# Structural Equation Modelling of Consumer Acceptance of Genetically Modified (GM) food in the Mediterranean Europe: a cross country study.

Montserrat Costa-Font & Jose M. Gil

The Centre for Research in Agro-Food Economics and Development

(CREDA-UPC-IRTA)

**Contact details:** **Montserrat Costa-Font**

**Edifici ESAB, Parc Mediterrani de la Tecnologia**

**Avinguda del Canal Olimpic s/n - 08860-**

**Castelldefels (Barcelona)**

**Tfno: ++34-935521213; Fax: ++34-935521121**

**e-mail: Montserrat.Costa-Font@upc.edu**

**Abstract**

There is some agreement in the food policy literature in that inception of genetic modification (GM) techniques in food production conveys both opportunities an risks which are found to differ across heterogeneous populations. One of the major limitations of previous research on perceptions of risk 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 to GM food using an empirical choice methodology that corrects for endogeneity in decision making relationships, namely Structural Equation Modelling. We undertake an empirical application 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.

*Keywords:* Genetically modified food, risks perceptions, benefit perceptions, Structural Equation Modelling, Mediterranean Europe, Spain, Italy, Greece,.

## 1. Introduction

Acceptance of new science developments, such as new biotechnology applications, is a matter of significance interest worldwide and has a huge 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. Interestingly, 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 – that the technology is conveys. Consumers perceive GM food as potentially threatening the sustainability of traditional food markets that have known for years. As a result, consumers might dread the expansion of GM food in supermarkets, and ultimately are said to even refuse 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 into European Mediterranean markets. This is especially the case in Spain, Italy and Greece where traditional values, such as the Mediterranean diet, contrast with the new claims of biotechnology. For instance, Spain is the country within Europe with the largest land devoted to GM food. In the last year Spain has increased the land devoted to GM food up to 75,000 hectares (MAPA, 2007). On the other side, Greece and Italy 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.

This study aims to explain the behavioural process and mechanisms that give rise to consumer attitudes concerning GM food and, 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 . We do so to tests whether public attitudes towards GM food are the result of a reasoning mechanism that hypothetically departs from trust in institutions and ultimately affects final purchase decisions. However, based on previous literature (Gaskell et al., 2003; Gaskell et al., 2004; Gaskell et al., 2006 ), this reasoning mechanism can slightly differ among consumers of different countries. This study employs a Structural Equation Model approach –namely causal models- to provide 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.

## 2. 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.1) is intended to describe the reasoning process that is behind GM food acceptance. Briefly, it attempts to isolate and define some of the most influential elements in the decision-making process concerning the purchases of GM food – trust on scientists and authorities, perceptions towards GM food and attitude formation.

Indeed, this study proves part of Chen and Li (2007) framework of consumer's attitude toward GM foods. They state that trust as well as other elements has influence on building risk and benefit perceptions. Moreover, these perceptions are responsible on defining GM attitudes, mainly benefit perceptions.

Furthermore, our underlying conceptual framework is directly related to the Theory of Planned Behaviour, which briefly states that "a person's intention to perform (or not), a behaviour is the most important immediate determinant of an action" (Ajzen, 2005). The main advantage of this theory is that it links individuals' attitudes with the associated valuation of the product by means of behavioural intentions.

**[Insert Figure 1 about here]**

*2.1. Trust*

In the area of GM technology, there is a lack of efficient risk and benefit communication due to "scientific uncertainty". In fact, this uncertainty comes up from a wide rage of information sources (Costa-Font and Mossialos, 2007). As a result, consumers present different levels of knowledge. Some reveal either rejection or acceptance of GM food, based on high levels of "subjective knowledge" (Lusk *et a.l,* 2004). Besides, there is a large social group that can be defined as "undecided or indifferent". This group does not have a clear idea of GM food, but is susceptible to new information (Onyango *et al.,* 2004*;* Hossain *et al.,* 2002*)*. Some empirical studies have detected this social stratification in both Europe and US (Martinez *et al.* (2004), Noomene & Gil *et al*. (2004), Schilling (2003), Szczurowska (2005), Vilella-Vila *et al.* (2005) and Gaskell et al. (2003, 2004 & 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 & 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 & 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 e*t 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 & 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 & 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:

> ***H1:*** *Consumers that trust both Scientists and European institutions perceive more benefits associated to GM food technology.*
>
> ***H2:*** *Consumers that trust both Scientists and European institutions perceive fewer risks associated to GM food technology.*

*2.2. 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 and Bredahl et al., 1998). Currently, consumers perceive more risks than benefits associated to GM technology (Moon & Balasubramanian, 2001 & 2004; Grunert et al., 2003; Onyango, 2004; and Hossain & Onyango, 2004; Costa-Font & 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; and Veeman et al., 2005).

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

> ***H3:*** *Perception of risks associated to GM food technology is negative related with perception of benefits associated to GM food technology.*

*2.3. Consumer attitudes towards GM food*

One of the main theories regarding the formation of consumer attitudes towards a product 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 develops on the attributes of a product weighted by an evaluation of each product attribute. This model was named by Grunert *et al.* (2003) the 'bottom-up' formation of attitudes. Later, Bredahl *et al.* (1998) developed a more detailed model for the 'bottom-up' consumer attitude explanation, specifically regarding GM food. This model implies that attitudes towards GM food technology are defined by means of a weighted sum of attitudes towards each product and its corresponding process. Moreover, each attitude also depends on the overall perceived risks and benefits associated with the product and process respectively.

This theoretical model has been empirically supported by many studies such as Moon & Balasubramanian (2001 & 2004); Grunert *et al. (*2003); Onyango (2004); and Hossain & Onyango *(*2004), which state that acceptance of agri-biotech depends on risk and benefit perceptions. Therefore, the following hypotheses are proposed:

***H4:*** *Consumers that perceive more benefits associated to GM food technology will have a more positive attitude toward GM food.*

***H5****: Consumers that perceive more risks associated to GM food technology will have a less positive attitude toward GM food.*

*2.4. Consumer final intentions towards GM food.*

An attitude towards a product, such as its acceptance or rejection, is the chief aspect that individuals evaluate in its purchasing decision. Two main theories have been used for analysing acceptance and purchase performance behaviour regarding GM versus non-GM products. First, Lancaster's theory of consumer demand (Lancaster, 1966), which positions consumers utility as a function of product attributes (benefits and risks). Otherwise, 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*).* These theories link individuals' attitudes regarding acceptance or rejection of a product with final intentions. Moreover, an important element that makes this theory useful for analysing GM purchase intention is *perceived behavioural control* (PBC), which explains intentions with a perceived impediment. In the case of GM versus non-GM food, the impediment is the 'inability to identify GM food' (Cook et *al.*, 2002) and the "uncertainty" associated to GM technology.

Most studies such as Lusk *et al.*, (2005c); Moon & Balasubramanian, (2003a,b); Onyango & Govindasamy, (2004); Chern *et al*., (2002); Bredahl (1999), Gifford *et al.* (2005), among others 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). 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 & Balasubramanian, (2003b); Onyango & Govindasamy (2004); Lusk *et al.* (2004) and Lusk *et al* (2005); Frewer *et al.* (1996) and Mucci & Hough (2003)). Although, some other studies do not support this change on behaviour (Jaeger *et al.* (2004), Lusk *et al.* (2002) and Canavari *et al.* (2005)). Therefore, the following hypothesis is proposed:

***H6:*** *Consumers with a positive attitude towards GM food will present a positive intention of consuming GM food.*

## 3. Research Methodology

*The Sample*

We employ microdata from the Eurobarometer survey 58.0 (2002), which collected representative data from different European countries. The questionnaire contains questions regarding biotechnological applications and it is publicly accessible[1]. 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% is of individuals are older than 65 years.

The initial number for the subsamples was N = 1000 for Spain, N = 992 for Italy and N= 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 N = 314 respondents for Spain, N= 330 for Italy and N= 336 for Greece. In the three countries the number of cases seems to be adequate since it exceeds 200 cases (Kline, 2005).

*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

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

acceptance and rejection (Costa-Font & 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. Otherwise, questions regarding attitudes were measures on a 4-level Likert scale, from “definitely agree” to “definitely disagree”. We based our selection of Eurobarometer questions to determine constructs on Chen & Li (2007) as shown in Table 1.

**[Insert Table1 about here]**

*3.3 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 & 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, on one hand, observed indicators with the endogenous latent variables;

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

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

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

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

where $y$, is a $p \times 1$ vector of observed endogenous or dependent variables, $\Lambda_y$ 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 $y$.

The 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 & Sörbom, 1996).

$$\eta = B \eta + \Gamma \xi + \zeta \qquad (3)$$

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, K. & Sörbom, 1996). Correlations among ordinal variables are called polychoric and polyserial correlations, which are theoretical correlations of the continuous version (Jöreskog, K. & 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 and polyserial correlations (Kline, 2007).

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

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 & Luque, 2000).

Finally, we will assess the goodness-of-fit of the model by analysing factor loadings which relate each indicator with the constructs. The composite reliability and the extracted validity for each construct will be also measured (Hair *et al*,.1999). Regarding the structural model, its analysis begins with an assessment of the significance of the estimated parameters in the structural equations (Hair *et al.,* 1999). From then, the reliability coefficient of each equation and the correlation matrix among constructs will be examined (Barrio & Luque, 2000). Finally, 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. Results

### *4.1 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. 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 on three main groups as also stated in previous literature (Gaskell *et al.,* 2004; Hossain *et al.,* 2003). However, the percentages of the groups differ among countries (see Fig.2). About 50% of the Spanish sample “tends to agree” while the “don’t know” option and “disagreement” options represent around 20-30%.  Therefore, about half of Spanish sample considers GM food technology to be useful, ethically acceptable, and must be encouraged but also 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 no need to be encouraged. Moreover, as in the case of Spain, respondents are aware of its associated risks.

**[Insert Figure 3 about here]**

General perceptions regarding to GM food were analysed on the basis of a set of questions that either support or reject a derived utility or a general statement concerning 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 GMF 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 consider 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.

*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: Trust; benefit perceptions; risk perceptions; GM food attitudes and Consumer intention in each country, assuming all errors to be uncorrelated. The initial analysis with all indicators resulted suitable for the case of Spain but not for Greece and Italy where some indicators were removed from the analysis. The correlation matrix among all variables by country is presented in Tables 2 to 4. All constructs were measured at least by two indicators as proposed by Kline (2005) among others.

**[Insert Tables2-4about here]**

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 three countries 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). Two additional parameters are important when examining internal consistency of the model, which include composite reliability (which must be > 0.7) and extracted validity (which must be >0.5) (Hair *et al.*1999 and Bagozzi and Yi, 1988). For every construct almost all composite reliabilities are greater than 0.8 but one, which is 0.73. Regarding the variance extracted, all are higher than 0.6 except in the case of Greece where the construct perception of benefit presented a extracted validity of 0.57 (Table 5).

**[Insert Table 5 about here]**

The generally considered goodness of fit measures for the overall confirmatory model indicates that the conceptual model satisfactory fits the data for the case of Spain. Alternatively, the model for Italy and Greece requires some additional adjustments on the proposed model.

The fit for the Spanish model is particularly high ($\chi^2_{(109)} = 124.54$ and $\chi^2/df = 1.14$, which is smaller than 3 (Carmines & McIver, 1981)). The Root Mean Square Error of Approximation (REMSEA) is 0.021, in average which is well under the 0.5-0.8 interval offered by Hair *et al.* (1999) and Kline (2005). The goodness-of-fit index (GFI) was 0.99, the Comparative-Fit Index (CFI) 1, the Normed-Fit Index (NFI) 0.99 and the Non-Normed Index (NNI) 0.94, all were greater than 0.90 as offered by Marcoulides & Schumacker (1996) and Chen & Li (2007). As for the case of Italy, also all measures were adequate ($\chi^2_{(80)} = 149.67$; $\chi^2/df = 1.8$; REMSEA = 0.05; GFI = 0.99, CFI =0.99, NFI = 0.97 and NNI = 0.98[2]). Finally, Greece presents major amendments from the conceptual model, with the removal of the construct that value risk perception from the model. This modifications have resulted in an adequate goodness-of-fit measures ($\chi^2_{(71)} = 126.78$; $\chi^2/df = 1.8$; REMSEA = 0.048; GFI = 0.99, CFI =0.99, NFI = 0.97 and NNI = 0.99[3]).

Summing up, we have obtained two main patterns among countries. On one hand, in Spain and Italy results support the proposed theoretical model, highlighting the role of perceived risks and benefits on the construction of attitudes towards GM food. On the

[2] The model including the removed indicators presents poorer fit such as $\chi^2/df = 2..2$; REMSEA = 0.06; GFI and CFI = 0.99

[3] The model including the removed indicators presents poorer fit such as $\chi^2/df = 2..3$; REMSEA = 0.062; GFI and CFI = 0.98

other, Greek respondents consider that perceived risks are not relevant in this process of attitude formation.

*4.2 Structural Model*

Testing the models using a Structural Equation Model demonstrates that a good fit has been obtained in Table 6. Figures 3, 4 and 5 show the path diagrams obtained. The estimated paths of the estimated coefficients indicate confirmatory evidence of hypothesis H1 and H4 for every country. Therefore, consumers that trust on institutions perceive more benefits associated to GM food technology. The path coefficient for H1 is relevant for the three countries, 0.32 (t= 5.45), for Spain, 0.24 (t= 4.52), for Italy, and 0.41 (t= 8.81), for Greece. Moreover, we have found a highly positive significant relationship between benefit perception and attitudes towards GM food, with paths of almost 1 in the three cases. This result suggests consumers perceiving benefits associated to GM food will generate a more positive attitude towards GM food.

**[Insert Table 6 about here]**

Hypotheses H2, H3, H5 were also confirmed for Spain and Italy. However, it is not been possible to test these hypotheses in the case of Greece since the construct “perceived risks” (PR) has been previously eliminated from the model. So far, we can conclude repeating what we have stated before that there are two main patterns among countries, regarding the consumers’ decision process towards acceptance of GM food. In Spain and Italy perceived risks are negative related to both trust and perceived benefits, that is, consumers that trust institutions perceive fewer risks associated to GM food. In addition, the perceptions of high benefits imply the perception of low risks. This last statement is supported by the high path coefficients (0.64 (t=11.09), for Spain and 0.80 (t=17.25), for Italy). However, hypothesis H5 is not significant in any model and therefore is not supported, which contradicts Chen and Li (2007). In other words perceived risks are not relevant in the creation of GM food attitudes. Finally, the three models support, with really high path coefficients (>0.9), the last hypothesis, H6. Therefore, consumers that reveal positive attitude towards GM food are –consistently with the theory of planning behaviour – more likely to buy GM food.

**[Insert Figures 3-5 about here]**

## 5. Discussion

In this paper, we claim that consumer intentions are the result of a complex decision-making process that results from a cumulative effect of attitudes, perceptions, and trusting information sources. To investigate whether this is the case, it is important to disentangle the process that gives rise to such intonations as far as they determine further purchase, and ultimately the introduction and diffusion of new technologies. This is especially the case of GM food in Spain, Greece, and Italy which all paradigmatic countries where we can examine the influence of the set important social constrains ( social constructs) affecting behaviour. Given that some of the underlying choice dimensions are simultaneously formed and interact with other aspects, 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. The evidence indicates that acceptance of GM food  rather than being well endowed in peoples 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 only in ultimate attitudes as some descriptive evidence has previously shown, but on the underlying behavioural processes. Not surprisingly, consumers of GM-free countries, such as Italy and Greece, are especially sceptical towards biotechnology applications on the food process. Consistently, consumers from “biotech” countries, such as Spain, are more “tolerant” towards these applications.

To better conceptualise the decision-making process our findings suggest that unlike previous studies, perceived risks are not the main factor underpinning attitudes and purchase intentions. Interestingly, the later are explained only by perceived benefits. Perceived risks seem to only have an effect through perceived benefits (Costa-Font & Mossialos, 2007). Moreover, even this results is heterogeneous as for Greek consumers, risk perception is not a relevant variable in the process at all. Yet, consistently with previous literature, social constructs such as trust in relevant institutions positively affects perceived benefits and negatively impacts on perceived risks. Finally, our findings are in line with the so-called theory of Planed Behaviour (Ajzen, 2005). That is, attitudes towards GM food clearly predict purchase intentions, almost perfectly.

In summary, this paper has attempted to contribute to the existing literature by presenting different mechanisms of decision making process for GM food consumption. Further research is needed to expand this approach to other European Union countries so as to determine the extent to which these results can be generalised to other countries, all Europe or, alternatively, are country specific. In this case, research should be conducted in order to determine factors (cultural, influence of mass media, regulations and so forth) explaining such differences.

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## Figures and Table

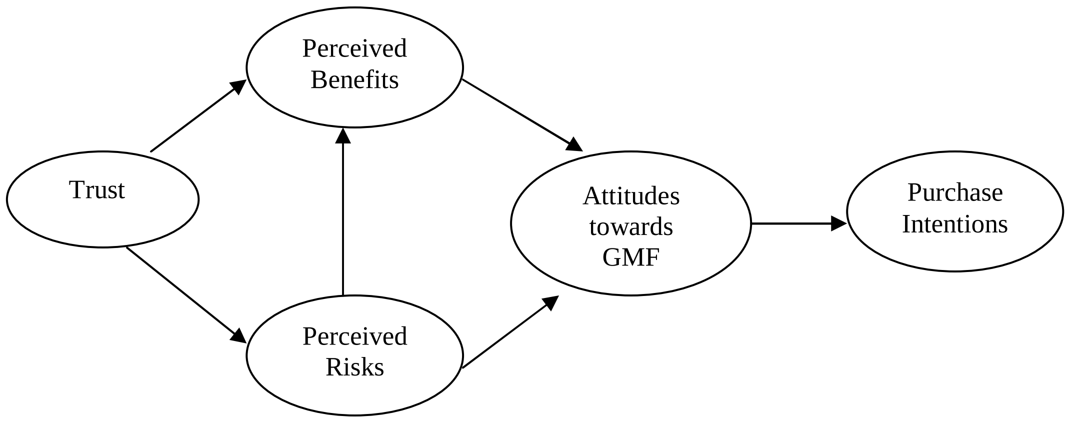


**Figure 1. Consumer conceptual process of acceptance**

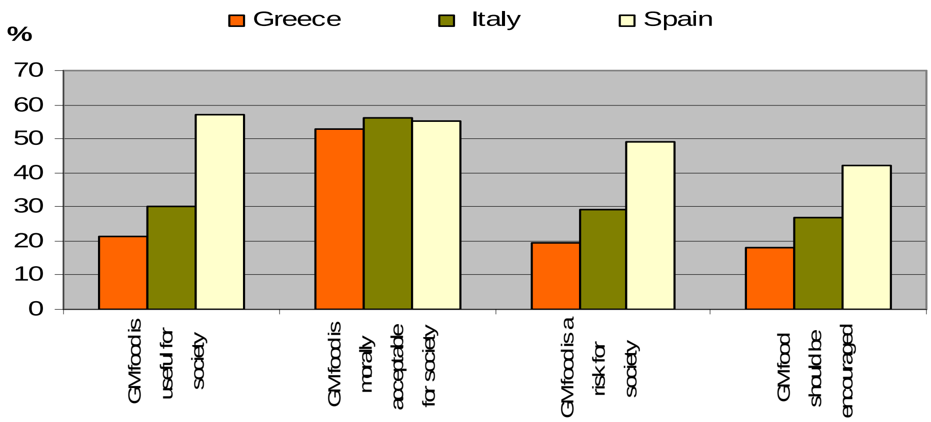


**Figure 2. Spanish, Italian and Greek GM food attitudes.**

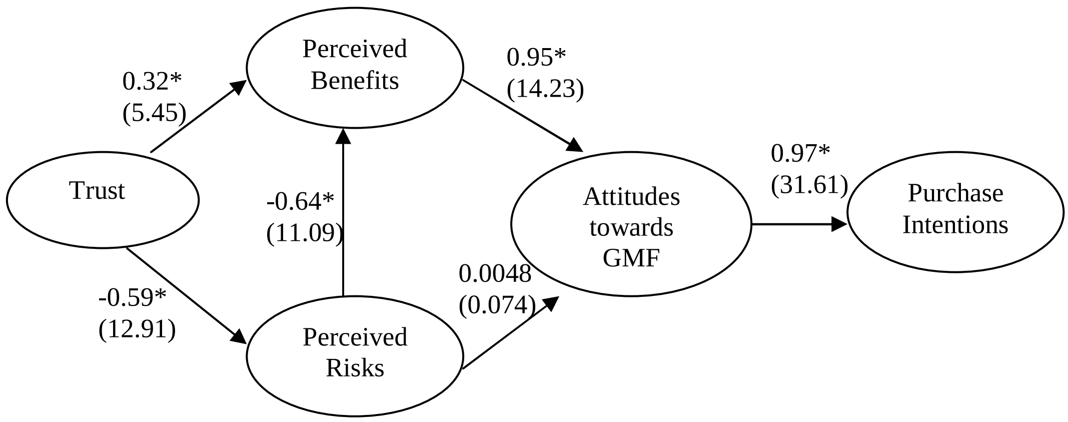


**Figure 3. Path diagram results for Spain**

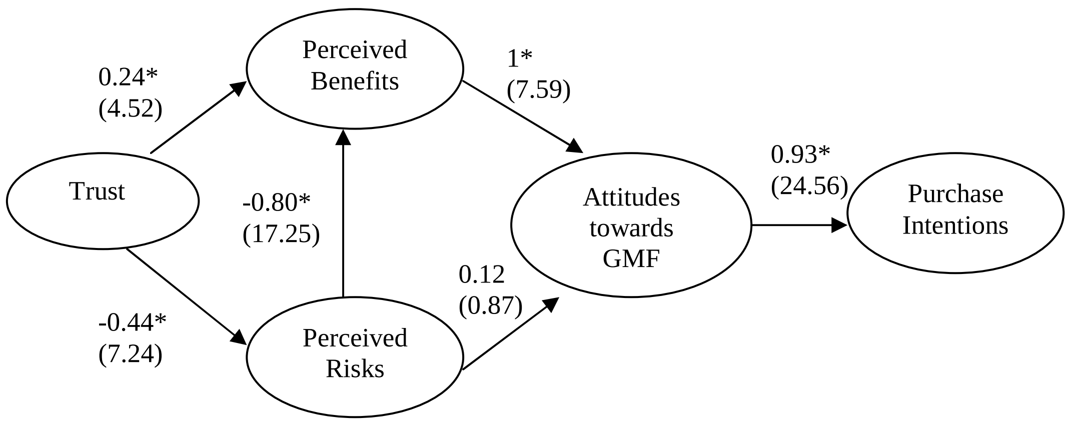


**Figure 4. Path diagram results for Italy**

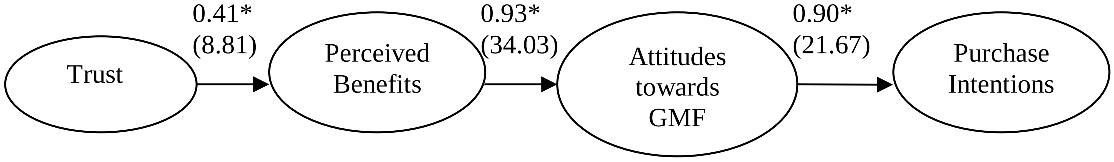


**Figure 5. Path diagram results for Greece**

Table 1. List of indicators used for each construct.

| Construct | Indicators |
|---|---|
| Trust (***C1***) | ***X1***: Do you think that University scientists doing research in biotechnology are doing a good job for society?<br>***X2***: Do you think that Scientists in industry doing research in biotechnology are doing a good job for society?<br>***X3***: 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 (***C2***) | ***X4***: Genetically modified food will be useful for me and other consumers<br>***X5***: Genetically modified food will be useful for the fight against third world hunger<br>***X6****:* In the long run, a successful (NATIONALITY) genetically modified food industry will be good for the economy.<br>***X7****:* I think it is safe for me to eat genetically modified food.<br>***X8***: Whatever the dangers of genetically modified food, future research will deal with them successfully. |
| Perceived Risks (***C3***) | ***X9***: Eating genetically modified food will be harmful to my health and my family's health.<br>***X10****:* Genetically modified food threatens the natural order of things.<br>***X11***: Growing genetically modified crops will be harmful to the environment. |
| Attitudes towards GM food (***C4)*** | ***X12****:* 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?<br>***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 morally acceptable for society?<br>***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, should be encouraged? |
| Consumer Intentions (***C5***) | ***X15****:* I would buy genetically modified food if it contained less fat than ordinary food.<br>***X16****:* I would buy genetically modified food if it were cheaper than ordinary food.<br>***X17****:* I would buy genetically modified food if it were grown in a more environmentally friendly way than ordinary food. |

Table2. Correlation matrix among indicators (Spanish model)

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 | X16 | X17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X1 | 1.00 | | | | | | | | | | | | | | | | |
| X2 | 0.72 | 1.00 | | | | | | | | | | | | | | | |
| X3 | 0.51 | 0.47 | 1.00 | | | | | | | | | | | | | | |
| X4 | 0.40 | 0.42 | 0.18 | 1.00 | | | | | | | | | | | | | |
| X5 | 0.37 | 0.46 | 0.07 | 0.70 | 1.00 | | | | | | | | | | | | |
| X6 | 0.38 | 0.32 | 0.11 | 0.62 | 0.53 | 1.00 | | | | | | | | | | | |
| X7 | 0.33 | 0.49 | 0.17 | 0.74 | 0.56 | 0.48 | 1.00 | | | | | | | | | | |
| X8 | 0.47 | 0.38 | 0.08 | 0.59 | 0.53 | 0.48 | 0.45 | 1.00 | | | | | | | | | |
| X9 | -0.46 | -0.39 | -0.22 | -0.65 | -0.47 | -0.39 | -0.49 | -0.54 | 1.00 | | | | | | | | |
| X10 | -0.23 | -0.24 | -0.03 | -0.58 | -0.34 | -0.33 | -0.46 | -0.32 | 0.73 | 1.00 | | | | | | | |
| X11 | -0.26 | -0.27 | -0.09 | -0.41 | -0.32 | -0.28 | -0.42 | -0.30 | 0.49 | 0.47 | 1.00 | | | | | | |
| X12 | 0.32 | 0.29 | 0.16 | 0.50 | 0.37 | 0.34 | 0.43 | 0.32 | -0.36 | -0.35 | -0.24 | 1.00 | | | | | |
| X13 | 0.30 | 0.27 | 0.14 | 0.41 | 0.33 | 0.32 | 0.44 | 0.27 | -0.34 | -0.35 | -0.24 | 0.77 | 1.00 | | | | |
| X14 | 0.23 | 0.25 | 0.14 | 0.50 | 0.39 | 0.36 | 0.45 | 0.34 | -0.33 | -0.34 | -0.28 | 0.87 | 0.83 | 1.00 | | | |
| X15 | 0.34 | 0.43 | 0.22 | 0.72 | 0.59 | 0.51 | 0.68 | 0.48 | -0.50 | -0.47 | -0.34 | 0.37 | 0.35 | 0.36 | 1.00 | | |
| X16 | 0.36 | 0.43 | 0.17 | 0.77 | 0.65 | 0.57 | 0.71 | 0.50 | -0.60 | -0.58 | -0.40 | 0.37 | 0.36 | 0.38 | 0.87 | 1.00 | |
| X17 | 0.38 | 0.44 | 0.15 | 0.80 | 0.61 | 0.56 | 0.66 | 0.59 | -0.52 | -0.44 | -0.34 | 0.48 | 0.41 | 0.47 | 0.81 | 0.80 | 1.00 |

Table3. Correlation matrix among indicators (Italian model)

| | *X2* | *X3* | *X4* | *X5* | *X6* | *X7* | *X8* | *X9* | *X10* | *X11* | *X12* | *X13* | *X15* | *X16* | *X17* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *X2* | *1.00* | | | | | | | | | | | | | | |
| *X3* | *0.42* | *1.00* | | | | | | | | | | | | | |
| *X4* | *0.38* | *0.07* | *1.00* | | | | | | | | | | | | |
| *X5* | *0.45* | *0.12* | *0.71* | *1.00* | | | | | | | | | | | |
| *X6* | *0.36* | *0.03* | *0.67* | *0.61* | *1.00* | | | | | | | | | | |
| *X7* | *0.46* | *0.22* | *0.71* | *0.49* | *0.48* | *1.00* | | | | | | | | | |
| *X8* | *0.29* | *0.20* | *0.31* | *0.36* | *0.28* | *0.34* | *1.00* | | | | | | | | |
| *X9* | *-0.32* | *-0.07* | *-0.67* | *-0.48* | *-0.45* | *-0.68* | *-0.31* | *1.00* | | | | | | | |
| *X10* | *-0.32* | *-0.10* | *-0.67* | *-0.36* | *-0.47* | *-0.66* | *-0.24* | *0.77* | *1.00* | | | | | | |
| *X11* | *-0.15* | *-0.07* | *-0.50* | *-0.25* | *-0.29* | *-0.47* | *-0.23* | *0.61* | *0.61* | *1.00* | | | | | |
| *X12* | *0.26* | *0.07* | *0.50* | *0.39* | *0.32* | *0.41* | *0.06* | *-0.44* | *-0.36* | *-0.18* | *1.00* | | | | |
| *X13* | *0.27* | *0.06* | *0.38* | *0.37* | *0.28* | *0.39* | *0.12* | *-0.42* | *-0.34* | *-0.19* | *0.80* | *1.00* | | | |
| *X15* | *0.40* | *0.18* | *0.69* | *0.50* | *0.45* | *0.67* | *0.25* | *-0.55* | *-0.43* | *-0.32* | *0.40* | *0.37* | *1.00* | | |
| *X16* | *0.47* | *0.22* | *0.75* | *0.56* | *0.58* | *0.75* | *0.40* | *-0.61* | *-0.54* | *-0.43* | *0.31* | *0.32* | *0.86* | *1.00* | |
| *X17* | *0.35* | *0.20* | *0.62* | *0.51* | *0.41* | *-0.52* | *0.52* | *0.39* | *-0.45* | *-0.39* | *0.33* | *0.29* | *0.76* | *0.70* | *1.00* |

Table4. Correlation matrix among indicators (Greek model)

| | *X1* | *X2* | *X3* | *X4* | *X5* | *X6* | *X7* | *X8* | *X12* | *X13* | *X14* | *X15* | *X16* | *X17* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *X1* | *1.00* | | | | | | | | | | | | | |
| *X2* | *0.75* | *1.00* | | | | | | | | | | | | |
| *X3* | *0.58* | *0.61* | *1.00* | | | | | | | | | | | |
| *X4* | *0.17* | *0.12* | *0.18* | *1.00* | | | | | | | | | | |
| *X5* | *0.17* | *0.13* | *0.16* | *0.53* | *1.00* | | | | | | | | | |
| *X6* | *0.28* | *0.39* | *0.30* | *0.43* | *0.58* | *1.00* | | | | | | | | |
| *X7* | *0.09* | *0.10* | *0.19* | *0.84* | *0.48* | *0.42* | *1.00* | | | | | | | |
| *X8* | *0.29* | *0.25* | *0.33* | *0.39* | *0.26* | *0.35* | *0.35* | *1.00* | | | | | | |
| *X12* | *0.12* | *0.11* | *0.18* | *0.59* | *0.34* | *0.25* | *0.55* | *0.32* | *1.00* | | | | | |
| *X13* | *0.07* | *0.15* | *0.14* | *0.49* | *0.23* | *0.20* | *0.49* | *0.24* | *0.81* | *1.00* | | | | |
| *X14* | *0.04* | *0.13* | *0.15* | *0.58* | *0.25* | *0.21* | *0.55* | *0.26* | *0.85* | *0.83* | *1.00* | | | |
| *X15* | *0.13* | *0.15* | *0.22* | *0.63* | *0.63* | *0.42* | *0.59* | *0.33* | *0.35* | *0.24* | *0.32* | *1.00* | | |
| *X16* | *0.24* | *0.01* | *0.23* | *0.73* | *0.37* | *0.42* | *0.62* | *0.29* | *0.40* | *0.35* | *0.37* | *0.69* | *1.00* | |
| *X17* | *0.19* | *0.18* | *0.21* | *0.57* | *0.50* | *0.43* | *0.45* | *0.32* | *0.36* | *0.22* | *0.29* | *0.74* | *0.72* | *1.00* |

Table 5. Reliability of the standardized Confirmatory Factor Analysis (CFA).

| **Construct** | **Indicators** | **Standardized loadings** | | | ***t*-Value** | | | **Composite reliability** | | | **Extracted Validity** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spain | Greece | Italy | Spain | Greece | Italy | Spain | Greece | Italy | Spain | Greece | Italy |
| ***C1*** | ***X1*** | 0.88 | 0.92 | deleted | 26.31 | 16.96 | deleted | 0.84 | 0.87 | 0.73 | 0.65 | 0.70 | 0.60 |
| | ***X2*** | 0.95 | 0.92 | 1.00 | 29.98 | 21.03 | 10.56 | | | | | | |
| | ***X3*** | 0.54 | 0.64 | 0.46 | 10.77 | 11.29 | 7.15 | | | | | | |
| ***C2*** | ***X4*** | 0.99 | 0.96 | 0.98 | 73.08 | 61.34 | 51.63 | 0.93 | 0.89 | 0.92 | 0.72 | 0.57 | 0.64 |
| | ***X5*** | 0.83 | 0.77 | 0.87 | 27.19 | 24.55 | 33.58 | | | | | | |
| | ***X6*** | 0.74 | 0.74 | 0.79 | 25.70 | 22.66 | 24.95 | | | | | | |
| | ***X7*** | 0.91 | 0.94 | 0.94 | 39.98 | 34.63 | 38.78 | | | | | | |
| | ***X8*** | 0.74 | 0.55 | 0.55 | 24.53 | 11.97 | 12.97 | | | | | | |
| ***C3*** | ***X9*** | 0.98 | deleted | 0.94 | 45.56 | deleted | 41.02 | 0.88 | deleted | 0.91 | 0.72 | deleted | 0.77 |
| | ***X10*** | 0.87 | | 0.92 | 28.51 | | 34.87 | | | | | | |
| | ***X11*** | 0.68 | | 0.77 | 15.03 | | 19.73 | | | | | | |
| ***C4*** | ***X12*** | 0.93 | 0.97 | 0.96 | 54.5 | 63.59 | 34.3 | 0.95 | 0.95 | 0.93 | 0.87 | 0.87 | 0.86 |
| | ***X13*** | 0.88 | 0.90 | 0.90 | 40.73 | 49.4 | 28.45 | | | | | | |
| | ***X14*** | 0.99 | 0.93 | deleted | 109.9 | 56.55 | deleted | | | | | | |
| ***C5*** | ***X15*** | 0.93 | 0.97 | 0.95 | 51.34 | 33.37 | 47.66 | 0.97 | 0.94 | 0.96 | 0.91 | 0.84 | 0.88 |
| | ***X16*** | 0.98 | 0.92 | 0.98 | 70.11 | 28.97 | 55.22 | | | | | | |
| | ***X17*** | 0.96 | 0.82 | 0.88 | 57.75 | 25.67 | 33.38 | | | | | | |

Table 6. Goodness-of-fit for the structural regression model

| | Spain | Italy | Greece | |
|---|---|---|---|---|
| $\chi^2_{df}$ | 224.05 | 226.65 | 183.89 | |
| $\chi^2_{df} / df$ | 1.9 | 2.6 | 2.4 | <3 (Carmines & McIver, 1981) |
| REMSEA | 0.05 | 0.07 | 0.06 | <0.5-0.8 (Browne & Cudeck, 1992; Kline, 207) |
| GFI | 0.98 | 0.98 | 0.98 | >0.90 (Bollen, 1989; Marcoulides & Schumacker, 1996) |
| AGFI | 0.98 | 0.97 | 0.97 | >0.90 (Bollen, 1989; Marcoulides & Schumacker, 1996) |
| CFI | 0.99 | 0.97 | 0.98 | >0.90 (Bollen, 1989; Marcoulides & Schumacker, 1996) |
| NFI | 0.98 | 0.96 | 0.96 | >0.90 (Bollen, 1989; Marcoulides & Schumacker, 1996) |
| NNFI | 0.99 | 0.97 | 0.97 | >0.90 (Bollen, 1989; Marcoulides & Schumacker, 1996) |