory and Empirical Findings

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W.H. Kaye-Blake

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As economies develop, novel products are created and markets for these products arise. Genetically modified food (GMF) is an example of such a novel product and provides economists with the opportunity to investigate an infant market. Of particular interest with GMF is the impact of consumer reactions on the market. The response of consumers to GMF and their willingness to pay for it has emerged as an important factor in the development of this technology.

This research investigates these consumer responses. Prior research suggests that two aspects of consumer behaviour may be relevant for the GMF market. First, consumers may react differently to different types of GMF, so that some products are potentially more economically viable. Secondly, some consumers appear to prefer not having GMF at all.

Consumer behaviour is often framed according to neoclassical economic theory. Consumer preferences over goods and the attributes of those goods are generally held to have certain properties. The aspects of consumers' reactions to GMF noted above, however, may be in conflict with two properties of preferences in neoclassical theory. First, preferences over food attributes are not *separable*, but may interact with each other. Secondly, some consumers may have preferences regarding GMF that are not *continuous*. As a result, aggregate impacts of introducing GMF may be difficult to measure, which raises a third issue for investigation, *aggregation*.

Finally, an alternative model of consumer behaviour is bounded rationality, which theorises that choices may be discontinuous as a result of specific protocols. It also suggests that consumers seek to make good-enough choices, rather than attempting to maximise their satisfaction. Thus, *optimisation* or *maximisation* is the fourth issue considered in this thesis.

In order to investigate these properties of consumers' preferences, a choice experiment survey was developed. The strength of a choice experiment for examining these issues is its focus on the impact of each product attribute on a respondent's choices. Thus, it may be possible to identify potentially discontinuous choice patterns and to identify choices affected by interactions between GM technology and other food attributes.

Results from a neoclassical analysis of the survey data suggest that some consumers consider the type of benefit created with GM technology in making their choices. In addition, one-quarter to one-half of respondents may have had discontinuous preferences with respect to GMF. Reactions to GMF appear related to respondents' attitudes, but not to socio-economic or demographic descriptors. As a result, aggregate measures of the impact of GMF may not fully account for consumers' responses. A boundedly rational model also has reasonable goodness of fit, and may provide a different perspective on consumer behaviour.

It is hoped that the results of this research provide a better understanding of consumer behaviour regarding GMF and, by extension, of the process of consumer adoption of novel products. It is further hoped that this attempt to incorporate choice protocols into discrete choice analysis will provide a useful example for further research.

Acknowledgements

Sometime in the middle of this research, I began to wonder why degrees are awarded to individuals when so many people are involved in the process. Because those people are not also awarded a degree, the best I can do is thank them here.

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Abbreviations

CE............Choice experiment

CM...........Choice modelling

CVM.........Contingent valuation method

GE............Genetic engineering, genetically engineered

GEV..........Generalised extreme value

GM...........Genetic modification, genetically modified

GMF ....Genetically modified food

GMO.........Genetically modified organism

MNL ....Multinomial logit

MNP ....Multinomial probit

RP ....Revealed preference

RPL...........Random parameters logit

SP..............Stated preference

WTP..........Willingness to pay

Chapter 1

Introduction

An issue that arises as economies develop is the challenge posed by the introduction of new products and new technologies. The agri-food system has seen many new products and technologies introduced since the rise of market economies. The success of these products and technologies can depend on consumer reactions, so that a product like margarine or a technology like food irradiation may have difficulties being adopted as a result of initial consumer resistance (Campbell, Fitzgerald, Saunders, & Sivak, 2000).

Genetic modification (GM) technology has been fairly recently introduced into the agri-food system. One of the first genetically modified food (GMF) products to be introduced was the Flavr Savr™ tomato (Martineau, 2001). This tomato, developed by Davis, California company Calgene, was modified to delay rotting so that it could be harvested ripe off the vine and yet have a long shelf-life. This introduction of GMF was accompanied by interesting consumer reactions; Davis consumers were divided on the acceptability of this new tomato. Consumers worldwide have been divided on the acceptability of GMF ever since, possibly affecting the success of this new technology.

Because consumers have not reacted uniformly to GMF, uncertainty has arisen regarding GMF: whether it should be produced, whether new genetically modified (GM) crops should be pursued, and what role government has in the regulation of the agri-food system when it comes to GMF. A basic economic approach to these questions is outlined by Miranowski *et al.* (1999). They advised farmers considering adopting GM crops that the prices they could receive for their crops would depend on relative demand for GM and non-GM crops, the cost of segregating the two types of crops (and verifying that segregation), the relative supplies of the two types, and the alternative products available to the market. Thus, producing GMF is economically efficient when the marginal cost of production is equal to the marginal revenue from consumers willing to pay for the products. This discussion of possible impacts on the market for GM crops provides a useful overall perspective for describing a market already in equilibrium. However, uncertainty arises as the market tries to find an equilibrium in response to increasing rates of GM adoption by producers in many countries (C. James, 2003), consumer reactions that are *a priori* unknown, and regulations that vary by country and over time (CEC, 2000; Organisation for Economic Co-operation and Development, 2000; Phillips & McNeill, 2000).

Key to the market situation is consumer reaction to GMF, which appears to operate on two levels. First, consumers seem to be deciding whether they are willing to consume GMF and the price they are willing to pay for it. Secondly, consumer reactions appear to have created pressures on policy-makers, food processors, and retailers in some countries. Governments have responded by creating regulations that affect what GMF may be produced and sold and how it needs to be labelled (ANZFA, 2001; M. F. Caswell, Fuglie, & Klotz, 1998; CEC, 2000; Organisation for Economic Co-operation and Development, 2000; Phillips & McNeill, 2000; Shoemaker et al., 2001). Some processors and retailers have responded by avoiding GMF products to some extent, such as processors who have reformulated products in order to avoid GM labels (Robertson, 2002) and retailers who attempt to avoid GMF products (CEC, 2000; Chapple, 2001).

The actual overall impact of consumer reactions, policy changes, and processor and retailer decisions on the market for GM crops is unclear. On the one hand, there is anecdotal evidence of trade shifts and price differentials (Agra Europe, 2000; M. Foster, Berry, & Hogan, 2003; INL Newspapers, 2003). On the other hand, the price differential appears to be small (Parcell, 2001), just enough to cover the increased costs of verifying whether a shipment is non-GM (USDA, 2001); consumer reluctance to purchase GMF does not appear to have created large price differentials or rents for non-GMF producers. These impacts may be small due to the inherently limited nature of non-GM demand for the commodities in question (Miranowski *et al.*, 1999), or due to the ability of the international agri-food system to funnel the existing sufficient supplies of non-GM commodities to their most efficient uses (Kaye-Blake & Saunders, 2003).

The impact on the present market may be unclear, but the future impact is even more uncertain. In the short term, marketing of new GM crops appears to have halted (BBC News, 2004; Black, 2004). There are even reports of impacts on products in the research and development phase (Lheureux *et al.*, 2003). However, new GM products may require eight years or more to reach the market (Shoemaker *et al.*, 2001), so the extent to which development of future products should be based on current consumer reactions is open to question. Complicating the decision is that future products, the so-called second generation GMF, are likely to deliver consumer-oriented benefits (Lheureux *et al.*, 2003; Shoemaker *et al.*, 2001). Demand for these benefits could reduce consumer wariness with regard to GMF (Rousu, Monchuk, Shogren, & Kosa, 2003).

Because consumer reactions to GMF appear to be central to the market effects of GM technology, this thesis examines consumers' decisions with respect to GMF. In so doing, this research considers several issues at once. One issue is whether consumers consider the type of benefit offered by GM technology when evaluating a specific product. If they do, then certain modifications, such as second-generation modifications, could be more valuable than others. The hypothesis is the following:

Hypothesis: Consumers' reactions to GMF are influenced by the specific modifications offered.

A second issue considered in this research is the extent of consumer refusal of GMF. Research into public perceptions of GM technology suggests that some consumers or respondents are categorically opposed to GMF (Gaskell *et al.*, 2003; Heller, 2003). If this is the case, then these consumers would not be expected to have any demand for GMF. Any 'improvements' or 'enhancements' created through GM technology would not be valuable to these consumers, because the method of producing such food would lead them to reject it. This can be stated as follows:

Hypothesis: Some consumers prefer to refuse all GMF.

These consumer reactions will need to be framed in economic theory or models of consumption. However, models are necessarily abbreviated versions of reality; the map is not the terrain. As a result, a third hypothesis considers the impact of the ways that these reactions are theorised on the conclusions from the research:

Hypothesis: The economic theory used to frame consumer reactions to GMF affects the conclusions drawn from the research.

Discussion of the present research proceeds in several steps. Chapter 2 presents background information the market for GMF, especially on prior research on public perceptions of and reactions to GM technology. Chapter 3 considers theoretical approaches that could be used to investigate consumer reactions to GMF. Chapter 4 reviews literature that has examined consumer behaviour, particularly with respect to GMF. Chapter 5 considers methodology for the present research. Chapter 6 presents and discusses results from the research. The final chapter, Chapter 7, provides a summary of this thesis, a consideration of the limitations of the present research, a discussion of future research directions, and concluding comments.

Chapter 2

Demand for GMF: A Background

2.1 Introduction

Genetic modification is a relatively new technology for producing new varieties or cultivars of food crops. Consumers have had a range of reactions to genetically modified food, leading to uncertainties in international commodity markets. In addition, governments have reacted in different ways to the possible release into commercial production of GM crops and the potential for using food labels to indicate whether food is from a GM or non-GM source. Economists have investigated the potential impacts of these different government policies. Consumer reactions are often an important consideration in this research for determining both potential profitability of GMF and the welfare impacts of its release.

This chapter serves as a general introduction to the market for GMF, particularly to issues with consumer demand. The general findings discussed here provide a basis for the later theoretical discussion and an impetus for empirical research. The chapter covers the definition of GMF, current market issues, and the literature concerning consumer reactions to GMF.

2.2 Definition of genetically modified food

The definition of GMF is not without controversy, as the following section will show. The discussion begins with a definition of genetic modification itself, then proceeds to a consideration of different definitions of GMF. Although there are a number of non-food applications of GM technology, particularly in medicine, the discussion concentrates on GMF.

2.2.1 Genetic modification

Genetic modification is a general term for a number of specific techniques that alter the genetic material – the DNA – of organisms. The DNA is often called the ‘blueprint’ of life, because it contains the instructions that an organism uses in building and operating itself. By altering the DNA, geneticists are able to change an organism’s physical characteristics or functioning.

The DNA may be altered in several ways, such as by introducing natural or synthetic genes or by eliminating or changing specific genes (European Commission, 2000; Royal Commission on Genetic Modification, 2001). In the case of delayed-ripening tomatoes, for example, modification altered the existing gene for an enzyme involved in ripening (Martineau, 2001). In that case, no foreign genes were inserted into the tomato. In the case of soft-rot resistant potatoes developed in New Zealand, a gene was synthesised based on a gene in the African clawed toad, and then this synthetic gene was inserted in potatoes (Conner, 2003). Such a genetically modified organism (GMO) is called *transgenic* because it involves the transfer of foreign DNA. Thus, ‘genetic modification’ is a general term referring to several techniques for creating novel organisms.

A number of terms have been used to describe these novel organisms. The main terms used are genetically modified, genetically engineered, genetically manipulated, bioengineered, and biotech. The United States Department of Agriculture (USDA) prefers ‘bioengineered’ or ‘biotech’ to indicate crops produced through genetic technology (Tegene, Huffman, Rousu, & Shogren, 2003), although the OECD considers ‘biotechnology’ a rather broader class of technologies (Organisation for Economic Co-operation and Development, 2005). In New Zealand, a Royal Commission investigated ‘Genetic Modification’, but indicated that the term was synonymous with ‘genetic engineering’. Some early research on consumer reactions tested the impacts of these different terms: gene technology, genetic engineering, genetic manipulation, and genetic modification. The different terms produced only small effects, with 'genetic manipulation' being more negatively viewed than the rest (Sparks, Shepherd, & Frewer, 1994). Similarly, a 2003 survey of U.S. respondents also found that reactions to 'genetically modified food' and 'biotech food' elicited similar responses (Pew_Initiative, 2003). In keeping with the New Zealand Royal Commission, this thesis uses the term 'genetic modification' and its variants.

2.2.2 Genetically modified food

These techniques for producing novel organisms have been used to genetically modify food crops. The main GM crops currently commercially grown are soybeans, maize, and canola, and the main modifications to these crops are tolerance to herbicides and insect resistance (Biotechnology Industry Organization (BIO), 2003a; C. James, 2003; Organisation for Economic Co-operation and Development, 2000). Farmer adoption of these crops is relatively concentrated: although 16 countries grew GM crops in 2002, the US accounted for 66 per cent of the world acreage of GM crops and Argentina another 23 per cent (C. James, 2003). GM soybeans are the most important GM crop, accounting for over 60 per cent of acreage of GM crops in 2002 (C. James, 2003). Soybeans genetically modified to be resistant to glyphosate, sold by biotechnology firm Monsanto as Roundup Ready soybeans, make up a majority of US soybeans acreage – about two-thirds of the soybean acreage in 2001 (Marra, Pardey, & Alston, 2002) – and are also widely grown in Argentina (C. James, 2003). Maize modified for insect resistance is the second most widely-grown GM crop (C. James, 2003) and accounts for something under one-quarter of US maize acreage (Marra *et al.*, 2002). Maize or corn modified for herbicide tolerance is less widely planted (C. James, 2003), and accounts for less than 10 per cent of maize acreage (Benbrook, 2002; Marra *et al.*, 2002). Some maize cultivars also contain 'stacked' traits, so they are both herbicide tolerant and insect resistant (Marra *et* *al.*, 2002). GM canola is the third most important GM crop (C. James, 2003), and although it occupies little of the worldwide GM acreage, it dominates the Canadian canola market (Malone, 2002).

While these are the main crops, they are not the only food crops to have been modified. Past GM food crops have included the FlavrSavr™ tomato with delayed ripening (Martineau, 2001), and New Leaf™ and Naturemark™ potatoes, modified to be insect and virus resistant (Phillips & Corkindale, 2002). Currently grown GM food crops include squash and papaya (S. James & Burton, 2003).

There is some disagreement over whether food from these crops should be called 'genetically modified food'. Some of these crops produce food sold in raw or unprocessed form, such as the tomatoes and potatoes described above. In those cases, the food contains proteins and genetic material, and thus it contains altered DNA. The genetic material in the food has thus been modified, so this food is the clearest example of GMF. Other crops are processed, but not in a way that removes the genetic material. Maize, for example, may be ground into meal and then used in food products. Again, the food contains modified genetic material. Other crops are processed to the extent that the resulting food products do not retain any modified genetic material. This is the case for soybean and canola oil, for example (ANZFA, 2000; Tegene *et al.*, 2003). Finally, an additional complication is that some food is produced using small amounts of GM micro-organisms. For example, by the late 1990s most cheese in the US was produced with GM rennet (Thompson, 1997). Thus, whether the term 'genetically modified food' should include all food produced from or with GM organisms or whether the term should only apply to food that actually contains significant amounts of altered genetic material is a matter of dispute.

Around the world, a number of different definitions of GMF are used and several different labelling regimes have been developed (Lau, 2004; Phillips & McNeill, 2000). The divergent approaches of the US and New Zealand demonstrate some of the differences amongst labelling regimes. The US summarises its policy with the term 'substantial equivalence': the Department of Agriculture and the Food and Drug Administration consider that food that results from GM technology is substantially equivalent to food that has not been produced through GM, as long as no food attributes have been altered substantially (Golan, Kuchler, & Mitchell, 2000; Huffman, Shogren, Rousu, & Tegene, 2001; Phillips & Corkindale, 2002). All food, whether produced with or without GM, may voluntarily label itself to inform consumers of its GM status, but labelling is not mandatory (Tegene *et al.*, 2003). Thus, up to 70 per cent or more of processed foods in the US could contain ingredients from GM crops but would not need labelling (Lau, 2004; Phillips & Corkindale, 2002),

A contrasting case is New Zealand. In conjunction with Australia, New Zealand established regulations requiring that most food with GM ingredients be labelled from December 2001 (ANZFA, 2001). These regulations require that most food that contains altered genetic material must indicate the GM ingredients on the ingredients label, and excludes highly refined ingredients which should not contain genetic material (ANZFA, 2001). Thus, GM foods like tomatoes and potatoes would need labelling, as would GM maize in a can of soup (Radio New Zealand Newswire, 2005). If food products from GM crops are processed to the point that genetic material should not remain, then the products or ingredient do not need to be labelled.

These two examples demonstrate some of the issues with determining exactly what should be considered GMF. However, it is certain that crops modified through genetic techniques are being grown and transformed into food. Furthermore, labelling of some of these food products is mandatory in New Zealand. Because New Zealand consumers may encounter food that is labelled as ‘genetically modified’, it may be useful to investigate their reactions to and willingness to pay for such food. These labelling laws also provide a convenient definition of GMF for New Zealand-based research.

An additional distinction is often made between ‘first-generation’ and ‘second-generation’ GM crops. The GM food crops in wide use, the GM soybeans, maize, and canola, are called first-generation GM crops (Shoemaker *et al.*, 2001). They focus on changes to inputs to the production system, and were marketed to farmers as improved varieties that would increase their production efficiency (European Commission, 2000). They are therefore also called ‘input-oriented’ GM crops. Second-generation GM crops are ‘output-oriented’ – they are intended to produce products with enhanced attributes (Rousu *et al.*, 2003; Shoemaker *et al.*, 2001). Producers would benefit from these products because consumers may be willing to pay a premium for them. However, it is important to note that only a few second-generation products are currently available, such as canola and soybeans with altered oils and reduced-nicotine tobacco (Information Systems for Biotechnology, 2003; Shoemaker *et al.*, 2001). Given the time to market for these products (Shoemaker *et al.*, 2001) and the types of products that are in the development pipeline (Biotechnology Industry Organization (BIO), 2003a), radically different products like low-calorie sugar or tomatoes with increased lycopene (an anti-cancer agent) (Biotechnology Industry Organization (BIO), 2003b; Organisation for Economic Co-operation and Development, 2000; Shoemaker *et al.*, 2001) are not likely to be on store shelves for many years. Research into demand for second-generation GMF thus has little to no market information for estimating potential consumer reactions.

2.3 GMF supply

While there is some disagreement over exactly what constitutes GMF, it is possible to describe the impacts of both GM crops and GM food on the agri-food system. This discussion focuses on two main aspects: trade impacts and producer and retailer responses.

The introduction of GM crops has affected world commodity trade, both commodity prices and quantities traded. The impact on prices does not seem to be large. The Tokyo Grain Exchange, for example, provides trading in futures contracts for non-GM soybeans. The premium over a standard contract is approximately the same as segregation costs (Parcell, 2001), suggesting that whilst there is a premium there are no excess profits for non-GM soybeans. Similar premiums are reported in Europe, with the USDA reporting premiums under US$4.00 per ton to cover the costs of testing (USDA, 2001). In both Japan and the EU, it is suggested that there is sufficient supply of non-GM soybeans so that large premiums are not required (Parcell, 2001; USDA, 2001).

The impact on trade volumes is more difficult to assess, and evidence is largely anecdotal. Foster, Berry, & Hogan (2003) list some of the impacts: Canada lost the EU as a market for canola, the US lost most of its maize exports to the EU, and Brazil has gained ground in the world soybean market, possibly as a result of its non-GM soybeans. One common assertion is that the US has lost around US$300 million per year in maize exports to the EU (INL Newspapers, 2003; Osborn, 2003). Another impact is that the EU has changed its in-quota supplier of maize, seemingly in reaction to the expansion of GM production in exporting countries (Agra Europe, 2000). Other similar anecdotes appear in the popular and trade press.

The evidence thus far is of fairly small overall impacts on the agri-food system but localised shifts in trade relationships. Commodity purchasers seem able to source the product they require and suppliers able to find markets for their commodities, all without large price differentials between GM and non-GM commodities.

These trade impacts are due, in part, to retailers and processors avoiding GM foods and ingredients. In New Zealand, for example, it has been reported that the introduction of mandatory labelling led food processors to reformulate their products in order to avoid the GM label (Robertson, 2002). In addition, many New Zealand supermarkets have stated their intentions to avoid stocking GM-labelled food (Chapple, 2001). Food retailers in continental Europe and the UK have taken similar actions, with many retailers pledging to avoid GM ingredients in their own-label products (CEC, 2000; Grice & Lawrence, 2003; Miranowski *et al.*, 1999; Noussair, Robin, & Ruffieux, 2004). The supermarkets are therefore demanding non-GM products from their suppliers, creating larger processor or intermediate demand for non-GM commodities (USDA, 2001). Frito-Lay, Gerber, McDonald's, and Nestle have all made moves to limit or end use of ingredients derived from GM crops (Milo, 2000).

2.4 Demand for GMF

The reaction of food retailers in New Zealand, the UK, and elsewhere have arisen from a combination of retailer risk-averseness and consumer uncertainty regarding GMF (European Commission, 2000; Loader & Henson, 1998; Marris, Wynne, Simmons, & Weldon, 2001). Consumer reactions to GMF have created uncertainty throughout the agri-food sector, even influencing the introduction of new GM crops. For example, biotechnology company Monsanto has abandoned plans to grow GM canola in Australia (Black, 2004) and decided not to pursue GM wheat, a new biotech crop, at all (BBC News, 2004). Consumer reactions even seem to be important enough to retard scientific research and development in agriculture (Huffman, Rousu, Shogren, & Tegene, 2003a; Krueger, 2001) . Farmers in the US are also faced with uncertainties over whether they will be able to market the varieties they plant and the prices they will receive (Saak & Hennessy, 2002).

Thus, the potential demand for any GMF products is an important consideration. Consumer reactions to GMF are currently creating uncertainties in the agri-food complex. In addition, public policy and investment decisions require projections about the future demand for GMF. Consumer reactions to GMF have therefore been widely studied with a variety of techniques and from several disciplinary perspectives. The following section discusses this research, considering first the economics literature and then the marketing and sociology literature.

2.4.1 Economic research

One source of economic data on consumers' reactions to GMF is information from real markets, from the quantities of GMF sold to consumers and the prices at which it was sold. Unfortunately, several features of the GMF market make such data difficult to obtain. With supermarkets avoiding stocking GM foods and processors reformulating their products, consumers in Australia and New Zealand do not have much scope for expressing their opinions regarding GMF through actual purchases. Similar reactions by food retailers in Europe and the UK (CEC, 2000; Grice & Lawrence, 2003; Miranowski *et al.*, 1999; Noussair *et al.*, 2004) make actual market data largely unavailable there, too. The US does not require that GM food judged substantially equivalent be labelled, so that ingredients from GM crops tend not to be labelled and consumers are not necessarily informed as to which products are derived from GMOs (Milo, 2000; Noussair *et al.*, 2004; Phillips & McNeill, 2000). Thus, the absence of labels makes drawing conclusions about consumer reactions to GMF difficult. This lack of market data has been noted in other research on GMF (*e.g.*, Chern, Rickertsen, Tsuboi, & Fu, 2002).

There are some products for which market data could theoretically be available. For example, positively labelled GM products have been available to consumers. The best known is perhaps the Flavr Savr™ tomato, Calgene's delayed-ripening tomato, sold as a fresh product in the U.S. and used by Zeneca for tomato paste in the U.K. (Martineau, 2001; Phillips & Corkindale, 2002). These two products are, however, no longer available. Demand for non-GM food could and has been inferred from demand for non-rbST milk (Kiesel, Buschena, & Smith, 2004). However, the data represent a small portion of total U.S. milk consumption (Kiesel *et al.*, 2004; Phillips & Corkindale, 2002), so drawing inferences about the total milk market is difficult. Overall, these market data sources seem either unavailable or unsatisfactory.

A further problem with assessing demand for GMF from existing products is that these data do not address the issue of future products. Some researchers maintain that the consumer-oriented benefits of second-generation GMF products will alter perceptions of GMF and thereby change demand (Burton & Pearse, 2002; Gamble, Muggleston, Hedderly, Parminter, & Richardson-Harman, 2000; Krueger, 2001). Because these products are not currently available, it is impossible to use actual market data to assess demand for them.

In response to the lack of revealed preference data, economists have relied on survey or stated preference data to understand consumer reactions to GMF. The stated preference methods employed can be usefully grouped into auction studies, contingent valuation survey, and choice experiments. The results of these different types of studies are described in turn.

One main centre for auction studies regarding willingness to pay for genetically modified food is Iowa State University. This research has used participants recruited from Des Moines, Iowa and St. Paul, Minnesota to determine average willingness to pay for GMF, which the researchers calculated to be 14 per cent less than the price for non-GMF (Huffman *et al.*, 2001). They have also looked at the importance of different food products. By conducting auctions with soybean oil, corn tortilla chips, and raw potatoes, they determined that consumer did not react differently to GMF depending on whether the product was highly refined, cooked, or raw (Huffman *et al.*, 2001). Another area of inquiry has been the effect of information on willingness to pay for GMF. They provided auction participants with what they described as positive, negative, and third-party information, and found that discounts for GMF ranged from 35 per cent when only negative information was presented, to 0 per cent to 11 per cent when all three types of information were presented, up to a small premium for GMF when only the positive information was used (Tegene *et al.*, 2003). A final use of auction experiments was determining willingness to pay for food products with different levels of GM ingredients. They found that participants applied a discount of 7 per cent to 13 per cent to products with 1 per cent and 5 per cent presence of GM material, compared to the price they were willing to pay for GM-free food. The researchers did not find a difference in bids between the two different levels of GM presence (Rousu, Huffman, Shogren, & Tegene, 2004).

Other researchers have also used auction methods to determine WTP for GMF. In Grenoble, France, researchers for the Institut National de Recherche Agronomique (INRA) examined both consumers' use of GM food labels and reactions to different levels of GM presence (Noussair *et al.*, 2004). They found, first of all, that consumers were unaware of GMF labels and did not use them. Secondly, consumers were split on whether they would buy GMF: 35 per cent would not buy GMF, 18 per cent would pay the same price for GMF and non-GMF, 5 per cent would pay more for GMF, and 42 per cent would buy GMF at a discount. The discount was on average 28 per cent of the non-GMF price. These researchers also found, contrary to the U.S. results, that the 1 per cent and the 0.1 per cent levels resulted in different bids. Finally, work by Lusk and colleagues has examined both WTP and WTA for GMF. One experiment used a non-representative sample of students from a Kansas university, and found that most participants would not pay a premium for non-GMF. Some of their participants, however, would pay a significant premium (Lusk, Daniel, Mark, & Lusk, 2001). They further found that attitudinal questions using a Likert-type response scale were good predictors of auction-established WTP. Another set of experiments compared responses of U.S., English, and French participants to positive information about biotechnology and genetic modifications (Lusk *et al.*, 2003). They found that bids varied across the three countries and across the three U.S. locations. They also found that participants placed different values on the three types of biotechnology benefits presented: environmental benefit, health benefit, or world (altruistic) benefit; health benefits had the largest positive impact on acceptance. In general, positive information about biotechnology caused participants to reduce the discount demanded. It seems, however, that the cookies (biscuits) used in the auction had a retail value of US$0.25 (Lusk *et al.*, 2003), but the discounts demanded even after the positive information were consistently higher than this price for Long Beach, California ($0.41 to $0.67); Reading, England ($0.63 to $1.31); and Grenoble, France ($2.45 to $3.03). This research did not provide indications of different groupings of participants according to whether they were indifferent to, supportive of, or opposed to GMF.

Contingent valuation has also been an important tool in examining WTP. One project assessed the WTP for GM tofu and GM noodles using a dichotomous choice format (McCluskey, Ouchi, Grimsrud, & Wahl, 2001). This format assessed WTP by using two questions. This first asked whether the respondent was willing to purchase the GM product at the same price as the non-GM product. If the respondent was not, a second question then offered the GM product at a randomly-assigned discount. The discounts used were not reported. Of 400 respondents, 16 individuals were willing to purchase the GM tofu without a discount and 12 individuals were willing to purchase the GM noodles without a discount. An additional 15 per cent would purchase GM tofu with the discount offered, while 17 per cent would purchase the noodles. The rest would not purchase at the offered discounts. The estimated model found that the results indicated that respondents were willing to pay a 60 per cent premium for non-GM noodles and a 62 per cent premium for non-GM tofu. Another CV survey, administered in Beijing, China, found results quite different to those in other countries (Li, Curtis, McCluskey, & Wahl, 2002). In this research, 80 per cent of respondents would buy GM rice with extra vitamins at same price as non-GM, and 43.9 per cent would pay premium for the GM product. Another 4.7 per cent were willing to buy the GM rice at discount whereas 14 per cent would not buy the GM rice at the offered discounts. The pattern of response was similar for oil from GM soybeans with no consumer-focussed enhancement: 39.6 per cent of respondents would pay a premium, 34.4 per cent would buy the GM oil but not pay a premium, 8.5 per cent would buy the oil at a discount, and 16.7 per cent would not buy the GM oil.

Another common method for estimating willingness to pay for GMF has been attribute-based stated choice methods (Adamowicz, Louviere, & Swait, 1998), including conjoint analysis and choice experimentation. An early example used conjoint analysis to determine WTP for pST-treated pork (Halbrendt, Pesek, Parsons, & Lindner, 1994). While this research did not calculate a WTP because of the survey method used, it did determine that ratings of pork products were essentially unaffected by use of pST for respondents who were unconcerned about pST. This would suggest indifference or a similar WTP for both the GM and non-GM products.

Choice experiment surveys have been used to determine WTP for GM as a general characteristic of the food system. In the U.K., respondents were surveyed on preferences for different ‘food futures’, future configurations of the food supply (Burton, Rigby, Young, &

James, 2001). These futures varied in the use of plant-only gene technology, plant-and-animal gene technology, changes in chemical use, changes in 'food miles' (the average distance food travels from farm to retail outlet), and risk of food poisoning. These different futures were also given different prices, as percentage changes from current food spending. This research provided valuable information about consumer reactions to GMF in the context of the wider food system. It also considered whether the type of GM technology could have an impact on consumers' reactions. Finally, the data analysis revealed significant differences in the reactions of different consumer groups to GMF.

This research (Burton *et al.*, 2001) estimated models for three consumer segments, Infrequent, Occasional, and Committed purchasers of organically grown food, all of which were also divided by gender. The estimated WTP for a GM-free diet was larger than the WTP for other attributes of a future food supply, suggesting that GM technology may currently be a dominant issue for consumers. When comparing different types of GM processes, the research found that the Infrequent and Occasional groups were indifferent to plant-only GMF, demonstrating the potential impacts of different types of technology. Finally, the researchers estimated WTP for a food future free of plant-and-animal GMF. The smallest WTP for such a GM-free food supply was estimated for males in the Infrequent group at 26.25 per cent of current food spending. The largest WTP was for females in the Committed group, at 471.95 per cent. These findings suggest that consumers have a wide range of reactions to GMF.

Rigby & Burton (2003) used the same data set to estimate a model that calculated not only the mean WTP within each category, but also the size of the variance around that mean, by category. WTP calculations were also presented for the original (Burton *et al.*, 2001) model, both for plant-only and plant-and-animal GM-free food futures. While the exact values changed, the magnitudes are similar between the two models for all groups and both genders.

Thus, Infrequent male purchasers of organically grown food would pay 44.48 per cent to have a GMF-free food supply, and Committed female purchasers would pay 472.27 per cent. There are two additional findings from the re-estimation. First, gender is insignificant when the variation within each respondent category is taken into consideration. Secondly, the variation suggests that extreme values can occur, with small probabilities, and that some consumers could value GMF over non-GMF.

James & Burton (2003) conducted similar research in Western Australia on WTP for food futures. Their results found that Australian consumers had reactions similar to those of UK consumers, in that WTP could be segmented by gender and type of GM technology. In addition, they found that WTP for a GM-free food supply declined with age. Overall, values ranged from zero – indifference to the technology – to a WTP 72.6 per cent more in order to have no plant-and-animal GMF.

Choice experiments have also assessed WTP for specific products rather than the whole food supply. Burton & Pearse (2002) examined preferences for different beers made from conventional and GM barley and yeast. They found, first of all, that respondents were not sensitive to the number of modifications; a beer containing one GM ingredients was valued the same as a beer containing two. The discount demanded for a GM beer depended on age, so that a 20-year-old respondent discounted a GM beer by $0.70 (from $3.00 for a conventional beer) and a 40-year-old respondent discounted a GM beer by $0.40. However, those respondents who were concerned about their cholesterol levels were prepared to pay $0.83 on average for a GM beer that reduced their cholesterol levels by 20 per cent. This research thus suggests that health benefits could be an important consideration in how consumers evaluate GMF. Another choice modelling survey examined WTP for GM salmon and for GM-fed salmon (which were not themselves genetically modified) in the U.S. and

Norway (Chern *et al.*, 2002). Premia for conventional salmon were between 41 per cent and 67 per cent, with Norwegians willing to pay slightly more. GM salmon attracted a larger discount than the GM-fed salmon. This research reinforces the above findings that the type of genetic modification could affect consumer WTP.

There has been at least one attempt at a meta-analysis of these WTP surveys. Hall, *et al.* (2004) reviewed several studies estimating WTP for GMF or non-GMF, including those discussed above, to analyse factors affecting WTP and compute an overall average. They estimated that the value of GMF without consumer-oriented enhancements is 24 per cent to 37 per cent lower that the value of non-GM, conventional food. Depending on the data set analysed, the most important variable affecting the price differential was either the method of survey distribution (mail, in-person, etc.) or the elicitation technique (contingent valuation, auction, etc.). Bivariate analysis, however, found that the impacts of distribution method, response rate, and type of participants (student, shopper, general population) on WTP are inconclusive.

The research on the relative WTP for GM and non-GM food is varied in methods, samples, and results. It indicates that some consumers are indifferent to or positive about GMF, while others are opposed. In between these groups are those who would purchase GMF if they received sufficient benefits, either in lower prices, consumer benefits, or both. Some studies found only a small market for GMF, while others found large and avid markets. In addition, some researchers have suggested that perceptions of GM may be affected by the benefits that consumers receive (Burton & Pearse, 2002; Gamble *et al.*, 2000; Krueger, 2001). The potential size of future markets for GMF is thus difficult to predict.

2.4.2 Marketing and sociology research

The marketing and sociological literature provides additional information on consumer reactions to GMF. Specifically, it suggests that there is significant heterogeneity in consumer reactions, so that different consumers react differently to GMF. Analysis of consumer segments or differences amongst opinion groups recognises that '…there can be no simple description of "the public's opinion about biotechnology"' (Fischhoff & Fischhoff, 2001). Research on this issue has used opinion polls, psychometric surveying, and statistical techniques to identify groups who vary in their perceptions of GMF or biotechnology. Analyses differ in the number of groups identified and the issues that determine the segmentation. The following discusses several examples of this research.

A non-representative survey of Singaporeans divided respondents simply into those Worried about eating GMF and those Not Worried (Subrahmanyan & Cheng, 2000). The two groups of respondents had significantly different responses on all the survey questions, which addressed such issues as ethics, beliefs, perceived knowledge of biotechnology, and the desirability of GMF.

There have also been studies that have attempted to categorise respondents by their reactions to GMF, and these have identified three respondent groups. Cluster analysis on results of the GM Nation survey in the U.K., for example, found that 47 per cent of the sample were 'Implacably Opposed to GM', 32 per cent were 'Somewhat Opposed to GM', and 12 per cent had 'No Fixed Position on GM' (Heller, 2003). Reporting on their review of literature on consumer reactions, Bredahl, *et al.* (1998) found that consumers tended to fall into three categories: refusers, undecideds, and triers. Finally, a large survey in Europe and the U.S. divided respondents according to patterns of response (Gaskell, Bauer, Durant, & Allum, 1999). 'Supporters' felt that biotechnology was useful, not risky, and acceptable. 'Risk-tolerant supporters' felt that it was useful but risky, as well as morally acceptable; they also thought it should be encouraged. 'Opponents' felt that biotechnology was not useful, that it was risky and unacceptable, and consequently that it should not be encouraged. These examples all agree that one group is opposed to GM, but present different pictures of the rest of consumers.

More detailed pictures of consumer segments are available from research identifying four or more groups of consumers. Results of a large European survey were used to identify four opinion groups (Gaskell *et al.*, 2004): Tradeoff respondents (18 per cent) saw risks and benefits from GMF, Relaxed respondents (14 per cent) saw benefits and no risks, Sceptical respondents (62 per cent) saw risks and no benefits, and Uninterested respondents saw neither risks nor benefits. U.K. respondents to the Eurobarometer had a similar pattern of responses (Gaskell *et al.*, 2003). Of those who were not classed as Uninterested, Sceptical consumers made up 27 per cent, Relaxed respondents were 31 per cent, and Tradeoff respondents were 43 per cent. Psychometric surveying of Belgian food shoppers used factor analysis to identify five consumer groups (Verdurme, Viaene, & Gellynck, 2003): Food Neophobics (30.8 per cent), Enthusiasts (17.5 per cent), Balancers (21.8 per cent), Cautious (13.3 per cent), and Green Opponents (16.8 per cent). The authors note that about 45 per cent of respondents held negative attitudes towards GMF, but the Food Neophobics are negative about new food products in general whereas Green Opponents are opposed to GMF as a result of environmental and ethical attitudes. Finally, a review of research for the Canadian government identified 'five groups of which 44 per cent, in all, were characterised as positive towards biotechnology (true believers, 21 per cent, and fearful supporters, 23 per cent), 32 per cent were characterised as indecisive, 6 per cent as disinterested, and 18 per cent as avid opponents' (Sheehy, Legault, & Ireland, 1998).

Research into attitudes and opinion regarding GM has found a number of factors that correlate with or underlie respondents' reactions to GM.

- Increased knowledge of GM may increase consumers' acceptance of the technology (Zechendorf, 1994), but it has been shown to lead to a hardening of pre-existing attitudes (Heller, 2003).

- Broadly speaking, biotechnology focussed on plants is more acceptable than animal biotechnology or plant-animal genetic transfers. This hierarchy of acceptability appears in Australia, New Zealand, North America, and Europe (Campbell *et al.*, 2003).

- Lower acceptance of GM has been linked to greater risk perceptions. One specific concern that has been raised is concern for the unintended consequences of the technology (Campbell *et al.*, 2003; Heller, 2003).

- Acceptance of biotechnology has been shown to be affected by respondents' trust in government and industry trust. A lack of confidence in regulatory bodies leads to more sceptical attitudes towards GM (Campbell *et al.*, 2003; Hoban, 1997).

- Acceptance of GM technology appears to be linked to more general attitudes, such as attitudes toward science and technology and general ethical concerns (Campbell *et al.*, 2003; Hoban, 1997; Zechendorf, 1994).

- Environmental concerns seem to have both positive and negative effects on attitudes towards GM. Respondents tend not to agree that GM is environmentally friendly (Small, Wilson, & Parminter, 2002), and ecocentric respondents (those that value nature intrinsically) tend not to support GM (Siegrist, 1998). On the other hand, surveys that attribute environmental benefits to GM in agriculture have found that respondents react positively to the technology (IFIC, 2002; Sheehy *et al.*, 1998).

Attitudes and perceptions of New Zealanders appear quite similar to those found in other industrialised countries (Macer, 1992, 1998). A majority of people studied seem to be willing to support GMF in some circumstances (Small, Wilson, Pedersen, & Parminter, 2001), and some GM products are more acceptable than others (Gamble & Gunson, 2002). For example, a product that is itself modified is less acceptable than a non-modified product produced using GM (such as beef fed with GM clover) (Gamble & Gunson, 2002). Acceptance of GM appears to be lower when there is greater environmental risk (Macer, 1992; Small *et al.*, 2002) and higher when the GM product offers an environmental benefit (Macer, 1994). Generally, women are less sanguine about GM food than men, and are more likely to have changed their food purchasing behaviour due to concerns about GM (Gamble & Gunson, 2002).

2.4.3 Issues with demand for GMF

The economic, marketing, and sociological literature would seem to indicate that consumers' reactions to GMF could be an issue. Some consumers appear to be completely indifferent to the introduction of gene technology into the food system, so that their demand for GMF may be identical to their demand for non-GMF. Other consumers appear to be willing to consume GMF as long as they receive a price discount. Still other consumers appear unwilling to consume GMF, preferring non-GMF at all relative price levels. Because of the range of consumer reactions to GMF, the impact on food markets is uncertain. As the supply of GMF increases relative to non-GMF, the price wedge between the two types of products would be expected to increase as the GMF needs to appeal to the more sceptical consumer segments. Furthermore, it is not clear what price discount might make GMF palatable for those consumers who appear not to want it at all. These uncertainties suggest that closer examination of GMF may be warranted.

Four specific issues that arise from the above discussion should be highlighted. The first issue is the way in which consumers assign a value to GMF. The value of genetic modification to consumers does not appear to be invariant, according to some of this research. In particular, the type of benefit that GM offers consumers may affect how they react to GMF products. The suggestion that consumers may view second-generation GMF products more positively than current GMF may imply that the value of gene technology in producing food is not a constant amount (Burton & Pearse, 2002; Gamble *et al.*, 2000; Krueger, 2001). Instead, as opinion polling suggests (Pew Initiative, 2003), some goals of biotechnology may be more positively viewed than others.

A second issue regarding demand for GMF that is raised by the marketing and sociological research is the evidence for a group of consumers 'implacably opposed' to GMF, who are 'avid opponents' or 'refusers' of GMF. This type of consumer response is less evident in the results of economic research. The economic surveys often calculate price discounts for everyone in the data sample, either as an average discount for the whole sample or discount for different subsamples. However, there is evidence of refusal, of a lack of willingness to purchase or consume GMF, in two groups of respondents to these surveys and auctions: those whose responses were deemed 'protest' responses, and other respondents who never selected GMF products. These two groups are discussed in turn.

'Protest' responses come from respondents refusing to indicate their true WTP. For contingent valuation surveys, protest responses can come from respondents who have a positive WTP but give a zero response, and from those who give an exaggerated estimate of their WTP (Bateman *et al.*, 2002). In both cases, respondents seem to be engaged in strategic behaviour, disguising their true WTP in order to influence unduly the results of the survey or to indicate their opposition to the survey. In choice modelling surveys, protest respondents are regarded as those respondents who refuse to consider the different alternatives presented (Burton et al., 2001; S. James & Burton, 2003). Respondents who always select the base or *status quo* response from the choice questions are considered protesters because they do not seem to be evaluating the options presented. These respondents, too, seem to be refusing to indicate their true WTP. Finally, economic experiments also generate protest responses. These are identified as respondents who present extreme bids during auction experiments (Lusk *et al.*, 2003). One exception is the research by Noussair, *et al.* (2004), which reported those who refused GMF as valid reponses. In general in survey and auction research, however, protest responses are identified and excluded from subsequent analysis (Bateman *et al.*, 2002; Lusk *et al.*, 2003).

Because these protest responses may be indicative of a desire amongst some consumers to refuse GM food, it may be valuable to consider this group of respondents more closely. The choice experiments reported in Burton, *et al.* (2001) identified up to 20 per cent of the returned surveys as protest respondents, and showed that including their responses in the data analysis resulted in significantly different model parameters. These respondents did not appear to be willing to accept any compensation in return for changes to the food system, whether the changes were the introduction of GMF or shifts in pesticide usage. James & Burton (2003) found that 31 per cent of respondents were unwilling to accept changes to the food system. It may be possible to extend this prior research to examine the motivations for protest responding and thereby obtain more information about consumers' reactions to GMF.

The second indication that some respondents in economic research do not want GMF is that they refuse to select or put a value on GMF options. In a CV survey of Japanese consumers, McCluskey, *et al.* (2001) offered respondents GMF at the same price as non-GMF and at a discount. They determined whether a respondent was in one of three categories: WTP at least as much for GMF as non-GMF, WTP between parity and the offered discount for the GMF, or not willing to purchase the GMF even at the offered discount. This is standard practice, and allows the researcher to estimate an average WTP for the sample. In this case, however, only 16 people of 400 said they would purchase GM tofu without a discount, and only 15 per cent would purchase it with the offered discount (the figures for GM noodles were 12 people and 17 per cent, respectively). Thus, only 20 per cent of the sample ever expressed a willingness to purchase the GM food. A similar example of possible refusal comes from a choice modelling survey of UK consumers (Burton *et al.*, 2001). The sample was segmented by attitude towards purchasing organically grown food, whether they were Infrequent, Occasional, or Committed purchasers. Amongst Committed purchasers, only 15 per cent of respondents ever selected a GM option from the choice sets presented. These two examples suggest that large numbers of respondents are not indicating the value that they would place on GMF options.

The economic data combined with the findings from sociological and marketing research suggest that some consumers might want to refuse GMF. From the economic research, there are two groups of respondents who potentially belong to this consumer segment, those excluded as protest respondents and those who never select or value GM options. Because they refuse GMF at any price, because they will not accept compensation in return for consuming products they do not prefer, the consumers are said to have *non-compensatory* demand for non-GMF.

The third issue regarding demand for GMF arises if indeed these consumers do want to refuse GMF. Their market behaviour becomes an important factor in aggregate estimates of market prices for GMF. Refusal to purchase GMF creates a maximum quantity demanded, but this might not be binding so long as sufficient non-GM supplies are produced. In fact, the low price differentials between GM and non-GM commodities seem to be related to the sufficiency of supply of both commodity types (Parcell, 2001; USDA, 2001). It is not clear how price would be affected should the levels of non-GM commodities become insufficient. In addition, if it is accepted that some consumers simply do not want GMF regardless of price, then the biotechnology industry can focus on creating products for those consumers who are willing to consume GMF. Economic research can provide analysis of acceptable products and acceptable prices for these consumers, and demand estimates can be based on those consumers who do demonstrate a willingness to purchase GMF.

A second measure of the aggregate impact of GM technology on consumers is the change in consumer welfare. Several researchers have developed models of the market for GM crops that measure, amongst other things, changes in consumer welfare from introducing and regulating GM technology. Moschini, Lapan, & Sobolevsky (2000), for example, model the impact of herbicide tolerant soybeans, considering different uptake rates and technology fees. In this model, demand is not segregated into consumers who are willing to accept GM crops and those who are not. The resulting estimates of consumer welfare increases rest on the assumption that consumers view GM crops as substantially equivalent to non-GM crops. Qaim & Traxler (2005) similarly modelled the impacts of herbicide tolerant soybeans without segregating demand into consumer segments. In their research, consumer welfare increases as the price of soybeans falls. An additional consideration could be the impact of wholesale introduction of a GM crop into a market that may include unwilling consumers. If one relaxes the assumption that all consumers are willing to purchase GMF, perhaps at a discount, then the change in consumer welfare may be uncertain.

Some researchers have considered the impact of differential consumer reactions on aggregate welfare. Lapan & Moschini (2002), for example, segregate the European market into consumers who accept GM and consumers who do not. The analysis indicates that the welfare of non-GMF consumers decreases as the price of non-GM products increases. It would be interesting to consider the welfare implications of the scenario in which consumers who do not want GMF could not access verifiably non-GM products. That is, although the cost of non-GMF might be higher than the cost of GMF and the cost of food in the pre-GM situation, the WTP for non-GMF is also higher – a shift of the demand curve. The calculations of welfare impacts could include an estimate of the benefits to these consumers of having non-GM products, which could be estimated by determining these consumers' relative WTP for GMF and non-GMF. Lindner, *et al.* (2001) similarly include segregated demand in a model of the canola market. They find that the welfare of consumers preferring non-GM canola can be significantly reduced, especially with higher segregation costs. Again, this model could be extended to consider a measure of the gains that consumers might have from being able to access the preferred non-GM products.

Research on the welfare impacts of segregating GM and non-GM commodities and the costs of such segregation typically finds that segregation costs reduce the welfare of consumers who prefer non-GMF. These findings are in essence determining whether a consumer is better off having conventional commodities (*i.e.*, pre-GM technology commodities) or non-GM commodities with segregation costs. This comparison may not be appropriate, because in a very real sense 'conventional' commodities ceased to exist with the introduction of GM crops. The appropriate comparison is between having access to non-GM commodities – and having to pay for that access through segregation costs – and consuming GM commodities. If this comparison is considered, then the impact of non-compensatory preferences for non-GMF is clear: as Tauer (1994) notes, consumers who want to refuse GMF are 'better off at any price' (p. 7) with a segmented market since they have non-GMF to consume.

This modelling research demonstrates the issue with summarising impacts on consumers with an aggregate measure of consumer welfare. Some research does not at all account for demand for non-GM products, but assumes that those consumers are not harmed by the introduction of GM crops. Other research segments demand into GM-tolerant and GM-intolerant, finding that the GM-intolerant have reduced welfare as the production costs or the verification costs of non-GM crops increases. However, these consumers could potentially face even larger decreases in their welfare if they were not able to access non-GM products. Thus, further investigation into consumers' reactions to GMF, particularly the apparent unwillingness to consumer GMF by some consumers, may provide more information about the welfare impacts of the introduction of GM technology into the agri-food system.

The fourth and final issue regarding demand for GMF specifically concerns New Zealand. Prior research has identified the attitudes and perceptions that affect New Zealanders' acceptance of GMF, and has also given some indication of the proportion of consumers who may be willing to purchase GMF. By using an economic valuation technique specifically designed to estimate consumer willingness to pay, it may be possible to extend this prior work and estimate demand for GMF. Including measures of attitudes or perceptions might allow such WTP research to link to the marketing and sociological research that has already been done in this country.

2.5 Conclusion

Evidence from food and commodity markets and consumer research suggests that demand for GMF is complex. Which consumers are prepared to accept GMF, which products they are likely to demand, and how much they are willing to pay for them is a central concern in the marketing of current products and the development of new ones. In its final report, the Royal Commission on Genetic Modification (RCGM) stated that consumer preferences will be important in determining demand for New Zealand’s exports, but considered that ‘it is too early to predict consumer reaction with any certainty’ (Royal Commission on Genetic Modification, 2001). Amongst its recommendations were that funding be provided to investigate socio-economic impacts of the use of GMOs, and implementation of GMO guidelines include economic impact assessments (Royal Commission on Genetic Modification, 2001). Therefore, consumer demand for GMF appears to be an important issue, both for the agri-food system and for national policy-makers.

Chapter 3

Theories of consumer choice

3.1 Introduction

This chapter explores economic theories of the market for goods to determine how they might be used to discuss, understand, and explain the issues raised in Chapter 2 regarding consumer demand for GMF. Two economic schools of thought about how consumers decide what to consume are considered. Neoclassical theory is reviewed first, and the theory of bounded rationality is reviewed second. The discussion considers the implications of the observed consumer and public responses to GMF for these theories.

3.2 Neoclassical theory

Neoclassical theory provides an explanation for the functioning of markets. Markets are divided into two sides, supply and demand (or production and consumption). On the demand or consumption side, neoclassical theory assumes that consumers are sovereign individuals and make their choice based on their own tastes and preferences. These preferences are generally considered relatively stable (McFadden, 2001b), at least in comparison to other elements in the economy (Robinson, 1962). If a consumer's preferences meet certain assumptions, that is, given that the preferences are *reflexive*, *complete*, *transitive*, *continuous*, and *non-satiable*, they may be represented by a utility function (Deaton & Muellbauer, 1980). Preferences may also be represented by *indifference curves* (Arrow, 1963; Deaton & Muellbauer, 1980). A single indifference curve describes the different combinations of amounts of products that leave a consumer's level of satisfaction unchanged, while an *indifference map* contains the indifference curves for higher and lower levels of satisfaction (Quirk, 1982). Well-behaved indifference curves are generally held to have certain properties (Varian, 1996):

- They are convex to the origin. For each good, the marginal benefit of consuming an additional unit decreases as more is consumed. If two situations are compared, one in which a consumer has a lot of a good and one in which she has little, the consumer will demand less compensation in return for the good in the first than in the second. This decreasing marginal benefit produces convex indifference curves.
- They do not cross each other. This is a requirement that indifference maps be rational. If two indifference curves cross each other, then it is possible that a consumer will be more satisfied by having less of both goods. For all normal goods, rational behaviour is assumed to be such that more is better.
- They have at every point a first and a second derivative. Indifference curves describe continuous relationships, rather than ones that exhibit instantaneous changes. For a combination of two goods, it is possible to determine a marginal rate of substitution, or the rate at which a consumer is willing to exchange them for each other. This rate is given by the first derivative. This rate is generally assumed to be decreasing, and the rate of change can be given by the second derivative.

These properties describe several important features of indifference curves in neoclassical theory. These properties are not always assumed to hold (Deaton & Muellbauer, 1980; Quirk, 1982; Varian, 1996), but they do tend to underpin analysis of preferences and willingness to pay. In the case of GMF, it is the property that indifference curves are continuous and twice-differentiable that is potentially challenged by the reactions or survey responses of some consumers, as described in Chapter 2.

The theory of the indifference curve is rooted in the behaviour of individuals. The decision to trade some of one good for some of another good is the decision of an individual. Indifference, too, is the reaction of an individual who is neither harmed nor benefited by exchanging some of one good for some of another. How to aggregate these individual choices into social choice functions or demand curves has been the subject of much research (Arrow, 1963; Deaton & Muellbauer, 1980). One way to represent the preferences of a group is with c*ommunity indifference curves* (Salvatore, 2004). Another method of modelling aggregate preferences is to treat demand as the result of an aggregate utility function of a 'representative' consumer (Deaton & Muellbauer, 1980). However, theoretical developments and increases in the power of microcomputers have led economists to analyse individual choice data (McFadden, 2001b). This allows aggregate welfare impacts and total willingness to pay to result directly from analysis of individual behaviour. At any single point, it is an individual's behaviour at the margin that results in the trade-off that is recorded at the aggregate level.

This aggregation, the adding up of individual indifference curves, is also potentially an issue when analysing consumption of GMF. If both GMF and non-GMF are present in a market, there exists a possibility of trading more of one against less of the other. This exchange behaviour is well described by an indifference curve. As long as there exists a sufficient number of consumers in the market who are willing to make such an exchange, the community indifference curve may be considered continuous. The research and findings discussed in Chapter 2 suggest, however, that the market may reach a point at which no additional individuals are willing to exchange their non-GMF for any amount of GMF. If the goal of research is to describe the impact of the introduction of GM technology on the total market for a good that formerly existed only in non-GM form, then it may be desirable to consider the entire market, including both those consumers who are willing to consume GMF and those who are not. In that case, the impact on the market from the summation of the individual indifference curves may require further investigation in those situations that would require very high acceptance of the GM form of the good.

The other half of the neoclassical theory of the market is production. The productive capacity of an economy may be represented by its production possibility frontier, which indicates the maximum level of production of an economy given its inputs and technology (Mikic, 1998; Salvatore, 2004). In an economy with more than one factor of production, the production possibility frontier is generally represented as a curve concave to the origin (Mikic, 1998; Salvatore, 2004). Like the indifference curve, the production possibility frontier represents a trade-off: at the limit of the productive capacity of an economy, producing more of one good entails producing less of another. The impact of GM on production is an important consideration in understanding the overall market impact of the technology. However, the production side of the economy is not the subject of this thesis and will not be examined in depth.

The two halves of the market interacting together determine market prices. When the rate at which consumers are willing to trade one good for another is just equal to the rate at which producing one good can be traded off against producing the other, the market is in equilibrium. This rate at which one product is exchanged for the other (either on the consumption or the production side of the economy) determines the relative prices of the two goods. At the equilibrium price, the market as a whole is indifferent between consuming or producing a little more of one good and a little less of the other. This indifference at the market level is a direct result of the indifference of an individual at the margin.

A key consideration of the classical and neoclassical depictions of the economy is how prices are set and how people 'know' how much to produce (Heilbroner, 1986 [1953]). That is, no authoritarian source seems to be commanding producers to generate specific amounts of goods or mandating consumption of certain products. Classical and neoclassical economics adopted the idea of an 'invisible hand', courtesy of Adam Smith, to describe the way that markets calibrate demand and supply to produce an equilibrium. Key to this equilibrium is the signalling function of prices: they communicate information to producers and consumers about the relative values of inputs and outputs and so regulate relative levels of production and consumption.

Not all economists agree with the notion that an invisible hand guides the market, even in so-called neoclassical market economies. One contrasting viewpoint is the vision promulgated by Galbraith (1967). He maintained that production required such enormous investment and long lead times, and that corporations had such an influence over society, that demand was essentially managed. Demand management meant that once products were finally fully developed and commercially available, there was sufficient demand for the products. A second viewpoint is that of Robinson (1962), who showed that industrialists view one of their functions as distributing income: they rightfully determine wages and dividends and thus income distribution. Income is an important determinant of demand, which is thus not negotiated but determined by fiat or industrial policy. Such questions of demand management and relative power of economic agents could be raised with respect to GMF.

This section has reviewed the general neoclassical theory of the market, describing how the interaction of two sides of the market leads to an equilibrium. It has also shown that issues may arise if certain properties of indifference curves are assumed to hold in relation to the consumption of GMF. Specifically, the assumption that indifference curves may be considered continuous may not hold for some consumers with respect to GMF. This potential lack of continuity at the individual level may also lead to difficulties when aggregating individual indifferences into a community indifference curve. Given the potential relevance of these issues, the discussion now turns to a more thorough treatment of neoclassical consumer theory.

3.2.1 Neoclassical consumer theory

Neoclassical consumer theory describes the choices that consumers make in the market. A key concept for this theory is *utility*. A single indifference curve is defined as the combinations of goods that leave a consumer's utility unchanged. What 'utility' means in this context has been the subject of debate in economics, but it is usually explained as satisfaction or pleasure or something else positive. However, in neoclassical theory it is essentially irreducible (Boland, 1981). '*Utility* is a metaphysical concept of impregnable circularity; *utility* is the quality in commodities that makes individuals want to buy them, and the fact that individuals want to buy commodities shows that they have *utility*' (Robinson, 1962). Metaphysical concepts are beyond proof; they cannot be empirically verified (Diesing, 1991). Thus, to the extent that utility is synonymous with the value or pleasure of a commodity, it may not be useful for empirical research.

For empirical research, it is possible to rely on a different definition. What neoclassical economists mean by utility has been developed axiomatically, so that it is now generally take to mean '*the value of a function that represents a person's preferences*' (Broome, [1991] 1996). It is possible to represent preferences over bundles of goods by a continuous real-valued utility function, given that they obey certain axioms that McFadden (2001b) referred to as 'mild regularity conditions'. These are (Deaton & Muellbauer, 1980; Fishburn, 1988; Varian, 1996):

1. Reflexivity. A bundle of goods is as good as itself. This can be written *x* · *x*, where x is a bundle of goods and the symbol · indicates 'is preferred or equal to'.
2. Completeness. For any two bundles of goods, a preference relation can be determined. That is, it is possible to compare two bundles of goods and determine whether one is preferred to the other or whether the consumer is indifferent between them. Thus, for any

x, y in the choice set C, either $x \succ y$, $y \succ x$, or $x \sim y$, where $\succ$ indicates 'is preferred to' and $\sim$ indicates the indifference relation.

3. Transitivity. If a consumer does not prefer one bundle of goods to a second bundle and does not prefer the second bundle to a third bundle, then the consumer does not prefer the first bundle to the third. This axiom may be expressed: if $x \cdot \; y$ and $y \cdot \; z$, then $x \cdot \; z$, where x, y, z are in the choice set C.

These three axioms are generally treated as the main axioms for preferences (Arrow, 1963; Deaton & Muellbauer, 1980; Varian, 1996). They result in a weak ordering of bundles of goods and lead to consumer consistency or rationality (Arrow, 1963). Rationality, however, does not preclude discontinuous preferences (Arrow, 1963; Deaton & Muellbauer, 1980); thus, a further axiom is generally added:

4. Continuity. If preferences are continuous, then it is possible to identify multiple bundles of goods that are of equal value to the consumer. Such bundles define the indifference relation and are designated by an indifference curve. As such, they indicate the trade-offs that a consumer is willing to make, or the amount of one good the consumer is willing to accept as compensation for giving up some of another good (Blatt, 1979-80; Fishburn, 1988; McIntosh & Ryan, 2002). This may be represented mathematically following Deaton & Muellbauer (1980) by defining two sets of bundles of goods. One set, $A(x)$, contains all those bundles to which x is not preferred. The other set, $B(x)$, contains all those bundles not preferred to x. For preferences to be continuous, these sets must be closed, that is, they must contain their own boundaries.

By including this axiom, it is now possible to represent preferences with a unidimensional utility function (Deaton & Muellbauer, 1980; Fishburn, 1974; Varian, 1996). That is, it is possible to define a function $U(\cdot)$ such that $U(x) > U(y)$ iff $x \succ y$. This function is not unique, but may be any function that preserves the preference order of x and y.

The above axioms are the main ones generally presented as allowing a utility function to represent preferences. Three related or additional properties of preferences may also be included in discussions of preferences, utility, and indifferences curves, although they may not be core to neoclassical theory. One such property is non-satiation, that more of any good is preferred to less (Deaton & Muellbauer, 1980; Gowdy & Mayumi, 2001). Convexity is also often assumed (Deaton & Muellbauer, 1980), and may be linked to the concept of a diminishing marginal rate of substitution (Quirk, 1982).

The third additional property regarding preferences that may be included relates to additive separability. It may be mathematically useful to restrict preferences so that total utility is the weighted sum of the utilities of goods in a bundle (McIntosh & Ryan, 2002). Such an additive utility function may be obtained by making the assumption of strong separability of preferences (Deaton & Muellbauer, 1980), so that it may be possible to consider preferences over certain pairs of goods or pairs of classes of goods independently of the consumption of other goods (Deaton & Muellbauer, 1980; McIntosh & Ryan, 2002). By assuming that preferences are separable and therefore that utility is a weighted sum of subutilities, it is possible to specify the marginal rate of substitution between two components of consumptions (which could be either goods or whole categories of goods) as a function of the change in quantities of only those two goods in isolation (Deaton & Muellbauer, 1980; Varian, 1996). Separability is frequently used in economic research (Deaton & Muellbauer, 1980).

With preferences described with these assumptions and with utility thus defined, it is possible to use utility functions to represent consumers' preferences (Broome, [1991] 1996; Deaton & Muellbauer, 1980) when they make choices from sets of alternatives. Neoclassical economics is based on the premise that consumers choose a good from a choice set in order to maximise their utility (Boland, 1981; McFadden, 2001b). That decision can be denoted as choosing a_i

from (a_1,…, a_j) in a choice set, C, where i indicates the chosen alternative, $j > 1$, and (a_1,…, a_j) $\in C$. A person chooses a_i because it offers the greatest utility. This can be stated as:

$$a_i \succ a_j \text{ for all } j \neq i,$$

is the result of the perceiving that

$$U(a_i) > U(a_j).$$

That is, when faced with choosing from several goods, consumers choose the good that maximises their utility.

Utility theory was further developed by Thurstone in 1927, when he theorised that utility had a random element: the true level of utility is perceived inexactly with some level of random error (McFadden, 2001b). The deciding factor in a choice situation is which alternative is perceived to have the greatest utility at the time the choice is made (McFadden, 1986). Marschak used this idea, the *Law of Comparative Judgement*, to create Random Utility Maximisation (RUM) theory (McFadden, 2001b). Separating out the random or latent portion of utility yields:

$$V(a_i) + \varepsilon_i > V(a_j) + \varepsilon_j,$$

where $V(\cdot)$ denotes the deterministic, observable portion of utility and ε denotes the random or latent portion.

Two aspects of this theoretical development may be noted. First, two different descriptions of the random or latent portion of utility appear in the literature. The first description is that consumers perceive utility imperfectly, with some degree of error. That is, the latent portion describes a consumer's own imprecision or errors with regard to perceived utility. This seems to be the original meaning of Thurstone's *Law of Comparative Judgement*, in which a stimulus is perceived with some level of error (McFadden, 2001b). The other description is that the latent portion describes an observer's error. This means that no matter how much data is gathered, there is still a part of the decision that eludes the observer but is known to the consumer (von Haefen, Massey, & Adamowicz, 2004). This description of the latent term raises the tantalising possibility that the observer might learn what the consumer already knows. Both descriptions of the latent term appear in the literature, suggesting that the latent portion of utility may be multi-dimensional[1]. The two sources of random error, the perceptual error on the consumer's part and the observer's error, both affect the possibility of fully describing the utility that consumers derive from goods. In order to collapse both types of error into a single random term, the two types must be somehow comparable. If they are not comparable, then it may be beneficial to consider the two types of random error separately.

The second interesting aspect of this theoretical development is that it seems to make utility measurable. The original observation was simply that one thing was preferred to another:

$$a_i \succ a_j .$$

The theory arrives at measurable quantities, measurable at least to within a degree of error:

$$V\left(a_i\right)+\varepsilon_i > V\left(a_j\right)+\varepsilon_j .$$

This development is aptly symbolised by the change from $\succ$ to $>$. Both the deterministic portion and the latent portion of the utility of each good are directly comparable with those of all other goods. The deterministic portion is directly comparable because it is observed and measured. The latent portion becomes comparable by defining it as a uni-dimensional distribution, so that it becomes defined probabilistically.

[1] Louviere (2001) makes a similar point about the multidimensionality of the latent term, indicating that error arises within an individual's choices, between two individuals, and between two separate tasks.

The RUM model described above is a mathematical expression of the neoclassical consumer theory. The RUM describes a decision process in which consumers are able to evaluate all goods and determine the places of those goods in a weak order of all goods. In the model, deterministic and random portions of utility are evaluated on a unidimensional scale that allows goods to be directly compared and their relative utilities assessed. However, the consumer and public opinion research reviewed in the previous chapter raises some concern with this assumption that a unidimensional ordering of all food, GM and non-GM, lies behind consumers' decisions. This axiom of neoclassical consumer theory thus requires further investigation.

3.2.2 Importance of continuity / unidimensionality

The continuity axiom is central to neoclassical market theory. This axiom guarantees that consumers will be willing to make exchanges amongst the goods on offer (Blatt, 1979-80; Fishburn, 1988; McIntosh & Ryan, 2002). The potential for such behaviour establishes the indifference relation, which forms the basis of neoclassical consumer theory (Earl, 1983). Given a specific level of utility, consumers can trade some of one good for more of another and maintain that same level of utility. They will be indifferent between the first bundle of goods and the second.

In order for continuity to hold, the goods on offer must be comparable in some dimension: they must be commensurate. The two goods must be measurable in a one-dimensional way such that more of one can be measured against less of the other. This is the essence of a uni-dimensional utility function and the continuity axiom. Without this axiom, utility can be regarded as multidimensional and represented as a vector. Whether commensurability accurately depicts consumer preferences is disputed. For example, Fishburn (1988) suggested that continuity 'does embody a degree of common sense'. Arrow (1963), on the other hand, asserted that a uni-dimensional ordering was unnecessary.

Multidimensional utility vectors can be ordered lexicographically (Fishburn, 1974, 1988; Nakamura, 2000). A lexicographic ordering proceeds like looking up a word in a dictionary. All options are examined one attribute at a time. First, the value or performance of all the options is assessed with respect to the most important attribute. The option that has the best value for the most important attribute is chosen. Should two or more options be equally good with respect to that attribute, they are then assessed on the second most important attribute. This process continues until only one option remains. As a result, high levels of less important attributes do not compensate for low levels of the most important attributes. To continue with the dictionary analogy, 'azure' will always come before 'Zanzibar' in the dictionary; having an 'a' in the second position is no substitute for an 'a' in the first position. Lexicographic preferences and orderings have been widely considered, both in consumer and mathematical theory (Coombs, 1964; Earl, 1983; Fishburn, 1971, 1974, 1988, 1996; Gowdy & Mayumi, 2001).

Lexicographic preferences, a specific type of discontinuous or non-compensatory preferences, are not fatal for utility theory in general. Arrow's work (1963), for example, did not need to assume continuity to assume rationality. Lexicographic orderings can still imply well-ordered utility functions: it is possible to have consistent preferences without circularity even with lexicographic ordering of alternatives. Lexicographic preferences can even be represented as a maximisation function (Plott, 1987).

However, whilst lexicographic preferences do allow for well-ordered preference amongst goods, and whilst they are also consistent with maximisation behaviour, they are not consistent with the assumption of continuous preferences. They may therefore conflict with the assumption that more of one good will compensate for less of another, so that lexicographic preferences are inconsistent with indifference curves. As the indifference relation is central to neoclassical market theory, lexicographic preferences may raise a theoretical issue for neoclassical theory. Furthermore, the use of a RUM model to describe consumer choice requires unidimensionality, which is also called into question by lexicographic preferences.

The possibility that some consumers have lexicographic preferences with regard to GMF has been raised in prior research. If these preferences are shown to exist, then they may raise an interesting issue for neoclassical theory, or at least for RUM models. The exact nature of this issue requires that a further development in neoclassical consumer theory be explored.

3.2.3 Lancastrian consumer theory

Neoclassical consumer theory was expanded with the insights of Lancaster (1966). He developed a model in which consumers produced their utility by using the attributes inherent in goods and their own consumption capabilities. His 1966 article contained two fundamental insights. The first is that the utility from consuming goods was produced by a 'consumption technology', rather than being something intrinsic in the goods themselves. Consumers actively transformed that which they purchased into that which they consumed. The second insight was that goods could be considered bundles of attributes. The attributes of goods entered into the consumption process, and the task of the consumer was to maximise utility from these attributes. Thus, the specific goods purchased could be varied in order to have the best bundle of attributes. This insight is core to the issue of GMF, because whether food is GM or not can be viewed as a discrete attribute, separate from taste, nutrition and price.

With the Lancastrian depiction of goods as bundles of attributes, the neoclassical theory of consumer choices over the set of goods could be extended to include the set of attributes of goods. Consumers are theorised to examine the attributes of the goods on offer and their own preference to determine the bundle of attributes that gives them the greatest utility. The same axioms regarding preferences over goods are generally assumed to hold over those goods' attributes.

Using Lancastrian theory, it is possible to decompose the alternatives into their attributes. Choice of a_i implies that:

$$U(x_{1i},\ldots, x_{ki}) > U(x_{1j},\ldots, x_{kj}),$$

where x_{jk} is the value that attribute k takes for alternative a_j. Using RUM theory, this statement can be transformed into the following:

$$V\left(x_{1i},\ldots,\ x_{ki}\right)+\varepsilon_i > V\left(x_{1j},\ldots,\ x_{kj}\right)+\varepsilon_j\,.$$

This inequality demonstrates the importance of uni-dimensionality in a neoclassical assessment of demand for GMF. All attributes are commensurate, so that consumers are willing to give up some of one attribute in exchange for more of another. By neoclassical theory, consumers measure GM-ness on the same scale as they measure taste and colour and price and healthiness and convenience and everything else. Some consumers may view GM-ness negatively, but some amount of the positive attributes will be sufficient to offset the negative opinion regarding GM. Fundamentally, unidimensionality implies that all consumers will buy GMF at some price. In fact, unidimensionality implies that they cannot behave otherwise (Marcuse, 1974 (1964)).

A consequence of unidimensionality is that it is possible to place a dollar value on the presence of GM in food. The value of GM can be obtained from the following equation (setting aside the latent term):

$$V(Food) = V(Food,\ Discount_{GM},\ GM),$$

where $Discount_{GM}$ takes a positive value and GM takes a negative value. This equation follows from the neoclassical model, and indicates that the value of GM can be found by finding the value of the price discount that would make a GM food item equal in value to a non-GM food item. Specifically:

$$-V(Discount_{GM}) = V(GM).$$

The key issue is that some individuals appear to indicate that no value of $Discount_{GM}$ is sufficiently large to compensate for the fact that food is GM. That is,

$$V(Food) > V(Food, Discount_{GM}, GM),$$

regardless of the price discounts. Thus, these individuals are never indifferent and no price can be determined.

It could be argued that neoclassical theory about market behaviour still holds at the aggregate level, regardless of individual behaviour. Because some people in the market exhibit compensatory behaviour, they are willing to accept compensation in the form of lower prices in order to consume GMF. As the price for GMF decreases and the compensation increases accordingly, more of these consumers enter the market. Thus, the market as a whole arrives at a price for GMF based on the willingness of some consumers to be compensated for consuming GMF. There are two potential issues with this application of neoclassical theory. First, although it describes the behaviour of the market given certain levels of supply, the market price may be undefined once supply passes a specific threshold. This could be an important concern if the research question concerns the impact of introducing GM technology into the pre-existing market for a food product. Once all the consumers who are willing to make trade-offs are supplied with GMF, it may be difficult to predict the price in the market because the remaining consumers are unwilling to purchase the product. Alternatively, if information about the GM content of the food is unavailable, then the market may not be able to segment into a GM component and a non-GM component. The welfare impacts of a lack of segmentation may be difficult to analyse given a group of consumers with non-compensatory preferences. The second issue with arguing that neoclassical theory may hold in the aggregate despite non-compensatory preferences is that underpinning the neoclassical model of the market is a notion of individual consumer behaviour. The basis of the market is that consumers make choices by weighing up the options offered and choosing the best ones, specifically trading goods or attributes against one another. If only some consumers are engaged in such compensatory behaviour, the result is the odd situation that some consumers in the market are behaving ‘economically’ while others are not (Earl, 1986).

Another issue that arises with Lancastrian theory is the functional form for $V(\cdot)$. In economic research, $V(\cdot)$ is often treated as a additive function in which product attributes enter linearly according to weights determined by consumers’ preferences (Deaton & Muellbauer, 1980). This functional form arises from the convenient assumption of separability of preferences (Deaton & Muellbauer, 1980; McIntosh & Ryan, 2002). That is, when separability of preferences is extended to attributes as well as goods or commodity categories, the result is that the marginal rate of substitution between two attributes is independent of the other attributes in the choice set.

Whether it is possible to make such an assumption may be tested empirically (McIntosh & Ryan, 2002). Consumers’ expressed attitudes towards GMF may be inconsistent with this additive functional form for utility. When consumers make their choices with respect to GMF, the fact that a product is GM could affect their utility calculations in two ways. The process of GM could be a discrete product attribute, evaluated separately from other attributes. For some consumers, GM may make no difference to a food’s utility. For others, it may decrease a food’s utility, even to the point that they never want to consume GMF. Either way, the value of GM does not vary according to the product offered. This is a process-based judgement, and is consistent with the assumption of separability.

The other possibility is that GM could affect utility in more complex ways. For example, GM has been found more acceptable when it is used to reduce pesticides than when it is used to reduce prices (Pew Initiative, 2003). It is commonly asserted that second-generation GMF, that will have consumer-oriented as opposed to production-oriented benefits, will be more positively viewed by consumers (Rousu *et al.*, 2003). This assertion suggests that the specific benefit produced through GM affects the perception of the technology, that the net value of GM is not discrete but the result of an interaction between the offered benefit and the GM technology. Such an interaction would mean that the evaluation of two potential benefits of GMF is not independent of the technology used to produce the benefit. To understand the importance of an interaction, consider that falling asleep in bed is generally pleasant, that falling asleep in a meeting may be professionally damaging, and that falling asleep behind the wheel may be physically dangerous. If consumers' evaluations are affected by such an interaction, then their assessments of GMF are product-based.

Lancastrian attribute-based consumer theory is an extension of neoclassical theory that provides a tool for segregating reactions to GM technology from reaction to all other food attributes. Conveniently, it allows lexicographic preferences over GMF to be isolated to a single potential discontinuity: a lexicographic preference over the GM attribute. Isolating the issue does not remove it, however. Although the discontinuity may be considered localised, it still represents a theoretical difficulty with applying neoclassical consumer theory to choices over GMF. Application of Lancastrian theory has also raised the issue of separability of preferences over food attributes. If the GM attribute is interacting with other food attributes in consumers' evaluations of food products, then it may not be possible to assume that preferences are separable.

3.2.4 Information integration theories

In addition to RUM theory and Lancaster's insights regarding product attributes, psychological theories of information integration are the third basis for consumer choice research based on neoclassical theory (Adamowicz, Louviere *et al.*, 1998). By integrating the available information on attributes and alternatives, consumers are able to transform a 'partially ordered' world (Coombs, 1964) into choices. According to information integration theory, respondents are able to assess the different levels of the different attributes in all the alternatives, and integrate them into a single decision.

An important consideration in research on decisions and choice behaviour is the risk or uncertainty surrounding the choice set or the choice situation. Decision-makers or consumer can have only expectations of the utility they will derive from elements of the choice set, so that their task is to maximise expected utility, $E(U)$. How assessments of risk and uncertainty are incorporated into the calculation of expected utility has led to a number of models of decision making(Schoemaker, 1982; Starmer, 2000) and research on the mental processes that lead to these assessments (Kahneman, Slovic, & Tversky, 1990; Slovic, 2000).

Decision making under risk and uncertainty has implications for demand for GMF (Fischhoff, Nadai, & Fischhoff, 2001; Gaskell *et al.*, 2004; Nelson, 2001). Some of the research discussed in Chapter 2 found that perceptions of the risk of GMF were significantly correlated with consumers' reactions to GMF and could be used to describe market segments. Although this thesis will not explore the formation of risk attitudes or their integration in decision making explicitly, nonetheless risk attitudes will be incorporated as indicators of consumer reactions to GMF.

The idea that consumers are able to integrate information fully in order to reach globally optimal decisions may be important for assessing potential alternative explanations of consumer behaviour. This assumption may also be affected by the ways that consumers process information regarding GM technology as they form their assessments of GMF.

3.2.5 Three formulations of utility

A final issue with regard to utility is the debate over three different formulations of utility. The first formulation is that of Bentham and Jevons: utility was a measurable, or *cardinal*, quantity (Albanese, 1988; Broome, [1991] 1996). Pleasure and pain could be measured on a scale, much as length is measured on a ruler. The assumption of cardinality has been a key point of criticism of utilitarianism (Broome, [1991] 1996; Ellsberg, [1954] 1996; Robinson, 1962). The second formulation, championed by Hicks & Allen, was that consumer theory depended only on utility being ordinal (Albanese, 1988; Broome, [1991] 1996). It was only necessary that utility describe which alternatives are preferred; it did not need to measure how much pleasure they afforded. This is the commonly taught version of utility in economics today, as a textbook indicates: ‘Economists today are uncomfortable with the notion of a cardinal, measurable utility …’ (Samuelson & Nordhaus, 1995). The third formulation was developed by von Neumann and Morgenstern, who used utility theory to describe choices over risky gambles (Schoemaker, 1982; Strotz, 1953). They showed that if preferences obeyed certain axioms, then they could be represented by some utility function (Camerer, 1995).Their formulation was cardinal in the way it laid out the equivalence of choices, but its intent was ordinal: it was meant to designate which gambles were better (Schoemaker, 1982). Their work has led to the field of game theory in economics (Camerer, 1995).

All three notions of utility can designate which alternative is preferred: it is the one with the most utility. Thus,

$$U(a_i) > U(a_j)$$

in all three formulations. Cardinal utility allows two additional conclusions that the others do not. First, it is possible to describe distances or differences between alternatives (Schoemaker, 1982). That is, it is possible to make a judgement about the intervals separating the utility derived from alternatives, for example,

$$U(a_1) - U(a_2) > U(a_3) - U(a_4).$$

The second use of cardinal utility is interpersonal comparisons of utility (Arrow, 1963; Broome, [1991] 1996). Unless utility is cardinally measurable, it is not possible to compare the utility of one person with the utility of another (Arrow, 1963). This is one of the foundations of Arrow's General Possibility Theorem (1963), which proves that there is no way to aggregate individual preferences into social choice without the social ordering being 'either imposed or dictatorial' (p. 59).

Whether utility is considered cardinal or ordinal, the potentially lexicographic preferences of consumers with regard to GMF create issues for aggregating individual preferences into market-level indifference curves. If it is accepted that utility is cardinal, then lack of data may prevent the aggregation of individual values into social choices. That is, if some consumers never indicate the level of compensation that would be sufficient for them to consume GMF, then it is not possible to determine the value of GMF to them or the welfare impact from a switch from non-GMF to GMF. If, on the other hand, utility is assumed to be ordinal, then the issue reduces to the one detailed in Arrow (1963). With ordinal utility, it is impossible to make inter-individual comparisons of utility (Louviere, 2001), so that it may not be possible to compare the welfare loss for one individual to the welfare gain for another. In that case, 'the only methods of passing from individual tastes to social preferences which will be satisfactory and which will be defined for a wide range of sets of individual ordering are either imposed or dictatorial' (Arrow, 1963). Specifically, either those who refuse GMF have it imposed on them, or they impose their lexicographic preferences on others. It thus seems that potentially lexicographic preferences regarding GMF may raise aggregate welfare issues, regardless of whether utility is considered cardinal or ordinal.

3.2.6 Summary of neoclassical consumer theory

Consumer demand in neoclassical theory is explained by people making choices. The theory has several principal components that describe the choice situation and decision-making. These are (McFadden, 1974, 1986; Simon, 1955, 1983):

1. An exhaustive set of alternatives, each described by its attributes;
2. A stable utility function that describes preferences over these attributes and thus provides a uni-dimensional valuation of all alternatives;
3. Probabilities regarding future states of affairs and how they are affected by the choices made; and
4. A model of choice behaviour or a decision protocol, which is maximisation of the utility function.

By examining all the attributes of all the alternatives, a consumer is able to assess the alternatives against his own preferences regarding the attributes, thereby assigning a value to each alternative so that the best one can be chosen.

In neoclassical theory, these preferences are consistent with several axioms. The main axioms are reflexivity, completeness, transitivity, and continuity. Further assumptions regarding preferences that may be made are non-satiation, convexity, and separability. If preferences are consistent with these assumptions, then they may be represented by a unidimensional, additive utility function. These assumptions may apply to preferences over goods but also, after Lancaster, over attributes. The above discussion has raised concerns with two of these preference axioms with regard to GMF. First, prior research on consumer reactions to GMF suggests that continuity may not hold for preferences over GMF, or specifically for preferences with regard to the GM attribute of food. Instead, some consumers may have lexicographic preferences, so that the reaction to the GM attribute cannot be measured against the reaction to any other attribute. Such preferences may be an issue for the assumptions of neoclassical economic theory, because price theory is based on indifference. Price is determined by the point at which a consumer is indifferent between more of one commodity and less of another. With lexicographic preferences, there is no point of indifference between GMF and non-GMF, because non-GMF is always superior.

The other potential issue that arises regarding preferences for GMF is whether preferences over food attributes are separable. There is the potential for reactions to GM technology to interact with other specific food attributes. These interactions might not allow utility to be additive and therefore might need to be explicitly considered.

If choices over GMF are inconsistent with these assumptions, then it may be fruitful to conduct further investigation of neoclassical consumer theory and its application to the market for GMF. The possibility that these assumptions, particularly the continuity axiom, might not hold has been recognised in the literature. The next section thus reviews literature that critically examines neoclassical theory.

3.2.7 Criticisms of neoclassical theory

The neoclassical theory of consumer choice is not without critics (Earl, 1983; Gigerenzer & Goldstein, 1996; Gowdy & Mayumi, 2001; Simon, 1983, 1987; van den Bergh, Ferrer-i-Carbonell, & Munda, 2000). The criticisms are generally directed at three aspects: the information requirements, the cognitive requirements, and the vacuum in which the theory operates.

The first criticism is that information requirements in neoclassical consumer theory are extensive. Decision makers must know the current state of the choice situation, how it might change, all the possible decision alternatives, how the alternatives will affect the choice situation and with what probabilities, and how the decision maker feels or will feel about all of the above (Earl, 1983, 1986; Earl & Potts, 2004; Rabin, 2002; Simon, 1987). Not only is this a lot of information, some of which cannot possibly be available to the agent, but it also assumes away interesting economic phenomena, such as the organisation of firms (Simon, 1983).

The second criticism concerns the cognitive ability needed to process all that information. Neoclassical theory assumes that the consumer maximises utility. To do so, all the attributes of all the goods on the market are assessed and a global optimum is computed. Neoclassical theory does recognise the impact of the budgetary constraint, and may recognise the impact of time constraints (Bianchi, 2003; Earl & Potts, 2004), but other constraints are inherent in the organism making the decision (Simon, 1955). That is, the cognitive limitations of the agent restrict the amount of information that can be processed, and so constrain the actual process of decision making (Conlisk, 1996; Diesing, 1991; Gigerenzer & Selten, 2001b; Simon, 1979).

In fact, researchers have found that people are unable to integrate information fully as Bayesian theory demands (Schoemaker, 1982). According to psychologists, people do not make decisions as though they are fully integrating available information and then finding the global maximum (Plott, 1987; Slovic, 2000). As a result, there seems to be a value to consumers from simplifying the decision process (Recker & Golob, 1979). One consumer strategy that has been theorised for dealing with complexity is the use of screening rules

(Bettman, Luce, & Payne, 1998; Coombs, 1964; Earl, 1986). Consumers may use simplified and non-compensatory rules to reduce the choice set to a few alternatives, and then use an integrative, compensatory process to decide amongst those few. Empirical tests of the impact of choice complexity on choice behaviour do not support the neoclassical assumption of perfect cognition (Mazzotta & Opaluch, 1995).

In fact, consumer research based on Random Utility Maximisation theory has recognised that the consumer is largely a 'black box', whose functioning or processes are unobservable (McFadden, 1986). This black box converts inputs – attributes, characteristics, information, experience, and constraints – into outputs. The outputs are the observed purchases, or in the case of survey research, the choices observed by the researcher. How the decision is made is unobserved, but it is assumed based on neoclassical theory that the choice represents a global optimum. This raises the classic assertion by Friedman, that behaviour can be assumed to proceed 'as-if' utility maximisation is happening; any other behaviour is suboptimal and irrational (Conlisk, 1996; Simon, 1983).

A number of theorists have rebutted Friedman's assertion. For example, Simon (1983) counters that Friedman's idea is satisfactory only if there is a unique equilibrium. Conlisk (1996) notes that making this assertion raises an empirical question: what do consumers actually do? Only once their behaviour has been determined can its optimality be assessed. This echoes Earl's (1986) focus on understanding consumer behaviours so as to make good predictions. Thus, it may be important to understand how consumers make their decisions, rather than assuming one given decision rule for every situation.

The third criticism of neoclassical consumer theory is the vacuum in which it seems to operate. Its focus on individual decision-making does not take into account the social context in which individuals exist (Fullbrook, 2004). Neoclassical theory says nothing about how agents learn about the world and where their judgements originate (Bettman *et al.*, 1998; Simon, 1983). There is therefore no place for learning or for preference formation (Earl, 1986; Earl & Potts, 2004).

These criticisms of neoclassical theory suggest that consumers may not be evaluating all the attributes of food products and integrating them into stable measurements of their utility value. If so, it might be incorrect to view GM technology as just another food attribute that consumers exchange for greater or lesser compensation. The food attribute 'GM' would then not possess a discrete value to consumers, which would raise the question of the appropriate discount to compensate individuals for consuming GMF. These criticisms of neoclassical theory have led to development of alternative theories for explaining consumer behaviour, which include behavioural economics.

3.3 Behavioural economics

An alternative to neoclassical economics in explaining consumer behaviour is behavioural economics, which is 'concerned with the empirical validity of these neoclassical assumptions about human behaviour and, where they prove invalid, with discovering the empirical laws that describe behaviour correctly and as accurately as possible' (Simon, 1987). This definition raises two questions: do neoclassical assumptions about consumer behaviour seem invalid with regard to GMF, and are there empirical laws that describe behaviour correctly? The above discussion suggests that the axioms underlying neoclassical consumer theory may raise certain issues when they are applied to GMF. Specifically, the results of consumer research do not appear consistent with the assumptions of continuity of preferences and separability of preferences. If these assumptions do not hold, there may be consequences for representing the collection of individual preferences with aggregate measures such as community indifference curves or demand curves. Furthermore, the neoclassical theory was shown to be based on the assumption that consumers reached their consumption decisions through a process of global maximisation. These aspects of neoclassical theory – continuity, separability, aggregation, and maximisation – could be empirically tested for validity. If they are found to be invalid, then alternative explanations of economic behaviour could be sought elsewhere.

A behavioural theory of choice may be appropriate for characterising consumer decision making regarding GMF. Several alternative models of decision making from behavioural economics are loosely grouped under the rubric 'bounded rationality'. Thus, this section explores behavioural economics and bounded rationality in order to investigate whether they might be useful in describing consumer behaviour with regard to GMF. A description of behavioural economics is suggested in the dictum of Frank Hahn: 'to discuss and analyse how the economy works it may be necessary to go and look' (quoted in Blatt, 1979-80). When one 'goes and looks' at the market for food, one finds that most markets are stable and consumers tend to purchase what they purchased in the past (Bareham, 1995). This description of consumer behaviour fits a cyberneutic model of consumer choice (Earl, 1983, 1986), in which consumers use rules of thumb to make satisfactory decisions, evaluate the outcomes, and then update their choices based on the limited available information. This model does away with demand functions, marginal rates of substitution, and uni-dimensional utility calculations (Earl, 1983). Such a model of consumer decision making specifically rejects the idea that consumer take decisions by finding global optimums.

Central to this model of consumer choice are these rules of thumb, called *heuristic strategies*, or simply *heuristics*. Cognitive psychology and artificial intelligence research has found that people use heuristics or decision rules rather than a process of formal logical deduction in order to make decisions (Camerer, 1995; Conlisk, 1996; Diesing, 1991). Purchasing out of habit (Bianchi, 2003) is an example of a heuristic strategy, and describes the actual market for food (Bareham, 1995). Examples of other heuristic strategies are the use of relative comparisons and piece-meal decisions, as well as lexicographic strategies (Hanley, Mourato, & Wright, 2001; Schoemaker, 1982).

According to behavioural economics, consumers use these heuristic strategies because their rationality is bounded rather than global. The theory of bounded rationality starts from the proposition that human cognition is too limited to evaluate all the available alternatives, integrate all the potentially relevant information, and determine a single globally optimal solution for each decision that people face (Conlisk, 1996; Rabin, 2002; Simon, 1979). From there, the research tends towards one of three interpretations of bounded rationality (Todd & Gigerenzer, 2003):

1. Optimisation occurs under the constraints of available resources, of which cognitive ability is one (Todd & Gigerenzer, 2003). This is in effect still a theory of holistic optimisation, but with an additional constraints often neglected in neoclassical theory (Rabin, 2002).
2. Bounded rationality describes the cognitive failings and illusions that plague decision-making (Kahneman *et al.*, 1990; Todd & Gigerenzer, 2003). This interpretation assumes that there exists some normative optimum for the choice situation, one that is however not being perceived.
3. Bounded rationality expressly rejects any notion of optimality, and instead focuses on the possibility of taking advantage of the structure of choice environments to reach decisions that work (Simon, 1956; Todd & Gigerenzer, 2003).

Optimisation under cognitive constraints is closest to the neoclassical paradigm, and has been suggested as an extension of it (Conlisk, 1996; Rabin, 2002). This version of bounded rationality suggests that people use heuristics because of cost of deliberation (Conlisk, 1996;

Hey, 1981), and the loss from limited rationality is less than the saved costs of deliberation. In this view, constrained optimisation is merely the next stage in the evolution of *Homo œconomicus* (Doucouliagos, 1994). Study of bounded rationality would therefore try to measure the suboptimality that results from using heuristic strategies (Conlisk, 1996). Rubinstein (1998) extensively studied ways to model bounded rationality using set theory and symbolic logic, specifically in order to compare results of boundedly rational and optimal models.

The second interpretation of bounded rationality, research on cognitive failings, essentially accepts the idea of optimality under constraints and then works to identify the specific mental heuristics used and their contributions to suboptimal decision making. There is a large literature on heuristics and biases that arise when decisions are made under conditions of risk and uncertainty (Camerer, 1995; Conlisk, 1996; Kahneman *et al.*, 1990; Rabin, 2002; Slovic, 2000). Common cognitive errors are availability bias, overconfidence, the law of small numbers, representativeness, and anchoring (Camerer, 1995; Kahneman *et al.*, 1990). This literature largely focuses on situations in which objective measures of probabilities can be calculated, as in experimental settings. The judgements that participants make are then compared to these objective measures to determine the impact of cognitive errors, such as disregard of base rates and improper updating. Key to this interpretation of bounded rationality is that it defines an optimal result, defined as proper Bayesian updating of probabilities, properly considering sample sizes and confidence intervals.

The third conception of bounded rationality is rather different. It rejects explicit optimisation (Augier, 2001; Gigerenzer & Selten, 2001a) and asserts that identifying and reaching an optimum is impossible. Global rationality and holistic or integrative decision making are impossible (Earl, 1986; Gigerenzer & Selten, 2001b; Simon, 1955, 1983). Furthermore, it suggests that global rationality has not been shown to be consistent with economic data (Augier & March, 2003). An issue that has been raised regarding the concept of utility is its circularity, which makes it impervious to evaluation (Boland, 1981; Robinson, 1962).This idea of bounded rationality starts with the proposition that decision-makers are attempting to survive in their environments. Survival does not depend on maximising some global utility function; rather, simple perceptual and choice mechanisms are sufficient (Simon, 1956).

This version of bounded rationality has two components: the limitations of the human mind and the structure of the environment (Gigerenzer & Selten, 2001b; Gigerenzer, Todd, & the ABC Research Group, 1999). Decision makers can exploit regularities and structure in their choice environments to make better decisions, given that they have limited cognitive capacity (Gigerenzer & Selten, 2001b; Simon, 1956). Research in this vein has thus examined both possible heuristics and the choice situations in which they would be appropriate. A number of specific heuristic strategies have been identified, including satisficing (Simon, 1955, 1956), Elimination by Aspects (Tversky, 1972a, 1972b), and fast and frugal heuristics (Gigerenzer & Selten, 2001b; Gigerenzer *et al.*, 1999).

An important question is whether heuristic strategies can lead to good choices. Heuristic tools can be effective, because they exploit the fact that choice situations often exhibit regularity or predictability (Gigerenzer & Selten, 2001a). Studies indicate that decision heuristics, such as reservation prices and cutoff rules, can both explain decisions and approach optimum solutions (Camerer, 1995). The question can be more complex when dealing with consumer behaviour: it is difficult to assess the goodness of consumers' choices (Bettman *et al.*, 1998) because there is no external yardstick for making that assessment. Bettman, *et al.* (1998) suggest that one possible measure is whether choices are *adaptive*: 'Although being adaptive is hard to define, we generally mean making intelligent, if not necessarily optimal, choices'(p.

26). This definition does not provide a way to measure whether decisions are adaptive, however. Thus, whether heuristics are successful seems to be an area for potential research regarding bounded rationality.

Another question that is important from an economic standpoint is the impact of these heuristics at the market level. For its part, neoclassical theory offers a global view of the operation of the market. Behavioural economics also provides views on how the market functions, but they are different to the neoclassical one. Earl (1983) proposed that a market solution can be determined if prices are set by cost-plus methods and consumers make their choices based on heuristics. He further maintained that coordination problems are too large in a market economy for the neoclassical model to be correct, echoing the work of Galbraith (1967).

3.3.1 Bounded rationality and genetically modified food

In the prior section on neoclassical theory, it appeared that its assumptions regarding consumer behaviour might be violated by consumers' reactions to GMF. Thus, it may be possible to gain further insight into these reactions through the literature on bounded rationality. For example, several decision heuristics that fit under the rubric of bounded rationality are intentionally discontinuous. The theory expects consumers to use screening rules to exclude choice alternatives or to base their decisions on a single criterion. Examining consumer decisions with regard to GMF in the light of such behavioural interpretation may provide a theoretical basis for seemingly lexicographic preferences. In addition, focusing on the way in which consumer decisions are made – the specific decision heuristics – may allow for aggregation into market-level demand even in cases where many consumers do not display behaviour consistent with neoclassical indifference curves. That is, it may be possible to aggregate observations about their choices without establishing the exact value that they place on GMF.

The reactions of some consumers to GMF do conform to a boundedly rational model of decision-making. Gaskell, *et al.* (2004) found evidence of a lexicographic process that first evaluated the benefits of GMF and then, given sufficient benefits, evaluated the risks. Bredahl (1999) found that many consumers have non-compensatory objections to genetic modification, so that other attributes of GMF are not examined. These and other examples described earlier suggest that consumers may not be examining all the available information and integrating it into a single dimension that measures the relative values of GMF and non-GM. Instead, they may be deciding on GMF by using simple heuristics, as theorised by bounded rationality research.

One important question is whether it is necessary to consider lexicographic decision making explicitly, or whether the focus can be shifted to a compensatory framework. Rekola (2003) showed that it may be possible to represent some lexicographic preferences as compensatory. If a one-to-one mapping between preferences and attributes is maintained, so that each attribute satisfies the desire for that attribute, then non-compensatory preferences need to be considered explicitly (Rekola, 2003). However, Lancaster's (1966) insight was that each need on the part of consumers could be satisfied in different ways by different combinations of commodities providing different combinations of attributes. This creates a many-to-many mapping in which needs or desires for goods can be satisfied in different ways (Rekola, 2003). Rather than focussing on the specific discontinuity, the analysis can focus on the need that can be satisfied in a number of ways. Thus, choice over commodity space could still be considered compensatory even where choice over attribute space is not. Unfortunately, this many-to-many mapping does not apply in the case of GMF. If a consumer desires non-GMF, then the only attribute that can satisfy this preference is a non-GM attribute. With GMF, the explicit consideration of lexicographic preferences cannot be set aside by shifting focus away from the attribute space into goods space or some other space.

Another feature of bounded rationality is its emphasis on decision environments or contexts. Food choices are complex decisions often made quickly in supermarkets and hypermarkets, which are information-rich environments. Food labels contain quite a bit of information that can be used in assessing which products to purchase (Golan *et al.*, 2000; Nayga Jr., 2001-2002). This information is available for most of the products in a modern supermarket, which may contain more than 30,000 products (Boatwright & Nunes, 2001). For breakfast cereals alone, Australian supermarkets have more than 80 brand-size combinations (Louviere, 2001). Looking beyond the food labels, consumers can obtain information about corporate behaviour, production methods, and nutrition to aid their decisions. In addition, some products naturally have nearly infinite natural variation: products such as fresh produce and meats can be examined item-by-item to compare colour gradations, flaws, smells, etc. (Harker, Gunson, Brookfield, & White, 2002; Harker, Gunson, & Jaeger, 2003; West, Larue, Gendron, & Scott, 2002). Bounded rationality theory maintains that consumers use simple cognitive short-cuts to cope with this abundant information.

Choosing what to eat is central to survival. The difficulty and complexity of the decision is captured in the 'omnivore paradox' (Fischler, 1993). This paradox arises because omnivores require diversity in their diets in order to obtain all the necessary nutrients. However, every additional food source exposes the omnivore to additional potential poisons and pathogens. Every new food is a possible source of health or sickness. 'What should I eat?' is a critical question, one an omnivore needs to answer correctly.

An integrative model of answering the question would have the eater analysing the nutritional profile of the food as well as the expected probabilities of future states of health resulting from eating the food. Furthermore, the eater must have made earlier decisions regarding the probabilities of actions leading to obtaining the food, including a cost-benefit analysis weighing the expected expenditure of resources on obtaining the food against the expected value of the food once obtained.

A boundedly rational model suggests that the eater uses heuristic strategies to decide what to eat. Human culture, for example, has developed a solution to the omnivore paradox, as Fischler (1993) explains. Foods are prescribed and proscribed by culture, so that a food culture – a cuisine – limits the choice set for members of that cuisine. By following a cuisine, eaters can be reasonably assured of surviving, if only because followers of unsuitable cuisines would be less able to transmit them. A cuisine reduces the amount of decision-making effort while at the same time providing members with a high probability of survival. It is therefore rational from a survival perspective to have membership in a cuisine, and this rationality is a function of the limitations or bounds the cuisine places on the food choice set (Laland, 2001).

Furthermore, GMF is characterised by a profound lack of knowledge on the part of consumers, who know they do not know (Marris *et al.*, 2001). The long-term impact of GM on consumers or the environment is unknown, simply because GM products have not been in existence for a long term. Where integrative, compensatory models suggest that decision-makers need more knowledge in order to make informed decisions, boundedly rational models suggest that they can make effective decisions *because* of their ignorance (Gigerenzer *et al.*, 1999). The satisficing decision with regard to GMF might thus be: the current food supply is 'good enough', so no change is warranted. This allows consumers to stick to eating patterns that have worked in the past (Fischler, 1993), make sufficient and satisfactory choices in complex environments (Simon, 1955, 1956), and reduce anxiety by maintaining to predictable diets (Earl, 1983).

Bounded rationality may be an appropriate theory of decision making with regard to GMF, because it accounts for observed non-compensatory stated preferences and choices, it conforms to the sociology of food consumption, and it considers the environment in which food choices are made. If it is true that decision-making about GMF does follow a non-compensatory heuristic, then the choices that choice experiment respondents make might not be modelled well by linear models (E. J. Johnson, Meyer, & Ghose, 1989). An alternative to a compensatory, linear model might provide additional insight into the choices that respondents make.

3.3.2 Criticisms of bounded rationality

A number of arguments against the theory of bounded rationality have been advanced. Perhaps the most significant criticism is the infinite regress that the theory sets up. Bounded rationality suggests that decision-makers use environmentally appropriate decision rules in order to take advantage of environmental regularities and thereby minimise cognitive effort. This raises the question of how decision-makers decide on the proper rule to use in each choice situation. By contrast, neoclassical economics proposes a single decision rule that always operates: maximisation (Boland, 1981). Gigerenzer (2001) compares boundedly rational decision-making to a toolbox, but the way that the decision maker selects the appropriate tool is an open question (Sadrieh *et al.*, 2001). For example, it may be possible to select an effective heuristic strategy given some prior knowledge of the relative importance of the different attributes of the choice set. In reality, decision makers need to learn the attributes' relative importance as they make their decisions about the alternatives themselves (Newell & Shanks, 2003).

In his survey of bounded rationality, Conlisk (1996) raised the issue of infinite regress. If bounded rationality claims to describe the rules used to make decisions, then it should also describe the rules used to select the rules for making decisions. Of course, there should also be rules for rules for rules, and so on *ad infinitum*. This is the infinite regress issue. Conlisk suggested that economists should focus on two stages: the decision and the initial deliberation costs of thinking about the decision. He felt that further backward steps are not likely to be as important. By limiting decision research to these two steps, he divided decision models into four types:

1. Models that treat problem, *P*, optimally
2. Models that consider *P* using bounded rationality
3. Models that consider the decision process, *f*(*P*), optimally
4. Models that consider *f*(*P*) using bounded rationality

The first of these types of models is the standard RUM model. The second type describes research that examines the use of specific heuristics in choice situations. The third type considers decision costs as part of the optimisation process, but maintains the use of optimisation. As discussed above, this is one interpretation of bounded rationality that extends current models of *Homo œconomicus* as rational optimiser. Models of the fourth type include some consideration of the rules for deciding how to decide, such as the aforementioned research comparing different heuristic strategies.

It is important to note, however, that bounded rationality is not alone in facing an infinite regress issue. Optimising behaviour also entails an infinite regress of search for information and its incorporation into the decision (van den Bergh *et al.*, 2000). For example, Hey (1981; 1982) examined optimal search rules in the context of shopping around for the best price on consumer goods. He noted that a very large number of searches were required in order to determine the distribution of prices in the choice situation. Furthermore, Bayesian updating of price information required an assumption about the shape of the price distribution, an assumption that would itself have to be subject to updating. The findings of this research suggested that decision-makers would not be able to act optimally given a sufficiently complex problem (Hey, 1981).

3.3.3 Summary of bounded rationality

Bounded rationality offers a different explanation of consumer behaviour from the neoclassical model. Preferences are not held to be continuous; rather, consumers commonly use simple decision heuristics and piece-meal decision making and thus create discontinuities in their choice spaces. It is not assumed that consumers have an underlying utility that they are seeking to maximise; instead, the inherent limits on their cognitive ability lead them to seek good-enough or adaptive solutions to the situations they face. Aggregation of consumer behaviour thus becomes a question of identifying and understanding the heuristics used and analysing the overall impact at the market level. The one issue raised above that bounded rationality does not seem to address is the separability of preferences over product attributes. If anything, the heuristic and piece-meal decision strategies of bounded rationality would argue strongly for separability, making this property a point on which the two theories are in agreement.

3.4 Conclusion

This chapter has discussed two economic theories of decision making and considered how they could help understand demand for GMF. Neoclassical consumer theory was reviewed first. A discussion of the axioms underlying neoclassical consumer theory found that prior research on consumer reactions to GMF suggested possible issues with two of the axioms. The possibility that the type of benefit offered to consumers might interact with their evaluations of the use of GM technology would potentially mean that preferences could not be treated as separable. In addition, the potentially lexicographic preferences that many consumers express are inconsistent with the idea that preferences are continuous. The lexicographic preferences also remove the possibility of defining an indifference relation with regard to the product attribute ‘GM’. Since the indifference relation is central to neoclassical market theory and necessary for the aggregation of indifference curves, lexicographic preferences do not allow for a market-level indifference curve to be estimated over all consumers. Finally, the idea that decisions are reached as the result of utility maximisation decisions on the part of consumers was shown to be an assumption, which raises the possibility of empirically examining decision rules rather than assuming specific consumer behaviours.

The second school of thought was behavioural economics, and specifically boundedly rational theories of decision making. It was shown that bounded rationality offers a theoretical framework for considering lexicographic preferences. By rejecting the assumption of global maximisation and instead focussing on decision protocols or heuristics, bounded rationality describes consumer behaviour without recourse to those axioms that behaviour with regard to GMF might violate. Aggregation becomes an exercise in describing consumer behaviour rather than finding a specific market price or consumer willingness to pay. However, bounded rationality does seem to assume, as neoclassical research sometimes does, that consumers assess each product attribute independently of the other attributes.

In order to determine how these theories might be used to describe consumer demand for GMF, the next chapter reviews literature on estimating and modelling consumer behaviour. It focuses in particular on research on GMF, as well as other research examining lexicographic preferences. Research based on both neoclassical theory and theories of bounded rationality are included.

Chapter 4

Literature review: consumer choices in neoclassical and behavioural economics

4.1 Introduction

The discussion in Chapter 2 reviewed research examining consumers' demand for GMF and the range of reactions that consumers have expressed in response to GMF. Chapter 3 considered economic theory that could explain these reactions, looking both to neoclassical consumer theory and behavioural notions of bounded rationality. This chapter examines prior research on consumer demand and on decision making to review potential methods for investigating the theoretical issues raised in the previous chapter. In so doing, the discussion below will identify ways in which prior research can be extended to elucidate consumer responses to GMF.

The purpose of this literature review is two-fold. First, it is to review previous studies to identify a robust methodology that is firmly grounded in economic theory. Secondly, the above discussion noted several potential theoretical issues that arise with GMF. The separability of product attributes, the continuity of consumer preferences, difficulties with creating an aggregate indifference curve and reliance on maximisation have all been identified as potential issues arising from consumer reactions to GMF. This review of the literature will therefore include an examination of how prior research has addressed these issues.

This chapter is organised as follows. Methods for assessing consumer demand are reviewed first. Revealed preference (RP) methods for examining consumer demand are considered, and this is followed by a discussion of stated preference (SP) methods, including contingent valuation methods (CVM) and choice modelling (CM). The next section considers approaches for incorporating boundedly rational decision-making models into the analysis. The results of this literature review are brought together in the concluding section.

4.2 Revealed preference methods

Revealed preference methods to elicit willingness to pay require a good that trades in a market (Bateman *et al.*, 2002) or a simulated market for the good (List & Shogren, 1998; Lusk *et al.*, 2001). There are thus two different sources of data for RP methods, which lead to different analytical treatments.

The most straightforward approach to assessing consumer demand for a good is to collect data on consumption of that good. The amount of the good that consumers purchase at the market price reveals their preferences regarding that good. Data may take different forms, such as the volume or dollar value of purchases, or the percentage of consumer spending on a specific good or on a category of expenditure. These data demonstrate actual behaviour with real economic consequences – consumers have had to exchange money for the good. Given accurate data, there is nothing hypothetical about this actual consumer behaviour.

In theory, an RP method of analysing WTP for GMF in New Zealand should be feasible. There is GMF available for consumer to buy in New Zealand supermarkets (Boniface, 2003; Collins, 2003; Radio New Zealand Newswire, 2005). However, there are several complications. First, the extent to which consumers are aware of GMF in their supermarkets is uncertain because they may not read product labels (Noussair, Robin, & Ruffieux, 2002). The impact of consumer unawareness on purchases of labelled GMF is thus unknown. The situation is further complicated because not all food derived from GM crops needs to be labelled in New Zealand (ANZFA, 2001; Boniface, 2003). In addition, the number of labelled GMF products in New Zealand is small (Radio New Zealand Newswire, 2005; Robertson, 2002), so obtaining a representative sample of consumers based on those few products might be difficult. In sum, although it would be possible to obtain actual market data regarding GMF in New Zealand, the above factors suggest that such data might not provide the best indications of total consumer demand for GMF.

Some RP research examines an actual good in a real market, but the good is a proxy for the one in which researchers are interested. If consumption of a marketed good is closely linked with a non-marketed good, then information about the marketed good – the proxy – can be used to infer results regarding the non-marketed good. The use of a proxy good is not possible in the case of GMF, because there is no clear proxy good whose consumption can be linked to GMF.

As a result of the above issues, research examining actual GMF markets is limited. The only actual product market that appears to have been studied is the US market for milk from cows that have been given rbST (recombinant bovine somatotropin), a GM hormone that stimulates lactation. Kiesel, *et al.* (2004) analysed market data for milk in the US and found that the presence of labels indicating that milk was produced without rbST increased demand. Similar research does not appear to have been published for any products in New Zealand.

The problems with data from actual markets has led economic researchers to use simulated markets in the form of experimental auctions to generate RP data for GMF (*e.g.*, Huffman, Rousu, Shogren, & Tegene, 2003b; Noussair *et al.*, 2004; Rousu *et al.*, 2004; Tegene *et al.*, 2003). Auctions do require participants to commit to their choices by paying money and, in some cases, actually eating the food they have purchased. Auction experiments also contain a hypothetical dimension absent from actual markets. For example, auctions are clearly laboratory exercises which require participants to trust the veracity of the experimental setup. Both the product attribute 'GM' and some of the product enhancements that are of interest, such as nutritional content, are credence qualities (Fulton & Giannakas, 2004; Masters &

Sanogo, 2002): consumers must trust the representations of the producer or provider. Auction research on GMF does not seem to have measured or investigated the strength of participants' belief in or commitment to the experimental market. This feature of auctions adds a hypothetical dimension to the research which, at least in the case of GMF, could benefit from further investigation.

RP methods of assessing consumer demand for genetically modified food would avoid some of the issues identified in the previous chapter. Since actual market data would be collected, the measurement of demand would not depend on continuity of preferences and would therefore not raise the issue of aggregating potentially incommensurate preferences. Demand would simply be whatever is measured.

However, RP methods also have limitations to which the above discussion has alluded. First, the restricted nature of actual market data would make RP methods difficult to use. The small number of products, the absence of labelling for some products, and the potential for a biased sample could all complicate the methodology and lead to results that could not be generalised.

Secondly, using actual market data to avoid the theoretical problems with preference continuity relies on consumers being informed about food's GM content. The issue of zero demand for a consumer good has been explored for other products, such as tobacco (Garcia & Labeaga, 1996). It has been shown that the consumption decision can be divided into the decision to participate in the market and the decision regarding how much to consume (Pudney, 1989). However, this research generally considers products which are easily identified: consumers are cognisant of what they are purchasing when they buy cigarettes. With the labelling issues surrounding GMF – that not all GM crop-derived foods need to be labelled (ANZFA, 2001) and that GM-labelled ingredients may not be immediately obvious (Radio New Zealand Newswire, 2005) – it is not certain that consumers are cognisant of the content of their food purchases (Lau, 2004; Phillips & Corkindale, 2002). It would therefore be possible for consumers who do not want GMF to purchase it anyway. This situation is the well-known problem that consumer can face of identifying inferior products or 'lemons' (Akerlof, 1970), and complicates the use of RP data.

A third issue that could be difficult to investigate with RP data is the separability of preferences. RP methods can assess consumers' reactions to whole products, but are less flexible for assessing reactions to different configurations of product attributes (Louviere, 2001). Several different versions of the product would need to be found or created, each one with different attributes. These different versions are not likely to exist in actual markets, and would create logistical difficulties for simulated markets. An additional issue with RP methods is their inability to predict demand for innovative products (McFadden, 1986). That is, when the goal is to anticipate future demand for products that have yet to be introduced, RP data is not available (Louviere, Hensher, & Swait, 2000).

This discussion suggests that RP methods for assessing consumer demand are appropriate for existing products in established markets with good information. They may be cumbersome for assessing specific product attributes, and inappropriate for considering demand for future products. Furthermore, they may not provide a method for investigating one of the key issues identified in the previous chapter: whether product attributes are separable. This discussion therefore turns to another area of research, stated preference methods.

4.3 Stated Preference methods

Stated preference (SP) methods for assessing consumer demand rely on asking individuals in a survey environment about their potential willingness to pay for goods or their choices from sets of possible options. They therefore assess behaviour in hypothetical settings or markets, rather than in actual markets. The two main classes of SP techniques are contingent valuation methods (CVM) and choice modelling (CM). Within each of these classes are a number of different valuation techniques, each with strengths and weaknesses. These methods are summarised in Table 4.1 and discussed below. After the valuation techniques are compared with each other, several issues that affect stated preference research generally, such as protest responses and hypothetical bias, are also discussed.

CVM techniques describe a possible product or policy to respondents and then ask them what they would be willing to pay for it. The researcher determines which aspects of the product or policy are likely to be most important, or *salient*, to survey respondents. These salient aspects or attributes might be the price that the respondent would pay, the way in which payment would be made, and the specific benefits that the respondent could expect. In a CVM survey, the product or policy is presented as a whole package, with all the salient attributes described (Bateman *et al.*, 2002). This makes it a useful technique for determining the value of complex, defined options in their entirety (Bateman *et al.*, 2002), such as a new programme for environmental amelioration (Amigues, Boulatoff, Desaigues, Gauthier, & Keith, 2002) or a new traffic scheme (Strazzera, Scarpa, Calia, Garrod, & Willis, 2003). This is similar to the RP focus on whole products rather than product attributes.

Different CVM techniques ask respondents the valuation question in different ways. *Open-ended* formats simply ask respondents how much they would be willing to pay for the option under consideration (Bateman *et al.*, 2002). While this method should elicit the maximum WTP from each respondent, the valuation task may be complex and unfamiliar, especially for non-market goods (Cameron, Poe, Ethier, & Schulze, 2002). The values elicited may therefore be unreliable and not actually reflect respondents' true WTP (Bateman *et al.*, 2002). *Dichotomous choice* (DC) questions ask respondents whether or not they would pay a certain amount, called the *bid amount* (Bateman *et al.*, 2002). Because the expected answer is either

Table 4.1. Summary of stated preference techniques

Survey technique	Strengths	Weaknesses	Comments
All contingent valuation methods	Values the options as whole packages	Requires large number of scenarios to value attributes Respondents need to be reminded that there may be substitutes for what is being valued	
Open-ended question	Less yea-saying Theoretically finds true WTP	Mentally complex May increase non-response, protest answers, zero bids Valuation task does not mimic markets	
Bidding	Theoretically finds true WTP	Suggested bid amount creates anchoring bias Yea-saying	
Single-bounded dichotomous choice (DC)	Consistent with RUM theory Reduces non-response and outliers	Creates larger estimates of WTP than open-ended Yea- and nay-saying More respondents needed than for other SP techniques	
Double-bounded DC	Consistent with RUM theory Reduces non-response and outliers More efficient than single-bounded DC	Creates larger estimates of WTP than open-ended Less yea-saying than single-bounded Less efficient than other SP techniques Suggested bid amount creates anchoring bias	This or 'payment card' preferred method for CVM survey
Payment card	Consistent with RUM theory Better than other CVM elicitation techniques	Range of prices can bias results Newer technique – less literature	This or 'double-bounded DC' preferred method for CVM survey

Table 4.1 (cont.). Summary of stated preference techniques

Survey technique	Strengths	Weaknesses	Comments
All choice modelling techniques	Allows efficient valuing of attributes Can examine impact of multi-attribute changes Procedure reminds respondent of possible substitutes	Assumes the whole has same value as sum of parts, which may not be true	Called 'conjoint analysis' in the Marketing literature
Choice experiments (CE)	Generalisation of DC CVM questions Consistent with RUM theory Better at determining marginal values than CVM More efficient – more data from fewer respondents Less yea-saying Easy task for respondents May avoid some types of protest votes	Survey design is more complex than CVM techniques	
Contingent ranking	Some applications are consistent with RUM theory Can provide more data than CE	Task is more complex than CE	Similar to CE
Contingent rating	Yields more detailed information about preferences	Not consistent with neoclassical theory – respondents do not directly compare options Task is more complex than CE	
Paired comparisons	Can generate data similar to binary choice	May not be consistent with RUM theory	

Sources: (Bateman *et al.*, 2002; Bennett & Blamey, 2001; Louviere *et al.*, 2000) yes or no, the valuation task is thought to be generally easier than the open-ended format (Bateman *et al.*, 2002; Cameron *et al.*, 2002). However, DC CVM questions have been shown to suffer from strategic bias: if a respondent wants to register that the option in question is valuable, then she must answer 'yes' to nearly any WTP amount asked; otherwise, she is lumped with those respondents who do not value the option (Blamey, 1998b). This difficulty is not present in the *payment card* approach. For this technique, respondents are presented with a list of potential WTP values and can select the maximum amount they are willing to pay. The range of prices presented to respondent can, however, affect the WTP bids (Bateman *et al.*, 2002), and the values generated from a payment card approach may be significantly different from those generated from a DC question (Cameron *et al.*, 2002).

Choice modelling techniques in general may avoid some of the issues with CVM techniques, particularly the cognitive complexity that respondents face when asked to put a dollar value on a non-marketed good whose worth they may never have previously considered (Bateman *et al.*, 2002; Louviere *et al.*, 2000), such as an innovative good. Instead, respondents are presented several options and asked either to choose their preferred option or to rank the options on some scale. There are several different techniques used in CM that differ in the type of valuation exercise and the data generated. *Choice experiments* (CE) and *paired comparisons* ask respondents to designate the preferred option. Choice experiments in particular have found wide use in transport, tourism, and environmental valuation (Bateman *et al.*, 2002; Crouch & Louviere, 2001). *Contingent ranking* and *contingent rating* surveys ask respondents to put options into a rank order to provide ratings on a scale for each option. These methods generate more complex data sets that determine not only which options are preferred but also the strength of the preference (Bateman *et al.*, 2002; Morrison, Blamey, Bennett, & Louviere, 1996). These last two approaches may be inconsistent with RUM theory because they do not require respondents to select one option from a choice set, *i.e.*, they do not require respondents to select the one option that maximises their utility (Louviere *et al.*, 2000).

CM has certain advantages for eliciting WTP for innovative products, such as GMF. In particular, CM varies product attributes in systematic ways to generate the WTP for separate attributes. By contrast, CVM methods value options as whole bundles of attributes. This makes CM more appropriate for assessing the impact of multidimensional product changes (Hanley *et al.*, 2001) and for determining the value of the discrete product attribute 'genetically modified', as apart from any other product attributes. It would also allow for the separability of preferences for product attributes to be tested empirically.

However, there are a number of issues surrounding design and implementation of SP valuation methods, which the following discussion will consider.

4.3.1 Non-response

Non-response is the lack of response to the survey; this is the case when a potential respondent does not answer the survey. It is difficult to determine the impact of non-response, because it requires some knowledge of those who are not responding (Bateman *et al.*, 2002). To the extent that non-respondents and respondents are similar, this is not an issue. However, if non-response is endogenous to the valuation process, *i.e.*, if the salient attributes of the valuation exercise affect response rates, then WTP estimates are biased if they are not corrected for non-response (Cameron, Shaw, & Ragland, 1999). For example, non-response has been shown to be correlated with socio-demographics by the use of postal codes in the United States (Cameron *et al.*, 1999). Non-response may therefore not be randomly distributed through the population. The statistical results from survey data are conditional on participation, so the modelling should take participation into account (Pudney, 1989).

The difficulty is in knowing whether non-response is endogenous to the survey, *i.e.*, whether it is affected by the survey or the survey topic (Bateman *et al.*, 2002; Cameron *et al.*, 1999). It is possible, for example, to test whether a sample is representative of the target population with respect to familiar socio-demographics. In addition, researchers have suggested that a CE survey should have a lower non-response rate than some other stated preference methods, because respondents may find the CE task of choosing one option easier than the CVM task of trying to decide how much they value a good (Morrison *et al.*, 1996).

Non-response is an issue when trying to generate aggregate results for an entire market based on the results of those people surveyed. If non-response or non-participation is affected by the same things that affect demand for the product in question, then results from the survey will not reflect the results one would expect in a market.

4.3.2 Protest responses

A second type of problematic response is protest responses. In SP surveys, protest responses are those in which respondents refuse to reveal their true willingness to pay for the good or alternative under consideration. Protest responses are defined differently for CVM and CM surveys (Bateman *et al.*, 2002). Comparatively more research has examined the impact of protest responses in the context of CVM surveys (*e.g.*, Lindsey, 1994; Strazzera, Genius, Scarpa, & Hutchinson, nd; Strazzera *et al.*, 2003), while less research has examined the impact on CM surveys.

CVM researchers consider protest respondents to be those who bid zero amounts for goods but do so for non-economic reasons. If a respondent's true WTP is zero, the good has no value; this is a 'valuation' reason for bidding zero (Lindsey, 1994). 'Non-market' reasons for expressing zero bids are many, and include displeasure with the survey or the payment vehicle, uncertainty about how to value the good, refusal to put a dollar value on something considered invaluable, and more (Hanley, Ryan, & Wright, no date; Lindsey, 1994; Spash, van der Werff ten Bosch, Westmacott, & Ruitenbeek, 2000; Stevens, Echeverria, Glass, Hager, & More, 1991; Yoo, Kwak, & Kim, 2001). To distinguish the two types of zero bids, some researchers use follow-up questions to probe the reasons for the bids (Bateman *et al.*, 2002; Yoo *et al.*, 2001). If the respondent gives reason that could be considered 'non-economic' then the bid is classified as a protest response (Bateman *et al.*, 2002; Blamey, 1998a; Lindsey, 1994). However, protest responses are not necessarily limited to zero bids: some positive WTP bids have also been shown to be protest responses (Spash *et al.*, 2000).

Once protest responses have been identified, the next step is to decide how to incorporate them into the modelling (Strazzera *et al.*, nd). Lindsey (1994) suggested that the modelling decision depends on whether the data are for use in a market or a political process. Zero bids that arise from non-economic concerns may have little bearing on whether a respondent would pay for a good in a private market. Those zero bids could thus be censored from the analysis. Blamey (1998a) reaches the opposite conclusion: if the protest response is motivated by a desire to deny responsibility for environmental harm, then the respondent would not purchase the environmental good in a private market, even if the good were valuable. A protest bid is therefore a valid zero from a market point of view and should be retained. Lindsey (1994) also discussed the case of a political market. In a political process, the median bid is important so that a majority is achieved. Determining an exact WTP is not as important as determining whether the value is above or below the median bid. Furthermore, non-economic reasons for expressing a zero WTP may be germane in a political process if, for example, the respondent would have a positive utility for an environmental project but objects to having public monies pay for it.

Protest bids may or may not be included in an analysis of data, depending on the context of the survey (public or private market for the good) and the discretion of the researcher. If protest bids are to be included, one approach is to include an indicator function that accounts for a respondent's willing to reveal his WTP (Strazzera *et al.*, 2003). Excluding protest responses, on the other hand, results in a sample selection bias that affects estimates of the median WTP, and the direction of bias is theoretically uncertain (Strazzera *et al.*, 2003).

CM protest responses are generally somewhat different from CVM ones. For CM surveys of any type, respondents are not revealing prices directly, so they have a different way to refuse to reveal their true WTP. WTP in a CE context is determined by respondents' willingness to receive more of one attribute in return for giving up some of another attribute (Louviere, 2001; McFadden, 2001b). A CE protest response by definition is thus the refusal to trade one attribute for another. Respondents can avoid revealing any WTP by always choosing the base or *status quo* option for all the choice questions (Louviere, 2001). Because the individual's choice does not vary in response to changes in the choice set, implicit prices cannot be calculated.

The difference between protest responses in the two types of SP research reveals a strength of choice-based surveys. For CVM, respondents who indicate a zero bid may truly be indifferent to the good – have no WTP for it – or may be protesting (Bateman *et al.*, 2002; Blamey, 1998a; Lindsey, 1994). The two types of zero bids may be distinguished with follow-up questions (Bateman *et al.*, 2002; Yoo *et al.*, 2001). In CM research, indifference is defined over the choice attributes rather than entire goods. Respondents who are indifferent to a particular attribute will have equal probabilities of choosing alternatives with and without that attribute. Protest responses, for their part, are a clear pattern of always choosing the *status quo*. Thus, indifference and protest register differently in CM research.

The standard procedure in CE research for handling data from respondents who always choose the *status quo* is to exclude them (Bateman *et al.*, 2002). This is a logical approach given that the focus of the research is determining WTP; if survey responses do not reveal WTP, then they should not be included. Furthermore, because respondents are violating a fundamental axiom of neoclassical consumer theory – that more of one attribute can substitute for less of another – their behaviour does not conform to RUM theory (Burton et al., 2001; S. James & Burton, 2003). As a result, regardless of the reasons that lead respondents to choose only the *status quo*, their responses are excluded. The proportion of excluded responses can in practice be quite large. Burton & Pearse (2002) found that 19 of the 64 respondents always chose the *status quo*; Burton, *et al.* (2001) excluded nearly 20% of households from their analysis because of such responses; James & Burton (2003) excluded 31% of respondents; and Onyango, *et al.* (2004) excluded 29% of respondents.

What CVM research has shown, however, is that the same response can be either a protest response or a real expression of the respondent's WTP. If *status quo* responses do not represent respondents' underlying preferences, then it may be proper to exclude them from analysis. It is possible, on the other hand, that a *status quo*-only respondent is not protesting – refusing to divulge the true value of the attributes – but is in fact revealing underlying preferences. For example, the survey designs in Burton & Pearse (2002) and Onyango, *et al.* (2004) included one non-GM product: the *status quo*. An issue with offering only one non-GM option in a CE survey is that respondents who always prefer non-GM food will always choose the *status quo*. This is the product with the preferred configuration of attributes. This choice exactly reflects the purchase one would expect in a market setting, given those respondents' preferences (and some availability of non-GM food). In this case, it may be appropriate to include these responses in order to capture or mirror the full market impact of GMF.

Another possibility, recognised in James & Burton (2003), is that the 'compensation' offered for consuming GMF was not enough: 'some of these [respondents] may be willing to consume GM under a different set of circumstances than was presented to them in the survey'. The circumstances may be an even greater price discount than was used in the survey, but it could also be a non-price attribute such as improved flavour or nutrition. As discussed above, consumers are potentially interested in these second-generation GM products, and research has found willingness to pay a premium for these enhancements (Burton & Pearse, 2002; Lusk, 2003). Increasing the types of compensation or the levels of compensation offered to respondents may be able to reduce the extent of protest responding. However, the structure of choice experiments, with defined attribute levels spread over finite intervals, always leaves open the possibility that some greater discount or some other attribute would change respondents' behaviour.

Adamowicz, *et al.* (1998) pointed out that it is not clear whether the estimated preference for the status quo really is a preference, or whether it instead represents a protest response or the effect of respondent fatigue with the survey. In his work on individual preferences and social choice, Arrow (1963) suggested that the status quo option has a built-in advantage over all other alternatives, that there is a preference for 'things as they are'. This preference, like any other, may be stronger for some respondents than for others. For some, it may be high enough that the offered alternatives are simply not attractive. Protest responses would again be a valid expression of their underlying preferences.

The impact of protest responses on estimates of WTP for GMF is potentially a subject for further research. There is evidence from GM consumer research that some form of protest response is a non-negligible percentage of the data. However, estimates of WTP for GMF do not seem to have included these protest responses in the analysis (Burton et al., 2001; S. James & Burton, 2003). As a result, the estimates of WTP may be biased. The existence of such a bias is implied by Burton, *et al.*, (2001) who reported in a footnote that a model estimated with their full dataset (including protest responses) was different from the model estimated with the dataset excluding protest responses, and that the difference was statistically significant. Protest responses may be indications by some consumers that they are unwilling to pay anything for GMF. If the unwillingness to buy GMF on the part of these consumers is not included in the analysis, then prior estimates of WTP for GMF are potentially biased upwards. For research whose intent is to examine the market-level impact of introducing GM technology into an existing market for food, these prior examples of GMF research could be extended to include reactions of all consumers.

Protest responses present a problem for aggregating the responses of all individuals to a SP survey. Regardless of the motivation of 'protesting' respondents, that is, regardless of whether their responses reflect their true preference or whether the response are meant to express displeasure with the survey, they have not indicated the point at which they would be indifferent between the good on offer and compensation for not having the good. It is thus not possible to create a market indifference curve that includes their preferences.

4.3.3 Lexicographic responses

Another type of response that appears to present a problem for the assumption of continuity is the lexicographic response. Respondents who make their choices based on the level of one attribute are said to have 'lexical' or 'lexicographic' responses (Bateman *et al.*, 2002; Bettman *et al.*, 1998). As discussed in the previous chapter, individuals who make lexicographic choices examine each choice attribute in order of descending importance. The first attribute that differentiates the choice alternatives from each other is used to select the 'best' or preferred alternative. Importantly, lexicographic responses are considered an 'aberration' in SP research (Bennett & Adamowicz, 2001).

Some discussions of lexicographic choices in SP research are confined to protest responses (Burton et al., 2001; S. James & Burton, 2003). Protest responses are held to be the result of lexicographic preferences, with respondents basing their decisions on whether an alternative is the *status quo* and nothing else. However, lexicographic choice can be based on any attribute (Bennett & Adamowicz, 2001; von Haefen *et al.*, 2004). The key is whether the respondent chooses according to the value of one attribute only, so that every chosen alternative is always highest in that attribute.

Other discussions of lexicographic choice relax this strict presentation. For example, a distinction has been made between naïve and behavioural versions of consumer lexicographic choice (Earl, 1983). The naïve version follows the strict definition of lexicographic choice: consumers consider one attribute at a time, assessing all alternatives according to that one attribute. Consumers proceed mechanically through a hierarchical list of attributes to make their final choices. This decision rule can be represented as:

$$x_{ki} > x_{kj} \text{ for } \min\left\{k : x_{ki} \neq x_{kj}\right\},$$

which indicates that x_i, the alternative actually chosen, is greater than x_j for attribute k, the first attribute for which the two alternatives are not equal. In the behavioural version of consumer lexicographic choice, consumers decide on target levels of the attributes that alternatives must meet to stay in the choice set. Thus, it may not be true that consumers choose the alternative with the highest level of the most important attribute. Instead, both x_i and x_j remain in the set of potentially selected alternatives as long as they exceed some minimum cut-off for attribute k. The chosen alternative is the one that remains after all unacceptable alternatives have been excluded.

Another relaxation of strict lexicographic orderings is semi-lexicographic preferences (Coombs, 1964). If one attribute or dimension is most important, a consumer may always choose the alternative that is best in that attribute. However, if several alternatives are all similarly high in that attribute, choice may then be compensatory with regard to other attributes. This is also the idea of 'dominance' (Scott, 2002): a consumer might always prefer an alternative that has more of the dominant attribute, regardless of other product characteristics. Preferences for the other attributes may be ordered lexicographically, but not necessarily.

Lexicographic responses to SP surveys may affect WTP calculations. First, such responses violate the axiom of continuity, making it impossible to identify the point at which respondents are indifferent. Thus, one cannot calculate these individuals' WTP. Utility for these respondents cannot be represented as a continuous unidimensional function, and one cannot calculate WTP over the discontinuity that arises from the lexicographic responses. For a respondent with a discontinuous preference for non-GM food, no amount of money could compensate for GM food (Tauer, 1994).

The second problem that lexicographic responses may pose is the difficulty in aggregating results to draw conclusions about the entire sample and the population of consumers. The amount of compensation that these consumers would require is simply unknown. This is a result of the utility theory underlying SP research. These respondents have not indicated the amount of compensation that would leave their utility unchanged. In fact, if their responses truly are the result of lexicographic preferences, then no amount of compensation would substitute for the good in question. As a result of discontinuous preference functions, survey results cannot be used to estimate changes to consumer welfare (Gowdy & Mayumi, 2001; Lockwood, 1998; Spash, 2000), which is a typical measure of aggregate impacts. In fact, the implied prices generated by choice experiments to calculate changes in consumer welfare will be biased (McIntosh & Ryan, 2002).

Because lexicographic preferences are problematic for SP research, they have been the subject of some research. One question has been the impact of such preferences on the responses that individuals give to surveys. Empirical research has shown that apparently lexicographic preferences do affect survey responses, but the results are complex. Spash (2000) examined bids made in CVM studies in combination with statements about attitudes towards the environment or feelings of environmental 'duties' to identify three types of lexicographic preferences:

1. Extreme lexicographic preferences: the individual always has a preference for the most important good or attribute, in this case environmental goods. The person does not require even a minimum of resources for other uses.

2. Strong modified lexicographic preferences (MLP): preferences are lexicographic within an unspecified range, and the person is willing to accept reduction of living standard to some minimum.

3. Weak MLP: preferences are lexicographic with a range, and the person gives up the rights-based position because a cost is imposed. Thus, the money is worth more than the ethical stance.

Thus, Spash (2000) found that ethical positions based on preferences for environmental goods, which he related to lexicographic preferences, could result in either zero bids or positive bids. He also found that respondents with lexicographic preferences could be willing to pay at least an order of magnitude more for environmental goods.

Lexicographic preferences also seem to affect responses to CM surveys. Rosenberger, *et al.* (2003) did a paired comparison survey – a type of CM survey that offers two alternatives at a time – to categorise respondents. Each pair contained one environmental good and one sum of money. Respondents who valued the offered good higher than any sum of money were classified as Potential Lexicographic Preferrers – PLP. The respondents either had true lexicographic preferences or their reservation price (the price the good is worth to them) had not been reached. The researchers found that PLP respondents tended to hold deontological ethical positions: they tended to agree with statements that prioritised the value of natural ecosystems over the human economic value system. In another paired comparison survey, the majority of respondents were willing to pay at least the maximum bid to prevent the extinction of a particular possum species in Australia (Lockwood, 1998).

These findings from SP research suggest that respondents may have values that they hold 'sacred' or non-negotiable. Respondents may avoid putting a price on these values (Bettman *et al.*, 1998), resulting in discontinuities in their expressed preferences. Some respondents have even been found to react to hypothetical trade-offs between money and the environment by reframing the survey, offering alternative solutions to the hypothetical problem (Gregory & Lichtenstein, 1994).

The importance of such preferences with regard to GMF is also apparent in the literature. Rigby & Burton (2004) interpret their choice experiment results as indicating that 'a significant section of the UK market is unwilling to trade-off the GM nature of food against price, certainly not over any range likely to occur in practice' (p. 16). Noussair, *et al.* (2004) found that 34.9% of their participants would not buy products that they knew contained GMOs. Finally, the impact of such preferences on market-level results were investigated by Tauer (1994). He created a model of the liquid milk market to examine the impacts of GM bovine growth hormone (bST). His conclusion was that '[c]onsumers who refuse to drink bST-produced milk are better off at any price with a differentiated market since they have non-bST milk to consume' (p. 7).

The above research examined the impact of seemingly lexicographic preferences on responses to surveys. Other research has looked at the issue from the other direction: the extent to which lexicographic preferences can be inferred from specific patterns of responses to surveys. McIntosh & Ryan (2002) examined preferences for different options regarding medical treatment. One of their concerns was identifying people who always preferred medical treatment at the nearby facility, regardless of cost or waiting time. However, the structure of the choice sets was such that there were no choice combinations that uniquely identified lexicographic preferences. That is, the same set of choices could mean that the respondent examined the attributes in the order (location, waiting time, cost) *or* in the order (cost, location, waiting time). Their findings suggest that in situations in which lexicographic preferences are suspected *a priori*, survey design needs to account for this possibility. Foster & Mourato (2002) raised a different issue. They found that 18% of their respondents provided rankings that were consistent with a lexicographic ordering of the attributes, but they also point out that these rankings are consistent with maximising of some utility function as long as the parameters are heavily weighted towards the most important attribute.

The proportion of respondents using lexicographic preferences has been estimated in several surveys. In the study by Spash (2000) discussed earlier, 11% of the sample were found to hold some form of lexicographic preference. Scott (2002) found that 45% of respondents had a ‘dominant preference’ for some attribute. These were respondents who ranked the attribute as most important and always chose the alternative with the highest level of that attribute. Stevens, *et al.* (1991) could not rule out ethically based lexicographic choice behaviour for two-thirds of their respondents. Svedsater (2003) found that eight of the 29 respondents would pay whatever was necessary to deal with an environmental problem. These findings generally suggest that respondents with lexicographic preference form a non-trivial portion of samples from SP surveys.

SP research has handled lexicographic responses in different ways. One approach used for research on GMF has been to estimate very large discounts for GMF. In essence, the discontinuity is ignored. Instead, it is assumed that respondents do have a point of indifference, one that is simply outside the limits of the values used in the SP survey. This approach has the advantage of consistency with underlying neoclassical and RUM theory: one assumes that the choice axioms hold. On the other hand, the estimated values are typically outside the levels included in the choice set. For example, Burton *et al.* (2001) estimated that some consumers would be willing to increase their food spending by 472% in order to have non-GM food. This estimate represents an extrapolation, however, as the range of changes to the food bill included in the survey was -50% to +40%. The estimate treats the few respondents in this particular consumer segment who did choose GM alternatives as the tail of a distribution. Assuming that there exists a continuous distribution allows an estimate to be made of the rest of the distribution. As a result, the estimated price level was an order of magnitude different from the surveyed levels.

A second approach to handling lexicographic responses has been to consider what prices might actually obtain in a market. Rigby & Burton (2004) thus interpreted their results as indicating that many British consumers would not buy GMF in any practical price range. This is a practical approach that recognises the limitations of the data while taking advantage of the capabilities of choice modelling for generating WTP estimates. This approach to interpreting potentially lexicographic data raises several issues. First, it may not be able to address the potential impact on prices should the supply of non-GMF fall below some threshold level. That is, if the price that consumers are willing to pay is a function of the amount of GM and non-GM food available, and if a significant percentage of consumers are considered ‘out of the market’, then what happens to prices when the supply of non-GMF falls below the level demanded by these consumers? A second potential issue is that no value for GMF has been determined. It would therefore not be possible to compare the value of the GM attribute with non-price enhancements, so that it may not be possible to assess the potential market for such future products. In addition, without a determination of the value of GMF, overall welfare estimates of the introduction of GM technology into the food supply may not be possible.

A third approach to lexicographic choice is to treat it as the result of a separate process (von Haefen *et al.*, 2004). Respondents can be divided into those who vary their survey responses in response to the attribute levels of the offered alternatives and those whose responses are invariant. Those who do vary their responses are modelled using a standard compensatory approach for which all the choice axioms hold. Respondents who do not vary their responses are engaged in non-participation, which can be modelled as a separate choice or decision. Thus, von Haefen, *et al.* (2004) present single- and double-hurdle models that account for two decisions: respondents first decide whether to participate in the market, and then secondly decide how much or what type of the good to consume. The two decisions may be conditioned on quite different factors, so that the choice attributes may not affect the decision to participate while they do affect the consumption decision.

Such a two-part decision process may be appropriate for recreation decisions, the use to which von Haefen, *et al.* (2004) put the model. It may be less applicable to decisions regarding GMF, because this interpretation of survey responses divides consumers into those who 'play the game' and those who do not (von Haefen *et al.*, 2004). This interpretation is tantamount to asserting that some consumers are behaving economically – because their responses conform to neoclassical theory – while others are not (see Earl, 1983). The 'game' is accepting compensation in exchange for varying one's responses to a survey. Those who vary their responses are providing true valuations of the offered alternatives. Those who do not vary their responses sufficiently are assumed to be protesting against the survey, expressing lexicographic preferences, or employing simplifying heuristics. These are, however, three very different interpretations of such responses. In the first interpretation, respondents are protesting against the survey by using external criteria to judge the choices offered. Reacting in such unforeseen ways has been observed elsewhere (Gregory & Lichtenstein, 1994), is consistent with a latent specification of utility in which the observer does not know all the choice criteria, and does not exclude the possibility that consumers behave similarly in real markets, as with consumer boycotts based on corporate behaviour and not product attributes. The second interpretation, that consumers are expressing lexicographic preferences, suggests that the stated choices reflect true preferences. The preferences might violate the axiom of continuity, but they represent the true value that consumers place on the attributes of the choice alternatives and are consistent with consumer rationality (Arrow, 1963). The third interpretation, that consumers are using choice heuristics, represents a challenge to neoclassical consumer theory. It suggests that the fact that consumers are using choice heuristics means that their responses cannot be modelled with a utility-maximising, compensatory modelling framework. If this is true, then it is difficult also to assert that consumer decision making can be modelled 'as-if' the neoclassical model holds regardless of whether it does hold in reality (Conlisk, 1996). The logic of arguing for separate treatment for so-called non-participation thus seems to require further precision, because it asserts that such decisions may or may not be based on criteria germane to market decisions, may or may not represent the true value of the choice alternatives, and could be the result of behaviour that calls into question the underlying assumptions of the original, neoclassically based analysis.

One contribution of the von Haefen, *et al.* (2004) research is that it underscores the importance of understating the motivations for observed respondents' choices. They suggest that exit questions or follow-up questionnaires may be useful for determining whether lexicographic responses are the result of protest reactions to the survey itself, true expressions of respondent preferences, or outcomes from decision heuristics.

From this discussion of potentially lexicographic responses, it seems that research into demand for GMF might benefit from further investigation of these responses. Such responses may be theoretically inconsistent with neoclassical consumer theory, because they violate the continuity axiom and they may render impossible calculations of aggregate impacts, such as market-level indifference curves or calculations of consumer welfare. Lexicographic responses seem to arise in empirical research, including research on GMF. They appear to be consistent with respondents' attitudes and are therefore likely to be the expressions of underlying preferences. These responses may arise in particular with research examining only one dimension, such as preferences for an environmental good or preferences regarding GM. Respondents with such preferences may be a non-trivial portion of consumers; they appear to have a different WTP than other respondents; and they could have an impact on the market for GMF. Some prior approaches for handling lexicographic responses were identified above, but further research may be able to extend these approaches, in particular as they relate to estimates of demand for GMF.

4.3.4 Zero demand

Some respondents to SP surveys have no demand for the good, product, or initiative that is the subject of the survey. Some research has investigated ways to incorporate this lack of demand explicitly. The way in which zero demand can be modelled depends on the form the data take. If the data are the quantities consumed, such as physical quantities (Blend & van Ravenswaay, 1999) or shares of household expenditures (Garcia & Labeaga, 1996), then there are several methods for modelling lack of consumption (Pudney, 1989). One method, the Tobit model, is a single-equation model that estimates the quantity demanded of a good as a function of price, income, and a vector of characteristics; it estimates a continuous demand conditional on the demand being above some level, typically conditional on non-negative consumption (Pudney, 1989). Several approaches to estimating this model have been proposed (Maddala, 1983) and empirically compared (Garcia & Labeaga, 1996), but the issue of appropriate estimation procedures will not be addressed here. This is one method that von Haefen, *et al.* (2004) adapted for use in CE research.

The Tobit model does not distinguish between different reasons that consumers might have for not consuming a good (Pudney, 1989). It may be necessary to separate two different reasons: that the consumer has no intention of purchasing the good or that the price of the good is too high. Positive consumption is the result of a decision to participate in the market and a decision to consume the good. Another model, the double-hurdle model, thus includes two equations, one for each different decision (Blend & van Ravenswaay, 1999; Garcia & Labeaga, 1996; Pudney, 1989). The advantage in this model is that there are two sources of zero consumption: non-participation and corner solutions (utility from the good is insufficient to warrant purchase). A double-hurdle model can be estimated either as independent or dependent. In a dependent model, a coefficient of correlation is estimated between the two equations, on the theory that the two decisions are not strictly independent (Garcia & Labeaga, 1996). The work of von Haefen, *et al.* (2004) also demonstrated how to use a double-hurdle model in the context of CE research.

Zero demand has also been investigated in the context of double-bounded dichotomous-choice contingent valuation method (DC-CVM) surveys. The different examples of techniques for investigating zero demand have two elements: first, they have investigated different adjustments to willingness-to-pay distributions, and second, they have used follow-up questions to better describe zero WTP.

The WTP distributions have been adjusted in several ways. In a standard double-bounded DC-CVM distribution, the probability that a respondent will say ‘yes’ to a bid amount is a function of the bid amount and other salient independent variables (Bateman *et al.*, 2002). The distribution is continuous and generally considered unimodal (An & Ayala, 1996). However, observed WTP is often bimodal (An & Ayala, 1996) and many respondents are indifferent to a good, or may even regard it as providing negative utility (Kristrom, 1997). Respondents who are indifferent or who view the good negatively would not be willing to pay for the good. If one ignores any demand they might make for compensation as a result of a negative WTP, in a market setting their WTP is zero. To include these observations, a point-mass at zero is modelled in the WTP distribution. In the spike model, this point-mass is equal to the integral of the negative tail of the WTP distribution (An & Ayala, 1996; Kristrom, 1997; Yoo *et al.*, 2001). In a mixture model, the size of the point-mass is independent of the continuous WTP distribution (An & Ayala, 1996). The probability of a respondent having a zero WTP is instead estimated separately from the distribution of positive WTP. As a result, the mixture model is a general form that includes the spike model and the standard model as special cases. The WTP distribution can also be adjusted to avoid unrealistically high WTP values, either by constraining to personal budgets for specific products (Veisten, 2002) or by constraining to income levels (Yoo *et al.*, 2001).

CVM research into zero WTP responses has highlighted the importance of follow-up questions. A project that intends to model a zero WTP as a point-mass, whether in a spike model or a mixture model, needs to question respondents on whether they are willing to pay anything for the target product or programme (Amigues *et al.*, 2002; Kristrom, 1997). This question could be in the form, 'Would you be willing to pay anything for this product or programme?' (An & Ayala, 1996), or could ask respondents what their maximum WTP is (Strazzera *et al.*, nd). This type of question essentially adds another bound to the WTP distribution. Some authors have recommended more extensive debriefing to determine more accurately the reasons for zero responses in a CVM survey (Amigues *et al.*, 2002). For example, respondents can be asked how certain they are of their answers (Veisten, 2002) or about their reasons for giving a zero WTP response (Amigues *et al.*, 2002; Strazzera *et al.*, nd). As discussed above, some zero responses can be included in the WTP analysis, while others should be considered protest responses.

This research on zero WTP in CVM studies has shown that accounting for zero WTP is important in modelling valuation data, and these types of responses influence estimates of mean and median values. The importance of follow-up questioning has also been demonstrated. Such questions can help determine whether a respondent can be modelled as part of the positive continuous WTP distribution or should be considered in the point-mass at zero WTP. They also help separate those with true zero WTP and those who are registering protest responses.

For CE research, the issue of zero demand presents somewhat differently. The first difference is between two types of zero WTP. Two reasons that a respondent might not consume a good are that it does not contribute to a consumer's utility, so the respondent is indifferent, and that it has negative utility, such as meat would have to a vegetarian (Kristrom, 1997). In a CE survey, if a respondent is indifferent to the attribute 'GM', then the estimated parameter for GM would be zero – it would not affect the choice probability. By contrast, a point-mass at zero, as in the CVM research, models indifference to the whole product, not indifference to the single attribute. On the other hand, if a respondent wants to refuse GM food, then all the positive utility from the other food attributes is insufficient to outweigh the negative utility of the GM attribute. The exact negative value is unknown, because it varies inversely with the other, positively-valued attributes. In this case, the value of the whole product is undetermined.

The second difference is in the type of data from the two forms of surveying. The DC-CVM approach asks a number of respondents whether they would pay specific amounts and then models the probability that respondents would pay as a function of the bid amount. The product in question is homogeneous except with respect to the bid amount, and the data are yes-no responses. For a CE survey, the data are the alternatives chosen from the choice sets, and the modelling task is estimating the probability that the alternatives would be chosen.

4.3.5 Data analysis methods

Once the data on respondents' WTP has been collected, it must be analysed. Analytical tools for estimating models using SP data have been the subject of much research. When estimating WTP from CVM surveys, the method of estimation depends in part on the elicitation methods, that is, the way that respondents have been asked about their willingness to pay (Bateman *et al.*, 2002). Some assumption needs to be made about the distribution of the willingness-to-pay parameter in order to estimate a model, but Kerr (2000) showed that the choice of distribution for DC CVM research was not important in WTP calculations. CM research has developed a range of models that differ in complexity and underlying assumptions (McFadden, 2001b; Train, 2003).

Data analysis in GMF research has followed the path of the larger literature on SP research. For CVM research, surveys using DC CVM question have been analysed using an ordered probit (Bukenya & Wright, 2004) as well as a double-bounded model (Li *et al.*, 2002). Other research has assumed that consumers would not be willing to pay more for GMF, resulting in a one-and-a-half bounded CVM survey question, modelled with a semi-bounded logit model (McCluskey *et al.*, 2001). Payment card approaches to ascertaining WTP have also been used, with both Moon & Balasubramanian (2003) and Kaye-Blake, Saunders, & Fairweather (2004) focussing on the percentage of respondents in each response category, rather than estimating a probabilistic distribution of WTP. Thus, a range of CVM data collection and analysis approaches are evident in the literature.

Analysis of CM data in GMF research also represents the range of tools available. Many examples of GMF research have used the most common model for analysing discrete choice, the multinomial logit (MNL) (Burton & Pearse, 2002; Burton et al., 2001; S. James & Burton, 2003). More complex models have also been estimated. In particular, a series of papers using a dataset collected in the UK has investigated several model specifications. Burton, *et al.* (2001) presented the survey, the data, and a standard multinomial logit analysis of consumer responses to GMF. Rigby & Burton (2003; 2004) followed with two extensions in analytical technique. The first extension was to use a random parameters logit (RPL) model that accounted for preference heterogeneity distributed in a defined way throughout the population. The next paper reshaped these preference distributions to determine the best way to model them. Another example of similar data analysis is the RPL model used by Onyango, *et al.* (2004).

Thus, there is a range of tools available for analysing data from SP surveys. The choice of model depends on the type of survey, the elicitation method, and assumptions on the part of the research of the required level of complexity.

4.3.6 Hypothetical bias

Because respondents to surveys are not making an economic commitment to their responses by paying money, their responses may be subject to bias and may provide researchers with hypothetical values rather than actual WTP. This is referred to as the hypothetical bias in SP research.

The exact impact of hypothetical bias is uncertain. The 1993 NOAA panel report offered the rule-of-thumb that CVM values should be divided by two to yield true WTP (List & Shogren, 1998). This has been challenged by research finding that CVM values can be within about 10% of RP values (Hanley *et al.*, no date) or three times RP results (List & Shogren, 1998). A meta-analysis of hypothetical bias comparing several studies that used both RP and SP methods found that the relationship between actual WTP and stated WTP was complex (Murphy, Allen, Stevens, & Weatherhead, 2005). The median bias, expressed as the ratio between the hypothetical value and the actual value, was 1.35. Researchers found that the distribution was very skewed, with a few observation exhibiting severe hypothetical bias. In other research examining RP data with several SP techniques, most of the SP methods were found to yield similar preference structures to the RP data (Cameron *et al.*, 2002). To complicate the issue, research indicates that the factors used to calibrate the two types of values depend on the person and product (Fox, Shogren, Hayes, & Kliebenstein, 1998) as well as the source of RP data (Shogren, Fox, Hayes, & Roosen, 1999). Furthermore, it is not clear that the bias is systematic or even the result of deliberate misrepresentation (Polome, 2003). Although Murphy, *et al.* (2005) suggested that hypothetical bias has been insufficiently theorised, Blamey (1998b) has made a start on a theory of hypothetical bias by describing and quantifying sources of hypothetical bias. He also found that the impact of hypothetical bias was *a priori* unknown.

Some researchers have suggested that values for non-GMF are inflated by hypothetical bias (Chern *et al.*, 2002). Because consumers do not have to commit money to their survey responses, they are free to indicate that they would double or treble their food spending in order to have non-GMF. Lusk (2003) examined the impact of hypothetical bias on expressions of WTP using a double-bounded dichotomous choice CVM question and a technique called ‘cheap talk’. With this method, researchers inform respondents about the problem of hypothetical bias in an attempt to reduce or remove it. Lusk found that cheap talk reduced by about 40% the premium on a vitamin-enhanced GMF product called ‘golden rice’. The result is that, while hypothetical bias may be influencing respondents’ valuations, the direction of the impact is *a priori* uncertain: it is not clear whether it is GM or non-GM products whose value is being inflated by hypothetical bias.

Conjoint analysis, a type of CM research used in the marketing literature, was one of several SP techniques that were all found to elicit similar preference structures (Cameron *et al.*, 2002). Thus, to the extent that respondents are giving hypothetical values in response to SP questions, conjoint analysis is no differently affected by this bias than any other SP technique, nor is there any reason to suspect *a priori* that it would be (Bateman *et al.*, 2002).

While hypothetical bias will always be an issue for survey-based research, because it is by its very nature not a market, it is possible to reduce its impact. Bateman, *et al.* (2002) provide a detailed discussion of hypothetical bias and the allied issue of validity. They suggest that a well-designed survey will create scenarios or options that would appear realistic to respondents; the survey must have content or face validity. An additional consideration is that the payment mechanism must also be realistic, so that the respondent would find the way of paying for the good plausible. Thus, while it is possible to test for hypothetical bias only by comparing the results of a survey to results from an actual market, the validity of SP research can be assessed without external measurement.

4.3.7 Validity

Validity of SP research is a multi-faceted concept. That a piece of research is 'valid' can mean one or more of the following (Bateman *et al.*, 2002; Morrison *et al.*, 1996):

- The results conform to prior expectations (expectations-based validity).
- The relationships between measures within a survey conform to relationships seen elsewhere (construct validity).
- The results of one survey tally with the results of another (convergent validity).

- The research produces accurate predictions (predictive validity).
- The content of the survey is accurate (content validity).

Because SP research is based on neoclassical economic theory, it is easy to identify prior expectations and then determine whether results conform to them. Economics research is nearly always assessing the expectations-based validity of research, and to some extent its construct validity: if the signs and magnitudes of estimated parameter are not as expected, then they must be explained.

SP research often generates estimates of WTP, which allow results from different surveys to be compared with each other to assess convergent validity. Convergent validity has been tested, and the results are mixed. Under some circumstances, some elicitations methods arrive at similar values, while in other circumstance the results may diverge (Adamowicz, Boxall *et al.*, 1998; Cameron *et al.*, 2002; List & Shogren, 1998).

To the extent that SP research is concerned with predicting demand for future products, there is scope for comparing the predictions generated by such research against future market data. However, predictive accuracy can only be determined after such market data become available. Research assessing predictive validity in other contexts has often but not always found good correspondence between predicted and actual choices (Louviere, 1988; Morrison *et al.*, 1996).

Finally, the constructed nature of a survey-based research and the use of questionnaires mean that both content validity and construct validity can be assessed by examining the design of a survey instrument.

4.3.8 Yea-saying

Respondents may respond positively to researchers' suggestions in order to be pleasant. Thus, they may agree with researchers regardless of their true WTP, creating a bias in survey results. DC CVM questions have been found to lead to higher values than payment card approaches, and a likely culprit is yea-saying (Hanley *et al.*, no date). Regardless of one's true WTP, one must respond 'yes' to some payment level in order to register a positive WTP on the survey (Blamey, 1998b). A payment card approach allows respondents to indicate positive response at lower payment levels, whereas they need to agree to whatever payment level is randomly generated in a DC survey, regardless of how high it is. DC CVM questions also generate higher values than open-ended questions (Amigues *et al.*, 2002; Bateman & Jones, 2003), possibly for the same reason.

Yea-saying may be less of a problem for choice-based SP methods than CVM techniques (Bateman *et al.*, 2002). The valuation task is not to say 'yes' or 'no' to a bid value, but instead to select one option from many. One may be equally pleasant by choosing any of the offered alternatives.

4.3.9 Information bias

Providing respondents information in the course of SP research can influence the results of research (Spash *et al.*, 2000). However, it is not clear to what extent this represents a bias, or, in particular, an improper influence on respondents (Spash *et al.*, 2000). It is important, for example, to provide respondents with enough information that they can accurately and comfortably respond to the valuation task (Bateman *et al.*, 2002). The point at which information provision becomes information bias is unclear.

The impact of providing information to individuals has been explored largely in the context of experimental economics using RP methods, but the findings may have relevance to SP research. In a series of auction experiments, researchers at Iowa State University examined how the provision of different types of information affected bids on GM food and cigarettes (Huffman *et al.*, 2003b; Huffman *et al.*, 2001; Lusk *et al.*, 2003; Rousu *et al.*, 2003; Tegene *et al.*, 2003). They found that negative information made people less willing to pay for GMF and that positive information made them more willing to pay. They also found that 'neutral' information reduced the sizes of both the positive and negative bids, and suggested that 'third party' information is welfare enhancing.

The main drawback to this research is that the tenor of the information is co-determined with the reaction of the auction participants. 'Negative' and 'positive' are qualities that are difficult to define except by the influence that information has on people's WTP. Particularly difficult is the notion of 'neutral' information: if information can only be considered neutral when it has little impact on WTP, then research into the impact of neutral information on WTP is begging the question. To further complicate the issue, other research using auction experiments found that 'it is possible that providing biased information contrary to that previously believed may have further entrenched prior-held beliefs' (VanWechel, Wachenheim, Schuck, & Lambert, 2003). That is, telling people things they do not agree with may push them to hold their ideas more strongly. The information issue might therefore be one of concordance: respondents' reactions to the information provided may depend on whether they are pre-disposed to believing it.

4.3.10 Framing effects

The way in which an issue is framed or presented to individuals can affect survey responses (McFadden, 2001b). This has been extensively studied in the context of risk assessments, and it has been demonstrated that the way in which risks are presented to respondents affects the judgements they make about those risks (Kahneman *et al.*, 1990). Some researchers maintain, however, that framing effects may not affect WTP estimates significantly (Hanley *et al.*, no date), at least in well-designed CM research (Louviere, 1988).

Framing effects have been discussed in the context of GMF. Most GMF research, particularly that using CVM methods, has focussed solely on the issue of genetic modification. Respondents may therefore have been sensitised to the GM issue and accorded it more weight in their survey response than it may have in their purchases. The 'food futures' research in the UK and Australia (Burton et al., 2001; S. James & Burton, 2003) attempted to place the issue of GM in the wider framework of the food system. Genetic modification was presented as one of a number of food-related issues, along with agrochemical use and the distance that food travelled from field to plate. This research did not compare different frames of reference, but their research had broadly similar results to more narrowly framed GMF surveys. This research highlighted one of the benefits of choice-based SP research over CVM, that the former tends to highlight the tradeoffs that consumers potentially face (Bateman *et al.*, 2002).

An important caveat for work on framing effects is that it may be difficult to design plausible scenarios when respondents want to find fault with them (Blamey, 1998a); for these respondents there may not be a 'right' or 'accurate' way to frame an issue, regardless of the content validity of the survey instrument.

4.3.11 Summary: SP methods

This discussion of SP research has pointed to a number of known issues. Response data may be affected by non-response, protest responses, and lexicographic responses. The research needs to consider the ways in which data will be collected and analysed. The survey instrument itself may lead to hypothetical bias, yea-saying, validity concerns, information bias, and framing effects. Nevertheless, as discussed earlier, research on demand for GMF needs to consider using SP methods simply because real market data are unavailable.

A number of SP methods are available, and they may have different strengths with regard to exploring the issues with GMF identified above. One issue was the separability of preferences over the GM attribute from preferences over other attributes of food. A second issue was the apparently lexicographic choices that some people make concerning GMF. This issue then led to the problem of aggregating individuals' choices into market-level indifference curves.

As Bateman, *et al.* (2002) point out, the main choice regarding SP methods is between CVM and CM. CVM is better for determining the total value of a good, such as the total value of a program of environmental remediation. CM, by contrast, is better for finding the values of the attributes of goods. Choice experiments, in particular, have been found to provide 'a richer description of the attribute trade-offs that individuals are willing to make' (Adamowicz, Boxall *et al.*, 1998). The issues that have been identified with regard to GMF centre on the values that people place on food attributes, especially on the single attribute 'GM'. This is true for both the issue of separability and the issue of continuity. Thus, some type of CM method may be best for considering these research questions.

Importantly, not all CM techniques are consistent with neoclassical economic theory (Bateman *et al.*, 2002; Louviere, 2001). Neoclassical theory, as described above, posits that consumers choose the alternative that provides the greatest utility. Contingent rating is not consistent with utility theory because it is not a choice-based process. Respondents do not directly compare the alternatives to each other, but instead give rating to each option individually. Thus, it is not a choice-based process (Bateman *et al.*, 2002; Louviere, 2001). Paired comparisons and contingent ranking both are problematic with regard to utility theory, unless they always contain a *status quo* option against which the alternatives can be compared. Otherwise, the evaluations made by respondents is not anchored, but merely a relative evaluation of two hypothetical alternatives (Bateman *et al.*, 2002). Contingent ranking additionally suffers from the concern that the scale that the respondent uses for making rankings is essentially unknown, so that responses to different question by the same respondent and responses from different respondents are not necessarily comparable (Bateman *et al.*, 2002; Louviere, 1988, 2001).

One CM technique that is consistent with neoclassical theory is choice experiments (CE) (Bateman *et al.*, 2002; Louviere, 2001). The valuation task for respondents to a CE survey is to choose the single best alternative from a set of options. This is exactly the type of decision theorised in neoclassical consumer theory. The chosen alternative must theoretically yield the greatest utility for the respondent. This utility can then be decomposed into the contribution that each attribute makes, using Lancaster's theory, and the effects of the latent term, using RUM theory. Thus, CE has a firm basis in neoclassical economic theory (Louviere, 2001).

A CE survey appears to be an appropriate method for considering the research issues identified above. It is well-grounded in neoclassical economic theory and provides a method for determining the effect of the specific product attribute 'GM' on consumer behaviour. In particular, a CE survey offers the potential for distinguishing protest responses from indifference and from lexicographic preferences regarding GM technology, allowing closer examination of the continuity issue. Furthermore, the attribute-based nature of CE surveys may make it possible to examine preference separability. To consider these issues further, and in particular to examine how they have been addressed in prior research, the next section examines choice experiments more closely.

4.4 Choice experiments

This section is a review of the CE literature. It covers the links between CE and neoclassical theory, a description of the survey method, and approaches to modelling data, including recent developments.

Before the 1960s, consumer theory relied on the 'representative agent' (McFadden, 2001b). This approach modelled demand with a single agent who represented the preferences of all consumers. Theoretical developments and increases in computing power led to disaggregated approaches that modelled individual choices (McFadden, 2001b). One of the earliest examples of this type of work was research on the choice of transport mode for the San Francisco Bay Area Rapid Transit (BART) system in the 1970s (McFadden, Train, & Tye, 1978). The success of this model relative to forecasts using earlier gravity models led to the further use of such choice models in transport analysis (McFadden, 2001a).

This approach for modelling observed choices amongst discrete alternative was developed further in the 1980s for use in analysing data from SP research (Bateman *et al.*, 2002; Hanley *et al.*, 2001). The result was choice experiments, which are also called *attribute based stated choice methods* (Adamowicz & Boxall, 2001), *stated preference discrete choice modelling* (Gerard, Shanahan, & Louviere, 2003), or simply *choice modelling*.

In a CE survey, a respondent is asked a series of choice questions. Each question presents several alternatives, including one which represents the *status quo*. For each question, the respondent is asked to choose one option from each set. Choice experiments are constructed to resemble the choice situation described in neoclassical consumer theory, so the elements of a choice experiment are similar to the theoretical situation.

4.4.1 Choice experiment design

The elements of a choice experiment are (Louviere, 2001):

1. A choice set, C, containing some number of different alternatives, $(a_1,\ldots, a_j)$.
2. The K attributes, $(x_1,\ldots,x_k)$, of the alternatives.

3. The levels of attributes, or the different values they could take. These are discrete values and can be either categories, such as ‘present’ or ‘absent’, or different levels taken from a continuous variable, such as several different price levels.

The levels and the attributes are used to define or describe the alternatives in the choice set. For example, given two attributes ‘apple colour’ and ‘price’ and their corresponding levels (red, green) and (low, high), the four possible alternatives in the choice set are shown in Table 4.2.

Table 4.2. Combinations of apple attributes

	Price	
Colour	Low	High
Red	Red apple, low price	Red apple, high price
Green	Green apple, low price	Green apple, high price

The number of alternatives in the choice set is thus a function of the number of attributes and the number of levels. Given K attributes, each with two levels, the number of possible combinations is 2^K ; more generally, the number of combinations is m_1 x m_2 x …x m_K, where m indicates the number of levels for each k, (1,…,K) (John, 1998). The number of alternatives in the choice set grows rapidly as levels and attributes are added.

The *complete factorial* includes all the alternatives as described above. However, the number of alternatives in the choice set is usually limited by means of a *fractional factorial design* (Hahn & Shapiro, 1966; John, 1998; Louviere *et al.*, 2000). Techniques for creating such fractional factorial plans as well as ready-to-use plans are available (Hahn & Shapiro, 1966; John, 1998; Louviere *et al.*, 2000). To determine the *main effects* of the attributes on respondents’ choices, it is generally only necessary to include a small fraction of the complete factorial. The main effects are the influences of each attribute in isolation from the other attributes on respondents' choices. Not included are any two-way, three-way, or more-complex interactions between or amongst the attributes. It is important to note, however, that by limiting the design to a main effects fractional factorial, some of the higher-order interactions are confounded with the main effects themselves (John, 1998). Empirical evidence suggests that 70% to 90% of explained variance is a result of main effects; 5% to 15% is a result of two-way interactions; the rest is explained by higher-order interactions (three-way and greater) (Louviere *et al.*, 2000).

There are thus two issues with using fractional factorial designs. The first is the bias introduced into the estimates, because the parameter calculated for the main effect is also capturing any influence from interaction effects. Prior research suggests that this bias is not likely to be very large (Louviere *et al.*, 2000), but the size of the bias is an empirical question. The second issue is that the interactions may in fact be significant and important in the choice process. Using a main effects design corresponds to assuming an additive functional form for utility, in which preferences over choice attributes are separable. However, whether this assumption holds could be tested empirically by designing choice sets that are larger than a main effects design. Two-way interactions between different attribute preferences, for example, could be estimated to determine their size and significance.

Appropriate design of choice sets requires finding an equilibrium amongst the competing demands of realism, orthogonality and balance. Realism is an important consideration in all stated choices research in order to obtain valid statements regarding respondents' preferences (Bateman *et al.*, 2002); that is, it is important for the validity of the survey results. Orthogonality in survey design allows researchers to separate the effects of one product attribute from the effects of another, and balance in attribute levels – having all attributes with the same number of levels – is desirable (Louviere *et al.*, 2000). Orthogonality and balance can be statistically assessed by calculating the D-efficiency of a choice set design (Chrzan & Orme, 2000; Kuhfeld, Tobias, & Garratt, 1994). The statistic is calculated as:

$$100 * 1 / [N_D \, |(\mathbf{X'X})^{-1}|^{1/p}],$$

where N_D is the number of runs or alternatives, p is the factors in the survey design[2], and **X** is the N_D x p design matrix. Kuhfeld, *et al.* (1994) caution that D-efficiency is a relative measure of design efficiency, not an absolute measure. The D-efficiency statistic is thus a way to compare two potential survey designs.

Once the all the alternatives in the full choice set have been constructed, the survey questions can be assembled. For each question, respondents are presented with several different alternatives (three or four is common) and asked to choose which of them is preferred. Each survey includes several of these choice questions: six to eight questions are recommended (Bennett & Adamowicz, 2001), but researchers may be able to ask up to twenty choice questions without the data declining in quality (R. M. Johnson & Orme, 1996). Several methods for assembling these choice questions from the set of alternatives are available, including random pairing, drawing from statistically similar choice sets, using a 'mix and match' approach, and 'shifting'(Chrzan & Orme, 2000; Louviere *et al.*, 2000). This last has been found to be an efficient design for choice questions (Chrzan & Orme, 2000).

There are a number of issues associated with choice set design (Blamey, Louviere, & Bennett, 2001):

*Number of attribute*s. Larger numbers of attributes lead to more choice alternatives, more-complex choice tasks, but also better descriptions of the alternatives. The task is to balance

[2] What *p* represents does not seem to be defined in Kuhfeld *et al.* (1994).

simplicity and salience. However, increasing the number of attributes may not affect parameter values, but does affect the model estimation (Louviere, 2001).

Generic versus alternative-specific labels. Whether to provide the different alternatives with meaningful labels (‘government option’ versus ‘private option’, for example) or generic labels (‘option A’, ‘option B’) is important (Bennett & Adamowicz, 2001). Meaningful labels have additional content that must be captured by extra terms in the data analysis.

Opt-out option. Surveys should include some way that respondents can opt out of a choice question (Bennett & Adamowicz, 2001). For some surveys, such as recreation surveys, this might be an option not to participate, while for studies of products this might be the option to stay with the current brand or product (Banzhaf, Johnson, & Mathews, 2001). Including an opt-out option avoids the problem of forcing respondents to make trade-offs, which is inappropriate (Scott, 2002).

Attribute descriptions. In order to assess the impact of a change in an attribute on choice behaviour, the description needs to present that change in a way that is both plausible (for the respondent) and measurable (for the researcher) (Blamey *et al.*, 2001).

Dominated alternatives. In a single choice question, one alternative may be strictly *dominated*: it may be worse than another alternative for all the attributes. In particular, an alternative from the full choice set may be dominated by the *status quo* alternative: switching from the current product or situation to the dominated one entails being worse in every dimension. Dominated alternatives are often discarded (*e.g.*, Burton *et al.*, 2001), as it would be irrational for someone to choose an alternative that was worse in every way. However, they have been retained in some research in order to test for rationality (V. Foster & Mourato, 2002).

Plausibility of alternatives. Choice experiments are stated preference methods, so the possibility of hypothetical bias is ever-present. It is important that the constructed alternatives are plausible and realistic (Blamey *et al.*, 2001), to maintain content validity of the survey and to improve the probability of getting non-hypothetical answers from respondents. In particular, combinations of attributes that imply large benefits at reduced costs may not be believable (Bateman *et al.*, 2002).

4.4.2 Modelling discrete choice data

For each choice question, the respondent chooses one alternative. This choice can be described using a neoclassical framework, which then leads to specific methods of data analysis. In taking a decision, the respondent chooses a_i from $(a_1,\ldots, a_j)$, where i indicates the chosen alternative, $j > 1$, and $(a_1,\ldots, a_j) \in C$. Neoclassical theory posits that the respondent has chosen a_i because it is the alternative with the greatest utility at the time the decision was made. Thus, if the respondent indicates that

$$a_i \succ a_j \text{ for all } j \neq i,$$

where $\succ$ indicates 'is preferred to', neoclassical theory suggests that this preference is the result of the respondent perceiving that

$$U(a_i) > U(a_j).$$

From Lancastrian theory (Lancaster, 1966), it is possible to decompose the alternatives into their attributes:

$$U(x_{1i},\ldots, x_{ki}) > U(x_{1j},\ldots, x_{kj}),$$

where x_{jk} is the value that attribute k takes for alternative j. Dividing utility into deterministic and latent components results in Random Utility Maximisation (RUM) theory (McFadden, 2001b). The result is that the choice of a_i indicates the following:

$$V\left(a_i\right)+\varepsilon_i > V\left(a_j\right)+\varepsilon_j \text{, or}$$

$$V\left(x_{1i},\ldots,\ x_{ki}\right)+\varepsilon_i > V\left(x_{1j},\ldots,\ x_{kj}\right)+\varepsilon_j \text{, or finally}$$

$$V\left(x_{1i},\ldots,\ x_{ki}\right)-V\left(x_{1j},\ldots,\ x_{kj}\right) > \varepsilon_j-\varepsilon_i .$$

The left-hand side of the inequality is comparing the observed levels of the attributes of the two options. The right-hand side compares the error terms or the random components.

McFadden (1974) showed that choice can be modelled with what he termed a ‘conditional logit’ (CL), now generally called a multinomial logit (MNL) by making an assumption about the error terms. The probability of choosing a_i is (Louviere, 2001; McFadden, 1974):

$$\Pr\left(a_i\right)=\Pr\left(V_i-V_j > \varepsilon_j-\varepsilon_i\right).$$

An important characteristic of this equation is its unidimensionality. The error terms for the different attributes can be subtracted, one from the other. This requires that the error terms be commensurate, that is, they can be measured on the same scale and in the same dimension(s). The deterministic portion of the equation, $V(\cdot)$, is also treated as commensurate, so that it is possible to compare the utility from one option with the utility from another. Furthermore, it is possible by this equation to compare the magnitudes of the observable utility with the magnitudes of the error terms. Finally, all of the above terms can be reduced to a single dimension in order to compute a single probability. This equation is therefore based on the continuity axiom, which allows unidimensional utility.

If it is assumed that the error terms are distributed with a specific distribution, which is variously referred to as a Weibull, Gumbel, Gnedenko, or type 1 extreme value distribution (Maddala, 1983; McFadden, 1974; Walker, Ben-Akiva, & Bolduc, 2003), which is:

$$F\left(\varepsilon_i < \varepsilon\right) = \exp\left(-e^{-\varepsilon}\right).$$

With this error distribution, it is possible to estimate the probability of choosing a_i with the following equation (Maddala, 1983):

$$\Pr(a_i) = \frac{\exp\left(V_i\right)}{\sum_j \exp\left(V_j\right)}, \text{ all } j \text{ in the choice question.}$$

This is the MNL equation. If the alternatives are once again decomposed into their constituent attributes, the choice probability can be written (Burton *et al.*, 2001):

$$\Pr(a_i) = \frac{\exp\left(\sum_{k=1}^{K} \beta_k X_{ki}\right)}{\sum_j \exp\left(\sum_{k=1}^{K} \beta_k X_{kj}\right)},$$

where X is the K-element vector of attributes and β (or, more properly, β') is the K-element vector of weights that respondents attach to the different attributes. Importantly, each attribute is treated as independent from the others. A separate β is estimate for each attribute, and the deterministic portion of utility is equal to the weighted sum of the attributes; that is, utility is considered additive. This formulation arises from an assumption that preferences over attributes are separable.

With this formulation, it is possible to estimate a model using data from a choice experiment. The model estimates values for β that maximise the probability or likelihood that the observed choices would occur. The estimated coefficients are thus the weight that respondents put on the attributes of the choice set; they are the values that respondents attach to the attributes.

This equation has only considered the value of the attributes. As such, the coefficients are some average measure of the attributes' values. Respondents are not all the same, so more complex forms of the MNL have been considered. Perhaps the most general form of the deterministic portion of utility is (Louviere, 2001)[3]:

$$V_{jn} = \beta_j + \sum_k \beta_k X_{kj} + \sum_p \theta_p Z_{pn} + \sum_{kp} \phi_{kp} X_{kj} Z_{pn} + \sum_p \varphi_{pj} \beta_j Z_{pn} ,$$

where the Greek letters ($\beta, \theta, \phi, \varphi$) are parameters to be estimated. The terms represent the following:

- β_j is a vector of *J*-1 intercept terms for the of the ($a_1, ..., a_j$) options. *Alternative specific constants* (ASCs) account for factors that are specific to each type of option, such as transport mode or recreation location, that are not otherwise included in the deterministic portion of utility (Horowitz, Koppelman, & Lerman, 1986). They capture the mean difference in utility between each option and the status quo (Bateman *et al.*, 2002).Typically, at least one intercept term is estimated. They thus allow the error term to have a zero mean (Bierlaire, 2003b).

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[3] The equation presented here has been modified from the original. Louviere (2001) gives this as $V_{an} = \beta_a + \sum_k \beta_k X_{kn} + \sum_p \theta_p Z_{pn} + \sum_{kp} \phi_{kp} X_{kn} Z_{pn} + \sum_{pa} \varphi_{pa} \beta_a Z_{pn}$ (where *a* substitutes for the *j* used here). However, it is not clear that the choice attributes *X* should vary by individual, *n*; they should more likely vary by alternative, *a* or *j*. It is also likely that the final term should be summed for all characteristics, *p*, given one option, *a*.

- $\sum \beta_k X_{kj}$ is the sum of the attributes weighted by the value of each attribute to the respondents.
- $\sum \theta_p Z_{pn}$ is a vector *Z* of *p* = (1,…,P) characteristics for each individual, *n*, for which the vector *θ* is the estimated weights. Generally, individual characteristics included in this way affect all alternatives equally, so they 'fall out' of the estimation and are not included (Burton *et al.*, 2001). They can be included as additive terms if they are included with some alternatives and not with others (Horowitz *et al.*, 1986).
- $\sum \phi_{kp} X_{kj} Z_{pn}$ yields the weighted sum the *k* x *p* interactions between attributes and characteristics. This is the more common method for including the characteristics of respondents in the estimation (Bateman *et al.*, 2002; Burton *et al.*, 2001; Horowitz *et al.*, 1986).
- $\sum \varphi_{pj} \beta_j Z_{pn}$ accounts for interactions between individuals' characteristics and the ASCs, allowing for the possibility that respondents have different mean values for the options.

The MNL is the most common method for estimating a model from choice experiment data (Adamowicz & Boxall, 2001; Adamowicz, Louviere *et al.*, 1998; Louviere *et al.*, 2000; Pudney, 1989). It is simple to estimate (Louviere *et al.*, 2000) using off-the-shelf software (Crouch & Louviere, 2001). In addition, although MNL is based on the assumptions that random components are uncorrelated and that utility parameters are fixed, MNL is robust to violations of these underlying assumptions (Louviere *et al.*, 2000). Williams & Ortuzar (1982) also suggest that MNL is robust to mis-specification. As a result, it has good predictive accuracy (Elrod, Johnson, & White, 2004). One caution with MNL, however, is that they can be sensitive to missing variable problems (Kennedy, 1992).

MNL models are usually estimated with a maximum likelihood estimator (Adamowicz & Boxall, 2001). The likelihood of observing the choices that respondents make is the product of the probabilities of observing each choice (Kennedy, 1992; Maddala, 1983):

$$L = \prod_{n=1}^{N} \mathrm{Pr}_n^{y_{na_1}}\left(a_1\right) \ldots \mathrm{Pr}_n^{y_{na_j}}\left(a_j\right),$$

where y_{na} is an indicator function (Train, 2003) that takes the value of 1 if the individual n chooses that alternative a_j, and equals 0 otherwise. This is often presented as the following log-likelihood equation (Bateman *et al.*, 2002; Maddala, 1983):

$$\log L = \sum_{n=1}^{N} \sum_{j=1}^{J} y_{na_j} \log \mathrm{Pr}_n\left(a_j\right).$$

The model solution is the set of parameters that maximises this log-likelihood. These parameters represent the average value that the respondents put on the attributes of the choice alternatives, as well as the average impacts of personal characteristics and differences between a specific type of alternative and the *status quo* (as estimated by the ASCs).

The log-likelihood of the final MNL estimation is used to determine the model's goodness of fit. In his original proposal of the conditional logit, McFadden (1974) suggested the pseudo-R^2 measure:

$$\rho^2 = 1 - \frac{L\left(\hat{\theta}\right)}{L\left(\hat{\theta}^H\right)},$$

where $L\left(\hat{\theta}\right)$ is the log-likelihood of the estimated model and $L\left(\hat{\theta}^H\right)$ is the log-likehood of the model with only the ASCs (Wooldridge, 2002). An alternative pseudo-R^2 is corrected for sample size (Maddala, 1983):

$$\rho^2 = \frac{L\left(\hat{\theta}\right)^{2/N} - L\left(\hat{\theta}^H\right)^{2/N}}{1 - L\left(\hat{\theta}^H\right)^{2/N}}.$$

For this statistic, the terms $L\left(\hat{\theta}\right)$ and $L\left(\hat{\theta}^H\right)$ denote the likelihoods of the estimated and intercept only models, respectively (Maddala, 1983), and are thus equal to *exp*(log-likelihood).

The log-likelihood is also used to compare models. The likelihood ratio (*LR*) test compares an original model and a restricted form of the model to determine if the restrictions affect the model significantly (Cramer & Ridder, 1991). If a group of variables has little explanatory power, then excluding or including them will have little impact on the *LR* (Horowitz *et al.*, 1986). The *LR* is defined as (Wooldridge, 2002):

$$LR \equiv 2\left[L\left(\hat{\theta}\right) - L\left(\tilde{\theta}\right)\right],$$

where $L\left(\hat{\theta}\right)$ is the unrestricted log-likelihood and $L\left(\tilde{\theta}\right)$ is the restricted log-likelihood. This test statistic is approximately χ^2 distributed (Wooldridge, 2002), with degrees of freedom equal to the difference in the number of parameters estimated for the two models (Louviere *et al.*, 2000).

Another measure of the fit of a model is its predictive ability. The most basic way this is expressed is as the percentage of the observed choices that the model correctly identifies (*e.g.*, Gensch & Svestka, 1984). This is, strictly speaking, not a measure of predictive ability but of mimicry. There are two criticisms of this basic statistic. First, with some datasets, a simple model could have a high prediction score (McFadden, 1978). For example, if 80% of a sample chose the red apple over the green apple, a model that simply predicted 'respondent will choose red apple' would be right 80% of the time.

The other criticism is that the predicted alternative is simply the one with the highest probability of being chosen, with no distinction between models that estimate very different probabilities (Elrod *et al.*, 2004). This criticism points out one of the strengths of using likelihood statistics, which are calculated on the estimated probabilities. They can therefore distinguish between models that generate different probabilities but similar predictions.

As a result of these criticisms, McFadden (1978) and Louviere, *et al.* (2000) proposed slightly different but largely equivalent statistics that adjust predictive success for the relative shares of the alternatives in the observed choices. For each choice alternative, the *success index* is the proportion successfully predicted less the observed share for that choice option. The overall *prediction success index* is calculated as the share of each choice alternative multiplied by its success index, summed for all the choice alternatives (Louviere *et al.*, 2000). It is thus the average success index, weighted by alternatives' observed shares. Louviere, *et al.* (2000) give the formula for the prediction success index as:

$$\sigma = \sum_{i=1}^{J} \left(N_{.i} / N_{..} \right) \left(\frac{N_{ii}}{N_{.i}} - \frac{N_{.i}}{N_{..}} \right),$$

where i is the observed choice from J alternatives, N_{ii} is the number of choices of a specific alternative that are correctly predicted, $N_{.i}$ is the number of times the alternative is chosen by respondents, and $N_{..}$ is the total number of choices. The first term in the summation thus gives the alternative share, the proportion of choices that are of one alternative. The second set of brackets subtracts this alternative share from the proportion of each alternative correctly predicted. The predictive success index, σ, is thus a weighted average of correct predictions of each alternative.[4]

Another practice that makes use of prediction statistics is the hold-out sample. Researchers separate the dataset into one part on which the model is estimated and another part, called the hold-out sample, that is used to verify the model (Arentze *et al.*, 2001; Bateman *et al.*, 2002; Kastens & Featherstone, 1996).

Goodness of fit is not the only criterion to be considered when assessing a model: it ‘is not as important as statistical and economic significance of the explanatory variables’ (Wooldridge, 2002). The explanatory variables are assessed in three ways. First, the signs of the raw parameters should conform to theoretical expectations. Secondly, the ratio of two parameters quantifies the implied trade-off between their two attributes. If one of these parameters is price, then the trade-off is the implied price of the other attribute. This *implied price* or *partworth* is (Bateman *et al.*, 2002):

$$-\beta_1 / \beta_2 ,$$

where β_2 is the parameter for the price attribute. Importantly, this calculation assumes that the relative value of two attributes is independent of the other choice attributes: the only consideration is the value of the two β’s, while the interactions of those values with other attributes are ignored. This expression for the marginal rate of substitution arises from an additive utility and an assumption of preference separability (Deaton & Muellbauer, 1980; McIntosh & Ryan, 2002). These partworths can be used to calculate the welfare impacts of

[4] In Louviere, *et al.* (2000), pp. 55-57, the discussion of the calculation of the predictive success index does not appear to match exactly the table provided as an example calculation. Specifically, the proportion successfully predicted is calculated as a proportion of the predicted share (column total in the table) rather than the observed share (row total). The notation in the equations and the text suggest that the correct denominator is the observed total, so that the number of correct predictions is compared to the number of times an alternative is observed to be chosen. Note that McFadden (1978) suggested that predicted and observed shares would be equivalent in certain circumstances.

changes to the status quo (Bennett & Adamowicz, 2001). Thirdly, some research also presents *odds ratios* (Burton, Rigby, & Young, 1999), which give the odds of choosing one options relative to another. The calculation of the ratio (Bateman *et al.*, 2002) is:

$$\Pr(a_1)/\Pr(a_2) = \exp(U_1 - U_2) .$$

MNL may be a common and arguably robust method of estimating models from choice experiment data, but two weaknesses are widely recognised: the Independence from Irrelevant Alternative (IIA) property and the average or fixed nature of the estimated parameters. Each of these two weaknesses will be discussed in turn.

4.4.3 Independence from Irrelevant Alternative (IIA) property

The IIA property is in evidence in the odds ratio calculation above: the relative probability of choosing between two options is unaffected by any other option in the choice set (McFadden, 1974; Wooldridge, 2002). This is often called the 'red bus/blue bus' issue (Horowitz *et al.*, 1986; Train, 2003), and was explained by McFadden (1974) as the problem of adding a new brand of bus into a choice problem. By MNL construction, the new bus takes equally from all other transit modes: car, bus, train, etc. However, logically, one would expect it to supplant the existing bus share and have little impact on other transport modes. Thus he advised that 'care must be exercised in avoiding application of these models in situations where the axioms are implausible' (McFadden, 1974)[5].

Whilst IIA is in theory a potential issue, in practice it is unclear how much bias this property introduces into MNL results. As discussed above, MNL is considered robust to mis-specification, although violations of IIA have been found (Alfnes, 2004; McFadden *et al.*,

[5] Arrow seems to argue that this property never holds: 'If empirically meaningful interpersonal comparisons have to be based on indifference maps, as we have argued, then the Independence of Irrelevant Alternative must be violated. The information which enables us to assert that individual *A* prefers *x* to *y* more strongly than *B* prefers *y* to *x* must be based on comparisons by *A* and *B* of *x* and *y* not only to each other but also to other alternatives.'

1978; Riddington, Sinclair, & Milne, 2000) and discussed theoretically (Arrow, 1963; Tversky, 1972a). There are many possible approaches to addressing IIA. One option is to test for violation of IIA. The most common test is developed in Hausman & McFadden (1984), and consists of computing likelihood ratios for different sets of parameters. Researchers who wish to test for IIA need to design experiments accordingly (Louviere *et al.*, 2000). However, the choice of subsample or parameter subset is arbitrary in the Hausman & Fadden test, which reduces its statistical rigor (Pudney, 1989). Another method for testing IIA is to estimate a nested model and test whether it is an improvement over the non-nested model with a likelihood ratio test statistic (Hausman & McFadden, 1984).

A second option is to estimate a model that relaxes IIA; several such models are available. The main alternative models are multinomial probit, nested MNL, and generalised extreme value models (Louviere *et al.*, 2000; McFadden, 1986).

The multinomial probit assumes that the latent component of utility has a normal distribution. Historically, the drawback with this approach has been the complexity of estimating the probability integrals (Batley *et al.*, nd; Maddala, 1983).

Nested MNL (NMNL) models are appropriate for choice situations that can be represented by a hierarchical structure (Louviere *et al.*, 2000). Where there are violations of IIA, nested models can have quite different results to a standard MNL. For example, Hoffman & Duncan (1988) model women as having three choices if they become divorced or separated: (1) to remain unmarried and receive AFDC (Aid to Families with Dependent Children, a type of transfer payment formerly available in the US), (2) to remain unmarried and not receive AFDC, and (3) to remarry. While the MNL treated these alternatives equally, the results of the NL model suggested that the two options to remain single are more similar than the option to remarry and should be nested together. However, NMNL models do raise questions about the appropriate configuration of the model nests (Rigby & Burton, 2003), and require that the full set of alternatives can be grouped into meaningful, identifiable subsets.

Generalised extreme value (GEV) models are a general class of models of which the MNL and NMNL are special cases (Bierlaire, 2001; Train, 2003). They are defined by their *generating functions*, which determine the choice probabilities. Several forms of GEV models have been proposed that relax the IIA assumption by allowing the latent utility of different alternatives to be correlated. Train (2003) gives a full account of the derivation of these models, while Bierlaire (2001) compares several generalised forms and shows them to be quite similar.

Deriving the MNL from a GEV formulation elucidates the role of this generating function. Following Train (2003), define

$$Y_j \equiv \exp\left(V_j\right),$$

where V_j is, as before, the deterministic portion of utility. If the generating function meets certain conditions, the probability of selecting alternative i is

$$\Pr(i) = \frac{Y_i G_i}{G},$$

where G represents the generating function and G_i is the partial derivative of the generating function with respect to Y_i,

$$G_i = \frac{\partial G}{\partial Y_i}.$$

If the generating function is

$$G = \sum_{j=1}^{J} Y_j ,$$

then the partial derivative for any alternative is

$$\frac{\partial G}{\partial Y_i} = 1 ,$$

so that the choice probability is

$$\Pr(i) = \frac{Y_i G_i}{G} = \frac{\exp(V_i)}{\sum_j \exp(V_j)} ,$$

which is the MNL equation.

Bierlaire (2001) showed that a general generating function that met the conditions for being a GEV model was the cross-nested logit (CNL) model from Ben-Akiva & Bierlaire (1999). The function is:

$$G = \sum_m \left(\sum_{j \in C} \alpha_{jm} y_j^{\mu_m} \right)^{\frac{\mu}{\mu_m}} .$$

The alternatives *j* are a subset of choice set *C*, grouped into *m* nests. Each alternative can be described by its deterministic utility y_j. The alternatives are apportioned to the different nests by the parameter α_{jm}, so that each alternative can belong to several nests to various degrees (Batley *et al.*, nd).

The *scale parameters* μ and μ_m require some explanation. With the basic MNL model, choice probability includes a scale parameter μ that is 'inversely proportional to the standard deviation of the error distribution' (Bateman *et al.*, 2002). Thus, the true MNL probability equation is:

$$\Pr(i) = \frac{\exp(\mu V_i)}{\sum_j \exp(\mu V_j)}.$$

This scale parameter cannot be identified when only one model is estimated because it is determined along with the parameters for utility (Swait & Louviere, 1993). The relative value of the scale parameter becomes important, however, in comparing different models from the same dataset (Burton *et al.*, 2001) or estimating single models from different data sources (Bateman *et al.*, 2002).

The scale parameter μ in the CNL generating function serves the same function as in the MNL model (Bierlaire, 2001). The parameter μ_m captures the similarity of the alternatives within each nest, or the extent to which the within-nest utilities are correlated (Train, 2003). This CNL model thus relaxes the IIA property by allowing different patterns of correlation amongst the choice alternatives.

There are several similar functions in the literature. The Generalised Nested Logit (Train, 2003; Wen & Koppelman, 2001) sets μ equal to unity (Bierlaire, 2001), which is an appropriate normalisation for a GEV model (Swait, 2001a). The Generation Logit (GenL) model (Swait, 2001a) does not include a nest membership parameter α_{jm}, instead estimating a different parameter μ_m for each possible subset of C. The early CNL in Vovsha (1997) includes nest membership parameters but makes μ_m constant for all nests. Each of these models represents a different attempt to relax the IIA property of MNL models and account for correlations amongst the choice alternatives.

A final option with regard to IIA is to assume that the data are consistent with IIA (Kennedy, 2003) or that the MNL is robust to misspecification (Louviere *et al.*, 2000). This course of action is particularly appropriate for choice situations in which there is no *a priori* case for expecting IIA violations. That is, an IIA violation would arise if two alternatives are more similar to each other than they are to other third alternatives. In a classic example from transportation mode research, a Red Car and a Blue Car are more similar than a Red Car and a Bus (McFadden *et al.*, 1978). A survey designed without alternatives that are more and less similar, particularly if it is designed with generic alternatives equally affected by choice attributes, may be less likely to suffer from violations of IIA.

4.4.4 Fixed parameters in MNL

The second important restriction of MNL models is the average or fixed nature of the parameters. For MNL that consider only the attributes of the choice alternatives, the parameter estimates the average impact of each attribute on choice probabilities. However, this may mask important differences amongst respondents.

Three approaches to dealing with *taste heterogeneity* have been developed (Adamowicz, Louviere et al., 1998): *a priori* definition of segments, based on prior knowledge; latent class models; and the random parameters logit (RPL). These are discussed in turn.

The definition of segments has already been introduced with the MNL term that accounted for interactions between choice attributes and respondents' characteristics. One way of creating segments is to collect information on respondents' characteristics in the survey. This information can then be used to divide respondents into different groups that the researcher, given prior literature, would expect to choose differently. For example, Burton, *et al.* (2001) used respondents' self-reported frequency of organically-grown food purchases to create three segments. These segments had different willingness to pay for GM food, as expected.

Defining *a priori* segments is difficult. On the one hand, Stigler & Becker (1977) maintain 'that tastes neither change capriciously nor differ importantly between people.' They suggest that changes in price and income are the only important drivers of differences in consumption, which would tend to suggest that the only respondent characteristic of interest is income. In empirical work, income has been shown to be an important factor in choosing food when food products are considered at a very disaggregate level (Jones, 1997). On the other hand, cultural worldviews (Langford, Georgiou, Bateman, Day, & Turner, 2000) and taste heterogeneity unrelated to demographics (Scarpa & Thiene, 2004) have also been important variables in choice analysis. In relation to food, research has shown clear links between personality traits and food purchases; however, these correlations explain only a portion of purchase behaviour (Bareham, 1995). Consumer segments with regard to genetically modified food are also problematic. As the review of consumer research showed, there is evidence of large differences of opinion regarding GMF. Identifying members of different segments is another matter.

One technique for identifying segments is to do a cluster analysis of the data to identify similar respondents, then perform a separate MNL for each cluster (Adamowicz & Boxall, 2001; Richards, 2000). With this approach, the partworths generated from each MNL could be compared to determine similarities and differences.

Latent class models allow group membership to arise from the choice data themselves, rather than imposing membership exogenously (Scarpa & Thiene, 2004). In these models, membership in one or another class is defined probabilistically, with choice probabilities conditioned on class membership (Adamowicz & Boxall, 2001; Swait, 1994). The unconditional probability of choosing an alternative is thus the combined probability of class membership and choice. While actual membership in a class is probabilistic and results from the choice data, the number of classes in the analysis is exogenously determined. For example, Scarpa & Thiene (2004) used statistical comparisons of different latent class models to determine the appropriate number of classes. The preferred model had a weaker statistical fit but had parameters that were more explanatory and interpretable.

The *random parameters logit* (RPL) is a flexible model specification that relaxes MNL assumptions regarding taste homogeneity and IIA (Bhat, 2003; Revelt & Train, 1998; Rigby & Burton, 2003), so it is becoming the preferred model for estimating discrete choice data (McFadden, 2001a; Walker *et al.*, 2003). The model goes by different names, variously called random-coefficients logit, random parameters logit, error-components logit, mixed logit, mixed MNL, and logit kernel (McFadden & Train, 2000; Revelt & Train, 1998; Walker *et al.*, 2003).

The RPL assumes that each parameter assumed to be random for the deterministic portion of utility is drawn from a distribution across the population of respondents (Rigby & Burton, 2003). This distribution can be described by a mean and variance, which are estimated for each choice attribute. The strength of this approach is that nearly any preference structure can in theory be estimated with the proper choice of distribution (Scarpa, Willis, & Acutt, nd), but it also raises the question what the choice should be (Rigby & Burton, 2004). Many applications of RPL modelling assume that parameters are normally distributed (*e.g.*, Bonnet & Simioni, 2001; Onyango *et al.*, 2004; Rigby & Burton, 2003), but more-complex estimations examine the impact of other distributional assumptions (*e.g.*, Rigby & Burton, 2004). In theory, any distributional assumption, including discrete or discontinuous distributions, is possible (Bhat, 2003).

RPL is similar to MNL in that the observed choices are conditional on choice attributes and the personal characteristics of the respondents. The insight of RPL is that choice probability is conditional on the values that respondents attach to the choice attributes, the estimated β's, and that these may take different values for different respondents (McFadden & Train, 2000; Revelt & Train, 1998; Train, 2003). Where it is possible to assume a constant value for these parameters, the unconditional probability can be modelled as a MNL. Where the parameters are random in the population, RPL allows these parameters to be defined by distributions, so that the unconditional probability is given by the integral for the parameters' entire distributions (Train, 2003):

$$\Pr(i) = \int L_i(\beta) f(\beta) d\beta .$$

In this equation, $L_i(\beta)$ is the standard logit function, and $f(\beta)$ is a density function on the coefficient vector.

The density function, also called a mixing distribution (McFadden & Train, 2000), is described by the parameters θ, which are typically the mean and variance of β. The RPL estimates these θ, given the observed choices, attributes, and personal characteristics.

The RPL cannot be estimated analytically because the integrals do not have a closed-form specification; it is therefore estimated by simulation (Revelt & Train, 1999; Train, 2003). Train (2003) provides an explanation of the simulation procedure. The researcher chooses values for θ, draws values of β at random given the described distribution, and calculates the value for the RPL equation. This is repeated many times, and the results are averaged to find the choice probabilities given the values of θ. The researcher then searches for the values of θ that maximise the simulated log-likelihood.

Despite its flexibility, the use of RPL raises some issues. The first is the choice of distribution. The distribution of the parameters must be specified exogenously. Using a normal distribution or any other infinite distribution can lead to extreme values for some parameters, albeit with small probabilities (Rigby & Burton, 2003). Some distributions can take both positive and negative values (Rigby & Burton, 2003), which can lead to parameter values that do not conform to prior economic theory. Because of these concerns, distributions can be truncated or censored (Rigby & Burton, 2004), or can be finite (Bhat, 2003).

A second issue, paradoxically, is the fixing of parameters. In practice, distributions are estimated for only some parameters, while other parameters are fixed. Of course, a fixed parameter could be viewed as a special case of distributional choice – a point mass at an average value – but that sort of distribution deserves special mention. For example, Revelt & Train (1999) assume a fixed coefficient for price. They make this assumption to improve the stability of the estimation, to make the calculation of willingness to pay easier, and to avoid problematic assumptions about the distribution of the price coefficient. However, a fixed coefficient for the price attribute assumes a constant utility of money. This assumption may be problematic for GMF, as the WTP for GM of types of consumers may be related to both different responses to GM and different marginal utilities of money (Burton *et al.*, 2001). As a result, if a RPL is necessary for taking into account respondent heterogeneity, then it may be important to estimate distributions for all attributes. On the other hand, the possibility of fixing some parameters raises the question of making the simplifying assumption that all parameters are fixed and that, consequently, a MNL is appropriate.

A third issue that parallels the other techniques for segmenting respondents is the conditioning of choices. If an RPL is conditioning the distribution of the parameters on some characteristic of the respondents, the question raised is how to condition the choices. In this respect, RPL is no different from MNL. Choice could be conditioned on membership in a cluster (Revelt & Train, 1999), on attitudes (Rigby & Burton, 2003), on demographics, or possibly on something else. Using RPL does not resolve this deeper issue.

A further issue is the open-form specification of RPL. The solution to RPL models is found through simulation techniques, which are less accurate than closed-form GEV models that can be estimated via analysis (Bhat, 2003).

RPL is one more data analysis tool, but it requires the researcher to exercise judgement, which complicates the work of assessing each model. For example, choosing a normal distribution for a taste parameter regarding, say, improving apple flavour, and a fixed parameter for price will mean two things: first, that the estimate starts from the assumption that most people have fairly similar preferences for improving the flavour of apples (two-thirds within one standard deviation); and second, that the WTP of each individual is a function only of their preference for the improvement and is unrelated to income, wealth, or money preferences. To some extent, these assumptions can be tested, but this then raises questions of which assumptions to test and how to do it. Thus, while RPL does not suffer from the same restrictive assumptions as MNL, each individual estimation relies on its own set of potentially problematic assumptions.

These two weaknesses of MNL models, the IIA property and the fixed parameters, have led to research on alternative specifications for RUM-based models. This research has developed a number of alternative approaches to modelling discrete choices, as discussed above.

4.4.5 Modelling discontinuous choices

The final complication to consider regarding discrete choice model is the range of methods that have been proposed for considering discontinuous or lexicographic preferences. As discussed above, the potential for lexicographic preferences is a concern for SP research, in particular because they would violate a key axiom of neoclassical choice theory. In this section, a number of approaches to modelling non-compensatory choices are considered.

The first point to make is that lexicographic strategies for choices are compatible with utility maximisation (V. Foster & Mourato, 2002; Plott, 1987). If continuity is not assumed, then a consumer's preferences could be such that one preference must be satisfied before the next most important preference can be considered. In that case, choosing the alternative with the highest value on the most important attribute maximises the consumer's utility.

Lexicographic strategies are a subset of combinatory strategies, which also include conjunctive and disjunctive strategies (Einhorn, 1970). These strategies differ from linear utility functions because they are not simply weighted sums of the attributes, but combine their assessments of the attributes in more complex ways. *Conjunctive* strategies require the chosen option to meet minimum levels or thresholds for all attributes; *disjunctive* strategies require it to be the best option on one of the attributes; and *lexicographic* strategies evaluate options using an ordered set of attributes (Camerer, 1995; Earl, 1983). All of these strategies are *non-compensatory*: if an alternative is not good enough with regard to one attribute, no combination of other attributes can compensate for this failure (Earl, 1983, 1986; Einhorn, 1970; Swait, 2001b). They are thus inconsistent with the assumption of continuity. Furthermore, they are inconsistent with the assumption of preference separability: non-compensatory strategies rely on interactions between choice attributes in the utility function (Einhorn, 1970).

Kurauchi & Morikawa (2001) noted that non-compensatory strategies have been considerably theorised, but they found few empirical applications in the literature. Furthermore, the empirical applications are not a literature in the sense of a coherent, interrelated body of knowledge, but are a few largely isolated attempts to deal with lexicographic preferences. What follows is a review of several empirical studies employing non-compensatory modelling.

Swait (2001b) developed an approach to non-compensatory modelling of CE data that allowed respondents to state threshold values for specific choice attributes. He surveyed consumers on rental car preferences and specifically asked whether they would rent cars of certain sizes or would rent cars from certain companies. What respondents said they would not do was modelled as thresholds. He added these thresholds to a standard logit model to create a penalised utility function. Individuals could make choices that violated their stated 'requirements', but with a cost to their utility. If the estimated penalty for violation was sufficiently high, then the threshold would never be violated. If the penalty for violation is not very high and the benefits were sufficient, such as a promotion being run by a rental company with which one would prefer not to do business, then violations could occur. As a result, Swait was able to estimate the 'value' to respondents of their stated requirements: what was it worth to drive a car of the wrong size? This penalised utility function incorporates the idea of thresholds, which is often how lexicographic preferences are viewed (Fishburn, 1974), but in a standard CE framework that allows for both compensatory and non-compensatory decisions.

There have been two main criticisms of this model. First, it is essentially a compensatory model; the thresholds 'merely serve to locate points of nonlinearity in an attribute value function that is compensatory' (Elrod *et al.*, 2004; see also Gilbride & Allenby, 2004). Swait (2001b), however, argued that this treatment was realistic: thresholds are 'fuzzy' and decision-makers do violate them. A second criticism is that this model relies on self-reports of what attribute levels are unacceptable (Gilbride & Allenby, 2004). Self-reporting on decision processes can interfere with the decision process by causing more careful processing, influencing decision criteria, and causing information overload (Elrod *et al.*, 2004; Gladwell, 2005). Other research on discrete choices has had some success in avoiding these two issues.

An attempt to address the two issues that Swait (2001b) encountered is a choice model developed by Elrod, *et al.* (2004). They replaced the linear function in a standard MNL with a general nonrectangular hyperbola (GNH). They argued that this functional form allows a fully non-compensatory modelling of decision-making, and can empirically distinguish compensatory, conjunctive, and disjunctive decision strategies from the actual choices made.

It also allows for combinations of compensatory and non-compensatory decision-making, as in the semi-lexicographic model. This model thus represents an alternative to standard MNL models and to an approach that relies on verbal protocols to determine use of decision thresholds or cut-offs.

Two aspects of the model in Elrod, *et al.* (2004) could be considered further. First, the model may be estimated by maximum likelihood, so that standard hypothesis tests can be used to assess model fit. However, one issue with the maximum likelihood estimation arises from the authors' statement that the model estimates any probability on the closed interval [0,1]. If the model is estimated via maximum likelihood and if the loglikelihood statistic is used to assess model fit, then the loglikelihood should be defined for every alternative. In a fully non-compensatory model, some alternatives would be completely excluded; the probability of choosing them would be nil. However, ln(0) is undefined, so it is likely that in practice these alternatives are treated as having very small but non-zero probabilities (McFadden, 1974). Although the probabilities may be small, the positive probabilities do result in a theoretically compensatory model. The second aspect of the model that could be extended is that it was developed for binary data – whether an applicant was or was not accepted. The model could potentially be modified to account for a choice made from several options.

Gilbride & Allenby (2004) also developed a model that was non-compensatory and that did not require the respondents to identify the attribute levels that were unacceptable. Choice was modelled as a two-step approach, in which consumers first decided which products (advanced cameras, in this case) were in the choice set and then decided in a compensatory way amongst them. The first step, a screening rule, was modelled as an indicator function that could accommodate both conjunctive and disjunctive rules for screening out unacceptable products. One finding from the research was that the two-step model was an improvement on a standard compensatory model.

Two issues arise with the model in Gilbride & Allenby (2004), however. First, whilst the authors found that they achieved better model fit 'despite the large increase in the number of parameters' (Gilbride & Allenby, 2004), this better fit could be due to the increase in the number of parameters. It would be interesting to assess whether the fit statistics were affected by an adjustment for the number of parameters. The second issue with the modelling for this research was the criteria for accepting or rejecting specific choice models. The researchers found that 92% of respondents were modelled as using the conjunctive rule plus compensatory process for making decisions. In addition, 58% of respondents were found to be screening choice sets based on one attribute only. It may have been difficult to distinguish compensatory decision making from a conjunctive screening process in the absence of information about the processes that respondents used to make their choices. In this research, this type of information was not available. It may also have been difficult to distinguish a one-reason conjunctive screening process from a lexicographic screening process. Thus, it may be possible to extend this research by combining the model from this research with an expanded survey method to collect not only choice information but also information on the decision process.

Researchers in Japan did consider lexicographic decision-making, and compared it to a compensatory model in the choice of whether to drive into the central business district (CBD) or use a public transportation park-and-ride facility. They were interested in determining the impact of dynamic road signs that displayed real-time information about the level of congestion in the CBD and the estimated travel time. One research question was whether the decision process was compensatory or non-compensatory, because new information from the signs would have different impacts depending on the decision process. In two publications (Kurauchi & Morikawa, 2001; Yamamoto, Kurauchi, & Morikawa, 2002), they assessed three different models: a standard compensatory model, a semi-lexicographic model, and a decision-tree derived from a data-mining tool. Their models also included a latent class approach that allowed respondents to have different hierarchies of attributes. They found that the semi-lexicographic model, which included a non-compensatory decision on the most important factor and a compensatory process for the remaining factors, had the best fit. The standard model was not sufficiently sensitive to the possibility of commuters being captive to certain transport modes, and the data-mining technique did not improve the analysis of commuters' choices. One important issue they discovered was that the theoretical analysis required richer data than the researchers actually had. While complex effects of threshold values and attribute hierarchies could be theorised, the practical modelling could examine only a limited range of non-compensatory effects.

Another dataset was the basis of research comparing five compensatory and non-compensatory models (Lee & Geistfeld, 1998). The researchers collected SP data on washing machines and analysed respondents' choices to determine which of five models best represented each person's decision-making. Importantly, they used a full factorial experimental design. By including all possible combinations of factors in their design, they had a dataset from which they could estimate the interactions of the product attributes, which is essential for identifying non-compensatory decision-making (Einhorn, 1970). The general compensatory model, the basis of MNL, was used least. A better compensatory model was the simple additive model, in which each attribute was equally weighted. The most-used model was conjunctive, and many respondents also used a general non-compensatory model. Two important lessons can be drawn from this research. First, non-compensatory decision-making may be more prevalent than compensatory decision-making – the researchers found that 64% of respondents used a non-compensatory model. Secondly, the research demonstrated a method for applying the conjunctive and disjunctive valuation function from Einhorn (1970) to choice modelling research. Unfortunately, this research modelled choices in a different way than other choice modelling research. The dependent variable was not which choice from choice set was made, but was whether or not each alternative was chosen. Because the fundamental choice problem is to determine which alternative from a set is preferred, CE analyses each chosen option in the context of its particular choice set. This analysis thus did not approach the choice situation in the same way as discrete choice analysis or CE research.

Another example of non-compensatory decision-making based on utility maximising is Sloss (1995). The proposed model assumed that parents selecting child-care facilities made a lexicographic decision based on one of three attributes of the facilities. Whichever facility ranked the best on the attribute that the parents valued most was the facility selected. In this way, the model was completely non-compensatory. However, because the model was entirely theoretical, it would need to be combined with empirical data in order to assess whether the proposed model did represent actual choice behaviour. In addition, by construction, all the facilities in the choice set had met certain minimum criteria of acceptability. The research did not include a discussion of how this process of identifying a consideration set had occurred.

An alternative approach to modelling non-compensatory choices as maximisation was introduced by Recker & Golob (1979). They developed a model in which decision-makers use a hierarchy of attributes and critical thresholds to make choices amongst alternatives, a model later used by Kurauchi & Morikawa (2001). However, rather than maximising the likelihood that the observed choices would be made, they constrained the model to predict the actual choices made, and then adjusted the distribution of the threshold values around a mean to simulate those choices. Importantly, they found that decisions could be modelled in this way. They created a hierarchy of attributes and threshold distributions that mimicked the actual data. As they pointed out, however, they could not address the question of whether a completely non-compensatory model was any more ‘realistic’ than a completely compensatory one.

Although these examples of modelling non-compensatory choices are not numerous, they raise several issues. They did find that non-compensatory models could describe actual choices, and they found that a variety of functional forms were useful. Some of the successful models were the semi-lexicographic, the GNH, and Einhorn's (1970) conjunctive and disjunctive functions. This research also compared the results of different models using standard statistics that were described earlier: prediction success percentages and likelihood-based statistics. The different models were more or less successful in part because of the data available; in order to test the assumption of compensatory decision-making, richer data seems necessary. Arising out of this research are two main issues. First, the extent to which the alternative models truly are non-compensatory is open to challenge. Secondly, the most successful non-compensatory research modelled binary choice: whether an alternative was chosen or not. Further research may be able to extend these models to choice situations with more than two alternatives.

One avenue of possible work on lexicographic preferences that has been discussed theoretically is the use of alternative distribution assumptions in a random parameter logit (RPL) model. Lexicographic preferences are discontinuous, and estimating RPL models with Bayesian techniques may allow the use of distributions that are discontinuous or multi-dimensional, or that represent point-masses at specific values (Bhat, 2003). Whether these can be made to mimic lexicographic preferences is an open question, but they are certainly able to model more than binary choice. It should be remembered, however, that Bayesian techniques have drawbacks, including complexity of model estimation and the unavailability of classical, likelihood-based hypothesis tests (Elrod *et al.*, 2004).

4.4.6 CE research: summary

In 2003, Bhat wrote of 'renewed excitement in the field' of discrete choice modelling (Bhat, 2003) because of the progress that researchers were making. There have been various choice experiment researchers extending this technique, and the above review has discussed several areas of advances in CE research. One important area is in removing or dealing with a number of known biases in SP methods. For example, the ‘cheap talk’ technique and calibration research are attempting to remove or compensate for hypothetical bias. Another important area of research is improved analytical tools. The GEV and RPL methods described above represent the most recent methods. They have even been combined into the mixed GEV, or MGEV, model (Bhat, 2003). A final important frontier in discrete choice analysis is expanding the model of decision-making. A Hybrid Choice Model (HCM) has been proposed (Ben-Akiva *et al.*, 2001) as a way of integrating economics, sociology and psychology. The aim is to develop practical models beyond RUM theory to incorporate insights from the study of cognitive processes.

It appears that CE methods could be used to address the issues surrounding consumer behaviour with regard to GMF that were raised in Chapters 2 and 3. One issue to consider is whether preferences over food attributes may be considered separable. Two examples in the literature of models that include attribute interactions are Gerard, *et al.* (2003) and McFadden & Train (2000), both of which estimate two-way interactions of choice attributes. In the first paper, the interactions are not significant, while they are found to be significant in the second paper. Furthermore, survey design techniques that may generate the appropriate data for exploring preference separability are available (Halbrendt *et al.*, 1994; Louviere *et al.*, 2000). The above research appears to demonstrate that assessing the preference separability is a concern of both survey design and modelling, which may be an important insight for considering attribute interactions in the choice of GMF.

The second issue to consider is the assumption of continuity. One consequence of assuming continuity is that protest responses may be viewed as intransigence on the part of respondents. Because respondents should in theory be willing to view different attributes as commensurate, the fact that their response patterns do not reveal trade-off behaviour results in the exclusion of their responses. It may be interesting to explore these types of responses in more detail, especially as they may represent 20 per cent to 30 per cent of respondents to CE surveys on GMF. If protest responses are not arising from economically valid reasons, *i.e.*, the respondent would not have a similar reaction in a market situation, then excluding the responses in an estimation of economic impacts appears to be appropriate. However, if protest responses in a survey situation are motivated by preferences or behaviours that would carry over into a market situation, then it may be appropriate to include those responses in an economic estimate (Blamey, 1998a; Lindsey, 1994; Yoo *et al.*, 2001). In the case of GMF, prior research appears to suggest that some consumers are opposed to the use of gene technology in food production, as discussed in Chapter 2. It may be expected that their market behaviour would reflect that stated belief. This suggests that there may be scope in SP research on GMF for allowing respondents to express discontinuous preferences with regard to the GM in such a way that their responses are not considered protest responses. It may be possible to consider possible violations of continuity in the design of a CE survey.

Another consequence of assuming continuity is that lexicographic choices are problematic for CE research. Data analysis assumes a compensatory model of decision-making. The different elements that go into a decision are held commensurate: they can all be measured on a single scale. This commensurability operates on two levels, at the level of the attributes and at the level of the whole alternative. Commensurability at the attribute level is clear in the equations for the deterministic portion of utility, which are linear in attributes even as the error structures are made more complex. Commensurability at the alternatives level is clear in the basic RUM preference inequality:

$$V\left(\mathrm{x}_{1\mathrm{i}},\ldots,\mathrm{x}_{\mathrm{ki}}\right)-V\left(\mathrm{x}_{1\mathrm{j}},\ldots,\mathrm{x}_{\mathrm{kj}}\right)>\varepsilon_j-\varepsilon_i\,.$$

In order for this inequality to have any meaning at all, the values on the left-hand side need to be comparable to or commensurate with each other. If the two options are strictly speaking incomparable, then this inequality makes no sense. For example, the following operation is nonsense because the quantities are measured on incommensurate scales:

$$10 \text{ pounds} - 3 \text{ yards} = ?$$

Current CE practice circumvents the issue of potentially lexicographic choices by assuming that preferences are indeed compensatory, but that the point of indifference at which one element is finally equal to the other is outside the levels of the attributes used for the choice set. Thus, one uses the information available within the bounds of the choice set to extrapolate about preferences outside those bounds. Another approach might be to assume that lexicographic choices are the results of non-compensatory preferences or strategies. Swait & Adamowicz (2001) have in fact identified the study of non-compensatory decision strategies as an area of future research.

A discussion of continuity leads naturally to the issue of aggregation. If it is not possible to determine the point at which an individual is indifferent between, for example, having GMF at a discount and having more expensive non-GMF, then it is not possible to monetise that person's indifference. Similarly, unless it can be shown that utility can be measured cardinally, then it is not possible to measure the utility that one person receives from consuming non-GMF. Without measurements of the monetary value or the cardinal utility value of non-GMF, it is not possible to compare the gains and losses to consumers that could occur in the market for a food product from the introduction of GM technology in food production. It would be possible to make some judgements about the WTP on the part of some consumers or about possible market penetration of some products, but statements about average discounts or welfare impacts – statements that require knowledge about all consumers – are theoretically impossible.

A final issue with CE research is the assumption of maximisation as the framework for modelling decision-making. In the choice situation diagram in McFadden (1986), 'decision protocol' is one of the variables affecting choice. The text, however, skips over how different decision protocols could be used, what they are, and how they could be modelled. Instead, a consumer is said to have 'a protocol to maximize preference taking into account the opportunity cost of the outlay for the product'. This description of consumer behaviour does not consider the decision processes that consumers might use. It also discusses 'maximising preferences', although it is not preferences that are maximised in RUM theory. *Utility* is maximised, subject to *fixed and stable* preferences. The same issue is apparent in the Hybrid Choice Model (Ben-Akiva *et al.*, 2001). The authors appear to intend that the HCM bring sociology and psychology into economics, but they also appear to focus on random utility maximisation and do not seem to include research on the cognitive processes that people might use in making decisions. In his Nobel address, McFadden (2001b) addresses the issue of rule-based choices or alternative decision protocols, but in the end maintains that the standard RUM model, with a few modifications, is the appropriate approach. The overall effect is what Boland (1981) called an unassailable all-some statement: 'All people maximise something.' This appears to remove a critical consideration of the maximising decision protocol from the realm of research questions.

These issues with CE research all arise from its foundation in neoclassical economic theory. They are also issues that have been examined by theories of bounded rationality, theories which were introduced in an earlier chapter. To extend CE practice in order to consider the issues raised by consumer reactions to GMF, it may be valuable to consider research from this area of economics.

4.5 Bounded rationality

At root, bounded rationality focuses on the idea that human cognition is limited or ‘bounded’, so that attempts to be fully rational are consequently also limited. As discussed earlier, this core idea has led in several directions. A central issue that differentiates notions of bounded rationality from each other is the existence or possibility of an optimum solution. Some notions of bounded rationality can be considered constrained optimisation, with consumers seeking a neoclassical-type optimum solution but with the additional constraint of their limited cognitive capacity. Other research has explicitly rejected this focus on optimisation in favour of understanding the choice processes that decision makers use. It is this strand of bounded rationality that the current research will follow in an attempt to consider the issues raised by a neoclassical treatment of consumer choice regarding GMF, especially with regard to CE research.

This version of bounded rationality has two components: the limitations of the human mind and the structure of the environment (Gigerenzer & Selten, 2001b; Gigerenzer *et al.*, 1999). Decision makers can exploit regularities and structure in their choice environments to make better decisions, given that they have limited cognitive capacity (Gigerenzer & Selten, 2001b; Simon, 1956). Research in this vein has thus examined both the possible heuristics and the choice situations. Some of the specific heuristics studied have been satisficing, Elimination by Aspects, and fast and frugal heuristics, which will be examined in turn. After a discussion of those specific heuristics, the literature that combines RUM-based models and heuristic decision making will be considered.

4.5.1 Simon’s satisficing

When Simon first proposed bounded rationality (Simon, 1955, 1956), he suggested that decision makers attempt to find solutions that satisfy and suffice – decision makers *satisfice*. This model of choice behaviour is particularly concerned with the serial nature of search that accompanies decision-making. A decision-maker accumulates information about the alternatives available in the choice set, rather than having all the information available all at once. One example is shopping for an appliance: different alternatives will be available at different shops, and collecting information on the possible alternatives requires time and effort (Earl, 1983, 1986; Earl & Potts, 2004). Another example is the impermanent nature of some alternatives, such as an offer on a house that will expire unless accepted (Simon, 1955).

Because alternatives or choice options are not available all at once, especially not without search, individuals need a decision process that does not require full information or full availability. Simon suggested that individuals have threshold levels of satisfaction and are willing to accept alternatives that meet those levels (Augier, 2001; Simon, 1955, 1956). Every attribute has a threshold level, although they may not all be constraining for a particular decision. Each option is examined in turn to see if it is sufficient and satisfactory. If it does not meet all the threshold levels of all the attributes, it is rejected and the next one examined in turn. The threshold levels are not necessary invariant; new information can be incorporated (Simon, 1955).

Critically, the outcome of this process depends on the order in which options are assessed (Gigerenzer & Selten, 2001b). The option chosen is not necessarily the one that would score highest on all the attributes if all options were available simultaneously. This aspect places the notion of time centre stage in decision-making and therefore economics (Earl, 1986). It also raises issues of shop layout, shopping district geography, telephone directory organisation, etc.[6]

Satisficing as a model of consumer behaviour poses several challenges for CE research. First, it suggests that the continuity axiom does not describe actual consumer behaviour. Satisficing

[6] I am indebted to Peter Earl and his lectures at Lincoln University for these examples.

is non-compensatory choice behaviour because options that do not meet attribute threshold levels are removed from consideration, regardless of their levels of other, less important attributes. Increasing the levels of these less important attributes, which are not the reason that the option was omitted, does not increase the ‘value’ of the option or the probability that it will be chosen. Thus, consumers are not exchanging more of one attribute for less of another, and no point of indifference can be located. As a result, it is impossible to measure aggregate consumer preference in terms of average discounts, average WTP, or changes in consumer welfare. Without being able to determine sets of attributes that render consumers indifferent, such aggregate measures are not possible.

Another challenge that satisficing poses to CE research is that the notion of maximisation has been set aside. For example, Simon (1956) developed a model of an organism with several goals. He showed that search time can be divided amongst several goals without the need for marginal calculations. RUM-based modelling of CE data relies on the assumption that the chosen alternative provides maximum utility for the respondent. The chosen alternative thus has more ‘value’ than the other alternatives, which allows calculation of the model parameters and, later, of the implied prices or partworths of the different attributes. If consumer choice proceeds by a process of satisficing, using CE survey results to make calculations of marginal utility and implied prices for attributes would be without foundation.

A final way in which satisficing challenges CE surveying is perhaps the most troubling. Satisficing places the process of searching for information, such as decisions on which attributes to examine and when to stop searching for more options or more information, at the centre of consumer theory (Earl, 1986; Gigerenzer & Selten, 2001b). A CE survey, by contrast, pre-determines for respondents which information is salient and then presents the entire choice set at once. It obviates the need for searching. If satisficing truly describes consumer behaviour, then CE surveying is unrealistic. It could not be assumed that the results of a CE survey would mimic the results from actual behaviour in a market, because the two processes of arriving at decisions are different, and the results could also therefore be different.

Satisficing is the original model for boundedly rational decision making. It focuses on the interaction of cognitive limitations and environmental structure, and provides a description of the choice process. It addresses some of the issues that have been raised with regard to the neoclassical model of choice in the context of GMF: it does not assume continuity of preferences, it does not attempt to aggregate individual choices in aggregate price or welfare measures, and it does not rely on maximisation. However, it also suggests that the whole approach of CE research, which is to identify a few attributes and present all the information about choice alternatives and attributes simultaneously, is potentially an unrealistic simplification of consumer choice environments. Satisficing as a model of decision making may caution researchers about making claims as to the ability of survey data to mimic actual markets. Unfortunately, research into reactions to GMF must rely on survey data, simply because real market data is virtually unavailable. Satisficing is thus a poor model for CE survey data.

4.5.2 Tversky's Elimination by aspects model

Elimination-by-aspects (EBA) is a choice model first proposed by Tversky (1972a; 1972b), and it is often cited as a non-compensatory decision-making model (Bettman *et al.*, 1998; Conlisk, 1996; Earl, 1986; Payne & Bettman, 2001). In EBA, the decision-maker examines all the alternatives in the choice set on each attribute in turn to determine whether they are acceptable. Whereas satisficing is a model of sequential search in which each alternative is assessed in turn, in EBA all alternatives are examined first on one attribute and then on another. Evaluation proceeds until only one alternative remains, one that has met the thresholds for all attributes examined. The order in which attributes are chosen is thus consequential.

The main strength of EBA when it was proposed was that it accounted for structural dependence of the choice alternatives, which relaxed the IIA assumption (Tversky, 1972a). The independence of the comparison of two choice alternatives from the rest of the choice set was no longer assumed. Tversky maintained that relaxing this assumption was important for making realistic choice models (Tversky, 1972b). Since the development of EBA, other models based on RUM theory have relaxed the IIA assumption, as discussed above. Furthermore, McFadden (1981) showed that an EBA model can be replicated with a modified MNL form. EBA is thus less compelling now than when it was introduced.

One problem with EBA is that the attributes are not evaluated in a fixed order (Tversky, 1972b). Whether an alternative is chosen is a function of whether it is acceptable on all the attributes examined, and the order in which attributes are chosen for examination is probabilistic. With no order to the attributes, any one attribute could be used at any time in the decision process (Conlisk, 1996; Earl, 1986). Alternatives could thus be accepted or rejected for trivial reasons, even if the decision maker has specific attributes that are of paramount importance. Critically, this violates the axiom of a weak order, in which each choice alternative has a fixed ranking in the choice set. The ranking of an alternative could shift, depending on the order in which attributes were examined. This led Tversky to conclude that the model was not rational, because it could lead a decision-maker away from the best choice (Tversky, 1972b). In the example of GMF, consumers could believe that avoiding GM was an important food issue, but might base actual product choices on, for instance, shape of the packaging.

Another issue with EBA is that the attributes are binary (Elrod *et al.*, 2004; Williams & Ortuzar, 1982): alternatives are either acceptable or not (Tversky, 1972a, 1972b). This limitation makes EBA less descriptive of alternatives than the MNL model. Rotondo (1986), developed a method for considering a range of prices, in which price is modelled as being acceptable or unacceptable at each price level. Expanding this approach to several attributes would make EBA more flexible but also more complex, detracting from the cognitive simplicity of the original model.

The EBA model may thus be a difficult model to apply to CE research. Although it allows for non-compensatory preferences, relaxing the axiom of continuity, it also violates another axiom, that of weak order. It is also complex to use in multiattribute situations, which are often exactly those choice situations that CE research considers. Finally, EBA has been superseded by other models; if the IIA assumption needs to be relaxed, there are other models available.

4.5.3 Fast and frugal heuristics

Cognitive simplicity is central to research on *fast and frugal heuristics*. These are decision algorithms that highlight the importance of the decision environment and the use of rules of thumb in making decisions (Gigerenzer & Goldstein, 1996). Using these heuristics, decision are made with little computation of relative values or weights, probabilities are not included, and choice alternatives are not reduced to unidimensional utility (Gigerenzer *et al.*, 1999). Choice is modelled as the result of one, single, non-compensatory reason, rather than a process of integrating available information (Gigerenzer & Goldstein, 1996).

In describing research on fast and frugal heuristics, Todd & Gigerenzer (2003) explain that:

> [t]he research program described so far encompasses three big questions: (1) What are reasonable heuristic principles for

> guiding information or alternative search, stopping search, and making a decision using the results of that search? (2) When and why do these heuristics perform well, that is, how can they be ecologically rational? (3) How well do fast and frugal heuristics actually perform in real-world environments? (p. 153).

In response to the question of reasonable heuristic principles, a number of heuristics have been defined. The most commonly investigated one is Take The Best (TTB) (Broder, 2000; Gigerenzer & Goldstein, 1996; Gigerenzer *et al.*, 1999; Newell & Shanks, 2003; Todd, 2001; Todd & Gigerenzer, 2003), which is similar to lexicographic choice in that it focuses on one attribute at a time and is non-compensatory (Broder, 2000). The steps for this choice algorithm are as follows. The first step is to examine all the choice options. If only one is recognised, then that option is chosen. This is called the 'recognition heuristic' (Gigerenzer & Goldstein, 1996). The second step is to assess all of the recognised alternatives attribute by attribute, starting with the attribute considered most important. If more than one alternative is best on the first attribute, then the decision maker uses a second attribute. This proceeds, as in lexicographic choice, until an attribute is decisive in identifying the best option. The main difference between TTB and lexicographic choice is thus the recognition heuristic.

The next two big questions, which concern the performance of these heuristics, raise an issue that makes research into these fast and frugal heuristics difficult: how does one measure the concept of 'performing well'? How well heuristics and boundedly rational theories 'perform' is at the heart of debate over their economic validity. For a seminal article on bounded rationality, Simon placed an organism's survival at the heart of the research: survival equals success (Simon, 1956). In *Lifestyle Economics*, Earl (1986) mentions the idea of successful consumption in the book's first sentence, but does not indicate what he or the consumers he studies would define as consumer success. Bettman, *et al.* (1998) do discuss the issue, saying that decision makers perform well if they are *rational* and *adaptive*. Although the rationality of decisions can be described in terms of consistency and transitivity (Arrow, 1963; Bettman *et al.*, 1998; Payne & Bettman, 2001), 'adaptive' does not seem to mean anything more than 'successful', which, again, is undefined.

Research on fast and frugal heuristics seems to treat 'performing well' as synonymous with one of three propositions:

1. Choices made by people are optimal.
2. Choices made by heuristic strategies are optimal.
3. Choices made by people are consistent with heuristics.

Curiously, although fast and frugal heuristics are in theory based on the idea that optimisation is impossible (Gigerenzer & Selten, 2001a), the first two propositions are derived from other notions of bounded rationality that accept the existence and primacy of an optimum. That the choices people make are optimal is true by assumption for neoclassical economics. People choose what they choose because they think it best for themselves (McFadden, 2001b). If it is true that fast and frugal heuristics lead to optimal choices, then Friedman's assertion that economists can model choices 'as if' they are optimal (Conlisk, 1996) is validated. It would not matter that real people used heuristics and models used optimisation, because both methods would reach the same choices.

The second measure of success puts the focus on the potential sub-optimality of bounded rationality. In order to find a heuristic strategy that leads to an optimal decision, one must first identify that optimum. The research then relates the result of different heuristic strategies to this optimum, finding which heuristics reach this best decision, and in what types of environments (*e.g.*, Rubinstein, 1998). To measure 'performing well', the research measures the difference between the pre-identified best decision and the heuristically determined decision. Thus, when Gigerenzer, *et al.* (1999) assert that simple heuristic tools can be just as accurate as optimisation, they are focussing on the potential sub-optimality of heuristics rather than their behavioural validity.

This type of research on heuristics has identified decision environments in which heuristics and explicit optimisation lead to similar choices. In this effort, it is expanding Simon's original idea of simple strategies suited to their environments. Compensatory, integrative decision protocols, such as posited in neoclassical theory, are better than heuristic strategies at finding the correct answer when the decision environment contains a number of dimensions or attributes that can take multiple values and are not correlated (Payne & Bettman, 2001). The effectiveness of compensatory, linear models is reduced, however, when attributes are negatively correlated (E. J. Johnson *et al.*, 1989), although it is not clear whether heuristic strategies are any better. In environments with limited information – where there are only a few salient attributes, where the attributes have few levels, or where attributes are highly correlated – non-compensatory heuristics can find the correct solution, but with less effort (Gigerenzer *et al.*, in press; Sadrieh *et al.*, 2001). In these environments, heuristic strategies may be said to perform 'better' than explicit optimisation, once the conservation of cognitive effort is taken into account.

Several researchers have looked at the impact of limited information in the context of a simple problem: choosing which of a pair of German cities has a larger population (Gigerenzer & Goldstein, 1996; Gigerenzer *et al.*, in press; Gigerenzer & Selten, 2001b). The cities were described by 10 binary attributes, such as whether a city has a soccer team or whether it was formerly in East Germany; one of the attributes was whether the simulated chooser recognised the city. When the Take The Best heuristic and multiple regression analysis were compared, they were equally accurate in choosing the larger city from each pair. Similarly, in choice situations in which some information was unknown, TTB and multiple regression also had nearly identical accuracies. Several other strategies were also examined, including a unit-weight linear model, in which all the attributes are weighted equally in making a decision, and a Minimalist choice algorithm, in which only one randomly chosen attribute was used to compare the two cities. These did not perform as well as TTB and multiple regression, but were better than random at choosing the large city.

Similar results have been obtained with other problems and in other decision environments (Czerlinski, Gigerenzer, & Goldstein, 1999; Gigerenzer *et al.*, in press). TTB is an accurate heuristic strategy that can find the correct answer to a binary problem nearly as well as multiple regression using in-sample data. With out-of-sample data, TTB can be even more accurate than the estimated regression model.

In assessing this research on fast and frugal heuristics, it is important to note the environments in which the choices are being made. In the German city problem described above and on a task of deciding which of two US cities has a larger per capita homeless population, the attributes are all presented as binary values (Gigerenzer & Goldstein, 1996; Gigerenzer *et al.*, in press). The information present in a binary value is limited, making these choice environments hospitable for simplified decision-making. In addition, the attributes are clearly correlated. The Minimalist decision heuristic, which chooses one attribute at random for making a decision, chose the larger German city correctly 67% of the time (when all attribute information was made available), only 2% worse than TTB or multiple regression (Gigerenzer & Goldstein, 1996). Although the choice of attribute might have been random, the attributes clearly tend to agree with each other on the question of which city is larger; they generally seem to point in the same direction.

These researchers have shown that heuristic strategies, and in particular the Take The Best heuristic, can find the correct answer as well as more complex models of decision making, especially in certain environments. But this research has two important drawbacks. First, it is focussed on decisions for which there are correct answers, an optimal solution. By modelling these situations, it maintains the focus of economic research on optimal solutions. Other behavioural economists have suggested that optimality is unnecessary, unrealistic or impossible. In addition, the evidence these researchers have gathered to demonstrate that heuristics are as good as specific integrative, compensatory models raises an important question: how good are those compensatory models? It may be possible to improve the compensatory models that the researchers are using, which would reduce the relative performance of the heuristic models. An optimised model should be better than any other, by definition.

The second drawback is the simplified decision environments studied. The experimental design in Gigerenzer & Goldstein (Gigerenzer & Goldstein, 1996) clearly had correlated attributes, or the Minimalist strategy would not have been as effective. The authors argue that this choice environment mimics real-world environments (Gigerenzer *et al.*, in press). Regardless of real world conditions, the constructed choice environment of a CE survey tends to be orthogonal by design, to remove any positive or negative correlations between attributes. In such a choice environment, fast and frugal heuristics are less likely to be effective at determining a 'correct' answer.

Furthermore, although a heuristic strategy can choose the larger city from a pair or cities, the decisions that consumers face each day are much larger and more complicated. For example, take the daily question, What should I have for lunch? The answer depends on what I might have for dinner, which depends on the time I shall have to prepare dinner, which depends on when I leave the office, which depends on how much work I get done, which depends on how much time I take for lunch. Furthermore, my dinner preparations depend on whether there are leftovers, whether someone in the household took the leftovers for lunch (information I might not have), whether I could maybe squeeze in a trip to the supermarket on the way home, etc. This task, deciding what to have for lunch, is part of a staggering web of decisions that all depend on each other. (If I eat leftovers tonight, I might have to cook tomorrow, which means missing a trip to the gym, so I should have a light lunch today and tomorrow. Unless, of course, I have takeaways for tea tomorrow.) And yet, people actually eat lunch.

The only measure of how well heuristics perform that does not imply the existence of an optimum solution is the third measure, which looks at what people actually do. This concern was not included in Todd and Gigerenzer's (2003) research agenda cited above, but forms the core of behavioural economics (Earl, 1986) and is most consistent with the idea of rejecting optimisation. One example of research into the use of heuristics is an experiment by Gabaix & Laibson (2000). Subjects were given a complex, branching payoff matrix. Their task was to select which of several starting boxes resulted in the highest payoff. The researchers computed the payoffs, and therefore had a correct answer for the maximum solution for each matrix; the researchers knew which starting box would yield the highest payoff. They also modelled a heuristic strategy called Follow The Leader, in which branches with low payoff probabilities were disregarded. While this strategy did not produce the maximum payoff, it did result in higher-than-random payoffs. The experimenters found that Follow The Leader with a cut-off probability of 0.25 (branches with probabilities under 0.25 were not followed and calculated) most closely modelled the actual choices made by subjects. A perfectly rational model, which computed expected value by multiplying pay-offs and probabilities, did not. In another experiment (Gigerenzer *et al.*, in press; Rieskamp & Hoffrage, 1999), respondents had to choose which of four companies had the highest annual profit. A lexicographic strategy modelled respondents' answers as well or better than the other strategies modelled, including an integrative approach. Both of these experiments focussed on the strategies that people actually used in making their decisions.

Two articles have specifically addressed whether respondents use the TTB heuristic in order to make decisions. Broder (2000) set up four experiments to test whether people used TTB and under what conditions. He found that it was a valid model for some people, but not for others. Furthermore, he found that participants tended to use different strategies depending on the experimental set-up. If the experiment required them to search for information (rather than having it available all at once) and to 'invest' or pay for the information they received, participants were more likely to make decisions that could be modelled with TTB. That is, their decisions were more 'frugal' with information. Newell & Shanks (2003), on the other hand, were not convinced of the general validity of TTB. In particular, they noted that Broder had informed participants of the relative weights of the different attributes in the choice environment, the *cue validities*. Newell & Shanks included learning about the choice environment as part of their experiment; participants would need to learn about *how* to decide at the same time as they were deciding. They found that respondents did not tend to use TTB. In particular, they did not stop and decide based on the first piece of discriminating information. Instead, participants looked for more information to confirm their earlier judgements before making a choice. Taken together, these two pieces of research suggests that TTB could be valid in some circumstances, but that it might be too simplistic.

These three ways of measuring whether fast and frugal heuristics perform well seem to fit together to form a complete rationale. If it can be shown (a) that people use heuristics and (b) that heuristics can lead to optimal solutions, then it could follow (c) that people behave optimally by using heuristics. This would undercut one of the chief objections to bounded rationality – that economic agents who perform optimally will out-compete agents who are sub-optimal because of bounded rationality (Rabin, 2002). Nevertheless, only one measure of ‘performing well’ – do people actually decide this way? – is closest to the idea of bounded rationality propounded by Simon and Earl.

A boundedly rational model of consumer choice with regard to GMF could therefore focus on mimicking or replicating the choices that people actually make, rather than attempting to identify an optimum solution. Such a model would need to contain a non-compensatory element to account for the possibility that some people make lexicographic choice when considering GMF. Thus, some version of a lexicographic model or TTB would be appropriate.

4.5.4 Issues with boundedly rational models

A first issue with boundedly rational models is that research on heuristic strategies has shown that identifying the specific decision strategy used is problematic. It may be true, first of all, that boundedly rational decision making converges with optimisation (Doucouliagos, 1994), validating Friedman’s contention that behaviour can be modelled as if it is optimising. However, whether the two types of decision making converge is an empirical question that argues for more study of bounded rationality, rather than dismissing it as unnecessary (Conlisk, 1996). Mathematical models for this purpose have been developed (Rubinstein, 1998), but have also been criticised for being armchair models without enough basis in psychology, decision theory, and empirical evidence (Friedman, 1998; see also Simon's chapter in Rubinstein, 1998).

Several empirical studies have investigated the use of heuristics, and have generally found it difficult to identify the specific decision protocol used. In the experiment discussed above that entailed choosing the company with the highest profit (Gigerenzer *et al.*, in press; Rieskamp & Hoffrage, 1999), subjects were asked to select the best company from a set of four companies described by six attributes. The researchers found it difficult to identify which strategies were being used because respondents' choices could have arisen either from integrative or lexicographic strategies, and both theories fit the data. In the German city problem described above, the different decision protocols led to the same answer in 92% of the pairwise comparisons (Broder, 2000), making it impossible to identify the simulated protocol just from the choices made. The identification problem is further exacerbated when considering choice probabilities of an entire sample: if some respondents make choices using integrative protocols while other use heuristic protocols, the overall sample probabilities can still be compatible with RUM theory (Koning & Ridder, 2003). It would seem from the perspective of the whole sample that decision-making was integrative, making it difficult to identify specific individuals' heuristic strategies.

These results are an example of a 'flat maximum' (Broder, 2000), and are not confined to difficulties identifying the use of heuristic strategies. Linear, integrative models continue to perform well even after the parameter weights are changed, as long as the signs of the parameters are maintained (Broder, 2000). For this reason, Payne & Bettman (2001) modelled both a standard decision protocol that attached weights to different attributes, but also modelled an 'equal weight strategy' in which all attributes were equally weighted. While this is a problem for identifying the decision protocol that respondents use – how is the researcher to identify the correct protocol when several fit the data? – it is also an argument in favour of bounded rationality. If a number of different decision protocols can all lead to the same alternative in a given decision environment, then a cognitively simple, heuristic strategy is more efficient than a holistic, integrative strategy (Gigerenzer & Selten, 2001b).

A second criticism of models of bounded rationality is their limited applicability. Nearly all research using EBA and fast and frugal heuristics has assessed their validity using binary attributes, so the models need to be expanded in order to apply more generally in multiattribute choice situations (Elrod *et al.*, 2004). There are some exceptions to the use of binary attributes that demonstrate the difficulties. Rotondo's (1986) nested model of EBA that allowed prices in the choice set to take several values, shows that the number of nests would expand exponentially with the number of additional levels modelled. Expanding such a model to include several multi-level attributes would create a cumbersome number of nests.

The number of alternatives in the choice situation is also an issue. Rieskamp & Hoffrage (1999) did expand fast and frugal heuristics to situations of more than two alternatives. However, subjects were taught the relative importance of choice attributes before engaging in decision-making (Broder, 2000). They were thus all using the same set of attribute weights. In the case of GM food, consumer research suggests that consumers will not all place the same weight on the attributes of food. The choice data needs to be analysed both for the decision protocol used and the weights given different attributes.

Because each decision rule has limited applicability, bounded rationality has been accused of being *ad hoc* (Conlisk, 1996). At root, this criticism resembles the infinite regress problem. If bounded rationality seems *ad hoc*, this is because it fits the decision protocol to the data but does not say how the protocol is chosen. If bounded rationality were to propose an invariable rule about how decisions were made or an invariable rule about how decision protocols were chosen, then it could no longer be accused of being *ad hoc*. The same rule would apply in all situations. This would end the infinite regress of deciding how to decide how to decide, etc. The infinite regress problem was discussed above. In essence, it is a problem with boundedly rational models and one that cannot be resolved. However, as also discussed above, maximising models have problems with infinite regress, too, so the issue is not limited to boundedly rational models.

The perception that boundedly rational models have limited applicability has also led this area of economic research to be accused of unnecessarily multiplying the number of options that must be considered (Rabin, 2002). It is true that a number of decision protocols have been suggested. However, only a few have been widely discussed and intensively researched, so the set of standard boundedly rational protocols is quite small. Furthermore, given the complexity of advanced discrete choice modelling, it would be difficult to argue that researchers are interested in reducing the number of parameters to be estimated, or that economic modellers are averse to complexity (Rabin, 2002).

4.5.5 Bounded rationality and RUM-based research

Bounded rationality's critique of RUM theory is neither new nor esoteric, so it is no surprise to find that this critique has had some effect on RUM-based discrete choice modelling research. The Hybrid Choice Model (Ben-Akiva *et al.*, 2001) is in part an attempt to incorporate bounded rationality into discrete choice theory by 'relaxing the basic RUM core, such as incorporating non-RUM decision protocols, in an effort to relax simplifying assumptions and enrich underlying behavioral characterizations' (p. 4). This statement appears to suggest that boundedly rational decision protocols should be considered in discrete choice research. It is important to note, however, that the specific extensions of standard discrete choice research proposed in Ben-Akiva, *et al.* (2001) are: making error terms more flexible, modelling attitudes and perceptions, and including latent population segments. These specific extensions discussed in relation to the HCM do not appear to address decision-making protocols or their potential impacts on discrete choice modelling. Thus, the specific research agenda outlined does not seem to incorporate bounded rationality's criticisms of neoclassical and RUM theory.

Most references to heuristic strategies in the discrete choice literature see them as mental shortcuts that respondents use because of task complexity, learning effects, or respondent fatigue (Adamowicz & Boxall, 2001). Task complexity is generally avoided by design in CE research because decision tasks are simplified to promote compensatory decision-making

(Louviere *et al.*, 2000). In research that has tested for effects from learning or fatigue, no effects have been found (V. Foster & Mourato, 2002; R. M. Johnson & Orme, 1996). Thus, if complexity, learning, and fatigue effects can be minimised, observed use of heuristics might represent respondents' preferred decision-making strategies.

Discrete choice theorists are in fact hesitant to incorporate alternative decision protocols (Bolduc & McFadden, 2001):

> A second reason for caution in moving away from compensatory RUM-based models is that these models can approximate many behavioural patterns, even if they arise from cognitive effects that do not appear to be consistent with preference maximisation. For example, rule-driven behaviour is likely to be broadly consistent with self-interest, and hence well-approximated by a RUM model, even if the selection process that leads to the use of such rules is quite different than utility maximisation….Non-compensatory models may be fully consistent with random preference maximisation, and may be approximated well by RUM models that mix over utility functions of different features of alternatives (p. 233).

This position is predicated on three ideas: behaviour can be modelled as maximisation, regardless of psychological motivation; the market impact of individuals' use of heuristics is negligible; and heuristic decision-making can be modelled by integrative linear models. The first idea, that something is being maximised, has been shown to be a metaphysical statement, a declaration of the researcher's paradigm rather than a statement with empirical content (Boland, 1981). Rabin (2002) further states that ignoring the behavioural accuracy of modelling assumptions is ‘bad social science’. The second idea, that the use of heuristics does not affect market results, seems to be at odds with established practice of CE research. The accepted practice is to identify respondents who seem to be using decision heuristics and exclude their responses from the dataset, because the use of heuristic strategies may affect the estimated model parameters (Blamey *et al.*, 2001). It is thus difficult to reconcile these two ideas: either heuristics are at base motivated by and indistinguishable from compensatory preference maximisation, as Bolduc & McFadden contend, or heuristics-based choices have the power to bias experimental results. Both contentions cannot be true. These conflicting statements thus argue for more study of the potential impacts of heuristic decision making. The third idea, that RUM models can approximate non-compensatory decisions, has been empirically studied. In fact, compensatory models do not necessarily accurately model choices made with non-compensatory decision rules, and the fit between a RUM-based model and a heuristic decision protocol is sensitive to the correlational structure of the choice environment (E. J. Johnson *et al.*, 1989). The reasons for being cautious in moving away from RUM-based models of decision making thus seem insufficient, and, when interrogated, seem to suggest the importance of empirical work on the question of the use and impacts of heuristic strategies.

Little empirical research has compared heuristic and RUM models for discrete choice analysis. One example of such research (Arentze *et al.*, 2001) examined three models, including one rule-based model, one RUM model, and a hybrid model. The RUM model had better predictive power than the other two, but the researchers found the results inconclusive. Importantly, the results of different models were not directly comparable because they required different data for their estimation. The researchers could not determine whether the difference in performance were due to the different datasets or the models themselves.

This review of research that uses theories of bounded rationality to model decision making has considered several different aspects of the literature. First, a number of different models were considered, but satisficing and EBA were shown to be inappropriate choices for CE research on GMF. Satisficing is in part a theory of focusing attention on which alternatives should be included in the choice set, but a CE survey has already narrowed the choice set and obviated the need for a focusing strategy. EBA, for its part, can be replicated by nested RUM models, so it might not be as useful an example of a boundedly rational decision process as other models. However, a lexicographic or TTB model, based on research into fast and frugal heuristics, appears to offer possible ways to analyse consumer reactions to GMF. Secondly, the relationship between bounded rationality and maximisation was considered from several perspectives. Some research on bounded rationality closely follows a neoclassical framework, but assumes additional cognitive constraints on optimisation. Other research professes to focus not on optimisation but on the performance of decision heuristics. This research, however, often makes reference to some presumed optimal state, which keeps the focus on the potential existence of an optimum.

One strand of bounded rationality research offers a different perspective on the motivation for consumers' choices to that offered by the neoclassical framework. This strand focuses on the decision tools that people use without trying to evaluate their optimality. It is this research that may provide a basis for considering the issues regarding discontinuous preferences and market-level aggregation.

4.6 Conclusion

This literature review has provided the background for an empirical examination of consumer responses to genetically modified food. It has first determined that such an examination would need to rely on a stated preference method, because of the limited availability of market data on consumption of GMF. It has also suggested that an attribute-based stated preference method is appropriate, and identified a choice experiment survey as the method of choice. CE surveys allow responses to different product attributes to be studied efficiently and are consistent with neoclassical economic theory.

This literature review has also indicated areas where prior research may be extended. One such area concerns the separability of preferences. If preferences are assumed to be separable, then the resulting utility function is additive (Deaton & Muellbauer, 1980). The extant literature that uses CE techniques to investigate WTP for GMF appears to assume that preferences over food attribute are separable (Burton & Pearse, 2002; Burton et al., 2001; S. James & Burton, 2003; Onyango et al., 2004). Both the survey designs and the resulting analysis in this literature appear to reflect such an assumption. It may be possible to test empirically the separability of preferences over the attributes of GMF by building on the CE research discussed in this literature review.

A second area where further research could be conducted concerns the assumption of preference continuity. The Archimedean axiom that guarantees continuity has been widely discussed in the theoretical, mathematical, and empirical literature. Many solutions have been proposed to accommodate discontinuous, that is, lexicographic, preferences. However, despite the suggestions of lexicographic preferences from some research regarding consumer reactions to GMF, these accommodations do not appear to have been considered in the context of GMF. As a result, SP research regarding GMF has shown large percentages of protest responses. In addition, many potentially lexicographic choice patterns have been treated as continuous.

By not explicitly considering lexicographic preferences, GMF research may not be fully representing aggregate welfare or demand impacts of GMF. Some research has considered the aggregation issue in a practical manner, for example, estimating the percentage of consumers who are ‘out of the market’ for GMF. Such estimates in effect represent an upper bound for market penetration of GMF. Nevertheless, CE research on GMF could be extended so as to attempt to provide a picture of the whole market. This would be valuable, for example, if one is considering the possible impacts on a particular product of a wholesale shift to production using gene technology or considering the welfare impacts of different policy options.

A final subject in CE research that might bear further investigation is the possibility of rule-based, heuristic, or boundedly rational decision-making in responses to surveys. The possibility that decisions might be rule-based has been raised by discrete choice researchers and identified as a potential area of future research (Ben-Akiva *et al.*, 2001). There is literature explicitly comparing rule-based and utility maximising behaviour. There may be further scope for exploring the connexions between bounded rationality and CE research. In particular, the issues surrounding demand for GMF suggest that a rule-based approach to choice behaviour may be an interesting avenue for research on consumers’ choices regarding GMF.

These issues – separability, continuity, aggregation, and maximisation – could be addressed by building on the current literature, especially through consideration of CE survey design and models for data analysis. The methodology for this will be considered in the next chapter.

Chapter 5

Methodology

5.1 Introduction

This chapter presents a method for a choice experiment survey that would allow investigation of the issues raised concerning demand for genetically modified food. This proposed method builds on the material presented in previous chapters, specifically the observed consumer reactions to GMF and the discussion of theory and empirical techniques for explaining and investigating consumer choices.

In attempting to theorise observed consumer reactions to GMF, several issues arose that might bear further investigation. First, there is evidence that some consumers are unwilling to accept GMF, regardless of the price discounts offered or the potential non-price benefits that GMF might provide (Bredahl, 1999; Gaskell *et al.*, 2003; Heller, 2003). As discussed in Chapter 3, this behaviour is inconsistent with the axiom of continuity, which guarantees that consumer will be willing to make exchanges between product attributes (Earl, 1983; Fishburn, 1988). The refusal to accept compensation in exchange for having GMF has the result that no point of indifference can be calculated. The prices at which these consumers would be indifferent between GMF and non-GMF cannot be determined.

A further consequence of the lack of continuity was discussed as part of the literature review above: aggregate measures of the market-level impacts of GMF cannot be obtained. Without an indication of indifference or a measure of WTP, the impact on the market for a commodity of a switch from non-GM production to GM production cannot be fully determined.

The theoretical discussion above also highlighted a second aspect of behaviour that might benefit from further research: the suggestion that GM technology may be viewed differently, depending on the types of benefits it produces (Pew Initiative, 2003; Rousu *et al.*, 2003). If the preference regarding the attribute ‘GM’ is separable from other preferences, then its marginal rate of substitution with price, which indicates the WTP for GM, should be independent of other product attributes.

The theoretical discussion suggested that concepts of bounded rationality could be useful in describing consumer reactions to GMF. In particular, the notion of heuristic or rule-based decision-making (Gigerenzer & Selten, 2001b; Gigerenzer *et al.*, 1999) provides a theoretical framework for lexicographic choice behaviour regarding GMF. Importantly, a major difference between bounded rationality and neoclassical theory is the latter’s focus on utility maximisation as the criterion by which individuals make decisions (Simon, 1955, 1956). A boundedly rational model of consumer decision-making regarding GMF would not assume that choices are optimal, but instead would suggest that they are made consistently and heuristically according to situation-specific criteria.

Two aspects of the present research suggest that a choice experiment survey is an appropriate method to investigate these four issues – separability, continuity, aggregation, and maximisation. First, the focus on future products, on GMF enhancements that are not currently available in the market, suggests that a stated preference research method is required (Burton *et al.*, 2001; Louviere *et al.*, 2000). The focus on product attributes and their potential interactions suggests that an attribute-based survey method would be preferred to other survey methods (Bateman *et al.*, 2002). A CE survey is thus an appropriate way to investigate these issues.

In Chapter 4, a number of studies were reviewed which have examined consumer demand for GMF. However, prior research can be extended to examine the main issues of the present research, and in particular the issues of preference separability and preference discontinuity highlighted in Chapter 2. By explicitly considering these two issues, it may also be possible to improve aggregate measures of the impact of introducing GM into the food supply.

Research on bounded rationality provides a basis for extending CE methods in another direction, so that heuristic models of decision making can be considered (Ben-Akiva *et al.*, 2001). While these alternative models of decision making have been used for discrete choice research in the past, the present research may be able to expand on prior research in two ways. First, the proposed research would use only one dataset for the different models. Thus, differences in the performance of the models would not be confounded with differences in datasets. In addition, the proposed research would use CE data containing several alternatives, several attributes, and several attribute levels. It would thus build on prior research demonstrating the success of heuristic models in cases of binary data.
This chapter will develop a possible method for examining these four issues and for considering consumer demand for GMF in the context of these two economic theories of consumer choice. The chapter thus proceeds with a step-by-step discussion of research design, with reference to the above considerations. The first step described is an appropriate design of the choice experiment itself, particularly the method for determining how to describe each choice alternative. The next step is the generation of the other elements of the survey besides the choice experiment questions. The final part of the chapter discusses the models that are proposed for analysing data from the CE survey.

5.2 Choice experiment design

Choice experiment design must consider the potentially competing concerns of realism, balance, and orthogonality. This discussion of the proposed choice experiment therefore begins with a discussion of these considerations.

Realism is a particularly important concern (Bateman *et al.*, 2002). First, as explained in Chapter 4, stated preference research can be influenced by hypothetical bias. In order to limit the impact of hypothetical considerations, choice experiments should be as realistic as possible. Secondly, the content validity of a survey can be enhanced with realistic portrayals of choice situations (Bateman *et al.*, 2002). The present research chose to survey respondents about a specific food product in order to heighten the realism of the survey. The product chosen was apples. They were selected because they are widely consumed, so that most respondents would be familiar with eating them. Furthermore, they can be modified to achieve changes in eating qualities, nutrition, and use of agricultural chemicals (Richardson-Harman, Phelps, Mooney, & Ball, 1998). Thus, it would be valid to represent apples as having such modifications. An addition appeal of apples is that they are whole, unprocessed food. Thus, they contain raw DNA and protein, which highly processed foods such as oils and sugars do not (Rousu et al., 2004). Thus, eating a GM apple would mean eating modified DNA. Choosing apples as the example product maintains a focus on consumer reactions to consuming modified protein and DNA.

The issues of balance and orthogonality arise with the statistical design on CE survey choice sets. The design of the choice sets is thus presented next, along with assessments of balance and orthogonality.

After consideration of prior research on GMF, the present research focussed on five attributes, listed with their factor levels in Table 5.1.

Table 5.1. Apple attributes for choice experiment

Attribute	Levels
Price ($ per kilogram) (*Price*)	1.50, 2.40, 2.70, 3.00, 3.30, 3.60, 4.50
Genetic modification (*GM*)	non-GM, GM
Level of chemical insecticide use (*Chem*)	30% less, current level, 10% more
Level of antioxidants (*Health)*	Current level, 50% more, 100% more
Flavour (*Flavr*)	Current, improved

There were several considerations in selecting these attributes and their levels. First, it is desirable that the Price attribute (*Price*) have several levels covering a wide range of prices. If *Price* is held to a few levels, then either the range would be small or the distance between the levels large. A small range, in particular, is problematic, because it would not distinguish consumer who would purchase GMF at large discounts from those who would not want to purchase it at all. The attribute *GM* is specified simply as a binary variable. This is in keeping with New Zealand labelling laws, which specify that certain ingredients need to be labelled as 'genetically modified'. This choice experiment thus mimics a label that consumers are likely to see (GE Free New Zealand, 2005). The level of chemical insecticide use (*Chem*) is included as an attribute because there are currently commercialised GM crops that affect insecticide use, such as Bt maize. Furthermore, pesticide residues have been shown to be an important consideration for apple consumers (Harker et al., 2003). The levels for this attribute are the same as those used in other research (Burton et al., 2001; S. James & Burton, 2003). The level of antioxidants in apples (*Health*) is an example of a potential second-generation GM trait (Bredahl, 1999; Chan, 2004), one that offers a health benefit to consumers. Another possible consumer-oriented impact of GM research is improving apple flavour, so this attribute is also included (*Flavr*). However, flavour is a complex function of sugars, acid levels, and texture (Harker *et al.*, 2003) and apple preferences are heterogeneous (Richards, 2000), so it is specified simply as two levels: current and improved.

The choice set as described above contains five variables: one with six levels, two with three levels each, and two with two levels, which can be written $6^1 \times 3^2 \times 2^2$. The full factorial has $6 \times 3 \times 3 \times 2 \times 2 = 216$ options. This is too large a choice set to be used for a single survey, so a fractional factorial was necessary. Importantly, the most common method of choice set design – main effects fractional factorial – collects data that can only describe the effects of each independent attribute on consumer choice. A main effects design does not consider the interactions between different attributes. However, as discussed above, there are indications in the literature that the value placed on the food attribute ‘GM’ may interact with the values other food attributes. To examine the possibility of interactions between choice attributes, it is necessary to use a larger fraction of the complete factorial.

The possibility that GM technology used in different ways can affect choice differently was considered by Burton & Pearse (2002). They presented the attributes to respondents as ‘health benefits through GM’ and ‘lower prices through GM’. Two aspects of the design of that survey are important for considering the issues raised in the present research. First, respondents who wished to avoid GMF could only select the *status quo*. That is, a respondent who wished to express an absolute preference for non-GMF would select only the *status quo*, which would result in a ‘protest response’ pattern of responding. Thus, it would not be possible to separate protest respondents from respondents with strong preferences for non-GMF. Secondly, with this approach it was not possible to determine separate values for each of the attributes healthfulness, price, and GM, so it was also not possible to determine how these attributes were interacting. To examine the impacts of interactions, it would be necessary to consider, for example, health benefits created with GM and health benefits created without GM. Thus, their research provides indications of possibilities for expanding survey design.

The present research thus proposes a choice set design that allows the estimation of the interaction of GM with each of the other product attributes. Such a design would clarify two issues: one, the extent to which the GM attribute was a dominant consideration, and two, the interaction of GM with other product characteristics.

The alternatives in the choice set were created in several steps. First, the attribute GM was set aside and a main effects design created for the remaining attributes. The main effects fractional factorial is based on Hahn & Shapiro (1966). This design also yields the same results as a graeco-latin square (Burton *et al.*, 2001), which can be presented thus:

Table 5.2. Græco-latin square

	B0	B1	B2
A0	C0, D0	C1, D2	C2, D1
A1	C2, D2	C0, D1	C1, D0
A2	C1, D1	C2, D0	C0, D2

The attributes describing the choice alternatives are indicated by letters and the attribute levels by numbers. The upper left-hand cell, A0, B0, C0, D0, represents the alternative with the lowest level for all four attributes.

This main effects design was only appropriate for a 3^4 factorial, however, so modifications were necessary in order to use the attribute levels in Table 5.1. The changes are more easily explained if the design is rewritten so:

Table 5.3. 3^4 main effects fractional factorial

Alternative	*Chem*	*Health*	*Flavr*	*Price*
1	0	0	0	0
2	0	1	1	2
3	0	2	2	1
4	1	0	1	1
5	1	1	2	0
6	1	2	0	2
7	2	0	2	2
8	2	1	0	1
9	2	2	1	0

The attributes *Chem* and *Health* were unchanged. *Flavr* was, as noted, collapsed from three levels to two. This was accomplished by substituting a ‘0’ for every ‘2’ in the design grid

(Hahn & Shapiro, 1966). *Price* in the choice set was modified after the re-introduction of GM, so it will be discussed below.

In order to observe not only the main effect of GM but also its interaction effects, the number of options was doubled. Each main effects combination of attribute levels occured twice, once as genetically modified and once as non-genetically modified. This is a recommended method for designing choice sets such that two-attribute interactions may be estimated (Hahn & Shapiro, 1966; Louviere et al., 2000). The data could thus be used to assess whether *GM* had differential impacts on choice depending on the type of product enhancement offered. If respondents reacted solely to the process of gene technology, then the parameters for the interaction terms would not be significant. An additional benefit of this design was that it allowed respondents who were not interested in GM to choose alternatives other than the *status quo*. This feature of the design allowed lexicographic choices regarding GMF to be distinguished from protest responses, an issue discussed in Chapter 4.

The resulting choice set is presented in Table 5.4. In order to verify this design, a fractional factorial design catalogue was consulted. It is possible to find a 2^2x3^3 fractional factorial design such that all interactions with one of the factors are estimable (Hahn & Shapiro, 1966). Such a design nominally has 27 profiles. However, if the variable whose interactions are of interest has only two levels, then there are 9 redundant profiles after that variable has been collapsed to two levels. Elimination of the redundant profiles result in a design with 18 product profiles. Therefore, whether the choice experiment design started from a catalogue design for a 2^2x3^3 factorial and collapsed a factor, or started with a 2^1x3^3 main effects fractional factorial and doubled the design, as described above, the final number of profiles is the same.

Table 5.4. Attribute codes for interaction design

Alternative	*Chem*	*Health*	*Flavr*	*Price*	*GM*
1	0	0	0	0	1
2	0	1	1	2	1
3	0	2	0	1	1
4	1	0	1	1	1
5	1	1	0	0	1
6	1	2	0	2	1
7	2	0	0	2	1
8	2	1	0	1	1
9	2	2	1	0	1
10	0	0	0	0	0
11	0	1	1	2	0
12	0	2	0	1	0
13	1	0	1	1	0
14	1	1	0	0	0
15	1	2	0	2	0
16	2	0	0	2	0
17	2	1	0	1	0
18	2	2	1	0	0

There was, finally, the issue of *Price*. The above design contained three levels, but more price levels were desired for the survey. Unfortunately, the experimental design had to sacrifice orthogonality in order to have a wide range of attribute levels. Burton, *et al.* (2001) had a similar problem, in that there were seven price levels to assign to 27 profiles. They chose a random approach: prices were randomly assigned the profiles. The same method was attempted in designing the present research, but the covariance between *Price* and other attributes was too great. If price levels were restricted to six, being 2 × 3, then it was possible to double each factor level. Thus, where the design indicated that Price should be 0, the level was either \$1.50 or \$2.40, randomly assigned. Where the design indicated 1, the level was either \$3.00 (the base price) or \$3.30, and where the design indicated 2, the level was either \$3.60 or \$4.50. This semi-random method produced lower covariance than the fully random method. The following table provides the calculated covariance between *Price* and the other attributes. All other covariances were effectively zero.

Table 5.5. Covariance between *Price* and other attributes

	Chem	*Health*	*Flavr*	*GM*
Price	0.0537	2.22×10^{-17}	0.0929	-0.0730

The overall efficiency of an experimental design can be calculated as its *D-efficiency* (Chrzan & Orme, 2000; Kuhfeld et al., 1994). The statistic is calculated as:

$$100 \times \frac{1}{N_D \left| (\mathbf{X}'\mathbf{X})^{-1} \right|^{1/p}},$$

where N_D is the number of alternatives, p is the number of attributes or factors, and **X** is the $N_D \times p$ design matrix. Generally, this statistic is most useful when selecting the best design from several candidates, as it is measure of relative efficiency rather than an absolute measure (Kuhfeld *et al.*, 1994). Although only one design was considered, the D-efficiency was calculated for this design, and yielded a value of 45.4. The relatively low value (compared to designs cited in Kuhfeld, *et al.* (1994)) is likely to be the result of an unbalanced design. A balanced design, in which all attributes have the same number of levels or multiples of the same number of levels, is generally preferred to an unbalanced design (Louviere *et al.*, 2000). However, Kuhfeld, *et al.* (1994) indicate that realism in survey design is also an important consideration. In the present research, *Flavr* and *GM* were better as binary attributes, while *Price* needed to take a number of different values. Additionally, it should be noted that the D-efficiency of the experimental design that specified three levels for the *Price* attribute was 43.1, so that splitting *Price* into six levels increased the design efficiency.

Overall, this experimental design balanced three considerations: orthogonality, balanced design, and realism. The design was nearly orthogonal, with the only correlations between

Price and other attributes. These correlations were less than 10 per cent in all cases. The design was unbalanced, but the more realistic portrayal of the choice situation and the increased range of prices in the choice set compensated for the lack of balance.

Substituting actual levels for the codes, the final list of profiles was:

Table 5.6. Final set of first alternatives for the choice experiment

Alternative	*Chem*	*Health*	*Flavr*	*Price*	*GM*
1	-30%	Current	Current	$1.50	GM
2	-30%	50% more	Improved	$4.50	GM
3	-30%	100% more	Current	$2.70	GM
4	Current	Current	Improved	$3.00	GM
5	Current	50% more	Current	$1.50	GM
6	Current	100% more	Current	$3.60	GM
7	10%	Current	Current	$4.50	GM
8	10%	50% more	Current	$3.00	GM
9	10%	100% more	Improved	$1.50	GM
10	-30%	Current	Current	$1.50	Non-GM
11	-30%	50% more	Improved	$4.50	Non-GM
12	-30%	100% more	Current	$3.00	Non-GM
13	Current	Current	Improved	$2.70	Non-GM
14	Current	50% more	Current	$1.50	Non-GM
15	Current	100% more	Current	$4.50	Non-GM
16	10%	Current	Current	$4.50	Non-GM
17	10%	50% more	Current	$2.70	Non-GM
18	10%	100% more	Improved	$2.40	Non-GM

In a choice experiment survey, respondents are presented with a *status quo* option and some number of alternatives. The present research used two alternatives to the *status quo*. The table above indicates the profiles of the first alternative. The second alternative was produced by a technique called *shifting* (Chrzan & Orme, 2000; Louviere *et al.*, 2000). This technique recodes one set of alternative to produce a second set. Levels that were 0 in the original set become 1 in the shifted set, levels that were 1 become 2, and levels that were 2 become 0.

This creates a new set of alternatives that are descriptively different from the first set and but are statistically similar in terms of orthogonality and balance. The shifted set is shown in the next table.

Table 5.7. Final set of second, shifted alternatives

Alternative	*Chem*	*Health*	*Flavr*	*Price*	*GM*
19	Current	50% more	Improved	$2.70	GM
20	Current	100% more	Current	$1.50	GM
21	Current	Current	Current	$3.60	GM
22	10%	50% more	Current	$3.60	GM
23	10%	100% more	Current	$2.70	GM
24	10%	Current	Improved	$1.50	GM
25	-30%	50% more	Current	$1.50	GM
26	-30%	100% more	Improved	$4.50	GM
27	-30%	Current	Current	$3.00	GM
28	Current	50% more	Improved	$2.70	Non-GM
29	Current	100% more	Current	$2.40	Non-GM
30	Current	Current	Current	$4.50	Non-GM
31	10%	50% more	Current	$4.50	Non-GM
32	10%	100% more	Current	$2.70	Non-GM
33	10%	Current	Improved	$2.40	Non-GM
34	-30%	50% more	Current	$2.40	Non-GM
35	-30%	100% more	Improved	$3.60	Non-GM
36	-30%	Current	Current	$3.00	Non-GM

Finally, the choice questions for the survey were created by pairing one profile chosen at random from the first set with another chosen at random from the second, shifted set, and then including the *status quo* alternative. This created 18 choice questions with three alternatives each. To reduce the burden on each respondent, the choice questions were split into two groups in a technique known as *blocking* (Bennett & Blamey, 2001). Two versions of the survey were generated, each with nine of the choice questions. The final choice questions used for the survey are contained in an appendix.

One design issue with choice experiments is the inclusion of an *opt-out* alternative, one that the respondent can choose if none of the offered alternatives is satisfactory. In surveys of recreational activity, in which it can be difficult to encompass the range of possible activities in a single choice set, the opt-out alternative has been shown to be important (Banzhaf et al., 2001). Including an opt-out alternative would expand on prior CE surveys of preferences regarding GMF, which have not included such an alternative (S. James & Burton, 2003; Young, 2000). Offering an opt-out alternative may allow respondents to register disapproval of a choice question without needing to resort to a protest response. Allowing respondents to differentiate between true preferences for 'things as they are' and distaste for the choice alternatives would capture more information about preferences, leading to greater understanding of respondents' motivations. Every choice question for the present survey therefore included a 'None of the above' alternative.

A second design issue is the use of labelled alternatives versus generic alternatives (Bennett & Blamey, 2001; Louviere *et al.*, 2000). Labelled alternatives identify the alternative as a particular brand of product or as a particular type of option, *e.g.*, 'Government's plan' versus 'Industry's plan'. Generic alternatives are labelled as A, B, C or 1, 2, 3. It would have been possible to design a choice experiment for this research that used labelled alternatives. They could have been labelled, for example, 'Current Apples', 'GM Apples', and 'Non-GM Apples'. However, using such labels would highlight the GM issue and prioritise it over the other attributes in the choice sets. The questionnaire for this research thus used generic alternatives, labelled 'Apple A', 'Apple B', and 'Apple C'.

5.2.1 Dominated alternatives

When choice experiments are designed in this essentially mechanical way, it happens that choice questions are created in which one alternative is worse than the others for every attribute: it is a *dominated* option (Bateman *et al.*, 2002). Dominated options can be dropped from surveys (Burton et al., 2001; Halbrendt et al., 1994), because according to neoclassical theory no rational respondent would choose a dominated option. Surveys can also be redesigned to remove dominated alternatives (Bateman *et al.*, 2002).

Identifying dominated options in the present choice experiment was difficult. In a physical experiment, it may be possible to decide *a priori* that a higher temperature or less of a catalyst is desirable, so that a judgement can be made as to which options are truly dominated. In the context of consumer preferences, deciding that an alternative is dominated begs the question: it assumes the preference order that the research is attempting to determine empirically. This difficulty was apparent in the research in four ways, as explained below.

First, the status quo option could never be dominated. Although another option might have been better than the status quo option on every attribute, there was no way to determine how much bias respondents had towards the current state of affairs without asking them. Thus, keeping choice sets with apparently dominated *status quo* options served to measure the strength of that bias. This discussion of dominated option therefore ignores all cases in which the status quo appears to be dominated on an attribute-by-attribute basis.

The second difficulty concerned the main topic of the research: reactions to GM. A GM option was not necessarily worse than a non-GM option; the point of this survey was to find out whether this was true. Prior research suggested that consumers vary greatly in their preferences regarding GM, and that some are enthusiastic supporters willing to pay more for it (Gaskell et al., 2003; Li et al., 2002; Rigby & Burton, 2003). Prior CE research on GMF has found that there may be respondents with a preference for GMF (Rigby & Burton, 2003), although it is not clear the extent to which this preference is an artefact of the method of modelling choices (Rigby & Burton, 2004). It may not be universally valid to assign a negative sign to the attribute GM when assessing choice questions for dominance.

The third difficulty in *a priori* designation of dominated options concerned insecticide use. It may be true that consumers value less insecticide use over more, but this is not necessarily universally true. Some consumers may see a reduction in insecticide use as an open invitation to worms in their apples. If anything, they may prefer slightly more insecticide use because they have found insects in or on their apples or other produce in the past. It was again not clear whether to assign a positive or negative value to the attribute.

The fourth difficulty concerned improving apple flavour. In this choice experiment, flavour was allowed to have two levels only, current and improved. It may be that some consumers do not perceive an 'improved' apple flavour as an improvement. They may prefer the current flavour to anything different, regardless of whether it is meant to be an improvement.

Despite these concerns, four cases of potential dominance in the choice questions were identified. Questionnaire Version A, Question 7, Apple B (see appendix for the questionnaire) could be dominated by the *status quo* for consumers who do not place a premium on GM and who prefer less pesticide to more. It could also be dominated by Apple C for consumers who prefer less insecticide use to more. Version A, Question 8, Apple B could be similarly dominated by the status quo. Leaving these options in the choice survey would allow for the possibility that some consumers prefer greater insecticide use or prefer GM products.

A third case of dominance could be Version B, Question 12, Apple C. Apple B is equal to or better than Apple C for all attributes. However, Apple B has an Improved flavour while Apple C has the Current flavour. Because of the possibility that consumers may prefer the Current flavour, it would not be possible to decide unequivocally that Apple C is dominated.

A fourth case of dominance could be Version B, Question 13, Apple C. The only difference between Apple A, the *status quo* alternative, and Apple C is that the latter costs more per kilo.

This appears to be a fairly simple case of domination, and one that could possibly be dropped from the choice experiment.

These cases of potential dominance could be retained, for two reasons. The first reason is that retaining them allows respondents to express the full range of preferences over such contentious attributes as GM and insecticide use. The second reason for retaining them is to verify respondents' rationality. Retaining dominated option could allow researchers to determine whether responses are consistent and well-ordered (V. Foster & Mourato, 2002). Weak preference order is one of the neoclassical axioms of consumer choice (Fishburn, 1988) and a necessary prerequisite for economic rationality (Arrow, 1963). Furthermore, Tversky (1972b) pointed out that some choice strategies can lead to irrational choices. The presence of dominated alternatives allows respondents to make irrational choices, thus signalling the potential use of choice heuristics. If respondents are perfectly rational, then clearly dominated options will never be chosen.

The choice set whose design is described above aims to allow the present research to examine the issues that were identified in the earlier chapters. By using a fractional factorial that is larger than a main effects fractional factorial, the design may allow complex effects of GM technology on choice behaviour to be determined. As a result, it may be possible to analyse two different phenomena. First, parameters may be calculated for the interactions between GM and the other choice attributes, to test for the size and significance of those interactions. These parameters would thus test whether preferences may be considered separable. Secondly, the number of non-GMF choice alternatives may allow lexicographic choice regarding GM to be distinguished from protest responses. By identifying lexicographic choices separately, the impact of discontinuous preferences could be assessed.

The final issue that may be considered with this choice set design is the possibility of using a boundedly rational model of decision making. The data that this choice experiment may be able to generate is similar to data analysed in prior research into bounded rationality, but the design expands on prior research in several ways. First, the data from this choice experiment would be multi-leveled and multi-attribute, whereas many prior examples of fast and frugal heuristics have used binary data. In addition, the complexity of the choice set may also allow lexicographic choice patterns to be determined exactly; different preference orderings would not lead to the same choice set, as in some prior research. Finally, the same data may be used both for a boundedly rational model and for a neoclassical, RUM model, avoiding an issue found in some prior research of trying to compare models while using two different datasets.

5.3 The questionnaire

The choice questions described above are designed to be part of a larger questionnaire. This section considers the rest of the questionnaire, indicating where appropriate the intended use of each question and its source in the literature. This discussion is separated into sections mirroring those in the questionnaire. The proposed questionnaire itself can be found in an appendix to this thesis.

Administration of the survey is partly determined by the nature of the choice modelling. In order to present this type of survey to respondents, it is preferable to use either a face-to-face, postal, or drop-off-pick-up method. A fourth method, describing choice sets over the telephone, is cumbersome for CE surveying. Of these methods, face-to-face surveying is preferable (Amigues *et al.*, 2002; Bateman *et al.*, 2002), and in particular is preferable for the present research for two reasons. First, given that GM is a contentious topic, it may be advantageous to attempt to avoid a biased sample. Since postal and drop-off-pick-up surveys would allow respondents to evaluate the survey and its topics before deciding whether to complete and submit it, it would not be unreasonable to expect a bias towards respondents with strong opinions regarding GM (Bateman *et al.*, 2002). To reduce further the possibility of this problem, the survey is presented as a study on consumer preferences for apples. GM is only raised as an issue once respondents are engaged. The second reason for preferring face-to-face surveying is that it can afford interviewers the opportunity to probe the reasons for protest responses. Without prompting, some protest respondents may skip debriefing questions on questionnaires that they complete privately.

The proposed questionnaire is titled 'Consumer Survey on Preferences for Apples' and it displays the Lincoln University logo and coat of arms. The questionnaire was approved by the Lincoln University Human Ethics Committee. Each individual questionnaire has an identifying number for data-entry purposes.

A pilot survey was administered. The feedback led to two changes to the choice sets for the final version of the questionnaire. The first change was to the presentation of prices. On the pilot survey, prices were expressed in percentage terms. On the final questionnaire, prices were expressed in dollar terms, as described above. The second change was a non-random change to the order of the choice questions. For both versions of the questionnaire, the first choice question randomly generated contained three non-GM apples. The final version was changed so that the first choice question included both a non-GM and a GM alternative. This change allowed respondents to become aware of the different levels of the *GM* attribute on the first choice question.

5.3.1 Survey Section I

Section I of the survey contains introductory questions, the choice experiment, and follow-up questions. The first four questions are relatively easy ones designed as filters and ice-breakers. The first two questions can be used to exclude people who do not eat apples at home and who are not over 15 years of age. If potential respondents are filtered out at this stage, no information is to be collected from them. The next question asks the respondent to rank several attributes of apples from one (most important) to seven (least important). This question engages respondents in the survey in a relatively easy way and starts the process of considering different food attributes. It also provides a ranking of attributes that can be used to examine heuristic decision strategies for modelling. Genetic modification is not included in this list, again to avoid highlighting the issue. The fourth question asks respondents whether they avoid purchasing certain foods, with a follow-up question to investigate their reasons for food avoidance. This allows for identification of respondents sensitive to food ingredients or production processes.

The next part of Section I presents the nine choice questions. Respondents are given a set of A5-sized laminated cards, one card for each choice question. Respondents can indicate their preferred choice from each card for the interviewer to mark on the questionnaire. As two versions of the survey were created, the versions and their associated choice cards are colour-coded, either yellow or pink, to avoid errors. At the end of the choice experiment is a follow-up question to be asked of respondents who always chosen Apple A, the *status quo* option. It asks them the reason(s) why they had always choose Apple A. This open-ended question gathers information for analysis of protest responses. This type of follow-up question has been recommended for examining protest responses (Bennett & Adamowicz, 2001), and has been used elsewhere (Young, 2000).

Question 15 is included as another method for eliciting preferences. It is an open-ended contingent valuation question asking respondents the price they would be willing to pay for an apple genetically modified to be resistant to black spot. The GM apple would not need to be sprayed, as apples currently are. Respondents can be anchored on the price of $3.00 per kilo by suggesting that this is the typical price for apples in supermarkets (Wansink, Kent, & Hoch, 1998). This question tests for respondents' consistency, largely for whether respondents who reject GM apples in the choice experiment also reject them in the contingent valuation exercise. Rejection of GM apples in both valuation exercises would tend to suggest that non-choice of GM apple in the choice experiment is an expression of a non-compensatory preference for non-GM apples. Similar open-ended questions were included in the survey used in James & Burton (2003).

The final question in Section I asks three follow-up questions. The first question asks respondents whether they think these new apples will be available in the next five years. This is included in order to assess the realism of the survey. The next two questions solicit information on the difficulty of the choice exercise and the salience of the attributes included in the choice set. These are all recommended follow-up questions (Bennett & Adamowicz, 2001), and similar ones have been used elsewhere (Young, 2000).

5.3.2 Survey Section II

This section of the survey is entitled 'Your opinions' and seeks to gather information about respondents' attitudes. As described above, attitudes towards genetic modification, GMF, and nature have all been shown to correlate with willingness to purchase and willingness to pay for GMF. A set of attitudinal questions is therefore included in the survey. The main drawback of including a section on attitudes is that it makes the survey longer. The benefit is that the information could allow consumer groups to be identified in the absence of significant demographic effects. Responses could also be used to test for consistency of responses, both within the set of attitudinal questions and with the choice questions.

These questions take the form of statements to which respondents can agree or disagree. Respondents are asked to respond on a 5-point Likert scale from 'strongly agree' to 'strongly disagree'. They are also given the opportunity to state 'Don't know'. The statements have been placed in a random order and include both positive and negative formulations.

The attitudinal statements are of three types, as indicated in Table 5.8. The first type includes general statements about food preferences, specifically targeted to the apple attributes included in the survey. These statements, survey questions 17, 20, 21, 24, are intended to distinguish consumers whose main concern is flavour, price, pesticide use, or genetic modification. The choices of these consumers could then be described with their concerns in mind. Consumers who agree with the statement, 'I choose the least expensive apples', are expected to be more price-sensitive than other consumers, for example. Reactions to the statement, 'I would buy apples that are genetically modified', can be used to check respondents' consistency with the choice experiment responses.

Table 5.8. Statements to elicit respondents' attitudes

Food preference statements
Q17. I choose the apples with the best flavour.
Q20. I would buy apples that are genetically modified.
Q21. I choose the least expensive apples.
Q24. Too many pesticides are used to produce food.
Statements regarding GM
Q18. The use of genetic modification technology in food production offers a solution to the world food problem.
Q19. Producing genetically modified food is too risky to be acceptable to me.
Q25. Using genetic modification technology fits with my cultural and spiritual beliefs.
Q26. Genetic modification technology is tampering with nature.
Q27. Genetically modified products are environmentally friendly.
Statements of ecocentric attitudes
Q22. Natural environments have a right to exist for their own sake, regardless of human concerns and uses.
Q23. We should try to get by with a little less so there will be more left for future generations.

The second type of attitudinal statements is intended to capture attitudes towards genetic modification and GMF. A large number of these questions have been developed and used in different surveys. It has been necessary to select only a few to keep the questionnaire to a reasonable length. The selected questions are also presented in Table 5.8. In New Zealand, Small (Small, Wilson, & Parminter, nd; Small *et al.*, 2001) has done considerable work on attitudes towards GM and GE, and questions 19, 25, and 27 were drawn from his research (Small, 2001). Verdurme & Viaene (2002) have also examined consumer attitudes and were the source for questions 18 and 26. These questions were useful in that prior research for identifying different consumer segments, and are intended for the same use in the present research.

The third type of statement originates in the New Environmental Paradigm (NEP) (Dunlap & Van Liere, 1978). Environmental attitudes as identified by agreement with NEP statements have been shown to affect consumer behaviour (Roberts & Bacon, 1997). The specific statements used for this questionnaire are taken from Rosenberger, *et al.* (2003), who found these and similar questions useful in distinguishing respondents with lexicographic preferences for environmental goods. Strong agreement with these statements or similar statements has been linked to an ecocentric attitude (Roberts & Bacon, 1997; Rosenberger *et al.*, 2003), which has in turn correlated with distrust or rejection of GM technology (Siegrist, 1998). These statements, questions 22 and 23, are included in order to describe GM-refusers and identify respondents who potentially have ecologically-based lexicographic preferences.

5.3.3 Survey section III

The final section of the questionnaire collects personal and demographic information from respondents. Prior research has found that age, income, and educational attainment are not good predictors of willingness to pay for GMF. Nevertheless, this information can be collected in order to verify these earlier findings and potentially describe different consumer segments. Respondents are also asked about ethnic identification.

Personal information that has proven useful in determining a respondent's willingness to pay for GMF is gender and purchases of organically grown food. Women in New Zealand have been found less accepting of GMF than men (Couchman & Fink-Jensen, 1990; Gamble & Gunson, 2002), although some overseas research has suggested that there is no independent effect of gender on choices regarding GMF (Rigby & Burton, 2003). Preferences regarding organically grown food are obtained two ways. Respondents are asked how often they purchase such food, using five categories from 'never' to 'always'. They are also asked the percent of their food budgets spent on organic food. Two questions are used because they obtain different information. The frequency question asks how often the respondent's shopping basket contains something organically grown; the percentage question asks how large a portion of food spending is made up of such food. It is possible, for example, to buy a little bit quite frequently. The two different measures, frequency and proportion, could in theory identify different consumer segments.

This personal and demographic information may also be used to determine the representativeness of the sample obtained.

5.4 The models

As discussed above, consumer behaviour regarding GMF seems to represent a challenge to two neoclassical assumptions regarding preferences: separability and continuity. The possibility that neoclassical theory does not fully describe behaviour in this circumstance raised the possibility of considering some other economic theory of consumer behaviour, specifically bounded rationality. Choice experiments have been tightly linked to RUM modelling in their historical and theoretical development (Louviere, 2001; Louviere *et al.*, 2000), but choice experiment data can be analysed with other types of models. This section proposes three RUM models and two boundedly rational models that may be appropriate for analysing data from this choice experiment survey. The models are: main effects multinomial logit, multinomial logit with interactions, cross-nested logit, strict lexicographic choice, and semi-lexicographic choice. The details of these models are discussed below.

5.4.1 Main effects multinomial logit

The MNL model is commonly used for analysing discrete choice data, whether from stated preference or revealed preference sources. It also often serves as a base model against which more complex RUM models are compared. A main effects MNL model is proposed for this research to provide a base model to which to compare not only a RUM model that includes interactions but also boundedly rational models.

If each attribute is considered to affect choice independently of the other attributes, the equation for the probability of choosing a particular alternative is:

$$\Pr(a_i) = f(Price, GM, Chem, Health, Flavr, SQ, \varepsilon),$$

where *Price*, *GM*, *Chem*, *Health*, and *Flavr* are the attributes from the choice experiment, *SQ* is an alternative-specific constant (ASC) estimating the impact of the *status quo* alternative, and ε is the latent utility term. Only one ASC needs to be estimated for these choice questions because of the use of generic alternatives (Bennett & Adamowicz, 2001). In theory, the *status quo* is the base case and the ASCs for the two non-*status quo* apples are set equal to each other. However, since this has the effect of estimating the bias against non-*status quo* alternatives, it is simpler to treat those alternatives as the base case and estimate one ASC for the *status quo*. Given the standard MNL form,

$$\Pr(a_i) = \frac{\exp\left(\sum_{k=1}^{K} \beta_k X_{ki}\right)}{\sum_j \exp\left(\sum_{k=1}^{K} \beta_k X_{kj}\right)},$$

the 6 × 1 vector X_j describes each of three alternatives in the choice question and the vector β is the set of parameters to be estimated.

5.4.2 Multinomial logit with interactions

The first extension of the modelling is to estimate parameters for the interaction terms. The design of the choice experiment allows four interactions to be estimated: *GM* × *Chem*, *GM* × *Health*, *GM* × *Flavr,* and *GM* × *Price*. The parameter for *GM* by itself captures the overall impact of gene technology on choice probabilities. The other main effects parameters capture the influence of each other attribute by itself on choice probability. The interaction terms allow for the possibility that attributes do not affect choice separately, but instead interact with the GM attribute. Including these interaction terms in a MNL allows the size and significance of such interactions to be estimated.

The choice probability equation is thus:

$\Pr(a_i) = f(Price, GM, Chem, Health, Flavr, SQ, GM \times Chem, GM \times Health, GM \times Flavr,$
$GM \times Price, \varepsilon),$

which expands the vector of attributes to 10 elements.

The key contribution of this model is that it directly examines the issue of how consumers evaluate GMF. If they have a uniform reaction to GM technology and do not consider technology in light of the potential benefits it offers, the parameters for the interactions should be insignificant. That is, regardless of the types of changes brought about through gene technology, their responses would always be the same for all GM apples. If, on the other hand, consumers are evaluating GM apples on a product-by-product basis, giving consideration to the potential benefits, then the interaction terms should be significant.

If the interaction terms were found to be significant, it might suggest that preferences over the attributes of GMF may not be assumed to be separable and utility may not be simply additive.

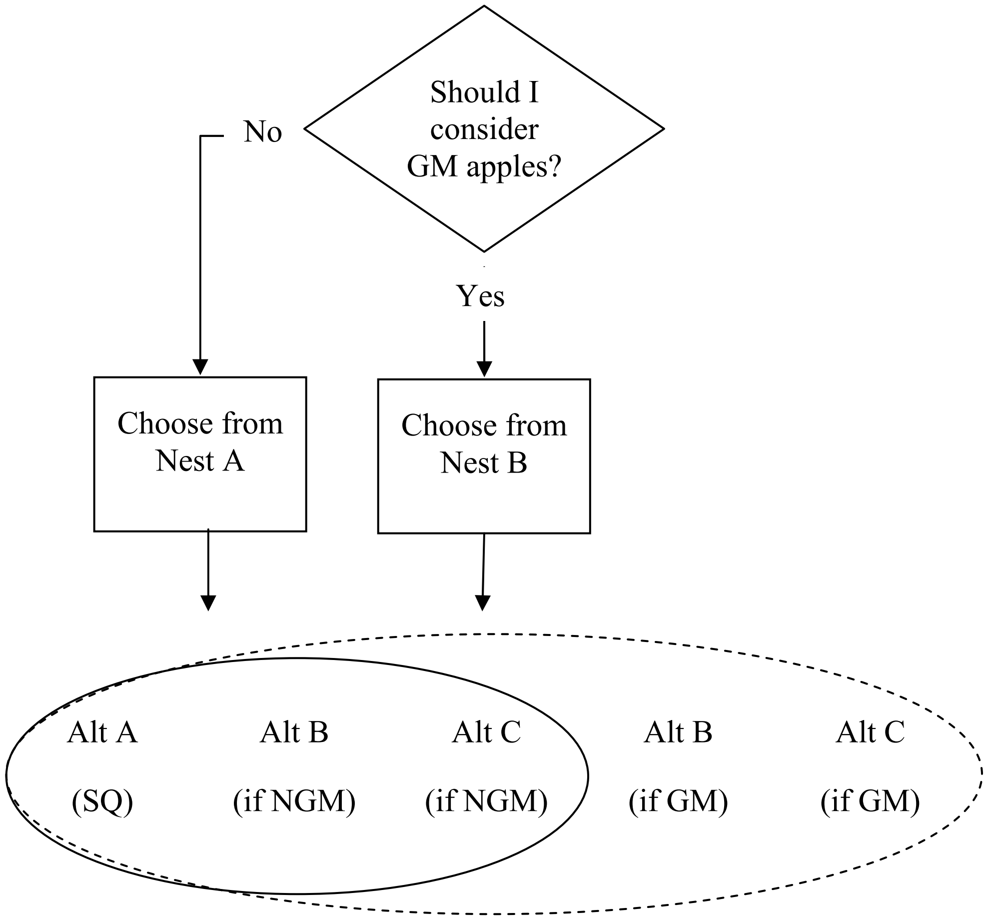
5.4.3 Cross-nested logit

The final RUM model to be estimated with the survey data is a cross-nested logit (CNL). This model is proposed for two reasons. First, a CNL relaxes the Independence of Irrelevant Alternatives (IIA) assumption, as discussed in Chapter 4. An MNL model assumes that the odds ratio between two alternatives – the probability of choosing one alternative from a pair of alternatives – is independent of the presence of other alternatives in the choice set. If, however, two alternatives are more similar to each other than they are to other alternatives, then this assumption might not hold. The example described in Chapter 4 was the Red Car – Blue Car – Bus example (McFadden *et al.*, 1978). One would expect the choice of transportation just between taking the Red Car and taking the Bus to be affected by the presence of another type of car in the choice set. For the present research, if the probability of choosing between two apples depends on whether the third alternative is present, then the IIA property is violated.

The second use of the CNL is to replicate a choice process that may effectively eliminate GM apples from consideration before deciding amongst the remaining alternatives. Although such a model is still compensatory, since it is a RUM model, the choice process it implies is similar to a lexicographic choice heuristic, as described below. It is therefore potentially useful for considering two issues: first, it may suggest the presence of discontinuous preferences regarding GM for some respondents, and second, it may allow a comparison of a maximising RUM model to a heuristic bounded rationality model.

It is hypothesised that respondents' decision process could be represented as in Figure 5.1. Respondents would first decide whether to consider alternatives that are GM. Their decisions

Figure 5.1. Cross-nested logit choice process



would then determine whether they choose from amongst all the alternatives presented in a choice question, or choose from a restricted set of alternatives that are non-GM. In the above diagram, 'Alt A' is alternative apple A, which is always the *status quo* alternative. 'Alt B' and 'Alt C' represent alternative B and alternative C, which are the alternative product profiles generated for the choice experiment. The indications 'GM' and 'NGM' denote whether the alternatives are genetically modified or not. For any single choice question, only three alternatives are available. Alternative A is always non-GM. Alternatives B and C may or may not be GM, depending on the product description generated by the experimental design. If both alternatives B and C are GM, then Nest A contains only the *status quo* alternative. As discussed previously, this is a possible source of protest responses to CE surveys about GMF. If both alternatives B and C are non-GM, then Nest A and Nest B are exactly the same.

An alternative survey design was considered, which would have led to a different nested structure. It was possible to use labelled alternatives, as opposed to generic alternatives, and to label one alternative 'GM' and the other 'non-GM'. Nest A would always contain two alternatives, the *status quo* and the non-GM alternative, and Nest B would always contain all three alternatives. This survey design was not chosen because it would emphasise the GM attribute over the other apple characteristics. If the goal is to determine the value of GM-ness relative to other attributes, then it is important that the survey design avoid highlighting one particular attribute.

Using the hypothesised structure diagrammed above, predictions could be made about the extent to which alternatives belonged to the two nests. Alternative A would belong to both nests in some proportion. Alternatives B and C, when non-GM, would also belong to both nests in some proportion. However, when alternatives B and C were GM, they would belong largely or exclusively to Nest B.

It is possible to translate this structure and these hypotheses into a cross-nested logit formulation. The generating function for the CNL model can be given as (Batley *et al.*, nd; Bierlaire, 2001):

$$G = \sum_{m} \left(\sum_{j \in C} \alpha_{jm} y_j^{\mu_m} \right)^{\frac{\mu}{\mu_m}},$$

where the alternatives j are a subset of choice set C, grouped into m nests; y_j represents the observed portion of utility; and parameters α_{jm} apportion the alternatives to the different nests (Batley *et al.*, nd). The scale parameter μ can be set to unity (Bierlaire, 2001; Train, 2003;

Wen & Koppelman, 2001), and the parameters μ_m capture the similarity of the alternatives within each nest, or the extent to which the within-nest utilities are correlated (Train, 2003). Thus, the generating function for the present research would be:

$$G = \left(\sum_{j=1}^{3} \alpha_{ja} y_j^{\mu_a} \right)^{\frac{1}{\mu_a}} + \left(\sum_{j=1}^{3} \alpha_{jb} y_j^{\mu_b} \right)^{\frac{1}{\mu_b}} .$$

If the hypothesised structure is correct, then the α_{jm} parameters will apportion the non-GM alternatives to both nests, but will apportion the GM alternatives mostly to only one nest.

5.4.4 Naïve lexicographic choice

The naïve lexicographic choice model is the first of two boundedly rational models proposed for examining the survey data. These models both examine the possibility that respondents may use a non-compensatory protocol in arriving at their decisions. Such a protocol would be inconsistent with the neoclassical axiom of continuity. This first model follows a strict lexicographic procedure, in which alternatives are assessed first on the most important attribute and then on each less important attribute in turn.

The key to this model is determining the order in which attributes are used. There are two sources of information from the survey on the relative importance of attributes to respondents. One source is the actual choices made. By examining the pattern of choices made, it may be possible to determine whether a respondent always chooses the alternative with the lowest price or the highest level of antioxidants. McIntosh & Ryan (2002) similarly used response patterns to identify respondents whose choices did not appear to conform to neoclassical choice theory. Response patterns from choice experiment surveys are often examined only to the extent that they identify protest behaviour. In that case, it is those respondents who always choose the *status quo* option who are of interest. They are identified by the response pattern ‘AAAAAAAAA’ in order to exclude their responses.

For the present research, if a respondent to Version A of the questionnaire ranks the attributes of the choice questions in the order *Price*, *Flavr*, *Chem*, *GM*, *Health*, then the responses to the choice experiment should be C, C, B, B, C, A, A, B, B. Given the five apple attributes, there are a possible 5! rank orders of attributes, or 120 possibilities. By contrast, the number of possible response patterns to the survey is 3^9, or 19,683 possibilities. Thus, although a naïve lexicographic choice process could lead to many different response patterns, they represent less than 1/100 of all possible patterns. Furthermore, because the survey design produced a choice set that is nearly orthogonal, the order in which attributes are examined should be evident from the response patterns. By contrast, the design of the choice experiment in research by McIntosh & Ryan (2002) meant that different lexicographic attribute orderings led to the same response pattern, so that orderings could not be uniquely identified.

The other source of information about the relative importance of the choice attributes is the introductory question asking respondents to rank the importance of seven attributes. This is a 'top-of-the-mind' question designed to solicit the importance that respondents place on attributes before they begin the choice experiment. By using the expressed rankings, it may be possible to determine the relative importance of several attributes in the choice experiment. This can help to confirm the rank order information from the naïve lexicographic choice model.

Data from each respondent can be summarised in a response pattern. These empirical response patterns will then be compared to the theoretical response patterns that signal potentially lexicographic choice. Correspondence between the empirical response pattern and the lexicographic pattern can be treated as *prima facie* evidence of a naïve lexicographic choice protocol and violation of the continuity axiom.

5.4.5 Semi-lexicographic choice

The semi-lexicographic choice model can be considered either a relaxation of the naïve model (Earl, 1986) or a screening procedure that combines non-compensatory and compensatory judgements (Bettman *et al.*, 1998; Coombs, 1964). Because prior research indicates that the use of genetic modification in food production could lead to non-compensatory decisions on the part of consumers, the semi-lexicographic choice allows some respondents to 'screen out' or exclude all GM alternatives. It is further hypothesised that some consumers may use *GM* to screen alternatives, while other may not. That is, some respondents may use a lexicographic protocol, while others may not. In addition to the screening rule, a compensatory decision can be modelled for the other attributes in the choice experiment. This part of the decision protocol can be modelled as compensatory but unweighted, which is a simplified alternative to the standard RUM model. This equal weight model is a simplification that Simon proposed in a seminal article (Simon, 1955). It is in keeping with the notion of cognitive simplicity (Earl, 1986; Simon, 1956) and has been examined in other contexts (Czerlinski *et al.*, 1999; Payne & Bettman, 2001).

The semi-lexicographic model can be represented as an additive function with a non-compensatory weighting for the one attribute, *GM*, and unitary weighting for all other attributes. In addition, to account for differences in respondents' judgements regarding GMF, respondents can be grouped into three segments: one would refuse GMF, one would be wary but ultimately accepting of GMF, and the third would be totally unconcerned about the GM issue. The final semi-lexicographic choice model can be expressed as:

$$V(j) = \sum_{k=1}^{K-1} x_{kj} - 10x_{GM,j}z_1 - x_{GM,j}z_2 ,$$

where x designates whether the alternative is best, worst, or neither for attribute k in a specific choice set, z_1 is equal to one if a consumer refuses GMF, and z_2 is equal to one if a consumer is wary of GMF (z_3, indifference, is the omitted base case)

In this model, all variables but one are unweighted and completely compensatory; effectively, their parameters are set to one. For respondents who want to avoid GMF, those who are included in the z_1 group, the parameter for *GM* is set to 10. Any value greater than the highest potential value of the sum of all other attributes could be used to produce this non-compensatory effect. With this proposed parameterisation, the *GM* attribute registers in the tens place for this group of respondents while all other attributes only register in the ones place, so that there is no potential for compensation for the *GM* attribute for refusing respondents.

For each attribute, alternatives are noted as being 'better' or 'worse' than the others. The alternative that is better than the others most often is chosen. Although this model is partially compensatory, it is cognitively less demanding than a weighted model. In keeping with a notion of bounded rationality that rejects the possibility of maximising utility, 'better' and 'worse' are relative judgements that apply to each choice question separately. The choice problem is to determine whether alternatives are better or worse than other alternatives in the same question. Thus, the same product profile could receive quite different 'scores' given two different choice sets. Respondents are not modelled as carrying over 'scores' from one choice question to the next. This feature of the semi-lexicographic choice model means that the utility value of different product profiles or willingness to pay for specific attributes is not calculated.

This semi-lexicographic choice model integrates observations regarding consumer reactions to GMF and notions of boundedly rational decision making. It is important to note that the

RUM models proposed above estimate parameters for the attributes, while this model uses the theory of bounded rationality and consumer research regarding GMF to develop a likely set of parameters. These parameters can then be imposed on the designed experiment to create a set of choices that can then be compared to the choices that respondents actually made. The main tool for assessing the fit of this model is therefore the predictive ability of the model: to what extent do the observed choices resemble the choices predicted by the model?

Another potential method for assessing the fit of this model is suggested by the recognition that lexicographic choice can be represented by a linear model with non-compensatory weights (Broder, 2000; Selten, 2001). Thus, the weights that are imposed in this semi-lexicographic choice model could have resulted from estimating a RUM model, given choice data that were consistent with such a set of attribute weights. If such a set of parameters were estimated through a probabilistic RUM model, then that model would also generate a loglikelihood statistic and a pseudo-R^2. In order to test the congruence between the observed choices and this hypothetical RUM model, it is possible to use the imposed semi-lexicographic choice model parameters to calculate what the loglikelihood and pseudo-R^2 of such a RUM model would be. Obviously, the estimated MNL models maximise the likelihood of observing the data collected, so that any other set of parameters would have a lower fit. However, by estimating the fit statistics of this hypothetical RUM model, it is possible to get some sense for the gap between the results from the neoclassical framework and those from a boundedly rational model.

5.4.6 Rationale for the models

In Chapter 3, it was suggested that the observed consumer reactions to GMF might be inconsistent with the assumptions of separability and continuity that appear in some research based on the neoclassical theory of consumer behaviour, and that consequently a boundedly rational approach might provide additional insight into consumer reactions to GMF. One central difference between these two theories is maximisation: for neoclassical theory, consumer behaviour is about maximising utility, whereas bounded rationality rejects the necessity, possibility, or centrality of maximisation. Furthermore, the lack of continuity renders theoretically impossible neoclassical approaches to aggregation, such as finding an average discount or the change in consumer welfare across an entire market.

The models proposed in this chapter examine these issues. First, the possibility that attributes cannot be treated independently or separately when it comes to GMF can be assessed by the MNL that includes interaction terms: if those terms are statistically significant, then interactions between GM and other product attributes are likely to be important.

Secondly, the importance of continuity can be assessed in two ways. The boundedly rational models are explicitly discontinuous, so if they are able to model the collected data, those results could suggest that modelling discontinuity explicitly is important. In addition, the design of the choice set allows respondents a range of GMF and non-GMF options over a range of values for the different attributes. If respondents do not select any GM apples, their responses would suggest that some consumers do not have preferences that conform to the continuity axiom.

The third way that these models examine the issue raised in this thesis is that both neoclassical and boundedly rational models are mathematically presented and their fit is statistically determined, using the same data for both types of models. Thus, the results enable the different types of models to be estimated using the same dataset. By considering both types of models, it may be possible to consider whether it is necessary to assume maximising behaviour to model consumer behaviour, or whether behaviour can be modelled as the result of a simplified decision protocol.

It is also envisaged that the final issue, aggregation, may also be addressed with this research. The survey design may allow the full range of consumer reactions to GMF to be apparent. If significant discontinuities are evident, then the theoretical requirements for estimating aggregate impacts in the neoclassical paradigm are not present. An alternative view of the aggregate market impact is the size of the potential market for GMF as a portion of the entire market. This research design should allow nearly all respondents to be included in the analysis, whereas some prior research has had to exclude data from many respondents. Thus, the present research should be able to assess the reactions of all consumers in the market, while at the same time determining whether neoclassical tools like welfare analysis are theoretically appropriate.

5.5 Survey administration

The above discussion presented the proposed survey design and modelling methods. This section describes the actual survey administration.

Of the options for different types of face-to-face interviews, it was decided to intercept people at supermarkets in Christchurch, New Zealand. This approach meant that the surveying on food preference was done where people are making their choices regarding food. It also meant that respondents would be more likely to be main food shoppers for their households. It was also judged that intercept surveys would be more time-efficient than door-to-door surveying.

The breakdown of survey respondents by location and day and time of surveying are presented in Table 5.9. The supermarket industry is segmented by price and level of service, so several different stores were approached to be survey locations. One Pak'N Save (Moorhouse Avenue), two Woolworths (Ferry Road and The Palms shopping centre), and one Countdown (Church Corner) granted permission. In addition, South City Centre shopping mall gave permission for the survey to be conducted inside the mall outside the entrance to the New World. The different locations meant that a range of shoppers could be contacted. As indicated, the surveys were also conducted at different times of day, mostly on weekdays. In this way, it was hoped that a range of shoppers who varied by demographics and attitudes would be contacted.

Table 5.9. Surveying locations, days, and times

Supermarket locations		Percent of sample (N = 374)
	Countdown Church Corner	30.7
	Pak'N Save Moorhouse Avenue	11.5
	South City Centre / New World	10.7
	Woolworths Ferrymead	19.3
	Woolworths The Palms	27.8
Day		
	Monday	21.9
	Tuesday	16.8
	Wednesday	10.7
	Thursday	10.7
	Friday	36.9
	Saturday	2.9
Time of day		
	Morning (before noon)	28.9
	Afternoon (noon to 5.00 PM)	62.8
	Evening (5.00 PM to 7.00 PM)	8.3

One of the issues regarding food in general and GM in particular is information: whether consumers use the information available and how the provision of information affects preferences. The potential impacts of information bias were discussed in Chapter 4. The present research aimed to capture the preferences for GMF given respondents' current state of knowledge. The effect of the provision of information on GMF preference is a different, though related, avenue of research. In addition, the topic of GMF is contentious. There would be little agreement on exactly what consumers should be told and what information is accurate. One possible solution was to tell interviewees nothing at all about biotechnology or GMF.

Including antioxidants in the choice experiment raised the issue of information provision. This research was intended to highlight the different trade-offs that consumers are willing to make between different food attributes, the healthiness of food being one of them. The choice experiment was also made as specific as possible, to heighten its realism and thereby its validity. The ‘healthiness’ of food is imprecise, so ‘antioxidants’ were used as a specific change in the nutrition of apples. Other possibilities were ‘vitamins’ and ‘minerals’, but ‘antioxidants’ was considered more specific and has been used frequently in general-interest publications.

Using a factor this specific created its own problem, however. While antioxidants and free radicals are discussed in the popular press, it was not certain that respondents would know what they are and their potential benefits. In that case, they would be unable to make a decision about how they would react to apple with increased antioxidants, and in particular to apples that achieved this increase through genetic modification. In addition, surveyors would be faced with respondents asking for more information and it was felt they should have something to tell respondents. Interviewers were therefore instructed to tell respondents that ‘antioxidants are vitamins and similar substances that may prevent the development of cancer’.

Once the door was opened to providing some information, then information about GMF was required. Because the survey was intended to capture current attitudes based on current information, interviewers were instructed to tell respondents that ‘genetic modification (GM) or genetic engineering (GE) is a process for altering specific genes of a living organism to change its characteristics’.

5.6 Conclusion

This chapter proposed a choice experiment survey design as well as three neoclassical models and two boundedly rational models for analysing the resultant data. It also described how the present research was in fact conducted. This chapter also related the design of the present research to the issues concerning prior research on GMF that were identified in previous chapters.

There were essentially three parts to the present research. One part was survey design. The bulk of this work was careful design of the choice experiment. Additional considerations were the other types of information that would be useful to have from respondents and the best questions for eliciting that information. The second part of the research was identifying and modifying models of decision making that would be suitable for modelling choice experiment data, especially given the potential issues regarding preference separability and continuity. The third part of the research was survey administration and data analysis. The results of the data analysis are presented in the next chapter.

Chapter 6

Results

6.1 Introduction

This chapter presents an analysis of the data collected in the choice experiment survey conducted as part of this research and a discussion of the findings. Throughout this analysis, reference is made to the material in previous chapters. In particular, the discussion refers to the prior research on demand for GMF discussed in Chapter 2; to the theoretical issues discussed in Chapter 3 surrounding the neoclassical and bounded rationality theories; to the literature review of Chapter 4; and to the methodology proposed in Chapter 5 for empirically investigating these issues.

The rest of this chapter is divided into four main sections. Analysis of the survey data is presented in two of these parts. The first part, the descriptive analysis, starts by describing the demographics of the sample, then discusses the responses to the other survey questions in the order that they appear in the actual survey instrument (which is available in the appendix). There is particular attention to the demographic and socio-economic composition of the sample, the consistency of responses, and the issue of protest responses. The second part, the choice analysis, presents the results of the five models proposed in the previous chapter. The third section discusses the ramifications of the empirical findings for the theoretical issues raised earlier with regard to GMF. The fourth and final section provides a conclusion to the chapter.

There were several steps to the data analysis. Survey data were entered into Microsoft Excel, which was used for some of the analysis and transformation of data. Descriptive statistics were computed with SPSS version 10 and Maple version 5.1. MNL and CNL models were estimated with BIOGEME versions 0.6 and 1.0, software for estimating Generalised Extreme Value Models (Bierlaire, 2003a). These were solved via Maximum Likelihood Estimation using the algorithm donlp2. Text files for BIOGEME, including data files, were edited with GNU Emacs version 20.7 for Windows, using a precompiled version. The naïve lexicographic and semi-lexicographic models were analysed with Microsoft Excel, which was also used for assorted calculations.

6.2 Descriptive analysis

6.2.1 Number of responses

The full descriptive and choice analysis used a dataset of 353 respondents. Data from several respondents could not be used, as the following describes. A total of 384 surveys were begun with individuals who answered 'yes' to both filter question. They thus ate apples at home and were over 15 years of age. Ten of these respondents aborted surveys before they were finished and the survey instruments were destroyed. Of the 374 completed interviews, 18 were eliminated from the final dataset because of incomplete attitudinal data, which will be discussed below. An additional three interviews were dropped because the respondents always chose 'None of the above' from the choice sets. The net result was data from 353 respondents who answered all the questions used in the analysis presented in this chapter. The following descriptive analysis focuses on these 353, but data from the larger set of 374 responses is also discussed for purposes of comparison.

6.2.2 Demographics

The demographics of the respondents are contained in Table 6.1. For purposes of comparison, results for the full sample of 374 respondents and the smaller sample of 353 respondents are both presented, as well as national data for New Zealand. The following section presents and discusses this data.

Nearly four-fifths of the respondents were female and, too, nearly four-fifths of respondents were the main food shoppers for their household. The portion of main shoppers was not unexpected, as the interviews occurred at supermarkets. The results for gender are similar to prior findings. Men have been found to comprise 14 per cent of household shoppers in New Zealand's South Island (A.-M. Johnson, 2004). In the sample, males made up 15.2 per cent of the main food shoppers. Thus, the gender distribution of the sample was representative of main household shoppers in the South Island.

Respondents were asked about the composition of their households. A little over one-tenth of both samples had young children at home, and over one-third had children of any age at home. Comparable national statistics could not be determined for New Zealand, so comparisons to national figures were not made.

Purchasing habits regarding organically grown food have been correlated with choices of GMF (Burton *et al.*, 2001; S. James & Burton, 2003), so respondents were asked about their purchases of organically grown food. The survey included two questions on the topic. When asked the categorical question, nearly one-half responded 'never' or 'rarely', while only 16.1 per cent said 'often' or 'always'. When asked to estimate the percentage of their food spending that was spent on organically grown food, the responses ranged from 0 per cent to 95 per cent. The bulk of respondents purchased little organically grown food, with 22.4 per cent indicating no purchases, 54.4 per cent indicating 5 per cent or less, and 67.7 per cent indicating 10 per cent or less.

Table 6.1. Demographic information for respondents

	Results for n=353 (%)	Results for n=374 (%)	New Zealand (%)	
Gender				
Male	21.5	21.4	48.7	a
Female	78.5	78.6	51.3	a
χ^2 probability, sample vs. NZ	0.000	0.000		
Main food shopper				
Yes	78.5	79.1		
No	21.2	20.6		
Did not respond	--	0.3		
Households with children				
0-4 years of age	11.3	11.6		
0-17 years of age	36.0	36.1		
Organically-grown food purchases				
Never	21.0	21.1		
Rarely	25.2	25.1		
Sometimes	37.4	36.6		
Often	12.7	13.4		
Always	3.4	3.5		
Did not respond	0.3	0.3		
Ethnic identification				
NZ European	80.2	79.9	76.3	a
Maori	6.5	6.4	10.1	a
Pacific Islander / Pacific Peoples	1.7	1.6	5.1	a
Other Ethnic Groups	11.0	11.5	8.5	a
Did not respond	0.6	0.5		
χ^2 probability, sample vs. NZ [b]	0.214	0.289		
Age				
15-19	5.7	5.3	9.2	c
20-29	24.1	23.3	16.8	c
30-39	20.1	20.1	20.0	c
40-49	18.7	19.5	18.6	c
50-59	17.8	17.6	14.5	c
60-69	10.8	11.0	9.8	c
70-79	2.5	2.9	7.4	c
80+	0.3	0.3	3.8	c
χ^2 probability, sample vs. NZ	0.109	0.142		

Table 6.1 (cont.). Demographic information for respondents

	Results for n=353 (%)	Results for n=374 (%)	New Zealand (%)	
Household income				
Up to 21,599	11.0	11.0	20.0	d
21,600 – 33,799	17.6	17.6	20.0	d
33,800 – 53,299	24.1	23.5	20.0	d
23,300 – 80,099	22.4	22.2	20.0	d
80,100 or more	18.4	18.4	20.0	d
Did not respond	6.5	7.2		
χ^2 probability, sample vs. NZ [b]	0.232	0.256		
Educational attainment				
Up to Fifth Form	17.0	16.8	25.8	a
School Certificate	19.5	21.1	17.0	a
UE/Bursary	18.7	17.6	9.6	a
Tertiary other than degree	17.8	17.1	34.8	a
University degree	26.3	26.7	11.3	a
Did not respond / not specified	0.6	0.7	1.5	a
χ^2 probability, sample vs. NZ	0.000	0.000		

[a] Source for New Zealand data: Statistics New Zealand, Average Weekly Income for All People Aged 15 years and over (Table 1), for June 2002 quarter.

[b] Excludes 'Did not respond' data.

[c] Source for New Zealand data: Statistics New Zealand, 2001 Census Usually Resident Population Count, Age Group by Sex (Table 3)

[d] Source for New Zealand data: Statistics, New Zealand, Household Expenditure Survey, year ending 30 June 2001, adjusted by Wage index, June 2003 (All industries and occupations, June 2001 = 1000)

This survey also elicited information about ethnic identification, age, household income, and educational attainment. The data on these demographics are presented in Table 6.1 as well. The sample was largely New Zealand European. A few respondents did choose more than one category; their responses were categorised as the minority response, *i.e.*, the non-NZ European category. Nearly half of the respondents were under 40 years of age, and only a few were 70 years of age or older. Household income was solicited by quintiles, based on the

Statistics New Zealand 2001 Household Expenditure Survey and adjusted by the wage index (Wage index for all industries and occupations, June 2001 = 1000). The respondents tended to report incomes in the middle quintiles rather than the lowest and highest quintiles. Educational attainment is also reported in Table 6.1. More than one-quarter of respondents had a university degree and less than one-fifth had no qualification.

These demographics are presented in Table 6.1 for both the sample of 374 respondents and the sample of 353 respondents. The loss of 21 respondents did not change the overall demographics of the sample. The results for both samples were also compared to New Zealand national statistics on gender, ethnic identification, age, household income, and educational attainment. Gender was not representative of the population as a whole, but, as noted above, it was consistent with research on main household shoppers (A.-M. Johnson, 2004). For ethnic identification, age, and household income, neither sample was statistically different from national figures at a probability of 0.10 (and thus not at a 0.05, either), as confirmed by χ^2 tests. The samples were, however, significantly different from national educational attainment statistics.

This analysis of the demographics of the sample suggests that it was largely but not perfectly representative of the demographics of the New Zealand population.

6.2.3 Answers to introductory questions

As discussed in the methodology chapter, the questionnaire started with introductory questions to encourage respondents to consider different attributes of apples. Respondents were first asked to rank seven attributes in order from the most important (to themselves) to least important. Of 353 respondents, 310 provided a complete ranking of attributes from one to seven. Twenty-six respondents declined to rank at least one attribute, and 17 ranked some attributes as equals. These rankings were analysed in order to provide an understanding of respondents' preferences regarding apple attributes and to provide a starting point for heuristic modelling of choice experiment data.

Table 6.2. Respondents' rankings of apples characteristics

Characteristic	Respondents ranking as most important (%)	Respondents ranking as least important (%)	Modal ranking	Mean ranking: Mean ranking score	Mean ranking: Implied ranking
Price	6.2	15.0	3	4.29	5
Nutrition	5.7	7.1	4	4.24	4
Flavour	36.5	0.0	1	2.25	1
Variety of apple	15.9	7.1	5	3.68	3
Freshness	29.5	0.0	2	2.30	2
Imported vs. domestic	2.3	29.7	6	5.55	7
Insecticide use	5.1	30.6	7	5.31	6

Table 6.2 summarises the results from this question in several ways. For each apple characteristic, the percentage of respondents who listed the characteristic as most important or least important is presented. The two most important apple characteristics for respondents were flavour and freshness, while the least important were insecticide use and whether the apple was imported or from New Zealand. In addition, the table contains two implied average rankings. The modal ranking is the rank most often given the characteristic by respondents. The mean ranking is based on the average scores of all the characteristics; for this, both the average score from the data and the implied rank of the characteristic are given. The mean and modal rankings are the same, with two exceptions. The first exception is that *Price* and *Variety* of apple exchange places 3 and 5 depending on whether a modal or mean approach is used. The fact that the places that these attributes exchange are not adjacent reflects the variety of responses and the skewed nature of their distributions. The second exception

concerns whether an apple is *Imported or domestic* and *Insecticide use*. They are both least important at ranks 6 and 7, but trade places depending on the method of ranking.

Another tool for examining responses to this question is the response pattern, as discussed in the previous chapter. The complete ranking that a respondent gave for all the apple characteristics, such as 1234567, is a response pattern. If two respondents view the apple characteristics similarly, it may be expected that their response patterns would be similar. By the same token, a large number of response patterns would suggest heterogeneity of preferences. In the case of this survey, the 327 respondents who gave a rank to every characteristic have 252 different response patterns. Of these, 196 patterns appear once and 42 appear twice. The most frequently any one pattern appears is five times. The large number of response patterns and the lack of any dominant pattern suggest that consumer preferences for apple characteristics are diverse.

A second introductory question asked respondents whether they avoided foods in the supermarket for any reason, such as medical or ethical reasons. Of 353 respondents, 38.2 per cent said that they did avoid foods and 61.8 per cent said that they did not. Respondents provided a variety of reasons for food avoidance.

6.2.4 Choice experiment

After the introductory section, respondents were presented with the choice questions. These were provided on laminated cards, one card for each of nine choice questions. The choice task was explained and the responses recorded by the interviewer. A choice analysis of the data from these questions is presented in the second part of this chapter. However, two results are appropriately noted here. First, when presented with choices between GM and non-GM apples that varied on several attributes, 48.2 per cent did not choose a GM option for any of the nine choice sets. This result suggests that many respondents did not care to select GMF, despite the health, price, and environmental inducements offered. The second result to note here is the low number of protest responses, in which respondents always chose the *status quo* alternative. As discussed above, prior choice experiment surveys on GMF have had protest rates of 20 to 30 per cent (Burton & Pearse, 2002; Burton et al., 2001; S. James & Burton, 2003; Onyango et al., 2004). One of the intentions of the design of the present research was to reduce this percentage by providing a sufficient range of alternative apples to respondents so that they were able to find non-*status quo* alternatives that were acceptable and preferred. In fact, only 16 respondents, or 4.5 per cent of the sample, were protest respondents. If the three respondents who always chose 'None of the above' are also considered to be protest respondents, the percentage increases to 5.3 per cent (19 of 356). Given this relatively low rate of protesting, the design appears to have been successful in reducing protest behaviour. In addition, with this design it was possible to distinguish lexicographic respondents – who do not want GM apples but may be willing to try other types of new apples – from protest respondents – who do not vary their responses at all.

After the choice experiment questions, a follow-up contingent valuation question asked how much the respondent would be willing to pay for an apple genetically modified to resist black spot so that it did not need to be sprayed. As part of the question, respondents were told that apples generally cost about $3.00 per kilogram (for example, at one market, interviewers were directly in front of a display of apples priced at $2.99 per kilogram). This provided an anchor price for respondents (Wansink *et al.*, 1998). Those who responded that they would not buy the apple were recorded as having a zero willingness to pay. Other responses are grouped together as those willing to pay more than nothing but less than $3.00, those willing to pay $3.00 only, and those willing to pay more than $3.00. Respondents were approximately evenly divided between those refusing the apple, those with stated indifference at $3.00, and those willing to pay a premium, with only a small percentage willing to buy the apple but at a discount. This is similar to findings from a New Zealand nationwide contingent valuation survey on GMF, in which approximately equal numbers of respondents expressed either rejection of GMF or indifference to GMF, while comparatively few respondents indicated that they would buy GMF given discounted prices (Kaye-Blake, Saunders *et al.*, 2004). A summary of responses to the CV question is given in Table 6.3.

Table 6.3. Responses to contingent valuation question [a]

Willingness to pay (WTP) ($/kg)	Number of respondents (n = 353)	Percentage of respondents
WTP = 0	109	30.9
0 < WTP < 3	19	5.4
WTP = 3 (anchor value)	101	28.6
WTP > 3	116	32.9
Did not respond	8	2.3

[a] The CV question asked respondents how much they would be willing to pay for an apple genetically modified so that it did not need to be sprayed for black spot disease. The exact wording is available in the survey instrument in the appendix.

Finally, general debriefing questions were included. To assess the realism of the survey, respondents were asked whether they expected the new apples in the choice experiment to be available in the next 5 years, to which 78.5 per cent responded ‘yes’. When asked whether they found the choice experiment difficult, 67.1 per cent responded ‘no’ and 23.8 per cent ‘yes’. A final debriefing question asked whether there were other food-related issues more important than the ones highlighted in the survey. Most respondents indicated that the most important issues had been covered, with 71.1 per cent responding ‘no’. These results suggest that, overall, the survey was perceived to be realistic, relatively simple, and pertinent.

6.2.5 Answers to attitude questions

As discussed in the Methodology chapter, the next section of the survey instrument solicited respondents’ attitudes on several issues. Respondents were read several statements and asked whether they agreed or disagreed with the statements on a 5-point Likert scale. Statements related to three general topics: food preferences, genetic modification, and environmental attitudes. Each topic is discussed in turn below, and responses are presented in Table 6.4.

For the most part, there is wide agreement on food preferences, despite the heterogeneity of response patterns when respondents were asked to rank different apple characteristics. Thus, most respondents indicated that they choose the apples with the best flavour and that too many pesticides are used to produce food. Likewise, most respondents disagreed that they choose the least expensive apples, although a significant minority (20.6 per cent) either agreed or strongly agreed that they do. The one exception to the general agreement regarding food preferences concerns the statement regarding purchases of GM apples. Those who disagreed to various extents that they would purchase GM apples were 45.9 per cent of the sample; those who agreed to various extents were 39.6 per cent of the sample; and those who were neutral were 12.7 per cent.

The statements about GM technology also elicited a range of responses. Question 19 asked whether GMF is too risky; about one-quarter of respondents neither agreed nor disagreed with the statement, while the rest were close to evenly split on the riskiness of GMF. Another question to highlight is Question 26 regarding whether GM technology is tampering with nature. A large majority, 71.1 per cent, agreed with the statement, suggesting that the technology's naturalness is viewed differently to its riskiness.

Two statements were used to assess general environmental attitudes. Most people expressed agreement with both statements, regardless of their responses to other questions. In addition, responses to the two statements were nearly identical, so they appear to be capturing the same information about respondents.

Table 6.4. Responses to attitudinal statements

	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)	Don't know (%)	Did not respond (%)
Food preferences							
Q17. I choose the apples with the best flavour.	43.3	46.2	7.1	3.1	0.3	--	--
Q20. I would buy apples that are genetically modified.	6.5	33.1	12.7	22.7	23.2	1.7	--
Q21. I choose the least expensive apples.	4.2	16.4	14.7	48.4	15.9	0.3	--
Q24. Too many pesticides are used to produce food.	23.5	51.0	13.3	5.1	0.6	6.2	0.3
GM attitudes							
Q18. The use of genetic modification technology in food production offers a solution to the world food problem.	7.1	29.2	25.2	18.7	14.2	5.7	--
Q19. Producing genetically modified food is too risky to be acceptable to me.	18.7	22.4	25.5	26.3	7.1	--	--
Q25. Using genetic modification technology fits with my cultural and spiritual beliefs.	1.4	15.6	31.7	28.0	20.1	2.5	0.6
Q26. Genetic modification technology is tampering with nature.	22.7	48.4	13.0	11.3	3.4	0.8	0.3
Q27. Genetically modified products are environmentally friendly.	2.3	13.3	30.6	24.6	15.0	13.9	0.3
Environmental attitudes							
Q22. Natural environments have a right to exist for their own sake, regardless of human concerns and uses.	20.4	53.5	13.0	10.5	0.8	1.4	0.3
Q23. We should try to get by with a little less so there will be more left for future generations.	21.5	55.5	12.5	8.8	0.6	0.8	0.3

6.2.6 *Consistency of responses*

One of the issues with stated preference surveys that was discussed in Chapter 4 was biased data as a result of respondent yea-saying (or nay-saying), which is a tendency by respondents to agree (or disagree) with statements or questions. One way to test for such a bias is to use both positive and negative formulations for statements. To be consistent, a respondent would thus need to agree with some statements and disagree with others.

In the present research, several attitudinal statements are used and they include both positive and negative statements. This arrangement can be used to test for yea-saying, as shown in Table 6.5. This table presents results from a cross-tabulation of responses to question 18, a 'positive' statement about GM, with question 19, a 'negative' statement. Nearly one-half (161 of 353, or 45.6 per cent) of respondents are on the diagonal, and 78.8 per cent (278 of 353) are either on the diagonal or within one cell of it. Thus, when respondents agreed with one statement, they tended to disagree with the other. This apparent consistency suggests that respondents were considering their

Table 6.5. Crosstabulation of Questions 18 and 19

	Q19 Responses					
Q18 Responses	Strongly agree (number)	Agree (number)	Neutral (number)	Disagree (number)	Strongly disagree (number)	Total (number)
Strongly agree	1	2	4	5	13	25
Agree	8	15	25	47	8	103
Neutral	6	21	39	22	1	89
Disagree	13	26	16	10	1	66
Strongly disagree	36	7	2	4	1	50
Don't know	2	8	4	5	1	20
Total	66	79	90	93	25	353

responses to the statements presented, rather than reflexively agreeing or disagreeing with the interviewers.

6.2.7 Continuity of preferences

The discussion in Chapter 3 raised discontinuity of preferences as a potential issue affecting demand for GMF. Prior research was shown to suggest that consumers may not want GMF at any price. This empirical finding is at odds with the neoclassical consumer choice axiom of continuity. Thus, a key goal of the present research was determining whether respondents really do have the intention of indicating categorical refusal of GMF.

The questionnaire gave respondents three ways to express refusal of genetically modified apples. The first way that respondents could refuse GM apples was to avoid all the GM options in the choice experiment, regardless of the beneficial changes in other attributes. The second way to refuse GM apples was to indicate a zero willingness to pay in the contingent valuation question. If respondents did not ever want GM apples, regardless of the benefits, they could say they would not pay anything for this particular apple. The third way to refuse was to disagree with the statement, ‘I would buy apples that are genetically modified’. The three expressions of refusal correspond to different survey methods. The first two expressions are based on choice modelling and contingent valuation, respectively, and are both focused on estimating willingness to pay. The third method for registering refusal is not strictly based on economic theory, but instead solicited respondent’s attitudes.

Analysis of the three measures of refusal suggests that respondents were largely consistent in their indications of refusal. Table 6.6 presents crosstabulation results that compare whether respondents ever chose a GM apple in the choice experiment with their contingent valuation responses and then with their responses to Question 20, the statement 'I would buy apples that are genetically modified'. Thus, the table compares results from the refusal in the choice experiment to refusal in contingent valuation and attitudinal surveying. The results indicate that most respondents who never chose a GM option in the choice experiment also refused to give a positive price in the contingent valuation question, and most also disagreed that they would purchase GM apples. Secondly, most respondents who chose GM options gave a price of at least \$3.00 in the CV question, and most agreed that they would buy GM apples. Thirdly, the distribution of responses to the CVM question and the attitudinal question are compared for the two groups of respondents, those who chose GM alternatives and those who did not. The χ^2 statistic is significant at the 0.01 level for both questions, indicating that the two groups of respondents did respond differently to the CVM and attitudinal questions. These results suggest consistency across the three measures of refusal or willingness to buy GM apples. People did what they said they would do, or, more accurately, their reported behaviour ('I would not buy GM food') was consistent with their prior actual behaviour (*i.e.*, not choosing GM apples).

Table 6.6. Crosstabulation of CV and attitudinal responses with CE choice

	Chose GM apple		
	Never (number)	At least once (number)	Total (number)
Contingent valuation response			
Refuse	92	17	109
Discount	10	9	19
Indifferent	34	67	101
Premium	32	84	116
Non response	2	6	8
Total	170	183	353
χ^2	87.4 ‡		
Q20, 'I would buy GM apples'			
Strongly agree	2	21	23
Agree	20	97	117
Neither	18	27	45
Disagree	57	23	80
Strongly disagree	70	12	82
Don't know	3	3	6
Total	170	183	353
χ^2	123.3 ‡		

‡ significant at the 0.01 level

Because this refusal behaviour is potentially counter to the basic assumptions of neoclassical theory, it may be argued that the evidence for such behaviour should be quite strong before its existence is accepted. To investigate further whether non-selection of GM alternatives in the choice experiment really does signal a desire on the part of respondents to refuse GMF, a three-way crosstabulation of all three methods of refusal was performed. This analysis suggests that the results from the three questions were not entirely consistent, as shown in Table 6.7. This table crosstabulates the responses to all three refusal questions. Those respondents who consistently refused GM apples for all three questions were 23.8 per cent of the

Table 6.7. Three-way crosstabulation of CE, CV, and attitudinal responses

	Contingent valuation response (number)										Total (number)	
	Refuse		Discount		Indifferent		Premium		Non response			
Q20	Never chose GM	Chose GM	Never chose GM	Chose GM	Never chose GM	Chose GM	Never chose GM	Chose GM	Never chose GM	Chose GM	Never chose GM	Chose GM
Strongly agree	2	--	--	--	--	5	--	14	--	2	2	21
Agree	2	4	1	3	7	41	10	46	--	3	20	97
Neither	2	--	3	4	5	10	8	12	--	1	18	27
Disagree	24	5	5	1	17	9	9	8	2	--	57	23
Strongly disagree	60	8	1	1	5	1	4	2	--	--	70	12
Don't know	2	--	--	--	--	1	1	2	--	--	3	3
Total	92	17	10	9	34	67	32	84	2	6	170	183

sample, or 84 (24 + 60) of 353 respondents (this increases to 86 of 353 or 24.4 per cent if the two non-respondents to the CV question are included). Those respondents who did choose GM options and did state that they would buy GM apples were also consistent in their responses. This is true even of the four such respondents who did not want the apple in the CV question, because it is possible that the specific modification on offer, resistance to black spot, was not attractive to those respondents. There are 145 such respondents who would definitely purchase GM apples, representing 41.1 per cent of the sample. The remainder, 122 respondents or 34.6 per cent of the sample, could be said to have inconsistent responses.

This crosstabulation contributes to the discussion of continuous preferences in two ways. First, it reduces the percentage of absolute refusers, from the 48.2 per cent suggested by the choice experiment results to the 23.8 per cent who refused GMF in all three ways. Secondly, it suggests that nearly one-quarter of respondents refuse GMF at every turn. Taken together, these finding suggest that discontinuous preferences, while present in only a minority of respondents, may be significant enough to affect demand for GMF and to warrant closer attention from the perspective of economic theory.

6.2.8 Crosstabulation of attitudinal responses by GM choice

The discussion of possible research methods found that a choice experiment was the preferred method for the present research, because it focuses specifically on respondents' reactions to product attributes. Thus, the results from the choice experiment are used here as the primary source of information about respondents' WTP for GMF. In particular, those results are used to divide respondents into those

Table 6.8. Attitudinal responses of GM apple Choosers and Non-choosers

	Strongly Agree (number)	Agree (number)	Neutral (number)	Disagree (number)	Strongly Disagree (number)	Mean of responses	χ^2
Q17. '… best flavour' (n=353)							
Never chose GM option	67	84	11	7	1	1.77	
Chose GM option	86	79	14	4	0	1.65	4.22
Q18. '… solution to the world food problem' (n=333)							
Never chose GM option	4	32	45	31	45	3.52	
Chose GM option	21	71	44	35	5	2.61	57.7 ‡
Q19. '… too risky to be acceptable to me' (n=353)							
Never chose GM option	57	53	35	22	3	2.18	
Chose GM option	9	26	55	71	22	3.39	88.5 ‡
Q20. '… would buy GM apples' (n=347)							
Never chose GM option	2	20	18	57	70	4.04	
Chose GM option	21	97	27	23	12	2.49	123.3 ‡
Q21. '… least expensive apples' (n=352)							
Never chose GM option	3	20	25	82	40	3.80	
Chose GM option	12	38	27	89	16	3.32	21.3 ‡
Q22. '… environments have a right to exist …' (n=347)							
Never chose GM option	49	91	16	10	1	1.94	
Chose GM option	23	98	30	27	2	2.37	21.6 ‡

Table 6.8 (cont.). Attitudinal responses of GM apple Choosers and Non-choosers

	Strongly Agree (number)	Agree (number)	Neutral (number)	Disagree (number)	Strongly Disagree (number)	Mean of responses	χ^2
Q23. '…get by with a little less …' (n=349)							
Never chose GM option	47	98	11	11	1	1.93	
Chose GM option	29	98	33	20	1	2.26	17.4 ‡
Q24. 'Too many pesticides …' (n=330)							
Never chose GM option	57	88	14	4	1	1.80	
Chose GM option	26	92	33	14	1	2.23	24.9 ‡
Q25. '… fits with my … beliefs' (n=342)							
Never chose GM option	0	10	44	55	57	3.96	
Chose GM option	5	45	68	44	14	3.10	59.4 ‡
Q26. '…tampering with nature' (n=349)							
Never chose GM option	61	85	13	6	5	1.88	
Chose GM option	19	86	33	34	7	2.58	50.5 ‡
Q27. 'GM products are environmentally friendly' (n=303)							
Never chose GM option	0	12	43	49	48	3.88	
Chose GM option	8	35	65	38	5	2.98	60.0 ‡

‡ significant at the 0.01 level

who would purchase GMF – the 'Choosers' – and those who would not – the 'Non-choosers'.

This section compares responses to the attitudinal questions in the survey by these two groups of respondents. The results are presented in Table 6.8. The table contains the number of responses at each Likert level for both Choosers and Non-choosers, the mean level of responses for both groups, and the χ^2 statistic for the two sets of responses. For these calculations, the response categories are given the values one through five, with 'Strongly Agree' set equal to one.

Respondents in both groups agreed with the statement, 'I choose the apples with the best flavour', as evidenced both by the similar means and the insignificant χ^2 statistic. This, however, was the only attitudinal question on which the groups agreed.

For all other questions, differences between the two groups are significant. The mean levels are quite different. They are greater than 1.0 for three questions, so that the difference in means represents an entire response category (*e.g.*, 'Agree' vs. 'Neutral'). The χ^2 statistic for all the questions is significant at the 0.01 level, indicating that that the two groups have different reactions to all the statements. Interestingly, this is true not just for those statements about GM technology, which is to be expected. It is also true for most of the food preference statements, such as 'I choose the least expensive apples' and 'Too many pesticides are used to produce food'.

Non-choosers were less likely to agree that GM technology offers a solution to world food problems or is environmentally friendly. They were more likely to agree that the technology is too risky for food production and is tampering with nature. They were less likely to choose the cheapest apples and more likely to agree that too many pesticides are used for food production. They were also more likely to express ecocentric attitudes, and did not believe that GM technology fits with their beliefs.

These results suggest that, while it may be simplistic to divide consumers into pro-GM and anti-GM groups, Choosers and Non-choosers seem to have statistically significant differences in food preferences, attitudes to GM technology, and environmental attitudes.

6.2.9 Crosstabulation of demographics by GM choice

The above discussion described the attitudinal differences between those who chose GM apples in the choice experiment and those who did not. One question is whether these differences extend beyond attitudes into demographic, social, or economic characteristics of respondents. Table 6.9 presents responses to the demographic questions, crosstabulated by whether respondents chose GM options. Significance is determined with a χ^2 statistic. The means for the two groups are also calculated.

Males and females were evenly spread between the two groups, Choosers and Non-choosers, with an insignificant χ^2 and similar means. The same is true for whether the respondent was the main shopper for the household: no difference was found in the propensity to choose GM apples.

The two groups of respondents had similar numbers of children at home, both for children under 5 years of age and for children between 5 and 17 years of age. The mean numbers of children were similar, and the χ^2 statistic is not significant.

Other socio-economic characteristics of the two groups were also similar. The distribution in different ethnicities, age cohorts, income quintiles, and levels of educational attainments were all similar across the groups of respondents. This is verified by the insignificant χ^2 statistics for all these characteristics. The means of the two groups were also similar for all these characteristics.

Table 6.9. Demographics of GM Choosers and Non-choosers

Characteristic and level		Never chose GM option	Chose GM option
Gender			
(n=353)	Male	34	42
	Female	136	141
	χ^2		0.454
	Mean	0.20	0.23
Main household shopper			
(n=352)	Yes	136	141
	No	34	41
	χ^2		1.27
	Mean	0.80	0.77
Number of children under 5 years of age			
(n=352)	0	152	160
	1	15	15
	2	3	6
	3	--	1
	χ^2		1.80
	Mean	0.12	0.16
Number of children 5 to 17 years of age			
(n=352)	0	122	127
	1	16	25
	2	19	18
	3	8	11
	4	4	1
	7	1	--
	χ^2		4.97
	Mean	0.59	0.54
Frequency of organically grown food purchases			
(n=352)	Never	25	49
	Rarely	37	52
	Sometimes	65	67
	Often	34	11
	Always	9	3
	χ^2		24.7 ‡
	Mean	2.79	2.27

‡ significant at the 0.01 level

Table 6.9 (cont.). Demographics of GM Choosers and Non-choosers

Characteristic and level		Never chose GM option	Chose GM option
Ethnicity			
(n=352)	Asian	4	5
	Did not respond	2	--
	European	1	1
	Maori	12	11
	NZ European	136	147
	Other	14	13
	Pacific Islander	1	5
	χ^2		4.88
Age			
(n=353)	1 (15-19)	7	13
	2 (20-29)	38	47
	3 (30-39)	41	30
	4 (40-49)	35	31
	5 (50-59)	33	30
	6 (60-69)	13	25
	7 (70-79)	3	6
	8 (80 or more)	--	1
	χ^2		0.179
	Mean	3.59	3.67
Income			
(n=330)	1^{st} quintile	19	20
	2^{nd} quintile	32	30
	3^{rd} quintile	44	41
	4^{th} quintile	38	41
	5^{th} quintile	25	40
	χ^2		0.528
	Mean	3.11	3.30
Highest level of education			
(n=351)	1 (Up to Fifth Form)	29	31
	2 (School Certificate)	33	36
	3 (University Entrance/Bursary)	31	35
	4 (Tertiary diploma, etc.)	36	27
	5 (University degree)	40	53
	χ^2		0.547
	Mean	3.15	3.19

The two groups do differ on one characteristic. Non-choosers of GM apples tended to purchase organically grown food more frequently; those who chose GM apples tended to purchase such food less frequently. The difference between the distributions of the two groups was significant at the 0.01 level. This confirms findings in prior research that purchases of organically grown food may be used to segment consumer regarding their willingness to purchase GMF (Burton *et al.*, 2001).

6.2.10 Dominated options

In the Methodology chapter, three possibly dominated options and one clearly dominated option were discussed. Dominated options are choice alternatives that are worse for every individual attribute than another alternative in the choice question. These options were included in the final choice experiment design to allow respondents to express the full range of preferences regarding the choice attributes and to test for rationality in choices, *i.e.*, to determine whether preferences were well-ordered. The results from the survey confirm that these dominated alternatives were indeed much less preferred to the other alternatives in their choice sets. These options were, however, chosen by a few respondents. In total, these four potentially dominated options were chosen 28 times, by 27 different respondents. This small number of responses and respondents makes drawing firm conclusions difficult. Nevertheless, the following discussion notes correspondences between minority choices and other data where appropriate.

Table 6.10 lists the dominated options and the number of respondents who chose them. It also summarises possible explanations of these choices.

Table 6.10. Dominated options

Questionnaire Version	Question	Option	Number of times chosen	Possible explanations for selection
A	7	B	6	• Premium for GM products • Preference for more insecticide • Respondent or interviewer error
A	8	B	9	• Preference for more insecticide • Use of higher price as signal of higher quality • Respondent or interviewer error
B	12	C	2	• Preference for Current over Improved flavour • Respondent or interviewer error
B	13	C	6	• Use of higher price as signal of higher quality • Respondent or interviewer error

For Version A, Question 7, only six respondents chose Apple B. This suggests that most respondents did not, *ceteris paribus*, prefer GM apples. Of these minority respondents, four of the six respondents placed a premium on the GM apple in the contingent valuation question. The choice of Apple B might therefore have resulted from a preference for GM apples. On the other hand, three of the six ‘Agreed’ that GM food was too risky to be acceptable.

The above results coupled with the responses to Version A, Question 8 suggest that respondents generally preferred less insecticide to more. The minority response to Question 8 could be the result of a preference for more insecticide, but four of the nine respondents ‘Often’ purchased organically grown food.

The alternatives in Version B, Question 12, were retained in order to allow respondents to express a significant negative reaction to the ‘Improved’ flavour. This reaction did not eventuate: only two respondents chose Apple C, an option with Current flavour and enhanced antioxidants. Meanwhile, 82 chose Apple B, an option with an Improved flavour and other benefits.

Version B, Question 13 contained the only truly dominated option. Only six respondents chose Apple C, an option dominated by the status quo. These six represent 3.3 per cent of the 181 respondents who were given Version B of the survey.

Generally, these results suggest two things. First, they suggest that preferences for apples were generally well-ordered. Alternatives that could be expected to be dominated, given plausible preferences for apple attributes, were in fact rarely chosen. Secondly, they suggest that there do not appear to be minority preferences for more insecticide use or the current apple flavour (beyond the preference for *status quo* apples). Thus, potentially dominated options probably did not need to be retained in the survey design to capture such preferences.

These dominated alternatives were chosen by 27 of 353 respondents, or 7.6 per cent of the sample. Given the small number of respondents, it is difficult to draw any firm conclusions regarding these choices. They do raise the possibility of inconsistency, which is to say irrationality, in respondents' choices. However, if they are a symptom of a lack of well-ordered preferences, then only a small percentage of respondents are so afflicted. It is also possible that these responses are simply errors, either on the part of respondents or interviewers. In that case, the error rate is low, suggesting both that respondents were engaged with the choice task and that interviewers were diligent in their work.

6.3 Choice analysis

The methodology chapter proposed five different models for analysing the choice data generated by the choice experiment survey. This section of the chapter uses those proposed models to analyse the observed choices. It proceeds with some introductory material regarding common features of the models, then discusses the results of each model in turn.

The effect of respondent demographics was considered in the RUM models. Only one characteristic, respondent gender, was included in these models. As discussed in Chapter 2, demographics and socio-economic characteristics have generally been shown to be poorly correlated with attitudes towards GM food, and for that matter with attitudes towards food in general (Bareham, 1995). In the above descriptive analysis, demographics did not seem to be related to behaviour regarding GMF. Some research, however, has found that gender has significant explanatory power in modelling GM food choices. Gender was thus included in the present choice modelling to determine its impact on choice regarding GM apples.

Respondent heterogeneity was considered for all the choice models. Attitudes towards GMF are known to be heterogeneous, so the choice of food product needed to be conditional on some characteristic of respondents as well as the product attributes. Attitude towards GMF was included in the models with the response data from Question 19, the statement 'Producing genetically modified food is too risky to be acceptable to me'. Respondents were asked to indicate on a 5-point Likert scale their agreement or disagreement with this statement. Only those respondents who used this scale were included in the model; those who did not answer or responded 'Don't know' were excluded. In order for the estimation to be valid, all responses needed to be points on the same scale. As indicated above, 18 of the 374 completed surveys were excluded from the analysis because of their responses to question 19.

Question 19 was used rather than any other GM attitudinal question because it pertained to personal tastes or opinion and was specifically about GM food. It was thus the most appropriate question for modelling individual choices of GM apples. On the other hand, responses to the different questions about GM food and general attitudes were fairly consistent. Any other attitudinal question may have produced similar results.

The 353 completed interviews with full attitudinal data yielded 3177 choices. Of these, 17 choices were 'None of the above' alternatives chosen by 5 different individuals. The number of 'None of above' responses was too small for useful statistical analysis, so these data were excluded. Of the remaining 3160 choices, 2378 were used to estimate the RUM models below. The remaining 782 were set aside as a holdout sample. A holdout sample can be useful when comparing models, because models with more parameters would be expect to model in-sample data better, but have been shown to model out-of-sample or holdout data worse than simpler models (Camerer, 1995). Holdout samples have also been used in prior research examining lexicographic or hierarchical models (*e.g.*, Arentze *et al.*, 2001; Gensch & Svestka, 1984).

6.3.1 Main effects multinomial logit

This analysis of respondents' choices starts with a MNL that does not contain terms for attribute interactions developed in the Methodology chapter. The MNL is a common model for estimating parameters from choice data (Adamowicz & Boxall, 2001; Adamowicz, Louviere *et al.*, 1998; Louviere *et al.*, 2000; Pudney, 1989). While it has the well-known restrictions that the disturbances are assumed to be identically and independently distributed and that the choices must conform to the Independence from Irrelevant Alternatives axiom, it is nevertheless the baseline for all other models. Furthermore, it is based on neoclassical choice theory, including the Lancastrian focus on the attributes of goods. The results from a simple MNL thus assume preference separability and continuity, which are two of the issues that have been raised in this thesis with regard to GMF.

Results are presented in Table 6.11. The model shows the impact of each product attribute on choice probability. The product attributes were price, insecticide use, antioxidant content, flavour, and GM technology. Insecticide use was specified as two variables, corresponding to either an increase or decrease from current levels. This specification is consistent with Burton *et al.* (2001) and was used because the current data, as in the previous research, exhibited strong non-linearity.

The parameters generally have the expected signs and significances. There is a bias towards the *status quo*, *i.e.*, the apples currently available. Amongst the product attributes, increases in antioxidants, improved flavour, and decreases in insecticide use all increase choice probability, indicating that respondents value these improvements. By contrast, increased insecticide use and increased price both decrease choice probability. The signs of these parameters are all as expected. Finally, although GM apples are less likely to be selected, the parameter is not significant at the 5 per cent level. This result suggests that, although attitudes towards GM are important in determining whether respondents choose GM apples, there is no 'average' GM discount being applied by all respondents.

With an insignificant GM parameter, it is the parameters for the attitudinal variables that are important. The estimated parameters for respondents' attitudes are also as expected. Those who strongly disagreed that GM food was too risky (that is, those who find the risk acceptable) are the base case. All other respondents were less likely to choose a GM apple. The more they agreed with the statement, the less likely they were to choose such an apple. Again, this interaction between respondents' attitudes and whether an apple was GM is the main driver of choice probability for GM apples.

Table 6.11. Estimation results for MNL models

Variable	Estimated parameter (standard error) Main effects MNL	MNL with interactions
Status quo constant	0.247 (0.087) ‡	0.258 (0.111) †
Product attributes		
Antioxidants	0.281 (0.084) ‡	0.428 (0.114) ‡
Flavour	0.453 (0.082) ‡	0.389 (0.102) ‡
GM	-0.294 (0.197)	-0.566 (0.414)
30% less insecticide	0.565 (0.081) ‡	0.495 (0.113) ‡
10% more insecticide	-0.649 (0.100) ‡	-0.766 (0.131) ‡
Price	-0.648 (0.039) ‡	-0.755 (0.053) ‡
'GM food is risky'		
Strongly agree	-3.021 (0.342) ‡	-3.055 (0.342) ‡
Agree	-1.865 (0.242) ‡	-1.882 (0.243) ‡
Neutral	-0.851 (0.215) ‡	-0.872 (0.216) ‡
Disagree	-0.325 (0.210)	-0.358 (0.211) *
Strongly disagree	(base)	(base)
Gender – respondent male	0.003 (0.144)	0.001 (0.144)
Interaction terms		
GM-Antioxidants		-0.363 (0.189) *
GM-Flavour		0.135 (0.169)
GM-30% less insecticide		0.089 (0.185)
GM-10% more insecticide		0.262 (0.210)
GM-Price		0.263 (0.085) ‡
Log-likelihood at convergence	-2078.01	-2070.07
Likelihood ratio test	1068.99	1084.86
pseudo-R^2	0.205	0.208

*significant at the 10% level
†significant at the 5% level
‡significant at the 1% level

The estimated parameter for gender was small and not significantly different from zero. This result is at odds with some research that has found gender correlated with GM attitudes, but agrees with other research, particularly that of Rigby & Burton (2003), that has found no independent impact of gender on GMF choices. However, one difference between this work and some other research (e.g., S. James & Burton, 2003; Lusk, 2003) is that respondents to this survey were all shoppers, and most of them were main household shoppers. The sample thus may not be similar to a sample collected from the general population.

The goodness of fit for the main effects MNL is given in Table 6.11 by the likelihood ratio test and the pseudo-R^2. The pseudo-R^2 calculated by BIOGEME and reported here is McFadden's test statistic (Bierlaire, 2003b; McFadden, 1974). These goodness of fit statistics indicate that this MNL performs well and represents a significant improvement over an intercept-only model that predicts respondent choice based on overall proportions of the choice alternatives in the dataset.

Another way to assess model goodness of fit is to determine the prediction success index (Louviere *et al.*, 2000; McFadden *et al.*, 1978), discussed in Chapter 4. This index calculates the proportion of choices correctly predicted for each alternative in the choice experiment, then calculates a weighted average based on each alternative's share of observed choices. The predicted choices and the resulting prediction success index for the main effects MNL are presented in Table 6.12. This goodness of fit statistic confirms that the model represents an improvement in predictive power over a model based on observed shares alone. Furthermore, the model is shown to fit the holdout data well, nearly as well as it fits the in-sample data. This last result suggests that the model does not overfit the in-sample data.

Table 6.12. Prediction success table for main effects MNL

		Predicted choice (number)			Total ($N_{.i}$)	Observed share ($N_{.i}/N_{..}$)
In-sample data						
		A	B	C		
Actual choice	A	540	232	228	1000	0.42
	B	169	457	112	738	0.31
	C	167	87	386	640	0.27
	Total	876	776	726	2378	1.00
Predicted share		0.37	0.33	0.31	1.00	
Proportion successfully predicted ($N_{ii}/N.i$)		0.54	0.62	0.60	0.58	
Success index ($N_{ii}/N.i$-$N_{.i}/N_{..}$)		0.12	0.31	0.33		
Prediction success index $\sum(N_{.i}/N_{..})\times(N_{ii}/N.i$-$N_{.i}/N_{..})$		0.236				
Holdout data						
		Predicted choice (number)			Total ($N_{.i}$)	Observed share ($N_{.i}/N_{..}$)
		A	B	C		
Actual choice	A	174	88	85	347	0.44
	B	51	152	38	241	0.31
	C	41	27	126	194	0.25
	Total	266	267	249	782	1.00
Predicted share		0.34	0.34	0.32	1.00	
Proportion successfully predicted ($N_{ii}/N.i$)		0.50	0.63	0.65	0.58	
Success index ($N_{ii}/N.i$-$N_{.i}/N_{..}$)		0.06	0.32	0.40		
Prediction success index $\sum(N_{.i}/N_{..})\times(N_{ii}/N.i$-$N_{.i}/N_{..})$		0.225				

One attraction of choice experiments for topics such as GMF is the calculation of partworths or implied prices for specific attributes. Partworths are the ratios between two parameters and quantify the trade-offs that respondents are willing to make. They are most often calculated as the ratio between the parameter for a non-price attribute and the price attribute. This allows the calculation of willingness to pay for a particular attribute. These partworths are presented in Table 6.13. It is important to note that, as modelled, the respondents' attitudes and genders affect the choice probability only when considering GM choice options.

Table 6.13. Partworths for main effects MNL

Attribute	Estimated partworths (NZ$ per kilo)
Status quo	0.371
Product attributes	
Antioxidants (100% more)	0.433
Flavour ('Improved')	0.699
GM	-0.454
30% less insecticide	0.871
10% more insecticide	-1.001
Price	-1.000
'GM food is risky'	
Strongly agree	-4.661
Agree	-2.877
Neutral	-1.313
Disagree	-0.501
Strongly disagree	(base)
Gender	0.005

As an example, consider the willingness to pay for a GM apple of a female consumer who is neutral about GMF's riskiness. The willingness to pay for a GM apple as opposed to a non-GM apple is the change in price that will leave the respondent's observed utility unchanged. This is calculated as follows:

$$V_{GM} - V_{Non} = 0$$

$$\left(\beta_1 price_{GM} + \beta_2 GM + \beta_3 (GM \times neutral)\right) - \beta_1 price_{Non} = 0$$

$$\beta_1 \left(price_{GM} - price_{Non}\right) + \beta_2 GM + \beta_3 (GM \times neutral) = 0$$

$$\beta_1 (price_{GM} - price_{Non}) = -(\beta_2 GM + \beta_3 (GM \times neutral))$$

$$price_{GM} - price_{Non} = -\frac{\beta_2 GM + \beta_3 (GM \times neutral)}{\beta_1}$$

$$price_{GM} - price_{Non} = -\frac{-0.294 + -0.851}{-.648} = -1.767$$

The negative of the ratio of the parameters is equal to the difference between the GM price and the non-GM price. This value is the price change necessary to maintain the same level of observed utility, and is thus the implied price of the attribute. In this example, the GM apple is worth $1.77 less per kilo than a non-GM apple to a female respondent with a neutral response to the riskiness statement. This calculation does not include the *status quo* effect, which would be an additional consideration when introducing a new apple to consumers.

6.3.2 Multinomial logit with interactions

The second MNL considers the impact of interactions between GM and other apple attributes. If preferences are assumed to be separable, each attribute should have an independent impact on choice probability. The choice experiment design in the present research allowed the impact of attribute interactions to be estimated statistically. The choice sets included apples modified for several reasons: greater nutrition, changes in pesticide use, better flavour, and price changes. The interactive effects captured how respondents reacted to different product changes achieved with GM technology. Consumer research suggests that some GMF products are more acceptable than others (Pew Initiative, 2003; Rousu *et al.*, 2003). The interactive effects estimated whether these differences in acceptability operate at the level of the specific product attribute.

Parameter estimates for the MNL with interactions are also presented in Table 6.11. The parameters for the main effects generally have the expected signs and levels of significance. There is again a bias towards the *status quo* apples, and respondents reacted plausibly to increases in antioxidants, improvement in flavour, changes in insecticide use, and price differences. With this model, too, the parameter for the GM attribute by itself is not significant at the 5% level.

The impact of GM on choice probability is complex. The GM attribute by itself, estimated by the parameter *GM*, is not significant. This result suggests that there is no average impact across all products and consumers. All of the parameters estimating the impact for attitudinal groups are significant at the 10% level, and three are significant at the 1% level. They all have the expected magnitudes and signs. As with the main effects MNL, the more that respondents felt that GMF was risky, the less likely they were to choose a GM apple. In addition, the parameter for gender is once again not significant.

The results of the interactions are mixed. GM technology does not seem to interact with two of the four other product characteristics: the parameters for *GM-Flavr* and the two insecticide variables are not significant. The parameter for *GM-Health* is significant at the 10% level (and very nearly at the 5% level) and negative. The parameter for the interaction of GM with price is highly significant and positive.

The goodness of fit of the MNL with interactions is assessed in several ways. Table 6.11 reports the likelihood ratio test and the pseudo-R^2, which indicate that this model fits the data well. Table 6.14 presents the calculation of the prediction success index, which confirms that the model is an improvement over an intercept-only model.

Table 6.14. Prediction success table for MNL with interactions

		Predicted choice (number)			Total ($N_{.i}$)	Observed share ($N_{.i}/N_{..}$)
In-sample data		A	B	C		
Actual choice	A	521	232	247	1000	0.42
	B	158	454	126	738	0.31
	C	152	78	410	640	0.27
	Total	831	764	783	2378	1.00
Predicted share		0.35	0.32	0.33	1.00	
Proportion successfully predicted ($N_{ii}/N.i$)		0.52	0.62	0.64	0.58	
Success index ($N_{ii}/N.i$-$N_{.i}/N_{..}$)		0.10	0.30	0.37		
Prediction success index $\sum(N_{.i}/N_{..})\times(N_{ii}/N.i$-$N_{.i}/N_{..})$		0.237				

		Predicted choice (number)			Total ($N_{.i}$)	Observed share ($N_{.i}/N_{..}$)
Holdout data		A	B	C		
Actual choice	A	171	86	90	347	0.44
	B	45	152	44	241	0.31
	C	38	29	127	194	0.25
	Total	254	267	261	782	1.00
Predicted share		0.32	0.34	0.33	1.00	
Proportion successfully predicted ($N_{ii}/N.i$)		0.49	0.63	0.65	0.58	
Success index ($N_{ii}/N.i$-$N_{.i}/N_{..}$)		0.05	0.32	0.41		
Prediction success index $\sum(N_{.i}/N_{..})\times(N_{ii}/N.i$-$N_{.i}/N_{..})$		0.222				

Calculations of the partworths or WTP for product attributes are presented in Table 6.15. Partworths for non-GM and GM alternatives are calculated separately because different denominators must be used for the two calculations. The significance of the GM-Price parameter means that it must be included in the denominator when calculating the partworths for GM alternatives. Thus, the denominator for non-GM alternatives is the parameter for Price; the denominator for GM alternatives is the sum of the parameters for Price and the

GM-Price interaction. The WTP for non-GM apple attributes is straightforward: respondents would pay a premium for more antioxidants, better flavour, or less insecticide use.

Table 6.15. Partworths for MNL with interactions

Attribute	Partworths for non-GM alternatives (NZ$/kg)	Partworths for GM alternatives (NZ$/kg)		
		Main effects	Interaction effect	Total
Status quo constant	0.342			
Product attributes				
Antioxidants	0.567	0.869	-0.737	0.132
Flavour	0.516	0.792	0.275	1.066
GM	--	-1.150		-1.150
30% less insecticide	0.656	1.006	0.181	1.187
10% more insecticide	-1.015	-1.557	0.532	-1.025
'GM food is risky'				
Strongly agree		-6.210		-6.210
Agree		-3.825		-3.825
Neutral		-1.772		-1.772
Disagree		-0.727		-0.727
Strongly disagree		--		--

The WTP for GM apples is not as straightforward. The main effects follow the same pattern as the non-GM apples (they are calculated with the same numerators but a different denominator). The interaction terms show different effects, however. The GM-Antioxidant interaction nullifies nearly the entire WTP for more antioxidants. The WTP for that attribute is $0.567 for non-GM apples, but only $0.132 when the antioxidants are in a GM apple. The interaction between the two attributes suggests that greater antioxidants are not viewed as positive when achieved through GM. The WTP for greater flavour and less insecticide are, on the other hand, increased by the interaction effects. That is, respondents prefer apples with greater flavour and have negative WTP for GM apples. Adding just the main effects together, however, overstates respondents' reluctance to purchase these GM apples. The positive interaction suggests that respondents are willing to set aside some of their aversion to GM apples when presented with apples with better flavour or less insecticide.

Table 6.15 also contains partworths for respondents' attitudes. Their magnitudes relative to apple attributes indicate that respondents who view GM food as risky would on average not purchase GM apples. Respondents who agreed or strongly agreed that GM food is risky apply total discounts to the GM apples greater than the base price for *status quo* apples, which was $3.00. Other respondents, however, are less negatively disposed and would choose GM apples given the right incentives. The partworths associated with other attitudinal groups are not as large, and suggest that GM apples would have a market, given the right prices and product attributes.

6.3.3 Cross-nested logit

A CNL was proposed for this research to relax the IIA assumption and to model in a compensatory, RUM fashion a decision process that treated GM and non-GM alternatives differently, as two different nests in the decision process.

In order to estimate this model, it was first necessary to recode the choice data. For all the other models, respondents were modelled as choosing one of three alternatives. For the CNL, it was necessary to model respondents' choices as if they had been made from a choice set of five alternatives: one *status quo*, two non-GM, and two GM. For any one question, however, only three of the five alternatives were modelled as being actually available.

The software used for estimating the RUM models, BIOGEME, has a convenient feature for this type of modelling. For each alternative, it is possible to specify a variable that indicates whether the option is available or not. Thus, if one were analysing the choice of travel mode, for example, one could add a variable to the dataset that indicated whether a bus service was available to a respondent or not. For the CNL estimation, the availability of alternatives was linked to the GM attribute. If Apple B, for example, was described as GM, it would then be available as a GM choice but not available as a non-GM choice. It is for this reason that, although there were five apple alternatives in the CNL dataset, only three were available at any one time.

Unfortunately, this recoding resulted in the failure of the CNL estimation. The number of zeros in the data matrix as a result of unavailable alternatives seems to have led to a singular matrix. Thus, the CNL could not be solved analytically.

As described in the Methodology chapter, it was necessary to decide for this research whether to use generic alternatives or labelled alternatives. Generic alternatives were chosen in order to limit focusing respondents' attention on the GM issue. Labelled alternatives could have been used, but might have biased the choices that respondents made. One result of this decision regarding survey design, however, is that a CNL could not be estimated. It is likely that a CNL could have been estimated on data generated from a survey using labelled alternatives.

6.3.4 Naïve lexicographic choice

The first heuristic model that was to be used to analyse the survey data was a naïve lexicographic model. This model examines two of the issues raised regarding GMF. First, it considers the possibility that respondents decisions are not compensatory and that they are instead the result of a decision protocol employing ordered ranking of product attributes. If this is true, then the continuity axiom does not describe actual respondent choices. The second issue that this model examines is the assumption of maximisation that underpins neoclassical theory. If decisions are the result of a protocol, then a boundedly rational description of consumer behaviour explains respondent choice without recourse to the notion of optimisation.

Respondents were presented with nine choice questions, each of which had three apples and a 'none of the above' option, with the set of nine choices forming a response pattern. If only the three apples are considered, the number of possible response patterns is 3^9, or 19,683 possibilities, and if 'None of the above' is considered an option, the number of possible response patterns is 4^9, or 262,144 possibilities.

This naïve lexicographic model allows for significant variation in observed responses, based on how respondents rank the choice attributes. There were five attributes in this choice experiment. These attributes can be listed in their order of importance to the respondent, such as: GM, Price, Insecticide use, Flavour, Antioxidant. Using this order, the respondent would evaluate the three options using the most important attribute, GM, and determine which option had the best value for this attribute. If this evaluation did not lead to a unique choice, the respondent would then compare prices and select the lowest-priced option from the alternatives that made the first cut. With five attributes, there are a possible 5!, or $5 \times 4 \times 3 \times 2 \times 1 = 120$, orders in which to evaluate the attributes. Furthermore, if respondents have similar attribute orderings and are using lexicographic decision making, some response patterns would occur more often and others only infrequently.

If the observed response patterns for the present research are simply catalogued, the challenge of modelling decision making is evident. For Version A of the questionnaire, there were 120 different response patterns from a total of 172 respondents; for Version B, there were 123 patterns from 181 respondents. Both versions had 102 patterns that appeared only once. The most often a single pattern was chosen was nine times. If all respondents were using similar simple cognitive models for deciding amongst the alternatives presented in the choice experiment, one would expect very few response patterns. For example, the research reviewed in Chapter 2 suggests that there are three to five consumer segments with regard to GMF.

Assuming that these groups were homogeneous in their decision-making would lead one to expect the same three to five response patterns to appear again and again.

The large number of observed response patterns and the small number of repeats of observed patterns creates a problem in establishing which patterns are important. There is no criterion for deciding whether the correspondence between an observed pattern and a theoretical lexicographic one is meaningful. The data collected with this choice experiment thus do not support a naïve lexicographic choice model.

6.3.5 Semi-lexicographic choice

The second proposed heuristic model was a semi-lexicographic choice model. For this model, respondents' decisions regarding the GM attribute could be either compensatory or non-compensatory, depending on their attitudes. All other product attributes entered into the choice process in a compensatory but simplified way. This model examines the same two issues as the naïve lexicographic model: that the continuity axiom does not hold for choices regarding GMF and that the assumption of maximisation is not required for modelling respondents' choices.

The descriptive analysis of the survey data suggests that a non-compensatory model for choices regarding GMF might be useful. Nearly one-half of respondents never chose a GM option from the nine choice sets. Modelling this refusal directly as a non-compensatory decision protocol, rather than indirectly as a high discount for GMF, could prove fruitful.

The proposed semi-lexicographic model proceeds by assigning a weight or a score to each alternative and predicting that respondents would choose the option with the highest score. Unlike a MNL model, there is no appeal to utility maximisation and no calculation of relative values for different attributes. Instead, it is assumed that the choices respondents make can be modelled by noting whether an option is better or worse than the others in its choice set. Each attribute except GM is equally valued, so that alternatives are valued by the number of attributes for which an they are better or worse. For the GM attribute, respondents are grouped into three segments: GM-refusing, GM-indifferent, and GM-supporting. They are assigned to these groups based on their reactions to Question 19, the same statement about the riskiness of GM food used for the MNL models. Those who strongly agreed or agreed that GM food was too risky were labelled ‘GM-refusing’. Those who said they were neutral were considered ‘GM-indifferent’. Finally, those who disagreed or strongly disagreed with the statement were labelled ‘GM-supporting’. The Methodology chapter presented the semi-lexicographic choice model as follows:

$$V(j) = \sum_{k=1}^{K-1} x_{kj} - 10x_{GM,j}z_1 - x_{GM,j}z_2$$

Results for the semi-lexicographic choice model are in Table 6.16. Parameters for this model are assigned or imposed on the data, so there is no attempt to calculate the significance of each parameter. Instead, the model is assessed by its goodness of fit, measured with a prediction success index. The results suggest that this model is an improvement over a model based on observed shares only. In addition, it performs similarly with both the in-sample and holdout datasets. Thus, a non-compensatory, heuristic model may be used to model the choice data.

Table 6.16. Prediction success table for semi-lexicographic choice model

		Predicted choice (number)			Total ($N_{.i}$)	Observed share ($N_{.i}/N_{..}$)
In-sample data						
		A	B	C		
Actual choice	A	270	433	297	1000	0.42
	B	28	582	128	738	0.31
	C	39	214	387	640	0.27
	Total	337	1229	812	2378	1.00
Predicted share		0.14	0.52	0.34	1.00	
Proportion successfully predicted ($N_{ii}/N.i$)		0.27	0.79	0.60	0.52	
Success index ($N_{ii}/N.i$-$N_{.i}$/ $N_{..}$)		-0.15	0.48	0.34		
Prediction success index $\sum(N_{.i}/N_{..})\times(N_{ii}/N.i\text{-}N_{.i}/N_{..})$		0.175				
Holdout data						
		A	B	C		
Actual choice	A	94	140	113	347	0.44
	B	6	184	51	241	0.31
	C	10	55	129	194	0.25
	Total	110	379	293	782	1.00
Predicted share		0.14	0.48	0.37	1.00	
Proportion successfully predicted ($N_{ii}/N.i$)		0.27	0.76	0.66	0.52	
Success index ($N_{ii}/N.i$-$N_{.i}$/ $N_{..}$)		-0.17	0.46	0.42		
Prediction success index $\sum(N_{.i}/N_{..})\times(N_{ii}/N.i\text{-}N_{.i}/N_{..})$		0.167				

However, closer examination of the prediction success table reveals an important weakness in the model. The model does not contain a term to account for respondent preference for the *status quo* apple, and that lack is apparent in the results. First, it underpredicts the choice of Apple A, so that the success index for Apple A is actually negative. Secondly, its errors on predictions for other alternatives are weighted towards the *status quo*. The predictions that the model makes can be divided between correct and incorrect predictions. If the model incorrectly predicts that a respondent chooses Apple B or Apple C, then the actual choice was either the *status quo* apple or the other alternative apple. The data in the table indicate that the actual choice in these cases was over twice as likely to be the *status quo* apple as it was to be the other alternative apple. That is, when the semi-lexicographic model makes an incorrect prediction, it tends to be the result of not predicting selection of the *status quo*.

As a result, an additional semi-lexicographic choice model including a *status quo* term was analysed. The prediction success of that model is presented in Table 6.17. The addition of the *status quo* term improves the model fit, both for the in-sample and holdout datasets. While incorrect predictions are still likely to be the result of failing to predict the *status quo*, the impact of such a failure has been reduced. In addition, the prediction success index has improved over the prior model.

Table 6.17. Prediction success table for semi-lexicographic choice model with *status quo* term

		Predicted choice (number)			Total ($N_{.i}$)	Observed share ($N_{.i}/N_{..}$)
		A	B	C		
In-sample data						
Actual choice	A	439	337	224	1000	0.42
	B	90	532	116	738	0.31
	C	133	175	332	640	0.27
	Total	662	1044	672	2378	1.00
Predicted share		0.28	0.44	0.28	1.00	
Proportion successfully predicted ($N_{ii}/N.i$)		0.44	0.72	0.52	0.55	
Success index ($N_{ii}/N.i$-$N_{.i}$/ $N_{..}$)		0.02	0.41	0.25		
Prediction success index $\sum(N_{.i}/N_{..})\times(N_{ii}/N.i$-$N_{.i}$/ $N_{..})$		0.202				
Holdout data						
		A	B	C	Total ($N_{.i}$)	Observed share ($N_{.i}/N_{..}$)
Actual choice	A	138	120	89	347	0.44
	B	30	167	44	241	0.31
	C	30	47	117	194	0.25
	Total	198	334	250	782	1.00
Predicted share		0.25	0.43	0.32	1.00	
Proportion successfully predicted ($N_{ii}/N.i$)		0.40	0.69	0.60	0.54	
Success index ($N_{ii}/N.i$-$N_{.i}$/ $N_{..}$)		-0.05	0.38	0.36		
Prediction success index $\sum(N_{.i}/N_{..})\times(N_{ii}/N.i$-$N_{.i}$/ $N_{..})$		0.186				

6.3.6 Model comparison

Three successful models presented above – the main effects MNL, the MNL with interactions, and the semi-lexicographic choice model with the *status quo* term – can be compared with one another. Fit statistics for the three models are presented in Table 6.18. The first fit statistic used for model comparison is the prediction success index, both for the in-sample and holdout datasets. The models are all somewhat successful at predicting respondents' choices. They do not appear to overfit the data, as their results with the holdout data are essentially similar to their results with the in-sample data. Finally, the RUM models have better predictive fit than the heuristic model.

Table 6.18. Comparison of model fit statistics

Statistic	Main effects MNL	MNL with interactions	SL choice with SQ
Prediction success index, all choices			
In-sample data	0.236	0.237	.202
Holdout sample	0.225	0.222	.186
Percent of GM choices correctly modelled			
In-sample data	29.2	29.7	36.7
Holdout sample	30.0	28.6	37.9
Likelihood ratio test [a]	1069	1085	-909
Pseudo-R^2 [a]	0.205	0.208	-0.177

[a] These are probability-based statistics, so they are incompatible with a heuristic framework. The values reported for the semi-lexicographic choice model are the model fit statistics for a RUM model with parameters that mimic the semi-lexicographic choice model.

The second fit statistic presented is the success of the models in predicting choices on those occasions when respondents chose GM alternatives. When predicting choices on those occasions, the MNL models predicted the correct choice about 30 per cent of the time. Given that these models correctly predicted 58 per cent of all choices in both the in-sample and holdout datasets (see Tables 6.12 and 6.14), they are significantly better at predicting non-GM choices than GM choices. The semi-lexicographic choice model correctly predicted 37 per cent of the in-sample GM choices and 38 per cent of the holdout GM choices, or about 8 per cent better than the MNL models. However, this model is also worse at predicting GM choices than it is at choosing non-GM choices, as it correctly predicted 55 per cent of in-sample choices and 54 per cent of holdout choices (see Table 6.17).

The final two fit statistics presented in Table 6.18 are the likelihood ratio and the pseudo-R^2, which are fit statistics based on the computed probabilities of observed choices. For the two MNL models, these fit statistics were presented with the model estimations in Table 6.11. They show that these models have reasonably good fit, and that adding the interaction terms increases the fit but only marginally. The semi-lexicographic choice model does not generate its own probability statistics. However, as described in the Methodology chapter, it is possible to use its parameters to calculate probability-based fit statistics that would be generated from a RUM model that mimics the semi-lexicographic choice model. While this is not an exact comparison, it provides some suggestion of the relative fit of the different models. As the results demonstrate, only a suggestion is required, because these statistics suggest that a RUM model estimated with this dataset would never generate the parameters associated with the semi-lexicographic model. The semi-lexicographic parameters create a model that fits the data worse than an intercept-only model. Thus, the likelihood ratio and the pseudo-R^2 are negative, where these statistics are positive for the MNL models.

6.4 Discussion

The present research was motivated by empirical findings regarding consumers' responses to genetically modified food, discussed in Chapter 2, and apparent inconsistencies between the neoclassical theory of consumer choice behaviour, discussed in Chapter 3. The proposed design of the empirical research focussed on investigating four specific issues. The results of that research provide some insights into these issues, and these insights are explored in the following discussion.

6.4.1 Separability

One assumption that may be made in neoclassically-based economic research is that preferences may be regarded as separable (Deaton & Muellbauer, 1980; McIntosh & Ryan, 2002). When applied in goods space – that is, to whole products – this assumption allows for a consumer's preferences over two products be independent of the other products in the set of choices available. This assumption in goods space allows for a marginal rate of substitution to be calculated between two goods without reference to the level of consumption of other goods (Deaton & Muellbauer, 1980; McIntosh & Ryan, 2002; Varian, 1996). When applied in attribute space in CE research, this assumption allows a partworth to be calculated simply as the ratio between two parameters. In order for this ratio to be constant and independent of the other attributes in the choice set, it must be separable from the other attributes in the choice set.

The choice experiment in the present research was designed to test whether preferences over GMF attributes may be assumed separable. The alternatives in the choice experiment were specified as a fractional factorial that could estimate the interactions between GM and other product attributes. Two models were specified, one that included parameters for these interactions and one that did not.

The two models fit the data similarly, with likelihood ratio, pseudo-R^2, and prediction success index results that were largely equivalent. However, the individual parameters for the MNL with interactions indicated that the presence of GM did interact with other attributes, particularly with the price attribute. It is interesting that the fit of the main effects MNL is nearly as good as the fit of the interactions model, confirming prior research suggesting that the MNL is a robust model (Bolduc & McFadden, 2001; Louviere *et al.*, 2000; Williams & Ortuzar, 1982).

The significance of the interaction parameters indicates that the assumption of separable preferences does not hold for the attributes of GMF. The presence of the GM attribute may affect the marginal rate of substitution between other attributes, and the change may be large enough to affect the preference order that the utility function is intended to represent. The specific example evident in the present research is the preference relationship between antioxidants and improved flavour. The model results suggest that greater antioxidants are preferred to (are more highly valued than) improvements in flavour in the case of non-GM apples, but the opposite is true for GM apples. Thus, the presence or absence of GM affects the preference relationship between two other attributes, suggesting that preferences may not be separable.

Two conclusions follow from this finding. The first is that researchers may not be able to transfer preference orders from non-GM to GM products. The relative willingness to pay for product attributes may be quite different for GM products, even leading to reversals of preference orders for attributes. The second conclusion is that there may be a need to include separability considerations in the design of GMF research. The findings from the present research suggest that choice sets that include attribute interactions may be used to account for these interactions. A drawback to such an experimental design is that including additional interactions limits the number of attributes and attribute levels that can be included. A second drawback is that this research included only two-way interactions between GM and other attributes. Additional interactions were not considered. Thus, a second possible way to account for such interactions is to include contingent valuation questions that evaluate whole products rather than their constituent attributes. Observed discrepancies between the sum of the values of the attributes and the value of their totality may be related, at least in part, to lack of separability.

6.4.2 The continuity axiom

Another of the axioms underpinning neoclassical choice theory is continuity. While some neoclassical theory has relaxed this axiom (*e.g.*, Arrow, 1963), it is theoretically essential for choice experiments. Most importantly, it leads to unidimensional utility, which is necessary in order to include choice attributes in a one-dimensional RUM model.

The focus of this research was on discontinuous preferences regarding GM. This focus was the result of indications from prior research that suggest that many consumers do not want GMF at all. This refusal of GM, regardless of compensation, suggests that preferences are not continuous. This discontinuity was empirically investigated in a number of ways, which can be divided into gathering evidence of violations of continuity and analysing their impact.

Review of previous research found suggestions that stated preferences regarding GMF are discontinuous, and this was supported by evidence from the present study. One piece of evidence was the large number of respondents who never chose a GM option from the choice experiment. Nearly one-half of respondents never chose a GM apple, despite the wide range of price discounts and other health and environmental inducements on offer. Thus, in a simple and concrete way, the choice data are discontinuous – the amount of compensation required to induce many respondents to choose GMF is simply unknown. The suggestion, then, is that their preferences are discontinuous.

It would be difficult to contend that the WTP for GMF of those who never chose a GM apple could be estimated based on the observed WTP of those who did choose GM apples. For this contention to be true, the two groups would have to be two samples drawn from the same population of consumers, with the WTP of the Choosers designating a portion of the total WTP function. This total WTP function would include all respondents, both Choosers and Non-choosers.

The reason that this contention is suspect is that the two groups are measurably different. When responses to nearly all of the attitudinal questions in the survey are analysed, the two groups of respondents have different distributions of responses. The mean responses are also different for the two groups. Thus, the two groups represent samples drawn from two populations, with one willing to choose GMF and the other unwilling. Interestingly, the two groups are not different in their demographics or socio-economic characteristics; it is their attitudinal differences and choices that distinguish them.

While the two groups do seem to be drawn from different populations, it is true that the choice experiment did provide a finite range of potential compensations for consuming GMF. It is impossible, then, to avoid the suggestion that greater or more enticing compensation could lead Non-choosers to select GMF. To determine the consistency with which respondents might refuse GMF, two additional methods for collecting preference data were included in this research: a contingent valuation exercise and an attitudinal question. The portion of respondents who consistently rejected GMF at every opportunity was nearly one-quarter of the sample. Thus, while the true number of respondents with discontinuous preferences may be less than indicated by the choice experiment, they are still a non-trivial portion of the sample and, by extension, of the food market.

This research has been concerned with identifying those respondents who would purchase GMF and those who would not. Those respondents who consistently indicated either acceptance or rejection of GMF were 64.9 per cent of the sample, while 34.6 per cent were inconsistent in their responses, sometimes indicating acceptance and sometimes indicating rejection. Whether respondents are willing to accept compensation in return for consuming GMF is key to the continuity axiom, so those respondents with inconsistent responses were considered more closely. Most of these inconsistent respondents can be placed into one of three groups:

- They chose GM options but said they would not purchase such apples.

- They never chose a GM option and said they would never purchase GM apples, but nevertheless gave a positive CV price.
- They never chose a GM option, but said they would buy GM apples and gave a positive CV price.

There are different possible reasons for inconsistent responses from these different groups. These potential causes of inconsistent responses were not tested in the present research, so the following discussion suggests directions for further research on potentially discontinuous preferences.

The first group has 35 respondents, or 9.9 per cent of the sample. When directly asked whether they would buy a GM apple, they said they would not. However, in the choice experiment they did choose GM apples. One possible explanation for their responses is hypothetical bias: when these respondents state what they would do, there are no consequences to their statements. They are therefore free to answer hypothetically, rather than with regard to real purchasing behaviour. The obvious problem with this reasoning is that all three questions are to some extent hypothetical. It is impossible to know which one should be considered the most realistic. A second possible reason for the inconsistency is that the choice experiment highlights the trade-offs that consumers would need to make in order to have non-GMF, whereas the statement of purchasing behaviour does not explicitly include those trade-offs. When those trade-offs are explicit, then respondents may be more inclined to accept GMF. A third explanation is simply that errors were made. It could be that the respondents chose GM options without realising it, and that they therefore did not choose what they would truly consider the 'best' option. It could also be that errors were made in recording responses, so that the apparent inconsistency is actually experimental error.

The second group of respondents disagreed that they would purchase GM apples and in fact never chose a GM option from the choice sets, but yet they gave a positive price on the CV question. There are 40 such respondents, or 11.3 per cent of the sample. One possible explanation is that these respondents were not providing their own willingness to pay for GM apples, but rather were estimating the price they would expect the apples to command in the market. This is particularly possible for those who assigned a premium price to the CV apples. Another possible explanation for those respondents who gave the CV apple a price of $3.00 is that this represents a refusal response, just as the nil price does. Spash (2000) found that lexicographic preferences can result in a range of willingness to pay for environmental goods, and that a positive willingness to pay may not indicate compensatory preferences. In the present case, the respondents might be indicating that they would not pay a premium even though the apple might be marketed as a ‘better’ product. Finally, those in this group who assigned the apples a positive but discounted price could be indicating that they have no intention of purchasing these apples. They may thus have obliged the researcher by offering a dollar value for the price, but a value they would never expect to see in a real market. Since the price is not expected to appear, the respondents do not expect to purchase GM apples.

The last group of inconsistent responses is interesting for the opposite reason to those above. This group said they would purchase GM apples and did assign positive prices in the CV question, but yet never chose a GM option in the choice card. At the very least, 17 people (7 +10) can be assigned to this group, or 4.8 per cent of the sample. This raises the question of why they did not choose any GM options. The modification offered in the CV question was similar to the changes in insecticide used in the choice sets, and some choice options were priced less than the status quo. One explanation, as in the previous groups, is that respondents were giving their expectation of the market price, not their own willingness to pay. A different explanation is that the CV question introduced an information effect. The choice experiment was conducted without additional information, while the CV question stated that apples are currently sprayed and that GM technology could end the practice. Affected by this new information, a few respondents may have become more positively inclined toward GM apples. Similar information impacts have been found in prior research (Huffman *et al.*, 2003b). A third possible explanation is fatalism, that some consumers do not really want GM apples, given the choice, but are resigned to having GM food and being charged at least as much for it.

The exact explanations for these inconsistencies are likely to vary by the type of inconsistency recorded. These responses do suggest that hypothetical bias, information bias, differential responses to the different types of valuation tasks, and simple errors could have affected some respondents. However, although some respondents seemed inconsistent, it is important to emphasise that nearly two-thirds of respondents were entirely consistent. In particular, nearly one-quarter of respondents consistently refused GMF at every opportunity. The fact that responses were largely consistent suggests that the data from the survey are reliable measures of respondents preferences or intended choice with regard to GMF, and that those preferences or intentions include discontinuities.

The evidence of discontinuous preferences can lead to a number of conclusions about their impact in the market. In a practical and concrete vein, discontinuous preferences mean that some consumers are not in the market for GMF. So long as they have access to non-GMF, they will not be willing to purchase GMF. This practical approach to handling discontinuous preferences has been suggested in prior research (S. James & Burton, 2003; Rigby & Burton, 2004). For choice experiments, this approach results in treating potentially discontinuous preferences as continuous, by estimating very large empirical discounts for GMF, such that GMF would have to be ridiculously cheap in order for Non-chooser to purchase it. This was the approach used to estimate the main effects MNL and the MNL with interactions. Both of these models treated preferences regarding the GM attribute as continuous, and both estimated very large parameters for those respondents who felt that GMF was risky. Thus, the estimated partworths for two groups of respondents were so large that GM apples could be free and the respondents would still prefer non-GM apples.

This evidence of discontinuous preferences regarding GMF has a strong implication. If such consumers were compelled to consume GMF, either because they did not know they were getting GMF, because GMF was incorporated into what they perceived was non-GMF, or because non-GMF was unavailable, the impact on their welfare might not be calculable. They have indicated that they are not indifferent between GMF-with-some-benefits and non-GMF: there is no point of indifference, no region in which these consumers are trading GM for other attributes. GMF is always inferior to non-GMF. Furthermore, neoclassical theory assumes that consumers' preferences are stable, so these preferences would not be expected to change. The logical conclusion, therefore, is that consumers with discontinuous preferences would have their utility immeasurably reduced if non-GMF did not continue to be available to them.

As discussed in Chapter 3, neoclassical theory does not allow for discontinuous preferences. It starts with the continuity axiom, which assumes that all preferences are continuous and therefore compensatory. The empirical evidence of discontinuities for one-quarter if not one-half of the present survey respondents is, however, inconsistent with the assumption that preferences are continuous. To apply neoclassical theory to this data and estimate RUM models like the two MNL models, one therefore must assume away an interesting empirical feature of the data: its discontinuity.

Given that the data is inconsistent with the neoclassical consumer theory underpinning RUM modelling – because some respondents provided responses that reflect discontinuous preferences and these respondents are clearly drawn from a different population than the respondents with continuous preferences – it was logical to consider an alternative theory of consumer behaviour. Drawing on the behavioural theory of bounded rationality, two heuristic models were proposed and analysed. One, the naïve lexicographic model, was rejected as also inconsistent with the data. Given some prior consumer research (Bettman *et al.*, 1998; Earl, 1983), this failure of the naïve lexicographic model is unsurprising. However, research on the success of heuristic decision making strategies has examined hierarchical, lexicographic strategies, such as Take the Best and Take the First (Gigerenzer & Selten, 2001b; Gigerenzer *et al.*, 1999). This prior research has found that such strategies are able to choose the best answer from certain kinds of choice sets. However, as discussed in the literature review, this thread in the research on bounded rationality is focussed on how to make the correct, *i.e.*, optimal, decision, rather than on identifying the strategies that consumers actually use. The present research contributes to the research strand investigating actual consumer strategies by finding that respondents to this choice experiment did not seem to be widely using the same simple hierarchical decision protocol. If they were using a lexicographic decision protocol, then the sample as a whole used over one hundred different orders for selecting attributes for evaluation. Thus, the data do not support a single, common, hierarchical decision model.

To analyse the data, it is therefore necessary to develop a model that pools and averages respondents' choices. However, given the evidence of discontinuous preferences and research on bounded rationality, it was useful to consider a model that included both a discontinuity for the GM attribute and a simplified decision protocol. The result was the semi-lexicographic choice model. When this model was used to analyse the choices that respondents actually made, it was somewhat successful at fitting both the in-sample and holdout data. This model demonstrates that it is possible to model the choice data without assuming that preferences are continuous; a discontinuity can be explicitly included.

6.4.3 Maximisation

One of the differences between neoclassical theory and bounded rationality is that the former assumes that consumer choice is the result of an optimising or maximising process while the latter does not. In neoclassical theory, product attributes provide some utility for consumers, and consumers seek for and choose the products that provide them the greatest utility, given their budget constraints. By contrast, bounded rationality suggests that consumer behaviour has regularities that allow consumers to be successful; at a minimum, behavioural regularities allow them to survive to consume another day.

The models used in this research were based on both neoclassical and bounded rationality theories, so they can be used to consider whether it is necessary to assume a process of utility maximisation to model decision making. The MNL models are based on neoclassical theory, which posits that consumers are choosing alternatives that maximise their utilities. As described in Chapter 3, this assumption leads to RUM models, of which one is the MNL. By contrast, the semi-lexicographic choice model proposed a decision protocol and then assessed how well it fit the data. Both types of models achieve some success in modelling the empirical data. The success of the boundedly rational model suggests that it is not necessary to assume maximisation in order to model consumer behaviour. It is possible to construct a model of a likely decision protocol and demonstrate its correspondence to the data.

Unfortunately for the boundedly rational model, however, the MNL models out-performed it. First, they fit the data better on probabilistic measures of model fit. Since these models provided the parameters that maximise the model fit, it would have been suspect to find that some other model fit the data even better. These models also fit the data better when assessed with a prediction success index. Thus, not only did they maximise the likelihood of observing the data, they also predicted respondents' choices better than the alternative model. This result suggests that, while maximisation is not a necessary assumption, it is useful.

The difference between the results of the MNL and the semi-lexicographic models can be likened to the difference between type I and type II errors. Given a null hypothesis, a type I error is defined as rejection of the hypothesis when it is in fact true, while a type II error is defined as non-rejection of the hypothesis when it is false (Geng & Hills, 1989). This research in essence assessed the following hypothesis for each respondent: 'This respondent would choose a GM apple'. The semi-lexicographic choice model, with its categorical treatment of the GM attribute, tended to reject the hypothesis when it was in fact true, a type I error. Thus, respondents who agreed that GMF was too risky were never expected to choose a GM apple. In fact, some of them did, which reduced the fit of the model. The MNL models tended toward the type II error, in which they accepted that respondents would choose GM apples when in fact they do not. This error is tied up in the issue of continuity: the MNL models assume that all respondents will choose GMF at some price level, when in fact some respondents have rejected GMF at every opportunity.

The difference in these two errors is linked to the issue of maximisation. The MNL models maximise the fit to the data within the bounds of this particular choice experiment. These bounds include the range of levels for each factor. Thus, given a range of prices from $1.50 to $4.50, a GM attribute, and some other product attributes, the MNL models fit the data better than a heuristic model. However, it is uncertain how well the models would predict a new dataset that was based on a wider range of prices and other product attributes. For example, if a similar sample of respondents was surveyed using larger GM discounts or even greater benefits, these MNL models would predict greater acceptance of GM alternatives. Once the price difference between GM and non-GM was greater than about $7.50 per kilo, the MNL would predict that all respondents would prefer the GM apples.

The semi-lexicographic choice model does not maximise the fit within the bounds of the choice experiment. Instead, it is considering additional data: the literature that suggests that some consumer do not want GMF at all. Thus, it does not fit the sample data as well as the MNL, but does ‘fit’ the wider literature concerning consumer reactions to GMF.

This research cannot offer a clear conclusion regarding maximisation. Clearly, it is not necessary to assume a process of maximisation. Instead, consumer decisions can be modelled as the result of a decision protocol. However, assuming a maximisation protocol added to this research in three ways. First, it maximised the model fit to the data, resulting in the parameters that provided the best probabilistic fit and highest prediction success. Secondly, it signalled the importance of the *status quo* bias, which had not been included in the semi-lexicographic model.

The third contribution of the maximisation protocol is perhaps the most important. Using RUM models solved by maximum likelihood allowed this research to compare MNL models with and without interactions terms, and then to assess the significance of those parameters. The two MNL models had essentially the same overall model fit, but the interaction parameters, particularly for *GM×Price*, were found to contribute to the analysis. Thus, maximising the fit of a complex model contributed to this research’s findings regarding consumer assessments of GMF.

6.4.4 Aggregation

The final issue regarding GMF that this thesis has raised is that of aggregation. Aggregation moves from the level of individual choices to summarise the impact on the sample and, by extension, the population. Typical measures of aggregate impacts are total changes in consumer welfare and average price discounts for GMF.

The first thing to note about these aggregate measures is that they can only be calculated by assuming preference continuity. As discussed above, consumers with discontinuous preferences regarding GMF might have their utility immeasurably reduced if they were compelled to consume it. Thus, it may not be possible to measure the total change in consumer welfare from adopting GMF throughout the food system. Certainly, some consumers would receive a benefit from GMF with perceived benefits, but their measured welfare improvement would be offset by the potentially immeasurable reduction in other consumers' welfare. Thus, in order to have a measurable result, some continuity, that is, some willingness to trade GM for compensation, must be assumed. Unfortunately, the data do not indicate what level of compensation should be assumed for almost one-half of respondents.

The second aggregation issue is that the data do not support the idea of an average discount for GMF. The discount that respondents applied to GM apples was divided into several components. The component that measured the baseline GM discount that all respondents applied was not significant, suggesting that there was no average impact of the presence of GM on choice probability. That is, respondents did not react to GM in a common, average way. In addition, the parameters that captured the impact of GM on choice for each group of respondents were mostly significant and varied by order of magnitude. These results demonstrate the range of responses that consumers have to GMF.

The impact on the market can be explained with a simple thought experiment, similar to the model of the milk market in Tauer (1994). The experiment starts by assuming that the supply of apples begins to segment into GM and non-GM varieties. At low levels of GM apple supply, there would be a ready demand and those consumers would probably not require a discount. If the GM apple provided some benefit, such as increased levels of antioxidants, these early consumers might be willing to pay a premium. As supply increased, the marginal price for the additional supply would fall, bringing the market price with it. According to market theory, in a well-functioning market, price acts as a signal to producers and consumers. Apple producers would continue to produce and sell GM apples until the price fell too far, and consumers would demand GM and non-GM apples until the relative prices allowed both markets to clear. Thus, an average discount in the sense of a discount that clears the market for GM and non-GM varieties depends critically on supply, which in turn depends on the relative cost of producing the two varieties.

This description of a market in search of an equilibrium does not address the issue of refusal of GMF. In part, the weakness in this description is that it does not distinguish between the intensive margin – existing consumers demanding more – and the extensive margin – new participants enticed into the market (Pudney, 1989). Smooth price adjustments may be possible as long as the supply of GMF is below some threshold that does not require an increase in new participation from consumers who are opposed to GMF. However, this description of the market provides little guidance about the market impact of an increase in GMF supply over this threshold. It is not clear how the price would be affected by such an increase. In theory, if the empirical findings of the present research are accurate, the relative prices of GM and non-GM food would rapidly widen, as shops found they could not sell their stocks of GMF and refusers bid up the price of non-GMF. What would happen in practice could not be investigated in the present research, because the enhanced products in the choice experiment are not currently available to consumers. The theoretical scenario, however, does give reason for concern, because it suggests that the market price of GMF might be volatile, at least once the supply represents a significant portion of total food supply.

Because of these issues with calculating consumer welfare impacts and market discounts, the simplest and most robust method for aggregating this data is to describe the market segments. The present research is particularly good for such a method of aggregation because it was able to collect usable choice data from nearly all respondents. The choice experiment was designed with the intention of reducing protest responses while at the same time allowing respondents to express lexicographic preferences regarding GMF. To do this, an expanded fractional factorial created choice sets that included a wide range of non-GM alternatives. Thus, respondents who wanted to avoid GMF did not have to select the *status quo* response for every choice question, which would lead to them being classified as protest respondents. Instead, they had a range of non-GM alternatives which they could compare with the *status quo* alternative. Ninety-five per cent of respondents found some alternative to the *status quo* enticing, which is a good result compared to other choice experiments on GMF (Burton & Pearse, 2002; Burton et al., 2001; S. James & Burton, 2003; Onyango et al., 2004). Thus, data from all survey respondents could be included in the analysis.

However, even though protest responses were minimised, respondents could still have choice patterns that indicated lexicographic preferences or choice protocols. For those who did not want GMF, the choice set allowed them to indicate such preferences with their choices. Standard choice modelling practice would be to regard such lexicographic responses as aberrations (Bennett & Adamowicz, 2001) and exclude them from the analysis. Such an approach would lead to the loss of nearly one-half the dataset, so instead these choices were included and analysed.

The research used two approaches to modelling market segments. All the successful models included variables that accounted for respondents' opinions regarding the riskiness of GMF. As described above, opinions regarding the riskiness of GMF correlated with responses to the other attitudinal questions, but this question was the most appropriate for modelling choices. The MNL models included five consumer segments, which varied in their willingness to pay for GMF. The discounts on GMF demanded by the most accepting of the consumer segments were under $1.00 per kilogram, and the parameters for these groups were not significantly different from zero at the 5 per cent level. By contrast, the least accepting consumers required discounts that exceeded the base product price, and the parameters for these groups were very significant. Thus, one way to aggregate the results to the market level is to suggest that small or zero discounts will be demanded by some consumers, who made up 33.4 per cent of the sample, while the products are unattractive at any price to other consumers, who are 41.1 per cent of the sample. The semi-lexicographic model used three market segments to account for consumer heterogeneity. The parameters assigned to the different groups mimicked indifference to GM, wariness, and complete refusal. Dollar values are not attached to these descriptions of consumer behaviour.

In a gross sense, the results from the two types of models are not very different. They both suggest that many consumers – as little as one-tenth but as much as one-third of consumers – do not place much if any weight on the GM attribute when making food choices. They also both suggest that a large number of other consumers – 40 per cent or more – are not inclined to purchase GMF at all. The remaining consumers – one-quarter to one-half – are more or less inclined to purchase GMF, and consider the GM attribute alongside other product attributes.

6.5 Conclusion

This chapter has presented the empirical results from the research design proposed in the Methodology chapter. The descriptive analysis found that the sample of respondents was largely representative of the New Zealand population. A significant portion of these respondents were found to give responses that suggested no willingness to choose or buy GM apples. For the choice experiment, nearly one-half of respondents demonstrated such unwillingness. If a stricter standard was applied to the data, then respondents who consistently refused GMF comprised nearly one-quarter of the sample.

This chapter also used the five models proposed above to analyse the survey data. The basic MNL was shown to fit the data well and to result in plausible parameter estimates. However, the MNL with interactions found that the interactions between product attributes are significant and should be included. Although this model led to only a marginal increase in overall goodness of fit, it did result in a different set of partworth estimates. The semi-lexicographic choice model corrected to include a *status quo* term was also successful, although not as successful as the MNL models. It did, however, out-perform the MNL models on those occasions when respondents chose GM apples. Nevertheless, it was shown that such a model would never arise from a RUM-based estimation, because the model performed very poorly when assessed with probability-based statistics.

Two models were unsuccessfully attempted. A CNL model could not be estimated, and this result was attributed to the design of the choice experiment. The drawback of the design was that a nested decision-making structure could not be estimated with a RUM model, but the benefit was that the design addressed concerns regarding realism, hypothetical bias, and respondent sensitisation. The other proposed model that was ultimately unsuccessful was a naïve lexicographic model. It was shown that the data were in fact inconsistent with such a model, so that this research found no evidence of significant use of a strict or naïve lexicographic decision-making process.

The present research was designed to explore four issues regarding demand for GMF. The findings from this research extend the understanding of the demand for GMF in several ways. First, the separability of preferences over food attributes was tested. The GM attribute was found to interact significantly with other food attributes, to such an extent that preferences over attributes were ordered differently depending on whether the apple in question was GM or non-GM. The second issue explored was whether preferences could be assumed continuous. The empirical results indicate that preferences regarding the GM attribute were not found to be continuous for one-quarter to one-half of the sample. In order to consider the impacts of discontinuous preferences, models from two different economic schools of thought were developed and analysed. Models from both economic perspectives were shown to fit the data, although the neoclassical models fit the data better than the heuristic model did. The comparative success of these models addressed the third issue raised in this thesis, the assumption of maximising behaviour. The heuristic model fit the data, suggesting that maximisation may not be a necessary assumption regarding consumer behaviour. However, the maximising models fit the data better and contributed valuable insights into the impact of product attributes on respondents' choices. Finally, the issues of continuity and maximisation raised questions about the appropriate way to aggregate individual-level data into market-level impacts. Aggregate measures based on the assumption of continuity are difficult to support fully, because of the likelihood of discontinuous preferences for some consumers. Such preferences create either theoretical problems or extreme conclusions regarding welfare impacts. Instead, aggregation based on simple consumer segments seems more defensible. In addition, the neoclassical and boundedly rational models reach similar conclusions regarding the reactions of different consumer segments.

These findings suggest that RUM modelling such as MNL may need to consider the assumptions regarding preferences that are contained within the modelling. These findings have suggested that preferences over GMF attributes may not be separable; attributes interact with each other to affect choice probabilities. In addition, the data do not exhibit continuity; because of the several ways in which continuity was examined, the findings suggest that the data are in fact evidence of discontinuities. Interestingly, the simple MNL that relied on both assumptions regarding preferences did work well, and the MNL with interactions improved the model fit only a little. The models mimic and predict choices well for the in-sample and holdout datasets, and they have better model fit than the heuristic models. One heuristic model could not be used to model the data, and the other did not have as large a prediction success index as the RUM models. Thus, regardless of whether the underlying assumptions regarding preferences are consistent with the data, RUM models appear to be useful from a practical standpoint for modelling choices.

Chapter 7

Conclusion

The introduction of GM crops into the agri-food system is providing economists with an opportunity to study a market in its infancy. Farmers are learning how much of these crops to produce, consumers are deciding how much of them to consume, and the products themselves are changing as new GM crops are developed. Economists can observe the *tâtonnement* of this market seeking an equilibrium, rather than treating the market as having already reached a timeless equilibrium (Robinson, 1962).

It is not clear where this groping will take the GMF market. Production of currently commercialised GM crops appears to be expanding in some countries (C. James, 2003), and new GM products are being developed and released (Biotechnology Industry Organization (BIO), 2003a; Rousu *et al.*, 2003). On the other hand, these crops appear to be sold at a discount, albeit small, to their non-GM counterparts (Parcell, 2001, 2002; USDA, 2001). Concerns about the acceptability of GM crops seem to have interrupted the introduction of new GM crops (BBC News, 2004; Black, 2004), and may even be retarding development of future crops (Huffman *et al.*, 2003a).

These new crops and food products also provide a reminder of another factor that affects economics: the legal or regulatory environment. In order for GMF to exist as a commodity that is distinct from pre-GMF or non-GMF, its existence must be signalled to consumers. Thus, it is not just consumers' perceptions of GM technology that have created uncertainties in the agri-food system, but also consumers ability to act on those perceptions in response to information about the presence in their diets of food derived from GM crops.

This regulatory environment has varied from country to country. The US, the largest producer of GM crops (C. James, 2003), has had one of the least restrictive responses to the introduction of GM crops and GMF, treating them as substantially equivalent unless there is proof to the contrary (Golan *et al.*, 2000; Huffman *et al.*, 2001; Phillips & Corkindale, 2002). The EU, on the other hand, had a *de facto* moratorium on new GM crops for several years while the member countries worked out an agreement on how to regulate them (M. Foster et al., 2003; INL Newspapers, 2003; Osborn, 2003). New Zealand, for its part, had a Royal Commission consider the issues surrounding a release of GM organisms in the country (Royal Commission on Genetic Modification, 2001). As a result, the New Zealand Government has designated biotechnology as a key source of future economic growth while carefully regulating the environmental release of new organisms (Ministry of Research Science and Technology, 2003).

An important element of the regulatory environment has been the food labelling regimes established in response to the use of GM crops and the potential presence of GMF in the food supply. These regimes could be either voluntary or mandatory, and could allow labelling of either the GMF or non-GMF products (J. A. Caswell, 1998). To the extent that GMF is substantially equivalent to non-GMF and method of production is considered irrelevant to the final product, discussions of labelling policies have tended to view limited, voluntary regimes as welfare enhancing and most appropriate (Carter & Gruere, 2003; J. A. Caswell, 1998). The US has relied on a voluntary regime (Golan *et al.*, 2000; Phillips & McNeill, 2000), allowing either GMF or non-GMF to be labelled. On the other hand, the EU, New Zealand and Australia have created mandatory regimes for labelling some but not all food derived from GM crops (ANZFA, 2001; CEC, 2000). Complicating labelling considerations is the difference between first- and second-generation GM crops: the first generation crops are largely focused on agronomic performance while the second generation is expected to offer consumer-oriented benefits (Rousu *et al.*, 2003; Shoemaker *et al.*, 2001). These labelling policies provide different amounts of information to consumers in different countries. Those consumers with less information on how their food is produced may have less scope for acting on their perceptions of GMF through their transactions in the food market.

It thus appears that consumer reactions to GMF are a key element in both the development of the GMF market (Huffman *et al.*, 2003a) and the regulatory environment surrounding GM crops and GMF (Caswell, 1998; Noussair *et al.*, 2004). Study of the economic impacts of consumer reactions may therefore be relevant to an understanding of the GMF market. The research reviewed in Chapter 2 of this thesis suggests that consumers in industrialised countries have not all reacted to GMF in the same way. Some consumers are not at all concerned about GM; it is not an issue for them (Gaskell *et al.*, 2004). Other consumers are willing to consume GMF, but the prices they are willing to pay for GMF range from a premium to a significant discount. Still other consumers appear to be completely opposed to GMF and may not be willing to consume it at all (Gaskell *et al.*, 2003; Heller, 2003; Sheehy *et al.*, 1998; Verdurme *et al.*, 2003). The exact proportion of consumers that fall into each category appears to vary by country and study.

Research in New Zealand has tended to focus on attitudes and perceptions of consumers with respect to biotechnology or GM. The research has found that New Zealanders' attitudes and perceptions regarding GMF appear to be similar to those in other industrialised countries (Macer, 1992, 1998). In particular, a majority of consumers is likely to support GMF (Richardson-Harman *et al.*, 1998; Small *et al.*, 2001). However, some consumers have expressed concerns with GMF. Some factors that influence the acceptability of GM are potential environmental impacts (Cook, 2000; Gamble *et al.*, 2000) and concerns over corporate control of the technology or the agri-food system (IBAC, 2000). As a result of these concerns, some New Zealanders have modified their purchasing behaviour, checking labels or buying non-GM products (Gamble & Gunson, 2002). How these concerns or perceptions translate into economic measures, such as willingness to pay, is unclear. WTP has been assessed in some research, both for food labelling (Kaye-Blake, Bicknell, & Lamb, 2004) and for some specific products (Kaye-Blake, Saunders *et al.*, 2004). WTP for GM as a discrete attribute of food products or the food system, however, does not appear to have been analysed in a New Zealand context.

In order to understand consumers' reactions to GMF from an economic point of view, demand has been assessed in prior research using survey methods based on the neoclassical theory of consumer choice. With this theory, the choices that a consumer makes may be regarded as ones that maximise the consumer's utility or satisfaction. The utility function is a mathematical representation of the consumer's underlying preferences concerning goods or the attributes of goods. Such a mathematical representative is possible if these underlying preferences can be assumed to be reflexive, complete, transitive, and continuous. Furthermore, applied consumer research may also include additional preference properties; one such additional property is that preferences over goods or attributes are separable.

An alternative theory for framing consumer behaviour is bounded rationality. This theory treats choices as resulting from decision rules or heuristics, rather than from a process of maximisation. Consumers learn convenient rules of thumb that allow them to make choices that satisfy and suffice. Some of these rules may be non-compensatory: some choice alternatives may be excluded for simple reasons, and no amount of compensation may be sufficient to restore them to the choice set. An example of such a decision rule is lexicographic choice.

Prior research on the WTP for GMF provides important information about potential demand. Generally, respondents have lower WTP for GMF than for non-GMF. The average GM discount appears to be lower in the US (Huffman *et al.*, 2001) than in France (Noussair *et al.*, 2004), the UK (Burton *et al.*, 2001), or Australia (S. James & Burton, 2003). However, these averages are taken from wide distributions of WTP, with some consumers not willing to buy GMF, others requiring large discounts, and still others WTP the same price for GMF as non-GMF (Burton et al., 2001; Huffman et al., 2001; S. James & Burton, 2003; Lusk, 2003; Noussair et al., 2004; Onyango et al., 2004). Willingness to pay appears to depend on several things, such as the tolerance level for adventitious presence of GM material in non-GMF (Noussair *et al.*, 2004), the type of GM technology being used (Burton et al., 2001; S. James & Burton, 2003), the specific product enhancements offered (Burton & Pearse, 2002; Lusk, 2003).

A review of the wider literature on consumers and GMF found suggestions that two neoclassical properties in relation to consumer preferences could be considered more closely with regards to GMF. First, there are suggestions that consumers may not evaluate the use of GM technology separately from its potential benefits (Gamble *et al.*, 2000; Krueger, 2001; Pew Initiative, 2003). If this is the case, it may not be possible to treat preferences over the attributes of GMF as separable. Secondly, there are strong indications in the literature that a sizeable minority of consumers appears to be opposed to GMF; they may not buy it regardless of the financial or quality incentives. These consumers may be directly identified in research as refusers or opponents (Gaskell *et al.*, 2003; Heller, 2003). It may also be that such consumers are included with the respondents considered ‘protest responses’, which appear to constitute up to 30 per cent or more of respondents for some survey research (Burton & Pearse, 2002; Burton et al., 2001; S. James & Burton, 2003; Onyango *et al.*, 2004). This type of non-compensatory preference does not appear be consistent with the axiom of continuity. If preferences regarding GMF are inconsistent with these two properties, the result could be that issues might arise with aggregate measures of the impact of GMF, such as average price discount or consumer welfare calculations (Gowdy & Mayumi, 2001; McIntosh & Ryan, 2002).

In order to investigate these issues, a choice experiment survey was developed and administered. The survey used a fractional factorial design that allowed both preference separability and preference continuity to be assessed empirically. Separability could be assessed, because the design collected data that could be analysed with a model that included terms for the interactions between GM and other product attributes. At the same time, this expanded choice set gave respondents a wide selection of non-GM alternatives. Respondents who wanted to engage in the choice task could demonstrate that they were willing to vary their choices in response to the levels of the choice attributes, but they could still avoid any GM alternative. Their responses would thus not be protest responses – they would not always choose the *status quo* – but they could be lexicographic, discontinuous, or non-compensatory – they could avoid choosing GM alternatives.

The survey was administered in Christchurch, New Zealand in supermarkets and a shopping mall over several days and at a range of times. A total of 353 respondents provided complete survey responses that could be analysed with the proposed models. Respondents participated in a choice experiment, consisting of nine questions with three alternatives each, and answered questions about their environmental attitudes, their food shopping behaviour, and their perceptions of GM. These respondents were approximately representative of the demographics of New Zealand. The final dataset consisted of 3160 choices, divided into an estimation set of 2378 and a holdout set of 782, and the associated demographic and attitudinal responses. Preliminary analysis of the data suggested that respondents who did choose GM apples were essentially similar in their demographic characteristics to those who did not, but were significantly different for nearly every attitudinal statement.

Choice data from the survey were analysed with two types of models. Three were RUM models, based on neoclassical theory. These were the main effects MNL, the MNL with interactions, and the CNL. This last model could not be estimated as a result of a survey design that sought to avoid sensitising respondents to the GM issue. The other two models performed well. In particular, the MNL with interactions fit the data well and demonstrated that the interactions between GM and other attributes could affect choice probability. The other models were heuristic models based on the theory of bounded rationality. One, a naïve lexicographic model similar to a Take The Best protocol (Gigerenzer & Selten, 2001b; Gigerenzer *et al.*, 1999) was shown not to fit the data. The other, the semi-lexicographic model, did fit the data, although not as well as the MNL models.

Analysis of the survey data led to a number of findings. First, respondents who could be classified as protestors were at most 5.3 per cent of all respondents, lower than protest response rates reported for many other CE surveys. Secondly, 48.2 per cent of respondents never chose a GM alternative from the choice sets. They were able to vary their responses and indicate preferences for such benefits as reduced prices or increased levels of antioxidants, but they were also able to avoid choosing GM alternatives if they so preferred. Further analysis that took into account responses to other survey questions suggested that the percentage of respondents who prefer to refuse GMF in all circumstances may be somewhat less, at 23.8 per cent of the sample.

A third set of findings concerns the WTP for GMF. The results of the modelling suggested that there did not appear to be an average discount being applied to GMF by all respondents: the parameter estimated for the attribute GM was not significant. Instead, different groups of respondents reacted quite differently to the presence of GM in the alternatives. Those who viewed GM as risky seemed essentially unwilling to pay for GM apples. They appeared to require discounts of $7.360 and $4.975 per kilogram on apples whose base price was $3.00 per kilogram. Those who did not view GM as risky appeared to require smaller discounts, and the parameters for those groups were statistically insignificantly different from zero. However, preferences regarding the attribute GM may not be separable from preferences over other attributes. The significant parameters for attribute interactions suggested that preferences orders regarding apple attributes are different for GM and non-GM apples. For example, an increase in antioxidants is preferred to an improvement in flavour for non-GM apples, but the preference order is reversed for GM apples.

These findings suggest three things. First, the results suggest that it may be relevant for research using RUM models to consider the underlying properties of preferences and examine the possible impact of those properties on data collection and analysis. The compensatory structure of RUM models and the additive form for utility equations are based on the preference properties of continuity and separability. The above analysis suggests that it may not be possible to include these two properties in the case of preferences for GMF. The RUM models in the present research, even the main effects MNL model, do have predictive power, but using them to draw conclusion about consumer willingness to pay for GMF or the welfare impacts of a shift to GM production may be problematic if the underlying properties do not hold (Gowdy & Mayumi, 2001; McIntosh & Ryan, 2002).

A second suggestion from these findings rests on the significant results from the heuristic model, which demonstrate that it may be possible to create choice models that do not assume globally maximising behaviour. It appears to be possible to start with a likely and plausible description of consumer behaviour, based on prior consumer research and the idea of cognitive simplification, and model a choice heuristic that exhibits good fit to the observed data. Thus, this research on heuristic strategies suggests that further research on the strategies that consumers actually employ could be a useful complement to research that evaluates the optimality of heuristic strategies.

A third implication of this research is that interpretation of the results of these models may benefit from caution. These are only models, after all, simplifications of reality that capture consumer choices only imperfectly. The fact that both types of models had some success (and some failure) while relying on different theoretical foundations and focusing on different aspects of choice, suggests that they each may be able to illuminate some facets of choice behaviour. This suggests that overall conclusions may be strengthened by a pluralistic approach that considers results from all the models (Fullbrook, 2005).

7.1 Policy implications

The implications of these findings can be grouped under two headings: implications for the market for GMF, and implications for stated preference research. These are treated in turn.

The implications for the GM market flow directly from the findings regarding consumer preferences. The possibility that some consumers might not want GMF at all was examined in several ways, and the results suggest that a non-trivial number of respondents may prefer to refuse GM apples. This finding is consistent with prior research, which has found that a segment of consumers do not want GMF. There are three potential policy implications from this finding. First, the fact that food is GM appears to be an important, salient attribute for consumers: they care about how their food is produced. Thus, the US government's policy of 'substantial equivalence', which holds that GMF can be deemed as substantially equivalent to its non-GM counterpart, may be out of step with the opinions of some consumers. GMF may not by definition be substantially equivalent to non-GMF for these consumers. This policy of substantial equivalence results in a voluntary labelling regime regarding GMF: food that is GM does not need to be labelled, although it may be labelled voluntarily. The findings in the present research appear to support the New Zealand and Australia labelling policies, that of mandatory labelling of GMF. By providing consumers with information that they might feel is salient to their decisions, these antipodean policies may be allowing consumers to make better choices. Without this information or these labels, consumers who prefer not to have GMF might pay more than they would want to for GMF, which would be equivalent to an implicit tax (Huffman *et al.*, 2001).

The second implication of consumer refusal of GMF is that the market equilibrium for food products that are supplied in both GM and non-GM forms is undefined once the GM portion is above a certain threshold. If, for example, apples are widely available as either GM or non-GM, there will be demand for both types at prices that can be predicted from this research and other similar work. As the quantity of GM apples increases and the quantity of non-GM decreases, the price differential between the two types will increase to entice more consumers to buy the GM apples. Once the percentage of the supply that is GM surpasses some threshold, however, a price differential may be insufficient to increase demand. Beyond this threshold quantity, when those who are prepared to buy GM apples are virtually fully supplied and those who refuse GM apples will not buy them, the price differential is unpredictable. A potential policy implication is that the agri-food system might benefit from maintaining the supply of non-GMF, in the interest of stability of food markets and growers' incomes.

There is another reason to maintain the supply of non-GM. Neoclassical theory suggests that it is possible to compensate consumers for accepting inferior products: they can be given discount or other compensation. One could therefore argue that the entire food supply should shift to potentially more-efficient GM production and rely on the compensation principle to avoid harming those consumers who do not want GMF. However, the present research suggests that the preference properties necessary for the compensation principle to hold are not met. The data on how much to compensate a percentage of respondents simply are not available, and discontinuous preferences regarding GM suggest that the required compensation is immeasurable. If the properties required for compensation to operate are not met, then the appropriate way to avoid reducing the welfare of consumers who prefer to avoid GMF is to maintain a sufficient supply of non-GMF. It may be that the only way to maintain aggregate welfare would be by continuing to allow consumers choice between non-GMF and GMF.

A fourth and final policy implication results from the findings regarding preference separability. The modelling of the choice data suggested that food attributes do not only enter the utility function additively, but they also interact with each other. The implication is that preferences over food attributes are not separable, at least not with respect to GMF. Thus, research on desirable and profitable genetic modifications may not be able to rely on existing preference information regarding non-GM crops or food. The implied preference rankings from non-GM research might not be transferable to GM research.

This research also has implications for stated preference research, regardless of the product or policy being evaluated. The first implication concerns the use of choice experiments for determining the value of a product or policy. As discussed in the literature review, choice experiments are a valuable method of stated preference research because they focus on the attributes in the choice situation. They provide a relative ranking of a large number of different product or policy configurations, allowing researchers to determine the implied prices of each of choice attribute. For some research, estimating the implied prices or marginal rates of substitution depends in part on assuming that preferences over attributes are separable. If preferences are not separable and attributes do not enter the utility function additively– if there are interactions between attributes that affects their relative values – then the value of the whole is not equal to the value of the sum of the parts. Furthermore, the marginal rate of substitution between two attributes could depend on the level of other attributes. This research found that attribute interactions were significant and large enough to affect the preference order of the attributes. This finding suggests two things. First, results from choice experiments could be compared to results from research that evaluates products or policies in their entirety. Thus, choice experiments could be used in combination with contingent valuation methods to compare the values of the sum of the attributes and the whole. Secondly, as prior research has indicated, attribute-based discrete choice research may need to consider possible interactions in the design phase of research in order to include interactions in the design of choice sets.

The second implication of this research is a result of its focus on protest responses. Prior research on GMF has found that up to 30 per cent or more of samples were unwilling to change their choices in response to changes in product attributes. An aim of the present research was to design and implement a survey so that these protest responses could be further investigated. The prior rates of protest responses suggested that a greater range of non-GM choices could increase the number of responses included in the analysis of survey results. The choice sets were designed to provide respondents with a large number of non-GM choices; in fact, some choice questions did not contain any GM alternatives. The data collected with this survey instrument had a protest response rate of 5 per cent, lower than prior research. The implication is two-fold: first, that higher rates of protest responding may signal that respondents are evaluating choice attributes with non-compensatory preferences; and second, that it may be possible to accommodate such preferences with survey design.

The third implication of this research for stated preference research concerns the assumption of optimising behaviour. The neoclassical foundation of this type of economic research has resulted in a reliance on maximising models. However, other economic theories, particularly bounded rationality, have taken issue with the assumption that consumers are seeking to maximise their utility. This research has two findings that relate to this assumption. First, one key assumption of choice behaviour in neoclassical economic research may not be supported by the data collected here. Specifically, there does not appear to be evidence that preferences are universally continuous. Given this, the present research examined the possibility that respondents were using choice heuristics rather than maximisation to reach their decisions. Contrary to work by Gigerenzer and others (Gigerenzer & Selten, 2001b; Gigerenzer *et al.*, 1999; Todd & Gigerenzer, 2003), the data did not support the use of a naïve lexicographic decision heuristic. The data, however, could be modelled using a simplified, semi-lexicographic choice model, as theorised by several prior researchers (Bettman *et al.*, 1998; Coombs, 1964; Earl, 1983; Simon, 1955). This success suggests that choice experiment research may benefit from explicitly considering the use of decision heuristics by respondents.

7.2 Limitations of the research

The present research was affected by several limitations. In this section, these limitations are catalogued and their potential impacts on findings are discussed.

The issue of information bias in surveys arose several times in the course of this research. It has been shown elsewhere that information provision can affect choices or WTP for GMF (Huffman, 2003; Huffman *et al.*, 2003a, 2003b; Huffman *et al.*, 2001; Lusk *et al.*, 2003; Tegene *et al.*, 2003). In the present research, the focus was on potential choices consumers would make in grocery stores, given their current information; information provision was not a focus of the research design. When the survey was being piloted, it became clear that some consistent information regarding GM (and antioxidants) was necessary. As a result, interviewers were given a scripted response for questions regarding GM. In hindsight, information provision could have been more rigorously developed. As information does affect WTP for GMF, the information provision in this survey might have affected the final results. The direction and size of the bias is unclear from prior research, and would likely depend on the type of information provided and the survey respondents themselves.

An issue from the survey design was consistency between the CV task and the CE questions. The CV question provided indications of respondents' WTP for GMF that supplemented the findings from the CE task. In the course of data analysis, it became clear that responses to the CV task could be used to check for consistency of refusal responses. In addition, the CV responses could be used to check for discrepancies between the value of a whole GMF product and the value of the attributes. However, the CV question included elements different to the factors that formed the CE questions. That is, the CV question did not exactly reproduce a set of factor levels that could be implied by the CE questions. The research could have been improved by creating a CV task that exactly replicated a product configuration that could be described with the CE attributes. Moreover, use of a different valuation task, such as a double-bounded dichotomous choice question, could have yielded more accurate estimates of WTP (Bateman *et al.*, 2002).

Another limitation of this research was its reliance on closed-form estimation techniques. The literature review found that MNL modelling was robust and appropriate for RUM modelling of choice experiment data. In addition, a CNL model was theorised, although it could not be estimated in practice. These were all models that could be estimated with closed-form techniques. By contrast, there are other models in the literature that may be estimated via simulation. Because it was possible to use MNL models to examine the properties of preferences on which this thesis was focussed – namely, separability and continuity – this research did not estimate such models. However, the results did find that the one model that imposed some structure on the choice situation – the CNL – could not be estimated analytically, and that respondent heterogeneity was significant in determining choices with regard to the GM attribute. Thus, it is possible that other types of models might have provided additional insight into the results from the survey.

Of course, what is true of the RUM models is true also of the heuristic models. The literature on bounded rationality includes a number of different choice protocols that consumers might use (Gigerenzer & Selten, 2001b; Gigerenzer *et al.*, 1999). Only two of these different protocols were tested in the present research, and only one of them was successful. The fact that a heuristic model was successful does support the basic finding that choice heuristic may influence consumer decision making. Analysis of additional models might have provided even more information on choice heuristics.

There is another limitation of this research from the point of view of the notion of bounded rationality. Choice experiments may in fact be inappropriate for examining heuristic decision making, for two reasons. First, bounded rationality assumes that human cognitive capacity is limited, so mental tools have been devised for limiting cognitive effort. When faced with the world and all its stimuli, humans select those cues that are perceived to be important and ignore the rest. Bounded rationality is a way of limiting the number of environmental cues that must be processed in order to reach a decision. From this point of view, a choice experiment is pre-processed. The researcher determines which attributes are salient and restricts them to a few different values or levels. Furthermore, only a few choices are presented at any one time. From the respondent's perspective, there may be little simplification required: the decision problem may already be sufficiently simplified. Thus, whether choice heuristics are used in the simplified environment of a choice experiment may provide little indication about their use in actual supermarket shopping.

The second reason that choice experiments may be inappropriate for assessing cognitive simplification is that Simon's vision of bounded rationality was based on the interaction of the choice environment with cognitive limitations. He maintained that real decision environments were structured, and that decision makers relied on those structures to help make the decisions for them. The choice experiment structure, specifically its focus on attribute orthogonality, makes it difficult to rely on decision heuristics. For example, in an actual market, it may be possible to rely on price as a signal of quality because of a lack of orthogonality: consumers may expect products with higher prices to be better. If they are correct, it may be sufficient for them to 'shop on price' rather than evaluate all the attributes of all the alternative products. Thus, while it may be possible to find evidence of the use of heuristics in choice experiments, not finding such evidence may provide little information about the use of heuristics in other choice environments.

Other limitations of the present research are more prosaic. The number of respondents in the dataset was only 374; this is not a small number, but more data might have provided greater indications of consumer preferences, particularly regarding attribute interactions. Furthermore, all respondents were interviewed in Christchurch. Although the sample was statistically representative of New Zealand in many ways, it was biased by being chosen from only one of the main centres of the country. Finally, the method of interviewing limited the data that could be collected. Face-to-face surveying allowed interviewers to talk with respondents who had time to respond, spoke English sufficiently well, and were not uninterested in talking with strangers with clipboards. This eliminated those potential respondents with high opportunity cost of time (at least at the moment they encountered the interviewers), poor English skills, or social phobias.

An additional limitation of this research is that it was attempting to recover the process for making decisions from the decisions actually made. It did not, however, collect information on the decision-making process directly. It is possible to determine that nearly one-half of respondents did not choose GM alternatives, and this could be taken as *prima facie* evidence of a desire to avoid GMF. These choices were checked against other parts of the survey to draw conclusions about respondent consistency. However, the real question is whether respondents reached their decision through a non-compensatory process, regardless of whether that process relied on preference considerations or choice heuristics. The present research did not uncover the actual process, just the results of the process.

As a result, it is not certain whether respondents to this survey who did not choose GMF were making choices as a result of non-compensatory preferences, or were instead simply at a corner solution for their demand. It is well known that not all consumers buy all goods (Deaton & Muellbauer, 1980; Pudney, 1989); for consumers, some goods are simply not worth the price. The present research found that the inducements offered to many respondents to this survey were insufficient to entice them to choose GM apples. This research is limited by the bounds of the choice set; it can thus only suggest what might the case about values and attribute levels outside those bounds.

One further limitation of this research affects stated preference surveying in general: hypothetical bias. Respondents were asked to make hypothetical choices from hypothetical choice sets and were further asked to state opinions or register their attitudes. Whether their behaviour in an actual market – standing in a supermarket produce section facing real GM apples – will match their stated behaviour cannot be determined from this type of survey.

Thus, how consumers really react in markets can only be proven by analysing real behaviour in real markets. A stated preference survey, such as the present research, can attempt to reduce the hypothetical bias, but it cannot eliminate the possibility of such a bias altogether.

7.3 Future research

There are several directions in which it would be interesting to extend this research. One direction concerns the models used to estimate this dataset. Models other than the ones used here are available, and could be estimated via simulation (Train, 2003). A random parameter or mixed logit model could account for respondent heterogeneity in more complex ways (Rigby & Burton, 2003, 2004). It could also explore dependence between choice alternatives, and in particular examine the issue of the IIA assumption (McFadden, 2001b). These models have been used in the context of GMF research, and might provide additional insights into the choice behaviour of survey respondents.

In fact, this research has compared models from the two paradigms, but has not attempted a convergence. It should be possible, at least by using simulation techniques, to define a model in which choice of decision protocols is modelled explicitly. Thus, it may be possible to model a respondent's choice of alternative as the result of first choosing the protocol that will be used to decide and then applying that protocol to the choice attributes. Respondents may approach the choice task by first deciding whether a maximising or a heuristic approach is more appropriate, then examining the attributes using that decision tool. Considering the choice problem in this way would move the present research from consideration of the problem itself to consideration of how respondents decide how to decide (Conlisk, 1996).

The results of this research suggest that non-compensatory processes or preferences might be important. The design used in this thesis is suitable for capturing the results of non-compensatory decision making. In order to expand this research, some method of gathering data on the decision process could be added to the current design. One tool for collecting process data, one that can collect data on the ways that respondents make decisions, is computer-aided surveying. Using a survey similar to on in the present research, but in addition collecting data on the types of information that respondents use for making decisions and the order in which they analyse that information, may allow the decision process to be analysed directly. In addition, computerised surveying could be developed that recognises in real time potentially non-compensatory response patterns and prompts follow-up questions to explore the decision-making process further.

An additional direction for future research would be an improved design for the choice set. The choice set reported here followed a recipe approach as described in Louviere, *et al.* (2000) and Hahn & Shapiro (1966). More complex, computer-aided experimental designs can improve design efficiency (Chrzan & Orme, 2000). In particular, using information on likely survey responses and feeding this information back into the survey design can result in more efficient choice set design (Scarpa, Hutchinson, & Campbell, 2005).

An additional direction for this research would be to examine an important question regarding GMF: how could one profit from GM technology in food and crop production? As discussed above, the market for GMF will be determined by the interaction of supply and demand. This research has focussed on consumers' reaction to and WTP for GMF. Exploring the potential profitability of different GMF products would require combining these insights with production information, especially information on the types of modifications that are likely or possible and the costs to produce these modified products.

7.4 Concluding comments

This thesis's literature review noted the reservation of Bolduc & McFadden (2001) to incorporating heuristic models in discrete choice modelling. The present research provides a response to their reservation. First, explicitly considering the possibility of non-compensatory decision making improved the survey design and increased the amount of useable data collected from respondents. Incorporating non-RUM considerations may have resulted in better social science, as Rabin (2002) suggested could happen. Secondly, models that examined the preference properties from neoclassical modelling had somewhat different results to the main effects MNL model that relied on these properties. These different results suggest that lack of preference separability and continuity may have impacts. Thirdly, the findings do confirm that RUM models can approximate rule-based and non-compensatory decision making (Bolduc & McFadden, 2001). However, if choices are non-compensatory, then the axioms necessary for calculations of partworths and welfare estimates are not necessarily supported by the data. Thus, investigating the use of decision heuristics and the properties of preferences underlying of RUM modelling could be important to discrete choice research, if only to indicate that estimated models should be treated with caution.

This research has shown that market demand for GMF cannot be described in simple terms. Some consumers clearly do not want GM apples at all, some are indifferent to the GM issue, and others use complex considerations of both GM and the specific product enhancements on offer. As a result, the best result for consumers is likely to be achieved when all consumers can easily access the products of their choice.

This research also contributes to a better understanding of the process of economic change and development. Creating new techniques or new products is not the only factor involved in successful economic development; consumer reactions to novelties can have profound impacts on their eventual market success.

References

Adamowicz, V., & Boxall, P. (2001, 10 April). *Future directions of stated choice methods for environmental valuation.* Paper presented at the Choice Experiments: A New Approach to Environmental Valuation, London, England.

Adamowicz, V., Boxall, P., Williams, M., & Louviere, J. J. (1998). Stated preference approaches for measuring passive use values: choice experiments and contingent valuation. *American Journal of Agricultural Economics, 80*(1), 64-75.

Adamowicz, V., Louviere, J. J., & Swait, J. (1998). *Introduction to attribute-based stated choice methods*. Washington, D.C.: National Oceanic and Atmospheric Administration, Department of Commerce.

Agra Europe. (2000, 22 Dec). Brazil joins the maize export club. *Agra Europe,* p. M/9.

Akerlof, G. A. (1970). The market for "lemons": quality uncertainty and the market mechanism. *Quarterly Journal of Economics, 84*(3), 488-500.

Albanese, P. (1988). The intimate relations of the consistent consumer: psychoanalytic object relations theory applied to economics. In P. Albanese (Ed.), *Psychological foundations of economic behavior*. New York, NY, USA: Praeger.

Alfnes, F. (2004). Stated preferences for imported and hormone-treated beef: application of a mixed logit model. *European Review of Agricultural Economics, 31*(1), 19-37.

Amigues, J.-P., Boulatoff, C., Desaigues, B., Gauthier, C., & Keith, J. E. (2002). The benefits and costs of riparian analysis habitat preservation: a willingness to accept/willingness to pay contingent valuation approach. *Ecological Economics, 43*, 17-31.

An, Y., & Ayala, R. A. (1996). *A mixture model of willingness to pay distributions*. Durham, NC, USA: Duke University.

ANZFA. (2000). Submission to NZ Royal Commission on Genetic Modification. Wellington, New Zealand: Australia New Zealand Food Authority.

ANZFA. (2001). Genetically Modified Foods: Australia New Zealand Food Authority.

Arentze, T., Borgers, A., Hofman, F., Fujii, S., Joh, C., Kikuchi, A., Kitamura, R., Timmermans, H., & van der Waerden, P. (2001). Rule-based versus utility-maximizing models of activity-travel patterns: a comparison of empirical performance. In D. Hensher (Ed.), *Travel behaviour research: the leading edge* (pp. 569-583). London: Pergamon.

Arrow, K. J. (1963). *Social choice and individual values* (2nd ed.). Sydney, Australia: John Wiley & Sons, Inc.

Augier, M. (2001). Sublime Simon: the consistent vision of economic psychology's Nobel laureate. *Journal of Economic Psychology, 22*, 307-334.

Augier, M., & March, J. G. (2003). The economic psychology of Herbert A. Simon: introduction to a special issue. *Journal of Economic Psychology, 24*, 135-141.

Banzhaf, M. R., Johnson, F. R., & Mathews, K. E. (2001). Opt-out alternatives and anglers' stated preferences. In J. Bennett & R. Blamey (Eds.), *The choice modelling approach to environmental valuation* (pp. 157-177). Cheltenham, UK: Edward Elgar Publishing Ltd.

Bareham, J. (1995). *Consumer behaviour in the food industry: a European perspective*. Oxford, UK: Butterworth-Heinemann Ltd.

Bateman, I., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D.W., Sugden, R., & Swanson, J. (2002). *Economic valuation with stated preference techniques: a manual*. Cheltenham, U.K.: Edward Elgar.

Bateman, I., & Jones, A. P. (2003). Contrasting conventional with multi-level modeling approaches to meta-analysis: expectation consistency in U.K. woodland recreation values. *Land Economics, 79*(2), 235-258.

Batley, R., Fowkes, T., Watling, D., Whelan, G., Daly, A., & Hato, E. (nd). *Models for analysing route choice*.Unpublished manuscript, Leeds, UK.

BBC News. (2004, 11 May). Monsanto drops plans for GM wheat. *BBC News*.

Ben-Akiva, M., McFadden, D., Train, K., Walker, J., Bhat, C. R., Bierlaire, M., Bolduc, D., Boersch-Supan, A., Brownstone, D., Bunch, D., Daly, A., de Palma, A., Gopinath, D., Karlstrom, A., & Munizaga, M. (2001). *Hybrid choice models: progress and challenges*.Unpublished manuscript, Cambridge, MA.

Benbrook, C. (2002). *Economic and environmental impacts of first generation genetically modified crops: lessons from the United States*. Winnipeg, Manitoba, Canada: International Institute for Sustainable Development.

Bennett, J., & Adamowicz, V. (2001). Some fundamentals of environmental choice modelling. In J. Bennett & R. Blamey (Eds.), *The choice modelling approach to environmental valuation* (pp. 37-69). Cheltenham, UK: Edward Elgar Publishing Ltd.

Bennett, J., & Blamey, R. (Eds.). (2001). *The choice modelling approach to environmental valuation*. Cheltenham, UK: Edward Elgar Publishing Ltd.

Bettman, J. R., Luce, M. F., & Payne, J. W. (1998). Constructive consumer choice processes. *Journal of Consumer Research, 25*(3), 187-217.

Bhat, C. R. (2003, 10-15 August). *Econometric choice formulations: alternative model structures, estimation techniques, and emerging directions.* Paper presented at the Moving through nets: the physical and social dimensions of travel. 10th International Conference on Travel Behaviour Research, Lucerne.

Bianchi, M. (2003). A questioning economist: Tibor Scitovsky's attempt to bring joy into economics. *Journal of Economic Psychology, 24*, 391-407.

Bierlaire, M. (2001). *A theoretical analysis of the cross-nested logit model* (Report No. RO-011218). Lausanne, Switzerland: Ecole Polytechnique Federale de Lausanne, Dept. of Mathematics.

Bierlaire, M. (2003a). BIOGEME (Version 0.6).

Bierlaire, M. (2003b, March). *BIOGEME: a free package for the estimation of discrete choice models.* Paper presented at the 3rd Swiss Transport Research Conference, Monte Verita, Ascona.

Biotechnology Industry Organization (BIO). (2003a). *Guide to biotechnology: agricultural biotech products on the market*. Retrieved July 31, 2003, from http://www.bio.org/

Biotechnology Industry Organization (BIO). (2003b). *Guide to biotechnology: food biotechnology*. Retrieved July 31, 2003, from http://www.bio.org/

Black, R. (2004, 13 May). GM canola backs out of Australia*. BBC News*.

Blamey, R. (1998a). Contingent valuation and the activation of environmental norms. *Ecological Economics, 24*, 47-72.

Blamey, R. (1998b). Decisiveness, attitude expression and symbolic responses in contingent valuation surveys. *Journal of Economic Behavior and Organization, 34*, 577-601.

Blamey, R., Louviere, J. J., & Bennett, J. (2001). Choice set design. In J. Bennett & R. Blamey (Eds.), *The choice modelling approach to environmental valuation* (pp. 133-156). Cheltenham, UK: Edward Elgar Publishing Ltd.

Blatt, J. M. (1979-80). The utility of being hanged on the gallows. *Journal of Post Keynesian Economics, 2*(2), 231-239.

Blend, J. R., & van Ravenswaay, E. O. (1999). Measuring consumer demand for ecolabeled apples. *American Journal of Agricultural Economics, 81*(5), 1072-1077.

Boatwright, P., & Nunes, J. C. (2001). Reducing assortment: an attribute-based approach. *Journal of Marketing, 65*, 50-63.

Boland, L. A. (1981). On the futility of criticizing the neoclassical maximization hypothesis. *American Economic Review, 71*(5), 1031-1036.

Bolduc, D., & McFadden, D. (2001). Methodological developments in travel behaviour modelling. In D. Hensher (Ed.), *Travel behaviour research: the leading edge* (pp. 227-237). London: Pergamon.

Boniface, L. (2003, 17 September). Bun fight. *The Dominion Post*.

Bonnet, C., & Simioni, M. (2001). Assessing consumer response to Protected Designation of Origin labelling: a mixed multinomial logit approach. *European Review of Agricultural Economics, 28*(4).

Bredahl, L. (1999). Consumers' cognitions with regard to genetically modified foods. Results of a qualitative study in four countries. *Appetite, 33*, 343-360.

Bredahl, L., Grunert, K. G., & Frewer, L. J. (1998). Consumer attitudes and decision-making with regard to genetically engineered food products -- a review of the literature and a presentation of models for future review. *Journal of Consumer Policy, 21*, 251-277.

Broder, A. (2000). Assessing the empirical validity of the 'Take-The-Best' heuristic as a model of human probabilistic inference. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*(5), 1332-1346.

Broome, J. ([1991] 1996). Utility. In A. P. Hamlin (Ed.), *Ethics and Economics* (Vol. 1, pp. 109-120). Cheltenham, UK: Edward Elgar.

Bukenya, J. O., & Wright, N. R. (2004, 18 February). *Determinants of consumer attitudes and purchase intentions with regard to GM foods.* Paper presented at the Southern Agricultural Economic Association Annual Meeting, Tulsa, OK, USA.

Burton, M., & Pearse, D. (2002). Consumer attitudes towards genetic modification, functional foods, and microorganisms: a choice modelling experiment for beer. *AgBioForum, 5*(2), 51-58.

Burton, M., Rigby, D., & Young, T. (1999). Analysis of the determinants of adoption of organic horticultural techniques in the UK. *Journal of Agricultural Economics, 50*(1), 47-63.

Burton, M., Rigby, D., Young, T., & James, S. (2001). Consumer attitudes to genetically modified organisms in food in the UK. *European Review of Agricultural Economics, 28*(4), 479-498.

Camerer, C. (1995). Individual decision making. In J. H. Kagel & A. E. Roth (Eds.), *The Handbook of Experimental Economics* (pp. 587-703). Princeton, NJ, US: Princeton University Press.

Cameron, T. A., Poe, G. L., Ethier, R. G., & Schulze, W. D. (2002). Alternative non-market value-elicitation methods: are the underlying preferences the same? *Journal of Environmental Economics and Management, 44*, 391-425.

Cameron, T. A., Shaw, W. D., & Ragland, S. R. (1999). Nonresponse bias in mail survey data: salience vs. endogenous survey complexity. In J. A. Herriges & C. L. Kling (Eds.), *Valuing recreation and the environment: revealed preference methods in theory and practice*. Cheltenham, UK: Edward Elgar.

Campbell, H., Fitzgerald, R., Saunders, C., & Sivak, L. (2000). *Strategic issues for GMOs in primary production: key economic drivers and emerging issues* (CSAFE Discussion Paper No. 1). Dunedin, NZ: Centre for the Study of Agriculture, Food and Environment, University of Otago.

Campbell, H., Plummer, C., Kaye-Blake, W., Saunders, C., Kitto, L., Polson, C., McKay, W., & Fitzgerald, R. (2003). Appendix 1: Background literature review. In K. Sanderson, C. Saunders, G. Nana, A. Stroombergen, H. Campbell, J. Fairweather & A. Heinman (Eds.), *Economic risks and opportunities from the release of genetically modified organisms in New Zealand (Report to the Ministry for the Environment)*. Wellington, New Zealand.

Carter, C. A., & Gruere, G. P. (2003). Mandatory labelling of genetically modified foods: does it really provide consumer choice? *AgBioForum, 6*(1&2), 68-70.

Caswell, J. A. (1998). Should use of genetically modified organisms be labeled? *AgBioForum, 1*(1), 22-24.

Caswell, M. F., Fuglie, K. O., & Klotz, C. A. (1998). *Agricultural biotechnology: an economic perspective* (No. 687). Washington, D.C.: Economic Research Service, United States Department of Agriculture.

CEC. (2000). *Economic impacts of genetically modified crops on the agri-food sector*: Commission of the European Communities.

Chan, K. (2004, March 29). NZ bio-tech boffins get close to Aussies. *The (Christchurch) Press,* p. B4.

Chapple, I. (2001, 21 November). Stores strike early with GM ban. *The New Zealand Herald*.

Chern, W. S., Rickertsen, K., Tsuboi, N., & Fu, T.-T. (2002). Consumer acceptance and willingness to pay for genetically modified vegetable oil and salmon: a multiple-country assessment. *AgBioForum, 5*(3), 105-112.

Chrzan, K., & Orme, B. K. (2000). *An overview and comparison of design strategies for choice-based conjoint analysis* (Research Paper Series). Sequim, WA, USA: Sawtooth Software, Inc.

Collins, S. (2003, 28 August). Grocery chains try to stay clear of modified foods. *The New Zealand Herald*.

Conlisk, J. (1996). Why bounded rationality? *Journal of Economic Literature, 34*, 669-700.

Conner, T. (2003). Toad gene myth rejected. *Food Technology in New Zealand, 38*(1), 3-4.

Cook, A. (2000). *Attitudes and intentions towards purchasing food produced using genetic engineering: modelling and understanding the motivations for purchasing behaviour.* Unpublished Master's, Lincoln University, Canterbury, N.Z.

Coombs, C. H. (1964). *A theory of data*. Sydney: John Wiley & Sons.

Couchman, P. K., & Fink-Jensen, K. (1990). *Public attitudes to genetic engineering in New Zealand* (DSIR Crops Research Report No. 138). Christchurch, NZ: DSIR Crop Research.

Cramer, J. S., & Ridder, G. (1991). Pooling states in the multinomial logit model. *Journal of Econometrics, 47*, 267-272.

Crouch, G. I., & Louviere, J. J. (2001). A review of choice modelling research in tourism, hospitality and leisure. In J. A. Mazanec, G. I. Crouch, J. R. Brent Ritchie & A. G. Woodside (Eds.), *Consumer Psychology of Tourism, Hospitality and Leisure* (Vol. 2, pp. 67-86). Wallingford, Oxon, UK: CABI Publishing.

Czerlinski, J., Gigerenzer, G., & Goldstein, D. G. (1999). How good are simple heuristics? In G. Gigerenzer, P. M. Todd & t. A. R. Group (Eds.), *Simple heuristics that make us smart*. Oxford: Oxford University Press.

Deaton, A., & Muellbauer, J. (1980). *Economics and consumer behavior*. Melbourne, Australia: Cambridge University Press.

Diesing, P. (1991). *How does social science work?: reflections on practice*. Pittsburgh, PA, USA: University of Pittsburgh.

Doucouliagos, C. (1994). A note on the evolution of Homo economicus. *Journal of Economic Issues, 28*(3), 877-883.

Dunlap, R. E., & Van Liere, K. D. (1978). The "New Environmental Paradigm": a proposed measuring instrument and preliminary results. *The Journal of Environmental Education, 9*, 10-19.

Earl, P. (1983). *The economic imagination: towards a behavioural analysis of choice*. Sussex, UK: Wheatsheaf Books, LTD.

Earl, P. (1986). *Lifestyle economics*. Brighton, Sussex, UK: Wheatsheaf Books, Ltd.

Earl, P., & Potts, J. (2004). The market for preferences. *Cambridge Journal of Economics, 28*(4), 619-633.

Einhorn, H. J. (1970). The use of nonlinear, noncompensatory models in decision making. *Psychological Bulletin, 73*(3), 221-230.

Ellsberg, D. ([1954] 1996). Classic and current notions of "measurable utility". In A. P. Hamlin (Ed.), *Ethics and economics* (Vol. 1, pp. 3-31). Cheltenham, UK: Edward Elgar.

Elrod, T., Johnson, R. D., & White, J. (2004). A new integrated model of noncompensatory and compensatory decision strategies. *Organizational Behavior and Human Decision Processes, 95*, 1-19.

European Commission. (2000). *Economic impacts of genetically modified crops on the agri-food sector: a first review*. Brussels: Directorate-General for Agriculture.

Fischhoff, B., & Fischhoff, I. (2001). Publics' opinions about biotechnologies. *AgBioForum, 4*(3&4).

Fischhoff, B., Nadai, A., & Fischhoff, I. (2001). Investing in Frankenfirms: predicting socially unacceptable risks. *The Journal of Psychology and Financial Markets, 2*(2), 100-111.

Fischler, C. (1993). *L'Homnivore: le goût, la cuisine et le corps*. Paris, France: Edition Odile Jacob.

Fishburn, P. C. (1971). A study of lexicographic expected utility. *Management Science, 17*(11), 672-678.

Fishburn, P. C. (1974). Lexicographic orders, utilities, and decision rules: a survey. *Management Science, 20*(11), 1442-1471.

Fishburn, P. C. (1988). *Nonlinear preference and utility theory*. Baltimore, MD, USA: The Johns Hopkins University Press.

Fishburn, P. C. (1996, 5-9 August). *Preference structures and their numerical representations.* Paper presented at the ORDAL '96 conference, Ottawa, Canada.

Foster, M., Berry, P., & Hogan, J. (2003). *Market access issues for GM products: implications for Australia* (ABARE eReport 03.13 to the Department of Agriculture, Fisheries and Forestry). Canberra, Australia.

Foster, V., & Mourato, S. (2002). Testing for consistency in contingent ranking experiments. *Journal of Environmental Economics and Management, 44*, 309-328.

Fox, J. A., Shogren, J. F., Hayes, D. J., & Kliebenstein, J. B. (1998). CVM-X: calibrating contingent values with experimental auction markets. *American Journal of Agricultural Economics, 80*(3), 455-465.

Friedman, D. (1998). Modeling bounded rationality (book review). *Southern Economic Journal, 65*(2), 366-368.

Fullbrook, E. (2005). The Rand portcullis and PAE. *post-autistic economics review*(issue no. 32, article 5).

Fullbrook, E. (Ed.). (2004). *A guide to what's wrong with economics*. London, UK: Anthem Press.

Fulton, M., & Giannakas, K. (2004). Inserting GM products into the food chain: the market and welfare effects of different labeling and regulatory regimes. *American Journal of Agricultural Economics, 86*(1), 42-60.

Gabaix, X., & Laibson, D. (2000). A boundedly rational decision algorithm. *American Economic Review, 90*(2), 433-438.

Galbraith, J. K. (1967). *The new industrial state*. Boston, MA, USA: Houghton Mifflin Company.

Gamble, J., & Gunson, A. (2002). *The New Zealand public's attitudes regarding GM food: May and October 2001 - Full Report*. Auckland, NZ: HortResearch.

Gamble, J., Muggleston, S., Hedderly, D., Parminter, T., & Richardson-Harman, N. (2000). *Genetic engineering - the public's point of view*. Mount Albert Research Centre: Horticulture and Food Research Institute of New Zealand Limited.

Garcia, J., & Labeaga, J. M. (1996). Alternative approaches to modelling zero expenditure: an application to Spanish demand for tobacco. *Oxford Bulletin of Economics and Statistics, 58*(3), 489-506.

Gaskell, G., Allum, N. C., Bauer, M. W., Jackson, J., Howard, S., & Lindsey, N. (2003). *Ambivalent GM nation? Public attitudes to biotechnology in the UK, 1991-2002* (Life Sciences in European Society Report): London School of Economics and Political Science.

Gaskell, G., Allum, N. C., Wagner, W., Kronberger, N., Torgersen, H., Hampel, J., & Bardes, J. (2004). GM foods and the misperception of risk perception. *Risk Analysis, 24*(1), 185-194.

Gaskell, G., Bauer, M. W., Durant, J., & Allum, N. C. (1999). Worlds apart? The reception of genetically modified foods in Europe and the U.S. *Science, 285*, 384-387.

GE Free New Zealand. (2005, 1 February). Commerce Commission warn consumers 'Check labels'. *Press release*.

Geng, S., & Hills, F. J. (1989). *Biometrics in agricultural science*. Dubuque, Iowa, USA: Kendall/Hunt Publishing Company.

Gensch, D. H., & Svestka, J. A. (1984). A maximum likelihood hierarchical disaggregate model for predicting choices of individuals. *Journal of Mathematical Psychology, 28*, 160-178.

Gerard, K., Shanahan, M., & Louviere, J. J. (2003). Using stated preference discrete choice modelling to inform health care decision-making: a pilot study of breast screening participation. *Applied Economics, 35*(9), 1073-?

Gigerenzer, G. (2001). The adaptive toolbox. In G. Gigerenzer & R. Selten (Eds.), *Bounded rationality: the adaptive toolbox*. Cambridge, MA: MIT Press.

Gigerenzer, G., & Goldstein, D. G. (1996). Reasoning the fast and frugal way: models of bounded rationality. *Psychological Review, 103*(4), 650-669.

Gigerenzer, G., Hoffrage, U., Martignon, L., Czerlinski, J., Goldstein, D. G., & Rieskamp, J. (in press). One-reason decision making. In C. R. Plott & V. L. Smith (Eds.), *Handbook of experimental economics results*. Amsterdam, Netherlands: Elsevier/North-Holland.

Gigerenzer, G., & Selten, R. (2001a). Rethinking rationality. In G. Gigerenzer & R. Selten (Eds.), *Bounded rationality: the adaptive toolbox*. Cambridge, MA: MIT Press.

Gigerenzer, G., & Selten, R. (Eds.). (2001b). *Bounded rationality: the adaptive toolbox*. Cambridge, MA, USA: MIT Press.

Gigerenzer, G., Todd, P. M., & the ABC Research Group. (1999). *Simple heuristics that make us smart*. Oxford: Oxford University Press.

Gilbride, T. J., & Allenby, G. M. (2004). A choice model with conjunctive, disjunctive, and compensatory screening rules. *Marketing Science, 23*(3), 391-406.

Gladwell, M. (2005). *Blink: the power of thinking without thinking*. Camberwell, VIC: Penguin Group (Australia).

Golan, E., Kuchler, F., & Mitchell, L. (2000). *Economics of food labeling* (No. 793). Washington, D.C.: Economic Research Service, United States Department of Agriculture.

Gowdy, J. M., & Mayumi, K. (2001). Reformulating the foundations of consumer choice theory and environmental valuation. *Ecological Economics, 39*, 223-237.

Gregory, R., & Lichtenstein, S. (1994). A hint of risk: tradeoffs between quantitative and qualitative risk factors. *Risk Analysis, 14*(2), 199-206.

Grice, J., & Lawrence, G. (2003). *Consumer surveys of biotechnology: asking questions until we get the right answers or empowering the public to express their opinion?* Paper presented at the Xth Agrifood Research Network Meeting, Akaroa, New Zealand.

Hahn, G. J., & Shapiro, S. S. (1966). *A catalog and computer program for the design and analysis of orthogonal symmetric and asymmetric fractional factorial experiments* (Technical Report No. 66-C 165). Schenectady, NY, USA: General Electric Research and Development Center.

Halbrendt, C., Pesek, J., Parsons, A., & Lindner, R. (1994). Consumer preference for pST-supplemented pork. *Australian Journal of Agricultural Economics, 38*(2), 189-202.

Hall, C., Moran, D., & Allcroft, D. (2004, 2-4 April). *The economic value of GM risk perceptions: a meta-analysis of WTP studies using multi-level modelling.* Paper presented at the The Agricultural Economics Society 78th Annual Conference, Imperial College, London.

Hanley, N., Mourato, S., & Wright, R. E. (2001). Choice modelling approaches: a superior alternative for environmental valuation? *Journal of Economic Surveys, 15*(3), 435-462.

Hanley, N., Ryan, M., & Wright, R. (no date). *Estimating the monetary value of health care: lessons from environmental economics*. Scotland: University of Glasgow.

Harker, F. R., Gunson, F. A., Brookfield, P. L., & White, A. (2002). An apple a day: the influence of memory on consumer judgement of quality. *Food Quality and Preference, 13*(3), 173-179.

Harker, F. R., Gunson, F. A., & Jaeger, S. R. (2003). The case for fruit quality: an interpretive review of consumer attitudes, and preferences for apples. *Postharvest Biology and Technology, 28*, 333-347.

Hausman, J., & McFadden, D. (1984). Specification tests for the multinomial logit model. *Econometrica, 52*(5), 1219-1240.

Heilbroner, R. L. (1986 [1953]). *The worldly philosophers: the lives, times and ideas of the great economic thinkers* (Sixth ed.). New York, NY, USA: Simon & Schuster, Inc.

Heller, R. (2003). *GM nation? The findings of the public debate*: UK Department of Trade and Industry.

Hey, J. D. (1981). Are optimal search rules reasonable? And vice versa? (And does it matter anyway?). *Journal of Economic Behaviour and Organization, 2*, 47-70.

Hey, J. D. (1982). Search for rules for search. *Journal of Economic Behaviour and Organization, 3*, 65-81.

Hoban, T. J. (1997). Consumer acceptance of biotechnology: an international perspective. *Nature Biotechnology, 15*, 232-234.

Hoffman, S. D., & Duncan, G. J. (1988). A comparison of choice-based multinomial and nested logit models: the family structure and welfare use decisions of divorced or separated women. *Journal of Human Resources, 23*(4), 550-562.

Horowitz, J. L., Koppelman, F. S., & Lerman, S. R. (1986). *A self-instructing course in disaggregate mode choice modeling*. Washington D.C., USA: Federal Transit Administration and Technology Sharing Program, U.S. Department of Transportation.

Huffman, W. E. (2003). Consumers' acceptance of (and resistance to) genetically modified foods in high-income countries: effects of labels and information in an uncertain environment. *American Journal of Agricultural Economics, 85*(5), 1112-1118.

Huffman, W. E., Rousu, M., Shogren, J., & Tegene, A. (2003a). *Better dead than GM-fed? Information and the effects of consumers' resistance to GM-foods in high-income countries* (No. 03017). Ames, Iowa, USA: Iowa State University.

Huffman, W. E., Rousu, M., Shogren, J., & Tegene, A. (2003b). The public good value of information from agribusinesses on genetically modified foods. *American Journal of Agricultural Economics, 85*(5), 1309-1315.

Huffman, W. E., Shogren, J. F., Rousu, M., & Tegene, A. (2001, August). *The value to consumers of GM food labels in a market with asymmetric information: evidence from experimental auctions.* Paper presented at the Annual Meeting of the American Agricultural Economics Association, Chicago, IL, USA.

IBAC. (2000). *Public views on the biotechnology question*. Christchurch, NZ: Independent Biotechnology Advisory Council.

IFIC. (2002). Support for food biotechnology holds with increased recognition of benefits: International Food Information Council.

Information Systems for Biotechnology. (2003). *Crops no longer regulated by USDA*. Retrieved 31 July 2003, from http://www.isb.vt.edu

INL Newspapers. (2003, 25 June). Europe and Bush battle over GM foods.

James, C. (2003). *Global review of commercialized transgenic crops: 2002 feature: Bt maize* (ISAAA Briefs No. 29). Ithaca, NY, US: International Service for the Acquisition of Agri-biotech Applications.

James, S., & Burton, M. (2003). Consumer preferences for GM food and other attributes of the food system. *The Australian Journal of Agricultural and Resource Economics, 47*(4), 501-518.

John, P. W. M. (1998). *Statistical design and analysis of experiments*. Philadelphia, PA, USA: Society for Industrial and Applied Mathematics.

Johnson, A.-M. (2004, 7 February 2004). Wellington men are kings of the aisles*. The Dominion Post*.

Johnson, E. J., Meyer, R. J., & Ghose, S. (1989). When choice models fail: compensatory models in negatively correlated environments. *Journal of Marketing Research, 26*(3), 255-270.

Johnson, R. M., & Orme, B. K. (1996). *How many questions should you ask in choice-based conjoint studies?* (Research Paper Series). Sequim, WA, USA: Sawtooth Software, Inc.

Jones, E. (1997). An analysis of consumer food shopping behavior using supermarket scanner data: differences by income and location. *American Journal of Agricultural Economics, 79*(5), 1437-1443.

Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1990). *Judgement under uncertainty: heuristics and biases*. Sydney, Australia: Cambridge University Press.

Kastens, T. L., & Featherstone, A. M. (1996). Feedforward backpropagation neural networks in prediction of farmer risk preferences. *American Journal of Agricultural Economics, 78*(2), 400-415.

Kaye-Blake, W., Bicknell, K., & Lamb, C. (2004). Willingness to pay for genetically modified food labelling in New Zealand. In V. Santaniello & R. E. Evenson (Eds.), *Consumer acceptance of genetically modified foods*. Wallingford, UK: CABI Publishing.

Kaye-Blake, W., & Saunders, C. (2003). *Evaluation of benefits, market access, and demand issues for applications for commercial release of genetically modified organisms* (Research report for the Environmental Risk Management Authority (ERMA)). Canterbury, New Zealand: Agribusiness and Economics Research Unit, Lincoln University.

Kaye-Blake, W., Saunders, C., & Fairweather, J. (2004). *Modelling the trade impacts of willingness to pay for genetically modified food* (Research Report No. 270). Canterbury, New Zealand: Agribusiness and Economics Research Unit (AERU), Lincoln University.

Kennedy, P. (1992). *A guide to econometrics* (3rd ed.). Cambridge, MA, USA: The MIT Press.

Kennedy, P. (2003). *A guide to econometrics* (5th ed.). Cambridge, MA, USA: The MIT Press.

Kerr, G. N. (2000). Dichotomous choice contingent valuation probability distributions. *Australian Journal of Agricultural and Resource Economics, 44*(2), 233-252.

Kiesel, K., Buschena, D., & Smith, V. (2004). Consumer acceptance and labelling of GMOs in food products: a study of fluid milk demand. In R. E. Evenson & V. Santaniello (Eds.), *Consumer acceptance of genetically modified foods* (pp. 9-22). Wallingford, Oxon, UK: CABI Publishing.

Koning, R. H., & Ridder, G. (2003). Discrete choice and stochastic utility maximization. *Econometrics Journal, 6*, 1-27.

Kristrom, B. (1997). Spike models in contingent valuation. *American Journal of Agricultural Economics, 79*(3), 1013-1023.

Krueger, R. W. (2001). The public debate on agrobiotechnology: a biotech company's perspective. *AgBioForum, 4*(3&4).

Kuhfeld, W. F., Tobias, R. D., & Garratt, M. (1994). Efficient experimental design with marketing research applications. *Journal of Marketing Research, 31*(4), 545-557.

Kurauchi, S., & Morikawa, T. (2001). An exploratory analysis for discrete choice model with latent classes considering heterogeneity of decision making rules. In D. Hensher (Ed.), *Travel behaviour research: the leading edge* (pp. 409-423). London: Pergamon.

Laland, K. N. (2001). Imitation, social learning, and preparedness as mechanisms of bounded rationality. In G. Gigerenzer & R. Selten (Eds.), *Bounded rationality: the adaptive toolbox*. Cambridge, MA: MIT Press.

Lancaster, K. (1966). A new approach to consumer theory. *Journal of Political Economy, 74*, 132-157.

Langford, I. H., Georgiou, S., Bateman, I. J., Day, R. J., & Turner, R. K. (2000). Public perceptions of health risks from polluted coastal bathing waters: a mixed methodological analysis using cultural theory. *Risk Analysis, 20*(5), 691-704.

Lapan, H. E., & Moschini, G. (2002). *Innovation and trade with endogenous market failure: the case of genetically modified products* (Working Paper No. 02-WP 302). Ames, Iowa, USA: Center for Agricultural and Rural Development, Iowa State University.

Lau, E. (2004, 10 June). Grocery quandary: for U.S. shoppers, a lack of labels limits choice on biotech products. *The Sacramento Bee*.

Lee, J., & Geistfeld, L. V. (1998). Enhancing consumer choice: are we making appropriate recommendations? *The Journal of Consumer Affairs, 32*(2), 227-251.

Lheureux, K., Libeau-Dulos, M., Nilsagard, H., Rodriguez-Cerezo, E., Menrad, K., Menrad, M., & Vorgrimler, D. (2003). *Review of GMOs under research and development and in the pipeline in Europe*. Brussels: Joint Research Centre - Institute for Prospective Technological Studies, European Commission.

Li, Q., Curtis, K. R., McCluskey, J. J., & Wahl, T. I. (2002). Consumer attitudes toward genetically modified foods in Beijing, China. *AgBioForum, 5*(4), 145-152.

Lindner, B., Burton, M., James, S., & Pluske, J. (2001). Welfare effects of identity preservation and labelling of genetically modified food. In R. Fraser & J. Taylor (Eds.), *Research profile: agricultural and resource economics at the University of Western Australia in 2001*. Perth: University of Western Australia.

Lindsey, G. (1994). Market models, protest bids, and outliers in contingent valuation. *Journal of Water Resources Planning and Management, 120*(1), 121-129.

List, J. A., & Shogren, J. (1998). Calibration of the difference between actual and hypothetical valuations in a field experiment. *Journal of Economic Behavior and Organization, 37*, 193-205.

Loader, R., & Henson, S. (1998). A view of GMOs from the UK. *AgBioForum, 1*(1), 31-34.

Lockwood, M. (1998). Integrated value assessment using paired comparisons. *Ecological Economics, 25*, 73-87.

Louviere, J. J. (1988). Conjoint analysis modelling of stated preferences: a review of theory, methods, recent developments and external validity. *Journal of Transport Economics and Policy, 22*(1), 93-119.

Louviere, J. J. (2001). Choice experiments: an overview of concepts and issues. In J. Bennett & R. Blamey (Eds.), *The choice modelling approach to environmental valuation* (pp. 13-36). Cheltenham, UK: Edward Elgar Publishing Ltd.

Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated choice methods: analysis and applications*. Cambridge, UK: Cambridge University Press.

Lusk, J. L. (2003). Effects of cheap talk on consumer willingness-to-pay for golden rice. *American Journal of Agricultural Economics, 85*(4), 840-856.

Lusk, J. L., Daniel, M. S., Mark, D. R., & Lusk, C. L. (2001). Alternative calibration and auction institutions for predicting consumer willingness to pay for nongenetically modified corn chips. *Journal of Agricultural and Resource Economics, 26*(1), 40-57.

Lusk, J. L., House, L. O., Valli, C., Jaeger, S. R., Moore, M., Morrow, B., & Traill, W. B. (2003). *Effect of information about benefits of biotechnology on consumer acceptance of genetically modified food: evidence from experimental auctions in the United States, England, and France*. West Lafayette, IN, U.S.: Department of Agricultural Economics, Purdue University.

Macer, D. (1992). *Attitudes to genetic engineering: Japanese and international comparisons*. Christchurch, N.Z.: Eubios Ethics Institute.

Macer, D. (1994). *Bioethics for the people by the people*. Christchurch, N.Z.: Eubios Ethics Institute.

Macer, D. (1998). *Public perception of biotechnology in New Zealand and the international community: Eurobarometer 46.1*. Christchurch, New Zealand: Eubios Ethics Institute.

Maddala, G. S. (1983). *Limited-dependent and qualitative variables in econometrics*. Cambridge, UK: Cambridge University Press.

Malone, L. A. (2002). *Literature review on genetically modified plants and bee products* (Technical Paper No. 2002/05). Wellington, NZ: Ministry of Agriculture and Forestry.

Marcuse, H. (1974 (1964)). *One dimensional man* (ABACUS ed.). London, UK: Sphere Books, Ltd.

Marra, M. C., Pardey, P. G., & Alston, J. M. (2002). *The payoffs to agricultural biotechnology: an assessment of the evidence* (EPTD Discusson Paper No. 87). Washington, D.C.: Environment and Production Technology Division, International Food Policy Research Institute.

Marris, C., Wynne, B., Simmons, P., & Weldon, S. (2001). *Public perceptions of agricultural biotechnologies in Europe*: Commission of European Committees.

Martineau, B. (2001). *First fruit: the creation of the Flavr Savr tomato and the birth of genetically engineered food*. San Francisco, CA, USA: McGraw-Hill.

Masters, W. A., & Sanogo, D. (2002). Welfare gains from quality certification of infant foods: results from a market experiment in Mali. *American Journal of Agricultural Economics, 84*(4), 974-989.

Mazzotta, M. J., & Opaluch, J. J. (1995). Decision making when choices are complex: a test of Heiner's hypothesis. *Land Economics, 71*(4), 500-515.

McCluskey, J. J., Ouchi, H., Grimsrud, K. M., & Wahl, T. I. (2001). *Consumer response to genetically modified food products in Japan* (No. TWP-2001-101). Pullman, WA, USA: Department of Agricultural Economics, Washington State University.

McFadden, D. (1974). Conditional logit. In P. Zarembka (Ed.), *Frontiers in econometrics*. New York: Academic Press.

McFadden, D. (1978). Quantitative methods for analysing travel behaviour of individuals: some recent developments. In D. Hensher & P. R. Stopher (Eds.), *Behavioural Travel Modelling* (pp. 279-318). London, UK: Croom Helm.

McFadden, D. (1981). Econometric models of probabilistic choice. In C. F. Manski & D. McFadden (Eds.), *Structural analysis of discrete data with econometric applications* (pp. 198-272). Cambridge, MA, USA: The MIT Press.

McFadden, D. (1986). The choice theory approach to market research. *Marketing Science, 5*(4), 275-297.

McFadden, D. (2001a). Disaggregate behavioural travel demand's RUM side: a 30-year retrospective. In D. Hensher (Ed.), *Travel behaviour research: the leading edge* (pp. 17-63). London: Pergamon.

McFadden, D. (2001b). Economic choices. *American Economic Review, 91*(3), 351-378.

McFadden, D., & Train, K. (2000). Mixed MNL models for discrete response. *Journal of Applied Econometrics, 15*(5), 447-470.

McFadden, D., Train, K., & Tye, W. B. (1978). An application of diagnostic tests for the independence from irrelevant alternatives property of the multinomial logit model. In *Transportation Research Record: Forecasting Passenger and Freight Travel, No. 637* (pp. 39-46): Transportation Research Board.

McIntosh, E., & Ryan, M. (2002). Using discrete choice experiments to derive welfare estimates for the provision of elective surgery: implications of discontinuous preferences. *Journal of Economic Psychology, 23*, 367-382.

Mikic, M. (1998). *International trade*. London, UK: MacMillan Press Ltd.

Milo, L. (2000). A defining time for GMOs. *Prepared Foods, 169*(6), 41.

Ministry of Research Science and Technology. (2003). *New Zealand biotechnology strategy : a foundation for development with care*. Wellington, N.Z.: Ministry of Research, Science and Technology.

Miranowski, J. A., Moschini, G., Babcock, B., Duffy, M., Wisner, R., Beghin, J., Hayes, D. J., Lence, S., Baumel, C. P., & Harl, N. E. (1999). *Economic perspectives on GMO market segregation* (Staff Paper No. 298). Ames, IA, US: Iowa State University.

Moon, W., & Balasubramanian, S. K. (2003). Is there a market for genetically modified foods in Europe? Contingent valuation of GM and non-GM breakfast cereals in the United Kingdom. *AgBioForum, 6*(3), 128-133.

Morrison, M. D., Blamey, R., Bennett, J. W., & Louviere, J. J. (1996). *A comparison of stated preference techniques for estimating environmental values* (Research Report No. 1). Canberra, Australia: School of Economics and Management, University College, The University of New South Wales.

Moschini, G., Lapan, H., & Sobolevsky, A. (2000). Roundup Ready soybeans and welfare effects in the soybean complex. *Agribusiness, 16*(1), 33-55.

Murphy, J. J., Allen, P. G., Stevens, T. H., & Weatherhead, D. (2005). A meta-analysis of hypothetical bias in stated preference valuation. *Environmental and Resource Economics, 30*, 313-325.

Nakamura, Y. (2000). *Lexicographic quasilinear utility* (mimeo). Tsukuba, Japan: Institute of Policy and Planning Sciences, University of Tsukuba.

Nayga Jr., R. M. (2001-2002). Looking for the nutritional label: does it make a difference? *Choices, 16*(4), 39-42.

Nelson, C. H. (2001). Risk perception, behavior, and consumer response to genetically modified organisms: toward understanding American and European public reaction. *The American Behavioral Scientist, 44*(8), 1371-1388.

Newell, B. R., & Shanks, D. R. (2003). Take the Best or look at the rest? Factors influencing 'one-reason' decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*(1), 53-65.

Noussair, C., Robin, S., & Ruffieux, B. (2002). Do consumers not care about biotech foods or do they just not read the labels? *Economics Letters, 75*(1), 47-53.

Noussair, C., Robin, S., & Ruffieux, B. (2004). Do consumers really refuse to buy genetically modified food? *The Economic Journal, 114*, 102-120.

Onyango, B., Govindasamy, R., & Nayga Jr., R. M. (2004). *Measuring U.S. consumer preferences for genetically modified foods using choice modelling experiments: the role of price, product benefits and technology* (Working Paper No. WP1104-017). New Jersey, USA: Food Policy Institute, Rutgers University.

Organisation for Economic Co-operation and Development. (2000). *Modern biotechnology and agricultural markets: a discussion of selected issues*: Directorate for Food, Agriculture and Fisheries, Committee for Agriculture.

Organisation for Economic Co-operation and Development. (2005). *Biotechnology, about*. Retrieved 15 August, 2005, from http://www.oecd.org/about/0,2337,en_2649_37437_1_1_1_1_37437,00.html

Osborn, A. (2003, 19 August). US escalates GM food row with Europe. *The Guardian*.

Parcell, J. L. (2001). An initial look at the Tokyo Grain Exchange non-GMO soybean contract. *Journal of Agribusiness, 19*(1), 85-92.

Parcell, J. L. (2002, 22-23 April). *Emerging IP markets: the Tokyo Grain Exchange non-GMO soybean contract.* Paper presented at the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management, St. Louis, MO, USA.

Payne, J. W., & Bettman, J. R. (2001). Preferential choice and adaptive strategy. In G. Gigerenzer & R. Selten (Eds.), *Bounded rationality: the adaptive toolbox*. Cambridge, MA: MIT Press.

Pew Initiative. (2003). *Survey Results: An Update On Public Sentiment About Agricultural Biotechnology*: Pew Initiative on Food and Biotechnology.

Pew_Initiative. (2003). *Survey Results: An Update On Public Sentiment About Agricultural Biotechnology*: Pew Initiative on Food and Biotechnology.

Phillips, P., & Corkindale, D. (2002). Marketing GM foods: the way forward. *AgBioForum, 5*(3), 113-121.

Phillips, P., & McNeill, H. (2000). A survey of national labeling policies for GM food. *AgBioForum, 3*(4), 219-224.

Plott, C. (1987). Psychology and economics. In J. Eatwell, M. Milgate & P. Newman (Eds.), *The new Palgrave: a dictionary of economics* (Vol. 3, pp. 1037-1040). London, UK: The MacMillan Press, Ltd.

Polome, P. (2003). Experimental evidence on deliberate misrepresentation in referendum contingent valuation. *Journal of Economic Behavior and Organization, 52*, 387-401.

Pudney, S. (1989). *Modelling individual choice: the econometrics of corners, kinks and holes*. Oxford, United Kingdom: Basil Blackwell Ltd.

Qaim, M., & Traxler, G. (2005). Roundup Ready soybeans in Argentina: farm level and aggregate welfare effects. *Agricultural Economics, 32*, 73-86.

Quirk, J. P. (1982). *Intermediate microeconomics*. Sydney, Australia: Science Research Associates, Inc.

Rabin, M. (2002). A perspective on psychology and economics. *European Economic Review, 46*, 657-685.

Radio New Zealand Newswire. (2005, 27 January). FSA denies labelling of GE ingredients in US tinned food is.

Recker, W. W., & Golob, T. F. (1979). A non-compensatory model of transportation behavior based on sequential consideration of attributes. *Transportation Research Part B, 13*(4), 269-280.

Rekola, M. (2003). Lexicographic preferences in contingent valuation: a theoretical framework with illustrations. *Land Economics, 79*(2), 277-291.

Revelt, D., & Train, K. (1998). Mixed logit with repeated choices: households' choices of appliance efficiency. *Review of Economics and Statistics, 80*(4), 647-657.

Revelt, D., & Train, K. (1999). *Customer-specific taste parameters and mixed logit* (Working paper). Berkeley, CA, US: University of California.

Richards, T. J. (2000). A discrete/continuous model of fruit promotion, advertising, and response segmentation. *Agribusiness, 16*(2), 179-196.

Richardson-Harman, N., Phelps, T., Mooney, P., & Ball, R. (1998). Consumer perceptions of fruit production technologies. *New Zealand Journal of Crop and Horticultural Science, 26*, 181-192.

Riddington, G., Sinclair, C., & Milne, N. (2000). Modelling choice and switching behaviour between Scottish ski centres. *Applied Economics, 32*(8), 1011-1019.

Rieskamp, J., & Hoffrage, U. (1999). When do people use simple heuristics and how can we tell. In G. Gigerenzer, P. M. Todd & t. A. R. Group (Eds.), *Simple heuristics that make us smart*. Oxford: Oxford University Press.

Rigby, D., & Burton, M. (2003). *Capturing preference heterogeneity in stated choice model: a random parameter logit model of the demand for GM food*. Manchester, UK: School of Economics, Manchester University.

Rigby, D., & Burton, M. (2004, 2-4 April). *Modeling indifference and dislike: a bounded Bayesian mixed logit model of the UK market for GM food.* Paper presented at the The Agricultural Economics Society 78th Annual Conference, Imperial College, London, UK.

Roberts, J. A., & Bacon, D. R. (1997). Exploring the subtle relationships between environmental concern and ecologically conscious consumer behavior. *Journal of Business Research, 40*, 79-89.

Robertson, D. (2002). Marking time: Australian rules on genetically modified food labels aren't as tough as they're made out to be. *Far Eastern Economic Review, 165*(5), 41.

Robinson, J. (1962). *Economic philosophy*. Mitcham, Victoria, Australia: Penguin Books Pty Ltd.

Rosenberger, R. S., Peterson, G. L., Clarke, A., & Brown, T. C. (2003). Measuring disposition for lexicographic preferences of environmental goods: integrating economics, psychology and ethics. *Ecological Economics, 44*(1), 63-76.

Rotondo, J. (1986). Price as an aspect of choice in EBA. *Marketing Science, 5*(4), 391-402.

Rousu, M., Huffman, W. E., Shogren, J. F., & Tegene, A. (2004). Are United States consumers tolerant of genetically modified food? *Review of Agricultural Economics, 26*(1), 19-31.

Rousu, M., Monchuk, D. C., Shogren, J. F., & Kosa, K. M. (2003). *Consumer perceptions of labels and willingness to pay for "second generation" genetically modified products*. Research Triangle Park, North Carolina, USA: RTI International.

Royal Commission on Genetic Modification. (2001). *Report of the Royal Commission on Genetic Modification*. Wellington, New Zealand.

Rubinstein, A. (1998). *Modeling bounded rationality*. Cambridge, MA, USA: MIT Press.

Saak, A. E., & Hennessy, D. A. (2002). Planting decisions and uncertain consumer acceptance of genetically modified crop varieties. *American Journal of Agricultural Economics, 84*(2), 308-319.

Sadrieh, A., Güth, W., Hammerstein, P., Harnad, S., Hoffrage, U., Kuon, B., Munier, B. R., Todd, P. M., Warglien, M., & Weber, M. (2001). Group report: is there evidence for an adaptive toolbox? In G. Gigerenzer & R. Selten (Eds.), *Bounded rationality: the adaptive toolbox*. Cambridge, MA: MIT Press.

Salvatore, D. (2004). *International Economics* (Eighth ed.): John Wiley & Sons, Inc.

Samuelson, P. A., & Nordhaus, W. D. (1995). *Economics* (15th ed.). New York: McGraw-Hill, Inc.

Scarpa, R., Hutchinson, G., & Campbell, D. (2005, 23-26 June). *Individual benefit estimates for rural landscape improvements: the role of sequential Bayesian design and response rationality in a choice experiment study.* Paper presented at the 14th Annual European Association of Environmental and Resource Economists Conference, Bremen, Germany.

Scarpa, R., & Thiene, M. (2004). *Destination choice models for rock-climbing in the North-East Alps: a latent-class approach investigating intensity of preferences*. York, U.K.: University of York.

Scarpa, R., Willis, K. G., & Acutt, M. (nd). *Comparing individual-specific benefit estimates for public goods: finite versus continuous mixing in logit models* (Working paper). York, UK: University of York.

Schoemaker, P. J. H. (1982). The expected utility model: its variants, purposes, evidence and limitations. *Journal of Economic Literature, 20*, 529-563.

Scott, A. (2002). Identifying and analysing dominant preferences in discrete choice experiments: an application in health care. *Journal of Economic Psychology, 23*, 383-398.

Selten, R. (2001). What is bounded rationality? In G. Gigerenzer & R. Selten (Eds.), *Bounded rationality: the adaptive toolbox*. Cambridge, MA: MIT Press.

Sheehy, H., Legault, M., & Ireland, D. (1998). Consumers and biotechnology: a synopsis of survey and focus group research. *Journal of Consumer Policy, 21*, 359-386.

Shoemaker, R., Harwood, J., Day-Rubenstein, K., Dunahay, T., Heisey, P., Hoffman, L., Klotz-Ingram, C. A., Lin, W., Mitchell, L., McBride, W., & Fernandez-Cornejo, J. (2001). *Economic issues in agricultural biotechnology* (Agriculture Information Bulletin No. 762). Washington, D.C.: Economic Research Service, United States Department of Agriculture.

Shogren, J. F., Fox, J. A., Hayes, D. J., & Roosen, J. (1999). Observed choices for food safety in retail, survey, and auction markets. *American Journal of Agricultural Economics, 81*(5), 1192-1199.

Siegrist, M. (1998). Belief in gene technology: the influence of environmental attitudes and gender. *Personality and Individual Differences, 24*(6), 861-866.

Simon, H. A. (1955). A behavioral model of rational choice. *Quarterly Journal of Economics, 69*(1), 99-118.

Simon, H. A. (1956). Rational choice and environmental structure. *Psychological Review, 63*(2), 129-138.

Simon, H. A. (1979). *Models of thought*. New Haven, Connecticut, USA: Yale University Press.

Simon, H. A. (1983). *Reason in human affairs*. Stanford, CA, USA: Stanford University Press.

Simon, H. A. (1987). Behavioural economics. In J. Eatwell, M. Milgate & P. Newman (Eds.), *The new Palgrave: a dictionary of economics* (Vol. 1, pp. 221-225). London, UK: The MacMillan Press Limited.

Sloss, E. S. (1995). Child care choice in a lexicographic framework. *Journal of Economic Issues, 29*(2), 629-637.

Slovic, P. (2000). *The perception of risk*. London, U.K.: Earthscan Publications.

Small, B. H. (2001). Genetically engineered milk survey (survey instrument). Hamilton, New Zealand: AgResearch.

Small, B. H., Wilson, J. A., & Parminter, T. (2002). *Clean, green and healthy? Genetically engineered food: a perceived threat to New Zealand's brand image*. Hamilton, New Zealand: AgResearch.

Small, B. H., Wilson, J. A., & Parminter, T. (nd). *Clean, green and healthy? Genetically engineered food: a perceived threat to New Zealand's brand image*. Hamilton, New Zealand: AgResearch.

Small, B. H., Wilson, J. A., Pedersen, J. A., & Parminter, T. G. (2001). *Genetic engineering and the public: attitudes, beliefs, ethics and cows*. Hamilton, New Zealand: AgResearch, Ruakura Research Centre.

Sparks, P., Shepherd, R., & Frewer, L. J. (1994). Gene technology, food production, and public opinion: a UK study. *Agriculture and Human Values*, 19-28.

Spash, C. L. (2000). Ecosystems, contingent valuation and ethics: the case of wetland re-creation. *Ecological Economics, 34*, 195-215.

Spash, C. L., van der Werff ten Bosch, J. D., Westmacott, S., & Ruitenbeek, J. (2000). Lexicographic preferences and the contingent valuation of coral reef biodiversity in Curacao and Jamaica. In K. Gustavson, R. M. Huber & J. Ruitenbeek (Eds.), *Integrated Coastal Zone Management of Coral Reefs: Decision Support Modelling* (pp. 97-117). Washington DC, USA: The World Bank.

Starmer, C. (2000). Developments in non-expected utility theory: the hunt for a descriptive theory of choice under risk. *Journal of Economic Literature, 38*, 332-382.

Stevens, T. H., Echeverria, J., Glass, R. J., Hager, T., & More, T. A. (1991). Measuring the existence value of wildlife: what do CVM estimates really show? *Land Economics, 67*(4), 390-400.

Stigler, G. J., & Becker, G. S. (1977). De gustibus non est disputandum. *American Economic Review, 67*(2), 76-90.

Strazzera, E., Genius, M., Scarpa, R., & Hutchinson, G. (nd). *The effect of protest votes on the estimates of willingness to pay for use values of recreational sites*: University of Cagliari, Italy.

Strazzera, E., Scarpa, R., Calia, P., Garrod, G. D., & Willis, K. G. (2003). Modelling zero values and protest responses in contingent valuation surveys (applied to traffic schemes in three English villages). *Applied Economics, 35*(2), 133-138.

Strotz, R. H. (1953). Cardinal utility. *American Economic Review, 43*, 384-397.

Subrahmanyan, S., & Cheng, P. S. (2000). Perceptions and attitudes of Singaporeans toward genetically modified food. *Journal of Consumer Affairs, 34*(2), 269-290.

Svedsater, H. (2003). Economic valuation of the environment: how citizens make sense of contingent valuation questions. *Land Economics, 79*(1), 122-135.

Swait, J. (1994). A structural equation model of latent segmentation and product choice for cross-sectional revealed preference choice data. *Journal of Retailing and Consumer Services, 1*(2), 77-89.

Swait, J. (2001a). Choice set generation within the generalized extreme value family of discrete choice models. *Transportation Research Part B, 35*, 643-666.

Swait, J. (2001b). A non-compensatory choice model incorporating attribute cutoffs. *Transportation Research Part B, 35*, 903-928.

Swait, J., & Adamowicz, W. (2001). The influence of task complexity on consumer choice: a latent class model of decision strategy switching. *Journal of Consumer Research, 28*, 135-148.

Swait, J., & Louviere, J. J. (1993). The role of the scale parameter in the estimation and comparison of multinomial logit models. *Journal of Marketing Research, 30*, 305-314.

Tauer, L. W. (1994). The value of segmenting the milk market into bST-produced and non-bST-produced milk. *Agribusiness, 10*(1), 3-12.

Tegene, A., Huffman, W. E., Rousu, M., & Shogren, J. F. (2003). *The effects of information on consumer demand for biotech foods: evidence from experimental auctions* (Technical Bulletin No. 1903). Washington, D.C.: Economic Research Service, United States Department of Agriculture.

Thompson, P. B. (1997). Food biotechnology's challenge to cultural integrity and individual consent. *The Hastings Center Report, 27*(4), 34-38.

Todd, P. M. (2001). Fast and frugal heuristics for environmentally bounded minds. In G. Gigerenzer & R. Selten (Eds.), *Bounded rationality: the adaptive toolbox*. Cambridge, MA: MIT Press.

Todd, P. M., & Gigerenzer, G. (2003). Bounding rationality to the world. *Journal of Economic Psychology, 24*, 143-165.

Train, K. (2003). *Discrete choice methods with simulation*. Cambridge, UK: Cambridge University Press.

Tversky, A. (1972a). Choice by elimination. *Journal of Mathematical Psychology, 9*, 341-367.

Tversky, A. (1972b). Elimination by aspects: a theory of choice. *Psychological Review, 79*(4), 281-299.

USDA. (2001). *Demand for certified non-biotech soybean meal expands in the EU* (International Agricultural Trade Report). Washington, DC, US: Commodity and Marketing Programs, Foreign Agricultural Service, United States Department of Agriculture.

van den Bergh, J. C. J. M., Ferrer-i-Carbonell, A., & Munda, G. (2000). Alternative models of individual behaviour and implications for environmental policy. *Ecological Economics, 32*, 43-61.

VanWechel, T., Wachenheim, C. J., Schuck, E., & Lambert, D. K. (2003). *Consumer valuation of genetically modified foods and the effect of information bias* (Agribusiness and Applied Economics Report No. 513). Fargo, ND, USA: Department of Agribusiness and Applied Economics, North Dakota State University.

Varian, H. R. (1996). *Intermediate microeconomics: a modern approach*. London, UK: W.W. Norton & Company.

Veisten, K. (2002). Potential demand for certified wood products in the United Kingdom and Norway. *Forest Science, 48*(4), 767-778.

Verdurme, A., & Viaene, J. (2002, 11-14 July). *Public acceptance and communication with regard to genetically modified food.* Paper presented at the 6th International Consortium on Agricultural Biotechnology Research Conference, Ravello, Italy.

Verdurme, A., Viaene, J., & Gellynck, X. (2003). Consumer acceptance of GM food: a basis for segmentation. *International Journal of Biotechnology, 5*(1), 58-75.

von Haefen, R. H., Massey, D. M., & Adamowicz, V. (2004). *Serial non-participation in repeated discrete choice models*. Tucson, AZ, USA: Department of Agricultural and Resource Economics.

Vovsha, P. (1997). Application of cross-nested logit model to mode choice in Tel Aviv, Israel, metropolitan area. *Transportation Research Record, 1607*, 6-15.

Walker, J., Ben-Akiva, M., & Bolduc, D. (2003). *Identification of the logit kernal (or mixed logit) model*. Cambridge, MA, USA: Massachusetts Institute of Technology.

Wansink, B., Kent, R. J., & Hoch, S. J. (1998). An anchoring and adjustment model of purchase quantity decisions. *Journal of Marketing Research, 35*, 71-81.

Wen, C.-H., & Koppelman, F. S. (2001). The generalized nest logit model. *Transportation Research Part B, 35*, 627-641.

West, G. E., Larue, B., Gendron, C., & Scott, S. L. (2002). Consumer confusion over the significance of meat attributes: the case of veal. *Journal of Consumer Policy, 25*(1), 65-88.

Williams, H. C. W. L., & Ortuzar, J. D. (1982). Behavioural theories of dispersion and the mis-specification of travel demand models. *Transportation Research Part B, 16*(3), 167-219.

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*. Cambridge, MA, USA: The MIT Press.

Yamamoto, T., Kurauchi, S., & Morikawa, T. (2002). *Comparison of non-compensatory models of driver's choice on dynamic park and ride.* Paper presented at the 9th World Congress on Intelligent Transportation Systems, Chicago, Illinois, USA.

Yoo, S.-H., Kwak, S.-J., & Kim, T.-Y. (2001). Modelling willingness to pay responses from dichotomous choice contingent valuation surveys with zero observations. *Applied Economics, 33*(4), 523-530.

Young, T. (2000). Food futures survey. Manchester, UK.

Zechendorf, B. (1994). What the public thinks about biotechnology. *Bio/technology, 12*, 870-875.

Appendix 1

Survey Instrument

Version A
Version B

LINCOLN UNIVERSITY
Te Whare Wānaka O Aoraki

Commerce Division

Lincoln University

Consumer Survey on Preferences for Apples

Hi! I'm a student at Lincoln University conducting a survey on what types of apples are most appealing. This survey will take about 10 minutes to complete. Would you have a few minutes to participate in this survey?

I am required to tell you a few things before we start:

- ♦ *You may decline to answer questions or stop the survey at any time.*
- ♦ *If you do stop at any stage, I will destroy any information you have provided.*
- ♦ *You may complete this survey privately without my help.*
- ♦ *I do not need your name or address.*
- ♦ *There are three parts to this survey.*

The project is supervised by Dr. Katie Bicknell. She can be contacted at 03 325 2811, ext 8275, and would be happy to discuss any concerns you have about participation in this survey. The results of the survey may be published.

For office use:

Store __________________ Day ____________ Time _____________

Q1. Do you eat apples at home?

- ❑ Yes
- ❑ No *IF 'NO' THEN THANK PERSON AND END INTERVIEW.*

Q2. Are you over 15 years of age?

- ❑ Yes
- ❑ No *IF 'NO' THEN THANK PERSON AND END INTERVIEW.*

Q3. Here are several characteristics or properties of apples. Would you please rank them from most important (1) to least important (7)?

Apple characteristic	Rank (1 is most important)
Price	___________
Nutrition	___________
Flavour	___________
Variety of apple	___________
Freshness	___________
Imported vs domestic	___________
Insecticide use	___________

Q4. Do you avoid purchasing certain foods for any of the following reasons?

- ❑ Yes
  - ❑ Medical ________________________________
  - ❑ Ethical ________________________________
  - ❑ Other ________________________________
- ❑ No

I. Choose your favourite apples

In this part of the survey, I will ask you to choose amongst several types of apples [hand the respondent the choice set cards]. Some of these apples are already on the market, but most are not. There are no 'right' or 'wrong' answers – we are just interested in your opinions.

The apples are described using five characteristics:

- *The level of antioxidants*
- *Whether the apple is genetically modified or not*
- *The price*
- *The flavour*
- *Insecticide use*

Each question has three different apples. The Option A in every question is the type of apple that is widely available now. The others are types of apples that could be available in the future. [If asked, say that the respondent should assume that the apples are all the same variety and are a variety the person prefers.]

Q5. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q6. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q7. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q8. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q9. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q10. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q11. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q12. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q13. If the three types of apples were the only ones available, which would you prefer?

A	B	C	None

Q14. When making your choices, did you always choose Apple A?

- ❑ Yes
- ❑ No

If yes, could you please explain why? ________________________________

____

Q15. Apples can get a disease called black spot. This disease makes apples rot. Currently, apples are sprayed to control black spot. A new type of apple can be genetically modified so that it does not need to be sprayed (to control this disease). How much would you be willing to pay for this new apple? Just to remind you, apples generally cost about $3.00 per kilogram.

$_______/kilogram

Q16. Could you give some feedback on the choice questions you just answered?

	Yes	No	Maybe/ Somewhat	Don't know
Do you think that these new types of apples will be available for you to buy in the next 5 years?	☐	☐	☐	☐
Was it difficult to choose which apple you preferred?	☐	☐	☐	☐
Are other food-related issues more important to you than the ones highlighted here?	☐	☐	☐	☐

What are those other issues? ______________________________

____

II. Your opinions

I am now going to read several statements. For each one, could you please give me your opinion and say whether you strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree.

	Strongly Agree 1	Agree 2	Neither Agree nor Disagree 3	Disagree 4	Strongly Disagree 5	Don't know DK
Q17. I choose the apples with the best flavour.	☐	☐	☐	☐	☐	☐
Q18. The use of genetic modification technology in food production offers a solution to the world food problem.	☐	☐	☐	☐	☐	☐
Q19. Producing genetically modified food is too risky to be acceptable to me.	☐	☐	☐	☐	☐	☐
Q20. I would buy apples that are genetically modified.	☐	☐	☐	☐	☐	☐

	Strongly Agree 1	Agree 2	Neither Agree nor Disagree 3	Disagree 4	Strongly Disagree 5	Don't know DK
Q21. I choose the least expensive apples.	☐	☐	☐	☐	☐	☐
Q22. Natural environments have a right to exist for their own sake, regardless of human concerns and uses.	☐	☐	☐	☐	☐	☐
Q23. We should try to get by with a little less so there will be more left for future generations.	☐	☐	☐	☐	☐	☐
Q24. Too many pesticides are used to produce food.	☐	☐	☐	☐	☐	☐
Q25. Using genetic modification technology fits with my cultural and spiritual beliefs.	☐	☐	☐	☐	☐	☐
Q26. Genetic modification technology is tampering with nature.	☐	☐	☐	☐	☐	☐
Q27. Genetically modified products are environmentally friendly.	☐	☐	☐	☐	☐	☐

III. Questions about yourself

The final set of questions will allow us to be sure that we have talked to people from a wide range of backgrounds. The accuracy of your answers is quite important to the quality of our survey results.

Q28. What is your gender?

- ☐ Male
- ☐ Female

Q29. Are you the main food shopper for your household?

- ❑ Yes
- ❑ No

Q30. How many people live in your household?

	Number
0 – 4 years of age	__________
5 – 17 years of age	__________
18+ years	__________

Q31. How often do you purchase organically grown food?

- ❑ Never
- ❑ Rarely
- ❑ Sometimes
- ❑ Often
- ❑ Always

Q32. Could you please indicate what proportion of your food budget is spent on organic food?

______%

Q33. With what ethnicity do you identify?

- ❑ New Zealand European
- ❑ Maori
- ❑ Pacific Islander
- ❑ Asian:____
- ❑ Other:____

Q34. What is your age?

- ❑ 15-19
- ❑ 20-29
- ❑ 30-39
- ❑ 40-49
- ❑ 50-59
- ❑ 60-69
- ❑ 70-79
- ❑ 80+

Q35. What is the total income for your HOUSEHOLD, before tax?

	Per week	- or -	Per year
❑	Up to $419		Up to $21,599
❑	$420 to $649		$21,600 to $33,799
❑	$650 to $1,029		$33,800 to $53,299
❑	$1,030 to $1,540		$53,300 to $80,099
❑	$1,540 or more		$80,100 or more

Q36. What is your highest level of education?

- ❑ Up to Fifth Form / Year 11
- ❑ School Certificate / NCEA I
- ❑ University Entrance / Bursary / NCEA II
- ❑ Tertiary qualification other than Degree (Diploma, vocational or technical, etc.)
- ❑ University Degree, including Postgraduate

That's all the questions I have for you. Is there anything you would like to tell me about this survey?

Thank you very much for you time. Your participation is a big help to this research.

Q5

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	Current level	GM	$1.50 / kg	Current flavour	30% less
Apple C	100% more	Not GM	$3.60 / kg	Improved flavour	30% less

☐ None of the above

Q6

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	50% more	Not GM	$2.70 / kg	Current flavour	10% more
Apple C	Current level	Not GM	$3.00 / kg	Current flavour	30% less

☐ None of the above

Q7

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	Current level	GM	$4.50 / kg	Current flavour	10% more
Apple C	Current level	GM	$3.00 / kg	Current flavour	30% less

☐ None of the above

Q8

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	Current level	Not GM	$4.50 / kg	Current flavour	10% more
Apple C	50% more	GM	$1.50 / kg	Current flavour	30% less

☐ None of the above

Version A

Q9

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	Current level	GM	$3.00 / kg	Improved flavour	Current level
Apple C	100% more	GM	$4.50 / kg	Improved flavour	30% less

☐ None of the above

Q10 **If these three types of apples were the only ones available, which one would you prefer?**

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	50% more	GM	$1.50 / kg	Current flavour	Current level
Apple C	50% more	Not GM	$2.40 / kg	Current flavour	30% less

☐ None of the above

Q11

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	50% more	Not GM	$1.50 / kg	Current flavour	Current level
Apple C	100% more	GM	$2.70 / kg	Current flavour	10% more

☐ None of the above

Q12 If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	100% more	Not GM	$3.00 / kg	Current flavour	30% less
Apple C	100% more	GM	$1.50 / kg	Current flavour	Current level

☐ None of the above

Version A

Q13 **If these three types of apples were the only ones available, which one would you prefer?**

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	100% more	Not GM	$4.50 / kg	Current flavour	Current level
Apple C	Current level	GM	$1.50 / kg	Improved flavour	10% more

☐ None of the above

Version B

Q5

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	Current level	Not GM	$2.70 / kg	Improved flavour	Current level
Apple C	50% more	GM	$3.60 / kg	Current flavour	10% more

☐ None of the above

Q6

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	Current level	Not GM	$1.50 / kg	Current flavour	30% less
Apple C	100% more	Not GM	$2.70 / kg	Current flavour	10% more

☐ None of the above

Version B

Q7

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	50% more	GM	$3.00 / kg	Current flavour	10% more
Apple C	Current level	GM	$3.60 / kg	Current flavour	Current level

☐ None of the above

Version B

Q8

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	100% more	GM	$3.60 / kg	Current flavour	Current level
Apple C	50% more	Not GM	$2.70 / kg	Improved flavour	Current level

☐ None of the above

Q9

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	100% more	GM	$1.50 / kg	Improved flavour	10% more
Apple C	Current level	Not GM	$2.40 / kg	Improved flavour	10% more

☐ None of the above

Q10

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	50% more	Not GM	$4.50 / kg	Improved flavour	30% less
Apple C	50% more	GM	$2.70 / kg	Improved flavour	Current level

☐ None of the above

Q11

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	\$3.00 / kg	Current flavour	Current level
Apple B	50% more	GM	\$4.50 / kg	Improved flavour	30% less
Apple C	100% more	Not GM	\$2.40 / kg	Current flavour	Current level

☐ None of the above

Q12

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	100% more	Not GM	$2.40 / kg	Improved flavour	10% more
Apple C	50% more	Not GM	$4.50 / kg	Current flavour	10% more

☐ None of the above

Q13

If these three types of apples were the only ones available, which one would you prefer?

	Level of antioxidants	Is it genetically modified?	Price	Flavour	Level of insecticide use
Apple A	Current level	Not GM	$3.00 / kg	Current flavour	Current level
Apple B	100% more	GM	$2.70 / kg	Current flavour	30% less
Apple C	Current level	Not GM	$4.50 / kg	Current flavour	Current level

☐ None of the above

Appendix 2

Model Outputs

Table A1. Results from main effects MNL estimation

Source: BIOGEME Version 0.6 [Sun Feb 9 15:03:33 2003], Michel Bierlaire, EPFL (c) 2001-2003

Date/Time stamp: Fri Jan 23 14:51:27 2004

Model:	Multinomial Logit
Number of estimated parameters:	12
Null log-likelihood:	-2612.5
Init log-likelihood:	-2612.5
Final log-likelihood:	-2078.01
Likelihood ratio test:	1068.99
Rho-square:	0.204591
Final gradient norm:	7.66E-05

Utility parameters

Name	Value	Std err	t-test	
ANTI	2.81E-01	8.37E-02	3.36E+00	
ASC1	2.41E-01	8.71E-02	2.76E+00	
ASC2	0.00E+00	fixed		
ATTIT1	-3.02E+00	3.42E-01	-8.84E+00	
ATTIT2	-1.87E+00	2.42E-01	-7.72E+00	
ATTIT3	-8.51E-01	2.15E-01	-3.95E+00	
ATTIT4	-3.25E-01	2.10E-01	-1.55E+00	*
FLAV	4.53E-01	8.19E-02	5.54E+00	
GM	-2.94E-01	1.97E-01	-1.49E+00	*
LINS	5.65E-01	8.06E-02	7.01E+00	
MALEGEND	3.02E-03	1.44E-01	2.09E-02	*
MINS	-6.49E-01	1.00E-01	-6.46E+00	
PR	-6.48E-01	3.85E-02	-1.68E+01	

Scale parameters

Name	Value	Std err	t-test 1
Scale1	1.00E+00	fixed	

Correlation of coefficients					
Coefficient1	Coefficient2	Covariance	Correlation	t-test	
MINS	PR	-5.71E-06	-1.48E-03	-4.79E-03	*
ATTIT4	GM	-3.51E-02	-8.50E-01	-7.82E-02	*
ANTI	ASC1	3.33E-03	4.57E-01	4.51E-01	*
ATTIT3	MINS	1.52E-04	7.02E-03	-8.56E-01	*
ATTIT3	PR	2.60E-05	3.14E-03	-9.29E-01	*
FLAV	LINS	3.58E-04	5.43E-02	-9.98E-01	*
GM	MALEGEND	-7.58E-03	-2.67E-01	-1.09E+00	*
ATTIT4	MALEGEND	2.37E-03	7.84E-02	-1.34E+00	*
ATTIT4	MINS	2.81E-05	1.33E-03	1.40E+00	*
ATTIT3	GM	-3.53E-02	-8.34E-01	-1.41E+00	*
ASC1	MALEGEND	5.63E-05	4.49E-03	1.41E+00	*
ANTI	FLAV	2.89E-04	4.21E-02	-1.50E+00	*
ATTIT4	PR	-1.60E-04	-1.99E-02	1.51E+00	*
GM	MINS	-7.93E-04	-4.02E-02	1.58E+00	*
ANTI	MALEGEND	9.54E-05	7.91E-03	1.67E+00	*
GM	PR	9.82E-04	1.30E-01	1.81E+00	*
ASC1	FLAV	3.01E-03	4.22E-01	-2.34E+00	
ANTI	LINS	2.33E-05	3.45E-03	-2.45E+00	
ASC1	ATTIT4	-3.31E-04	-1.81E-02	2.47E+00	
ASC1	GM	1.96E-03	1.14E-01	2.60E+00	
ANTI	ATTIT4	-4.37E-04	-2.49E-02	2.66E+00	
ANTI	GM	2.74E-04	1.66E-02	2.70E+00	
FLAV	MALEGEND	5.08E-05	4.31E-03	2.72E+00	
LINS	MALEGEND	-6.13E-05	-5.28E-03	3.40E+00	
ATTIT4	FLAV	-2.25E-04	-1.31E-02	-3.44E+00	
ATTIT3	MALEGEND	3.45E-03	1.11E-01	-3.48E+00	
ATTIT1	ATTIT2	3.50E-02	4.24E-01	-3.57E+00	
FLAV	GM	7.92E-04	4.92E-02	3.57E+00	
ATTIT3	ATTIT4	3.45E-02	7.64E-01	-3.61E+00	
MALEGEND	MINS	-1.21E-04	-8.36E-03	3.70E+00	
ATTIT2	GM	-3.54E-02	-7.44E-01	-3.83E+00	
ASC1	LINS	3.58E-03	5.10E-01	-3.90E+00	
ATTIT4	LINS	-1.55E-04	-9.16E-03	-3.95E+00	
GM	LINS	-3.24E-05	-2.04E-03	-4.04E+00	
MALEGEND	PR	-3.63E-05	-6.55E-03	4.36E+00	

ASC1	ATTIT3	-3.84E-04	-2.05E-02	4.67E+00
ATTIT2	MINS	3.91E-04	1.61E-02	-4.68E+00
ANTI	ATTIT3	-4.63E-04	-2.57E-02	4.86E+00
ATTIT2	PR	1.34E-04	1.44E-02	-4.98E+00
ATTIT2	ATTIT3	3.48E-02	6.69E-01	-5.41E+00
ATTIT3	FLAV	-3.59E-04	-2.03E-02	-5.63E+00
ATTIT1	GM	-3.55E-02	-5.29E-01	-5.73E+00
ATTIT3	LINS	-3.78E-04	-2.18E-02	-6.12E+00
ATTIT1	MINS	2.08E-04	6.05E-03	-6.67E+00
ANTI	MINS	-9.70E-04	-1.15E-01	6.74E+00
ATTIT1	PR	1.04E-04	7.91E-03	-6.91E+00
ATTIT2	MALEGEND	3.85E-03	1.11E-01	-6.99E+00
ATTIT1	ATTIT3	3.49E-02	4.74E-01	-7.10E+00
FLAV	MINS	-1.57E-03	-1.92E-01	7.81E+00
ASC1	MINS	2.37E-03	2.71E-01	7.83E+00
ASC1	ATTIT2	-2.76E-04	-1.31E-02	8.16E+00
ANTI	ATTIT2	-4.10E-04	-2.03E-02	8.34E+00
ATTIT1	MALEGEND	4.16E-03	8.44E-02	-8.41E+00
ATTIT2	ATTIT4	3.45E-02	6.82E-01	-8.44E+00
ASC1	PR	-5.18E-04	-1.54E-01	8.84E+00
ATTIT1	ATTIT4	3.46E-02	4.83E-01	-8.92E+00
ATTIT2	FLAV	-2.40E-04	-1.21E-02	-9.05E+00
ASC1	ATTIT1	-6.65E-04	-2.23E-02	9.20E+00
ANTI	ATTIT1	-9.96E-04	-3.48E-02	9.31E+00
ATTIT2	LINS	-6.26E-04	-3.22E-02	-9.45E+00
ANTI	PR	-5.04E-04	-1.56E-01	9.53E+00
ATTIT1	FLAV	-2.36E-04	-8.45E-03	-9.87E+00
ATTIT1	LINS	-8.72E-04	-3.17E-02	-1.01E+01
FLAV	PR	-2.15E-04	-6.83E-02	1.19E+01
LINS	MINS	3.54E-03	4.38E-01	1.25E+01
LINS	PR	-4.48E-04	-1.44E-01	1.29E+01

* not significant

Table A2. Results from MNL with interactions estimation

Source: BIOGEME Version 0.6 [Sun Feb 9 15:03:33 2003], Michel Bierlaire, EPFL (c) 2001-2003

Date/Time stamp: Fri Jan 23 15:25:06 2004

Model:	Multinomial Logit
Number of estimated parameters:	17
Null log-likelihood:	-2612.5
Init log-likelihood:	-2612.5
Final log-likelihood:	-2070.07
Likelihood ratio test:	1084.86
Rho-square:	0.207629
Final gradient norm:	0.000118449

Utility parameters

Name	Value	Std err	t-test	
ANTI	4.28E-01	1.14E-01	3.76E+00	
ASC1	2.58E-01	1.11E-01	2.33E+00	
ASC2	0.00E+00	fixed		
ATTIT1	-3.06E+00	3.42E-01	-8.93E+00	
ATTIT2	-1.88E+00	2.43E-01	-7.75E+00	
ATTIT3	-8.72E-01	2.16E-01	-4.03E+00	
ATTIT4	-3.58E-01	2.11E-01	-1.69E+00	*
FLAV	3.89E-01	1.02E-01	3.83E+00	
GM	-5.66E-01	4.14E-01	-1.37E+00	*
GMANTI	-3.63E-01	1.89E-01	-1.92E+00	*
GMFLAV	1.35E-01	1.69E-01	7.99E-01	*
GMLINS	8.89E-02	1.85E-01	4.81E-01	*
GMMINS	2.62E-01	2.10E-01	1.25E+00	*
GMPR	2.63E-01	8.45E-02	3.11E+00	
LINS	4.95E-01	1.13E-01	4.39E+00	
MALEGEND	9.99E-04	1.44E-01	6.92E-03	*
MINS	-7.66E-01	1.31E-01	-5.85E+00	
PR	-7.55E-01	5.33E-02	-1.42E+01	

Scale parameters

Name	Value	Std err	t-test 1
Scale1	1.00E+00	fixed	

Correlation of coefficients					
Coefficient1	Coefficient2	Covariance	Correlation	t-test	
GMMINS	GMPR	3.34E-03	1.89E-01	-3.37E-03	*
ASC1	GMMINS	-6.01E-03	-2.59E-01	-1.50E-02	*
ATTIT4	GMANTI	-5.51E-04	-1.38E-02	1.73E-02	*
ASC1	GMPR	3.64E-04	3.89E-02	-3.40E-02	*
MINS	PR	2.59E-04	3.71E-02	-8.26E-02	*
GMFLAV	GMLINS	3.67E-03	1.18E-01	1.96E-01	*
ANTI	FLAV	1.12E-03	9.68E-02	2.64E-01	*
GM	GMANTI	-5.06E-02	-6.47E-01	-3.66E-01	*
GMLINS	MALEGEND	-3.26E-05	-1.22E-03	3.74E-01	*
ATTIT4	GM	-3.25E-02	-3.72E-01	3.93E-01	*
ATTIT3	MINS	1.09E-04	3.84E-03	-4.18E-01	*
GMFLAV	GMMINS	-8.40E-03	-2.37E-01	-4.24E-01	*
ANTI	LINS	7.45E-04	5.80E-02	-4.33E-01	*
GM	MINS	4.10E-03	7.56E-02	4.71E-01	*
GM	PR	7.75E-03	3.51E-01	4.73E-01	*
ATTIT3	PR	1.28E-04	1.11E-02	-5.26E-01	*
ASC1	GMFLAV	-4.61E-03	-2.46E-01	5.49E-01	*
ATTIT3	GM	-3.41E-02	-3.80E-01	-5.71E-01	*
FLAV	GMMINS	2.75E-03	1.29E-01	5.77E-01	*
GMFLAV	MALEGEND	4.28E-04	1.75E-02	6.08E-01	*
GMFLAV	GMPR	-2.76E-03	-1.93E-01	-6.28E-01	*
ASC1	GMLINS	-6.99E-03	-3.42E-01	6.88E-01	*
FLAV	LINS	8.72E-05	7.60E-03	-6.98E-01	*
ANTI	GMMINS	4.27E-04	1.79E-02	7.00E-01	*
GMMINS	LINS	-1.07E-02	-4.53E-01	-8.34E-01	*
GMLINS	GMPR	-4.64E-04	-2.97E-02	-8.45E-01	*
GMLINS	GMMINS	2.02E-02	5.21E-01	-8.91E-01	*
FLAV	GMPR	4.15E-04	4.84E-02	9.83E-01	*
GMMINS	MALEGEND	-2.71E-04	-8.94E-03	1.02E+00	*
FLAV	GMFLAV	-1.00E-02	-5.84E-01	1.05E+00	*
ASC1	FLAV	4.83E-03	4.30E-01	-1.16E+00	*
ANTI	GMPR	7.35E-04	7.65E-02	1.21E+00	*
GM	MALEGEND	-7.71E-03	-1.29E-01	-1.24E+00	*
GM	GMLINS	-1.68E-02	-2.19E-01	-1.34E+00	*
ANTI	GMFLAV	-1.13E-03	-5.87E-02	1.40E+00	*
ASC1	MALEGEND	-8.23E-06	-5.15E-04	1.41E+00	*
FLAV	GMLINS	1.11E-04	5.91E-03	1.43E+00	*
ATTIT4	MALEGEND	2.33E-03	7.64E-02	-1.45E+00	*

GMLINS	LINS	-1.40E-02	-6.71E-01	-1.48E+00	*
GM	GMFLAV	-6.34E-03	-9.05E-02	-1.52E+00	*
ANTI	GMLINS	-8.40E-04	-3.99E-02	1.53E+00	*
GMANTI	MALEGEND	2.08E-04	7.66E-03	-1.54E+00	*
GMPR	MALEGEND	-9.09E-05	-7.44E-03	1.56E+00	*
GMPR	LINS	-9.21E-04	-9.65E-02	-1.58E+00	*
ATTIT4	GMLINS	3.96E-04	1.01E-02	-1.60E+00	*
ANTI	ASC1	7.14E-03	5.67E-01	1.62E+00	*
ATTIT4	MINS	-4.04E-05	-1.46E-03	1.64E+00	*
GM	GMMINS	-1.85E-02	-2.13E-01	-1.65E+00	*
GMANTI	GMLINS	-1.21E-03	-3.47E-02	-1.68E+00	*
GMFLAV	LINS	-2.00E-04	-1.05E-02	-1.76E+00	*
ATTIT3	GMANTI	-7.72E-05	-1.89E-03	-1.77E+00	*
ATTIT4	GMFLAV	-1.22E-03	-3.42E-02	-1.79E+00	*
GM	GMPR	-1.63E-02	-4.66E-01	-1.80E+00	*
ATTIT4	PR	1.35E-04	1.21E-02	1.83E+00	*
GMANTI	MINS	2.96E-03	1.20E-01	1.87E+00	*
GMANTI	PR	4.15E-04	4.13E-02	2.02E+00	
GMANTI	GMFLAV	2.29E-03	7.18E-02	-2.04E+00	
ATTIT4	GMMINS	1.17E-04	2.64E-03	-2.09E+00	
GMANTI	GMMINS	-3.44E-03	-8.71E-02	-2.12E+00	
ASC1	GM	1.98E-02	4.32E-01	2.17E+00	
FLAV	MALEGEND	-7.90E-05	-5.38E-03	2.19E+00	
ASC1	LINS	6.94E-03	5.55E-01	-2.25E+00	
FLAV	GM	5.53E-03	1.31E-01	2.31E+00	
ANTI	MALEGEND	1.60E-05	9.72E-04	2.32E+00	
ATTIT2	GM	-3.48E-02	-3.46E-01	-2.40E+00	
ASC1	GMANTI	-8.48E-03	-4.06E-01	2.44E+00	
ASC1	ATTIT4	-3.74E-05	-1.60E-03	2.58E+00	
ANTI	GM	2.09E-02	4.43E-01	2.63E+00	
GM	LINS	1.15E-02	2.46E-01	-2.64E+00	
ATTIT4	GMPR	-7.12E-04	-3.99E-02	-2.69E+00	
LINS	MALEGEND	-1.06E-05	-6.51E-04	2.69E+00	
ANTI	GMANTI	-1.43E-02	-6.68E-01	2.84E+00	
GMANTI	GMPR	-1.18E-03	-7.43E-02	-2.94E+00	
ATTIT4	FLAV	2.84E-04	1.32E-02	-3.21E+00	
ANTI	ATTIT4	-2.04E-04	-8.48E-03	3.26E+00	
GMLINS	MINS	-7.82E-03	-3.23E-01	3.30E+00	
GMMINS	MINS	-1.76E-02	-6.40E-01	3.31E+00	
ATTIT3	GMLINS	-4.18E-04	-1.04E-02	-3.36E+00	
FLAV	GMANTI	-1.86E-03	-9.71E-02	3.38E+00	

ATTIT3	ATTIT4	3.50E-02	7.66E-01	-3.51E+00
ATTIT3	MALEGEND	3.38E-03	1.08E-01	-3.53E+00
ATTIT4	LINS	-2.24E-04	-9.41E-03	-3.55E+00
ATTIT3	GMFLAV	-1.28E-03	-3.49E-02	-3.61E+00
ATTIT1	ATTIT2	3.55E-02	4.28E-01	-3.62E+00
ATTIT3	GMMINS	-3.62E-05	-7.97E-04	-3.76E+00
GMANTI	LINS	-6.86E-04	-3.22E-02	-3.85E+00
MALEGEND	MINS	-4.78E-06	-2.53E-04	3.94E+00
ATTIT2	MINS	2.17E-04	6.82E-03	-4.06E+00
ATTIT1	GM	-3.32E-02	-2.34E-01	-4.18E+00
GMLINS	PR	7.17E-04	7.28E-02	4.47E+00
ATTIT2	PR	1.54E-04	1.19E-02	-4.55E+00
GMFLAV	MINS	3.43E-03	1.55E-01	4.57E+00
ASC1	ATTIT3	-5.97E-05	-2.49E-03	4.64E+00
GMMINS	PR	-4.99E-04	-4.47E-02	4.65E+00
ATTIT3	GMPR	-3.35E-04	-1.83E-02	-4.85E+00
MALEGEND	PR	1.62E-07	2.11E-05	4.91E+00
ATTIT2	GMANTI	4.64E-04	1.01E-02	-4.97E+00
GMFLAV	PR	9.14E-04	1.02E-01	5.17E+00
ATTIT3	FLAV	8.01E-05	3.64E-03	-5.28E+00
ANTI	ATTIT3	-3.25E-04	-1.32E-02	5.29E+00
ATTIT2	ATTIT3	3.53E-02	6.71E-01	-5.38E+00
ATTIT3	LINS	-2.14E-04	-8.77E-03	-5.58E+00
GMPR	MINS	-1.38E-03	-1.25E-01	6.26E+00
ATTIT1	MINS	2.95E-04	6.59E-03	-6.26E+00
ATTIT2	GMLINS	-1.26E-03	-2.81E-02	-6.37E+00
FLAV	MINS	-2.67E-03	-2.01E-01	6.38E+00
ANTI	MINS	-1.90E-03	-1.28E-01	6.49E+00
ATTIT1	PR	2.71E-04	1.48E-02	-6.66E+00
ATTIT2	GMMINS	2.95E-04	5.80E-03	-6.70E+00
ATTIT2	GMFLAV	-1.36E-03	-3.31E-02	-6.72E+00
ATTIT1	GMANTI	2.26E-06	3.50E-05	-6.89E+00
ATTIT2	MALEGEND	3.81E-03	1.09E-01	-7.01E+00
ASC1	MINS	4.35E-03	3.00E-01	7.12E+00
ATTIT1	ATTIT3	3.54E-02	4.78E-01	-7.15E+00
ASC1	PR	-8.60E-04	-1.46E-01	7.81E+00
GMPR	PR	-3.07E-03	-6.82E-01	8.01E+00
ASC1	ATTIT2	3.29E-05	1.22E-03	8.02E+00
ATTIT1	GMLINS	-7.26E-04	-1.15E-02	-8.05E+00
ATTIT1	GMMINS	-2.56E-04	-3.57E-03	-8.25E+00
ATTIT1	GMFLAV	-1.45E-03	-2.51E-02	-8.28E+00

ATTIT2	GMPR	-2.87E-04	-1.40E-02	-8.31E+00
ATTIT2	ATTIT4	3.50E-02	6.83E-01	-8.33E+00
ATTIT1	MALEGEND	4.09E-03	8.28E-02	-8.49E+00
ANTI	ATTIT2	-3.87E-04	-1.40E-02	8.57E+00
ATTIT2	FLAV	9.11E-05	3.69E-03	-8.64E+00
ATTIT2	LINS	-1.57E-04	-5.73E-03	-8.86E+00
ATTIT1	ATTIT4	3.52E-02	4.87E-01	-8.93E+00
ANTI	PR	-8.48E-04	-1.40E-01	8.94E+00
ASC1	ATTIT1	-1.10E-04	-2.90E-03	9.21E+00
ATTIT1	GMPR	-7.33E-04	-2.54E-02	-9.36E+00
ANTI	ATTIT1	-7.27E-04	-1.87E-02	9.61E+00
ATTIT1	FLAV	2.22E-04	6.39E-03	-9.67E+00
FLAV	PR	-3.28E-04	-6.05E-02	9.73E+00
LINS	PR	-3.15E-04	-5.24E-02	9.82E+00
ATTIT1	LINS	-3.37E-04	-8.74E-03	-9.83E+00
LINS	MINS	7.78E-03	5.26E-01	1.05E+01

* not significant

Table A3. Results from CNL estimation

Sourcce: BIOGEME Version 0.6 [Sun Feb 9 15:03:33 2003], Michel Bierlaire, EPFL (c) 2001-2003

Date/Time stamp: Tue Nov 9 13:20:45 2004

Model:	Cross-Nested Logit
Number of estimated parameters:	22
Null log-likelihood:	-3471.61
Init log-likelihood:	-3471.61
Final log-likelihood:	-2746.45
Likelihood ratio test:	1450.33
Rho-square:	0.208884
Final gradient norm:	30.7018

Utility parameters

Name	Value	Std err	t-test
ANTI	1.56E-01	5.31E-02	2.95E+00
ASC2	-2.14E-01	5.10E-02	-4.19E+00
ASC3	-3.46E-01	1.19E-01	-2.90E+00
ATTIT1	-2.41E+00	4.18E-01	-5.78E+00
ATTIT2	-1.49E+00	2.92E-01	-5.10E+00
ATTIT3	-6.80E-01	1.81E-01	-3.77E+00
ATTIT4	-3.41E-01	1.37E-01	-2.49E+00
FLAV	2.55E-01	5.19E-02	4.91E+00
LINS	3.31E-01	6.87E-02	4.82E+00
MINS	-4.74E-01	8.46E-02	-5.60E+00
PR	-4.37E-01	7.18E-02	-6.08E+00

Model parameters[A]					
Name	Value	Std err	t-test 0	t-test 1	
NESTA	1.00E+00	fixed			
NESTB	2.14E+00	3.08E-01	6.93E+00	3.69E+00	
NESTA_Alt1	1.00E-05	+NaN	+NaN	+NaN	
NESTA_Alt2	+7.5839447e-01	+1.6850958e-01	+4.5006015e+00	-1.4337792e+00	*
NESTA_Alt3	+9.9999997e-06	+2.6529746e-09	+3.7693538e+03	-3.7693162e+08	
NESTA_Alt4	+4.9634033e-01	+2.0175439e-01	+2.4601216e+00	-2.4964000e+00	
NESTA_Alt5	+6.1969431e-01	+2.6085951e-01	+2.3755864e+00	-1.4578946e+00	*
NESTB_Alt1	+9.9999000e-01	-0.0000000e+00	-Infinity	+Infinity	
NESTB_Alt2	+2.4160553e-01	+1.6850958e-01	+1.4337792e+00	-4.5006015e+00	*
NESTB_Alt3	+9.9999000e-01	+2.9488973e-09	+3.3910642e+08	-3.3910980e+03	
NESTB_Alt4	+5.0365967e-01	+2.0175439e-01	+2.4964000e+00	-2.4601216e+00	
NESTB_Alt5	+3.8030570e-01	+2.6085951e-01	+1.4578947e+00	-2.3755864e+00	*

Scale parameters			
Name	Value	Std err	t-test 1
Scale1	+1.0000000e+00	fixed	

Correlation of coefficients					
Coefficient1	Coefficient2	Covariance	Correlation	t-test	
ASC3	ATTIT4	-7.0529396e-03	-4.3284920e-01	-2.5501124e-02	*
MINS	PR	+4.2662601e-03	+7.0201222e-01	-6.0195998e-01	*
ATTIT4	PR	+4.5514213e-03	+4.6322718e-01	+7.9349150e-01	*
ASC3	PR	+3.5470474e-03	+4.1440033e-01	+8.2072406e-01	*
ASC2	ATTIT4	+1.1202647e-03	+1.6046291e-01	+9.1801802e-01	*
ASC3	MINS	+1.7008427e-03	+1.6876445e-01	+9.5477241e-01	*
ATTIT4	MINS	+4.1901342e-03	+3.6219181e-01	+1.0093177e+00	*
FLAV	LINS	+1.5116454e-03	+4.2407180e-01	-1.1540197e+00	*
ASC2	ASC3	+2.4725673e-03	+4.0654462e-01	+1.2150700e+00	*
ATTIT3	MINS	+7.9109705e-03	+5.1774083e-01	-1.3339818e+00	*
ASC3	ATTIT3	-4.3207282e-03	-2.0076840e-01	+1.4199383e+00	*
ANTI	FLAV	+6.2248348e-04	+2.2592318e-01	-1.5071739e+00	*
ATTIT3	PR	+8.6038137e-03	+6.6299451e-01	-1.6974645e+00	*
ANTI	LINS	+1.3335013e-03	+3.6567802e-01	-2.5063151e+00	
ASC2	ATTIT3	+1.9612524e-03	+2.1269606e-01	+2.6374988e+00	
ASC2	MINS	+1.7199835e-04	+3.9831680e-02	+2.6814201e+00	
ASC2	PR	+1.2817631e-03	+3.4950097e-01	+3.0938739e+00	
ATTIT3	ATTIT4	+1.9722556e-02	+7.9835399e-01	-3.1178376e+00	
ANTI	ATTIT4	-1.8174587e-03	-2.5030482e-01	+3.1335516e+00	

ANTI	ASC3	-1.9618958e-03	-3.1016064e-01	+3.4731077e+00
ATTIT1	ATTIT2	+9.5550252e-02	+7.8275133e-01	-3.5264525e+00
ASC3	ATTIT2	+8.0210459e-04	+2.3050741e-02	+3.6520241e+00
ATTIT4	FLAV	-1.4405818e-03	-2.0296755e-01	-3.8216332e+00
ATTIT4	LINS	-3.4715681e-03	-3.6956159e-01	-3.8559073e+00
ANTI	ASC2	-1.5790362e-03	-5.8262668e-01	+3.9965222e+00
ATTIT2	MINS	+1.4368750e-02	+5.8159028e-01	-4.0198450e+00
ANTI	ATTIT3	-3.1317303e-03	-3.2655846e-01	+4.0980771e+00
ASC3	LINS	-3.4495832e-03	-4.2153522e-01	-4.2166248e+00
ASC3	FLAV	-1.7124214e-03	-2.7695259e-01	-4.2168634e+00
ATTIT2	PR	+1.5810206e-02	+7.5348040e-01	-4.3357675e+00
ASC2	ATTIT2	+3.3606476e-03	+2.2540544e-01	+4.4745162e+00
ATTIT3	LINS	-6.5021356e-03	-5.2406976e-01	-4.5093651e+00
ATTIT2	ATTIT3	+4.3490233e-02	+8.2434967e-01	-4.5940977e+00
ATTIT3	FLAV	-2.7131271e-03	-2.8942148e-01	-4.6339247e+00
ASC3	ATTIT1	+4.6126589e-03	+9.2632202e-02	+4.8795052e+00
ATTIT1	MINS	+1.8652449e-02	+5.2758294e-01	-5.1036552e+00
ASC2	LINS	-2.0279308e-03	-5.7837286e-01	-5.1103295e+00
ATTIT2	ATTIT4	+2.7897323e-02	+6.9840979e-01	-5.2290954e+00
ANTI	ATTIT2	-5.3974022e-03	-3.4807823e-01	+5.2309678e+00
ASC2	FLAV	-1.3432095e-03	-5.0702117e-01	-5.2449639e+00
ATTIT1	PR	+2.0669220e-02	+6.8835943e-01	-5.3130266e+00
ASC2	ATTIT1	+4.2454045e-03	+1.9898359e-01	+5.3559617e+00
ATTIT2	LINS	-1.1696717e-02	-5.8305909e-01	-5.4045347e+00
ANTI	MINS	-1.5060751e-03	-3.3535256e-01	+5.5324186e+00
ATTIT1	ATTIT3	+5.5039234e-02	+7.2903583e-01	-5.5601910e+00
ATTIT2	FLAV	-4.7304819e-03	-3.1209118e-01	-5.5853541e+00
ANTI	PR	-1.6235736e-03	-4.2566042e-01	+5.6005840e+00
ATTIT1	ATTIT4	+3.4013776e-02	+5.9505813e-01	-5.8569659e+00
LINS	PR	-3.6430699e-03	-7.3827010e-01	+5.8643457e+00
ANTI	ATTIT1	-6.9671917e-03	-3.1398334e-01	+5.8755357e+00
ATTIT1	LINS	-1.5078849e-02	-5.2525902e-01	-5.9977914e+00
ATTIT1	FLAV	-5.8484449e-03	-2.6963314e-01	-6.1385542e+00
FLAV	MINS	-2.1036413e-03	-4.7919327e-01	+6.1481509e+00
LINS	MINS	-2.2032201e-03	-3.7920091e-01	+6.3119698e+00
FLAV	PR	-1.8052752e-03	-4.8419324e-01	+6.4616200e+00

User defined linear constraints
1*NESTA_Alt1 + 1*NESTB_Alt1 = 1 [1 = 1]
1*NESTA_Alt2 + 1*NESTB_Alt2 = 1 [1 = 1]
1*NESTA_Alt3 + 1*NESTB_Alt3 = 1 [1 = 1]
1*NESTA_Alt4 + 1*NESTB_Alt4 = 1 [1 = 1]
1*NESTA_Alt5 + 1*NESTB_Alt5 = 1 [1 = 1]

* not significant

[A] Alt1 is the status quo (Apple A), Alt2 is a non-GM Apple B, Alt3 is a non-GM Apple C, Alt4 is a GM Apple B, and Alt5 is a GM Apple C.