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Consumer Acceptance, Choice and Attitudes towards Genetically Modified (GM) Food

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Introduction

1.1 Introduction

New technologies influence people's decision making patterns and those of societal institutions (e.g., cooking, socialising patterns, etc). Changes arise through new processes and novel products, often improving some lifestyle dimensions but also making some others worse. In many cases, costs are uncertain in the form of a probability of a threat, normally referred as risks. This is because new technologies are associated with scientific uncertainty given that not all the social and individual consequences of their inception are fully known. Moreover, innovations also have an impact on people's social life, generating conflicts with their own previous views and values. This is especially relevant in the case of food and nutrition where people are confronted with daily decisions on how best to feed themselves. Whether the price or other characteristics of foods balance out its benefits in nutrition, identity and/or taste is a broad question to carefully research.

The introduction of new technologies in the food industries have revolutionized the efficiency of food production, but has also exerted important demand side effects that cannot be dismissed. On the contrary, in order to determine the limits of technology dissemination and transfer, it becomes a priority to examine and disentangle which factors stand behind technology acceptance. This thesis will examine these effects looking at food choice, attitude formation and consumer acceptance. The empirical analysis will circumscribe one of the clearest examples of technology innovation in food and nutrition in the last decade, namely genetic modified food (GMF). Following the Food Standards Agency, GM food involves "altering a plant, animal or micro-organism's genes or inserting one from another organism"[1].

A consumer's perspective on the introduction of new GM products (which add to pre-existing products) depends largely on the existing information in the system. Therefore, the release of more information related to risks associated with food shapes peoples' risk perceptions. Consequently, people act upon carefully perceived risks in balancing out the benefits and costs, both in the short run but especially in the long run. Given that long run hazards are not known with certainty, we will typically refer to those effects as risks, given that there is some information for individuals to

[1] http://www.food.gov.uk/gmfoods/

qualitatively form an expectation or a probability of hazard. The same can be applied to benefits, which largely influence product acceptance that is based on individual subjective knowledge. Moreover, the specific influence of product characteristics (e.g., organic or not), individual attributes (e.g., gender, age and so forth), attitudes towards science and perception of risks associated with food are elements that also deserves careful examination when determining product acceptance, and consequently motivate the research undertaken in this thesis.

In this chapter we aim at unfolding the origins of the economic and food policy problem of introducing GM food in European member states, and more particularly in Spain and Southern Europe. We begin in section two by describing what GM food implies for food production, followed by how European regulation has proceed with existing risks and benefits. Then, the chapter moves on to demand side issues looking at consumer reactions to GM food. Finally, in the fourth section, the thesis objectives and research hypotheses are unveiled. The chapter also deals with data sources and presents a basic sketch of how the thesis is structured.

1.2 Genetically Modified (GM) agro-food production as a case study

1.2.1 Genetically Modified food production and size

Genetically Modified (GM) technology applied to the agro-food production represents a small part of modern biotechnology (Moschini, 2008) and began its development in United States of America and the Republic of China during the end of last century (James, 1997 and Muñoz, 2001). During the last 1990's and the beginning of this century, this technology has been disseminated worldwide. The global area devoted to GM crops has increased from 2.8 million hectares, in 1996, to 114.3 million hectares in 2007 (James, 2007 and 1997) (Table 1.1). In the same way, the number of countries involved in this technological revolution has increased from 6, in 1996 – USA, China, Canada, Argentina, Australia and Mexico- to 23. Indeed, about 43% of the worldwide biotech crop area is located in developing countries, even though, the world's major producer of GM crops is currently the EEUU with about 50% of the global biotech area. Moreover, about 80% of the biotech global area in 2007 is concentrated within 3 countries: EEUU, Brazil and Argentina. Additionally, the area devoted to maize has increased compared to soybeans and cotton due to the emergent ethanol market (James, 2007).

Table 1.1 Worldwide GM crop area harvested from 1996 to 2007 by countries (Million hectares)

Country	Area (million hectares)			GM Crops
	1996	2005	2007	
USA	1.5	49.8	57.7	Soybean, maize, cotton, canola, squash, papaya, alfalfa.
Argentina	0.1	17.1	19.1	Soybean, maize, cotton.
Brazil	--	9.4	15.0	Soybean, cotton.
Canada	0.1	5.8	7.0	Canola, maize, soybean.
India	--	1.3	6.2	Cotton.
China	1.1	3.3	3.8	Cotton, tomato, poplar, petunia, papaya sweet pepper.
Paraguay	--	1.8	2.6	Soybean.
South Africa	--	0.5	1.8	Soybean, maize, cotton.
Uruguay	--	0.3	0.5	Soybean, maize.
Philippines	--	0.1	0.3	Maize.
Australia	<0.1	0.3	0.1	Cotton.
Mexico	<0.1	0.1	0.1	Cotton, soybean.
Sapain	--	0.1	0.1	Maize.
Romania	--	0.1	<0.1	Soybean.
Colombia	--	<0.1	<0.1	Cotton, carnation.
Iran	--	<0.1	--	Rice.
Chile	--	---	<0.1	Maize, soybean, canola
Honduras	--	<0.1	<0.1	Maize.
Portugal	--	<0.1	<0.1	Maize.
Germany	--	<0.1	<0.1	Maize.
France	--	<0.1	<0.1	Maize.
Czech Republic	--	<0.1	<0.1	Maize.
Slovakia	--	--	<0.1	Maize.
Poland	--	--	<0.1	Maize.
World	2.8	90	114.3	

Source: JAMES (1996, 2005 and 2007)

Although Europe has some representation in the agro-biotech field, it does not stand as a major producer of biotech crops. However, it must be highlighted that Portugal and France restarted their biotech cultivation in 2005, following a 5 year moratorium. In addition, the Czech Republic started its GM crop cultivation within the same year (James, 2005). Contrary to other world areas, EU grows only GM maize (MON810) with Spain being the largest producer (Moschini, 2008). Within Spain, GM maize cultivated area is basically concentrated in Aragón, Castilla la Mancha and Catalonia and stands up to about 70,000 hectares, in 2007 (James, 2007).

The reason to explain the low impact of GM crops in Europe has to do with its restrictive regulation which can also have an impact on the future potential of biotechnology in Europe (Moschini, 2008). Recent developments in the agro-biotech field involves policy-makers, other stakeholders and society as a whole in decisions on the safety and marketing regulations of new products. However, incomplete expert knowledge and/or a reluctant and uninformed public, creates some degree of unavoidable scientific uncertainty.

1.2.2 An overview of the existing risk regulation of GM food in Europe

Policy-making in the agro-biotech field is a paradigmatic area in which substantial uncertainty constrains new technology developments. Indeed, when risks are unknown, risk regulation becomes complex and risk analysts often search for simple rules to guide decision-making. One of those rules is that of "*erring on the side of caution"* or "*absence of risk is not the same as risk of absence*" (ERSC, 1999). This rule has been purported to guide the regulation of new technologies and, to date, has been the cornerstone for health and environment policy developments in the European Union (EU). Given the inevitable existence of uncertainty with regard to the possible risks of new technologies, a common conservative criterion for risk decision-making is the simple rule of "caution first, science second", sometimes expressed as "better being safe than sorry". The legal jargon has named these criteria the "precautionary principle (PP)".

The PP is based on what could be classified "technology risk aversion", often supported by conservationists, although the link is not direct insofar as it is based on a conservative view of society and nature, grounded on the notion of irreversibility. The stated objectives for conservationism were, as outlined in Jarvis (2000): (1) essential ecological processes and life support systems must be maintained; (2) genetic diversity must be preserved; and (3) any use of species or ecosystems must be sustainable. However, the application of single precautionary rules is regarded as troublesome as it implies a delay in technology diffusion, and when taken too far – so that societies avoid all risks, the zero-risk scenario- no technology can be proven to be "absolutely safe", and thus little or no innovation takes place. Though, even when some sort of formal risk assessment is undertaken, regulatory controversies remain as decision-makers need to tackle the normative question of "how safe is safe enough".

The European Commission communication of 2 February 2000 on the understanding of the principle the EU has clarified the issues somewhat, although some ambiguity prevails[2]. In particular, it was established that the PP "*can under no circumstances be used to justify the adoption of arbitrary decisions… [it] is no excuse for derogating from the general principles of risk management*"[3]. When the scientific evidence is insufficient, a country may adopt provisional measures on the basis of the pertinent available information. Therefore, the Commission recognises the need for a risk-benefit analysis to ground decision-making. However, to be complete and to fully include society's perceptions, it should involve the public and establish what determines acceptance. Indeed, the aforementioned European Council Resolution establishes in resolution B that:

…*Public authorities have a responsibility to ensure a high level of protection of human health and the environment and have to address increased public concern regarding the risks to which the public are potentially exposed.*

In light of the PP, the European Commission (EC) approved in the early 1990s the first main legislation on the deliberate release into the environment of genetically modified organisms, with the Directive 90/220/EC.

This regulation press the EU member states to regulate the GMOs release and to create organizations for the valuation and assessment of the risks derived from GMOs and also for the inspection of activities regarding to GMOs (Sáinz-Cantero, 2004). This directive also determines the process of notification and authorisation of new GM products. Moreover, it establishes the possibility for the EC to remove authorization to any product in the case of a detection of risks associated with it after the date of authorisation and notification.

Later on, the EC approved the Regulation 258/97 on the placing on the market of GMOs intended for food purposes. This regulation determines the necessary evaluation of novel food before placing them into the market with a consequent authorisation and

[2] Council resolution on the precautionary principle presidency conclusions, Nice European Council meeting 7, 8 and 9 December 2000.
[3] *Ibid.*

labelling requirements. This regulation allowed the authorisation of some products derived from GMOs by the fact to be substantially equivalent to another product which had already been authorized.

In 2002, the Directive 90/220/EC was repealed by Directive 2001/18/EC, which can be considered the current reference European framework for the regulation of GMOs. This directive emphasizes the application of preventive actions, public consultation prior to the acceptance of new GMOs, and transparency in the decision process. Moreover, Directive 2001/18/EC, not only asks for a prior evaluation of the possible risks associated with the use of GMOs, but also for the cumulative and indirect effects derived from this use. This ongoing evaluation leads to an important point related to the assessment of GMOs, its traceability.

In 2003, Regulation 258/97 was replaced by Regulation 1829/2003 on genetically modified (GM) food and feed. This regulation stipulates the conditions for imports, cultivation, and the use of GMOs in food and feed products. Specifically, this regulation sets down the procedures for the authorisation and supervision of GM food and feed and also lays down provisions for its labelling. The rules for the implementation of Regulation 1829/2003 were defined by the Commission Regulation 614/2004 regarding the application for the authorisation of new genetically modified food and feed, the notification of existing products and the adventitious or technically unavoidable presence of genetically modified material which has benefited from a favourable risk evaluation. Hence, the self-imposed moratorium on importing GM food within Europe was lifted in April 2004, alongside new labelling. Indeed, a parallel European regulation regarding GMOs is the one related with the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms, which is Regulation 1830/2003.

It is also relevant to refer to the Commission Regulation 65/2004 that establishes a system for the development and assignment of unique identifiers for genetically modified organisms. In addition, there are three important regulations related with the environmental implications of the release on the environment of GMOs. These are, Decision 2002/623/EC – on environmental risk assessment- Recommendation of the

Commission 2003/556/EC – on the coexistence of genetically modified crops with traditional and organic farming- and, finally, Decision 2003/710/EC – on the model for presentation of the results regarding the liberation into the environment of superior plants with genetic modifications. However, the main concern of this last regulation is to address economic and market implication instead of safety concerns (Moschini, 2008)[4].

1.3 Consumers and GM food: some starting points

Some studies, such as Falck-Zepeda et al. (2000), Moschini et al. (2000), Alston et al. (2002), Bennett et al. (2004) and Brookes and Barfoot (2006), among others, have evaluated some positive effects associated with GM agro-food applications, namely economic effects, environmental impact from changes in the use of insecticides and herbicides and the contribution towards reducing greenhouse gas (GHG) emissions. Most of these studies are focused on economic first generation benefits and especially on analysing the distribution of welfare from the introduction of GM crops. They conclude that although consumers receive some benefits, the majority accounts for farmers and multinational corporations. This conclusion can partially explain the existing vigorous public opposition towards GM crops, especially in the EU, in spite of the budding scientific consensus[5] about the no inherent risk for human health and environment of GM technology (Moschini, 2008).

Certainly, worldwide attitudes towards GM agro-food products have been widely analysed -as chapter 2 will deeply report- by means of either stated preferences (surveys and choice experiments) or experimental markets (auctions) among other methods. It can be said that a generalised feeling of dislike towards GM food exists. However, respondents can be classified by three main groups regarding both their attitudes and final intentions towards GM food products. Regarding attitudes, there is a first group that reveals a clear opposition to GM products. A second important group

[4] Finally, it is important to highlight that many GM traits that are currently commercialised in US and other countries are not approved by ht EU regulation with the consequent associated trade problems and WTO debates (Moschini G.C., 2008).

[5] From institutions such as the International Council for Science or the *Codex Alimentarious* Comission on food safety.

does not have a defined opinion about these products and, finally, some can be considered GM food supporters (Gaskell et al., 2006; O'Connor et al., 2006 and Onyango et al., 2004, among others). regarding intentions, several respondents are not prepared to choose GM agro-food products at any price, while a second group would require some price discount to purchase GM products and, finally, a third group places a premium to GM agro-food products with direct consumers' benefits (Burton and Pearse, 2002; James and Burton, 2003; and Rigby and Burton, 2006; among others).

This general classification does have some cross-country differences. Although a global non-GM preference exists, US consumers were revealed to be more optimistic about possible benefits of GM food and feed (Hossain et al., 2002 and 2003; Onyango et al., 2003; Onyango et al., 2004b and Lusk et al., 2002). Moreover, European consumers are willing to pay higher premium for non-GM foods compared to North American consumers (Lusk et al., 2005; Jaeger et al., 2004; and Moon and Balasubramanian, 2003a). In addition, within Europe, consumers from countries such as Spain and Portugal, reveal a more positive attitude towards GM food than Nordic populations or Germans among others (Gaskell et al., 2003 and 2006).

As Moschini (2008) argued, based on Gaskell et al. (2006), general public opposition or reticence towards GM agro-food applications responds to: i) human health and environmental concerns, ii) ethical considerations and iii) the role of patents and property rights of multinational corporations. This variety of reasons against GM agro-food production reveals a complex formation process of public opinion towards GM agro-food production and therefore a complex process for understanding consumers' final decision and intentions regarding GM food.

Fortunately, consumer behaviour towards GM agro-food production has many analogies with other behaviours analysed in the past. This is the case of other risky technologies such as pesticide risk exposure, hormone-treated meat, atomic energy and so forth. Then, similar consumer behaviour models can be used to better understand consumer decision-making process regarding GM food. For instance previous studies based on the Fishbein Multi-attribute Model (Fishbein, 1963) revealed that an attitude or intention towards a product or behaviour is based on knowledge about the product or behaviour itself (Bredahl, 1998); that is, on the attributes that people associate to the product or behaviour (Frewer et al., 1998). Following this theory, we have considered that the best way to study consumers' final intentions towards agro-food products entail the application of choice experiments- see chapter 3. Within the choice experiment framework individuals are allowed to select among different alternative options, where each option is characterised by a number of attributes with different levels (Burton et al., 2001). Therefore individuals will choose an alternative, among a set of alternatives that generates to them the highest utility.

In this thesis, we go one step further as we aim to understand the full behavioural process that ends with the final intention towards purchasing GM agro-food products. To this end and based on previous studies (Chen and Li, 2007; and Lobb et al., 2007; among others) the Theory of Planed Behaviour (TPB) (Ajzen, 1991) has been employed. This theory states that an intention towards a behaviour is a function of different behavioural elements, such as: i) personal attitude towards the behaviour; ii) personal perception of social pressure; and iii) individual perceived behavioural control of the corresponding intention (Ajzen, 2005). Special attention is paid to the last element of this theory. Perceived behavioural control is a complex factor which depends on the beliefs about the presence or absence of factors that help or obstruct the execution of behaviour (Ajzen, 2005); that is, perceived risks and benefits associated with the behaviour, which have been stated to explain consumers' attitudes towards GM food (Moon and Balasubramanian, 2001 and 2004; Grunert et al., 2003; Onyango, 2004; and Hossain and Onyango, 2004).

Consumers' perceptions of risks and benefits vary depending on the type of risk, level of understanding and availability of information about the risk (Slovic et al., 2004). Moreover, individual general values can also become key determinants that shape consumer attitudes towards biotechnology (Onyango et al., 2003; Lahteenmaki et al., 2002; and Bredahl, 2001). The implementation of these theoretical causality relations has been performed by means of structural equations models (chapters 3 to 5) trying to partially support with each model the TPB. A further step of this study will be to define a more complete model with all the behavioural parameters of the TPB in a single complex model for explaining the GM agro-food behaviour.

Both in the analysis of final consumer intentions or when defining the full decision making process for GM agro-food behaviour, it is important to consider consumer heterogeneity regarding to age, gender, income level, risk aversion and so on. Indeed, different conclusion regarding the influence of these parameters has been reached by different authors (see chapters 1-5).

1.4 Objectives, research questions and hypotheses.

The extensive controversy over GMOs and the need for a better understanding of consumer reactions to GM food have become imperative to the different stakeholders involved. This includes consumers as key agents in the process of technology transfer as well as citizens that could affect the regulation of GM food in Europe. Hence, this PhD dissertation attempts to explore the consumer behavioural processes determining acceptance of GM food in the context of Europe and, more particularly, in Spain. It has been partly motivated by the lack of comprehensive evidence on explaining cross-country heterogeneity, and by the demand for a more detailed examination of the determinants of consumers' attitudes and acceptance of GM agro-food products.

The main objective of this research is to examine the behavioural processes that explain choice, acceptance and attitudes towards GM food. We draw upon an interdisciplinary approach so as to benefit from the findings from several research disciplines to answer a set of questions that this broad debate raises. In fact, this thesis contributes to the current literature on GM food behaviour with the definition of a complete theoretical decision-making picture that explains the process that leads consumers to purchase GM food, as well as indirectly understand the current European market regulation and process of technology change in the food sector. In addition, an empirical assessment is performed for the case in Spain and compared with those of other European countries. A key empirical result of our study refers to the effect of risk and benefit perceptions on attitudes and intentions. Moreover, this dissertation also looks at the current willingness to pay for GM and organic food for Spanish consumers, which has not yet been empirically tested. In the light of the theoretical decision-making picture, this PhD dissertation has a set of hypothesis to be examined in some detail in different chapters.

Most studies using the stated preferences methodology (Lusk et al., 2005; Moon and Balasubramanian, 2003b; Onyango and Govindasamy, 2004 and Chern et al., 2002) have found evidence that consumers were willing to pay a premium for non-GM food. Moreover, others also found some willingness to pay if health effects were associated with GM products (Burton and Pearse, 2002 and James and Burton, 2003). In fact, Loureiro and Bugbee (2005) find that willingness to pay for GM is directly related to immediate benefits, such as 'enhanced flavour', 'nutritional value' and 'pesticide reduction'. Therefore, we hypothesised the following:

H1: Spanish consumers obtain more utility with conventional products, relative to GM foods. Moreover, Spanish consumers place a negative value (WTP) on GM food.

In addition, an important feature that has been dismissed in the literature lies with product characteristics: whether fresh GM food would be valued differently than processed GM food. Accordingly, we hypothesised the following:

H2: Valuation differences exist among the type of GM food analysed, that is, processed or fresh food.

In the process that leads towards intentions, acceptance becomes an essential issue. Moreover, the Theory of Planned Behaviour (TPB) states that a person's intention to perform, or not, a behaviour is the most important immediate determinant of an action (Ajzen, 2005*)*. Hence, we hypothesise the following:

H3: Attitudes towards GM food are directly related to intentions toward GM food, although final actions are influenced by other elements, such as price, which can modify intentions

Departing from Eurobarometer results (Gaskell et al., 2003; Gaskell et al., 2004; Gaskell et al., 2006) and from previous studies (Grunert et al., 2003; Bredahl, 2001), it is assumed that some opposition to the introduction of GM food by the European public exists. However, little evidence has explored whether behavioural mechanisms that lead to consumer acceptance are country-specific. Merely, some cross country differences are observed, especially for the cases of GM-free and producer countries. Therefore, it would be interesting to deeply analyse the Spanish case due to its leader position in GM production within Europe. Accordingly we hypothesised the following:

H4: Spanish consumers' reveal a negative attitude towards GM food.
H5: Attitudes and behavioural processes leading to GM food acceptance are heterogeneous and country specific, especially among GM producer and GM free countries.

Currently, Spanish GM production is all devoted to first generation GM food. This has resulted in farm income benefits from 1996 to 2005 of about 28 million US $ and a reduction in environmental impacts from changes in pesticide use associated with GM crop adoption of about 30% of the Environmental Impact Quotient (EIQ[6]) during the same period (Brookes and Barfoot, 2006). However, indirect consumer benefits are also quantified. Indeed, consumers' decision making strategy, especially for "undecided" ones, consists on the research of all the possible costs and benefits weighted by their probabilities (Gaskell et al., 2004). Therefore, if no direct benefits and some risks are associated with the product under analysis, the individual learning process regarding this product will bias toward risks. Moreover, a negative correlation among risks and benefits has been reported and are of major importance regarding benefits among risks when performing food decisions (Traill et al., 2006). Thus, we hypothesise that:

H6: Perception of risks and benefits has an important influence on consumers' attitudes and, as a result, on intentions towards GM food.
H7: Spanish citizens perceive more risk than benefits associated to GM food.
H8: Spanish respondents place a major value on health benefits associated to GM food than in environmental contamination reduction.

One important bias to examine, which comes out in several technology risk assessments, is the difference between expert and consumer points of view. Moreover,

[6] "The EIQ distils the various environmental and health impacts of individual pesticides in different GM and conventional production systems into a single 'field value per hectare' and draws on all of the key toxicity and environmental exposure data related to individual products" (Brookes and Barfoot, 2006).

ambiguity might lead individuals to develop the perception that technology is not under their control, thus leading to a social amplification of risk (ambiguity-adverse) (Costa-Font and Mossialos, 2007). Accordingly, we hypothesise that:

H9: Expert risk assessment of GMOs is an incomplete tool and deviates from consumers' perceptions regarding to GM food.

Risk and benefit perceptions, and therefore GM food acceptance, are determined by what is known as "subjective knowledge" of the technology (Lusk et a.l, 2004), even thought, little is known about the effects of knowledge. In addition, consumers' knowledge on GM food mainly depends on their trust on information received, which is directly associated with the sources from which information is transmitted (Siegrist et al., 2000; Koivisto Hursti and Magnusson, 2003; Huffman et al., 2004). New developments in perception of food technology products assume that trust in some information sources is an essential determinant of consumer acceptance; hence we hypothesise that:

H10: The level of subjective knowledge is a key factor in building individual perceptions and is related to individual general values.
H11: Trust on government and science is related to the consumer acceptance regarding to GM food.

Furthermore, besides knowledge, individuals' values or general attitudes, such as attitudes towards science and nature, are expected to act as boundaries of consumer GM food risks and benefit perceptions (Brendahl, 2001), following the theory of planned behaviour (Azjen, 1991). It is in this case when consumers reveal a clear 'Pessimistic' and 'Optimistic' position and consequently develop what is known as a lexicographic process, where a product attribute (risk or no-risk) dominates the decision (Gaskell et al., 2004), hence:

H12: Meta-Attitudes such as science in general and the environment have some impact on consumer perception of risks and benefits associated to GM food.

A further consideration regarding the previous hypothesis is about the relation between GM food and organic food perception. Some previous studies, such as Dreezens et al. (2005), Saher et al. (2006) and Burton et al. (2001), stated that a negative relation among this two food valuations exist, since consumers relate these products to contrasting values. Therefore, we hypothesised the following:

H13: Consumers that reveal a positive attitude towards organic production are expected to reveal a negative attitude associated to GMF.

Finally, in examining the role of decision making towards GM food, the role of socio-economic background is often dismissed and the influence of individual experiences and gender appears to be particularly relevant. Moreover, previous research does not reveal a homogeneous conclusion on this matter. Hence the last hypothesis comes out as a key question to explore, namely:

H14: Socio-economic and demographic variables can have some degree of influence in the definition of a behaviour regarding to products derived from food related innovations such as GM food.

In order to answer all these questions, this thesis is structured into five chapters as follows. First, we examine previous literature on the acceptance of GM food to clarify the state of research in this area. This review would allow us to specify the theoretical model to explain the whole consumer's decision-making process regarding GM food. The model will be validated and tested through the rest of the thesis (chapter 2). This chapter concludes with some policy recommendations.

Chapter 3 focuses, by means of a choice experiment, in the last stage of the consumer decision process: the intention to purchase GM food. In fact, chapter 3 explores whether (Spanish) consumers are willing to accept GM food products, and whether they are willing–to-pay a premium for non-GM food. Moreover, we analyse whether any relationship can be drawn between consumers' behaviour towards GM and organic food as suggested in previous studies. To tackle these issues, we use data coming from an ad hoc survey carried out in 2007.

Finally, the main core of this dissertation is aimed at examining what gives rise to the final choice (chapters 4 to 6). The methodological approach followed in all cases is based on structural equation models, although in each case, different databases have been used to account for the information needed to test specific hypotheses[7]. Choice can be conceptualised as the outcome of a behavioural process which is affected by a well known sequence of factors including trust with information sources, especially given the complexity of technology related questions (Earle and Cvetkivich, 1995), individuals' knowledge and information on risks and benefits along with broad and risk specific attitudes. Indeed, the formation of consumers' behaviour towards GM food might well be different depending on the contextual and institutional determinants; hence differences between GM friendly and GM-free areas should be translated in to attitudes and acceptance. In this dissertation, we examine the extent to which consumers trust available information sources regarding safety and public health effects of consuming GM foods, the role of benefit/risk perception as well as the influence of individual values or wider attitudes, such as attitudes towards science or nature that shape this benefit/risk perception. Finally, given that market research studies focus on the examination of relevant attributes influencing individuals' product acceptance, we specifically focus on some attributes which appear to be most influential in directing consumer behaviour.

Chapter 4, using the same survey as chapter 3 focuses on the influence of risk perception (*perceived behavioural control*) and risk attitudes (*individual attribute*) on the final consumer intentions towards GM agro-food products. Moreover, this chapter also analyses the relation between perceptions towards GM and organic food production. Chapter 5 draws upon survey evidence from Spain (Centro de Investigaciones Sociologicas (CIS) 2001), to evaluate the causal relationship between attitudes toward science and environment and attitudes toward GM food as a specific science application. This study also focuses on exploring the heterogeneity regarding age, gender, region and attitudes towards GMF. Chapter 6, by using Eurobarometer 58 data (2002) tests a more complete picture of public attitudes towards GM food. It hypotheses that attitudes towards GM food are the result of a reasoning mechanism that departs from either trust in institutions or general attitudes towards science and

[7] Since the same methodology has been used for the three chapters a repetition on methodology description in each chapter will be unavoidable.

technology. Both define consumer benefits and risk perceptions, which ultimately affect final purchasing decisions. Eurobarometer studies indicate that the majority of European countries do not support GM food, although there is considerable variation among countries. In this thesis we will validate the performance of the theoretical model by making a cross-country comparison among Mediterranean countries. Finally, some conclusions are drawn in chapter 7 which summarizes the main findings of each chapter and puts them into context of the main discussion questions examined in this thesis. The relation between tested hypotheses and chapters are shown in Table 1.2.

Table 1.2 Relation among chapters and hypothesis of analysis.

Dissertation chapters	**Hypothesis tested**
Chapter 2	Specification of the decision-making theoretical model.
Chapter 3	H1, H2, H3, H8, H13, H14.
Chapter 4	H6, H9, H12, H13, H14.
Chapter 5	H10, H12, H14.
Chapter 6	H3, H4, H5, H6, H7, H11, H12, H14.
Chapter 7	Concluding remarks.

1.5 Data sources

As mentioned above, three databases were selected for developing this dissertation (see Table 1.3). First, the data used in chapters 3 and 4 were obtained from the implementation of an ad hoc survey administered during spring 2007. A total of 314 personal interviews were performed and distributed among 6 regions in almost equal percentages –Galicia, Murcia, Andalusia, Madrid, Extremadura and Catalonia. The sample age distribution was almost equal among predefined age groups starting at 18 years old and up to +65. Moreover, 80% of respondents are within the medium income level and 15% declare themselves to be high household income earners. The remaining 5% is allocated to the lowest income category. There is a clear majority of females among Spanish respondents (about 80%), as the focus was on those responsible for shopping within the household. As for education level, more than 60% of the Spanish respondents continued studies after 16 years old. However, only about 25% of respondents achieved higher education. About 5% do not respond this question. Finally, around 60% of the respondents do not have children in school or pre school age. Moreover, 18% have only one child, from where 36% are pre-school age and 44% are school age. The remaining 10% have two or more children, 18% of which are pre-school age.

The second sample examined was a public survey developed by the Centro de Investigaciones Sociológicas (CIS) in 2001 for Spain as a whole. The survey contains information from 2492 respondents. The sample is made approximately by 48% of males and 52% women. Ages go from 18 to 96 with nearly a uniform distribution. More than 90% of respondents have gone to school. From these, 6% do not end primary school; 25% finish primary School; 22% finish “EGB”; 27% finish “secondary education”; 18% are “graduates”; and finally, 1% have postgraduate studies and 1% other studies. Almost half of the respondents are responsible for household income. Moreover, half are working, almost 20% are pensioners, 20% do not work, around 5% are unemployed and another 5% are students.

Finally, the last sample employed is obtained from the Eurobarometer survey 58 (2002). It contains a representative sample from different European countries and is publicly accessible. We have empirically examined the information for the sub samples of the Spanish, Italian and Greek populations. The initial number for the sub samples was 1000, for Spain; 992, for Italy; and 1001, for Greece. However, missing values due to non responses required the application of “list wise deletion” in order to obtain a complete database to be analysed. Finally the sample used for the analysis was of 502 respondents, for Spain; 454, for Italy; and 490, for Greece. The three databases are made up of 50% respondents of each gender. Age distribution is representative of the whole population in each country. About 20% of the respondents are between 15-25 years old, 30 %, between 26-44, 30%, between 45-64 and, finally, the 20% of individuals are older than 65 years old.

Table1.3 Descriptive information for the samples.

Samples	Own survey (2007)	CIS (2001)	Eurobarometer 58 (2002)		
Country	Spain (314)	Spain (2492)	Spain (502)	Greece (490)	Italy(454)
Intent population	Household Shopping responsible	Country Representative (50% responsible of household income)	Country Representative (about 50% responsible of household income)	Country Representative	Country Representative
Gender	Male 20% Female 80%	Male 48% Female 52%	Male 50% Female 50%	Male 50% Female 50%	Male 50% Female 50%
Age (years)	18 to +65 proportional distribution	18 to 91 proportional distribution	15 to +65 proportional distribution	15 to +65 proportional distribution	15 to +65 proportional distribution
Education	Primary School 60% Higher education 25% No answer 5%	Primary School or less 31% Secondary education or EGB 49% Graduate or more 19%	Up to 16 38% 16-19 29% 20+ 20% Still stud. 13%	Up to 16 41% 16-19 24% 20+ 24% Still studding 11%	Up to 16 31% 16-19 32% 20+ 23% Still studding 14%
Employment Status	No data	Working 50% Pensioners 20% Unemployed or not working 25% Students 5%	Self employed 9% Employed 37% Not work. 54%	Self employed 17% Employed 26% Not working 57%	Self employed 12% Employed 33% Not working 55%

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Chapter 2:

Consumer acceptance, valuation of and attitudes towards Genetically Modified (GM) food: review and implications for food policy.

2.1 Abstract

An increasing set of evidence has been reported on how consumers could potentially react to the introduction of genetically modified food. Studies typically contain some empirical evidence and some theoretical explanations of the data, however to date limited effort has been posed on systematically reviewing the existing evidence and its implications for policy. This paper contributes to the literature by bringing together the published evidence on the behavioural frameworks and evidence on the process leading to the public acceptance of Genetically Modified (GM) food and organisms (GMOs). In doing so, we employ a set of clearly defined search tools and a limited number of comprehensive key words. The study attempts to gather an understanding of the published findings on the determinants of the valuation of GM food - both in terms of willingness to accept and the willing–to-pay a premium for non-GM food-, trust with information sources on the safety and public health and ultimate attitudes underpinning such evidence. Furthermore, in the light of such evidence, we formulate some policy strategies to deal with public uncertainly regarding to GMOs and, especially GM food.

2.2 Introduction

The development of genetically modified (GM) food has been a matter of considerable interest and worldwide public controversy. As a result, 'uncertainties', 'risks' and 'benefits' concerning these new technologies have been widely disseminated to the food industry and consumers. However, there is limited understanding of the "demand side effects" of these 'potential food industry innovations'. Among demand influences, preference, valuation along with underpinning attitudes - leading toward potential (un)acceptance - have received attention in the literature. However, the fact that many GM foods are typically products that are consumed daily (e.g., GM milk, tomato, etc) increase its complexity. Firstly, the valuation of a new good implies the provision of information from several sources - public and private, formal and informal, etc – while conditioning on the credibility and trustworthiness of each relevant information source. Given the information available, a further issue concerns attitude expression and formation, which ultimately leads to the final question regarding product valuation and consumer preference.

The subject of GM food has been of particular interest given the number and variety of issues at stake. Indeed, the European Union maintained a long "de facto" moratorium against the importation of GM food that ended in 2005. The rationale for the moratorium was largely based on regards for health and environmental concerns as well as the underlying protection of European agriculture. While new transformation events of maize and other crops are being authorised in Europe, the debate still remains as to whether individuals and their surrounding cultural society value these GM food products; whether they perceive any risks and/or benefits for their health and the environment; and, of course, whether the development of biotechnology in food products will remain a controversial subject. Even though there is a growing body of literature concerning consumers' acceptance of GM food, little attention has so far been devoted to examining and evaluating the findings from these different studies in order to make recommendations for policy reform regarding the introduction of GM foods.

In this context, the present study is the first attempt to provide an overall picture of the consumer decision process in relation to GM food. In a sense, we update and upgrade the work by Bredahl et al (1998), which merely addresses the issues of consumer attitudes and purchase intention. Moreover, the paper provides a complementary view to the meta-analysis carried out by Lusk et al. (2005a), which on the other hand, only focuses on the empirical literature aimed to elicit the Willingness-to-pay premium for a non-GM food, or the willingness- to-accept a compensation for a GM food product.

This paper attempts to bring together the published evidence from several studies, typically from a variety of research disciplines, but all dealing with the issue of ultimate public acceptance of GM food and its underlying behavioural processes. Specifically, this review aims to respond to some well determined questions, namely whether and under which circumstances are consumers willing to accept GM food; whether they are willing–to-pay a premium for non-GM food; and the extent to which they trust the available information regarding the possible safety and public health effects of consuming GM foods. Furthermore, given that market research studies focus on the examination of relevant attributes influencing individuals' product acceptance, this paper examines what the significant attributes are; which appear to be most influential in directing consumer behaviour; and from this it aims to present some possible policy strategies to deal with public uncertainty regarding to GMOs and specially GM food.

The paper is structured as follows. First, it explores the existing evidence on consumer attitudes to GM food-related applications. Second, the role of risk and benefit perceptions in the development of consumer attitudes is analysed, as well as how individual values and attributes are related to individual attitudes. The third section is devoted to the role of product knowledge that is also considered as being the underlying determinant of consumer risks and benefits perceptions. Fourth, the paper focuses on the potential links between attitudes and consumers' acceptance of GM products while examining the determinants of consumers' valuation of GM products. The paper concludes with some policy implications along with specific recommendations for further work.

2.3 Evidence on worldwide consumer attitudes to GM technology – food related applications.

Evidence on attitudes has become clearer in European countries after the publication of the Eurobarometer series after 1991. Interestingly, evidence suggests that some reluctance towards the introduction of GM foods exist (Grunert et al., 2003; Bredahl, 2001), even thought the recent Eurobarometer surveys (Gaskell et al., 2003; Gaskell et al., 2004; Gaskell et al., 2006) also reveal evidence of a progressive recovery on people's support for GM food products from 1999 to 2002. Surprisingly, a return to scepticism is found in the 2005 data (Gaskell et al., 2006). This evidence reveals a split within European consumers on several dimensions, which are mainly classified into three groups regarding their perception of GM food: 'optimistic'- 25%, 'pessimistic'- 58%, and 'undecided'- 17%. In Addition to this general attitude, national differences are also remarkable. Gaskell et al. (2003) finds that support for GM food is observed until 2002 in only four countries - Spain, Portugal, Ireland and Finland. However, this has changed in 2005, when the high supporter countries were – Spain, Malta, Portugal, Czech Republic, Ireland, Italy and Lithuania. A recent study in Ireland, using cluster analysis techniques, revealed that there was still a considerable segment (25%) who could best be described as 'anti-GM' and others (20%) who had 'complex reservations' regarding the wholesale introduction of GM products (O'Connor et al., 2006). In an analysis of attitudes towards GM technology, Bech-Larsen and Grunert (2000) and Honkanen and Verplanken (2004) confirm the negative attitude of the Nordic populations towards GM food. The same conclusion is achieved in some surveys for consumers in Poland, who in general have a significant distrust of genetic modification, especially where this may occur in food products (Szczurowska, 2005; Bukraba-Rylska, 2003; Janik-Janiec and Twardowski, 2003).

Besides Europe, evidence from the US is insightful and suggests that opinions concerning GM foods are not significantly different from those found in Europe. Particularly, US students mainly prefer non-GM products for chips, banana, corn flakes, and corn-beef (Onyango and Govindasamy, 2004; Lusk et al., 2002). Moreover, Hossain et al. (2003) uses discrete choice modelling for GM fresh fruit and vegetables and finds two main segments; those who are totally opposed to GM technology and those labelled as 'undecided', who would accept GM technology if there were some demonstrable benefits to the consumer. These results are echoed in other studies such as Hossain and Onyango (2004). Finally, a study in an Asian setting - South Korea - suggests a similar picture. Indeed, Onyango et al. (2004) found that consumers are divided in groups that range from acceptance and optimism regarding GM food improvements to pessimism and rejection.

2.4 The role of risk and benefit perceptions in the construction of consumer attitudes

Possibly the most accepted underlying theory of the formation of consumer attitudes is the Fishbein Multi-Attribute Model (Fishbein, 1963). Under this framework, an attitude towards a product is based on knowledge about the product itself as well as its attributes, which is referred to as the so-called 'bottom-up' formation of attitudes (Grunert et al., 2003). However, attitudes do not depend only on one specific belief but on a handful of them. More recently, Bredahl et al. (1998) developed a more detailed model for the 'bottom-up' consumer attitude explanation specifically regarding GM food, which implies that attitudes towards GM food technology are defined by means of a weighted sum of attitudes towards each product and its corresponding process. Therefore, each attitude also depends on the overall perceived risks and benefits associated with the product and process, respectively.

Interestingly, this theoretical model has been empirically supported by some studies such as Moon and Balasubramanian (2001 and 2004); Grunert et al. (2003); Onyango (2004); and Hossain and Onyango (2004), which state that, consumers associate, on the whole, more negative than positive attributes to agro-biotechnology. In addition, a set of evidence suggests that individual behaviours are driven by perceptions or beliefs about risks rather than the technical risk estimates provided by experts (Frewer et al., 1998). Other authors manage to find an association between perceptions of opposition and resistance to GM food explaining consumers' segmentation regarding GM food attitudes. This is consistent with Gaskell et al. (2004), who analysed by means of multinomial regression and multiple regression, a set of different decision-taking strategies for each group identified among European consumers. Findings suggest that 'Pessimistic' and '*Optimistic*' respondents tend to develop what is known as a lexicographic process, where a product attribute (risk or no-risk) dominates the decision. On the other hand, the *'undecided'* respondents use an *"expected utility method" (*SEU), which consists of a combination of all the possible costs and benefits weighted by their probabilities to explain learning of GM food technology and products. A recent work by Traill et al. (2006) suggests that risk and benefit perceptions are negatively, but not perfectly, correlated, and that benefits are more important than risks in the determination of consumers' willingness to consume. They conclude that it is best to measure risks and benefits separately. Finally, Yeung and Morris (2001) conceptualised risk perceptions and related them to a combination of characteristics, such as dread, unknown and extent.

Hossain et al. (2002 and 2003), Onyango et al. (2003) and Onyango and Govindasamy (2004) detect that US consumers are optimistic about possible benefits of GM food and feed, but they are also concerned with their associated health, safety and environmentally harmful consequences. A similar conclusion is reached by Lusk et al. (2002) in a study regarding the consumption of corn chips by US students. They conclude that, although US consumers preferred non-GM products, GM products that exhibited clear-cut benefits are acceptable. In the same line, Savadori et al. (2004) and Martinez et al. (2004) revealed that providing information on their benefits could reduce public perception of risk from biotech applications. Indeed, Loureiro and Bugbee (2005) show, by using a multiple-bounded probit methodology that the highest valued GM-associated benefits are: the 'enhanced flavour' modification followed by 'enhance nutritional value' and 'pesticide reduction'. However, these conclusions cannot be generalised. Siegrist et al. (2000a; 2000b) stated that, for north European consumers, perceived benefits do not significantly impact consumers' attitudes regarding GMOs. Also, Bech-Larsen and Grunert (2000) stated that the Nordic populations consider the benefits to be derived from GM food as a helpful, but an insufficient condition for increasing consumer acceptance of GM food products. Fortin and Renton (2003) in their study of GM bread and milk in New Zealand reached the same conclusion. Following Bredahl (2001), it seems that cross-country differences exist in relation to consumers' risks and benefits perceptions related to GM food. In his study of European citizens, he concluded that Danish, German and British consumers identified risks as an obstacle for the perceptions of benefits associated with GM food, whereas Italians considered that risks and benefits were in a clear-cut compensatory relationship.

Indeed, consumers do not perceive GM technology as being a one-dimensional skill. Some studies, such as Gaskell et al. (2003); Grunert et al. (2001); Hossain et al. (2002 and 2003); and Savadori et al. (2004) argue that European and US consumers distinguish between different types of applications within biotechnology. Moreover, they state that consumer attitudes and their consequent acceptance of a GM technology depend on the purpose of its use. More precisely, medical applications of GM are supported, whereas agri-food applications are not, since they are characterised as not especially useful and more risky. In a similar way, consumers consider GM technology on plants in a less negative way than on bacterium, animals or human genetic material (Frewer et al., 1998; and Onyango and Govindasamy, 2004). Other studies conclude that consumers do not differentiate among applications. This is the case of Bredahl (2001), who conclude that Europeans reject GM technology overall.

Finally, consumers' risk perception of GM technology has been compared to that of other risks associated to different technologies. Hwang et al. (2005 a), showed that US consumers' concerns were highest for pesticides and artificial growth hormones, followed by antibiotics, genetic modification and irradiation. Moreover, Townsend et al. (2004), using rating measures, concluded that for UK consumers GM food, relative to other current concerns such as cancer, terrorism and biological warming among others, was 'not dreaded', was thought to be 'controllable', was not viewed as 'unethical', and was seen as the least 'risky' among all other consumer concerns.

2.5 Individual attributes and values: the construction of perceptions and attitudes towards GM food.

As previously stated, consumers can be categorised or classified according to their attitudes towards GM food. Certainly, following Baker and Burnham (2001); and Onyango et al. (2003), the US consumers 'attitudinal' segment can be partially explained by cognitive variables that are not necessarily observed. Namely, individual attributes and values can become key determinants, which shape consumer biotechnology acceptance (Onyango et al., 2003). However, different studies utilitze diverse ways to evaluate the significance of these personal attributes on consumer's final attitude.

Frewer et al. (1998), Moon and Balasubramanian (2001 and 2004) and Loureiro and Hine (2004) refer to the relationship between both moral and ethical considerations and consumer attitudes. In contrast, Vilella-Vila et al. (2005) conclude that moral issues appear not to be relevant for attitude formation as with GM food. Other attributes, such as education and knowledge were also analysed by Onyango (2004), Veeman et al. (2005), Costa-Font and Mossialos (2005 a), Hwang et al. (2005 a), Noomene and Gil (2004) and Hossain et al. (2002) find a significant influence on consumer perceptions concerning food biotechnology. Moreover Traill et al. (2004) also concluded that: 'a high level of education is associated with the acceptance of GM benefits, and conversely the opposite holds for high levels of perceived risks'. The attribute of knowledge, due to its relevance, is analysed in some detail in the next section.

Another important relationship among the different stages of a consumer's attitudinal process is their association with socio-economic and demographic attributes such as age, ethnicity, residence and income level, which are found to be directly related to consumers' attitudes towards GM food. This relation is supported by Costa-Font and Mossialos (2005 a), Hossain et al. (2002 and 2003), Veeman et al. (2005) and Noomene and Gil (2004) using mainly logit and probit models. Moreover, Siegrist (2000a), through causal models, relate gender differences with benefit perceptions. These studies consistently find that women perceive lower benefits and are less likely to accept gene technology than men. Moreover some of them revealed that middle age, less affluent and those who live in suburban areas are more concerned with GM food. On the other hand, Frewer et al. (1998) revealed no significant gender differences among respondents with high level of environmental concern. In a similar manner, Hossain and Onyango (2004) and Baker and Burnham (2001) concluded that economic and demographic attributes are not important in defining consumers' attitudes towards GM technology. However, Baker and Burnham (2001) as well as Hwang et al. (2005 a) suggest that issues besides income-related factors might influence attitudes.

Finally, Hossain and Onyango (2004) included religious beliefs as a personal attribute for attitude construction. However, there is limited agreement on the role of religion. As an example, Hossain et al. (2002 and 2003), using a logistic model, found no evidence of a link between religiosity and GM attitudes.

Besides individual attributes, individual values should be taken into account when analysing the construction of consumers' attitudes (Verdurme and Viaene, 2002). Following the 'top down' formation theory of attitudes, consumers' attitudes towards a product are affected by more general individual attitudes and values (Grunert et al., 2003 and 2004; Bredahl, 2001). The value set of an individual consumer will thus be derived from that consumer's attitude towards the environment, technology, culture and so on. Yet, this approach complements the so-called 'bottom up' approach and both give rise to some recursive system.

A relevant theory regarding the role of values on consumer attitude formation is the 'means-end' approach. This approach basically links product perceptions with consumers' values. Grunert et al. (2001) empirically validated the cognitive 'means-end approach' theory with three GM products - cheese, candy and salmon. Grunert and colleagues specifically used the 'laddering' method and noted that Danish, Finnish, Norwegian and Swedish consumers preferred conventional products to GM products mainly because of the *conventional means of production*. The key element of this finding is that consumers associate conventional production with safe and healthy products and view these as either general attributes or personal values. On the other hand, GM products are associated with two negative general values, that is, uncertainty and poor health. Vilella-Vila et al. (2005) refer to the effect of perceptions on equity in a world where a few companies distribute GM product, i.e. a seemingly monopolistic market. Something similar takes place when comparing consumer attitudes towards GM and organic food. Dreezens et al. (2005) observed that consumers relate GM and organic food to power and universalism values. Explicitly, respondents who contend that man should be dominant over the natural environment, present the least negative feelings towards GM food. On the other hand, respondents favouring organic food production systems reveal their inherent opposition to man dominating nature. Therefore, attitudes regarding GM and organic food were negatively related.

Other relevant studies that find empirical evidence of the role of individual values as determinants of consumer attitudes towards GM food are Bredahl (2001), Traill et al. (2004) and Gaskell et al. (2003). These studies refer to both European and US consumers with regard to GM food and find that consumers can be classified as: (i) 'opposed' to biotech, entailing concern about nature as well as technology (post materialistic); and (ii) 'optimistic' about biotech and more materialistic. In addition, Brant et al. (2004) note that other general attributes seem to be significant in explaining consumer attitudes towards GM food. These were 'sport fan, present thinking, auto-innovativeness interest, poetry, retirement, education and physical needs'.

Besides means-end approaches, complementary theoretical frameworks have been used to explain the influence of individual values on consumer attitudes towards a GM product. Honkanen and Verplanken (2004) distinguish between '*valence attitudes'* that define the agreement with the product either favourably or unfavourably- from '*centrality attitudes',* which consider the importance or relationship to values. They state that 'attitudes strongly associated to general attitudes or values are more difficult to modify than those based only on knowledge of product attributes and services*'.* If an individual's attitudes are not strongly related to values, due to lack of information, contradictory beliefs, or lack of involvement, then it will be easy for them to internalise information and, as a consequence, be subject to potential modifications. In the next section, we will analyse the impact of values on trust and therefore on information strategies.

2.6 Individuals knowledge and consumers risk and benefit perceptions

Consumer perceptions of risks and benefits are dynamic processes insofar as attitudes towards GM technology are in continuous evolution (Frewer et al., 1998; Bredahl et al., 1998). This dynamism can be motivated by the increasing knowledge of GM products as well as enhanced individuals' knowledge regarding GM technologies (Bredahl et al., 1998).

It is noted that some studies link individual attributes, particularly knowledge, to consumer attitudes and perceptions towards GM food. Certainly, information is the key element of the Fishbein Multi-Attribute Model. In other words, knowledge about a specific GM product and the underlying production process become essential in order to shape attitudes. Some studies (Boccaletti and Moro, 2000; Moon and Balasubramanian, 2001 and 2004; Moerbeek and Casimiv, 2005; and Vilella-Vila et al., 2005) have empirically shown the direct association between knowledge and attitudes, revealing that there is a direct and positive relation between an increasing knowledge of GM technology and an increasing support to GM applications (Koivisto Hursti and Magnusson, 2003). Moreover Saavadori et al. (2004) and Madsen and Sandoe (2005) highlight, as have other authors, that experts perceive less or different risk for all GM applications than the public.

Some differences remain in disentangling the effect of different types of knowledge. It is worthwhile to differentiate between the 'objective knowledge', which, can be defined as the real knowledge people have about GM food, and 'subjective knowledge', which refers essentially to what consumers think they know about GM food. Subjective knowledge is clearly related to general attitudes and values. Some studies have analysed the importance of each type of knowledge in the task of building attitudes towards GM food. Interestingly, House et al. (2004) noted that both types of knowledge are important in the process of attitude-building towards GM food among US, UK and French consumers. However, each type of knowledge exerts different influences. The association between consumer knowledge and consumer location was also analysed in House et al. (2004), who conclude that only subjective knowledge appears to be related to consumer location. Alternatively, education was detected as the unique individual attribute related to consumer knowledge, which is a relationship also noted by Onyango (2004). Additionally, House et al. (2004) reveal that while subjective knowledge appears to be related to acceptance, objective knowledge seems to be less related. This conclusion was also noticed by Lusk et al. (2004) who found that individuals with higher levels of subjective knowledge were less influenced by new information.

Some studies suggest that the level of subjective and objective knowledge regarding GM food, among Spanish, European and US consumers, is low and that more information should be provided to consumers to increase both knowledge and understanding of these matters (Martinez et al., 2004, Noomene and Gil et al., 2004, Schilling, 2003, Szczurowska, 2005 and Vilella-Vila et al., 2005). The majority of these populations (European, Spanish and American) have made little effort to be informed about biotech applications in food production. In particular, 'undecided' consumers is the segment that exhibits a high desire for learning more about GM technology in order to assess more clearly their attitudes towards GM food (Onyango et al., 2004; Hossain et al., 2002). On the contrary, those consumers, who reveal either rejection or acceptance of GM food, seem to be strongly influenced by individual values and hence by subjective knowledge.

A related question is how individuals learn about risks. The process by which individuals acquire knowledge regarding GM food is not straightforward. There are three main elements which are interrelated and must be taken into account. First, 'substantial content' information is a key issue that influences the level of acceptance of GM products (Bredahl et al., 1998), which includes concrete, reliable, accurate, and tangible information (Frewer et al., 1998; Yee et al., 2005, Costa-Font and Mossialos, 2005 a). Second, trust in the source of information is also important. Lastly, communication of the information must be taken into account.

As mentioned previously, trust stands as a key dimension that motivates information updating and, therefore, knowledge acquisition and credibility of information sources. Moreover, trust is directly related to individual values and envisaged as a key element of the acceptance of biotechnology (Siegrist et al., 2000b; Koivisto Hursti and Magnusson, 2003; Huffman et al., 2004). In addition, it can be stated that trust is also determined by individual attributes such as schooling, age, and religious affiliation (Huffman et al., 2004).

The concept of trust is related to confidence and credibility in someone or something. 'Trusting in someone involves a risk that the person will act unreliably' (Siegrist, 2000a). Therefore, in order to reduce risk, consumers are likely to believe the opinion of experts who appear to hold similar values to themselves (Siegrist, 2000a, Cook et al., 2002) Consequently, to increase consumers' knowledge, it is important that the information received by consumers are not only 'believable' but credible (Bredahl et al., 1998). The building of credibility was analysed by Yee et al. (2005), who revealed that the benevolence and integrity of producers are key factors in building consumer trust.

Many studies have revealed that for GM technology and especially GM food, consumer organisations, environmental groups and scientists are considered to be more trustworthy than the biotech industry and government (Bredahl et al., 1998; Onyango et al., 2003; Savadori et al., 2004; and Veeman et al., 2005). Interestingly, Eurobarometer data reveals that Europeans' most trusted stakeholders are doctors, university scientists, consumer organisations and patients' organisations, followed by scientists working in industry, newspapers and magazines, environmental groups, shops, farmers and the EU. Governments and industry are the least trusted (Gaskell *et al.,* 2003). Indeed, Vilella-Vila et al. (2005) reported that trust in public authorities appeared to be in decline, especially in the UK. Moreover, cross-country comparisons developed by Traill et al. (2004) revealed that Americans exhibited a more favourable and trusting attitude towards GM technology than Europeans. Therefore, an explanation of the difference in attitude to GM food between the citizens of Europe and the US might well originate with trust.

It is also appropriate here to highlight the importance of consumer perception about which stakeholder appears to be the most influential regarding GM technology. Results obtained from two studies conducted by Frewer et al. (1996) and Moon and Balasubramanian (2001), reveal that US and UK consumers consider government and science as the main actors regarding GM technology control. Therefore, trust in government and industry can be concluded to be an important determinant of attitudes towards GM technologies (Hossain et al., 2003; Hossain and Onyango, 2004; and Onyango, 2004). Consequently, the fact that consumers appear not to trust government and industry infers that merely underlining the associated benefits of GM food over conventionally produced food is not a sufficient stimulus to modify consumers' perceptions towards such a technology (Siegrist, 2000b). Furthermore, the lack of consumer trust in institutions may seriously hinder the complete acceptance of transgenic technology (Onyango, 2004).

Interestingly, individuals seem to more strongly accept the risks reported by environmentalists than the benefits reported by industry and government. As Traill et al. (2004) state, the majority of respondents see GM in food production as having a 'middle risk level' since 'government and industry trust implies counterbalancing perceptions of GM benefits, and trust in environmental groups more risk perception'.

Moreover, Frewer et al. (2004) conclude that much of the public controversy over the introduction of GM food results from the failure of the relevant regulatory bodies to take full account of the actual concerns of the public, which leads to the public's distrust of regulators, science and industry, a view also expounded in an earlier study by Lassen et al. (2002). This evident distrust is despite the introduction in the EU of the European Food Safety Authority (Jensen and Sandoe, 2002).

A different approach to explaining the relationship between trust, information and consumer attitudes can be attained as follows. Not 'trusting' not only drives information provision but consumer attitudes to GM food and aids in determining individuals' trust levels: 'that is, the relationship between trust, information source and impact of this information on risk perceptions is more complex than a simple one-way causal relation' (Frewer et al., 2003). This approach was demonstrated through the use of a multi-sample structural equation model in Denmark, Germany, Italy and the UK. In particular, Frewer et al. (2003) revealed that 'people who favour the use of genetic modification are more likely to trust a source promoting its benefits whereas those who oppose its development are more likely to distrust the same source providing the same information'. Similarly, Lusk et al. (2004) found that consumers' reaction to information depends on their prior acceptance of GM food. Therefore, trust and values are potentially associated as long as values determine the extent to which people select amongst alternative information sources.

It is clear that the impact of information provision on consumers' knowledge depends essentially on the level of trust that individuals have as well as on the source of the information. However, it is important to highlight that the means by which information is conveyed to the public is not irrelevant. Frewer et al. (1998) highlighted the relevance of developing effective risk-benefit communication strategies, not only in the acceptance of a new technique but also in a crisis context, in order to enable the public to make informed choices. Since the majority of the information regarding new technologies, such as GM food, is disseminated by the mass media, Vilella-Vila et al. (2005) stated in their study some key points for a good media communication strategy: (i) to inform the people about not only risks but also about benefits in an objective manner; (ii) for consumers to obtain their information from trusted organizations; and (iii) to provide information in a credible and persuasive manner. Hence, simply providing information on the risk and benefits of GM food would not be sufficient in itself to promote attitudinal change in consumers (Frewer et al., 2003; and Bührlen, 2005).

Communication campaigns may, in the future, need to focus on providing information that addresses those characteristics of GM food that negatively influence the fears of individual consumers insofar as those fears might constrain the development of the market for GM food (Costa-Font and Mossialos, 2005 a). Indeed, when conflicting information is presented to them, consumers tend to favour any prior beliefs they may have held, such as 'subjective knowledge' based on individual values (Costa-Font and Mossialos, 2005 a). Additionally, Costa-Font and Mossialos (2005 b) also reveal that if there is a 'trade-off' between individual values and attitudes in the mind of consumers towards the product derived from 'objective knowledge', then individual values prevail over attitudes to the detriment of biotechnology and GM food.

One important source of information for consumers includes product labelling. Labelling appears as a mechanism for communication of information to enable consumers to undertake an informed choice (Gath and Alvensleben, 1998). That is, choices are consistent with their preferences (Baker and Burnham, 2001; Moon and Balasubramanian, 2004; and Loureiro and Bugbee, 2005). Moreover, labelling can provide additional information about GM technology and its benefits thus raising awareness and improving transparency (Frewer et al., 1998). As a consequence, consumer trust in the biotech industry should increase.

Labelling can assist in increasing individual perception of personal control over a particular situation, which in this case concerns the consumption of GM food (Frewer et al., 1998). However, this study did not find empirical evidence regarding an increase in consumers' perception of personal control. Therefore, it might be concluded that consumers' attitudes toward GM food would not be changed by increased product information (Szczurowska, 2005; Bukraba-Rylska, 2003). However, there is evidence that consumers may change their attitude to GM food based on their own experiences with products produced using GM techniques that involve clear consumer benefits (Grunert et al., 2003). Kiesel et al. (2005) reveal that the provision of additional positive information - in the label – would likely increase USA consumption of the commodity that included a desirable characteristic.

Different labelling policies exist and, therefore, different product communication strategies are followed, which are influenced both by regulations and driven by the product companies themselves. First, mandatory labelling is required in many countries. In fact, European regulations have introduced mandatory labelling to ensure consumers are advised that the final product contains GMOs. Mandatory regulation is seen by some authors to generate over-regulation and, with some justification, is said to increase industry costs (Moon and Balasubramanian, 2003a). Alternatively, voluntary labelling, as developed under US regulations, generates the opportunity for companies to label their products as including GM but does not permit consumers to gather all the information regarding the product they might wish to acquire. Therefore, 'only consumers who value non-biotech food pay higher prices' (Moon and Balasubramanian 2003a). The issue of mandatory or voluntary labelling of food products has generated much discussion. Some studies, such as Moon and Balasubramanian (2003a), conclude that voluntary labelling appears to be an effective approach. Others, such as Lusk and Coble (2005), view voluntary labelling as clearly insufficient, concluding that European mandatory labelling has increased consumers' welfare. Moreover, this study also suggested that, if segregation costs diminished and consumers perceived an increase of GM products on the US market, a mandatory labelling policy would be needed in the USA.

Consumer labelling preferences have been analysed by as Harrison and McLennan *(*2003); Chern *et al*. (2002) and Veeman et al. (2005), among others concluding that consumers in the US, Japan, Norway, Taiwan and Canada support mandatory labelling of GM food. Alternatively, Loureiro and Hine *(*2004) stated that US consumers had divergent opinions regarding labelling policies based on consumer trust in government. Indeed, some US consumers are confident with the safety regulations of the Food and Drug Administration (FDA) and therefore implicitly with voluntary labelling, whereas others were not. Finally, it is instructive to take account the conclusion reached by Harrison and McLennan *(*2003) who noted that US consumers revealed their desire for more information regarding GM technology as well as the GM content of the product itself. This result suggests that consumers preferred labelling formats containing a description of the benefits of biotechnology as well as a biotech logo.

2.7 From attitudes to valuation and acceptance: consumer purchasing behaviour.

Most studies using the stated preferences methodology (Lusk et al., 2005a; Moon and Balasubramanian, 2003b; Onyango and Govindasamy, 2004 and Chern et al., 2002) have found evidence that consumers are willing to pay a premium for non-GM food. Therefore, consumers place a higher value on non-GM food relative to GM food (Lusk et al., 2003). Rousu et al. (2003) draws from an alternative approach using an n^{th} price auction on a real market and concludes that consumers were willing to pay a large premium to avoid GM contamination in an uncontaminated product. However, no evidence was found that consumers take into account the tolerance thresholds when valuing food. The discounting effects on consumers' purchase intentions was also detected by Bredahl (1999), in their study on bread, ice cream and pasta, produced with GM enzymes and conducted with Finnish, German and Italian consumers. In spite of this general conclusion, other studies such as Moon and Balasubramanian (2003a), for breakfast cereals, and Gifford et al. (2005), for potatoes, potato chips, milk, milk chocolate, corn, and tortilla chips, found that a US potential niche market for non-biotech foods could emerge if consumers were given the right to choose between biotech and non-biotech food.

Cross-country differences regarding consumer purchasing behaviour have been observed for consumer valuation and acceptance. Chern et al. (2002) conducted a study in Japan, Norway, Taiwan and the USA, and concluded that students in all countries were willing to pay higher premiums for non-GM food although American and Taiwanese students were more favourable to GM foods than Norwegian and Japanese students. Generally speaking, most studies report that European consumers are willing to pay higher premiums for non-GM foods compared North American consumers (Lusk et al., 2005a and Jaeger et al., 2004). In fact, Moon and Balasubramanian (2003a) state that the demand for non-biotech food is greater in the UK than in the USA. Also, Lusk et al. (2003), through analysing consumers' WTP for hormone-treated/GM-fed beef, noted that European consumers placed much higher value on beef from animals not fed with genetically modified corn than US consumers. Additionally, Lusk et al. (2004), comparing US, French and UK consumers willingness to accept (WTA), noted that French consumers are the most averse to GM food and the most resistant to change. Differences between the EU and the US consumer behaviour can be explained by the diversity of government trust and media coverage between the two populations.

Table 2.1 presents data synthesising a number of recent studies that reveal the level of premium some consumers in a number of different countries might be prepared to pay for some different food products that do not contain GM ingredients. It is freely adapted from Lusk et al (2005b) with the addition of data from a recent paper (Kaneko and Chern, 2005). The premium price range data presented are simply the range of minimum and maximum percentage.

Other relevant elements have also to be taken into account when a purchasing decision is made. First, the information regarding benefits associated with GM food. Interestingly, Moon and Balasubramanian (2003a); Onyango and Govindasamy (2004); Lusk et al. (2004) and Lusk et al (2005a) using alternative methodological approaches, find that when UK and US respondents were faced with positive information regarding GM food, such as environmental or health benefits, valuation of non-biotech foods relative to GM foods is modified, indicating a potential niche for GM-foods in the future (Magnusson and Koivisto Hursti, 2002; Mucci and Hough, 2003; Onyango and Govindasamy, 2004). Similar conclusions were reached by Frewer et al. (1996), who analysed UK consumers' real purchasing behaviour for yogurt, tomato, and chicken drumsticks, as well as Mucci and Hough (2003), who find that consumers may be more willing to accept genetic modification to food products where there were benefits to health and the environment but less likely to accept GM where the main benefits were to increase shelf-life of a product or to reduce the purchase price. The Frewer et al. study specifically linked the likelihood of purchasing GM products with perceived 'naturalness' of the products. In a more recent study, Tenbült et al, 2005 conclude that consumers were less likely to accept genetic modification to food products that they considered to be natural and they would, therefore, be more likely to resist buying products of that type that incorporated GM.

Table 2.1. A comparison of price premia for some non-GM foods.

Product	Tangible consumer benefit?	Percent premium for non-GM (%)
Beef	No Yes	10 to 110 -33
Salmon GM-fed GM-fish	 No No	 28 to 54 30 to 67
Potato	No	5 to 17
Rice	Yes	-19 to –38
Vegetable oil	No	5 to 62
Soybean oil	No	-16
Potato chips	No Yes	8 to 9 -63
Corn chips	No Yes	10 to 16 -0.33
Cornflakes	No	14 to 40
Breakfast cereal	No	28 to 96

Source: Adapted from Lusk et al. (2005b) and Kaneko and Chern (2005).

However, Jaeger et al. (2004), use a non-hypothetical market experiment setting to demonstrate that information seems not to be a positive factor in increasing WTA monetary compensation for consuming GM food. Moreover, Lusk et al. (2002) analyses US consumers' preferences for corn chips and concludes that, although consumers prefer GM products to be associated with some benefits, those benefits would not imply a willingness to pay a premium for those GM products. Canavari et al. (2005) concluded that Italians were not willing to buy GM food products even if they were nutritionally enhanced. However, enhancement could help increase consumer acceptance of GM food products in Italy generally, but only if it is a plant based food product and not an animal based food product. Indeed, acceptance of GM technology does not imply a willingness to buy. The same conclusion was reached by Bredahl (1999), in a study conducted in four countries, Denmark, Germany, the UK and Italy.

The relationship between consumer intentions and final purchase behaviour has also been analysed by Townsend and Campbell (2004) with a blind taste experiment. The study revealed that, although the majority of the UK participants were willing to taste GM food (intention), only half of the sample stated their willingness to buy GM food when it became available. This study also reveals the concerns about future risks portended by GM animals used in food were key determinants of unwillingness to purchase GM food. That is, perceived risks have a negative impact on consumers' WTP for GM food (Loureiro and Bugbee, 2005). The negative impact on consumer demand (WTP) for GM products of information reporting risks associated with GM food, was empirically displayed by Rousu et al. (2004), who notes that negative GM-product information supplied by environmental groups could significantly reduce the consumer demand for GM food products. Moreover, risk perceptions had more impact on choice than benefits (Lusk and Coble, 2005).

As well as the type of product and perceived associated risk, price is also linked to consumers' purchasing intentions (Boccaletti and Moro, 2000, Veeman et al., 2005, Bredahl, 1999). Bukenya and Wright (2004) conclude that grocery shoppers in Alabama could be classified into three groups: those that will not consume GM tomatoes at any price, which amounts to 45% of the sample; 35% who said that they would consume GM-tomatoes if they became cheaper than conventional tomatoes; and, finally, the remaining 20%, who would consume GM tomatoes at the same price as traditional ones. Therefore, for only a small proportion of the sample, price is a significant factor, which explains consumers' attitudes towards GM food. Canavari *et al.* (2005), in a study of Italian consumers, reached the same conclusion. Additionally, Hwang et al. (2005 b) evaluated bread, corn, and eggs, to show that consumers use price as a signal of product quality, though heterogeneously amongst products. The study determined that, for GM bread and GM corn, purchasing intentions increased as their price decreased until a limit was reached. In the case of eggs, the price was monotonic over the whole price range. The authors analysed the possible marketing strategies arising from these results.

It can be said that there exists other factors capable of explaining consumer purchasing behaviour, such as: ingredients and labelling (Veeman et al., 2005); 'attitudinal' variables (Loureiro and Bugbee, 2005; Bredahl, 2001; Gifford et al., 2005); knowledge of science and trust in science (Canavari et al., 2005); government policies

(Lusk et al., 2006); and product brands and place of purchasing (Lusk et al., 2002). In addition Cook, et al. (2002), following the Theory of Planned Behaviour and defining a probit model, proved that self-identity is also an important influence on purchasing intention. The study also suggested gender differences regarding GM behavioural purchase intentions, that is, males seemed to be more likely to feel in control when purchasing GM food than females.

Finally, some studies have also related consumer acceptance of GM food with traced production. This was highlighted in the study conducted by Nielsen et al. (2003), which states that if consumers could be persuaded to consider GM products as conventional products, then the biotech industry would expand. If consumers were willing to pay a premium for non-GM food, the biotech industry would not expand and, should consumers reject GM varieties, regardless of the price differential, then production would decline.

2.8 Conclusions remarks, policy and research implications

This paper has attempts to systematically summarise the evidence on the acceptance of GM food and its underlying processes. In doing so this study brings together the published findings on the main issues under discussion including risks and benefits perceptions, trust, knowledge, and valuation, as well as purchasing decisions. On the basis of this evidence, a tentative general framework arises and might contribute to further research in the area. On the basis of the evaluated literature, the population inspected in the set of studies examined can be segregated in three main groups regarding attitudes toward GM food, namely: (i) anti-GM food or pessimistic, (ii) risk-tolerant or information searchers and finally (iii) GM-accepters or optimistic. Yet, different compositions of such groups in a specific society determines final country acceptance of GM food. On this basis it is apparent that in the U.S. and some European countries, such as Spain and Portugal among others, the population is found to be broadly more tolerant to GM food as compared to France or the Nordic population.

However, in light of the large array of determinants identified in the literature, it can be concluded that this personal attitude is formed by a complex decision-making process which we attempt to simplify in Figure 2.1 While most of the revised literature has proposed partial models to explain different aspects of consumer behaviour towards GM food, Figure 2.1 aims to integrate them into a single one by providing an overall picture of the different stages of the consumer decision making process. The main implication of this Figure is clear: Policy makers and firms' decision makers need more research specifically addressed to better understand the full process in order to adopt meaningful and efficient strategies and policies. This is one of the main challengers for social scientists' future research.

As can be observed in Figure 2.1, consumer attitudes towards GM food are driven by three main dimensions. First, risks and benefit perceptions associated to GM food as well as their weights in determining acceptance and final decisions. In most European countries, and specifically in Nordic countries, Britain, and Germany, consumers find benefits associated to GM food as insufficient to overcome their associated (perceived) risk. On the other hand, in the US and also in some European countries, such as Spain and Italy, consumers mainly reveal perceptions of risks and benefits associated with GM food, where benefits can potentially outweigh risks.

Socio-economic and demographic attributes, such as age, ethnicity, residence, and income level have been detected by many authors to be related with either benefit perception or consumer acceptability of GM food at a worldwide level. Nevertheless, there are also some studies, which do not support this statement. Therefore it will be important to further analyse this issue by means of a cross-country study that consider this issue over time.

Second, individual values and attributes appear as key determinants underpinning consumer attitudes. Risk and benefit perceptions towards a GM product are found to be conditioned on what is known as "individual values", such as environmentalism, conservationism, materialism, equity etc. Moreover, the stronger this association – determining the strength of the trade-off perception vs. values- the more pervasive becomes the influence of underlying individual attitudes. On the other hand, the less important the role of values the more important new information becomes in order to shift consumer behaviour.

Finally, knowledge and its relation with values must be considered as an especially human complex attribute. Indeed, knowledge can be divided into “objective” and “subjective”, where “subjective” knowledge is the most related with values and has more impact on individual attitude development. This paper explains that in countries where limited knowledge of GM food exists, one would expect to find information searchers with very negative (positive) information conveyed with pessimistic (optimistic) attitudes. In a way, values are predetermined knowledge which can filter information by means of elements such as trust and confidence. Therefore the level of consumer trust on the different sources of information must also be considered. In fact, worldwide consumers have stronger trust for sources of information that are supposed to be driven towards the protection of individuals’ wellbeing and environmental rights. This is the case of consumer organisations, environmental groups, physicians and also scientists. In contrast, biotech industry and governments are less trusted. Nevertheless, an important trust divergence exists among Europeans and Americans, since the last ones reveal more reliance on the FDA than Europeans on either the EU or the worldwide biotech technology.

These three elements are strongly connected and their parallel study we believe it is needed so as to understand consumer’s behaviour. It is a combination of how people perceive, learn and process information on new food technology developments that ultimately determines acceptance. Therefore, policies that tackle acceptance of new developments in the food industry should operate in different arenas, including the media, the education system, and a correct population analysis to determine information availability and processing through individuals transmission of values and societal trust enhancing factors, and, finally, by being able to communicate the benefits of new developments, especially when those overcome potential perceptions of risk in order to avoid the existence of ambiguity in the existing information channels.

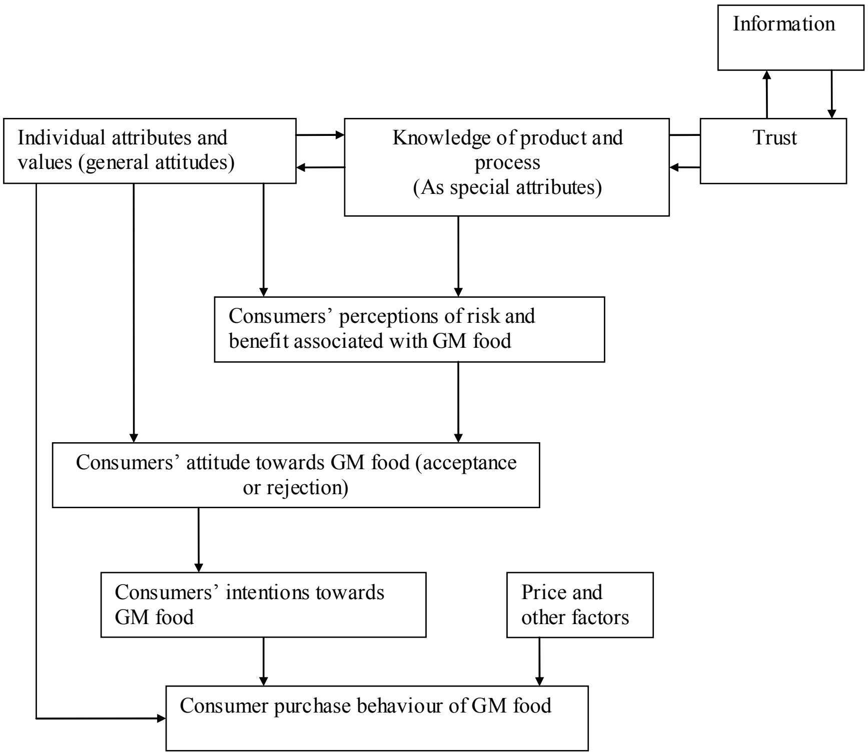

Figure 2.1 An explanatory process of GM food acceptance

The last concept analysed is consumers purchase behaviour regarding GM food, which is mainly negative. That is, all the papers revised, whatever the technique of analysis used – stated preferences, real markets, blind taste, etc -, detected that, on the one hand consumers mainly prefer GM free food, until the point to pay a premium for them. And on the other, cross country differences exist. The main difference is among Americans and Europeans. Indeed, Americans seem to be more tolerant to GM food. This can be explained from a policy view by two main elements: trust among stakeholders, already analysed and information policies. US consumers do not have complete information about the food products, due to the voluntary labelling policy, whereas in Europe more detailed information exists, however, the GM threshold is not well-defined and communicated to consumers. For Europeans purchasing GM free food is essential and not mater the GM threshold. This is important when analysing the right of consumers to have the necessary information to perform adequate choices. We can conclude therefore, that US consumers are more tolerant with GM products because they don't know in detail what they are consuming. However, they have more trust regarding safety governmental policies, which allow products to be on the market.

Finally, consumer behaviour also can be related to the associated benefits of GM food. Indeed, these benefits can be of many different types and are only considered by consumers concerned with health and environmental benefits. Moreover, there are conflicting results regarding the impact of these benefits on consumers' behaviour. Some authors consider them relevant and others not enough. Negative information associated with GM food seems to have negative impact to consumer behaviour towards GM food. As well as for attitude formation, other factors also seem to influence consumers purchasing behaviour, such as gender, age, knowledge and so on.

Besides the obvious need of further research to disentangle the behavioural mechanisms underlying consumer behaviour, this literature review suggests a number of points that could be relevant for policy decision makers:

First, mandatory labelling seems to be a policy proposal having a marked consensus among consumers, even in the USA, which may imply a necessary shift in current food labelling policy. Second, Threshold levels information on GM contamination is not a major issue from a consumer perspective, despite the long lasting discussion encompassing the introduction of new European regulations on GM food.[8] Interestingly, a third recurrent finding suggests that the inclusion of contact information in labels (telephone number, e-mail address...) appears to increase consumers' trust and confidence. Fourth, paradoxically, whilst worldwide consumers' behaviour is mainly sceptical about GM food, a correct segmentation of country population is needed in order to predefine potential market niches for GM products and GM free products. In many studies it appears that the most reluctant consumers are typically those relatively more risk conscious and that exhibit attitudes favouring sluggish technology innovation in the food sector. This finding could be the reflection of some mass media influence. If it is the case, and policy makers are aware of the absence of yet scientifically proven risks associated with GM food, then possibly there are products that should become progressively more popular among those individuals who believe that the benefits of the new product outweigh the potential risks (Baker and Burnham, 2004)[9]. To date, most of

[8] Apart from the fact that the current technology (at reasonable cost) can not easily discriminate between GM or non GM food based on the 0,9 threshold level

[9] Remember for instance, the consumer's reluctance to purchasing microwave ovens in the late 1950s (even though communication technology was not so well developed in comparison with nowadays), when now nobody bothers about its potential harmful effects.

the commercial traits of GM food – insecticide resistance or herbicide tolerance – are aimed to reduce consumer's food costs, while empirical studies indicate that such indirect benefits are not easy for consumers to understand in the return of the perceived increased risk. Hence, a consistent result from the literature review suggests that regulation should be mainly addressed to provide food products that have a direct benefit to consumers; hence the benefits of GM should be more heavily communicated.

Knowledge has been categorized as a singular human attribute that noticeably enhances the likelihood of GM food acceptance, especially when objective rather than perceived knowledge is examined. Therefore, policy makers should guarantee the dissemination of GM scientific knowledge in order to assure a high level of objective knowledge among their base population. Marketing claims about the non-GM nature of food products should be supervised, as it increases consumers' perception of risk. Finally, the role of the public sector in this area is fundamentally to provide objective information to consumers in order to allow them undertake informed and ideally reasoned choices.

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Chapter 3:

Measuring consumer preferences for Genetically Modified (GM) and organic food: an empirical analysis for cornflakes and tomatoes.

3.1 Abstract

Genetic Modification (GM) technologies offer health and environmental effects that are heterogeneously perceived among individuals. However, little is known on the influence of organic food, which is typically consumed for health benefits or sustainable development concerns. In this paper we utilize a choice model to examine the formation of social attitude towards GM and organic food in Spain. We exploit experimental survey data collected in spring 2007. The database contains records on the valuation of GM foods using the willingness to pay (WTP) and the willingness to accept (WTA) measures for Genetically Modified (GM) and organic food, namely cornflakes and tomatoes. Our findings suggest consumer responses that differ from previous studies. Second, consumption patterns of both GM and organic products do not exhibit significant differences between processed and fresh food. The latter is consistent with a robust preference for organic food rather than GM food. In addition, Spanish consumers appear to be more concerned with the potential health benefits of GM food (rather than its benefits to the environment). Choice results suggest that environmentally friendly GM products require a price premium.

3.2 Introduction

Acceptance of new biotechnology developments has been a matter of significant interest worldwide and has impacted the technology diffusion of agribiofood applications. From a supply side, the inception of Genetic Modification (GM) techniques in food production is envisaged as an opportunity to improve food production technologies. Farmers and manufacturers perceive potential benefits from efficiency improvements, despite some associated costs due to the reimbursement of intellectual property rights. From a demand side, GM products offer new products in the food chain and ultimately fulfil consumer's preference for diversity. However, public controversy resulted from the "uncertainties" – or perceived "risks" – both to health and the environment' that the technology is arguably enhancing or, communicated to exert to individuals and society (Huffman et al., 2004). These controversies render different labelling regulations across countries[10] and consumers often perceive GM food as being potentially threatening to the sustainability of traditional food markets[11]. Consequently, consumers might dread the expansion of GM food in supermarkets, and ultimately refuse to consume any product made out of this technology.

In the light of this evidence, both economic theory and policy call for a careful understanding of consumer's reactions towards GM food. These reactions have important implications on the subsequent introduction of GM food into the market. European countries were more deliberant and proactive with regards to GMOs until the moratorium came to an end in 2004. Among European countries, the Mediterranean countries have a stark contrast between traditional values - which arguably confer organic food a strong priority – and the modern benefits of technology. This is especially the case in Spain, the country that tops the European raking in land devoted to harvesting GM food, which has increased by approximately up to 75,000 ha (MAPA, 2007) in the last few years before the study was carried out.

[10] The European Union along with other countries have mandatory labelling and traceability regulations after 2004 the moratorium was finally removed
[11] Some evidence fins some risks and benenfits perceptions (Gaskell et al., 2001), and particulalrly relevat is the evidence sguugesting that some social equity and environmenta concerns might be present as well (Gaskell et al., 2005).

Given the sluggish market introduction of GM foods, the relative unawareness of its components by consumers, along with the potential noise of market data, the valuation and characterisation of behavioural market reaction to the GM component of foods call for experimental data rather than revealed by market mechanisms. Among existing technologies to elicit the market value of consumer willingness to pay, choice modelling outperformed other alternative preference elicitation methods. The latter results from the multi-attribute nature of consumer choices and existing interdependent preferences, which is likely to be affected by the valuation of attributes primarily as traditional models would predict (Lancaster, 1966 and 1979).

This paper empirically explores preferences and valuation of GM food in Spain drawing for a choice modelling methodology. We elicit consumers' willingness to pay (WTP) or willingness to accept (WTA) for both G*enetically Modified (GM) food* and *Organic food* using data from Spain. Our contribution lies in the following. First, we examine the effect of GM information in individual's willingness to pay, and hence this allows us to ascertain the effect of labelling in consumer demand. Second, we test the effect of different choice design and product characteristics, namely fresh v processed food. Third, we estimate the effect of environmental benefits and other characteristics in the individual's choice and product valuation of GM food.

The paper is structured as follows: it first presents a literature review on choice modelling for food marketing research followed by a description of the choice experiment methodology. Next, the case application to the Spanish market is developed. After that, the statistical model to be used is presented. Finally, the empirical estimation results are reported and some conclusions on the attitudes of Spanish consumers towards GM and organic food are stated.

3.3 Background and Literature Review

Literature regarding choice experiments started in the field of environmental valuation (Adamowicz et al., 1994), analysing public preferences on freshwater recreation (Boxall et al., 1996; Adamowicz et al., 1997), evaluating moose hunting in Canada (Hanley et al., 1998) for the valuation of the Breadalbane ESA, in Scotland, among others. Lately, this methodology has been applied to many other disciplines such as health care and food marketing research. Moreover, many food marketing research studies focus on food safety and novel foods, such as GM foods. In fact, it has been confirmed through choice experiments that the concern about food safety is a key issue for consumers' food purchases. This concern has been revealed in different fields such as pesticide risk exposure (Florax et al., 2005), hormone-treated beef (Alfnes, 2004), food safety inspection and "quality and safety" labelling for the meat sector (Loureiro and Umberger, 2007; Enneking, 2004), GM presence on food (Burton and Pearse, 2002) and GM labelled food (Carlsson et al., 2007), among others.

Florax et al. (2005), by means of a meta-analysis, show that consumers are willing to pay a premium for reduced pesticide risk exposure. Moreover, non geographical differences in WTP values were detected. A similar conclusion was reached by Onyango et al. (2004a), who calculated that consumers were willing to pay for using less chemicals/pesticides in corn production in U.S. However, if the cornflakes that use less chemicals/pesticides were GM using plant, bacterium or animal genes, consumers needed to be compensated to purchase it. In addition, cornflakes with added antioxidants to reduce aging and increase energy were also revealed by Onyango et al. (2004a). That is, consumers place a premium on functional food if GM technology is not used for its production. This conclusion is consistent with Christoph et al. (2006) who analysed German consumers' WTP for GM food and non-food products, concluding that respondents were more willing to pay a premium to avoid risk than to receive additional benefits.

A previous study performed by Burton and Pearse (2002), regarding functional food and GM technology, examines Western Australian attitudes towards GM beer with a lower cost of brewing (GM first generation) or increased antioxidants (medical benefits). Authors conclude that consumers are divided in three groups regarding the GM presence in beer. The first group of respondents were not prepared to select a GM beer at any price. The second group would require some price discount to purchase a beer with first generation GM involved, and finally, the third group places a premium on GM beer with medicinal benefits. This segmentation regarding to GM food was confirmed by James and Burton (2003). Actually, they reveal that some respondents require an infeasible discount to consume GM foods, whereas two thirds of the sample studied was prepared to consume GM foods under certain conditions. Moreover, one third of the sample was not prepared to pay any premium to avoid GM foods. A further analysis was performed by Rigby and Burton (2006) for the UK market. They conclude that a segment of the UK market (ranging from 5% to 24%) may be prepared to buy GM food at discounts of up to 10%, whereas an additional market share gained by further discounting is small.

A further important determinant of consumers' attitudes towards GM food was revealed by Burton et al. (2001), James and Burton (2003) and Onyango et al. (2004a). These studies recognized that attitudes toward GM foods are related to the type of genes involved in the modification. Onyango et al. (2004a) measures U.S. consumer preferences for GM food (banana) and show that genetic modification involving animal genes, bacterium, and plant genes had a negative effect on choice, and that compensation was required to include acceptance of processes involving animal, bacterium and plant genes. Conversely, if the GM bananas were a result of own gene transfer, consumers were willing to pay 3% more for the product. Analogously, Burton et al. (2001) revealed that U.K. consumers were more concerned with the use of animal genes in GM technology than of plants genes as a significant determinant of their choice. In addition James and Burton (2003) conclude that Australians are more willing to accept GM food production if animal genes are not included in that technology. Burton et al. (2001) show that attitudes towards organic food are found to be a useful indicator of attitudes towards GM technology. In fact, consumers concerned with organic food consider the use of plants genes in GM technology as a significant determinant for their choice, whereas consumers who are not concerned are indifferent regarding this attribute. Conversely, almost all consumers consider the use of animal genes in GM technology as a significant determinant for their choice.

The empirical literature on the issue also show some consensus when identifying significant individual specific characteristics for determining attitudes towards GM technology. In fact, Burton et al. (2001), and James and Burton (2003) recognize that gender significantly affects the preferences for GM food. Moreover, Burton and Pearse (2002) and James and Burton (2003) find that age of the respondent was a significant modifier of attitudes. Finally, Burton and Pearse (2002) show that concerns about cholesterol level affects consumers' preferences for GM food.

Finally, the analysis of consumers' WTP for GM food was also performed based on labelling. Particularly, Onyango et al. (2004b) and Carlsson et al. (2007) examine U.S. and Swedish consumers WTP for GM products, respectively, under a particular labelling regime. Onyango et al. (2004b) conclude that a positive mean willingness to pay was associated with the following labelling statement: "Contains NO genetically modified corn", "USDA approved genetically modified corn", and "Corn genetically modified to reduce pesticide residues in food". Contrary, consumers will require a discount for the statement "may contain GM corn" and "contains genetically modified corn". Carlsson et al. (2007) reveals that Swedish consumers are willing to pay a significantly higher premium to ensure a total ban on the use of GM in animal fodder. However, there is no significant difference in WTP between a ban of GM content and a labelling scheme. In fact, this outcome is consistent with finding from north-European countries such as Germany. Enneking (2004) show that German consumers are able to charge a price premium of up to 20 per cent to those products marketed with a label indicating food safety by means of a Q&S "quality and safety" label.

3.4 Description of choice experiment methodology

Within the Choice experiment framework, individuals select among alternative options, where each option is characterised by a number of attributes with different levels (Burton et al., 2001). Discrete choice experiments are based on the premise that a good can always be characterized by its characteristics or attributes. Moreover, the Lancaster consumer theory (Lancaster, 1966) states that goods are selected by consumers, either independently or in combination, based on their characteristics which are the source of consumers utility (Louviere et al., 2000). Random utility theory states (MacFadden, 1974) that individuals will choose, among a set of alternatives, the good that generates the highest utility. Therefore, the probability of choosing an alternative will be higher if its associated utility is higher than alternative choices (Loureiro et al., 2007). Moreover, as Hensher et al. (2005) state, this utility level is related to the utility of another alternative in the choice set.

Thus, the utility associated with the choice for individual q of alternative $i\,(U_{iq})$, comprise two separate utilities: a deterministic or observable component V_{iq} and an unobservable or random component ε_{iq} (the random error), such as:

$$U_{iq} = V_{iq} + \varepsilon_{iq}\,, \tag{1}$$

There are as many equations as alternatives in the choice set. Therefore, it can be defined as a choice of $j = 1,...,i,...,J$ alternatives, where J is the number of available alternatives in the choice set faced by an individual.

V_{iq} is called the "representative utility", which is generated by attributes that can be observed by the researcher (Louviere et al., 2000), and can be defined as a linear expression in which each attribute is whitened by a unique weight to account for an attribute's marginal utility input (Hensher et al*.,* 2005). That is,

$$V_{iq} = (\Sigma_{k=1}^{K} \beta_{ik} X_{ikq})\,, \tag{2}$$

where, X is the set of vectors of measured attributes. There are $k = 1,...,K$ attributes. Moreover, β 's are utility parameters associated with attribute X_k and alternative i, and initially assumed to be constant across individuals. It is important to highlight that consumers maximize deterministic utility. Utility is a stochastic parameter only from the analyst's standpoint (Louviere et al., 2000; Burton et al., 2001).

The key assumption is that individual q will choose alternative i if and only if:

$$U_{iq} > U_{jq} \text{ all } j \neq i \in A \tag{3}$$

As mentioned above, the probability of an individual q choosing alternative i is equal to the probability that the utility of the alternative is greater than the utility associated with any other alternative in the choice set (Louviere et al., 2000). That is,

$$P_{iq} = \Pr ob(U_{iq} \geq U_{jq}) \forall j \in j = 1,...,J; i \neq j)\ , \tag{4}$$

which is equivalent to:

$$P_{iq} = P\lfloor \varepsilon_{jq} < V_{iq} - V_{jq} + \varepsilon_{iq}\,, \quad \forall j \in j = 1,...,J; j \neq i \rfloor \tag{5}$$

The unobserved component in (1) (ε_{iq}) is treated as a random piece of information (Hensher et al*.,* 2005). Usually two assumptions are made on this component. First, every sampled individual resides along a real line and is randomly assigned to a location. Second, this real line has an allocation rule that is driven by a specific statistical distribution (Hensher et al*.,* 2005). Therefore, the location of each individual, although randomly assigned, will ensure that the mapping takes a specific shape in the utility space (Hensher et al*.,* 2005).

A popular distribution in discrete choice analysis is the extreme value type 1 distribution (EV1). This distribution states that the random elements in utility (ε_{iq}) are independent across alternatives and are identically distributed (IID) (Maddala, 1997), and is given by:

$$P(\varepsilon_j \leq \varepsilon) = \exp(-\exp - \varepsilon) = e^{-e^{-\varepsilon}} \tag{6}$$

Louviere et al. (2000) state that each ε_j is assumed to be independently distributed and the probability of choosing alternative $i, (P_i)$, may be written as the product of $J-1$ terms using (6). In fact, for some given value of ε_i (say b), equation (6) can be written as:

$$P_i = \exp(-b)\exp\left[-\sum_{j=1}^{J}\exp-(b + V_i - V_j)\right]. \tag{7}$$

From (7) following (Louviere et al*.,* 2000) we can calculate the probability of an individual q choosing a particular alternative i out of the set of J alternatives as:

$$P_i = \frac{1}{\sum_{j=1}^{J}\exp-(V_i - V_j)}; j = 1,...i,...,J \quad i \neq j, \tag{8}$$

Which lead to use the conditional logit choice or conditional multinomial logit (MNL) model.

Maximum likelihood is usually used to estimate the population parameters from the observed sample. Particularly, the likelihood function for the multinomial conditional choice model is given by:

$$L^* = \sum_{q=1}^{Q} \sum_{j=1}^{J} f_{jq} \ln P_{jq} , \tag{9}$$

where $f_{iq} = 1$ if alternative j is chosen and $f_{iq} = 0$ otherwise.

It is also important to consider that socio-demographic characteristics (SDC) are suitable to be introduced in the former model that leads us to define a model considering respondents heterogeneity. However, these characteristics are invariant across choices made by individual q, which implies that they will not impact all choices made if they are introduced linearly (Burton, 2001; and Hensher et al., 2005). Therefore, SDC must be introduced into the analysis as follows (Hensher et al., 2005):

$$V_i = \beta_{oiq} f(X_{1iq}) + \beta_{2iq} f(X_{2iq}) + \ldots + \beta_{kiq} f(X_{kiq}) + \alpha_{1qi} f(S_{1q}) + \alpha_{2qi} f(S_{2q}) + \ldots + \alpha_{nqi} f(S_{nq}) \tag{10}$$

where α_{nqi} is the weight for the nth SDC for alternative i and person q and S_{nq} is some measurement of the associated nth SDC for person q.

Replacing equation (10) in equation (8), the probability of an individual q choosing option i out of the set of J alternatives will be:

$$P_{iq} = \frac{\exp\left(\sum_k \beta_k X_{ki} + \sum_k \sum_n \alpha_{kn} (X_{ki} \times S_{nq} \right)}{\sum_{j=1}^{J} \left[\exp\left(\sum_k \beta_k X_{kj} + \sum_k \sum_n \alpha_{kn} (X_{kj} \times S_{nq}) \right) \right]} \tag{11}$$

3.5 Experimental design

The survey was administered by a research market company during spring 2007 by a face to face questionnaire. Before implementing the survey, a pre-test was conducted by means of telephone interviews. Finally, a total of 314 final questionnaires were completed[12.] These were distributed among 6 regions in almost equal percentages –Galicia, Murcia, Andalusia, Madrid, Extremadura and Catalonia.

In addition to the choice-modelling question, the survey also considers other socioeconomic and demographic questions in order to examine how heterogeneity influences the respondents' choices (Table 3.1). First, sample age distribution was almost equal among predefined age groups starting at 18 years old. Moreover, 80% of respondents are located in what is defined as the medium income level and 15% of the sample corresponds to high income levels. Unlike, the 5% remaining can be allocated on the lowest income category. There is a clear majority of females among Spanish respondents that can be explained by the fact that women are the ones that traditionally perform food purchasing. More than 60% of Spanish respondents continue educational studies after 16 years old. However, only about 25% of respondents achieve higher education. About 5% do not respond to this question. Finally, around 60% of the respondents do not have children in school or at preschool age. Moreover, 18% have only one child, from where 36% are pre-school age and 44% are school age. The remaining 10% have two or more children, of which 18% are pre-school age. These variables have been included in the analysis by interaction with the attribute levels as explained in equations (10) and (11) (Burton et al., 2001; and Kallas at al., 2007).

Table 3.1 Socio-Demographic characteristics.

Characteristic	Levels
Income level (currency/year)	<7; 7-22; 22-37; 37-52; >52 *1000 €
Age	18-25; 26-40; 41-65; >65
Gender	Male; Female
Studies	Primary School; High school; University
Children in school/nursery	No; Yes

Questions regarding food purchasing behaviour have been also requested in this survey, such as: food qualities that can influence food purchasing, awareness of GM issues, information sources about genetic engineering in food production and finally attitudes towards GM technology and organic products/methods.

Finally, a choice-modelling experiment was performed within this survey. The first step in the choice-modelling experiment is the selection of product attributes,

[12] Three were not fully responded and eliminated from the analysis.

which was completed taking into account the most relevant parameters associated to the product in order to define a realistic good. To do so, some possible techniques are available and commonly used, such as focus groups, pilot questionnaires and a Delphi survey, among others. For this study a pilot questionnaire was performed. After that, two choice-modeling experiments with three attributes each were defined, one analysing cornflakes and the other analysing tomatoes. On the one hand, price, production technology and product functionality were used for the cornflakes design. Alternatively, for the tomato case, price, production technology and country of origin were employed (Table 3.2).

Table 3.2 Attributes and levels

Cornflakes		**Tomatoes**	
Attribute	Level	Attribute	Level
Production technology	Conventional, Organic, GM health benefits, GM environmental benefits	Production technology	Conventional, Organic, GM health benefits, GM environmental benefits.
Price (500g)	1.00, 2.00, 2.80 , 3.50 €	Price (1kg)	1.00, 2.00, 2.70 , 3.50 €
Product functionality	Regular, less carbohydrates	Origin	Imported, Locally produced

In addition to attribute definitions, attribute levels also require discussion. In fact, attribute levels were defined based on different parameters. For the attribute price, a market research was performed in order to define the lower and the highest price in the current market. Next, some research on consumer concerns for food purchasing was performed both by the pilot questionnaire and via scientific publications, in order to define the associated levels to production technology and product functionality attributes. Finally, some efficiency parameters on efficient choice design were also considered. At the end of the day, both product functionality and origin were defined as dichotomous variables. Cornflakes were defined to be normal or with less carbohydrates. Otherwise, tomatoes could be locally produced (Spanish) or imported. The second attribute specified was production technology, which could be *conventional*, *organic*, *GM with associated health benefits and GM with associated environmental benefits.* Finally, the last attribute defined was price, which presents also four levels, based in real market prices (See Table3.2).

The already defined combination levels and the decision to construct a main effect design, with three choices for choice set, lead to a 100% efficient design (Table 3.3). The decision of using a main effects design without considering interaction effects is based on a trade-off between simplicity and efficiency; that is, on the choice between the total explained variance and the number of choice sets associated with each design. Particularly, main effects explain up to the 80% of the model variance, whereas interaction effects explain an additional 2 or 3% (Louviere et al., 2000). In contrast, the interaction effect increases the number of choice sets, which has made the experiment implementation very complicated.

To construct the main effects model, a fractional factorial design generation was used giving a total of 16 alternatives (orthogonal main effects design[13]) -since a full factorial design implies too many combinations-. Each respondent was asked to select between three alternatives within a choice set (Table 3.3). Moreover, to avoid respondents tiring, the 16 choice sets were split on two groups (blocking), therefore, each respondent was asked to complete 8 random choices for each product – two products per respondent (cornflakes and fresh tomato) (Louvier et al*.,* 2000).

Table 3.3 Final Fractional Factorial design

	Choice	Option 1			Option 2			Option 3		
		A1	A2	A3	A1	A2	A3	A1	A2	A3
Block 1	Choice 1	0	1	1	1	2	0	3	0	0
	Choice 2	2	1	0	3	2	1	1	0	1
	Choice 2	3	0	0	0	1	1	2	3	1
	Choice 4	1	0	1	2	1	0	0	3	0
	Choice 5	2	0	1	3	1	0	1	3	0
	Choice 6	1	2	1	2	3	0	0	1	0
	Choice 7	2	3	0	3	0	1	1	2	1
	Choice 8	2	2	1	3	3	0	1	1	0
Block 2	Choice 9	0	2	0	1	3	1	3	1	1
	Choice 10	0	3	1	1	0	0	3	2	0
	Choice 11	3	3	1	0	0	0	2	2	0
	Choice 12	0	0	0	1	1	1	3	3	1
	Choice 13	1	3	0	2	0	1	0	2	1
	Choice 14	1	1	0	2	2	1	0	0	1
	Choice 15	3	2	0	0	3	1	2	1	1
	Choice 16	3	1	1	0	2	0	2	0	0

A: attributes (A1: Price; A2: Production technology; A3: Product functionality/country of origin)
0,1,2 : attribute levels.

Up to this point a "*conditional choice*" (Hensher et al*.,* 2005) has been defined. However, an addition question for each choice was introduced into the survey. This was the real intention of buying the selected alternatives elected for each choice set. This

[13] Employing the SPSS statistical package.

question allows us to distinguish among consumers who would prefer not to buy as a fourth alternative. This additional question allowed us to test for the necessity of including the no choice option. Previous literature disagrees on this matter (Loureiro et al., 2007). Therefore, a repetition of the empirical analysis considering a four alternative choice model was done.

3.6 Statistical model to be used

Two basic empirical specifications for each product were defined in order to detect model consistency. Particularly, price has been considered alternatively as a linear continuous variable or a discrete variable. All other variables are discrete. In addition, discrete variables were coded using effect code[14] and specifications are as follows:

Cornflakes case:

- Price as a continuous variable

$$U_{iq} = \beta_1 price_{iq} + \beta_2 organic_{iq} + \beta_3 GMhb_{iq} + \beta_4 GMeb_{iq} + \beta_5 less\,carb_{iq} + \varepsilon_{iq} \qquad (12)$$

- Price as a set of dummy variables

$$U_{iq} = \beta_1 price2_{iq} + \beta_2 price3_{iq} + \beta_3 price4_{iq} + \beta_4 organic_{iq} + \beta_5 GMhb_{iq} + \beta_6 GMeb_{iq} + \beta_7 lesscarb_{iq} + \varepsilon_{iq} \qquad (13)$$

Tomato case

- Price as a continuous variables

$$U_{iq} = \beta_1 price_{iq} + \beta_2 organic_{iq} + \beta_3 GMhb_{iq} + \beta_4 GMeb_{iq} + \beta_5 locally\ produced_{iq} + \varepsilon_{iq} \qquad (14)$$

- Price as a set of dummy variables

$$U_{iq} = \beta_1 price2_{iq} + \beta_2 price3_{iq} + \beta_3 price4_{iq} + \beta_4 organic_{iq} + \beta_5 GMhb_{iq} + \beta_6 GMeb_{iq} + \beta_7 loc.prod._{iq} + \varepsilon_{iq} \qquad (15)$$

where, U_{iq} is the latent unobservable utility level that the qth consumer obtains from choosing the ith alternative. Moreover, the intrinsic attributes associated with the

[14] For effects code the utility of the base level can be estimated as $\beta_{0i} - (\beta_{2i} + \beta_{3i} + \beta_{4i})$ for each attribute (Hense et al., 2005 and Louviere et al., 2000). Since the choice experiment is unlabelled, β_{0i} equals zero. Therefore, the base level was computed as zero minus the sum of the other levels' coefficients

product examined are noted as *price*, *organic*, *GMhb*, *GMeb*, *less carb and locally produced* , see Table 3.1. This conditional multinomial logit model was estimated using the maximum likelihood statistical specification.[15]

Finally, the financial indicator WTP (willingness to pay) will be calculated for the model in which the price has been introduced as a continuous linear variable. In particular, consumers' WTP was computed as the premium to shift from level (i) to level (j) of attribute (A), ceteris paribus. This can be defined as:

$$\beta_{Ai} + \beta_p p_i = \beta_{Aj} + \beta_p p_j \quad considering,\ p_j = p_i + x \qquad (16)$$

where β_{Ai} and β_{Aj} are the estimated coefficients of the i and j levels of attribute A, and β_p is the coefficient of the continuous linear price component (Mtimet, 2006).

Therefore:

$$x = \frac{\beta_{Ai} - \beta_{Aj}}{\beta_p} \qquad (17)$$

In addition, the Krinsky and Robb with 1000 repetitions, and the Delta approach were used to estimate confidence intervals for WTP measures. These methods were compared by Risa (2006) who generated similar confidence intervals.

3.7. Results

The survey was completed by 314 maize and Tomato consumers. However, three questionnaires where not totally completed and therefore, eliminated from the sample. The final amount of questionnaires analyzed was 311, providing a total of 2,488 choice sets by product (7,464 observations).

[15] the statistical package used has been STATA 10

3.7.1 Aggregate results for Cornflakes

Results obtained from the *conditional* choice model, already described, are presented in Table 3.4. Primarily, the likelihood ratio test (LR) values show that the models are statistically significant at conventional critical levels, that is, the joint hypothesis that β_s parameters are equal to zero is rejected. In addition, the pseudo R^2 value shows that the specifications are acceptable. Moreover, the Hausman test of independence of irrelevant alternatives (Hausman and McFadden, 1984) leads us to fail to reject the hypothesis of no systematic difference in coefficients for all specifications, which supports the adequacy of the conditional logit model for the analysis.

Table 3.4 Discrete Choice conditional multinomial logit results for cornflakes in Spain (*Conditional* choice).

Attributes	*Model 1*		*Model 2*	
	Coef	Std. Err.	Coef	Std. Err.
Organic	0.361***	0.037	0.363***	0.037
GM Health Benefits	0.157***	0.038	0.156***	0.038
GM Environmental Benefits	-0.651***	0.046	-0.651***	0.046
P3 (3.5 €)	---	---	-0.428***	0.042
P2 (2.8 €)	---	---	-0.255***	0.040
P1 (2 €)	---	---	0.216***	0.037
Price	-0.376***	0.024	---	---
Low carbohydrates	0.001	0.022	0.001	0.022
N. Observations	7464		7464	
LL value	-2487.1975		-2483.0062	
LR	492.30***		500.68***	
Pseudo R^2	0.090		0.091	

*** Significant at the 1% level.

Results also show that all variables except the carbohydrate level have a significant influence on Spanish consumers' utility. Moreover, the estimation of utility parameters coefficients reveal that for the attribute production technology, "organic" is the level that increases more consumers' utility measure compared with conventional cornflakes. As well, Genetic Modified (GM) maize with associated health benefits also has a positive impact on respondents' utility in relation to conventional maize. In contrast, GM maize with environmental effects is associated with a negative impact on consumers' utility, which implies less probability to be chosen by consumers, relative to the conventional product. The sign of the coefficient on attribute price is negative, indicating that as price increases consumers' utility decreases. In this context, both model specifications are robust. Moreover, this result is also consistent with the other findings from the survey where respondents revealed that price was considered for purchases.

From the estimated parameters, concerning WTP, each attribute level has been calculated as indicated in expression (17). Results are shown in Table 3.5. The Spanish sample show a positive premium to GM cornflakes with associated health benefits (0.064€ per box). That is, on average, 0.064€ per box is the premium that consumers are prepared to pay for GM cornflakes with associated health benefits compared to conventional ones, implying to raise its cost of almost 3% more relative to the average market price for cornflakes in Spain. In any case, the largest WTP refers to organic cornflakes which is about 0.607 € per box. This represents a 26% increase in price compared with the market average price for cornflakes in Spain. Finally, the purchase of GM cornflakes with associated environmental benefits requires a discount of 2.082 € per box, that is more than 89% less than the market average price for conventional cornflakes.

Table 3.5 Estimated WTP to change from conventional to other attribute level for a 500gr box of cornflakes (€/500g of cornflakes) (*Conditional* choice).

Attributes	*Organic*	*GM Health Benefits*	*GM Environmental Benefits*
WTP	**0.607**	**0.064**	**-2.082**
Confident intervals			
Krinsky and Robb	(0.275;0.923)	(-0.270;0.357)	(-2.548;-1.706)
Delta method	(0.295;0.919)	(-0.249;0.377)	(-2.521;-1.643)

If we consider the no option alternative, we observe minor changes on results compared with the *conditional* choice model results shown in Tables 3.6 and 3.7. In fact, the same variables are significant and the same signs were obtained. So as for WTP, we observe that a modestly higher willingness to pay or willingness to accept is revealed by means of the *conditional* model estimations. Indeed, the only relevant difference exists for the GM cornflakes with associated health benefits. In this case, consumers willingness to pay shifts from about 3% more than the average, if we consider the non option possibility, to a willingness to accept a discount of 1% less than the average price for conventional cornflakes when introducing the non option possibility.

Table 3.6 Discrete Choice conditional multinomial logit results for cornflakes in Spain (considering the no choice option).

Attributes	*Model 1*		**Model 2**	
	Coef	Std. Err.	Coef	Std. Err.
Organic	0.449***	0.040	0.451***	0.040
GM Health Benefits	0.127***	0.042	0.124***	0.042
GM Environmental Benefits	-0.711***	0.052	-0.711***	0.052
P3 (3.5 €)	---	---	-0.509***	0.048
P2 (2.8 €)	---	---	-0.259***	0.045
P1 (2 €)	---	---	0.229***	0.040
Price	-0.431***	0.024	---	---
Low carbohydrates	0.016	0.022	0.015	0.024
N. Observations	6330		6330	
LL value	-2057.64		-2054.8605	
LR	520.87 ***		526.42 ***	
Pseudo R^2	0.1123		0.1135	

*** Significant at the 1% level.

Table 3.7 Estimated WTP to change from conventional to other attribute level for a 500gr box of cornflakes (€/500g of cornflakes) (considering the no choice option).

Attributes	*Organic*	*GM Health Benefits*	*GM Environmental Benefits*
WTP	**0.723**	**-0.024**	**-1.967**
Confident intervals			
Krinsky and Robb	(0.404;1.025)	(-0.348;0.277)	(-2.411;-1.599)
Delta method	(0.424;1.021)	(-0.326;0.279)	(-2.383;-1.550)

3.7.2 Aggregate results for Tomato

Table 3.8 shows the estimated parameters for the *conditional* model, taking into account the tomato election, as well as its main goodness-of-fit measures. As can be observed, the likelihood ratio test (LR) values show that in both models we fail to reject the joint non significance of estimated parameters. In addition, the pseudo R^2 show that the specifications are acceptable. Moreover, the Hausman test of independence of irrelevant alternatives (Hausman and McFadden, 1984) leads us to accept the hypothesis of no systematic difference in coefficients for all specifications, whick supports the conditional logit model for this analysis.

Table 3.8 Discrete Choice conditional multinomial logit results for tomato in Spain. (*Conditional* model)

Attributes	*Model 1*		**Model 2**	
	Coef	Std. Err.	Coef	Std. Err.
Organic	0.401***	0.038	0.398***	0.038
GM H. B.	0.109***	0.039	0.115***	0.039
GM E.. B.	-0.532***	0.045	-0.537***	0.046
P3 (3.5 €)	---	---	-0.492***	0.045
P2 (2.7 €)	---	---	-0.260***	0.042
P1 (2 €)	---	---	0.185***	0.038
Price	-0.443***	0.025	---	---
Locally produced	0.345***	0.023	0.344***	0.023
N. Observations	7464		7464	
LL value	-2374.7701		-2372.3044	
LR	717.15***		722.09***	
Pseudo R^2	0.132		0.132	

*** Significant at the 1% level

All variables have a significant influence on Spanish consumers' utility and have the expected sign. In particular, the attribute production technology presents similar utility relations as in the case of maize. That is, organic tomato increases consumer utility, compared with conventional tomato, followed by Genetic Modified (GM) tomatoes with health benefits. Contrary, GM tomatoes with environmental benefits is associated to a negative impact on consumers' utility related to conventional tomatoes. The second attribute, origin, has also a positive effect on consumers' utility, indicating that Spanish consumers prefer to consume locally produced tomato than imported. Finally, the price attribute also presents results similar to the case of maize. Higher prices are associated to decreasing utilities.

The calculated WTP from the estimated parameters are shown in Table 3.9. As can be observed, Spanish consumers, as in the case of cornflakes, place a positive premium on GM tomatoes with associated health benefits (0.198€/kg) compared to the conventional counterpart. That is, consumers are prepared to pay on average 2% more relative to the Spanish average market price for tomatoes. Alternatively, the presence of associated environmental benefits on GM tomatoes correspond to a discount of 1.25€/kg compared with conventional tomatoes, implying a reduction on the cost of tomatoes by about 13%, relative to the Spanish average market price for tomatoes. In addition, Spanish consumers are willing to pay the highest premium (0.856€/kg), compared to the conventional tomato, which represents an average increase of 9% in relation to the average market price for tomatoes, in Spain. Finally, locally produced tomatoes are higher valued than imported tomatoes. The premium Spanish consumers are willing to pay is 1.56 €/kg (or 17% over the average market price).

Table 3.9 Estimated WTP to change from conventional or imported tomato to other attribute level for a kg of tomatoes (€/kg of tomato). (*Conditional* model)

Attributes	*Organic*	*GM Health Benefits*	*GM Environmental Benefits*	*Locally Produced*
WTP	**0.856**	**0.198**	**-1.250**	**1.558**
Confident intervals				
Krinsky and Robb	(0.555;1.141)	(-0.094;0.458)	(-1.599;-0.947)	(1.324;1.834)
Delta method	(0.575;1.137)	(-0.079;0.476)	(-1.589;-0.911)	(1.303;1.813)

Considering the no option alternative, as well as in the cornflakes case, minor changes result when compared with the *conditional* choice model (see Tables 3.10 and 3.11). In fact, all variables but GM tomatoes with associated health benefits are significant on the two models. For this type of product the level of significance changes from 1% to 10% when considering the no option alternative. No differences are observed among the variables signs. Furthermore, a small decrease on the WTP for locally produced tomatoes is detected when considering the non option alternative. Moreover, a slight decrease on the discount required for the consumption of GM tomato with associated environmental benefits has also been noticed.

Table 3.10 Discrete Choice conditional multinomial logit results for tomato in Spain. (Considering the no choice option).

Attributes	*Model 1*		**Model 2**	
	Coef	Std. Err.	Coef	Std. Err.
Organic	0.484***	0.042	0.486***	0.042
GM H. B.	0.073*	0.044	0.073*	0.044
GM E.. B.	-0.568***	0.051	-0.566***	0.051
P3 (3.5 €)	---	---	-0.671***	0.053
P2 (2.7 €)	---	---	-0.233***	0.046
P1 (2 €)	---	---	0.231***	0.042
Price	-0.443***	0.025	---	---
Locally produced	0.369***	0.026	0.367***	0.026
N. Observations	6345		6345	
LL value	-1939.24		-1937.8379	
LR	768.66 ***		771.45 ***	
Pseudo R^2	0.165		0.166	

*** Significant at the 1% level; * Significant at the 10% level

Table 3.11 Estimated WTP to change from conventional or imported tomato to other attribute level for a kg of tomatoes (€/kg of tomato). (Considering the no choice option).

Attributes	*Organic*	*GM Health Benefits*	*GM Environmental Benefits*	*Locally Produced*
WTP	**0.880**	**0.119**	**-1.070**	**1.368**
Confident intervals				
Krinsky and Robb	(0.609;1.132)	(-0.152;0.369)	(-1.394;-0.787)	(1.166;1.609)
Delta method	(0.628;1.132)	(-0.134;0.372)	(-1.373;-0.767)	(1.148;1.588)

3.7.3 Models considering respondents heterogeneity (with SDC)

In order to examine how respondent's heterogeneity influence consumers' choices, a hybrid conditional logit model with sociodemographic characteristics has been defined. These variables were included as interactions since they do not change within alternatives (see equation 10). Each specific characteristic was separately estimated. In brief, results show that the likelihood ratio test (LR) values are statistically significant at conventional critical levels for all models, and all pseudo R^2 show that model specifications are good. Therefore, the models can be considered as statistically relevant.

All attributes are significant for all models. However, not all interactions are significant. This lack of importance of interactions in the hybrid model does not imply insignificance of the individual specific variables when computing WTP values; see Kallas et al. (2007).

The WTP for the hybrid model has been calculated as follows (Kallas et al., 2007):

$$x = \frac{(\beta_{Ai} + \alpha_{Ai} * S_1 + ... + \alpha_{Ai} * S_n) - (\beta_{Aj} + \alpha_{Aj} * S_1 + ... + \alpha_{Aj} * S_n)}{(\beta_p + \alpha_P * S_1 + ... + \alpha_p * S_n)} \quad (18)$$

where all variables have been previously defined.

In the case of cornflakes (Table 3.12), SDC are not relevant when explaining differences in consumer's utilities associated with product attitudes in Spain. Only age and education seem to partially explain some differences. As can be observed in Table 3.12, younger consumers value GM cornflakes with associated environmental benefits more positively than oldest people. On the other hand, respondents with a university degree place a higher premium on organic cornflakes than other respondents with lower degrees. In addition, the higher the respondents' income level is, the higher is the compensation required to buy GM cornflakes with associated environmental benefits compared with conventional cornflakes, except for consumers with the highest level, who are willing to pay to get this product. In any case, this income group represents less than 3% of the Spanish sample and individual values shows great heterogeneity.

However, in the case of tomatoes, all SDC seem to be relevant explaining differences in consumer's utilities associated with the origin attribute (Table 3.13). As can be observed, respondents' income level increases the WTP for local production compared to imported tomatoes (except for the upper extreme, for which the same comment as above applies). Middle age respondents (from 26-65 years old) are willing to pay a higher premium for locally produced tomatoes than both the oldest and the youngest; the latter being the ones that are willing to pay the lower premium to locally produced tomatoes. Education level also matters. A higher education level is associated with higher premiums for locally produced tomatoes. Finally, both females and respondents with children in school are willing to pay a higher premium for local produced tomatoes than males and people with no children in school, respectively.

In the end, considering the hybrid model with the no option alternative, similar changes as for the aggregate model were observed compared with the *conditional* choice. Consequently, Tables with the WTP for the no option hybrid model are not presented.

Table 3.12 Estimated WTP for a 500gr box of cornflakes considering individual specific characteristics (€/500g of cornflakes).

	organic					**GM Health Benefits**					**GM Environmental Benefits**				
INCOME -1000	*<7*	*7-22*	*22-37*	*37-52*	*>52*	*<7*	*7-22*	*22-37*	*37-52*	*>52*	*<7*	*7-22*	*22-37*	*37-52*	*>52*
WTP	**0.216**	**0.273**	**0.867**	**2.799**	**0.144**	**0.027**	**-0.220**	**0.410**	**0.464**	**-1.140**	**-0.687**	**-2.169**	**-1.998**	**-2.851**	**-18.184**
Age	18-25		26-40	41-65	>65	18-25		26-40	41-65	>65	18-25		26-40	41-65	>65
WTP	**0.848**		**0.881**	**1.374**	**-0.053**	**0.577**		**0.223**	**-0.130**	**-0.371**	**0.577**		**0.223**	**-0.130**	**-0.371**
Gender	Male			Female		Male			Female		Male			Female	
WTP	**0.503**			**0.629**		**0.311**			**-0.026**		**-1.053**			**-2.470**	
Studies	Primary School		High school		University	Primary School		High school	University		Primary School		High school	University	
WTP	**0.233**		**0.501**		**2.317**	**0.165**		**-0.124**	**1.086**		**-1.947**		**-1.944**	**-2.290**	
School	No			Yes		No			Yes		No			Yes	
WTP	**0.333**			**0.692**		**-0.013**			**0.087**		**-1.346**			**-2.255**	

Table 3.13 Estimated WTP for a kg of tomatoes considering individual specific characteristics (€/kg of tomatoes)

	organic					**GM Health Benefits**				
INCOME -1000	*<7*	*7-22*	*22-37*	*37-52*	*>52*	*<7*	*7-22*	*22-37*	*37-52*	*>52*
WTP	**0.575**	**0.810**	**0.777**	**1.250**	**-11.506**	**0.097**	**0.090**	**0.328**	**0.464**	**2.254**
Age	18-25		26-40	41-65	>65	18-25		26-40	41-65	>65
WTP	**1.027**		**1.186**	**0.958**	**0.313**	**0.861**		**-0.090**	**-0.132**	**0.171**
Gender	Male			Female		Male			Female	
WTP	**0.485**			**0.959**		**-0.070**			**0.295**	
Studies	Primary School		High school		University	Primary School		High school	University	
WTP	**0.704**		**0.559**		**2.516**	**0.363**		**0.032**	**0.978**	
School	No			Yes		No			Yes	
WTP	**0.217**			**0.980**		**-0.293**			**0.282**	

	GM Environmental Benefits					**Locally Produced**				
INCOME -1000	*<7*	*7-22*	*22-37*	*37-52*	*>52*	*<7*	*7-22*	*22-37*	*37-52*	*>52*
WTP	**-0.121**	**-1.172**	**-1.393**	**-1.964**	**42.344**	***0.222***	***1.497***	***1.799***	***1.657***	***-42.562***
Age	18-25		26-40	41-65	>65	18-25		26-40	41-65	>65
WTP	**-0.961**		**-1.025**	**-1.113**	**-1.779**	***0.786***		***2.046***	***1.993***	***1.480***
Gender	Male			Female		Male			Female	
WTP	**-0.855**			**-1.428**		***0.797***			***1.849***	
Studies	Primary School		High school	University		Primary School		High school	University	
WTP	**-0.963**		**-1.127**	**-2.515**		***1.534***		***1.181***	***3.191***	
School	No			Yes		No			Yes	
WTP	**-1.267**			**-1.244**		***0.723***			***1.706***	

3.8 Concluding remarks

This study has attempted to estimate the valuation or willingness to pay for GM as compared to organics food using the stated choice experiments methodology. Our findings are the following.

Labelling and consumer reactions. While previous choice modelling literature on GM foods, such as Onyango et al. (2004a) and Christoph et al. (2006) among others, conclude that consumer's utility valuation of GM food is negative and no premium is found, we find that even though consumers do generally prefer organic food compared to conventional and GM food, Spanish consumers exhibit a moderate value GM food when it conveys associated heath benefits compared to conventional food. Our results highlight the importance of the labelling GM foods (information provision) and the type of genes involved in the modification. Some individual specific characteristics such as age and gender have been found significant in determining consumers' preferences.

Methodological contribution and choice design. Our methodological contribution lies in using two choice experimental designs to elicit consumers WTP for GM and organic food. In addition, we have explored the impact of introducing the no choice option for choice modelling analysis. A specific finding of the Spanish sample to highlight is that when consumers are forced to choose one of the three choice alternatives[16], results are consistent with the findings of Burton and Pearse (2002) at last for some segments of Australian consumers. However, when consumers have the option of not buying anything, individuals willingness to pay drops significantly. Hence, part of the former effect can be attributed to the nature of choice setting.

Product characteristics. From our results, we find that revealed consumption patterns, regarding GM and organic products, do not vary between processed and fresh food. That is, consumers revealed similar attitudes associated with the "production technology" attribute, for both cornflakes and tomatoes.

[16] To be prepared to pay a premium for GM processed food with associated health benefits of about 3% higher than the market average price

Compensation for environmentally friendly consumption. Respondents demanded compensation in order to choose GM food products enhancing environmental beneficial effects (first generation GM). Furthermore, individual characteristics, such as income, age, gender and education, seem to partially explain some differences between GM and organic food acceptance. Finally, no significant differences were found when comparing the *conditional* model and the model with the no choice option, suggesting that results are robust to choice settings.

Some caveats should be mentioned. Primarily, SDC are not especially relevant when explaining differences in consumer's utilities associated with product attitudes. Yet, policy implications are important. First, our findings suggest that labelling will have an effect on consumer reactions to GM food consumption. Second, these reactions are the same for both processed and fresh food. Third, research design exerts some mild effects on consumers' willingness to pay and finally, even though some GM products convey environmentally friendly characteristics, we still find that consumers demand a monetary compensation when as compared to existing choices.

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Chapter 4:

Risk perceptions, risk attitudes and the formation of consumer acceptance of Genetically Modified (GM) food.

4.1 Abstract

The influence of risk perception and risk attitudes in the process of accepting genetically modified (GM) food is often ignored, and particularly whether both constructs (latent variables) have a combined effect in explaining consumer acceptance. Similarly, the inclusion of organic product standards juxtaposed to GM food is unknown. This paper attempts to shed some light on this question by examining the decision making process through the use of structural equation modeling (SEM). We use survey data from Spain and a set of theoretical constructs that allow us to identify independent mechanisms underlying individuals' risk decision making. Our results suggest that the conceptualized model captures the decision making process, and that both perceptions and attitudes toward risk have independent effects on consumer acceptance. However, the effect from risk perception is larger in intensity. Finally, attitudes towards organic production emerge as an informative determinant of attitudes towards GM food.

4.2 Introduction

Consumer behavior regarding food has been intensely evaluated over time. However, technology changes bring new behavioral dimensions that shift decision making processes. The most relevant framework to understanding how individuals form their behaviors is the so-called "Theory of Reasoned Action" (TRA) (Fishbein and Ajzen, 1975). The TRA argues that an individual behavior is determined by her behavioural intention, which in turn is a function of personal attitudes towards the specific choice, along with her personal perception of social pressure. However, the TRA assumes that individuals have sufficient control over their decisions and that they have perfect information. This is not the case with newly commercialized products made from new technologies, where the choice scenarios are based on incomplete information. To fully incorporate imperfect information, the "Theory of Planned Behavior" (TPB) (Ajzen, 1991) considers the so-called "perceived behavioral control" parameter as a determinant for consumer behavior. Hence, individuals decide their actions with regard to future consequences, conditioned upon *available* information.

"Perceived behavioral control" is defined by (Ajzen, 2005), to be a function of beliefs concerning the presence or absence of factors that encourage or obstruct the execution of behavior. Perceived potential hazards related to behavior, namely *risk perceptions*, have been shown to be important determinants of this control issue. Indeed, risk perception, which depends on *available* information, is hypothesized to be a central element for the formation of consumer intentions under lack of full information (Fischhoff et al., 1993). Fischoff et al. (1993) argue that individuals need to understand the costs and benefits of behavioural choices as well as the limits to their knowledge and that of experts.

A paradigmatic example of risk decision making under incomplete information is the case of GM food and other food related choices, where incomplete information forces individuals to form risk perceptions based on uncertain damages (Costa-Font and Mossialos, 2007). Incomplete information may lead individuals to develop the perception that technology is not under their control, which in turn might exaggerate its risk perceptions intensity (Costa-Font and Mossialos, 2007). This adds to existing evidence that concluded that people overestimate low probability events and underestimate high probability events (Kahneman and Tversky, 1979; Viscusi, 1992; and Hurley and Shogren, 2005). Furthermore, Eom (1994) compared the effects of risk information across models and observed that technical risk information did not significantly affect purchase intention but it did when risk perceptions were controlled for. The role of risk perception as influencing GM food attitudes is confirmed in a number of studies such as Siegrist (1999 and 2000); Tanaka (2004); Yeung and Morris (2006); Loureiro and Bugbee (2005); and Bukenya and Wright (2007) among others. Other studies such as Baker and Burnham (2001) find the level of risk aversion (attitudes) to be a significant factor in determining engineering technology acceptance. However, the two characteristics, namely risk perceptions and risks attitudes, might show an independent influence on purchase likelihood, including "perceived knowledge" and "own control" which has a positive relationship with purchase likelihood (Yeung and Morris, 2006). To date, no behavioral evidence has been found conclusive on these effects.

Food decision making under limited information questions the adequacy of conventional risk models, which assume full knowledge of outcomes and probabilities Yeung and Morris (2006). Indeed, when information is scarce, individuals are subject to high levels of "unknown uncertainty" (or ambiguity) regarding the consequences of their behavior. Ambiguity has been defined by Frisch and Baron (1988) as "the subjective experience of missing information relevant to a prediction". When this ambiguity situation exists, consumers do not perceive control over the situation and therefore perceptions of risk increase due to the existence of ambiguity aversion described in several studies (see Slovic and Tversky, 1974; Saring and Weber, 1993; and Costa-Font and Mossialos, 2007). This explains the need for new models to analyze factors affecting potential food risk perception and its relation with consumer intentions from a more psychological standpoint.

The subjective dimensions affecting the intensity of risk perceptions in the case of GM food include the lack of voluntary acceptance of some aspects of risk-taking behavior, the lack of knowledge about certain risks, the existence of dread associated with some risks, the immediacy, irreversibility and intensity of impacts, and the possibilities to control or reduce the risk, among other factors (Kasperson et al., 1988). There is also evidence of gender-specific effects on risk perceptions (Hurley and

Shogren, 2005). Another important bias affecting the way people perceive risks for GM food is referred to as availability bias, which acts heuristically in the risk assessment process when individuals judge the likelihood of an event taking place based upon the mind's ability to recall previous occurrences of the same event (Tversky and Kahneman, 1973; Slovic et al., 1981).

In addition to how people perceive GM food risks, another important dimension to evaluate includes risk attitudes – in the form of risk aversion - in influencing consumer acceptance. Yet, the net effects of risk attitudes, once risks perceptions are controlled for, are still a matter of academic scrutiny. Weber and Hsee (1998) argue that culture significantly affects the determinants of risk perceptions, which might also impact risks aversion. As a result, the final amount of risk individuals take on is largely determined by both risk attitudes and perceptions. Though it is important to separate individual preferences and certain technologies, it is also important to separate the specific influence of risk perception from the influence of risk attitudes. Measurement is another issue concerning risk and attitudes. Risk attitudes are measured through different theoretical approaches (Hartog et al., 2002) or indirectly via survey data data (Barsky et al., 1997). However, a straightforward way to identify risks attitudes is by assuming revealed preferences, so that those who are risk averse would tend to purchase different forms of insurance. The latter is the approach followed in this study by disentangling the individual's effects of risk attitudes and perceptions in determining acceptance of GM food.

Under incomplete risk information, knowledge about product attributes is a key tenet of behavior intentions which calls for the consideration of the Fishbein Multi-attribute Model (Fishbein, 1963). Similarly, the role of personal characteristics and individual values (Grunert et al., 2003 and 2004; Bredahl, 2001; and Saher et al., 2006) appear as being important constructs as found in Grunert et al. (2001) who find that conventional foods are associated with safety and health, while GM foods are associated with uncertainty and poor health. Hence, values regarding the role of nature and particularly the consumption of organic food become key tenets underpinning behavior intentions. Indeed, Arvola et al. (2008) and Saher et al., (2006) find that Organic Food (OF) purchases are motivated by expected positive consequences for the self and for others, based on moral considerations and general attitudes (Chen and Li, 2007).

Consumers with high levels of food neophobia are less likely to try "unfamiliar" foods, such as GM food (Chen and Li, 2007). Similarly, Cox et al. (2007) observed that addressing an "information deficit" does not overcome aversion to novel technologies applied to food concepts. Finally, consumers appear to be cautious about accepting new technologies applied to food because of perceived risks and lack of benefits (Christoph et al., 2006).

The role of values explains the negative relationship observed when valuing GM and OF. Dreezens et al. (2005) observed that consumers relate GM to power and universalism values contrary to OF. This was also demonstrated by Saher et al. (2006) and Burton et al. (2001). Their results from a choice experiment indicate that attitudes towards organic food may be taken as a useful indicator of attitudes towards GM technology. In addition, Saher et al. (2006) explained this negative relation by means of the so-called behavioral inhibition responses to new and negative situations. He stated that since GM is associated with risk and OF with avoidance of it, there must be a negative relation between risk perceptions. Further, Lind et al. (2005) relate subjective food hypersensitivity with concern to food additives and GM food. Finally, Devcich et al. (2007) found that people with high "modern health worries" were more likely to choose functional foods with disease-preventing properties than either risk-reducing or appearance-enhancing properties. Moreover, they also found that modern health worries were significantly associated with a higher use of organic foods.

This paper attempts to examine the decision making process of GM food acceptance through the use of structural equation modeling (SEM) and incorporating two unexplored dimensions in previous work, Costa-Font and Gil (2008), namely the role of risk attitudes as separate from risk perceptions, and the importance of organic production *vis-à-vis* GM food purchase intentions. We use survey unique data from Spain and a set of self-determined variables that allow us to identify independent mechanisms underlying individuals' decision making regarding acceptance of GM food. Our results provide suggestive evidence of the empirical validity of the conceptualized decision making model. We find that both risk perceptions and risk attitudes have independent effects on consumer acceptance of GM food, although the effect of risk perception is comparatively more intense. As hypothesised, the study finds an independent relationship between individuals' personal values (e.g., "natural" food production) and purchase intentions. In addition, our results are consistent with the hypothesis of a positive relationship between valuation of OF standards and GM food risk perception.

This paper is structured as follows: section two present the hypothesis of analysis. Section three develops the utilized methodology as well as a description of the data. Then, section four provides the results of the study. Finally, section five contains conclusions and discussion.

4.3 Hypothesis

Base on the previous findings discussed above, the main factors affecting potential food risk perception and its relation with consumer purchasing intentions were presented in Figure 4.1 and summarized in the following hypothesis of analysis:

H1*: Consumers that reveal a positive attitude towards sensory considerations associated to naturalness and safe food - flavour, freshness and appearance- are expected to reveal a positive attitude towards organic food production standards.*

H2: *Consumers that perceive more risks associated with general food production technologies are expected to reveal a positive attitude towards organic production standards.*

H3: *Consumers that perceive more risks associated with general food production technologies are expected to perceived more risk of GMF.*

H4: *Consumers that reveal a positive attitude towards organic production standards are expected to perceive more risks associated with GMF.*

H5*: A perceived risk of GMF is expected to negatively influence consumer purchase intentions towards GM food.*

***H6**: Consumer risk- aversion is expected to negatively influence consumer purchase intentions towards GM food.*

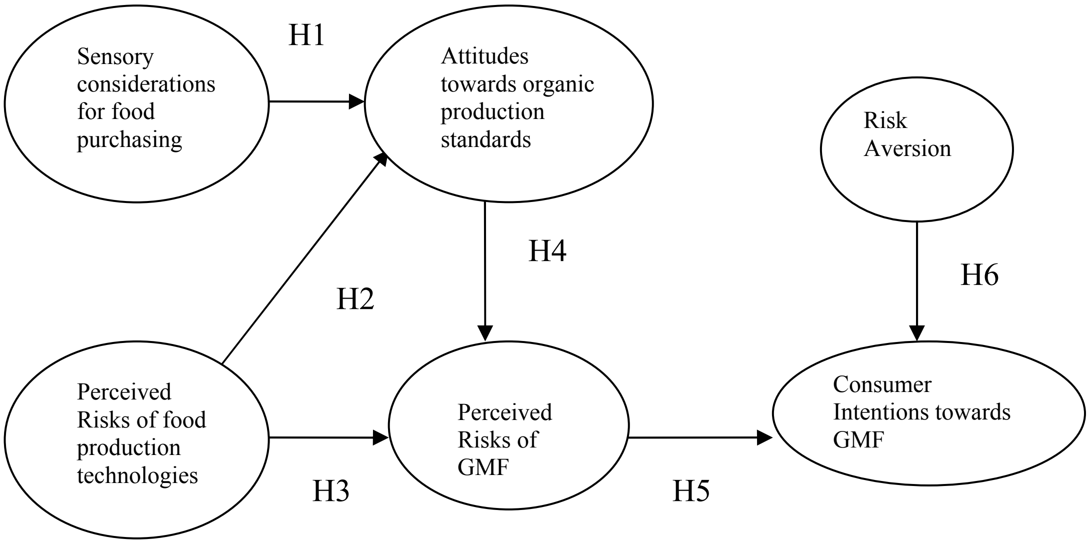

Figure 4.1 Theoretical process for shaping GM food purchase intentions.

4.4 Data and Methods

4.4.1 The sample

The data used in this study is a separate part of the survey described in chapter 3. It was administered, during spring 2007 by a face to face questionnaire. A total of 314 final questionnaires were used and distributed among 6 regions in almost equal percentages –Galicia, Murcia, Andalusia, Madrid, Extremadura and Catalonia. The sample age distribution was almost equal among predefined age groups starting at 18 years old and up to +65. Moreover, 80% of respondents are located in the medium income level and 15% of the sample are in the high household income, while the remaining 5% is allocated into the lowest income category. There is a clear majority of females among Spanish respondents (about 80%). More than 60% of Spanish respondents continue educational studies after 16 years old. However, only about 25% of respondents attended higher education. About 5% do not respond to this question. Finally, around 60% of the respondents do not have children in school or at pre-school age. Moreover, 18% have only one child, from where 36% are pre-school age and 44%

in school age. The remaining 10% have two or more children, while 18% of them are pre-school age.

4.4.2 Measurement

We consider possible survey responses to range from agree to disagree with responses of “undecided or indifferent” to be placed somewhere in between (Gaskell et al., 2004; Gaskell et al., 2006; and O’Connor et al., 2006; Costa-Font and Mossialos, 2007). All attitudinal questions and food technology risk perceptions were measured on a 5-level Likert scale, where “totally disagree” or “not at all important” responses are codified by an ordinal value of 1, “tend to disagree” or “not very important” by 2, “undecided or indifference” by 3, “tend to agree” or “important” by ordinal value 4 and finally, “totally agree” or “very important” by value 5. Questions regarding purchase intentions were measured in a 3-level Likert scale: “not willing to pay” (1), “willing to pay les than for conventional products” (2) and finally “willing to pay more than for conventional products” (3). Finally, in order to value risk aversion respondents were asked about their contracted insurances. A dichotomous variable was constructed to differentiate between those having contracted a compulsory insurance and those who did not. The list of indicators for each construct is shown in Table 4.1.

Table 4.1 List of indicators used for each construct.

Construct	Indicators
Sensory considerations for food purchasing (***C1)***	***X1:*** Please tell me how important is flavour in your food purchasing decisions? ***X2:*** Please tell me how important is freshness in your food purchasing decisions? ***X3:*** Please tell me how important is appearance in your food purchasing decisions?
Attitude towards organic production standards (***C2***)	***X4***: I am concerned about the harmful effect of chemical residues in food ***X5***: Organic products taste better than conventional ones
	X6: I am concerned about the effects of agriculture on the environment
Perceived Risks of GMF (***C3***)	***X7***: Eating genetically modified food might harm my health ***X8:*** Growing genetically modified crops will be harmful to the environment ***X9***: Genetically modified technologies will lead to healthier foods
Risk Aversion (***C4***)	***X10:*** Do you currently have health insurance? ***X11***: Do you currently have live insurance? ***X12:*** Do you currently have not compulsory car insurance?
Perceived Risks of food production technologies (***C5)***	***X13:*** Please rate irradiation of food in terms of risk to human health. ***X14:*** Please rate artificial colours and flavours in terms of risk to human health. ***X15:*** Please rate artificial preservatives in terms of risk to human health.
Consumer Intentions towards GMF (***C6***)	***X16:*** A 500 gram box of conventional cornflakes is on offer at 2€. How much would you be willing to pay for a 500 gram box of genetically modified cornflakes with health benefits? ***X17:*** A kilo (around two pounds) of conventional loose tomatoes is on offer at 2€. How much would you be willing to pay for a kilo (two pounds) of genetically modified loose tomatoes with health benefits?

4.4.3 Analytical procedures

Structural equation modelling has been used in this study in order to arrange the decision making process. Indeed, the structural regression (SR) model has been tested following a two-step modelling approach (Anderson and Gerbing, 1988), where we first define an acceptable confirmatory factor analysis (CFA) and next an adequate SR model.

Following Jöreskog and Sörbom (1996), we have specified a Structural Equation Model which consists of three main types of relationships. First, a measurement model is identified after performing confirmatory factor analysis. The outcome relates, on one hand, observed indicators with the exogenous latent variables;

$$x = \Lambda_x \ \xi + \delta \qquad (1)$$

where x, is a $q \times 1$ vector of observed exogenous or independent variables, Λ_x is a $q \times n$ matrix of coefficients of the regression of x on ξ, ξ is an $n \times 1$ random vector of latent independent variables and δ is a $q \times 1$ vector of error terms in x.

On the other hand, observed indicators are related with the endogenous constructs;

$$y = \Lambda_y \ \eta + \varepsilon \qquad (2)$$

where y, is a $p \times 1$ vector of observed endogenous or dependent variables, Λ_y is a $p \times m$ matrix of coefficients of the regression of y on η, η is an $m \times 1$ random vector of latent dependent variables and ε is a $p \times 1$ vector of measurement errors in y.

A third equation defines the structural model, which specifies the causal relations that exist among the latent variables, while describing its causal effects and assigns the explained and unexplained variances (Jöreskog and Sörbom, 1996).

$$\eta = \mathrm{B}\,\eta + \Gamma\,\xi + \zeta \qquad (3)$$

where B is a $m \times m$ matrix of coefficients of the η variables in the structural relationship, Γ is a $m \times n$ matrix of coefficients of the ξ - variables in the structural relationship, and ζ is a vector of errors.

This study uses ordinal data, arguably a rudimentary measurement of continuous variables, where the scale is considered as thresholds of the continuous variables (Jöreskog, and Sörbom, 1996). Correlations among ordinal variables are called polychoric correlations, which are theoretical correlations of the continuous version

(Jöreskog, and Sörbom, 1996). In order to perform the analysis we use the Generalized Weighted Least-Squares (WLS) method instead of Maximum likelihood (ML) since both the data present a nonnormal distribution and because ML does not allow us to employ the weighting matrix required for the analysis, which is the inverse of the estimated asymptotic covariance matrix, W, of the polychoric correlations (Kline, 2005).

$$F(\theta) = (s - \sigma)' W (s - \sigma) \qquad (4)$$

where s' is a vector of the elements in the lower half of the covariance matrix S of order $k \times k$, σ' is the vector of corresponding elements of $\Sigma(\theta)$, W^{-1} is the positive definite matrix of order $u \times u$ where $u = k(k+1)/2$. The WLS function is the weighted computation of the square residuals (Barrio and Luque, 2000).

Finally, we will assess the goodness-of-fit of the model by analysing factor loadings, which relate each indicator with the constructs. Reliability will be measured by means of composite reliability and Cronbach's α. Moreover, the extracted validity for each construct will be also measured (Hair et al., 1999).

Regarding the structural model, we begin with an assessment of the significance of the estimated parameters in the structural equations (Hair et al*.,* 1999). We proceed with estimating the reliability coefficients of each equation and the associated correlation matrix among constructs examined in our model (Barrio and Luque, 2000). Finally, diagnostic parameters such as Chi square (X^2); Root Mean Square Error of Approximation (RMSE); Goodness of Fit Index (GFI); the Adjusted Goodness of Fit Index (AGFI); the Comparative-Fit-Index (CFI); the Normed-Fit-Index (NFI) and the Non Normed-Fit-Index (NNFI) will be also considered as indicators of the model goodness-of-fit for the CFA and the SR model.

4.5 Results

4.5.1 Descriptive Analysis

As already mentioned in chapter 3, the survey employed for this analysis asked respondents questions regarding food purchasing behaviour such as: food qualities that can influence food purchasing, awareness of GM issues, information sources about genetic engineering in food production and finally attitudes towards GM technology and organic products/methods. Although not all these questions have been used for the development of the structural equation model, a brief description of its results is reported in this section in order to better understand the general behaviour of participants.

Based on the theoretical framework, this study assumes that when purchasing food people value a diverse range of attributes. In order to develop which are more relevant, this survey presents respondents a list of food attributes that can arguably influence food purchasing and asks them a value based on five Likert scale ranges – from 1 not at all important to 5 very important[17]. Actually, as Figure 4.2 shows, freshness and flavour are the most important parameters for food purchasing decision. This is the case for almost 70% of respondents. These dimensions are followed by use-by-date and appearance, which are very important for 50-60% of respondents. Moreover, ingredients and price rank high for about 40% of respondents. Finally, brand dimensions and production location are very important for only 12% of respondents.

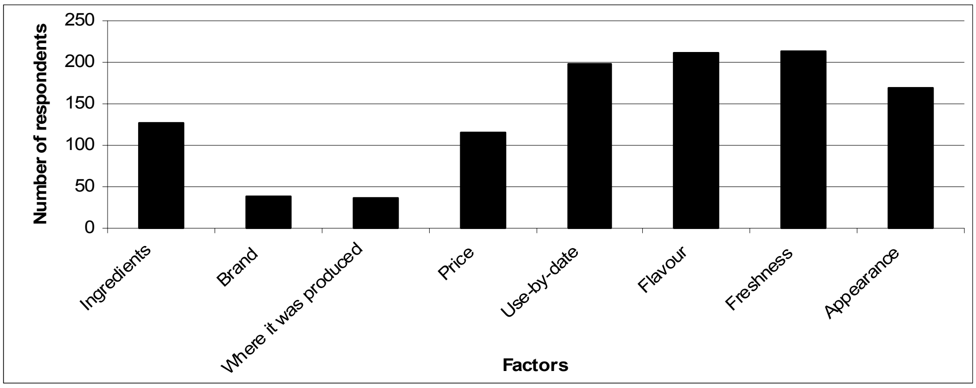

Figure 4.2 Importance of a range of factors in food purchasing decisions in Spain

The next behavioural element which has been accounted for in our survey design was people's knowledge about GM food technology. Here it is important to acknowledge the complexity of measuring this issue. Indeed, at least two broad types of knowledge can be defined. First, *objective knowledge* refers to what people know about something based on some type of examination or facts. The latter type is not as

[17] In order to contrast the internal consistency of responses we employed Cronbach's alpha. It is important to note that we attain a coefficient of 0.64, which indicates an acceptable reliability.

easy to disentangle due to difficulties in coming up with unbiased indicators and is ignored in this study. Instead, an index of subjective knowledge –namely, what people suggest to know about some object- was elicited, by means of a direct question: How knowledgeable are you on the issue of genetic engineering in food production? Up to 60% of respondents see themselves as not very well or not at all informed about GM food. In addition, about 15% of respondents consider themselves as quite or well informed. The remaining 25% are not able to value their knowledge degree. This question supports the hypothesis of Spaniards as exhibiting an extremely low level of knowledge regarding GM food, consistent with Martinez et al. (2004); Noomene and Gil (2004); and Vilella-Vila et al. (2005).

Not only was the level of knowledge accounted for but also its trust with information sources. Indeed, if individuals would follow some kind of Bayesian updating, then the sources of information are key. Hence, our survey requested respondents to reveal their information sources of trust about genetic engineering in food production. As Figure 4.3 shows, Spanish respondents trust more consumer organizations, followed by medical doctors and commercial scientists. Next in the rank comes university scientists and environmental groups, both closely followed by the mass media. The last reliable source of information was producers or retailers (who might be perceived as self interested parties) along with government and EU institutions. These findings are consistent with previous results such as Eurobarometer surveys (Gaskell et al., 2003; 2004; 2006)[18].Finally, it is important to highlight that Spaniards, when compared with other Eueopean respondents are found to reveal significantly lower level of trust with respect to national and European institutions.

[18] Indeed, gasket el al 2006 find that Europeans' most trusted stakeholders are doctors, university scientists and consumer organisations, followed by scientists working in industry, newspapers and magazines, environmental groups, shops, farmers and the EU

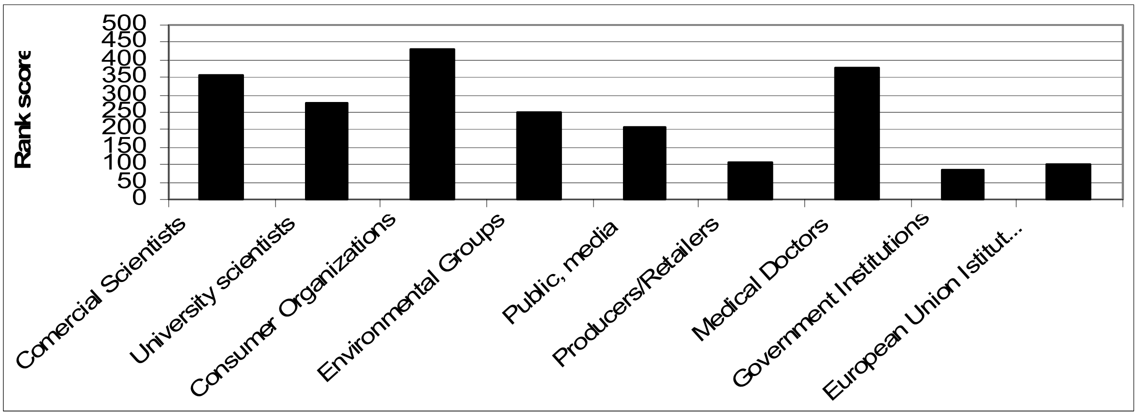

Figure 4.3 Sources trusted by Spanish consumers to provide reliable information about genetic engineering in food production.

Public attitudes towards GM and organic foods were measured through five-point Likert scale –from 1 strongly disagree to 5 strongly agree[19]. As Table 4.2 exhibits, the statement that people agree most refers to the consumers' right to choosing between GM and not GM food. Finally, the survey finds that what respondents tend to agree less regarding the possibility of GM technology developing healthier foods. In addition, it is also important to highlight the high level of "Neither agree nor disagree" and "Don't Know" answers. These answers, commonly come from people with not a clear position regarding GM food, named as "undecided". This is consistent with preceding results about subjective knowledge. Indeed, for the statement regarding environmental effects of GM crops, more than 50% of respondents can be labelled as "undecided". Moreover, the chance to develop healthier food is not clear for almost half of the respondents. Finally, about 40% of respondents do not really know if GM food might harm their environment.

Table 4.2 Spanish public attitudes towards GM products (%)

	Strongly disagree or disagree	Neither agree nor disagree	Agree or strongly agree	DK
Eating GM food might harm my health	13	19	49	19
I wish to have the choice whether to eat GM food or not	4	15	70	11
Growing GM crops will be harmful for the environment	11	28	38	23
GM technologies will lead to healthier foods	21	26	32	21

Question: How much you agree with the statement…?

[19] We have looked at the reliability of responses using Crombach alpha coefficient, interestingly it is of 0.74, which indicates a very good reliability or internal consistency.

In relation to organic food (see Table 4.3) [20], 82% of Spanish respondents are highly worried about the harmful effects of chemical residues in food. In the same fashion, effects of agriculture on the environment are also envisioned as an issue which alarms at least 68% of the Spanish sample. For the other raised statements – if organic production managed to taste better than conventional food – there is a clear propensity to agree with the statement. Nevertheless, many people do not have an opinion. That is, 43% of the sample "neither agree nor disagree" or "Don't know" (see Table 4.3).

Table 4.3 Spanish public attitudes towards organic products (%)

	Strongly disagree or disagree	Neither agree nor disagree	Agree or strongly agree	DK
I am concerned about the harmful effect of chemical residues in food	3	11	82	4
Organic products taste better than conventional ones	11	27	46	16
I am concerned about the effects of agriculture on the environment	5	22	68	5

Question: How much you agree with the statement…?

In relation to organic food, a declared behavioural question was also included: the food expenditure allocated to organic products. Results indicate, as expected, that Spanish consumers do not spend much money on organic products. More precisely, respondents' budget allocated for organic consumption is around 10%. Indeed, more than 25% of Spanish respondents reveal no purchase of organic food at all. Moreover, almost 30% do invest from 1 to 10% of their food budged on organic food and only 20% devote more than 10% of their budget to organic consumption.

The last part of the survey analyses questions related to risk perception and attitudes or risk taking. To tackle these issues, two related questions are introduced. On the one hand, respondents were requested to reveal which type of non compulsory insurances they hold (as a proxy to measure risk aversion). The widely held insurances are car and life insurances. Health care insurances are less demanded, possibly due to the relevant public sector role in health care. On the other hand, respondents were requested to rank in a Likert scale from 1 to 5 –1 very high risk and 5 very low risk- the following technologies in terms of risk to human health. Irradiation is perceived as the

[20] The reliability of responses using Crombach alpha coefficient is of 0.63, which indicates an acceptable reliability level.

most risky technologies for around 80% of Spanish respondents, artificial colours, flavours and preservatives follow in the rank.

4.5.2 Measurement Model or scales validation analysis

As mentioned in Section 3, first a Confirmatory factor analysis for all constructs was performed, that is: 1) Sensory considerations for food purchasing; 2) attitude towards organic production standards; 3) perceived risks of food production technologies; 4) perceived risks of GM food; 5) risk aversion; and 6) consumer intentions towards GM food, assuming all errors to be uncorrelated. The confirmatory factor analysis with all indicators resulted suitable and the correlation matrix among all variables is presented in Table 4.4. In addition, all constructs but one was measured by three indicators as proposed by Kline (2005) among others.

Table 4.4 Correlation matrix among indicators

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17
X1	1.00																
X2	0.75	1															
X3	0.52	0.63	1														
X4	0.29	0.29	0.33	1													
X5	0.17	0.15	0.10	0.47	1												
X6	0.13	0.15	0.23	0.52	0.40	1											
X7	0.10	0.12	0.15	0.20	0.13	0.24	1										
X8	-0.06	0.01	0.11	0.00	0.13	0.21	0.53	1									
X9	-0.04	0.05	-0.08	0.00	0.12	0.07	-0.08	-0.13	1								
X10	0.03	-0.10	-0.05	-0.03	-0.15	0.06	-0.05	-0.09	0.02	1							
X11	0.04	-0.13	-0.13	0.07	-0.05	0.14	0.02	-0.06	0.04	0.65	1						
X12	0.11	0.17	0.05	0.16	0.08	0.11	0.01	-0.08	0.14	0.46	0.38	1					
X13	0.28	0.32	0.33	0.40	0.30	0.33	0.27	0.08	-0.01	-0.01	-0.11	0.23	1				
X14	0.15	0.23	0.22	0.24	0.21	0.23	0.33	0.20	0.07	-0.03	-0.05	0.13	0.52	1			
X15	0.04	0.14	0.16	0.13	0.16	0.26	0.29	0.17	0.04	0.00	-0.13	0.08	0.43	0.74	1		
X16	0.07	0.19	0.04	0.04	-0.04	0.00	-0.26	-0.18	0.45	-0.03	-0.05	-0.02	-0.01	-0.03	-0.13	1	
X17	0.04	0.15	0.06	0.06	-0.03	-0.03	-0.30	-0.21	0.39	-0.01	-0.04	0.05	0.04	0.01	-0.08	0.94	1

The main parameters to test for the robustness of the constructs, following Hair et al. (1999); and Kline (2005) appear to show acceptable results as shown in Tables 4.5. Analysis of test statistics showed that constructs exhibited good reliability of estimation. In fact, reliability of factor loadings are high for all constructs (above 0.5) and t-values associated with the loadings are all significant ($P<0.001$), implying a satisfactory convergent validity (Olsen, 2003; and Bagozzi et al. 2001). Regarding internal consistency of the model, we can state that is robust, including composite reliability (which must be > 0.7), internal consistency reliability, measured by Cronbach's α, (which must be about 0.7), extracted validity (which must be >0.5) and discriminant validity (correlations among constructs < 0.85) (Hair et al.1999; and Bagozzi and Yi, 1988). Moreover, for every construct, all composite reliabilities are greater than 0.7 and all Cronbach's α are over 0.7 but for construct C3 (perceived risk of GM food) which is 0.5, thus we can say that reliability is acceptable. Regarding the variance extracted, it is 0.50 or higher for all cases (Table 4.5). Finally, since the correlations among latent factors do not exceed 0.85, in any case, it can be stated that discriminant validity has been accomplished too.

Table 4.5 Reliability of the standardized Confirmatory Factor Analysis

Construct	Indicators	Standardized loadings (*t*-Value)	Composite reliability (Variance extracted)	Goodness of fit parameters
C1	***Cronbach's α***	0.73	0.92 (0.79)	$\chi^2 = 358$
	X1	0.91 (28.64)		$df = 104$
	X2	0.96 (38.46)		$p = 0.00$
	X3	0.79 (25.62)		
C2	***Cronbach's α***	0.65	0.78 (0.55)	
	X4	0.80 (24.11)		
	X5	0.63 (16.30)		*RMSEA* = 0.08
	X6	0.77 (22.29)		
C3	***Cronbach's α***	0.50	0.73 (.50)	*GFI* = 0.98
	X7	0.94 (23.70)		
	X8	0.64 (15.30)		
	X9	-0.45 (9.07)		*AGFI* = 0.97
C4	***Cronbach's α***	0.60	0.85 (0.65)	
	X10	0.82 (16.96)		*CFI* = 0.98
	X11	0.69 (15.46)		
	X12	0.90 (16.24)		
C5	***Cronbach's α***	0.75	0.89 (0.72)	*NNFI* = 0.97
	X13	0.78 (25.01)		
	X14	0.88 (36.45)		*NFI* = 0.97
	X15	0.89 (32.92)		
C6	***Cronbach's α***	0.90	0.96 (0.93)	
	X16	1.00 (71.55)		
	X17	0.95 (64.09)		

Note: REMSEA <=.05-0.08 (Browne and Cudeck, 1992; Kline, 2007) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

The model meets the widely accepted goodness of fit standards indicating that the conceptual model satisfactory fits the data (see Table 4.5). However, it must be pointed out that the chi-square statistic was significant and the Normed chi-square (NC) NC = $\chi^2/df = 3.4$ is about 3, demonstrating a good model fit (Carmines and McIver, 1981; and Bollen, 1989). The Root Mean Square Error of Approximation (RMSEA) is 0.08, which is well inside the 0.05-0.08 limit interval offered by Hair et al. (1999) and Kline (2005). The goodness-of-fit index (GFI) was 0.98, the Comparative-Fit Index (CFI) 0.98, the Normed-Fit Index (NFI) 0.97 and the Non-Normed Index (NNI) 0.97, all were greater than 0.90 as offered by Marcoulides and Schumacker (1996); and Chen and Li (2007).

4.5.3 Structural Model

Following the results of the measurement model, the proposed theoretical causal relationships have been analysed using Lisrel 8.51 statistical program. We find a satisfactory fit for the model as Table 4.6 shows. Moreover, Figure 4.4 reveals the paths coefficients obtained for the structural model. It must be highlighted that all causal relations (Hypothesis) were supported with paths significant at $p = 0.001$ level.

First of all, we found that an important negative relationship between "Perceived Risks of GMF" and "Consumer Intentions towards GMF" exists (H5), with a correlation coefficient of almost -0.70. This result is consistent with all previous literature and verifies the importance of negative information on behavioural intentions, as already stated by some studies such as Yeung and Morris (2006) and Rousu et al. (2004) among others. Nevertheless, and as stated in the theoretical framework, the role of "Risk Aversion" has also been shown to be a significant factor in determining if consumers are willing to accept the consumption of GM food (H6). In fact, a negative relationship between "Risk Aversion" and "Consumer Intentions towards GMF" with a path of 0.13, has been obtained from the structural model.

Table 4.6 Goodness-of-fit for the structural regression model

χ^2_{df}	382	
χ^2_{df} / df	3.4	<3-5 (Carmines and McIver, 1981; Bollen, 1989)
RMSEA	0.08	<0.5-0.8 (Browne and Cudeck, 1992; Kline, 207)
GFI	0.98	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)
AGFI	0.97	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)
CFI	0.98	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)
NFI	0.97	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)
NNFI	0.97	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

Hypotheses 2 and 3 are also supported with relevant correlation coefficients: 0.43 and 0.28. Consequently, we can tentatively conclude that Spanish respondents risk perception towards food technology as general science is very important for the perception of a single food technology application. As stated in section 2, more general attitudes are considered by respondents when evaluating new and unfamiliar GM foods, Chen and Li (2007). That is, perceived risks associated with GM foods rely on the perceived risks associated with general food technology. Indeed, this relating is tested either by a direct causal relation (H3) or by means of an indirect path (H2+H4). This conclusion supports the empirical evidences explained by Krishna and Qaim (2008) and Roe and Teisl (2004) who stated that consumers with low levels of concern for an "uncertain-risk" food technology will present a similar level of concern for other "uncertain-risk" food technologies.

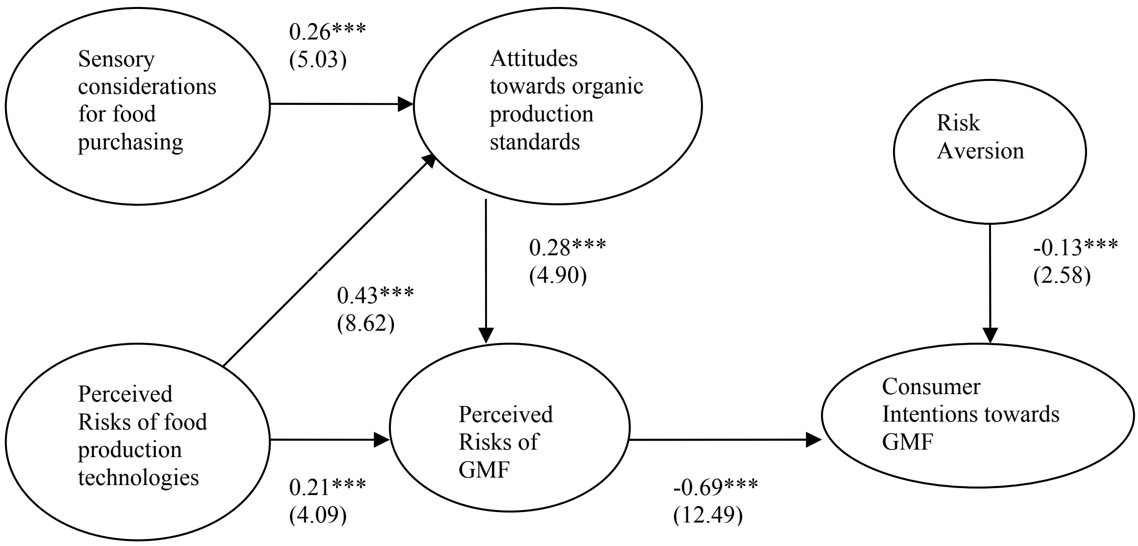

Figure 4.4 Structural model results.

It has been stated that consumers relate OF with healthy food and also that individuals consider OF as a way of avoiding risks related to food technology (Devcich et al., 2007). Our results support these statements since respondents that perceive more risks associated to food production technologies reveals a positive attitude towards organic production standards (H2). Moreover, the negative relation among GMF and organic food perceptions reported by many studies such as Dreezens et al. (2005); Saher et al. (2006); and Burton et al. (2001) is also supported in the case of Spain (H4). That is, a significantly positive relation between attitude towards organic production standards and risk perception associated to GM food has been observed with an associated path of 0.28.

Finally, this study also confirmed the existence of a positive relation between, "natural" factors affecting behaviour (such as flavour freshness or appearance) with a positive attitude towards organic production standards (H1).

4.6 Discussion

The combined effect of risk attitudes and perceptions in determining consumer acceptance of GM food has been the motivation for this paper. This study has sought to test using data from GM food decision making, the combined role of risk perceptions and risk attitudes in shaping the "perceived behavioral control" parameter of the TPB. We examined these parameters using SEM, which accounts for an endogenous association between theoretical constructs and specifically designed survey data from a sample of individuals responsible for the food shopping in their household. In doing so, we propose a model that accounts for a set of constructs that altogether explains consumer intentions. Our results support the all the hypothesis outlined regarding the decision making process as well as the independent role of risk perceptions and risk attitudes.

In this study we find a clear negative independent correlation between both risk aversion and risk perception and GM food consumer intentions (H5-H6). This result is consistent with some findings from previous studies outside the food sector (Weber and Hsee, 1998) that separate the effect of risk aversion for they way individuals learn about risks. Moreover, the overall effect of risks perceptions, as compared to that of risks attitudes, is higher possibly due to the cumulative influence present when risk attitudes are not controlled for, as well as to the influence of other risk learning constructs including age, gender and other relevant variables as hypothesised in out structural model. Therefore, we conclude that that some aspects that influence risk perceptions might not impact risks attitudes, and instead are affected by more structural personality treats. On the other hand, the fact that risk attitudes are still significant when risk perceptions are included in the model indicates that a neo-phobic type would be defined as an individual with a relatively higher risk aversion and/or perceiving nonexistent risks.

In addition, as stated in the second and third hypothesis of analysis (H2-H3), the role of attitudes towards food are found to be important in the formation of consumers' perceptions and attitudes towards GM food. That is, we find that in order to be able to value a particular scientific application, individuals rely on their general attitudes towards an object of study, which suggests that individuals are likely to follow some shortcuts based on values and attitudes in forming their behavior when they have limited information. This result is very important and consistent with the fact that about 85% of the Spanish sample reveal to have low levels of information or not enough knowledge about GM food. Finally, food applications associated with opposite values are contrarily valued by consumers. This is the case of GM and organic food production. A positive relationship among individuals GM food risk perception and attitudes towards organic production standards has been identified (H4). Therefore, we can support Dreezens et al. (2005), Saher et al. (2006) and Burton et al. (2001) which conclude that attitudes towards organic production can be considered as an indicator of attitudes towards GM food.

Some important caveats of the study should be mentioned. First of all, although the model analyzes a key element of the TPB, the introduction of other variables, such as, attitudes towards the behavior and subjective norm improve the model. Moreover, the impossibility of achieving a larger sample did not lead us to perform some form of multi-group analysis which might identify heterogeneity regarding age groups, gender or income levels among other variables might still exist. However, this paper shows that the process of decision making regarding new foods produced with genetic modification is the result of complex behavioural mechanisms. Furthermore, the role of information and education of society regarding new technologies is a mechanism to reduce uncertainty, and transform it into known risks that can be balanced out with benefits.

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Chapter 5:

Meta-Attitudes and the local formation of consumer judgements towards Genetically Modified (GM) food.

5.1 Abstract

In explaining the mechanisms that explicate individuals' acceptance of Genetically Modified (GM) food, one mechanism that has been largely ignored in the growing body of current research lies in the influence of "meta (wider) attitudes" such as the general attitudes towards science. Similarly, if attitudes are socially formed, we expect that regional self-interest will be determinant. This paper draws upon survey evidence from Spain to examin the causal relationship between attitudes towards science and attitudes towards GM food. It employs structural equation modelling and explores this association by using sub-samples made of regional groups that have GM agriculture. Our results suggest specific behavioural mechanisms in explaining GM consumer attitudes involving attitudes towards science whilst medical and food applications appear to have no (or mild) significant connection in the formation of attitudes towards GM food. Finally, we find significant influence from age and previously characterized attitude in the formation of structural models.

Keywords: GM food, attitudes towards science, regional self-interest, structural modelling, attitude formation.
JEL: Q11, D87.

5.2. Introduction

Public opinion data reveals that European consumers seem to be persistently concerned about the use of genetically modified (GM) foods (Gaskell et al., 2006)[21], which partially explains the Europeans moratorium on GM food. While Europeans seem to value some biotechnology applications, especially in medicine, food related applications exhibit different behavioural reactions. These reactions occur in spite of efforts to communicate their potential benefits. Indeed, after the commercialisation of Recombinant Bovine Sematoropin (BST) in 1994, a growth hormone, the US milk production from cows treated with BST increased from 15% in 1994 to 35% in 2001 (Chakraborty, 2005). Hence, consumer reactions in Europe might be driven by other features that overshadow potential benefits of GM food.

Consumer attitudes toward GM foods are found to be explained by a combination of risk and benefit perceptions associated with this new food generation (Moon and Balasubramanian, 2001 and 2004; Grunert et al., 2003; Onyango, 2004; and Hossain and Onyango, 2004). However, general attitudes towards science and biotechnology have been disregarded as standing behind specific attitudes towards GM food (Lahteenmaki et al., 2002; and Bredahl, 2001). Moreover, perceptions of risk and benefits are based on different elements such as a general attitude towards science, knowledge, trust, education and values, among others (Chen and Li, 2007; and Saher et al., 2006). Hence, we hypothesize that meta-attitudes, namely general attitudes towards science and technology, influence consumer acceptance of GM food.

In any case, attitudes toward GM food in Europe are widely divergent among countries and regions within countries. In fact, few regions have tried to establish GM-free zones[22] using Article 19 of Directive 2001/18/EC, which allows authorities to specify conditions of consent including the protection of particular

[21] Gaskell et al, (2005) concludes as follows: "Overall Europeans think that GM food should not be encouraged. GM food is widely seen as not being useful, as morally unacceptable and as a risk for society."
[22] Upper Austria's attempt to declare itself GM-free in September 2003 was rejected by the European Commission (EC), on grounds that no new scientific evidence had emerged to support a ban, and that Upper Austria had failed to prove the existence of a problem specific to the region that justified such an approach. The Upper Austrian parliament will appeal this decision.

ecosystems/environments and/or geographical areas. This implies that such zones can be excluded from GM marketing consents if a scientific case is made demonstrating that the GM product in question poses a particular risk to the area. Therefore, it remains as an empirical question whether attitudes in GM free regions are different or, more specifically, follow a different structural causal model that those of GM producer regions.

Given the important policy implication of a better understanding of the behavioural mechanisms behind the acceptance of GM food, this study employs a structural equation approach to examine data from a representative sample of the Spanish population in 2001. Particularly, this article puts forward several hypotheses on the influence of general meta-attitudes (towards science and technology) underpinning behavioural explanations for consumer judgments of acceptance towards GM food. Second, given that Spain is a significantly heterogeneous country with GM free and GM producer regions, we examine whether the underlying structural model explaining GM food attitudes are different among respondents in these two regions. Finally, we explore a set of hypothesis regarding the influence of age, gender, and other related factors, as well as the reliability of survey respondents.

The structure of the paper is as follows. Next section is devoted to the theoretical foundation of the models underlying attitudes towards GM food and a set of empirical hypothesis are outlined. Then, the third section explores the heterogeneity of GM attitudes and regulation. Section four is devoted to data and methods while section five reports the results. We end with some concluding remarks.

5.3 Theoretical framework

5.3.1 Perceived benefits and attitude towards science and technology

Understanding the influence of consumer attitudes toward science and technology – for instance attitudes toward nature or food neophobia - is important in order to define the perceived risk and benefits associated with technological applications (Chen and Li, 2007). Indeed, attitudes towards science and technology reflect inner respondents' belief in the ability of technological progress. Accordingly, gene technology can be conceptualised as one specific application of new technologies. Hence, general attitudes toward gene technology are expected to be positively associated with technology acceptance (Bredahl, 2001).

In explaining the behavioural processes that explain GM food acceptance, another important determinant is information processing and regulation along with trust. Some survey research (Hoban, 1997) suggests that factual information increases consumer acceptance in the US and Japan. Moreover, information gathering in the area of GM foods have been linked to the perceived importance of the issue by Wilson et al. (2004). However, different information channels are more credible than others. In fact, many studies reveal that, regarding GM technology, consumer organizations, environmental groups and scientists appear to be more trustworthy than the biotech industry and government (Bredahl et al., 1998; Onyango et al., 2003; Savadori et al., 2004; and Veeman et al., 2005). Similarly, theoretical research (Artuso, 2003) points out that the larger the expected net benefits of approved products and the more stringent the regulation is, the more confident the consumer might be on the safety of the science innovation. Furthermore, Grobe and Raab (2004) found in a referendum that took place in the US state of Oregon, on whether to label GM food, that the vast majority rejected labels due to its economic and alarmist impacts although there was a positive impact on trust building (McCullum, 2000). However, shopping, preparing and eating food is no longer only a matter of tradition and consumers direct experience, but are also a matter of mediated experience (Thompson, 1995).

Skepticism towards GM food is supported by evidence suggesting behavioral inhibition (Saher et al., 2006). Following Baker and Burnham (2001) and Onyango et al.

(2003), the US consumers' 'attitudinal' segment can be partially explained by cognitive mechanisms that are not necessarily observed, such as individual values, or, as in our study, meta-attitudes. However, there is no agreement regarding the significance of these personal attributes on consumer's final attitude. Some scientists such as Frewer et al. (1998); Moon and Balasubramanian (2001 and 2004) and Loureiro and Hine (2004), refer to the relationship between both moral and ethical considerations and consumer attitudes. By contrast, Vilella-Vila et al. (2005) concludes that moral issues appear not to be relevant in attitude formation with regards to GM food. Indeed, attitudes towards science and technology and attitudes towards nature are found to underpin individuals' trust towards scientific progress, where gene technology is a particular application (Lahteenmaki et al., 2002; and Bredahl, 2001). In other words, "*high regard towards nature makes people more suspicious towards gene technology" and "attitude to technology reflects respondents' belief in the ability of technological progress to solve the world's problems in the future"* (Lahteenmaki et al., 2002).

A strong relationship between an individual's feeling about the environment and their environmental attitude was observed by Fraj and Martinez (2007). Namely, people who are worried about pollution show a positive attitude towards the environment and are predisposed to act in an environmentally friendly manner. Moreover, attitudes towards gene technology are negatively associated with the general attitudes toward nature (Bredahl, 2001). In studies based on interviews, applying gene technology in food production has been regarded as unnatural and risky (Lahteenmaki et al., 2002). Moreover, (Loureiro and Bugbee, 2005) concluded that in the case of the tomato plant, attitudinal variables, such as concern about environment, play a negative and statistically significant role in explaining US consumer acceptance and WTP for different modifications. Finally, evidence that self-transcendence values like responsibility for nature are related to negative GM opinions have been reported by Bredahl (1999) and Dreezens et al. (2005).

Summing up, the hypotheses this paper aims to test on this issue are the following (see Figure 5.1):

H1: *Consumers that reveal a positive general attitude towards science and technology are expected to perceive more benefits associated with science and technology.*

H2: *Consumers that reveal a positive general attitude towards the environment are expected to perceive fewer benefits associated with science and technology.*

H3: *Consumers that perceive more benefits associated with science and technology are expected to reveal a positive attitude towards biotechnology.*

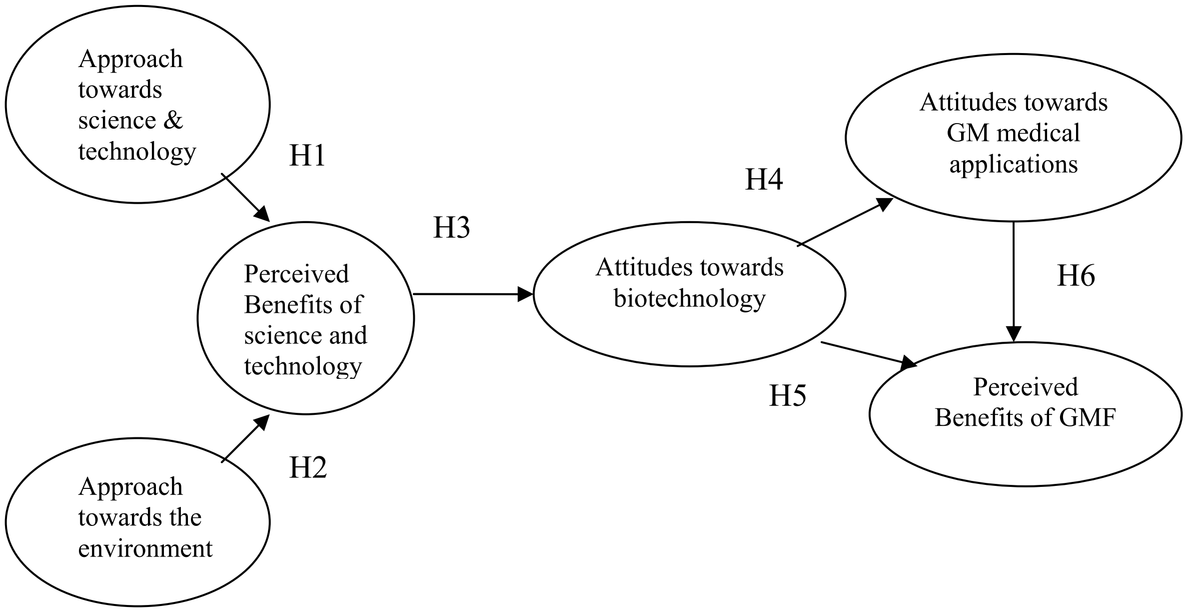


Figure 5.1 Consumer conceptual process of acceptance

5.3.2 Attitude and benefit perception of different biotechnological applications

Consumers do not perceive GM technology as being a one-dimensional skill. That is, although consumers reveal a positive attitude towards biotechnology, in general, this attitude is not the same for all applications. In fact, some studies, such as Gaskell et al. (2003); Grunert et al. (2001); Hossain et al. (2002 and 2003); and Savadori et al. (2004) argue that European and US consumers distinguish between different types of applications within biotechnology. They find that consumer attitudes and their consequent acceptance of a GM technology depend on the purpose of its use. More precisely, medical applications of GM are more frequently supported than agri-food applications. In any case, evidence on attitudes has become clearer in European countries, suggesting some reluctance towards the introduction of GM foods (Gaskell et al., 2003; Gaskell et al., 2004; and Gaskell et al., 2006). Hossain et al. (2003), use a discrete choice model for fresh fruit and vegetables and find two main segments of consumers: those who are totally opposed to GM technology and those who would accept GM technology if there were some demonstrable benefits to the consumer. In addition, Loureiro and Bugbee (2005) observed that U.S. consumers are willing to pay a premium for "enhanced flavour", followed by the "enhanced nutritional value" and "pesticide reduction" attributes.

Then our hypotheses are the following (see Figure 5.1):

H4: *Consumers that reveal a positive general attitude towards biotechnology perceive more benefits associated with GM food technology.*

H5: *Consumers that reveal a positive general attitude towards biotechnology reveal a positive attitude towards GM medical applications.*

H6: *Consumers that reveal a positive general attitude towards GM medical applications perceive fewer benefits associated with GM food technology.*

5.4 Heterogeneity GM food attitudes: regulation in Spain

As stated in the literature, a further important relationship among the different stages of a consumer attitudinal process is their association with socio-economic and demographic attributes such as age, ethnicity, residence and income level, which are found to be directly related to consumers' attitudes towards GM food. These relationships are supported by Costa-Font and Mossialos (2005); Hossain et al. (2002 and 2003); Veeman et al. (2005); and Noomene and Gil (2004) using mainly logit and probit models. Furthermore, Siegrist (2000), and Grimsrud et al. (2004) relate gender differences with benefit perceptions. These studies consistently find that women perceive lower benefits and are less likely to accept gene technology than men. Moreover, some of them revealed that young and middle age, less affluent and those who live in suburban areas are more concerned with GM food. On the other hand, Frewer et al. (1998) revealed no significant gender differences among respondents with high level of environmental concern. Therefore, this paper has attempted to examine whether age and gender are important determinants of Spanish consumers GM food benefit perception. To this end, the full population has been segmented into two groups regarding gender (males and females) and into three groups regarding age (18-35, 36-56 and +56 years old).

We assume that:

H7: *Age is a relevant individual attribute shaping consumers' GM food benefit perceptions. That is, older people trust less in new food technologies such as GM food.*

H8: *Gender is a relevant individual attribute shaping consumers' GM food benefit perceptions. Specifically, females trust less in new food technologies such as GM food.*

On the basis of previous literature, population can be segregated in three main groups regarding GM food attitudes and intentions, namely: (i) anti-GM food or pessimistic, (ii) risk-tolerant or information searchers and finally (iii) GM-accepters or optimistic. Yet, different compositions of such groups within a specific society determines final country acceptance of GM food. On this basis it has become apparent that in the U.S. and some European countries such as Spain and Portugal among others, the population is found to be broadly more tolerant to GM food as compared to France or the Nordic population. Indeed, Huffman et al. (2007) observed that, prior subjective beliefs affect bidding behaviour of people for food items that might be genetically modified. Therefore, in this study we have segmented the sample in two groups based on consumers intentions towards GM food (willing to consume and not willing to consume), in order to show that previously defined attitudes towards a market product vary the process of perception of its associated benefits.

We assume that:

H9: *previously characterized attitude towards GM food can alter the building process of GM food benefit perception.*

Finally, in Spain, several regions have reacted to the authorization of commercially grown GM varieties, granted by the central government since 1998. The Parliament of Castilla la Mancha asked the central government to declare a moratoria on commercial GM crops until risk assessment is done for crops and food that contain GMOs (May 2000). In the Balearic Islands, the parliament expressed its worries for the introduction of GMOs and asked the central government not to authorize more GMOs until an international protocol guarantee their safety (February 2000). In Andalucía, the regional Parliament adopted in June 2000 a 5-year moratorium on trials of GM corps and asked the central government to do the same for all of Spain. The Basque country has issued a five-year blanket moratorium on GMOs. The Basque Government claims full powers on agricultural policy and can provisionally ban GMOs. The Basque country has also joined the European Network of GMO-free regions. There are also initiatives in Catalonia where several organizations are asking for a GM-free Catalonia. In particular, the most recent was carried out in August 2008 by an important Catalan social platform (*Som lo que sembrem*) composed by several organizations, such as the most important Catalan farmers union (Unio de Pagesos) among others. This platform has asked the regional government on March 9th to declare Catalonia GMO-free. Asturias declared itself GMO-free on 20/05/2004. The regional Parliament adopted a resolution that calls on the regional government to become part of the European Network of GMO-free regions in order to put pressure on the EU to take into account in its policy on GMOs. The agricultural and environmental strategies of the European regions and avoid the negative impacts of GMOs on the quality of farming products from Asturias and point out in the National Biosafety Commission the negative impact of GMOs on the production strategy of the farming sector in Asturias.

The Spanish crop area currently devoted to GMOs is summarized in Table 5.1. Aragón, Castilla la Mancha and Catalunya are the major producers of GM maize in Spain. Thus, we segmented the sample between consumers living in GM free (Asturias, Baleares, Canarias, Galicia, Castilla-Leon, La Rioja, Murcia, Païs Vasco and Valencia) and GM producer regions (Andalucía, Aragón, Castilla-la Mancha, Catalonia, Extrmadura, Madrid and Navarra) in order to detect if GMOs regional policy affect their GMF benefit perception process.

Table 5.1 Spanish area devoted to GM maize production by regions.

Year	1998	1999	2000	2001	2002	2003
Andalucía	780	2.800	1.500	450	1.800	2.089
Aragón	11.500	7.300	9.000	4.250	9.200	12.905
Asturias	0	0	0	0	0	6
Baleares	2	2	26	0	30	2
Castilla la Mancha	4.500	6.800	5.650	870	4.150	8.171
Castilla León	200	360	270	0	0	0
Catalunya	1.700	3.000	4.500	3.250	5.300	5.278
Extremadura	1.000	2.500	2.500	600	1.500	1.633
La Rioja	25	30	30	0	0	0
Madrid	660	1.560	1.970	1.940	780	678
Navarra	1.760	300	220	80	500	1.401
Valencia	190	300	150	100	20	1
Total	22.317	24.952	25.816	11.540	23.280	32.164

Source: MAPA[23]

We assume that:

***H10:** The GM food benefit perception process differs between consumers of GM free and producer regions within Spain.*

Spain is one of the few European countries that produce agricultural biotechnology products. Spain, unlike in other countries, the GM controversy has not been severe and has had a small influence (Vilella et al., 2005) in the earlier stages of implementation. Environmental organizations – which have headed the debate in other EU countries – have had a weaker role in Spain. However, from the mid–nineties, critics to GM have acquired a more prominent role and have been discussed in the Parliament. The governmental regulation bodies, namely the National Biosafety Commission and the public regulatory authorities, have responded to public concerns in certain circumstances that include the use of maker genes resistant to antibiotics. In 1997, commercialization of antibiotic resistant maker genes were banned in response to public debate as it were regarded as unnecessary (Tordt and Lujan, 2000). Indeed the dynamics of policy making in the European Union are not irrelevant for policy making in Spain. The question of consumer acceptance has been rather diffuse (Atienza and Lujan, 1997) and relies on important uncertainty on the future consumers reactions to new products that gives rise to precautionary measures e.g., some retailers avoid implicitly GM products.

[23] http://www.mapa.es/ga/alimentacion/pags/omgs/omgs_espana.htm

Past studies have examined attitudes towards biotechnology and science in Spain. Most of them were very descriptive in nature (Atienza and Lujan, 1997; Lujan and Moreno, 1994). A deeper analysis of attitudes towards GM products is needed given the complexity of the issue. To this end, a multivariate approach is used in this paper and is one of the main contributions. Results from this research allow us to derive some policy implications on how to manage the information that presumably affects the evolution of the market for GM food in Spain.

5.5. Data and Research methodology

5.5.1 The sample

In order to test the hypotheses mentioned in the two above sections, we have used the survey carried out by the Centro de Investigaciones Sociológicas (CIS) in 2001. The questionnaire concerns science and technology and its genetic engineering and biotechnological applications. The sample was composed by 2,492 respondents from Spain, proportionally distributed among the 17 regions. The sample is comprised of approximately 48% males and 52% women, either for the whole sample and or by regions. Ages range from 18 to 96 with almost uniform distribution. More than 90% of respondents have gone to school. From these, 6% do not end primary school; 25 % finish primary school; 22% finish “EGB”; 27% finish “secondary education”; 18% are “graduates”; finally 1% have postgraduate studies and 1% other studies.

Almost half of the respondents are solely responsible for household income. Moreover, half are working, almost 20% are pensioners, 20% do not work, around 5% are unemployed and another 5% are students

5.5.2 Measures

We have considered, as the literature points out, that responses range from agree to disagree going through some uncertainty threshold (Gaskell et al., 2004; Gaskell et al., 2006; and O’Connor et al., 2006). Therefore, “don’t know” answers are classified as “undecided or indifference” which are accordingly placed somewhere between acceptance and rejection (Costa-Font and Mossialos, 2007). All questions except for general attitudes toward science and the environment were measured on a 3-level Likert scale, where “tend to agree” responses are coded as an ordinal value of 1, “undecided or indifference” by 2 and finally, “tend to disagree” by ordinal value 3. Similarly, questions regarding general attitudes toward science and the environment were measured on a 4-level Likert scale, from a lot to nothing. Our selection of CIS questions are shown in Table 5.2.

Table 5.2 List of indicators used for each construct.

Construct	Indicators
Approach towards science and technology (***C1***)	***X1:*** I am interested in science and technology ***X2:*** I feel well informed about science and technology
Approach towards the environment(***C2***)	***X3***: I am interested in the environment ***X4***: I feel well informed about the environment
Perceived Benefits of science and technology (***C3***)	***X5***: In the next twenty years, science and technology development will be positive for the world. ***X6****:* In the next twenty years, science and technology benefits will overcome its risks. ***X7***: The problems of current technology will be solved by future technology. ***X8***: Science and technology have made this world dangerous.
Attitudes towards biotechnology and genetic engineering (***C4***)	***X9****:* Genetic engineering have contributed to increase human quality live. ***X10***: Biotechnology have contributed to increase human quality live ***X11****:* Biotechnology and genetic engineering advances are dangerous for humans. ***X12****:* Biotechnology and genetic engineering advances are dangerous for the environment.
Attitudes towards genetic engineering medical applications (***C5***)	***X13****:* Genetic engineering is totally acceptable for identify genetic illness in humans. ***X14:*** Genetic engineering is totally acceptable for application in new medical treatments.
Perceived Benefits of GMF (***C6***)	***X15****:* The existence of GMF will benefit almost all population. ***X16****:* Risks associated to GMF are acceptable. ***X17****:* Although GMF have benefits this product is a danger for nature. ***X18****:* The idea of GMF frightens me. ***X19****:* GMF do not raise any danger for future generations.

5.5.3 Analytical procederes

Structural equation modelling has been used in this study in order to arrange the decision making process. Indeed, the structural regression (SR) model has been tested following a two-step modelling approach (Anderson and Gerbing, 1988), where we first define an acceptable confirmatory factor analysis (CFA) and next an adequate SR model.

Following Jöreskog and Sörbom (1996), we specified a Structural Equation Model which consists of three main types of relationships. First, a measurement model is identified after performing confirmatory factor analysis. The outcome relates observed indicators with the exogenous latent variables;

$$x = \Lambda_x \ \xi + \delta \qquad (1)$$

where x, is a $q \times 1$ vector of observed exogenous or independent variables, Λ_x is a $q \times n$ matrix of coefficients of the regression of x on ξ, ξ is an $n \times 1$ random vector of latent independent variables and δ is a $q \times 1$ vector of error terms in x.

On the other hand, observed indicators are related with the endogenous constructs;

$$y = \Lambda_y \ \eta + \varepsilon \qquad (2)$$

where y, is a $p \times 1$ vector of observed endogenous or dependent variables, Λ_y is a $p \times m$ matrix of coefficients of the regression of y on η, η is an $m \times 1$ random vector of latent dependent variables and ε is a $p \times 1$ vector of measurement errors in y.

A third equation defines the structural model, which specifies the causal relations that exist among the latent variables, describing its causal effects and assigning the explained and unexplained variances (Jöreskog and Sörbom, 1996).

$$\eta = \mathrm{B}\,\eta + \Gamma\,\xi + \zeta \qquad (3)$$

where B is a $m \times m$ matrix of coefficients of the η variables in the structural relationship, Γ is a $m \times n$ matrix of coefficients of the ξ - variables in the structural relationship, and ζ is a vector of errors.

The model assumes that the ε is uncorrelated with η, δ is uncorrelated with ξ, and ξ is uncorrelated with ξ. Moreover, ξ, ε and δ *are* mutually uncorrelated. Furthermore, the covariance matrices of the model are defines as:

Cov (ξ) = $\Phi \quad (n \times n)$; Cov (ε) = $\Theta_{\varepsilon} \quad (p \times p)$; Cov (ξ) = $\Psi \quad (m \times m)$

and Cov (δ) = $\Theta_{\delta} \quad (q \times q)$.

This study uses ordinal data, where the scale is considered as thresholds of the continuous variables (Jöreskog and Sörbom, 1996). Correlations among ordinal variables are called polychoric correlations, which are theoretical correlations of the continuous version (Jöreskog and Sörbom, 1996). In order to perform the analysis, we use the General Weighted Least-Squares (WLS) method instead of Maximum likelihood (ML), since both the data present a non-normal distribution and because ML does not allow us to employ the weight matrix required for the analysis, which is the inverse of the estimated asymptotic covariance matrix, W, of the polychoric correlations (Kline, 2005).

$$F(\theta) = (s - \sigma)' W (s - \sigma) \qquad (4)$$

where *s'* is a vector of the elements in the lower half of the covariance matrix S of order $k \times k$ used to fit the model to the data, σ' is the vector of corresponding elements of Σ (θ) reproduced from the model parameters θ, finally W^{-1} is the positive definite matrix of order $u \times u$ where $u = k(k+1)/2$. The WLS function is the weighted computation of the square residuals (Barrio and Luque, 2000).

We will assess the goodness-of-fit for the model by analysing factor loadings that relate each indicator with the constructs. Reliability will be measured by means of composite reliability and Cronbach'α. Moreover, the extracted validity for each construct will be also measured (Hair et al,.1999).

Since cross group comparisons were performed, the level of invariance will already be measured. In this case, the confirmatory factor analysis will be defined by means of Multi-Sample analysis (Steenkamp and Baumgartner, 1998). For Multi-Sample analysis it is assumed that equations (1), (2) and (3) holds in each group. Considering a set of G groups, the model for group g is defined by the parameter matrices: $\Lambda_y^{(g)}$, $\Lambda_x^{(g)}$, $\mathrm{B}^{(g)}$, $\Gamma^{(g)}$, $\Phi^{(g)}$, $\Psi^{(g)}$, $\Theta_\varepsilon^{(g)}$, $\Theta_\delta^{(g)}$, where the subscript (g) refers to the g-th group, $g = 1,2,...,G$ (Jöreskog and Sörbom, 1996). Each of these matrices may contain fixed, free and constrained parameters as before. To estimate all the models simultaneously, the following fit function is minimized,

$$F = \sum_{g=1}^{G} \left(N_g / N \right) F_g (S^{(g)}, \Sigma^{(g)}, W^{(g)}), \qquad (5)$$

where, F_g is the fit function (4), N_g is the sample size in group g and $N = N_1 + N_2 + ... + N_G$ is the total sample size; $S^{(g)}$ and $\Sigma^{(g)}$ are the sample and population covariance matrices in group g, and $W^{(g)}$ is the weight matrix for group g.

Once the parameters have been estimated, the "configual" or "pattern" invariance is considered. This level of invariance implies that the pattern of salient and non salient factor loadings for the measurement model is the same for the different segmented groups (Steenkamp and Baumgartner, 1998). In this case, similar but not equal latent variables are presented in the different groups. We have to note that, "configural" invariance does not indicate that people in different groups respond to the same items in the same way (Steenkamp and Baumgartner, 1998). However, it allows us to explore the basic structure of the construct cross-groups.

As a second step, full or partial metric invariance has to be satisfied because the scale intervals of the latent constructs have to be the same or at least comparable across groups. In other words the following condition must be fulfilled.

$$\Lambda_y^{(1)} = \Lambda_y^{(2)} = \ldots = \Lambda_y^{(G)}, \; and \quad \Lambda_x^{(1)} = \Lambda_x^{(2)} = \ldots = \Lambda_x^{(G)}$$

This allows us to examine structural relationships with other constructs cross-groups.

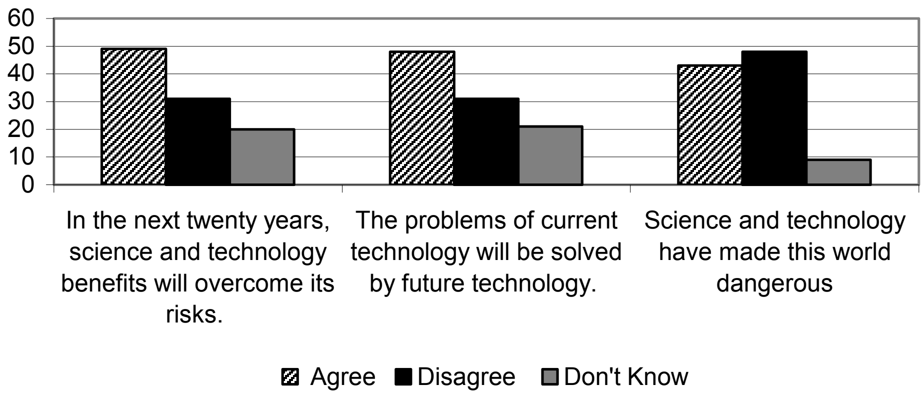
Regarding the structural model, we begin with an assessment of the estimated parameters in the structural equations (Hair et al., 1999). We proceed with estimating the reliability coefficients of each equation and the associated correlation matrix among constructs examined in our model (Barrio and Luque, 2000). Finally, diagnostic parameters such as Chi square (X^2); Root Mean Square Error of Approximation (RMSE); Goodness of Fit Index (GFI); the Adjusted Goodness of Fit Index (AGFI); the Comparative-Fit-Index (CFI); the Normed-Fit-Index (NFI) and the Non Normed-Fit-Index (NNFI) will be also considered as indicators of the model goodness-of-fit for the CFA and the SR model.

5.6 Results

5.6.1 Descriptive analysis

Before empirically testing the theoretical structural model defined in this study, some descriptive results from the survey are provided. First, some questions regarding science and technology are evaluated. Interestingly, there is some ambivalence in public opinion on science and technology. One the one hand, 61% of respondents agree that science and technology is a source of risk, which is characterized as "skepticism on science".

However, about 63% of the respondents also trust in science for solving current and future problems. Moreover, the Spanish society seems to be divided into three groups regarding their perception of science (see Figure 5.2). This division has been already detected by Gaskell et al. (2003, 2004 and 2006) and Onyango et al. (2004): 49% of the respondents answered that science will be beneficial in the next 20 years (“science supporters”), 31% just opposite (“science reluctance”) and 20% either don’t know or don’t answer (“indifferentist”). This last group is relevant and should have something to do with the lack of information already stated. The final consumer decision of “undecided” is a key element for social acceptance or reluctance of science advances.



Question: Now I will read you some opinions on science and technology, and would like you to tell me if you agree or disagree with them.

Figure 5.2 Public benefit perceptions of Science and Technology.

Although 65% of the respondents are interested on science, only 37% are self-defined as “informed”, while, 60% describe themselves as not well informed. These percentages display evidence of a lack of compressible information available on science and technology for Spanish citizens. A similar situation takes place for environmental issues. Around 74% of respondents reveal to be interested, but only 46% consider themselves as “informed”, while 50% declared they are not well informed.

Looking at regional differences, Aragon, Canary Islands, Catalonia and Madrid are the most interested in science and technology – with more than 70% of respondents interested. Regions on the opposite side include Andalusia, Asturias, Cantabria, Extremadura and the Bask Country. Moreover, the only region with a relevant “doesn’t know" response is the Balearic Islands with almost 7% of respondents. Likewise, public "subjective knowledge" on science and technology is only relevant for two regions, Rioja (76% of respondents in this region feel well informed about science and technology) and Navarra (50%). Catalonia, Aragon, Valencia and Madrid are near the average (40% of respondents feeling well informed about science and technology) while in the rest the percentage rages from 20 to 30%.

A second section of the survey focused on specific scientific and technologic applications. As Table 5.3 shows, when comparing new technologies, we find that those technologies that offer direct benefits to consumers or environment – Organ transplant, solar energy, computers, IVF and internet –are considered much more useful than others in which benefits are either national or corporative –Nuclear energy, space exploration, biotech or genetic engineering. Indeed, for the former group of technologies, respondents are more clearly positioned than for the second group (less "don't know" responses). We can presume, therefore, that more benefits imply clearer opinion. In addition, respondents were also requested about which of these technologies must be promoted. Solar energy and computers are considered the more interesting, followed by genetic engineering, organ transplants, space exploration and biotechnology.

Table 5.3 Cross valuation among different new technologies.

	Improve (%)	Does not affect (%)	Worsens (%)	DK (%)
Biotechnology	54.86	4.65	8.07	32.42
Computers	74.76	5.66	6.5	13.08
Genetic engineering	56.3	4.05	12.48	27.17
Space exploration	51.08	16.01	9.71	23.2
Solar Energy	80.14	4.01	1.85	14
Internet	66.65	8.63	6.86	17.86
Telecom	81.9	4.25	2.21	11.64
IVF	69.02	7.26	6.3	17.42
Nuclear technologies	29.41	7.22	42.94	20.43
Organ Transplants	87.88	2.61	0.8	8.71

Question: Do you think that the following technologies will improve quality of life in the next years?

The last part of the questionnaire aims to examine Spanish public perception towards biotechnology and genetic engineering. First, general public subjective knowledge on this technologic application seems to be lower than on science and technology taken as a whole. Results indicate that only 18% of the sample feels well informed about genetic engineering or biotechnology. These results are consistent with previous studies in Spain, as those by Martinez et al. (2004), Noomene and Gil et al. (2004) and Vilella-Vila et al. (2005), among others. Moreover, these authors also state that the Spanish population has not made a significant effort to be informed. As well as for science and technology, the region with major "subjective knowledge" is Rioja – where almost 60% of the sample feel well informed about genetic engineering and biotechnology- followed by Cantabria – with almost 30% - and Navarra – with more than 26%.

Risk perception of damages derived from biotechnology and genetic engineering on people and environment is visibly important for Spanish society. Almost 50% of the sample considers these applications as dangerous for people and more than 50% consider them a danger for the environment. This important level of risk perception seems strange as many people who perceive biotechnology as a risky activity admit to be under-informed on the topic. In Rioja and Cantabria, those regions with a higher subjective knowledge about biotechnology and genetic engineering, more than 40% of respondents consider that this technologies are little or not dangerous for people and environment. It is also important to note the case of Navarra where, although 26% of respondents declared to be well informed, 50% of the samples marked the answer "don't know" to this question. Finally, those regions where less than 20% of respondents declare to be well informed about biotechnology and genetic engineering, consider this application to be very or somewhat dangerous either for people and environment or do not answer this question. In other words, it seems that better information is negatively correlated with risk perception.

In spite of this general attitude, some differences exist depending on the type of application. In general, people tend to positively value those applications with major direct benefits to the public, as it happened when evaluating science and technology in broad sense. As can be observed in Table 5.4, people mainly value medical applications, followed by environmental applications and agricultural applications. In addition, no main regional differences on perceptions and use of genetic engineering applications appear to exist. Respondents in Aragon give high value to agricultural applications, (average value of 8). This can be partially explained by the fact that it is one of the main producer regions of GM maize.

Table 5.4 Public opinion on the genetic engineering applications (Note: 0 "totally disagree" and 10 "totally agree")

Question	mean	s.e
To develop crops resistant to frozen and "plagas".	6.37	0.072
To develop cattle "engordar" fater.	1.58	0.052
To develop bacterium for cleaning up black "marea"	7.72	0.059
To detect people hereditary diseases	8.36	0.044
To apply new medical treatments	8.45	0.044

Question: how you would value the use of genetic engineering for the following purposes?

Table 5.5 shows that respondents feel alarmed about these products, and find them unnecessary and unnatural. There are no significant regional differences, in relation to this question: However, Asturias shows a clearer pattern of GM food tolerance, as items considering GM food as beneficial, and with acceptable risks, get an average score of 6.

Table 5.5 Public opinion on GM food (Note: 0 "totally disagree" and 10 "totally agree")

Question	mean	s.e
The existence of GM will benefit most of the population	3.55	0.071
Risks associated with GM food are acceptable	3.50	0.067
Although some benefits are associated to GM food, these are unnatural	7.50	0.057
The idea of GM food alarms me	6.50	0.066
The existence of GM food is not dangerous for future generations	3.02	0.069

Question: Now I will read you some opinions on the existence of GM food, and would like you to tell me the degree of agreement or disagreement with them.

Finally, respondents were asked about labelling information and purchasing intention regarding to GM food. We have found that 90% of Spanish respondents are in favour of mandatory labelling. Moreover, when asking about their consumption intentions, less than a 30% will consume a GM food - such as potato with corn genes- neither if it's cheaper than conventional one. Not surprisingly, Asturias is the region with a higher percentage of consuming GM food (40% of the sample), followed by Valencia, Madrid, Rioja, Navarra and Balearic Islands (around 30%).

5.6.2. Measurement Model (Confirmatory factor analysis)

Following the methodological approach described in section 3, the first step of the study is to carry out a confirmatory factor analysis for the whole set of constructs considered in the theoretical model: 1) consumers approach towards science and technology; 2) consumers approach towards the environment; 3) perceived benefits of science and technology; 4) attitudes toward biotechnology; 5) attitudes toward GM medical applications; and 6) Perceived Benefits of GM food, assuming all errors to be uncorrelated. It has been performed using both a single full population analysis and some Multi-Group Analyses[24]. More precisely, in this study the sample has been segmented by: a) consumer intentions towards GM food; b) GM-free and GM producer regions; c) gender; and d) age. The confirmatory factor analysis with all indicators resulted suitable for both the full sample and Multi-Group Analyses. The correlation matrix among all variables for the full model is presented in Table 5.6[25].

Table 5.6 Correlation matrix among indicators (Full population)

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.00																		
X2	0.66	1																	
X3	0.60	0.44	1																
X4	0.47	0.72	0.65	1															
X5	0.28	0.20	0.10	0.13	1														
X6	0.16	0.16	0.02	0.07	0.67	1													
X7	0.18	0.20	0.04	0.14	0.46	0.47	1												
X8	-0.09	-0.13	0.00	-0.06	-0.33	-0.40	-0.28	1											
X9	0.21	0.16	0.13	0.11	0.26	0.28	0.21	-0.18	1										
X10	0.28	0.27	0.17	0.19	0.33	0.30	0.25	-0.25	0.64	1									
X11	-0.09	-0.07	0.01	-0.05	-0.24	-0.37	-0.28	0.38	-0.36	-0.26	1								
X12	-0.05	-0.04	0.07	-0.02	0.21	-0.34	-0.29	0.36	-0.26	-0.24	0.84	1							
X13	0.24	0.21	0.17	0.21	0.28	0.22	0.27	-0.09	0.25	0.25	-0.27	-0.25	1						
X14	0.21	0.19	0.14	0.16	0.28	0.25	0.30	-0.12	0.26	0.25	-0.32	-0.29	0.92	1					
X15	0.13	0.13	0.03	0.11	0.24	0.31	0.29	-0.25	0.28	0.30	-0.43	-0.43	0.28	0.30	1				
X16	0.09	0.13	-0.01	0.06	0.22	0.28	0.25	-0.26	0.27	0.27	-0.39	-0.38	0.20	0.26	0.65	1			
X17	0.00	0.02	-0.05	-0.02	0.14	0.24	0.23	-0.18	0.22	0.23	-0.36	-0.35	0.15	0.17	0.52	0.62	1		
X18	-0.01	-0.05	0.10	0.00	-0.04	-0.16	-0.09	0.38	-0.11	-0.20	0.28	0.29	0.04	0.02	-0.46	-0.48	-0.35	1	
X19	-0.07	-0.11	0.07	-0.03	-0.13	-0.22	-0.18	0.41	-0.17	-0.21	0.40	0.37	-0.06	-0.05	-0.49	-0.51	-0.43	0.62	1

The main parameters to test for the robustness of the constructs, following Hair et al. (1999) and Kline (2005), appear to show acceptable results for the full sample as well as for the Multi-Sample models, as shown in Tables 5.7 to 5.11. Indeed, the reliability of factor loadings for all constructs are above 0.5 and the t-values associated with the loadings are all significant ($P<0.001$), implying a satisfactory convergent validity (Olsen, 2003). Four additional parameters are important in examining the

[24] The main question addressed in a multiple-sample SEM is if values of model parameters vary across groups, which is equivalent to measure interaction effects (Kline, 2005).
[25] Correlation matrices for the segmented sample analyses are available under request.

internal consistency of the model, which include composite reliability (which must be > 0.7), internal consistency reliability, measured by Cronbach's α, (which must be around 0.7), extracted validity (which must be >0.5) and discriminant validity (correlations among constructs < 0.85) (Hair et al., 1999; and Bagozzi and Yi, 1988). For every construct, all composite reliabilities are greater than 0.7 and all Cronbach's α are around 0.7, thus we can say that reliability is acceptable. Regarding the variance extracted, it is higher than 50% in all cases. Finally, since the correlations among latent factors do not exceed 0.85, in any case, it can be stated that discriminant validity has been accomplished too.

Table 5.7 Reliability of the standardized Confirmatory Factor Analysis (Full population).

Construct	Indicators	Standardized loadings (*t*-Value)	Composite reliability (Variance extracted)	Goodness of fit parameters
C1	***Cronbach's α***	0.73	0.89 (0.80)	χ^2 = 1263.14
	X1	0.88 (62.63)		df = 137
	X2	0.91 (74.43)		p = 0.00
C2	***Cronbach's α***	0.72	0.90 (0.82)	
	X3	0.87 (51.71)		
	X4	0.94 (64.60)		
C3	***Cronbach's α***	0.64	0.83 (0.50)	*RMSEA* = 0.06
	X5	0.77 (43.42)		
	X6	0.84 (55.34)		*GFI* = 0.98
	X7	0.66 (34.11)		
	X8	-0.69 (34.94)		*AGFI* = 0.97
C4	***Cronbach's α***	0.66	0.89 (0.59)	
	X9	0.70 (39.93)		*CFI* = 0.95
	X10	0.74 (43.49)		
	X11	-0.94 (90.06)		
	X12	-0.89 (74.76)		*NNFI* = 0.94
C5	***Cronbach's α***	0.88	0.96 (0.93)	
	X13	0.97 (47.51)		*NFI* = 0.94
	X14	0.96 (50.76)		
C6	***Cronbach's α***	0.75	0.85 (0.65)	
	X15	0.85 (61.93)		
	X16	0.85 (65.80)		
	X17	0.72 (42.71)		
	X18	-0.71 (36.82)		
	X19	-0.80 (49.87)		

Note: REMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

The model meets the widely accepted goodness of fit standards for the Full sample confirmatory model and for the Multi-Sample confirmatory models (configural invariance) indicating that the conceptual model satisfactory fits the data, (see also Tables 5.7 to 5.11). It must be pointed out that although the chi-square was significant, it is highly affected by sample size (Kline, 2005). Therefore, alternatively goodness of fit criteria were considered. For the full sample (see Table 5.7), the Root Mean Square

Error of Approximation (RMSEA) is 0.06, which is well under the 0.5-0.8 limit interval offered by Hair et al. (1999) and Kline (2005). The goodness-of-fit index (GFI) was 0.98, the adjusted Goodness of Fit Index (AGFI) was 0.97, the Comparative-Fit Index (CFI) 0.95, the Normed-Fit Index (NFI) 0.94 and the Non-Normed Index (NNI) 0.94, all were greater than 0.90 as suggested by Marcoulides and Schumacker (1996) and Chen and Li (2007).

Table 5.8 Reliability of the standardized Confirmatory Factor Analysis (Gender segmentation)

Construct	Indicators	Standardized loadings (t-Value)		Composite reliability (Variance extracted)		Configural invariance	Metric invariance
		Males	Females	Males	Females		Full:
C1	***Cronbach's α***	0.71	0.74	0.90 (0.81)	0.89 (0.80)	χ^2 = 1580.74	χ^2 = 1597.04
	X1	0.87 (41.71)	0.90 (46.90)				
	X2	0.93 (50.94)	0.90 (53.56)				
C2	***Cronbach's α***	0.72	0.72	0.93 (0.87)	0.90 (0.82)	df = 274	df = 293
	X3	0.88 (40.42)	0.87 (45.10)				
	X4	0.98 (48.90)	0.94 (51.82)				p = 0.00
C3	***Cronbach's α***	0.65	0.63	0.85 (0.5)	0.84 (0.50)	p = 0.00	
	X5	0.81 (34.95)	0.82 (36.27)				
	X6	0.88 (48.00)	0.85 (47.78)				*RMSEA* = 0.065
	X7	0.69 (27.16)	0.65 (25.28)			*RMSEA* =0.067	
	X8	-0.68 (24.53)	-0.68 (24.82)				*CAIC* = 2349.90
C4	***Cronbach's α***	0.66	0.66	0.91 (0.64)	0.90 (0.61)	*CAIC* =2498.01	
	X9	0.76 (33.41)	0.73 (32.77)				*CFI* = 0.96
	X10	0.77 (34.03)	0.73 (33.19)			*CFI* = 0.96	
	X11	-0.97 (72.56)	-0.97 (71.64)				*NNFI* = 0.95
	X12	0.89 (56.60)	-0.89 (57.02)			*NNFI* =0.95	
C5	***Cronbach's α***	0.89	0.88	0.98 (0.95)	0.96 (0.92)		
	X13	0.96 (43.32)	1.00 (48.13)				
	X14	1.00 (48.97)	0.94 (49.66)				
C6	***Cronbach's α***	0.76	0.73	0.85 (0.65)	0.83 (0.61)		
	X15	0.85 (48.04)	0.86 (47.07)				
	X16	0.82 (39.29)	0.78 (37.17)				
	X17	-0.74 (29.12)	-0.70 (27.46)				
	X18	-0.83 (40.89)	-0.79 (38.81)				
	X19	0.74 (30.58)	0.72 (28.65)				

Note: REMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

Finally, the results for the levels of invariance, regarding the different Multi-Group Confirmatory Factor Analyses, indicate that configural invariance is accomplished across all segmented groups (see Tables 5.8 to 5.11). This model is estimated with science as the baseline model against other models (Steenkamp and Baumgartner, 1998). Although the chi-square was significant ($p<0.001$), the RMSEA, the GFI, AGFI, CFI, NFI and the NNFI were above the commonly recommended levels. Moreover, all factor loadings were highly significant for all Multi-Group Analyses, and standardized factor loadings exceeded 0.6 in all cases. Therefore, it can be stated that the model exhibits configural invariance across age, gender, consumer intentions and

GM regional regulation groups. This level of invariance implies that the pattern of salient and non salient factor loadings for the measurement model are the same for the different segmented groups (Steenkamp and Baumgartner, 1998). That is, the model of interest fits across the groups, that is, the basic structure of each construct fits across groups; however, the unknown parameters (latent variables) of the model are assumed to be similar but not identical across the groups.

Table 5.9 Reliability of the standardized Multi-Group Confirmatory Factor Analysis (age segmentation).

Construct	Indicators	Standardized loadings (*t*-Value)			Composite reliability (Variance extracted)			Configural invariance	Metric invariance	
		18-35	36-56	+56	18-35	36-56	+56		Full:	Partial:
C1	***Cronbach's α***	0.71	0.67	0.75	0.88	0.90	0.92	χ^2 =	χ^2 =	χ^2 =
	X1	0.91 (37.87)	0.85 (39.69)	0.90 (41.57)	(0.78)	(0.82)	(0.85)			
	X2	0.86 (38.36)	0.96 (43.37)	0.94 (44.01)				1909.70	2044.40	1956
C2	***Cronbach's α***	0.68	0.67	0.75	0.89	0.92	0.93			
	X3	0.89 (33.10)	0.85 (32.52)	0.87 (36.28)	(0.80)	(0.84)	(0.87)	df = 411	df =	df =
	X4	0.89 (33.56)	0.98 (38.32)	0.99 (40.84)					449	439
C3	***Cronbach's α***	0.65	0.66	0.60	0.86	0.88	0.82			
	X5	0.84 (29.71)	0.80 (28.60)	0.76 (24.28)	(0.6)	(0.6)	(0.5)	p = 0.00	p = 0.00	p = 0.00
	X6	0.88 (41.26)	0.93 (41.04)	0.83 (33.26)						
	X7	0.69 (24.64)	0.73 825.73)	0.70 (21.62)				*RMSEA*	*RMSEA*	*RMSEA*
	X8	-0.67 (22.13)	-0.73 (23.71)	-0.60 (17.57)				=0.072	= 0.071	= 0.07
C4	***Cronbach's α***	0.60	0.68	0.69	0.88	0.95	0.90			
	X9	0.65 (22.08)	0.82 (29.67)	0.72 (23.42)	(0.54)	(0.75)	(0.61)	*CAIC*	*CAIC*	*CAIC*
	X10	0.65 (22.03)	0.88 (30.97)	0.74 (24.15)				=3285.61	= 3091.47	=3090.4
	X11	-0.96 (59.23)	-0.99 (62.56)	-0.94 (52.62)						
	X12	-0.89 (50.35)	-0.90 (50.85)	-0.91 (43.17)				*CFI*	*CFI*	*CFI* =
C5	***Cronbach's α***	0.84	0.91	0.89	0.96	0.98	0.99	= 0.96	= 0.96	0.96
	X13	0.96 (31.75)	0.96 (37.92)	1.01 (34.95)	(0.93)	(0.96)	(0.99)			
	X14	0.97 (34.00)	1 (42.17)	1.00 (34.02)				*NNFI*	*NNFI*	*NNFI*
C6	***Cronbach's α***	0.74	0.75	0.75	0.85	0.83	0.83	=0.95	=0.95	=0.95
	X15	0.89 (49.46)	0.86 (45.98)	0.85 (40.84)	(0.66)	(0.62)	(0.62)			
	X16	0.81 (34.92)	0.78 (32.95)	0.79 (30.28)						
	X17	-0.72 (23.95)	-0.72 (23.85)	-0.72 (21.42)						
	X18	-0.79 (33.15)	-0.87 (35.46)	-0.77 (28.64)						
	X19	0.73 (27.06)	0.75 (27.59)	0.75 (24.19)						

Note: REMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

A stronger test of invariance (the metric invariance) has also been analyzed. This analysis examines whether respondents of the different groups respond to the items in the same way by allowing us to examine structural relationships among constructs (Steenkamp and Baumgartner, 1998). Results indicate that the hypothesis of full metric invariance, that is, factor loadings being invariant across groups, is supported only for gender. As Table 5.8 shows, there is a non significant increase in chi-square between the model of configural invariance and the model of full metric invariance ($\Delta\chi^2(19) = 16.03, p > 0.10$). Moreover, other goodness of fit criteria such as RMSEA are also adequate. Therefore, we can support full metric invariance for the 19 loadings.

Table 5.10 Reliability of the standardized Confirmatory Factor Analysis (consumer intentions towards GMF).

Construct	Indicators	Standardized loadings (t-Value)		Composite reliability (Variance extracted)		Configural invariance	Metric invariance	
		Willing to consume GMF	Not Willing to consume GMF	Willing to consume GMF	Not Willing to consume GMF		Full:	Partial:
C1	***Cronbach's α***	0.75	0.70	0.88 (0.79)	0.88 (0.79)	χ^2 = 1454.97 df = 274 p = 0.00 *RMSEA* =0.067 *CAIC* =2363.60 *CFI* = 0.97 *NNFI* =0.96	χ^2 = 1606.95 df = 293 p = 0.00 *RMSEA* = 0.068 *CAIC* = 2352.71 *CFI* = 0.96 *NNFI* = 0.95	χ^2 = 1478.53 df = 289 p = 0.00 *RMSEA* = 0.065 *CAIC* = 2258.58 *CFI* = 0.96 *NNFI* =0.96
	X1	0.94 (39.32)	0.85 (46.84)					
	X2	0.93 (46.85)	0.93 (58.97)					
C2	***Cronbach's α***	0.72	0.71	0.90 (0.82)	0.90 (0.82)			
	X3	0.89 (29.81)	0.87 (42.92)					
	X4	0.96 (38.98)	0.94 (56.87)					
C3	***Cronbach's α***	0.62	0.63	0.81 (0.50)	0.81 (0.50)			
	X5	0.83 (29.11)	0.76 (34.61)					
	X6	0.81 (34.01)	0.84 (42.67)					
	X7	0.66 (21.42)	0.64 (24.96)					
	X8	-0.77 (23.53)	-0.63 (24.40)					
C4	***Cronbach's α***	0.64	0.64	0.89 (0.57)	0.89 (0.57)			
	X9	0.73 (26.86)	0.72 (34.07)					
	X10	0.83 (29.10)	0.71 (32.25)					
	X11	-0.92 (50.84)	-0.95 (66.76)					
	X12	-0.89 (40.32)	-0.86 (51.77)					
C5	***Cronbach's α***	0.79	0.90	0.97 (0.93)	0.97 (0.93)			
	X13	1.01 (34.66)	0.99 (33.23)					
	X14	1.00 (36.95)	0.94 (36.03)					
C6	***Cronbach's α***	0.67	0.68	0.75 (0.51)	0.75 (0.51)			
	X15	0.81 (28.19)	0.74 (32.86)					
	X16	0.70 (21.92)	0.73 (31.21					
	X17	-0.62 (18.37)	-0.66 (23.86)					
	X18	-0.87 (26.59)	-0.71 (28.67)					
	X19	0.69 (21,43)	0.75 (29.81)					

Note: REMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

For the other three Multiple-Group analyses, a significant increase in the chi-square statistic between the model of configural invariance and the model of full metric invariance was detected (Age segmentation: $\Delta\chi^2(38) = 134.70, p \prec 0.001$; Consumer intentions: $\Delta\chi^2(19) = 151.98, p \prec 0.001$; GM regional policy: $\Delta\chi^2(19) = 114.4, p \prec 0.001$). The analysis of the Modification Indices (MIs) shows that five, four and six of the nineteen factor loadings for age, consumer intentions, and regional GM policy, respectively, are responsible of the model lack of invariance. Let us consider each of these three segmentations.

In relation to the age segmentation factor loading of items X2, X9, X10 and X18 (see Table 5.2 to name the items) were lower in Age 18-36 than in the other age groups. In addition, X8 was higher in Age 36-56 than in the other age groups. We set free these factor loadings to test partial metric invariance. Table 5.9 shows the statistical results of this model. We can see that the increase in chi-square between the configural invariance model and the metric invariance model is not significant ($\Delta\chi^2(28) = 46.3 p \geq 0.01$), moreover, other goodness of fit values such as RMSEA are also adequate. Therefore, we can support partial metric invariance with five of the 19 invariance constrains relaxed.

Table 5.11 Reliability of the standardized Confirmatory Factor Analysis (GM-free and producer regions).

Construct	Indicators	Standardized loadings (t-Value)		Composite reliability (Variance extracted)		Configural invariance	Metric invariance	
		GM free region	GM producer region	GM free region	GM producer region		Full:	Partial:
C1	*Cronbach's α*	0.71	0.74	0.90 (0.81)	0.92 (0.85)	χ^2 = 1497.11 df = 274 p = 0.00 *RMSEA* =0 .064 *CAIC* =2418.62 *CFI* = 0.96 *NNFI* =0.95	χ^2 = 1611.51 df = 293 p = 0.00 *RMSEA* = 0.064 *CAIC* = 2367.84 *CFI* = 0.96 *NNFI* = 0.95	χ^2 = 1551.77 df = 287 p = 0.00 *RMSEA* = 0.063 *CAIC* =2360.26 *CFI* = 0.96 *NNFI* =0.95
	X1	0.87 (52.11)	0.91 (57.08)					
	X2	0.93 (55.29)	0.90 (58.14)					
C2	*Cronbach's α*	0.73	0.71	0.96 (0.92)	0.89 (0.80)			
	X3	0.92 (40.40)	0.88 (39.75)					
	X4	0.99 (48.38)	0.91 (46.40)					
C3	*Cronbach's α*	0.66	0.64	0.87 (0.60)	0.82 (0.50)			
	X5	0.87 (34.39)	0.76 (32.81)					
	X6	0.89 (41.22)	0.82 (40.73)					
	X7	0.65 (24.50)	0.68 (27.48)					
	X8	-0.76 (26.88)	-0.65 (25.42)					
C4	*Cronbach's α*	0.68	0.64	0.93 (0.70)	0.88 (0.55)			
	X9	0.79 (32.41)	0.67 (29.23)					
	X10	0.85 (34.75)	0.70 (30.48)					
	X11	-0.95 (66.05)	-0.94 (68.26)					
	X12	-0.90 (54.29)	-0.88 (56.99)					
C5	*Cronbach's α*	0.89	0.88	0.99 (0.97)	0.96 (0.92)			
	X13	0.98 (41.91)	1.01 (48.16)					
	X14	0.99 (49.61)	0.92 (46.21)					
C6	*Cronbach's α*	0.75	0.74	0.86 (0.67)	0.81 (0.59)			
	X15	0.91 (44.35)	0.82 (43.29)					
	X16	0.83 (36.81)	0.75 (36.43)					
	X17	-0.69 (27.29)	-0.74 (31.03)					
	X18	0.80 (36.70)	-0.81 (42.07)					
	X19	0.67 (27.46)	0.75 (33.08)					

Note: REMSEA <0.05-0.08 (Browne and Cudeck, 1992; Kline, 2007; Baumgartner and Homburg, 1996) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

As can be observed in Table 5.10 factor loadings of X1, X8, X14 and X18 in the consumer intentions segment were lower in the not willing to consume GM food segment than in the other group. We also observe that the increase in the chi-square statistic between the configural and metric invariance models is not significant ($\Delta\chi^2(19) = 23.56 p \geq 0.10$). As a result, we can support partial metric invariance with four of the 19 invariance constrains relaxed.

Finally, for the regional GM policy segmentation, factor loadings of X4, X5, X8, X15 and X16 (see Table 5.2 to name the items) were lower in the GM producer regions group than in the other group. In addition, X19 (see Table 5.2 to name the item) was lower in the GM free regions. Thus, we set free these factor loadings to test partial metric invariance. Table 5.11 shows the statistical results of this model. Contrary to the other two cases, in this case there is a significant increase in the chi-square statistic between the configural and the metric invariance models ($\Delta\chi^2(13) = 54.6\, p < 0.01$). As a consequence, even though other goodness of fit values such as RMSEA are adequate, we cannot support partial metric invariance.

To sum up, we have obtained a common pattern among all different segments regarding the adequacy of the used constructs. That is, the structure of each construct is equal across groups. However, a perfect comparison of the structural relationships among groups can only be ensured for gender segmentation on the basis of our diagnostic tests. In any case, valid cross-group comparisons of the structural model can be conducted even when the ideal of full invariance is not realized (Steenkamp and Baumgartner, 1998). Therefore we can clearly compare among gender, age and consumption intentions groups since at least partial metric invariance has been checked. On the contrary, the comparison of structural relations between regions with different GM policies must be analyzed in further analysis due to its lack of metric invariance.

5.6.3 Structural Model

When testing the structural relations of the models using a Structural Equation Model we find that a satisfactory fit has been obtained for all models (Table 5.12). Figure 5.3 shows the path diagrams obtained for the full sample model. All hypothesis except H6 are with paths significant at $p = 0.001$ level and therefore supported. This means that consumer's attitude towards science and technology does have a positive and important influence on its benefit perceptions of science and technology ($\beta = 0.5$). The opposite takes place when considering attitudes towards the environment ($\beta =$ -0.21). The estimation of path coefficients from perceived benefits of science and technology to attitudes towards biotechnology reveals that there is a positive relation among these two constructs ($\beta = 0.73$). Finally, H4 and H5 that assume a better acceptance of GM medical applications and major GM food benefit perception if consumers reveal a positive attitude towards biotechnology were also supported

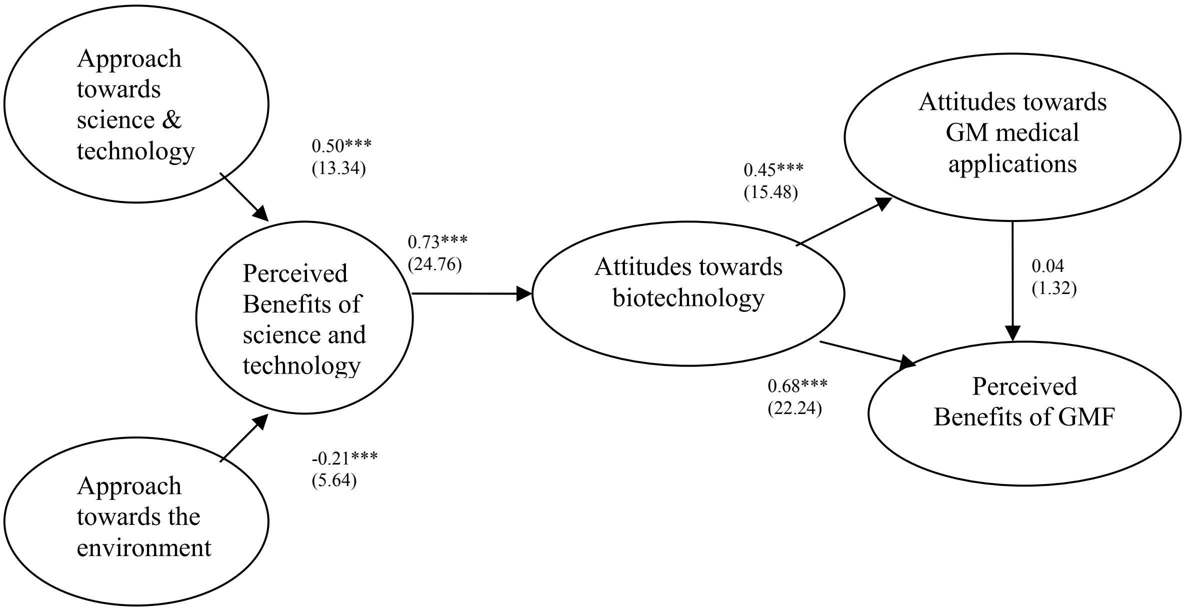
($\beta = 0.45$ and 0.68 respectively). In contrast, a negative relation among attitudes towards medical applications and GM food benefits perception was not supported (H6).

Table 5.12 Goodness-of-fit for the structural regression models

	Full	18-35	36-56	+56	WTC	NWTC	GMfree	GM producer	Male	Female
χ^2_{df}	1326.80	704.10	695.38	669.41	658.97	953.05	743.61	853.73	812.21	851.69
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RMSEA	0.062	0.070	0.070	0.070	0.070	0.060	0.066	0.063	0.067	0.069
GFI	0.98	0.97	0.98	0.97	0.98	0.98	0.98	0.98	0.98	0.97
AGFI	0.97	0.96	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.96
CFI	0.95	0.94	0.96	0.96	0.97	0.95	0.96	0.96	0.96	0.94
NFI	0.94	0.92	0.95	0.95	0.96	0.94	0.95	0.95	0.96	0.93
NNFI	0.94	0.93	0.96	0.95	0.97	0.94	0.96	0.95	0.96	0.93

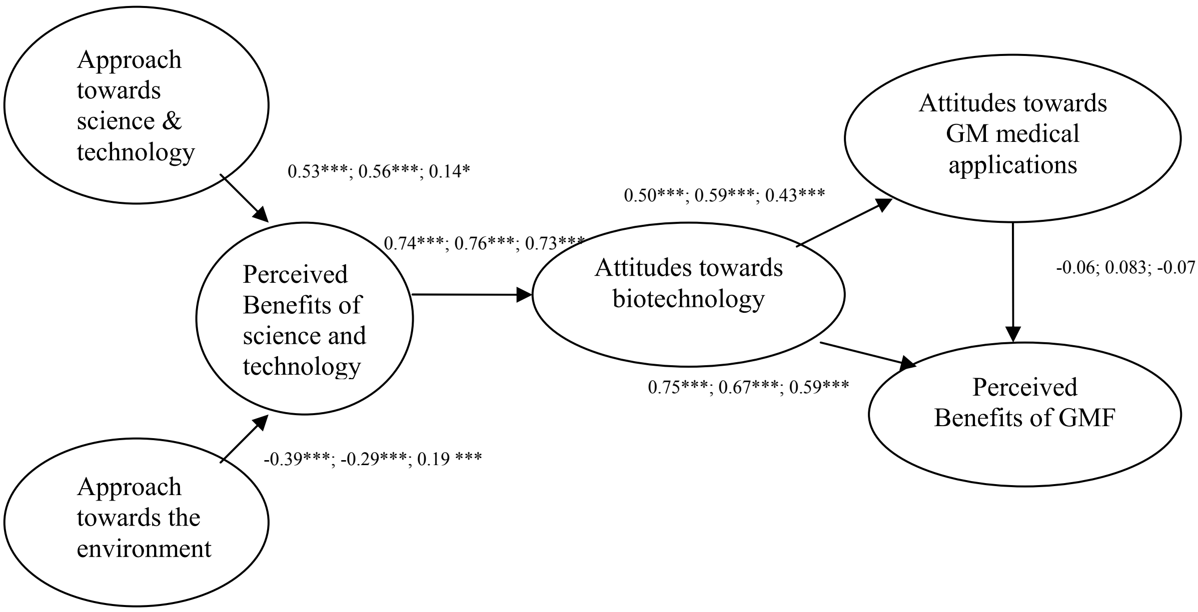
REMSEA <0.5-0.8 (Browne and Cudeck, 1992; Kline, 207) GFI; AGFI; CFI; NFI and NNFI >0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)

If we examine Spanish consumers' heterogeneity by age (Figure 5.4), we observe that younger respondents tend to be more homogenous than the full population. However, the behaviour of the oldest group is different. As can be observed in Figure 5.4, for this segment there is a weaker relationship of attitudes towards science and technology and benefits perception. In addition, there is a positive relationship between attitudes regarding the environment and science and technology perceived benefits. Hypothesis 3, 4 and 5 have the same sign and level of significance as other groups, but the path coefficient is lower, especially for H4 and H5. Finally, the negative association between attitudes towards GM medical applications and GM food benefits perception (H6) is not supported as it was the case in the other age groups, as well as in the full sample. In conclusion, older people (+56 years old) understand benefits of science and technology differently than the rest of respondents, especially regarding its relation towards the environment. However, the behavioural process that goes from science and technology benefit perception to GM food benefit perception is similar for the entire sample no matter the age of respondents.



* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure5. 3 Path diagram results Spanish full sample

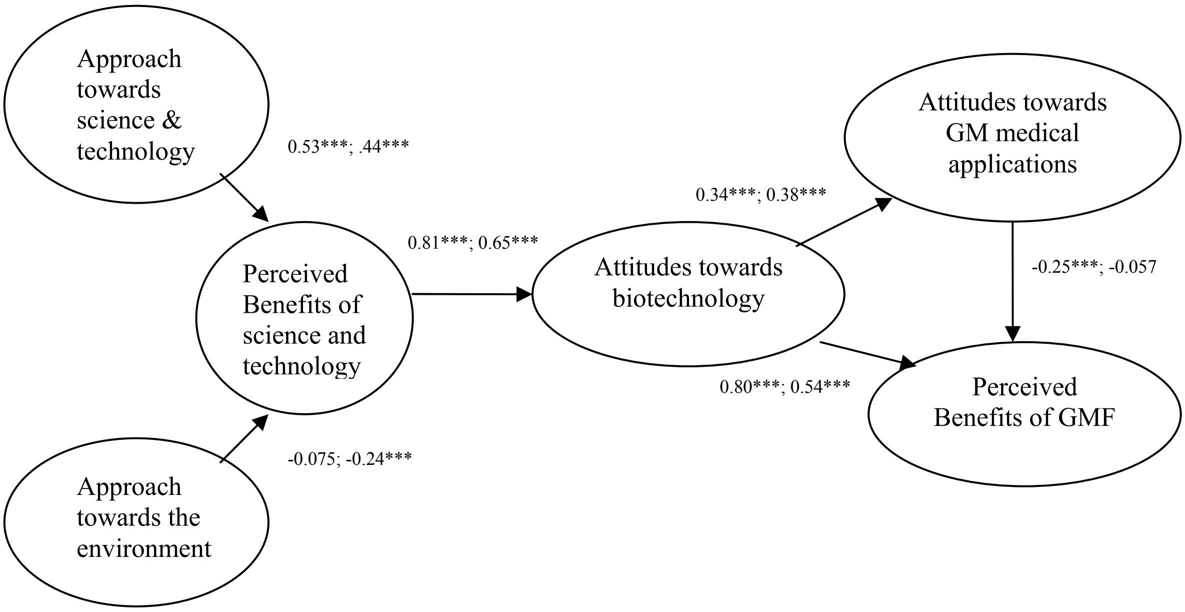


* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure 5.4 Path diagram results Spanish age segmented sample (18-35; 36-56; +56)

Figure 5.5 shows the main relationships concerning consumer intentions. Regarding to Hypothesis 1, 3, 4 and 5, there is a clear agreement among groups, that is: H1, a positive approach towards science and technology has a positive impact on science and technology benefit perception with a path of about 0.5; H3, attitudes towards biotechnology rely on benefit perception of science and technology, more for people willing to consume GM food; either H4 and 5 were supported for the two groups. That is, attitudes towards GM medical applications depend on consumers attitudes towards biotechnology with similar path coefficients and significance for the two segmented groups. However, GM food perceived benefits depend on attitudes towards biotechnology with a major path coefficient for consumers willing to consume GM food than for consumers not willing to consume GM food. Finally, H2 and H6 were significant for only one of the two segmented groups. Explicitly, a positive approach towards the environment has a negative impact on science and technology benefit perception only for people not willing to consume GM food (H1). Furthermore, positive attitudes towards GM medical applications were considered to have a negative influence on GM food perceived benefits for the group willing to consume GM food. Therefore, we can conclude that attitudes towards biotechnology rely more on benefit perception of science and technology for people willing to consume GM food. Moreover, a positive approach towards the environment has a significant negative impact on science and technology benefit perceptions for people not willing to consume GM food. And parallel, attitudes towards biotechnology have a major influence on GM food perceived benefits for consumers willing to consume GM food and attitudes towards medical applications are significantly negative related to GM food perceived benefits only for the group willing to consume GM food.

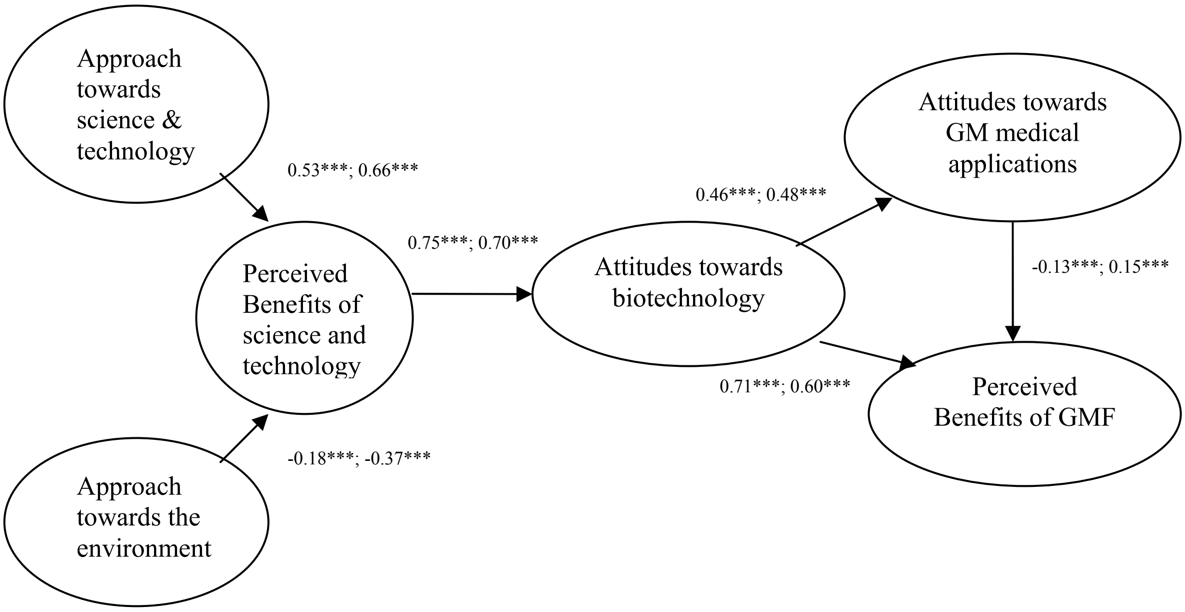
Although metric invariance was not supported, we compared the structural model results among Spanish GM free and producer regions. Indeed, all hypotheses were significant for the two groups. Moreover, hypothesis 1, 3, 4 and 5 present similar path coefficients among groups- see Figure 5.6. Dissimilar, the path coefficient of H2 is bigger for the GM free group. That is, respondents from GM free regions reveal a more important negative relation between consumers' positive approach towards the environment and consumers benefit perception towards science and technology. Finally, an important difference in H6 exists among groups. That is, respondents from GM producer regions reveal a negative relation between positive attitudes towards GM medical applications and GM food benefit perception, opposite the positive relations revealed for consumers of the GM free regions. Indeed, this comparison must be cautiously considered since we cannot ensure that the structural relations among the Latent Variables that we are relating are comparable among the two groups.



* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

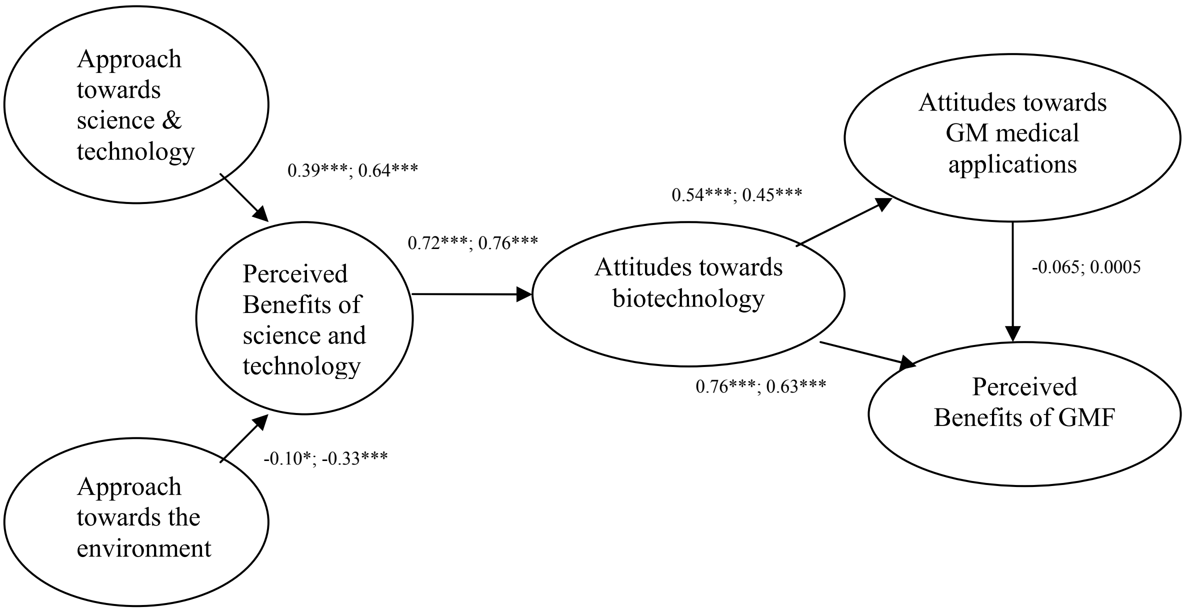
Figure 5.5 Path diagram results Spanish consumer intentions towards GMF segmented sample (willing to consume; not willing to consume)

Finally, gender heterogeneity is analyzed, see Figure 5.7. Minor heterogeneity was detected for this segmentation. All paths present the same singe and significance for the two groups. Moreover, almost all groups have similar path coefficients but for H1 and H2 that females reveal a bigger coefficient. That is, the positive and negative influence that science and environmental approaches have on science and technology perceived benefits is more important for females than for males.



* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure 5.6 Path diagram results Spanish GM producer region segmented sample (GM producer; GM free)



* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure5. 7 Path diagram results Spanish segmented sample by gender (male; female)

5.7 Conclusion

The motivation of these papers is grounded on exploring the influence of meta-attitudes in explaining specific consumer judgments of GM food. In this paper, we test the causal and empirical validity of a behavioural mechanism to explain evidence of scepticism towards Genetically Modified (GM) food. Consumer reactions to GM food appear to demonstrate a simultaneous endorsement of risk and benefit perceptions (Pidgeoen et al., 2005).

From exploring the causal empirical model, we found that individuals' interest and information towards either science or the environment are key factors in defining their perceived benefits associated with scientific and technological applications, supporting H1 and H2 of the analysis. This finding is important for policy makers in directing future communication strategies regarding scientific and technological applications. Results show that a positive approach towards science and technology is positively related with science and technology benefit perception (H3). This result exhibits the relation among what is know as "subjective knowledge" and attitude towards a behavior, stated by some studies such as Lusk et al. (2004). Indeed, "subjective knowledge" depends on an individual's general values and this makes people search information from diverse sources - consumer organisations, environmental groups and scientists among others. Therefore, more effective risk-benefit communication strategies are needed regarding new scientific applications, such as GM food.

This study also supports a link between positive attitudes toward biotechnology and the perception of benefits associated to either GM medical applications (H4) or food applications (H5), consistent with earlier research. However, consumers do not perceive GM technology as being a one-dimensional skill. Therefore, no significant relation has been detected between the acceptance of GM medical applications and GM food applications (H6). Consequently different risk-benefit communication strategies must be developed for each GM application.

In addition to the behavioral mechanism, this study also considers the relevance of individual values and social elements in constructing this mechanism. For that, a

Multi-Sample analysis has been performed. We segmented the sample by: consumer intentions towards GM food; consumer of GM-free and GM producer regions; gender and age. Results indicate that for the Multi-group analyses, the measurement instruments are at least partially invariant for almost all cases – not for GM-free and GM producer regions. Nevertheless, valid cross-group comparisons can be conducted even when full invariance is not realized (Steenkamp and Baumgartner, 1998).

First of all, no main gender heterogeneity was detected in this study (H8), except for the female group, which was more positively and negatively influenced by science and environment approaches, respectively, on science and technology benefit perceptions. Regarding to respondents age (H7), two main behavioral mechanism groups were defined: less than 56 and more than 56 years old. The main difference is the positive, instead of negative, relations of consumers approach towards the environment and its perceived benefits of science and technology. That is, older people who are more interested and knowledgeable about nature do perceive benefits associated to science and technology, which is in contrast to younger people. Furthermore, some heterogeneity was detected regarding consumer previous characterized attitude towards GM food (H9). Finally, no main results can be reported regarding the structural relations of GM free and producer regions since measurement invariance among these groups is not supported (H10).

The model developed in this study examines only one side of the complex process that underpins individuals' purchase intentions towards GM food. An extension of the model definition could be undertaken with the introduction of additional latent variables such as, GM food "subjective knowledge", labelling information, risk attitudes, social behaviour regarding GM food and purchase intentions towards GM food. Although the model developed in this study highlights the relevance of general values (meta-attitudes) in shaping individuals behaviour, our findings call for a future research to explore alternative explanations. As one of the main limitations of this study it is worth mentioning the use of externally designed data that restricts the availability of existing constructs including "subjective knowledge" and consumer purchase intentions

5.8 References

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Chapter 6:

Structural equation modelling of consumer acceptance of genetically modified (GM) food in the Mediterranean Europe: a cross country study.

6.1 Abstract

There is some agreement in the food policy literature in that inception of genetic modification (GM) techniques in food production conveys both opportunities and risks which are found to differ across heterogeneous populations, which calls for a better understanding of behavioural responses to risk and benefit information . One of the major limitations of previous behavioural research lies in taking into account food values and trust in information sources in a way that causality is accounted for. This paper contributes to the literature by examining the behavioural process that drives individual's perceptions of GM food taking advantage of an empirical choice methodology that corrects for endogeneity in decision making relationships, namely Structural Equation Modelling. We report the results of an empirical application to conceptualise food decision making in three specific Mediterranean countries, namely Spain, Italy and Greece. Our first major finding indicates that public attitudes toward GM food are being formed from a reasoning mechanism that departs from trust in science and in public authorities, ultimately determining consumer's final purchasing decisions. Our second important finding suggests marked differences in the reasoning mechanism that lead to the acceptance of GM food in the three countries examined suggesting different food communication strategies to each culture.

6.2 Introduction

Acceptance of new science developments, such as new food biotechnology applications, is a matter of significance interest worldwide for a variety of reasons including the remarkable impact on the extent of technology diffusion in key areas such as food production. The inception of genetic modification (GM) techniques in food production is envisaged as an opportunity to improve food production technologies and/or product differentiation in the food chain and ultimately fulfil consumer preferences for diversity. Indeed, on the one hand, farmers and manufacturers perceive potential benefits from efficiency improvements despite some associated cost due to the reimbursement of intellectual property rights. On the other hand, public controversy has arisen as a result of the "uncertainties" and perceived "risks" – both to health and the environment – which the technology conveys. The latter is explained by consumer's perceptions of GM food as potentially threatening the sustainability of traditional food markets that have known for years. As a result, consumers might dread for instance the commercialisation of GM food in supermarkets, and ultimately could be thought of even refusing to consume any product made with this technology.

In light of this evidence, a careful understanding of consumer's reactions towards GM food is needed before the introduction of several varieties of GM food, especially in European Mediterranean markets where a strong culinary culture arguably has prevailed over time. Particularly, this is the case of Spain, Italy and Greece where traditional values, such as the Mediterranean diet, contrast with the new efficiency and benefit claims of new food biotechnology. However, large differences appear to prevail when one looks at the commercialisation of GFM food. Indeed, whilst Spain is the country within Europe with the largest land devoted to GM food[26], Greece and Italy arise are two countries free of transgenic production (James, 2006). This makes the comparison between Spanish, on one hand, and Greek and Italian, on the other hand, very relevant for the purpose of a better understanding of consumers' behaviour regarding GM products. Particularly, important intermediary factors that the literature

[26] In the last decade, Spain has increased the land devoted to GM food up to 75,000 hectares (MAPA, 2007)

has addressed are those of consumer trust and general attitudes towards science and technology as we explain in the next section in detail.

This study aims to explain the country specific behavioural process and mechanisms that give rise to consumer attitudes concerning GM food in Mediterranean countries. More broadly, new food related products with intensive technology innovation by taking into account of endogenous relationship between underlying latent variables or social constructs such as trust or values which as we explain are pointed out as explaining consumers reactions. We do so by testing whether public attitudes towards GM food are the result of a reasoning mechanism departing from either trust in institutions or general attitudes towards science and technology and then we hypothesise that ultimately affects final purchasing decisions. The rationale of the paper lies in that previous literature (Gaskell et al., 2003; Gaskell et al., 2004; Gaskell et al., 2006) points out good reasons to expect that the causal reasoning mechanism explaining technology acceptance can differ (even though slightly) across countries, yet the causal mechanisms are largely unknown. An important contribution to this literature requires the use of Structural Equation Modelling –often regarded as causal models- given that it can provide us with insights into the consumers' decision-making process in this setting.

We have structured the paper in five sections. First, we describe the conceptual model and the research questions examined, followed in a second section by the specification of the research methodology. A third section is devoted to the results. First it contains some preliminary data analysis, followed by the main results. Finally, the paper ends with a concluding section.

6.3 Theoretical framework for consumers' process of GM food acceptance.

To better understand the behavioural process underlying GM food consumption we have developed a simple conceptual model. The conceptual model presented in this study (see Fig.6.1) is intended to describe the reasoning process that underpins GM food acceptance. Briefly, it attempts to isolate and identify the influence of the most influential constructs in the decision-making process concerning the purchases of GM food – Attitude towards science and technology, trust on scientists and authorities, perceptions towards GM food and attitude formation. Indeed, this study is inspired in Chen and Li (2007) framework and Loob et al. (2007) SPARTA model of consumer's decision process toward GM foods[27]. On one hand, Chen and Li (2007) state that trusts as well as general attitude and knowledge have influence on building risk and benefit perceptions. Moreover, these perceptions are responsible on defining GM attitudes, mainly benefit perceptions. On the other hand, Loob et al. (2007) proved that intention to purchase is determined by Subjective Norm, Perceived Behavioural Control, Attitudes towards the behaviour and trust on institutions.

Furthermore, our underlying conceptual framework as well as Chen and Li (2007) and Loob et al. (2007), is related to the Theory of Planned Behaviour[28]. This theory reveals that an intention is based on three main elements: the attitude towards the behaviour, individual perceptions of what is socially accepted regarding that behaviour and finally the perception of control that the individual own in towards the behaviour (Ajzen, 2005). In our theoretical model, we first attempt to identify individual's social referents by means of their level of trust on GM food scientific experts and institutions. As Ajzen (2005) states, the approval or disapproval of individual referents regarding behaviour can be understood as a subjective norm that pressures individuals towards their actual behaviour. Indeed, as stated by Lobb et al. (2007), the influence of subjective norms may include friends, religion and family among others. However, it is importance to state that not all the theoretical elements have been examined, and instead we have selected the most relevant constructs, namely decisions and recommendation of European institutions which have had a stake in regulating GM foods, university community and industry scientists' opinions as being the most relevant social elements to account for as influencing behaviour. Therefore, both elements of the so called SPARTA model namely subjective norms and trust are explicty considered in our model. We next try to define the elements underlying the formation of perceived behavioural control by means of the inclusion of individuals' interest and understanding on science and technology together with the subjective perception of the risks and benefits associated to the behaviour on study. Finally, following the theory of planned

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[27] Notice that Chen and Li (2007) use a reflective measure of the main overall constructs, following Jarvis (2003), whilst this study employs formative measures primarily.

[28] However, its is important to note that we proce only s reduced from of this theory, adapted to the specific case study examined.

Behaviour[29] (Ajzen, 2005), we allow for the link between individuals' attitudes with the associated valuation of the product by means of behavioural intentions.

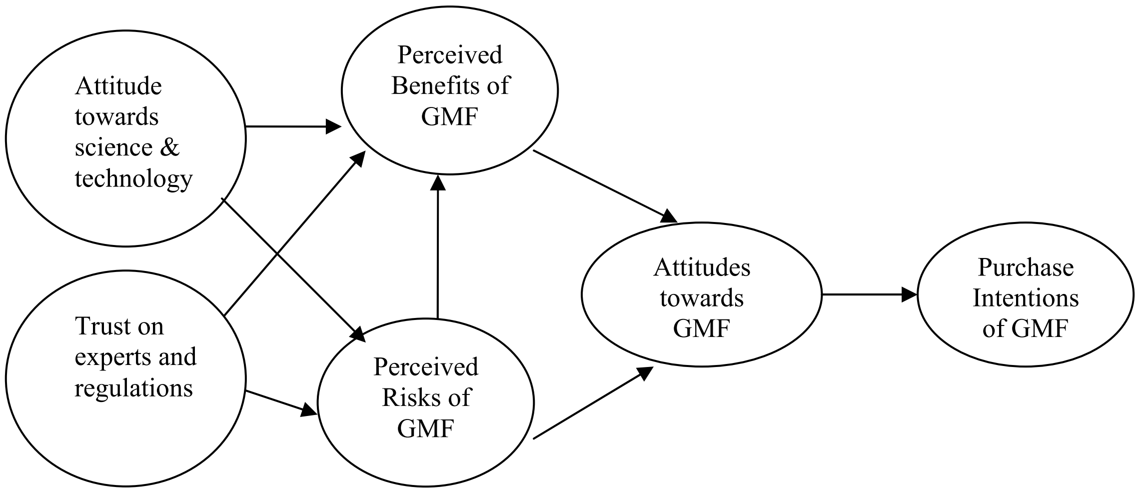


Figure 6.1 Consumer conceptual process of acceptance

6.3.1 Attitude towards science and technology.

Understanding the influence of consumer's attitude towards science and technology – for instance attitudes towards nature or food neophobia - is important in order to define their perceived risk and benefits of technological applications (Chen and Li, 2007). In fact, confirmatory evidence of this association has been interpreted by Saher et al. (2006) as evidence of the importance of behavioural inhibition. Indeed, attitudes towards science and technology determine individuals trust towards scientific progress, being gene technology a particular application (Lahteenmaki et al., 2002). Consequently, the hypothesis is the following:

> ***H1:*** *Consumers that reveal a positive attitude towards science and technology perceive more benefits associated to GM food technology.*
> ***H2:*** *Consumers that reveal a positive attitude towards science and technology perceive fewer risks associated to GM food technology.*

[29] Which states that "a person's intention to perform (or not), a behaviour is the most important immediate determinant of an action"

6.3.2 Trust on scientific experts and institutions.

In the area of GM technology, there is a lack of efficient risk and benefit communication in part due to due to the existence of "scientific uncertainty" resulting from a wide rage of information sources (Costa-Font and Mossialos, 2007). As a result, consumers exhibit different levels of certain knowledge, which might explain either rejection or acceptance of GM food, based on "subjective knowledge" (Lusk et al., 2004). Besides, a large social group is made up of those "undecided or indifferent". This group does not appear to have a clear idea of what GM food is, but are irrespectively highly influential by new information (Onyango et al., 2004; Hossain et al., 2002; Costa-Font and Mossialos, 2006). Some empirical studies have detected this social stratification in both Europe and US (Martinez et al., 2004; Noomene and Gil et al., 2004; Schilling, 2003; Szczurowska, 2005; Vilella-Vila et al., 2005; Gaskell et al., 2003, 2004 and 2006).

Furthermore, the process by which individuals acquire information regarding GM food is still not clearly defined. However, some studies suggest that trust is a key element on this process (Siegrist et al., 2000; Koivisto Hursti and Magnusson, 2003; Huffman et al., 2004). Indeed, trust is a matter of confidence on someone or something (Siegrist et al., 2000). It is broadly acknowledged, by many empirical studies, as acting as a filter of information determining the access of people to information sources (Siegrist et al., 2000; Koivisto Hursti and Magnusson, 2003; Huffman et al., 2004). Therefore, consumers are likely to believe the opinion of sources that appear to hold values similar to themselves (Siegrist, 2000; Cook et al., 2002; Frewer et al., 2003).

We also consider the importance of consumer perception depending on which information sources appears to be the most influential regarding GM technology. Indeed, some studies such as Frewer et al. (1996) and Moon and Balasubramanian (2001) revealed that U.S. and U.K. consumers considered government and science as the main actors regarding GM technology control. Therefore, trust in government and scientists are considered to be an important determinant of acceptance of GM food technology (Hossain et al., 2003; Hossain and Onyango, 2004; and Onyango, 2004). In order to define the construct "trust", we use questions regarding consumers' confidence on university, industry scientists, and EU institutions. Overall, confidence on science and government regulations is envisaged as determining consumer – both positive and negative - perceptions regarding to GM food (Traill et al., 2004; Chen and Li, 2007). Therefore, we expect, as explained next, these two variables to be causally related.

Therefore, the following hypotheses are proposed:

H3: *Consumers that trust both Scientists and European institutions perceive more benefits associated to GM food technology.*

H4: *Consumers that trust both Scientists and European institutions perceive fewer risks associated to GM food technology.*

6.3.3 Consumer perceptions of risk and benefit about GM food technology.

Consumer's perceptions of risk and benefit of a GM product are the result of individual evaluations of the product attributes (Fishbein, 1963; Bredahl et al., 1998). Currently, consumers perceive more risks than benefits associated to GM technology (Moon and Balasubramanian, 2001 and 2004; Grunert et al., 2003; Onyango, 2004; Hossain and Onyango, 2004; Costa-Font and Mossialos, 2007), even though, risks perceived are not necessarily for real. In the case of GM food technology there is a lack of information to allow consumers to develop objective risk estimation (Costa-Font and Mossialos, 2007). This major association of GM food to risky attribute can be explained by the fact that consumers trust more environmental groups and consumer organizations than governmental institutions and biotech industry researchers (Bredahl et al., 1998; Onyango et al., 2003; Savadori et al., 2004; Veeman et al., 2005).

Interestingly, some studies such as Siegrist et al. (2000); Fortin and Renton (2003); Beech Larsen et al. (2000); Traill et al. (2006) and Costa-Font and Mossialos (2007) identify a significant negative relationship among risk and benefits perceptions for GM food. Indeed, they state that although benefits are perceived in relation to GM technology consumers do not totally value them enough to overcome other associated risk. This fact can be explained, as well, by the "uncertainty" associated to GM technology. Therefore, the following hypothesis is proposed:

H5: *Perceptions of benefits of GM food technology are negative associated to perception of risks of GM food technology.*

6.3.4 Consumer attitudes towards GM food.

One of the main theories regarding the formation of consumer attitudes is the Fishbein Multi-attribute Model (Fishbein, 1963). This theory states that a consumer attitude is a function of the beliefs that each individual person upholds on the attributes of a product weighted by an evaluation of each product attribute. This model has received other labelles such as the 'bottom-up' formation of attitudes (Grunert et al., 2003). These model parallels Bredahl et al. (1998) 'bottom-up' consumer attitude explanation, specifically regarding GM food whereby attitudes towards GM food technology are defined by means of a weighted sum of attitudes towards each product and its corresponding process[30]. This theoretical model has been empirically supported by many studies such as Moon and Balasubramanian (2001 and 2004); Grunert et al. (2003); Onyango (2004); and Hossain and Onyango (2004), which states that acceptance of agri-biotech depends on risk and benefit perceptions. Therefore, the following hypotheses are proposed:

H6: *Consumers that perceive relatively more benefits associated to GM food technology will have a relatively more positive attitude toward GM food.*
H*7: Consumers that perceive more risks associated to GM food technology will have a less positive attitude toward GM food.*

6.3.5 Consumer final intentions towards GM food.

Given that attitudes towards a product - such as its acceptance or rejection-, are the chief factor underlying purchasing decisions, we draw upon two potential explanations of the choice between GM versus non-GM products. First, Lancaster's theory of consumer demand (Lancaster, 1966), which positions consumers utility as a

[30] Moreover, each attitude also depends on the overall perceived risks and benefits associated with the product and process respectively.

function of product attributes (benefits and risks). Second, the Theory of Planned Behaviour states that 'a person's intention to perform, or not, a behaviour is the most important immediate determinant of an action' (Ajzen, 2005). Both link individuals' attitudes regarding acceptance or rejection of a product with final intentions. Moreover, an important element that makes these theories useful for analysing GM purchase intention is *perceived behavioural control* (PBC), which explains individuals perceived impediment. In the case of GM versus non-GM food, the impediment lies in the 'inability to identify a product as being genetically modified' (Cook et al., 2002) and the "uncertainty" associated to GM technology.

Most studies such as Lusk et al. (2005); Moon and Balasubramanian (2003 a,b); Onyango and Govindasamy (2004); Chern et al. (2002); Bredahl (1999), Gifford et al. (2005), among others have found evidence suggesting that consumers are willing to pay a premium for non-GM food. Therefore, consumers place a higher value on non-GM food relative to GM food (Lusk et al., 2003). Moreover if new positive information is presented to consumers -such as health benefits, environmental benefits or increased shelf-life- their attitude can be modified leading to revised final purchase intentions (Moon and Balasubramanian, 2003b; Onyango and Govindasamy, 2004; Lusk et al., 2004; Lusk et al., 2005; Frewer et al., 1996; Mucci and Hough, 2003). Although, some other studies do not support this change on behaviour (Jaeger et al., 2004; Lusk et al., 2002; Canavari et al., 2005). Therefore, we propose testing the following hypothesis:

> ***H8:*** *Consumers with a positive attitude towards GM food will exhibit a positive intention of consuming GM food.*

6.4 Research methodology

6.4.1 The Sample.

We employ microdata from the Eurobarometer survey 58.0 (2002), which contains a representative sample from different European countries. The questionnaire contains questions regarding biotechnological applications and it is publicly accessible[31]. We have empirically examined the information for the sub samples of the Spanish, Italian and Greek populations in order to gather a detailed picture of their attitudes towards GM Food.

The three subsamples are made of approximately 50% male and 50% women. Moreover, the age distribution goes much more the same for the three subsamples, approximately 20% of respondents are between 15-25 years of age, 30 % 26-44, 30% 45-64 and finally the 20% of individuals are older than 65 years.

The initial number for the subsamples was 1000 for Spain, 992 for Italy and 1001 for Greece. However, the amounts of missing values due to non responses require the application of "list wise deletion" in order to obtain a complete database to be analysed. Finally the sample used for the analysis was of 502 respondents for Spain, 454 for Italy and 490 for Greece. In the three countries the number of cases seems to be adequate since it exceeds 200 cases (Kline, 2005).

6.4.2 Measures.

We have considered, as the literature points out, that responses range from agree to disagree going through some uncertainty threshold (Gaskell et al., 2004; Gaskell et al., 2006; O'Connor et al., 2006). Therefore, "don't know" answers are classified as "undecided or indifference" which are accordingly placed somewhere between acceptance and rejection (Costa-Font and Mossialos, 2007). All questions about perceptions, intentions and trust were measured on a 3-level Liket scale, where "tend to agree" responses are codified by an ordinal value of 1, "undecided or indifference" by 2 and finally, "tend to disagree" by ordinal value 3. We based our selection of Eurobarometer questions to determine constructs on Chen and Li (2007) as shown in Table 6.1.

[31] See http://ec.europa.eu/environment/barometer/index.htm

Table 6.1 List of indicators used for each construct.

Construct	Indicators
Attitude towards science and technology (***C1)***	***X1:*** I am interested in science and technology
	X2: I feel well informed about science and technology
	X3: I understand science stories in the news
Trust (***C2***)	***X4***: Do you think that University scientists doing research in biotechnology are doing a good job for society?
	X5: Do you think that Scientists in industry doing research in biotechnology are doing a good job for society?
	X6: Do you think that the European Commission making laws on biotechnology for all European Union countries is doing a good job for society?
Perceived Benefit (***C3***)	***X7***: Genetically modified food will be useful for the fight against third world hunger.
	X8*:* In the long run, a successful (NATIONALITY) genetically modified food industry will be good for the economy.
	X9: Whatever the dangers of genetically modified food, future research will deal with them successfully.
Perceived Risks (***C4***)	***X10***: Eating genetically modified food will be harmful to my health and my family's health.
	X11*:* Genetically modified food threatens the natural order of things.
	X12: Growing genetically modified crops will be harmful to the environment.
Attitudes towards GM food (***C5)***	***X13****:* To what extend do you agree that use modern biotechnology in the production of foods, for example to make higher in protein, keep longer or improve the taste, is useful for society?
	X14*:* To what extend do you agree that use modern biotechnology in the production of foods, for example to make higher in protein, keep longer or improve the taste, is morally acceptable for society?
	X15*:* To what extend do you agree that use modern biotechnology in the production of foods, for example to make higher in protein, keep longer or improve the taste, should be encouraged?
Consumer Intentions (***C6***)	***X16****:* I would buy genetically modified food if it contained less fat than ordinary food.
	X17*:* I would buy genetically modified food if it were cheaper than ordinary food.
	X18*:* I would buy genetically modified food if it were grown in a more environmentally friendly way than ordinary food.

6.4.3 Analytical procedures.

Structural equation modelling has been used in this study in order to test the causal links specified in the theoretical model, what is not possible via regression analysis. Indeed, the structural regression (SR) model has been tested following a two-step modelling approach (Anderson and Gerbing, 1988), where we first define an acceptable confirmatory factor analysis (CFA) and next an adequate SR model.

Following Jöreskog and Sörbom (1996), we have specified a Structural Equation Model which consists of three main types of relationships. First, a measurement model is identified after performing confirmatory factor analysis. The outcome relates, on one hand, observed indicators with the exogenous latent variables;

$$x = \Lambda_x \ \xi + \delta \qquad (1)$$

where x, is a $q \times 1$ vector of observed exogenous or independent variables, Λ_x is a $q \times n$ matrix of coefficients of the regression of x on ξ, ξ is an $n \times 1$ random vector of latent independent variables and δ is a $q \times 1$ vector of error terms in x.

On the other hand, observed indicators are related with the endogenous constructs;

$$y = \Lambda_y \ \eta + \varepsilon \qquad (2)$$

where y, is a $p \times 1$ vector of observed endogenous or dependent variables, Λ_y is a $p \times m$ matrix of coefficients of the regression of y on η, η is an $m \times 1$ random vector of latent dependent variables and ε is a $p \times 1$ vector of measurement errors in y.

A third equation defines the structural model, which specifies the causal relations that exist among the latent variables, describes its causal effects and assigns the explained and unexplained variances (Jöreskog and Sörbom, 1996).

$$\eta = \mathrm{B}\,\eta + \Gamma\,\xi + \zeta \qquad (3)$$

where B is a $m \times m$ matrix of coefficients of the η variables in the structural relationship, Γ is a $m \times n$ matrix of coefficients of the ξ - variables in the structural relationship, and ζ is a vector of errors.

This study uses ordinal data, arguably a rudimentary measurement of continuous variables, where the scale is considered as thresholds of the continuous variables (Jöreskog and Sörbom, 1996). Correlations among ordinal variables are called polychoric correlations, which are theoretical correlations of the continuous version

(Jöreskog and Sörbom, 1996). In order to perform the analysis we have used the General Weighted Least-Squares (WLS) method instead of Maximum likelihood (ML) since both the data present a nonnormal distribution and because ML do not allow us to employ the weight matrix required for the analysis, which is the inverse of the estimated asymptotic covariance matrix W of the polychoric correlations (Kline, 2005).

$$F(\theta) = (s - \sigma)'\, W\, (s - \sigma) \qquad (4)$$

where s' is a vector of the elements in the lower half of the covariance matrix S of order $k \times k$, σ' is the vector of corresponding elements of Σ (θ), W^{-1} is the positive definite matrix of order $u \times u$ where $u = k\,(k+1)/2$. The WLS function is the weighted computation of the square residuals (Barrio and Luque, 2000).

Finally, we will assess the goodness-of-fit of the model by analysing factor loadings which relate each indicator with the constructs. Reliability will be measured by means of composite reliability and Cronbach'α. Moreover, the extracted validity for each construct will be also measured (Hair et al., 1999).

Since cross group comparisons were performed, the level of invariance will already be measured. In this case, the confirmatory factor analysis will be defined by means of Multi-Sample analysis (Steenkamp & Baumgartner, 1998). For Multi-Sample analysis it is assumed that equations (1), (2) and (3) holds in each group. Considering a set of G groups, the model for group g is defined by the parameter matrices: $\Lambda_y^{(g)}$, $\Lambda_x^{(g)}$, $B^{(g)}$, $\Gamma^{(g)}$, $\Phi^{(g)}$, $\Psi^{(g)}$, $\Theta_\varepsilon^{(g)}$, $\Theta_\delta^{(g)}$, where the subscript (g) refers to the g-th group, $g = 1,2,...,G$ (Jöreskog & Sörbom, 1996). Each of these matrices may contain fixed, free and constrained parameters as before. To estimate all the models simultaneously, the following fit function is minimized,

$$F = \sum_{g=1}^{G} \left(\frac{N_g}{N} \right) F_g (S^{(g)}, \Sigma^{(g)}, W^{(g)}), \qquad (5)$$

where, F_g is the fit function (4), N_g is the sample size in group g and $N = N_1 + N_2 + ... + N_G$ is the total sample size; $S^{(g)}$ and $\Sigma^{(g)}$ are the sample and population covariance matrices in group g, and $W^{(g)}$ is the weight matrix for group g.

Once the parameters have been estimated, the "configual invariance" or measurement model is considered. That is, the pattern of factor loadings for each indicator its tested to be equivalent across groups (Byrne, 2001). This level of invariance implies that the pattern of salient and non salient factor loadings for the measurement model is the same for the different segmented groups (Steenkamp & Baumgartner, 1998). In this case, similar but not equal latent variables are presented in the different groups. We have to note that, "configural" invariance does not indicate that people in different groups respond to the same items in the same way (Steenkamp & Baumgartner, 1998). However, it allows us to explore the basic structure of the construct cross-groups.

As a second step, full or partial metric invariance has to be satisfied because the scale intervals of the latent constructs have to be the same or at least comparable across groups. In other words the following condition must be fulfilled.

$$\Lambda_y^{(1)} = \Lambda_y^{(2)} = \ldots = \Lambda_y^{(G)}, \, and \quad \Lambda_x^{(1)} = \Lambda_x^{(2)} = \ldots = \Lambda_x^{(G)}$$

This allows us to examine structural relationships with other constructs cross-groups.

Regarding the structural model, we begin with an assessment of the significance of the estimated parameters in the structural equations (Hair et al., 1999). We proceed with estimating the reliability coefficients of each equation and the associated correlation matrix among constructs examined in our model (Barrio and Luque, 2000). Finally, diagnostic parameters such as Chi square (X^2); Root Mean Square Error of Approximation (RMSEA); Goodness of Fit Index (GFI); the Adjusted Goodness of Fit Index (AGFI); the Comparative-Fit-Index (CFI); the Normed-Fit-Index (NFI) and the Non Normed-Fit-Index (NNFI) will be also considered as indicators of the model goodness-of-fit for the CFA and the SR model[32].

[32] We have tried a multi-group analysis for the structural model specification but lack of convergence in the model solution suggested that out existent specification appears as a preferred option.

6.5 Results

6.5.1 Descriptive analysis.

Before empirically testing the theoretical structural model defined in this study we begin by presenting in this section a general cross-country description of evidence on Spanish, Italian and Greek behaviour towards GM food. We hope this ultimately will allow the reader to better understand the results from the empirical study.

When asking about the product utility, risk, moral acceptance and whether to encourage GM food technology, respondents are divided into three main groups following previous literature (Gaskell et al., 2004; Hossain et al., 2003). However, the percentages employed for each groups differ among countries (see Fig.2). We find clear difference between Spain and other two countries examined.. Indeed, about 50% of the Spanish sample "tends to agree" whilst the "don't know" option and "disagreement" options represent around 20-30%. Therefore, about half of Spanish sample agree in the statement that GM food technology is useful, ethically acceptable, and must be encouraged but they are at the same time aware of its associated risks. On the contrary, in Greece and Italy more than half of the respondents do not consider GM food technology as being useful or ethically acceptable, and there is agreement in that that there no need to be encouraged. Yet, as in the case of Spain, respondents are aware of its associated risks.

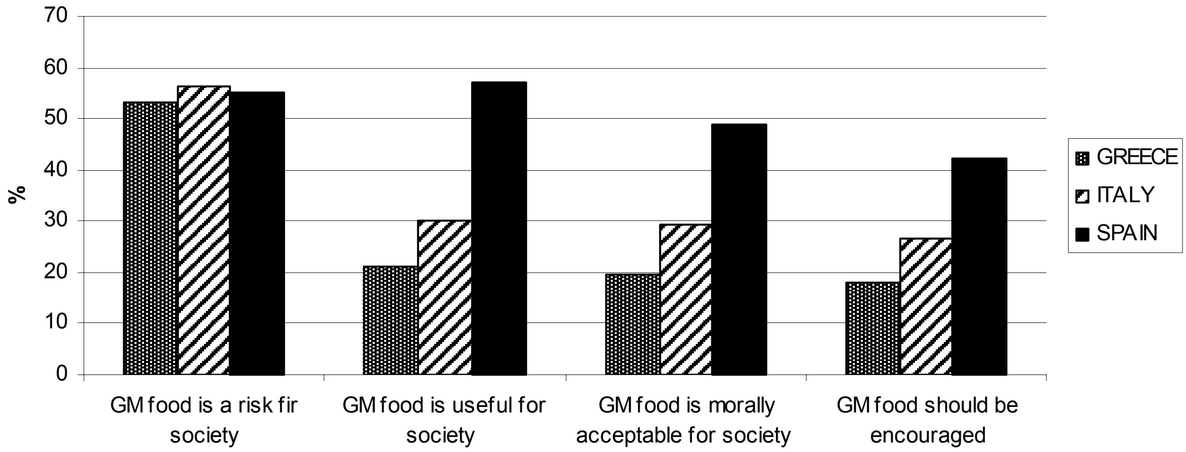


Figure 6.2 Spanish, Italian and Greek GM food attitudes.

General attitudes towards science and technology have been analysed by means of three questions regarding to science and technology. Interestingly, about 50% of the Greek sample is most of the time interested on science and technology, about 40% in Italy and only 20% of Spanish respondents are most of the time interested on science and technology. Consequently, almost 50% of the Spanish respondents revealed that they feel well informed about science and technology. Contrary, only 30% of the Italian and Greek samples reveal to feel not well informed on science and technology. Finally, only 20% of the Spanish sample understands science stories in the news, whereas, almost 25% and 35% of the Greek and Italian samples does.

General perceptions regarding to GM food were analysed on the basis of a set of questions on individuals support or rejection of the derived utility of GM food. Approximately 40 % of Spanish respondents state that GM food is useful for them, for their economy and for the third world. The percentage is significantly higher than in the other countries in which this percentage is around 20%. What is common in the three countries is that around 20% of the sample has no opinion on this issue. Indeed, ignorance is markedly important when asking about the adequacy of GM food regulations (30% in Italy and Greece and 40% in Spain). Moreover, the majority of respondents consider that current regulations are not enough to protect people from GM food risks.

Questions revealing higher agreement are those related to *personal ability and interest in the selection of GM food for consumption purposes*. In fact, the majority of the population in the three countries revealed ability and they thought that it uses were important for them in the judgement and selection of GM food. Paradoxically, most respondents reveal that it is difficult to perform judgements on GM food. Also for these questions the indecision is about 20%.

Finally, the last group of questions refer to the purchase or consumption intentions. As for this set of questions, there is a clear pattern pointing out towards a rejection of GM food purchase intentions. A vast majority of respondents from the three countries (more than 80%) refuse to buy GM food whatever the associated benefit, while the remaining 20% is undecided. Lastly, only in Spain there seems to exist a more positive outlook if GM food is grown in a more environmental-friendly way.

6.5.2 Measurement model (Confirmatory factor analysis).

As mentioned in section 3, the first step of the study has been to carry out a confirmatory factor analysis for the whole set of constructs: Attitude towards science and Technology; Trust; Benefit perceptions; Risk perceptions; GM food Attitudes and Consumer Intentions towards GM food in each country, assuming all errors to be uncorrelated. It has been performed both a country per country analysis and a Multy-Sample Analysis, all three groups together. The confirmatory factor analysis with all indicators resulted suitable for both individual case and Multy-Sample Analysis. The correlation matrix among all variables by country is presented in Tables 2 to 4. All constructs were measured by three indicators as proposed by Kline (2005) among others.

Table 6.2 Correlation matrix among indicators (Group1: Spain)

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18
X1	1.00																	
X2	0.71	1																
X3	0.67	0.69	1															
X4	0.13	0.25	0.15	1														
X5	0.12	0.19	0.09	0.7	1													
X6	0.09	0.14	0.06	0.82	0.75	1												
X7	0.11	0.13	0.09	0.26	0.27	0.37	1											
X8	0.19	0.13	0.23	0.29	0.36	0.33	0.49	1										
X9	-0.12	-0.12	-0.12	-0.36	-0.3	-0.34	-0.35	-0.33	1									
X10	-0.07	-0.11	0	-0.34	-0.23	-0.31	-0.24	-0.25	0.66	1								
X11	-0.15	0.18	0.23	0.35	0.32	0.33	0.5	0.48	-0.41	-0.19	1							
X12	-0.07	-0.10	-0.06	-0.28	-0.23	-0.23	-0.23	-0.19	0.41	0.4	-0.27	1						
X13	0.07	0.04	0.06	0.35	0.27	0.39	0.52	0.46	-0.45	-0.41	0.36	-0.26	1					
X14	0.09	0.17	0.2	0.35	0.31	0.4	0.61	0.52	-0.56	-0.47	0.44	-0.34	0.84	1				
X15	0.18	0.20	0.25	0.41	0.39	0.38	0.54	0.51	-0.48	-0.3	0.48	-0.33	0.77	0.86	1			
X16	0.21	0.20	0.17	0.32	0.35	0.18	0.35	0.38	-0.31	-0.12	0.42	-0.18	0.26	0.28	0.37	1		
X17	0.13	0.19	0.15	0.24	0.28	0.26	0.37	0.26	-0.27	-0.11	0.35	-0.16	0.28	0.34	0.38	0.67	1	
X18	0.13	0.19	0.11	0.15	0.2	0.07	0.06	0.1	-0.08	0.02	0.16	-0.06	0.1	0.12	0.14	0.56	0.51	1

Table 6.3 Correlation matrix among indicators (Group2: Italy)

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18
X1	1																	
X2	0.75	1																
X3	0.70	0.73	1															
X4	0.05	0.09	0.03	1														
X5	0.00	-0.02	0.04	0.75	1													
X6	0.00	0.1	0.06	0.86	0.78	1												
X7	0.06	-0.01	-0.02	0.38	0.24	0.32	1											
X8	-0.03	-0.08	-0.08	0.29	0.22	0.27	0.54	1										
X9	-0.14	-0.07	-0.13	-0.38	-0.30	-0.41	-0.47	-0.38	1									
X10	0.06	0.07	0.00	-0.31	-0.27	-0.31	-0.35	-0.43	0.72	1								
X11	0.02	-0.01	0.00	0.03	0.04	0.13	0.32	0.29	-0.28	-0.24	1							
X12	-0.01	0.00	-0.06	-0.18	-0.12	-0.20	-0.29	-0.31	0.56	0.57	-0.21	1						
X13	-0.01	0.07	-0.03	0.37	0.29	0.44	0.42	0.43	-0.49	-0.38	0.25	-0.34	1					
X14	-0.09	-0.01	-0.05	0.29	0.21	0.34	0.47	0.53	-0.52	-0.50	0.36	-0.41	0.82	1				
X15	0.07	0.03	0.07	0.26	0.24	0.28	0.50	0.40	-0.46	-0.38	0.33	-0.41	0.72	0.68	1			
X16	0.25	0.25	0.20	0.15	0.12	0.13	0.24	0.11	-0.10	-0.02	0.27	-0.13	0.13	0.07	0.16	1		
X17	0.06	0.04	0.07	0.29	0.16	0.24	0.42	0.33	-0.26	-0.23	0.26	-0.18	0.32	0.36	0.32	0.52	1	
X18	0.13	0.11	0.01	0.06	0.06	0.01	0.11	0.06	-0.03	0.01	0.18	-0.08	0.18	0.13	0.22	0.39	0.41	1

Table 6.4 Correlation matrix among indicators (Group 3: Greece)

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18
X1	1																	
X2	0.68	1																
X3	0.62	0.75	1															
X4	0.02	0.05	0.03	1														
X5	-0.08	0.13	0.09	0.76	1													
X6	-0.08	0.02	0.06	0.81	0.79	1												
X7	0.08	0.12	0.2	0.24	0.21	0.24	1											
X8	0.27	0.19	0.19	0.13	0.17	0.11	0.59	1										
X9	0.23	0.09	0.07	-0.38	-0.31	-0.45	-0.21	-0.04	1									
X10	0.17	-0.02	0.07	-0.29	-0.25	-0.34	-0.14	-0.05	0.74	1								
X11	0.10	0.17	0.13	0.26	0.24	0.27	0.29	0.39	-0.18	-0.24	1							
X12	0.12	0.01	0.00	-0.36	-0.31	-0.41	-0.22	-0.07	0.63	0.51	-0.18	1						
X13	-0.01	0.04	0.06	0.34	0.24	0.33	0.52	0.32	-0.56	-0.49	0.28	-0.38	1					
X14	-0.09	0.05	0.07	0.33	0.33	0.36	0.32	0.31	-0.56	-0.55	0.24	-0.44	0.78	1				
X15	0.05	0.12	0.06	0.41	0.29	0.36	0.44	0.33	-0.50	-0.43	0.22	-0.42	0.79	0.81	1			
X16	0.21	0.26	0.13	0.00	-0.06	-0.11	0.11	0.24	-0.01	-0.06	0.26	-0.04	0.12	0.20	0.35	1		
X17	0.21	0.18	0.14	0.11	0.03	0.03	0.06	0.29	-0.06	0.04	0.23	0.07	0.16	0.09	0.26	0.76	1	
X18	0.16	0.17	0.09	0.09	0.15	0.14	0.18	0.31	0.06	0.17	0.30	0.06	0.02	0.01	0.10	0.53	0.57	1

The main parameters to test for the robustness of the constructs, following Hair et al. (1999) and Kline (2005), appear to show acceptable results for the Multy-Sample model as shown in Tables 5. Indeed, reliability of factor loadings are higher for all constructs in all countries (above 0.5) and t-values associated with the loadings are all significant (P<0.001), implying a satisfactory convergent validity (Olsen, 2003; Bagozzi and Phillips, 2001). Four additional parameters are important in examining the internal consistency of the model, which include composite reliability (which must be > 0.7), internal consistency reliability, measured by Cronbach's α, (which must be > 0.7), extracted validity (which must be >0.5) and discriminant validity (correlations among constructs < 0.85) (Hair et al., 1999; Bagozzi and Yi, 1988). For every construct, all composite reliabilities are greater than 0.7 and all Cronbach's α are over 0.7 but for construct ***C3*** which is above 0.6, thus we can say that reliability is acceptable. Regarding the variance extracted, it is 0.50 or higher for all cases (Table 5). Finally, since the correlations among latent factors do not exceed 0.85, in any case, it can be stated that discriminant validity has been accomplished too.

Table 6.5 Reliability of the standardized Confirmatory Factor Analysis (CFA).

Construct	Indicators	Standardized loadings (*t*-Value)			Composite reliability (Extracted Validity)		
		Spain	Italy	Greece	Spain	Italy	Greece
C1	***Cronbach's α***	0.82	0.81	0.79	0.91 (0.77)	0.91 (0.77)	0.91 (0.76)
	X1	0.86 (31.81)	0.90 (29.14)	0.82 (30.31)			
	X2	0.88 (27.11)	0.90 (24.31)	0.90 (27.69)			
	X3	0.88 (32.36)	0.82 (30.79)	0.90 (33.83)			
C2	***Cronbach's α***	0.75	0.71	0.81	0.83 (0.63)	0.76 (0.52)	0.89 (0.73)
	X4	0.92 (28.40)	0.65 (19.84)	0.92 (29.30)			
	X5	0.81 (25.53)	0.92 (21.22)	0.87 (27.59)			
	X6	0.62 (14.72)	0.55 (11.67)	0.77 (18.42)			
C3	***Cronbach's α***	0.63	0.60	0.61	0.78 (0.54)	0.73 (0.50)	0.79 (0.56)
	X7	0.75 (23.79)	0.78 (22.27)	0.74 (20.96)			
	X8	0.73 (24.67)	0.74 (21.89)	0.80 (23.78)			
	X9	0.72 (23.99)	0.52 (16.98)	0.70 (20.95)			
C4	***Cronbach's α***	0.70	0.75	0.75	0.82 (0.61)	0.91 (0.78)	0.90 (0.76)
	X10	0.88 (31.98)	0.94 (35.33)	0.97 (36.98)			
	X11	0.86 (26.01)	0.91 (29.97)	0.84 (30.40)			
	X12	0.56 (13.07)	0.79 (18.76)	0.79 (19.95)			
C5	***Cronbach's α***	0.89	0.87	0.90	0.95 (0.86)	0.95 (0.86)	0.96 (0.90)
	X13	0.91 (48.47)	0.93 (44.69)	0.93 (48.01)			
	X14	0.84 (33.48)	0.88 (32.21)	0.92 (34.69)			
	X15	1.00 (58.61)	0.97 (56.84)	1.00 (61.29)			
C6	***Cronbach's α***	0.79	0,70	0.83	0.97 (0.91)	0.94 (0.84)	0.97 (0.91)
	X16	0.93 (48.00)	0,93 (45.59)	0.93 (47.77)			
	X17	1.00 (76.47)	0.97 (72.05)	0.97 (74.44)			
	X18	0.93 (59.77)	0.86 (50.45)	0.96 (57.64)			

Configural invariance	**Metric invariance**	
	Full:	Partial:
χ^2 = 762.38	χ^2 = 885.57	χ^2 = 794.67
df = 360	df = 396	df = 384
p = 0.00	p = 0.00	p = 0.00
RMSEA = 0.048	*RMSEA* = 0.051	*RMSEA* = 0.047
CAIC =2028.7	*CAIC* =1853.9	*CAIC* =1862.3
CFI = 0.98	*CFI* = 0.98	*CFI* = 0.98
NNFI =0.98	*NNFI* =0.98	*NNFI* =0.98

The model meets the widely accepted goodness of fit standards for the Multy-Sample confirmatory model (configural invariance model) indicating that the conceptual model satisfactory fits the data (see Table 5). However, it must be pointed out that the chi-square was significant, $\chi^2/df = 2.11$ is smaller than 3, demonstrating a good model fit (Carmines and McIver, 1981). The Root Mean Square Error of Approximation (RMSEA) is 0.048, which is well under the 0.5-0.8 limit interval offered by Hair et al. (1999) and Kline (2005). The goodness-of-fit index (GFI) was 0.98, the Comparative-Fit Index (CFI) 0.98, the Normed-Fit Index (NFI) 0.97 and the Non-Normed Index (NNI) 0.98, all were greater than 0.90 as offered by Marcoulides and Schumacker (1996) and Chen and Li (2007). If we consider the confirmatory factor analysis country by country, goodness of fit measures are also fine for all three country models[33].

[33] Data available from the authors upon request

Finally, the results for the levels of invariance indicate that configural invariance is accomplished across the three countries, see previous paragraph. This level of invariance implies that the pattern of salient and non salient factor loadings for the measurement model is the same for the three countries (Steenkamp and Baumgartner, 1998).

Moreover, metric invariance has also been analysed. Yet, the hypothesis of full metric invariance, that is, factor loadings being invariant across groups, was not supported. As Table 5 shows there is a significant increase in chi-square between the model of configural invariance and the model of full metric invariance ($\Delta\chi^2(18) = 123.19, p \prec 0.001$). The analysis of the Modification Indices (MIs) shows that six of the eighteen factor loadings are responsible of the model lack of invariance. On one hand, factor loading of X10 and X12 were lower in Spain than in Italy and Greece. On the other, factor loadings X4, X6, X9 and X18 were lower in Italy than in Spain and Greece.

We set free these factor loadings to test partial metric invariance. Table 5 shows the statistical results of this model. We can see that the increase in chi-square between the configural invariance model and this is not significant ($\Delta\chi^2(12) = 32{,}29 p \geq 0.10$), moreover, other goodness of fit values such as RMSEA hare also good. Therefore, we can support partial metric invariance with six of the 18 invariance constrains relaxed.

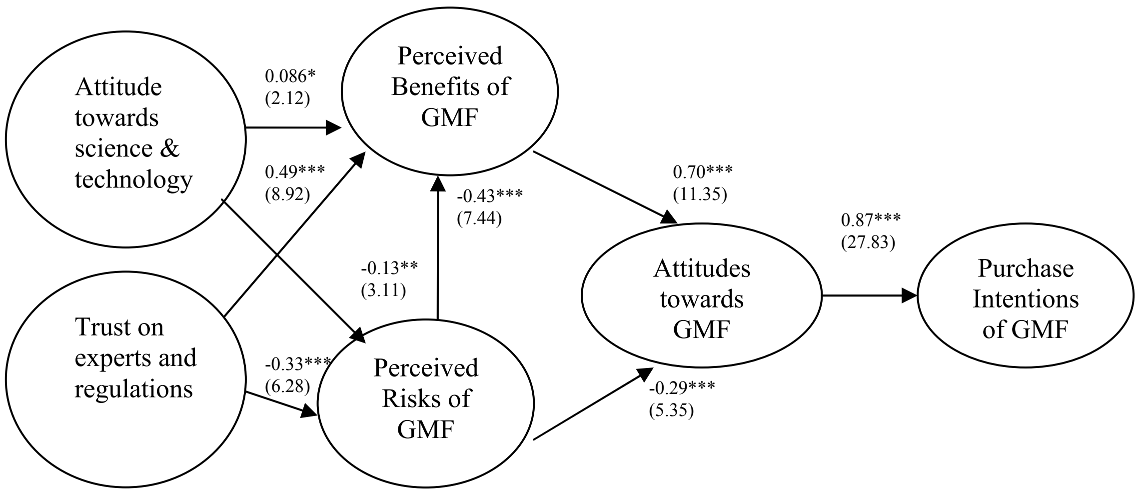
To sum up, we have obtained a common pattern among countries regarding the adequacy of the constructs used measuring the formation process of consumers purchase intentions. However, a perfect comparison among countries, even when high, could not be always ensured on the basis of our diagnostic tests.

6.5.3 Structural model.

In testing the models using a Structural Equation Model we find that a satisfactory fit has been obtained for all country models, see Table 6. Figures 3, 4 and 5 show the path diagrams obtained for each country. Hypothesis 5 - Hypothesis 8 are supported in all countries with paths significant at $p = 0.001$ level. Regarding to Hypothesis 5 there is a clear agreement among countries that the perception of risks related to GM food has a negative impact on the perception of benefits associated to the same food products. Moreover the estimated path is about 0.5 for all three countries, a little higher for the Italian case.

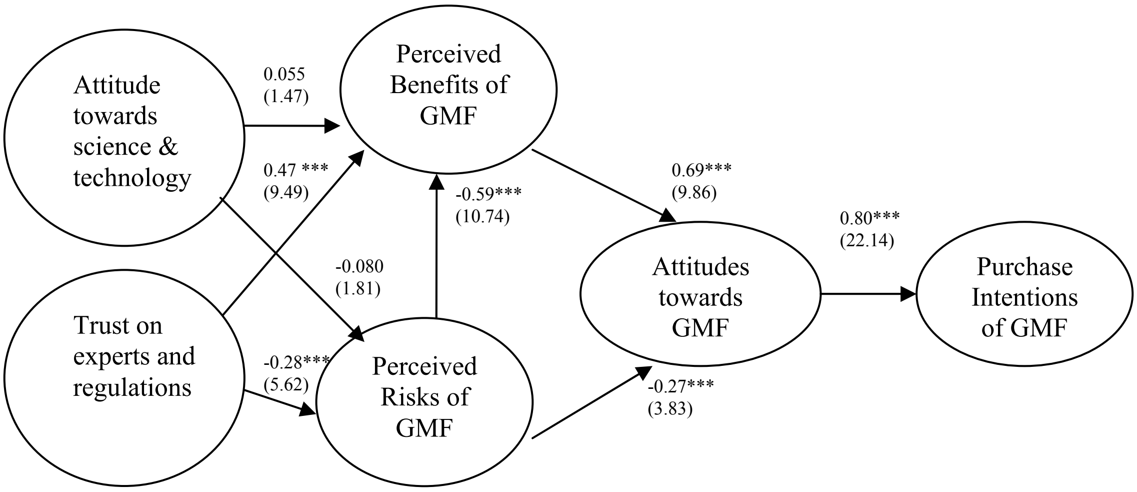
Table 6.6 Goodness-of-fit for the structural regression model

	Spain	Italy	Greece	
χ^2_{df}	347.26	314.41	389	
χ^2_{df} / df	2.7	2.5	3	<3 (Carmines and McIver, 1981)
RMSEA	0.05	0.05	0.07	<0.5-0.8 (Browne and Cudeck, 1992; Kline, 207)
GFI	0.98	0.98	0.97	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)
AGFI	0.98	0.97	0.96	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)
CFI	0.98	0.98	0.96	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)
NFI	0.96	0.96	0.94	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)
NNFI	0.97	0.97	0.95	>0.90 (Bollen, 1989; Marcoulides and Schumacker, 1996)



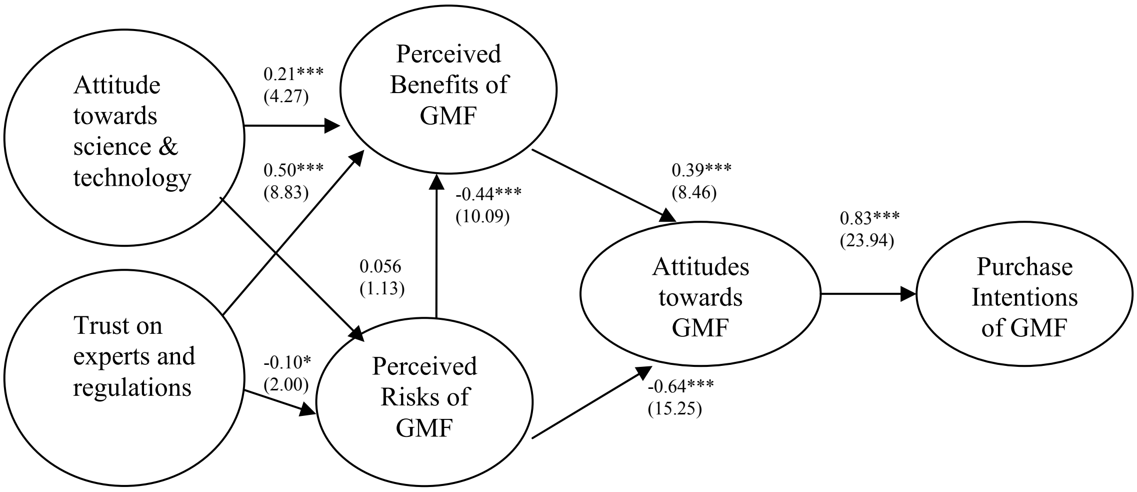
* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure 6.3 Path diagram results for Spain



* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure6 4 Path diagram results for Italy



* $p = 0.05$ ** $p = 0.01$ *** $p = 0.001$

Figure 6.5 Path diagram results for Greece

Next, Hypothesis 6 has been also supported in all countries samples with a path coefficient of around 0.70 for the Spanish and Italian case but much lower, 0.39 for the Greek structural model. Consequently, we can tentatively conclude that Spanish and Italian attitudes towards GM food rely on the perceived benefits associated to this GM food. This contrasts with Greek consumers for whom benefits only partially define attitudes towards GM food. These results are consistent with the path coefficient estimated for Hypothesis 7. Indeed, Greek respondents consider perceived risks as more important defining their attitudes towards GM food with a path coefficient of about 0.60. Contrary, this path coefficient for either the Spanish or the Italian model is about 0.30. Finally, Hypothesis 8 has much more the same path coefficient for all three countries models 0.8, a bit higher for the Spanish case. Hence, this finding indicates an agreement among countries regarding the importance that an attitude towards behaviour has when defining an intention towards that behaviour.

The estimated paths coefficients also suggest confirmatory evidence of Hypothesis 3, with a $p = 0.001$ level. For all three countries we find a similar path coefficient of about 0.5, indicating that consumers that trust on scientific experts and institutions opinions perceive more benefits associated to GM food technology. The negative association between trust on scientific experts and regulations (Hypothesis 4) has been supported for the Spanish and Italian model with a $p = 0.001$ level and for the Greek model with a $p = 0.05$ level. Moreover, the highest path coefficient has been estimated for the Spanish and Italian case, about 0.3, followed by the Greek model with a estimated coefficient of 0.1. Finally, the association between General attitude towards science and technology and perceptions of risks and benefits has not been widely supported among countries. Actually, the negative influence on perceived risks has only been supported by the Spanish case with $p = 0.01$ and a coefficient of 0.33. Finally, the relation of general attitude and perceived benefit has been supported by the Greek case with a $p = 0.001$ level and for the Spanish case with a $p = 0.05$ level. For both cases the path coefficient is lower that 0.1.

So far, we can conclude that there is a common pattern among countries, regarding consumers' decision process towards purchase intentions on GM food. However, some differences have also been detected, especially on the association between perception of risks and benefits and attitudes towards science and technology. This relation is significant for both the Spanish and the Greek case regarding to benefits. However, this does not apply to the Italian model. Finally in both Spain and Italy perceived risks are negatively associated with trust on experts and regulations, whilst in the Greek model this hypothesis does not receive enough support.

6.6 Discussion.

In this paper, we have tested our claim that consumer intentions towards GM food are the result of a complex decision-making process that results from a specific cumulative interaction of attitudes towards science, risk and benefit perceptions along with and trust in information sources. In addition, we have tested our model for three different Mediterranean countries. Particularly, we have examined the behavioural model resulting from the introduction of GM food in Spain, Greece, and Italy , namely three paradigmatic countries where we can examine the influence of the set important social constrains (social constructs/social norms) affecting behaviour arguably similar due to cultural and geographical reasons. Given that some of the underlying choice dimensions are simultaneously formed and exhibit interactions among constructs, traditional decision making models that assume parameter exogeneity are not meaningful. To overcome this methodological problem we have taken advantage of structural equation modelling which allows for endogeneity. This study has implied designing a suitable empirical model to carefully understand the process of attitude formation, which defines our structural equation to be tested. Our Structural Equation Model assumes that perceptions of GM food are expressed both as the interactions of positive and negative dimensions, as well as moral concerns. Accordingly, it allows identifying and quantifying the underling constrains of revealed decision making.

This study employs a large representative subsample of the Eurobarometer 2002 database for the three countries examined. Our results suggests that that acceptance of GM food rather than being well endowed in people's attitudes, is still in a very early stage of the behavioural process that has both knowledge and time dependent constrains (experience). Therefore, individuals still do not reveal to have a clear cut position on the matter. However, this study has detected unambiguous cross country difference not in ultimate attitudes as some descriptive evidence has previously shown, but on the underlying behavioural processes. Not surprisingly, consumers of EU GM-free countries, actually Austria, Denmark, France, Germany, Greece and Luxembourg, are especially sceptical towards biotechnology applications on the food process. Contrary to the hypothesis of an homogeneous behavioural reaction model across the three countries, our indicates significant cross country differences among Mediterranean countries[34]. Consistently, consumers from Spain and Italy, are found to be more "tolerant" towards these applications.

Our findings suggest that, consistently with previous studies such as Chen and Li (2007), perceived risks are an important construct underpinning attitudes and purchase intentions towards GM food. However, its influence is revealed either in a direct or indirect way since results indicates for all countries that perceived risks have an important negative influence on perceived benefits as was already stated in other works such as Costa-Font and Mossialos (2007). Interestingly, in both the Spanish and Italian models, we find that perceived benefits exhibit a significant and large effect on attitudes towards GM food (as compared to perceived risks), whilst in the Greek model we find that perceived risks are the prevailing factor explaining attitudes in line with evidence from other GM-free countries such as Germany and Finland (Bredahl, 1999).

Consistently with previous literature, social constructs such as trust in relevant institutions is found to positively affect perceived benefits and negatively impact on perceived risks for the Italian and Spanish case. Nevertheless, the Greek model reveals that the impact of trust on perceived risk is not highly significant. The latter is explained by the positive impact that attitudes towards science exert the perceived benefits of GM food, which is only highly significant in Greek case but not in the Spanish and Greek models. Finally, our findings are in line with the so-called theory of Planed Behaviour, which state that attitudes towards GM food clearly predict purchase intentions for the three country model.

In summary, this paper has attempted to contribute to the existing behavioural literature on the consumer reactions to new food technologies by presenting a common cross-country decision making process for GM food. Our model is inspired in previous works of Chen and Li (2007) and Loob et al. (2007) and extends its applications to countries that arguably expected to be culturally more homogeneous, though findings do not suggest evidence of this and instead point out that possibly a culturally specific (decentralised) communication process might be required to attain similar cross country reactions. Further policy implications call for a wider consideration of trust and attitudes

[34] Note that multi-group analysis for the structural model was not achieved.

towards science which are far from straightforward. Food scares might have affected consumers trust and potential the communication of undesirable effects – both individual and social- resulting from new technologies does exert an influence in how through analogic decision making conceptualisation of risk and benefits perceptions.

It's important to mention few caveats such as the absence of an examination of the level of knowledge regarding to GM food. The use of secondary data, primary data is more appropriate for "theory testing". Other caveats lie in the selection of only three countries. Thus, it would appear as particularly relevant to improve the model by expanding this approach to other European Union countries. This will allow ascertaining whether these results can be generalised. However, a large set of cultural and institutional heterogeneity will have to be disentangled (cultural, influence of mass media, regulations and so forth).

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Chapter 7:

Conclusions

7.1 Conclusions

Food choice and behaviour stands out as a centrepiece of daily consumer decisions. Consumers choose repeatedly among different food product alternatives, drawing upon a variety of criteria that includes product attributes, such as safety and long term individual and social risks. The latter is especially the case when new products are produced through modern technologies are incepted into the market. Genetically modified products as well as those resulting from irradiation are the clearest examples. Normally, the intangible value and significance of foods are assessed by experts, especially regarding "food safety" parameters. However, consumers might not generally update their information and behave along the lines of expert assessments; this is especially the case of GM food in European countries. However, what are the main findings regarding patterns of consumer attitudes and decision regarding GM foods? Would choices regarding GM foods follow similar patterns as those guiding people's skeptical attitudes? Are consumers' intentions driven by general values towards science when assessing the value of new foods? Or, alternatively, are consumer intentions and behavioural patterns following some form of risks aversion?

With the aim to shed some light into these questions, this thesis attempts to provide a conceptual and an experimental examination of the formation of consumers' intentions, attitudes (towards) and choice of foods concerning new technology production processes, particularly genetically modified (GM) organisms. This research has attempted to contribute to the current knowledge regarding the formation of attitudes and consumer intentions towards GM food. The main contribution of this thesis has been to point out a set of features that condition choice, intentions and reveal purchase intentions for GM food.

Our wok is innovative in that: 1) it contains an innovative literature review; 2) it develops choice modelling of scenarios that includes, apart from methodological features, the choice between GM processed and organic food; and 3) unlike most of behavioural analysis it exploits, using structural equation modelling, several theoretical structures that explain decision making and, particularly, the role of broader attitudes towards science and technology and the effect of both risks attitudes and risks perceptions in determining consumer acceptance. We used mainly European and

Spanish data from various databases available, including data from the Eurobarometer surveys, the Centre of Sociological Research in Spain and a self developed survey. The sequence and findings of the thesis can be summarized as follows:

First and foremost, the thesis has provided an exhaustive review of published findings regarding public intentions towards GM food that has led us to conclude that worldwide consumers place a negative value on GM food. But the most important outcome has been to find that final purchasing intentions are the result of a complex decision process which only has been partially explained in the literature. Therefore, given the definition of a general theoretical model, this thesis has tried to explain some specific issues in order to validate the framework in a cross-country exercise in the last chapter.

The first step of the analysis, chapter 3, focused on the last stage of the decision-making process, that is, consumer intentions towards GM food. Based on Lancaster's consumer theory (1966), we have assumed that consumers' behaviour towards a single good is formed based on its characteristics, rather than on the goods per se. Moreover, since the good will be used indepenently or in combination with others, these characteristics should be defined in terms of the properties of the good itself. Two main methods are used in order to gather data to elicit consumers' intentions towards a good by means of the valuation of its attributes: stated preferences (SP) - which involves choice respondents in hypothetical markets- as it is the case of choice experiments, and revealed preferences (RP) - to understand preferences within an existing market- such as experimental bidding. Following Louviere et al. (2002) , RP data contains information about current market equilibrium and the inherent relationship between attributes; has only existing alternatives as observables; embodies market and personal constrains on the decision maker; has higher reliability and face validity; and, finally, yields one observation per respondent at each observation point. In parallel, SP describes hypothetical or virtual decision contexts; control relationships between attributes (which permits mapping of utility functions with technologies different from existing ones); seems to be reliable when respondents understand, are committed to and can respond to tasks; and, finally, yields multiple observations per respondent at each observation point. So, SP are more useful for forecasting changes in behaviour in the case of products derived from new technologies. Therefore, we defined and implemented a stated choice modelling methodology in order to elicit consumers' valuation for both GM and organic food.

Once consumers' intentions have been determined, we then evaluate the mechanisms that explain the formation of consumer attitudes and acceptance of GM food. Our analysis is grounded in the theory of Planned Behaviour (TPB) especially to establish a causal association between attitudes and intentions. This theory reveals that an intention is based on three main elements: the attitude towards the behaviour, individual perceptions of what is socially accepted regarding that behaviour and, finally, the perception of control that the individual has towards the behaviour- risk and benefit perception- (Ajzen, 2005). To do that, we have employed Structural Equation modelling (SEM). It is a multiple-equation regression model able to estimate multiple and simultaneous relationships in which the response variable in one regression equation can appear as an explanatory variable in another equation (Kline, 2005; and Mazzocchi, 2008). Moreover, this model permits the introduction of latent variables that, although not directly measured, are expressed by means of a group of indicators (Mazzocchi, 2008). The goal of SEM is to determine the extent to which a theoretical model is supported by sample data. Therefore, the model specification must be based on some theoretical background. (Kline, 2005 and Schumacker and Lomax, 2004). We have applied this methodology in chapters 4, 5 and 6 in order to disentangle the underlying process that gives rise to consumer intentions towards GM food, as a better way to understand how consumers react to the introduction of food related new technologies. The main elements examined were; 1) the role of risk/benefit perception on shaping consumers attitudes towards GM food; 2) the influence of meta-attitudes, trust on available information and knowledge on the formation of consumers attitudes towards GM food; 3) the impact of risk aversion on final purchase intentions towards GM food; and 4) the examination of consumers attributes on defining either consumers attitudes, intentions and knowledge on GM food. In spite of the advantages of SEM, some weakness can also be mentioned among which linearity and the need of larger samples are the more relevant. Indeed, recent studies have shown the possibility of performing SEM with higher-order (and curvilinear) effects. However, this will require a larger sample. Another alternative would have been to estimate some type of simultaneous equation models or multivariate probit model in order to test some of the results obtained in this dissertation by means of SEM. Further research on this field can be useful in the future to analyse the consistency of results depending of the analytical tool used.

Results allowed us to respond to the 14 research question presented in the introduction chapter. First of all, drawing upon the evidence reported from a choice experiment techniques on a sample of Spanish respondents, we conclude that even though consumers generally prefer organic food compared to conventional and GM food, Spanish consumers exhibit a moderate value on GM food compared to conventional when it conveys human heath benefits. Therefore we cannot support ***H1 – Spanish consumers obtain more utility with conventional products, relative to GM foods*** *Moreover, Spanish consumers place a negative value (WTP) on GM food.* It is important to highlight that although the majority of previous studies reported that consumers always prefer conventional over GM food, our result is consistent with Burton and Pearse (2002) and James and Burton (2003).

We also find that, paradoxically, revealed consumption patterns regarding GM and organic products do not vary between processed and fresh food; thus not supporting the hypothesis ***H2 -*** *Valuation differences exist among the type of GM food analysed, that is, processed or fresh food.* Therefore, the freshness dimension does not appear to exhibit an effect in balancing out behavioural decision making processes underpinning GM consumer acceptance.

A further step in the analysis allows us to conclude that attitudes towards GM food appear as good predictors for purchase intentions and this result is particularly robust given that no cross-country differences are observed. Moreover, the relevance of the parameter price has also been detected as a key determinant in explaining consumer final intentions. Hence, a reduction of the price is likely to result in a higher consumer intention regarding GM food. Thus we can support ***H3 -*** *Attitudes towards GM food are found to be directly associated to intentions towards GM food, although final choice is influenced by other constructs, such as price, which can modify intentions.*

In relation to consumer attitudes towards GM food, and consistent with prior studies, it has been found that Spanish consumers are ambivalent regarding to GM food as, on one hand, overall the population agrees with the statements that GM foods are useful, ethically acceptable, and must be encouraged but, on the other, they are aware of their associated risks. This finding in Chapter 6 speaks to the choice response in Chapter 3 regarding the willingness to pay for second generation GM food, and led us not to support ***H4*** - *Spanish consumers' reveal a negative attitude towards GM food.*

Chapter 6 tested if cross-country differences exist when defining the decision-making process for consumer intentions towards GM food. It concluded that attitudes towards GM food were different between Spain (more acceptable) and Greece or Italy (lees acceptable). Moreover, it also concluded that, although the defined decision-making process that led to consumer intentions towards GM food could be comparable among countries, while some differences among these processes existed. More precisely these differences were relevant when comparing: 1) the effect of benefits and risks on attitudes towards GM food; 2) the influence of trust on relevant institutions on perceived risks; and 3) on the effect that attitudes towards science exert on the perceived benefits of GM food. This result leads us to conclude in support of ***H5*** - *Attitudes and behavioural processes leading to GM food acceptance are heterogeneous and country specific, especially among GM producer and GM free countries*.

A key element shaping consumers attitude towards GM food has been hypothesised to be consumer perceptions of risks and benefits. We tested this relation in chapters 4 and 6 and concluded that both perceived risks and benefits determine attitudes and purchase intentions towards GM food, which is consistent with previous studies such as Chen and Li (2007). Moreover, we also concluded that in Spain the perceived benefits appear to exhibit a more important influence on attitudes towards GM food than risks. Hence we support ***H6-*** *Perception of risk and benefit has an important influence on consumers' attitudes and intentions towards GM food*, but not ***H7-*** *Spanish publics perceive more risks than benefits associated to GM food*. Furthermore, when analysing consumer purchasing intentions, we detected that GM food with associated environmental effects decreases respondent's utility compared to conventional food. The opposite takes place when considering health benefits. Therefore, we can support ***H8 -*** *Spanish respondents place a major value on health benefits associated to GM food than on environmental contamination reduction.* Finally, besides risk perceptions, risk attitudes also portray information on the behavioural determinants of the consumption process. That is, individual intentions and acceptance depends ultimately on their overall attitudes towards risks. Moreover, high levels of “don’t know” answers led us to conclude that not enough information was available for a fully informed rational judgement to be made and, accordingly, consumers find difficulties making decisions as they do not feel to have enough information. Therefore, we can support ***H9-*** *Expert risk assessment of GMOs is an incomplete tool and deviates from consumers' perceptions regarding to GM food.*

The former conclusion drives us to an important step in our study, namely the role of individual’s knowledge and the amount of information consumers have to motivate their behavioural reactions towards GM food. The association between knowledge and values, such as meta-attitudes, should be taken into account given that our literature review in chapter 2 revealed that knowledge can be divided into “objective” and “subjective”. IN this case, “subjective” knowledge is highly associated with the individual valuation of GM food and final acceptance. Results suggest that in order to be able to value a particular scientific application under limited technology information, individuals rely on their general attitudes towards the object of study. This suggests that individuals are likely to follow some shortcuts based on values and attitudes in forming their behaviour when they have limited information to come up with a reasoned risk benefit decision. Indeed, meta-attitudes are employed as an alternative to instrumental decision making models based on risk benefit comparisons. In light of these findings, we support ***H10 -*** *The level of subjective knowledge is determinant in building individual perceptions and is related to individual values,* and ***H12 -*** *Meta-Attitudes such as science in general and the environment have some level of impact on consumer perception of risk and benefit associated to GM food*. Furthermore, trust and confidence were found to act as filters of information and, therefore, knowledge sculptors. The concept of trust has been analysed in Chapter 6, where trust in relevant institutions, such as national and the European Union governmental agencies has been found to positively influence perceived benefits and negatively impact perceived risks; thus supporting ***H11 -*** *Trust on government and science is related to the consumer acceptance regarding to GM food.* Moreover, we also concluded that food applications associated with the opposite attitudes (i.e. GM vs. Organic food) are also valued as opposite by consumers. Then we support ***H13 -*** *Consumers that reveal a positive attitude towards organic production are expected to reveal a negative attitude associated to GMF.*

Finally, this thesis examined the role of socio-economic and demographic characteristics of respondents, such as age, ethnicity, residence, and income level, among others, on either the benefit perception or consumer acceptability of GM food. This point has been analysed in different chapters obtaining different results. For example, results in chapter 5 led us to conclude that no main gender and age heterogeneity have been identified regarding consumers benefits perception of GM food. However, it seems from chapter 3 that individual characteristics such as income, age, gender and education partially are able to explain some differences towards GM food acceptance. Jointly considering these results we do not support ***H14 - ****Socio-economic and demographic variables can have some degree of influence in the definition of a behaviour regarding to products derived from food related innovations such as GM food.*

Results from this study identified a key policy implication: the need of a well defined communication strategy to provide information in such a way that allows individuals to feel adequately informed. Conflicting information on GM food risks and benefits led consumers to rely on information shortcuts and to decide, depending on their perception and attitudes towards risks, as well as on their global attitudes towards science. Since individual interest and information towards either science or the environment have been noted as key elements in defining their perceived benefits associated to scientific and technological applications, there is need to improve communication mechanisms that can overcome people's reliance on "relative more trustworthy and more conservative" information sources. We tried to be as rigorous as possible with this research and the decisions adopted. Let us finish this thesis by mentioning a list of caveats and limitations that future research should take into account. First, the absence of a unique database able to collect all information needed to undertake a study like this, aimed at more closely understanding the complex nature of the consumer decision making process regarding GM food. In this sense, we had to use different information sources to extend this study. For instance, our data sources have not included records on several measures such as objective knowledge of GM food so as to tests how robust our results are. Second, the consideration of subjective norm indicators would improve the study, since it would fit better with the Theory of Planned Behavior. Third, this study could be generalized to other countries looking for wider confirmation of the tested hypothesis. In this context, we would recommend to public organizations that perform cross country surveys, such as Eurobarometer, to include a higher number of questions regarding consumers' knowledge and behaviour, allowing researchers to provide a full view of the topic.

Last but not least, we would like to mention that longitudinal and larger sample sizes would allow multi-group analysis, which would enhance the robustness of our findings to existing heterogeneity regarding age groups, gender or income levels, among other variables. Moreover, the analysis of other non food products, such as cotton, will also improve the approach of the study to consumers' general attitudes towards GM technology. Finally, the use of alternative non-linear methodologies of analysis instead of SEM, or the implementation of experimental bids can be considered as potential issues for further research.

7.2 References

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