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GM foods and the misperception of risk perception

Abstract

Public opposition to genetically modified (GM) food and crops is widely interpreted as the result of the public's misperception of the risks. With scientific assessment pointing to no unique risks from GM crops and foods, a strategy of accurate risk communication from trusted sources has been advocated. This is based on the assumption that the benefits of GM crops and foods are self-evident. Informed by the interpretation of some qualitative interviews with lay people, we use data from the Eurobarometer survey on biotechnology to explore the hypothesis that it is not so much the perception of risks as the absence of benefits that is the basis of the widespread rejection of GM foods and crops by the European public. Some respondents perceive both risks and benefits, and may be trading off these attributes along the lines of a rational choice model. However, for others, one attribute – benefit- appears to dominate their judgements: the lexicographic heuristic. For these respondents, their perception of risk is of limited importance in the formation of attitudes towards GM food and crops. The implication is that the absence of perceived benefits from GM foods and crops calls into question the relevance of risk communication strategies for bringing about change in public opinion.

Keywords

Biotechnology; Risk perception; Decision theory; Risk communication

1 Introduction

One of the defining elements of an innovation, for example a new technological development, is that it offers benefits over and above what is currently available. An innovation without such additional benefit is almost an oxymoron. The nature of the benefit and the category of beneficiary may vary. Benefits may be seen in lower costs, more functionality or enhanced quality. Agri-food biotechnologies, at least in the minds of the developers, are one such leading edge scientific innovation.

Genetically modified (GM) crops and foods are claimed to offer a range of benefits to a variety of beneficiaries, including higher productivity and lower pesticide costs for producers; less environmental pollution from pesticides and herbicides, and new crop varieties to ameliorate hunger in developing countries. Many Western governments have weighed in behind the industry as biotechnology has come to be viewed as an economic opportunity and achieved the status of a strategic technology for the 21st century.

Against these projected benefits and governmental support, opposition to agri-food biotechnologies from environmentalists and sections of the wider public comes as a surprise to the promoters of the technology. While environmentalists raise questions about gene drift, super-weeds, biodiversity and the unknown longer term consequences of GM crops, the public is concerned about the ethics of genetic modification, the labelling of foods with GM ingredients and the possible health effects of consuming GM foods.

For industry and regulatory bodies, for whom risk assessments point to no unique risks from GMOs, this opposition is seen as an example of the public's failure to understand risk. Many experts judge that the benefits outweigh the possible risks - if indeed there are any risks at all. And as these experts observe the public opposition, they assume that since the benefits are not in dispute the public must be misperceiving the risks, a view that accords with early research on risk perception.

1.1 Biotechnology and the public perception of risk

In the early research, 'hazards' or technologies were used as stimuli to investigate perceptions of risks. In this sense, risk perception is akin to the psychophysics of hearing or vision[1] and this approach came to be known as the 'psychometric paradigm'.[2,3] Investigations of the cognitive and evaluative structure of risk perceptions led to the identification of two main dimensions of judgement labelled "dread risk" and "unknown risk". As early as 1985, Slovic found DNA technology, along with nuclear power, was high on the factor "unknown risk" and moderately high on the factor "dread risk"[4] suggesting that before genetic modification became a focus of controversy it was a potential source of concern to the public. This work led on to both extensions and new approaches to the study of risk perception. For example, Sjoberg[5] extends the two factor model of risk perception to include other characteristics of technologies related to risk perception such as "interference with nature", "unnatural" and "immoral". Siegrist[6] links risk perceptions to trust, showing that perceptions of the benefits and risks associated with biotechnology are related to levels of trust in companies and scientists. According to Siegrist, worldviews and trust play an important role in perceptions of gene technology. This echoes the pioneering work of Douglas and Wildavsky.[7] These cultural theorists take as a starting point the ways in which people's prior dispositions, group membership and cultural values affect the ways in which social groups attend to some hazards while ignoring others.

Most recently, Slovic emphasises the role of affective processes in risk perceptions.[8] The widely held assumption that beliefs about risks (cognitions) are prior to evaluations of risks (preferences) is reversed with the "affect heuristic": here it is preferences that shape beliefs. Thus for example, uncertain outcomes that are attractive will be perceived as less risky, while unattractive outcomes will appear as more risky. As a consequence, and consistent with cultural theory, risk perception can be seen an expression of already existing values and preferences. Such a formulation runs counter to models of rational choice in which, for example, the judgement of a new technology is made on the basis of weighing up independent assessments of risks and benefits.

Since it has been established that public perceptions of risk deviate systematically from actuarial and 'sound science' based risk assessments[9], opposition to agri-food biotechnologies is attributed to the public's misperception of risk. Furthermore, it is suggested that this is due in part to the manipulation of public opinion by campaigning groups and amplification by the media.[10] Hence, a widely proposed and supported solution is the dissemination of accurate risk information by credible and trustworthy sources. This explanation of opposition to agri-food biotechnologies has framed many expert debates and policy initiatives. Essentially, it is based on the assumption that the public, like experts themselves, use a risk-benefit analysis in the formation of judgements about the new technology, but that the former and not the latter assess the risks incorrectly. Both, it is also assumed, agree on the benefits.

1.2 Representations of biotechnology risks: a qualitative study

That the public do not invariably think in terms of risk and benefit trade-offs was strongly implied by some qualitative research that we conducted in ten countries (Austria, Denmark, Finland, France, Germany, the United Kingdom, Italy, Portugal, Sweden and Switzerland).[+] As we have reported elsewhere,[11,12] the group discussions showed more similarities than differences across the European countries. While often illustrated in the context of national events, the currents of opinion and the nature of concerns that emerged were strikingly similar; there were also some unexpected findings. Firstly, the word 'risk', in the sense of a scientific definition in relation to probabilities of negative consequences, does not feature prominently in lay discourse.[13,14] Rather, people talk in terms of dangers and in this category there are a wide range of potential problems including what might be deemed moral and democratic hazards.[15] Secondly, discourses around medical applications of

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[+] A minimum of four group discussions, with 5-8 participants per group was conducted in each country. The participants were not selected not to be statistically representative. Rather, the aim was to choose people from different social groupings, who collectively could be expected to articulate a wide range of currents of opinion. In each group, the participants were balanced between men and women, within more of less the same age category and of similar educational level. In addition, country-specific selection criteria, such as urban/rural were used.

A common topic guide was developed by the research group. This included free associations to word "biotechnology", awareness and representations of actors involved, a card sorting task of a range of application and an in-depth exploration of representation of GM food or cloning. Around these broad topics, as the issues of risk, benefit and moral acceptability, trust and regulation were raised in the discussions they were followed up in more detail. This ensured that people could approach the issues in terms of ideas and words that appeared natural and obvious to them before being confronted with researchers' categories.

The group discussions were audiotaped and later transcribed verbatim. The transcripts were analysed with to a common coding frame, using the computer program ATLAS.ti. In order to attempt the ambitious task of drawing comparative conclusions across ten European countries, the analysis and the final interpretation was a collective enterprise involving researchers from each participating country.

biotechnology, seen to be useful in alleviating pain and curing illnesses, are generally positive. But crucially, a strong and critical current of opinion was associated with some biotechnologies including GM food. This concerned the absence of perceived benefits and the possibility of non-GM alternatives to achieve similar ends. People would question the point of genetic modification of food; was it necessary when there is plenty of food in the shops? Why change the character of food when it is already good and wholesome? Questions of a similar nature were raised around xeno-transplantion: would it not be easier to get people to carry organ donation cards than to develop transgenic pigs? Arising out of such views people wondered why society should take any risks that might be involved when the claimed benefits appear to be non-existent or the ends achievable by other 'tried and tested' means.

Such concerns about the lack of utility of some biotechnologies were often embedded in other arguments: is regulation possible for such a fast moving technology? Can government and industry be trusted? Are the longer-term consequences of biotechnology fully understood? Hence the focus groups pointed to a syndrome of critical opinion – a number of concerns resulting in opposition to some, but not all, applications of biotechnology.

Our interpretation of the focus groups is best treated as suggestive. With relatively small numbers of respondents and the very nature of a group conversation it is not possible to disentangle all the related currents of opinion, nor to make inferences about their prevalence in the wider population. It is a social research method that highlights currents of opinion that might lie behind opinions and judgements presented in response to survey questions. That said, we were struck by the questioning of the benefits and by the possibility that benefit perception might in some circumstances 'trump' risk perception. Were this to be the case, then people are clearly not involved in weighing up and making a trade off between what they perceive to be the innovation's benefits and its possible costs.

In this paper, using quantitative social survey data, we attempt to model the way in which the public comes to a decision to encourage or discourage the development of GM foods. Do they make trade-offs between risks and benefits, as is widely assumed? Or do they use other strategies or heuristics?

1.3 Modelling judgments of GM foods

We briefly review earlier research carried out by the authors[16,17] using the Eurobarometer survey on biotechnology (EB52.1). This survey was fielded as part of a regular series to a representative sample of 1000 respondents in each of 17 European countries. The summary of the survey findings set a context for some new analyses that explore the ways in which risk and benefit perceptions inform people's judgements. In the Eurobarometer survey, respondents were asked whether they thought each of seven biotechnologies was useful for society (an index of benefit), risky for society (an index of risk), morally acceptable and whether it should be encouraged (an index of overall support). These rather global questions were designed to be intelligible as part of a survey interview with respondents coming from different social and national backgrounds. The response alternatives for these questions were 4-point scales from definitely agree to definitely disagree. The seven applications were genetic testing, cloning human cells and tissues, cloning animals, environmental remediation, GM medicines, GM crops and GM foods. Each application was introduced with a short description. The GM foods question was introduced as follows:

> *GM Food: using modern biotechnology in the production of foods, for example to make them higher in protein, keep longer or change the taste.*

Our initial approach to modelling the structure of judgements used a typical risk-benefit framework, with the added attribute of moral acceptability. Here it is assumed that the level of encouragement for a particular application is some combination of its perceived usefulness, riskiness and moral acceptability. This was tested using multiple regression in which encouragement was treated as the dependent variable and regressed onto the independent variables – the presumed predictors of encouragement – usefulness, riskiness and moral acceptability. Standardised regression weights were high for 'use' and 'moral' (in the range 0.5 to 0.7). For 'risk' the weights were significant but relatively small (typically between 0.2 and 0.35).[17]

In a second approach to modelling judgements, the combinations of the dichotomised choices useful/not useful; risky/not risky; morally acceptable/morally unacceptable and encourage/not encourage were inspected. For all of the seven applications of biotechnology that were considered, of the sixteen possible combinations of these four attributes, three 'logics' (patterns of attribute combination) were prototypical. These were the logic of *support* (useful, not risky, morally acceptable and encourage), of *risk* *tolerant support* (useful, risky, morally acceptable and encourage) and of *opposition* (not useful, risky, morally unacceptable and no encouragement). What is interesting here is that support for biotechnology is evidenced by some respondents who, while perceiving risk, appear to discount it and, in so doing, show support. By the same token, there is no evidence of comparable groups that are prepared to express support for GM food despite considering it to be morally unacceptable or without benefit.

2 Analysis

2.1 Risk and benefit perceptions in judgements about GM food

Our analyses of both the qualitative and quantitative data point to the possibility that benefit perception might be more important than risk perception. To explore this hypothesis in more depth, in this study we use two further questions from the survey. These questions tap similar concepts of risk and benefit and have the advantage of being more concrete in their formulation (results for the following analyses are, in fact, substantively identical regardless of which pair of a number of risk and benefit questions are used).

Benefit was assessed through agreement or disagreement, on a 5-point scale, with the statement: 'GM food will bring benefits to many people'. Risk was similarly assessed with the statement: 'GM food poses no risk to future generations'. Note for the purposes of analysis responses to the risk question were reverse coded. We categorised the sample into four groups reflecting different combinations of risk and benefit perception. The categorisation of respondents into the four groups is shown in table 1.

Table 1: Respondents grouped according to perceptions of riskiness and usefulness

Cell 1: Here respondents perceive both benefit and risk associated with GM foods. As such, they are potentially confronted by a trade-off between the two attributes. Hence we will refer to these respondents as the 'trade-off' group. Of the total sample this group comprises 18%, of whom 52% express encouragement.

Cell 2: Here benefit perception is combined with the absence of risk perception. For these respondents it is a situation of riskless choice. This group, which we call the 'relaxed', comprises 14% of the sample of whom 81% express encouragement.

Cell 3: This group do not perceive benefits (challenging a defining characteristic of an innovation) and they perceive risks. These we call the 'sceptical' group. A striking 62% of the sample is in this group. Not unexpectedly some 83% express opposition to GM foods. This group takes the same position of some of the focus group respondents who questioned the very need for GM foods.

Cell 4: In this group we have respondents who perceive neither risk nor benefit. This is not a prevalent group, only 6% of the sample. It seems likely that such a view would to be associated with non-attitudes,[18,19] hence the label 'uninterested'. From this point on we drop consideration of the 'uninterested' group from our analysis.

This categorisation raises the question as to whether the different groups are using different decision strategies in the formation of their judgements of encouragement.

For the trade-off group there are potentially two relevant attributes – risk and benefit. For the other groups (the 'relaxed' and 'sceptical') the picture is not so clear. To further our understanding of the differences between the three groups of interest we use other data from the survey to determine the distinguishing characteristics of the respondents and the resources, in terms of prior knowledge and attitudes, which they may bring to the decision.

2.2 The characteristics of the 'trade off', 'relaxed' and 'sceptical' groups

2.2.1 Variables for analysis and their rationale

From a range of other questions in the Eurobarometer survey we construct a model to predict membership of each group. The variables selected for this model are trust, scientific knowledge, technological optimism, education and gender. Each of these has been shown in previous research to be correlated with attitudes to science and technology.[17]

2.2.2 Technology optimism

It has been shown that people vary in their general optimism about the contribution of new technologies to society.[20] Those who are optimistic about one technology tend to be optimistic about others. It is therefore expected that optimists will show greater encouragement for biotechnology. Respondents were asked whether they thought each of six technologies (for example, 'the internet', 'civil nuclear power' and 'space exploration') 'will improve' our lives, 'make no difference' or 'make them worse' in the next 20 years. A scale was constructed by summing the number of 'will improve' responses.

2.2.3 *Knowledge*

It is often argued that scientific knowledge is crucial for making valid judgements about scientific matters and that it is the public's lack of relevant knowledge that leads to 'irrational' and 'emotional' opinions. Many surveys have shown the two to be positively correlated, albeit that the correlation is often low [21]. Yet the relations between scientific knowledge and attitudes to science are highly debated. Without exploring these issues in detail (but see Gaskell et al[17] for a more extensive discussion), we include scientific knowledge as a control variable. Our measure of scientific knowledge comes from a quiz consisting of ten true/false statements about biology and genetics (for example, 'there are bacteria that live in waste water', 'genetically modified tomatoes contain genes while normal tomatoes do not').

2.2.4 *Trust*

The issue of trust, or more appropriately the lack of trust has become a focus of academic research and policy debates.[22] There is a widely held assumption that if people trusted scientists and regulators more then there would be fewer reasons for the public to challenge technological developments such as GM foods. Our index of trust focussed on three actors in the food chain. Respondents were asked separately whether government, industry and shops were 'doing a good job' or a 'bad job' for society in respect of biotechnology. The count of 'bad job' responses provided an index of distrust, which was recoded such that high scores indicate greater trust.

2.2.5 *Gender*

Gender has been found to be a correlate of attitudes to science and technology in many studies.[23,24] Females are generally less interested, less knowledgeable and less supportive of science and technology than are males. Gender was coded 1 = male and 2 = female.

2.2.6 *Education*

Level of education is also associated with attitudes to science and technology.[25] Our measure contrasts those with college/university education with the rest.

A multinomial regression[26] was conducted using the above variables to predict membership of the three groups. The contrasts of interest are between the 'trade off' group and the other two. The comparison of the 'trade off' and 'relaxed' group contrasts 'benefit and risk' versus 'benefit and no risk', thereby showing the correlates of the perception of risks, while holding benefit constant. By the same token, the comparison of the 'trade off' and 'sceptical' groups contrasts 'benefit and risk' versus 'no benefit and risk', showing the correlates of the perception of benefits, while holding risk constant.

Table 2 shows the proportional change in odds of 'sceptical' and 'relaxed' group membership compared to the 'trade off' group (the reference group in the analysis) with unit changes in the explanatory variables as listed. It can be seen that the odds of being a member of the 'relaxed' group compared to the 'trade off' group are about

50% higher per unit increase in the trust in the food chain index and about 30% higher for men than for women.

By contrast, the odds ratios of being in the 'sceptical' group compared to the 'trade off' group are lower for those who are optimistic about the contribution of technologies to society (about 20% lower for each unit increase in the 'optimism' scale), for those having greater trust in the food chain (about 20% lower per unit increase), are more knowledgeable about biology and genetics (about 10% lower per correctly answered question) and are male (again by about 30%, compared to women). In other words people in the 'sceptical' group are more likely to be pessimistic about technology, have less trust, less scientific knowledge, and to be female.

Table 2 Multinomial regression predicting cell membership (odds ratios)

This analysis suggests that the 'relaxed' and 'sceptical' groups bring different backgrounds and frames of reference to the perception of risks and benefits associated with GM foods. By comparison with the 'trade off' group, the 'sceptical' group's disavowal of benefits may be the result of lower trust and their general pessimism about technology. It is also linked to scientific knowledge and to gender, as would be predicted on the basis of past research.[17] For the 'relaxed' group that differs from the 'trade off' group only in their perception of lower risks, this is associated with greater levels of trust and with the traditional sociological variable of gender, in line with past work on risk perception.[23]

2.3 How benefit and risk relate to encouragement for GM foods

The analysis thus far suggests the possibility that the 'trade off', 'relaxed' and 'sceptical' groups come to the issue of GM foods with different resources and may be weighing up risks and benefits in different ways in making a judgement on encouragement. An appropriate model to test this is a regression analysis, with encouragement as the dependent variable, regressed onto the main effects of risk and benefit, plus the interaction effect. If the interaction effect is significantly different from zero this would indicate that the respondents in the different groups are giving different weights (levels of importance) to the attributes of risk and benefit. The results are shown in table 3. As can be seen, perception of benefit is positively associated with encouragement (B=0.44) while perception of risk is negatively associated (B=-0.30). The interaction is negative which means that as the perception of benefits increases, so does the slope of risk perception on encouragement become greater. That is to say, as people increasingly see benefits, so does risk perception become more important in how they come to a judgement about whether or not to encourage GM foods.

Table 3 Multiple Regression of food encouragement on benefit and risk with an interaction

The interaction between benefit and risk can be demonstrated by plotting separate regression lines for subgroups that differ in their perception of benefits. In figure 1, the slope of risk perception (X axis) on predicted encouragement score (y axis) is steeper for those who perceive greater benefits from GM food. The difference between people's predicted scores at the highest and lowest levels of risk perception is about

0.7 for those who strongly agree that there are benefits. For those who do not see any benefit, the difference in encouragement between the lowest and highest risk perceivers is only about 0.3. Risk becomes a more discriminating attribute in the formation of attitudes to GM food when people perceive benefits than when they do not.

Figure 1: Predicted encouragement for GM food by levels of perceived benefit

2.3.1 The robustness of the interaction

An alternative interpretation of the significant interaction effect of risks and benefits is that it is a consequence of some of the background variables that are associated with group membership. For example, trust clearly distinguishes between the 'relaxed' and 'sceptical' groups in comparison to the 'trade off' group. In the context of a judgement on encouragement, could different levels of trust lead to different patterns of relations between risk and benefit? To test this hypothesis we conducted two further multiple regressions, the results of which are shown in table 4. In model 1 the dependent variable, encouragement of GM foods, was regressed onto risk and benefit and all the background characteristics previously discussed - technological optimism, trust, knowledge, gender and education. In the model 2 the interaction of risk and benefits was added. If the interaction effect is still significant in model 2, with all the background variables included, then we can rule out all of these background variables as explanations of the effects shown in table 3. In the event, the coefficient of the

Table 4: Multiple Regression of food encouragement on benefit and risk with an interaction and control variables

interaction of risk and benefit remains significant, and its value is unchanged (B = -0.04) compared to the simple model of the main effects and the interaction shown in table 3. Whatever is the explanation of the interaction effect of risk and benefits on encouragement, it cannot be attributed to any of the background characteristics, selected to reflect what are known to be correlates of attitudes to science, technology and risk perception.

Not surprisingly, all of the control variables, with the exception of college education, are significant predictors of encouragement. Clearly, the debates about the role of trust and of scientific knowledge in the formation of attitudes to new technologies are not misplaced. However, our present interest is on an effect that lies outside the domains of trust and knowledge.

3 Discussion

In this analysis of the Eurobarometer survey data, informed by qualitative interviews, and previous quantitative analyses, we identified four different groups of respondents based on a two by two classification of risk and benefit perceptions. It is notable that in the context of GM foods there are a sizeable number of respondents in the group labelled 'sceptical'. Fully 60% of the sample believes that GM foods offer no benefits and carry risks. The other two groups of interest were labelled 'trade off' - perceiving both risk and benefit - and 'relaxed' - perceiving benefit and no risk. Analysis of the characteristics of these three groups shows that they differ in respect of key social and cognitive resources that may inform their views of GM foods. Furthermore, comparing the 'trade off' group with each of the other two groups shows that different resources are predictive of both risk perception and of benefit perception. This suggests that the three groups might be making judgements about GM foods in different ways. This hypothesis is confirmed in a set of analyses. First, although risk and benefit perception are significant predictors of encouragement, a significant interaction effect was also found. This effect was also found to be robust to the inclusion of a number of relevant background variables as controls.

We interpret the interaction between risk and benefits in the following way. As people perceive greater levels of benefit so does risk perception increasingly enter into their judgements of encouragement. Conversely, as perceived benefit declines, so is the effect of risk perception on encouragement attenuated.

The interpretation of the interaction effect invites parallels with decision theory. Of particular relevance are the decision making strategies of maximising subjective expected utility (SEU).[27] The strong version is based on the assumption of fully rational choice. Derivatives of this model relax some of the assumptions, acknowledging 'bounded rationality',[28] in order to provide a more accurate descriptive account of actual decision-taking behaviour. One such heuristic model is termed 'lexicographic'.[29] While the strong version of SEU theory assumes that choices are the outcome of a combination of all possible costs and benefits, weighted by their probabilities, the lexicographic heuristic assumes that the decision taker ranks the available attributes and in most circumstances bases the decision on the single most important one, ignoring the others. Slovic's 'affect heuristic' in which an almost automatic evaluation of the hazard determines subsequent cognitions, could be seen as an example of a lexicographic decision.

Our finding of a robust interaction between risk and benefit may be interpreted as evidence of different decision taking strategies in the three groups. If benefit is perceived then the respondent goes on to think about risk and these two attributes are combined into an overall judgement of encouragement. The implied decision heuristic is something akin to the SEU model. This is the possible strategy for the 'trade off' group. By contrast, for the sceptics, the absence of perceived benefits acts to truncate their deliberation on the issue; the attribute of risk is deemed irrelevant and accordingly has less influence on the final judgement of encouragement. Here, the implied decision model is lexicographic, possibly based on Slovic's affect heuristic. One attribute, the absence of benefit, is dominant. For the 'relaxed' group the implied heuristic is far from clear. Their perception of benefits may lead them to ignore the risks (lexicographic) or they may deliberate on the risks, judge them to be minimal and combine the two attributes according to the SEU model.

However, we must be cautious in these speculations, not only because they are ex post, but also due to limitations in our data. We do not, for example, have any independent assessment of the relative importance of benefits and risks as dimensions of judgement, as would be required to test a multi-attribute decision strategy.[30] Here, a parsimonious explanation would be that the three groups attach systematically different weights to the two attributes, risks and benefits and it is the use of differential weights that could account for the interaction effect.

Yet, our primary interest is in the group of sceptics. Their perception of the absence of benefits associated with GM foods is important, as is the finding that this group is larger by far than the other two. For this group GM food fails to meet the key criterion of an innovation, an improvement on the status quo. Our analysis of the qualitative and quantitative data lead us to the tentative conclusion that perceptions of benefits, and in particular the absence of perceived benefits, acts as a dominant attribute: a non-conditional prerequisite of any level of support.

4 Implications

The implication of this conclusion is that assumptions about the bases of opposition to GM foods need to be reconsidered. From the expert's viewpoint, GM food is an innovation with obvious benefits. Opposition is seen as the result of exaggerated risk perception. Hence, policy responses have been directed towards allaying public anxieties about any possible the risks. For example, the dissemination of 'accurate' risk assessments by trusted experts; the making of risk assessment procedures more transparent and the relativising of the possible risks against other hazardous activities that engage people without apparent concern. Many of these approaches have been based on, or at least parallel, some of the literatures of risk analysis and risk communication.

A recent development in the literature is the concept of mental models of risk.[31] Given the relative failure of risk communication based on scientific conceptions of risk, the idea is to understand lay people's mental models such that messages can be couched in ways that will be more readily understood. Lying behind policy and social scientific thinking on the GM food controversy is a framing of the problem as almost exclusively a risk issue (but see Wynne[32] for a counter example).

However, the current analysis shows that the 'Achilles heel' of GM foods is not so much the misperception of the scientific risks, but rather the perceived absence of benefit for the consumer. In the minds of a large proportion of the European public, GM foods are a 'non-innovation' about which risk communication is more or less an irrelevance. Without the perception of an improvement on the status quo in terms of quality, price or other attributes there is simply no incentive to deliberate further on the issue.

Could it be argued that it was 'misinformation' about the risks, stirred up by activists and circulated by the media, which led the public to the view that GM foods were not beneficial? It is possible, but consider the case of another new technology - mobile phones. Concerns about the health risks of this technology are frequently aired. The risk of brain damage, particularly to children has been discussed in many countries. But at the same time, the penetration and use of mobile phones has increased by the year. Why? Because they are useful and as such people are prepared to accept the possibility that there may be problems in the future. In passing it is also important to note that using a mobile phone is a voluntary activity in contrast to GM foods for which labelling has been a controversial issue.

Thus, we conclude that the risk issue has been misperceived in the case of GM foods. In some sections of the public the perception of risks appears to be relevant and this, along with perception of benefits, informs public attitudes. But for a larger group of the European public in 1999, risks appear to be less relevant. Their opposition to GM foods arises from a perception of the absence of benefits, a sufficient condition for rejection, as would be predicted by any model of the diffusion of innovations. Interestingly, in the US by contrast, the public are much more likely to affirm the benefit of GM food. The Eurobarometer survey, also fielded in the US, shows that 69% of Americans agree that GM foods are useful, whereas in Europe it is only 46%. As we have argued elsewhere, this may be one of the more important factors in explaining the striking difference public opinion between the two continents.[33,34]

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Figures and Tables

Table 1

		GM food poses RISKS for future generations			
		Agree		Disagree	
GM food will bring BENEFITS to many people	Agree	(1. Useful & risky) **5.1 'Trade off'**		(2. Useful & not risky) **5.2 'Relaxed'**	
		Total	Encourage	Total	Encourage
		18%	52%	14%	81%
	Disagree	(3. Not useful & risky) **5.3 'Sceptical'**		(4. Not useful & not risky) **5.4 'Uninterested'**	
		Total	Encourage	Total	Encourage
		62%	17%	6%	27%

(Europe: N = 4524; excluding DK and 'neutral' responses)

Figure 1

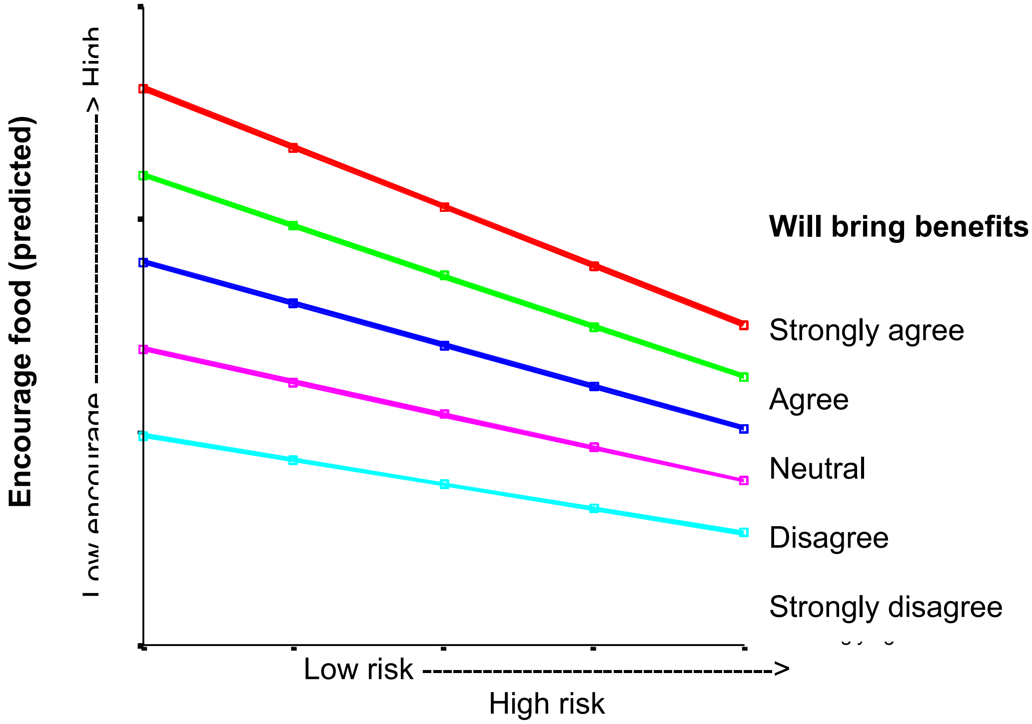
Encourage food (predicted)
Low encourage ------------------------> High
Will bring benefits
Strongly agree
Agree
Neutral
Disagree
Strongly disagree
Low risk ------------------------------------>
High risk

Table 2

	'relaxed' group		'sceptical' group	
Tech Optimism	1.01	(ns)	.82	
Trust in food chain	1.51		.78	
Knowledge	1.02	(ns)	.88	
College education	1.06	(ns)	.98	(ns)
Male	1.32		.73	

Table 3

	B	Std. Error	Beta	t	Sig.
(Constant)	4.23	0.10		40.4	0.000
Benefit	0.44	0.03	.56	13.5	0.000
Risk	-0.30	0.03	-0.34	-10.9	0.000
Benefit*Risk	-0.04	0.01	-0.29	-4.9	0.000

r^2=.24

Table 4

Variables in model	**Unstandardized regression coefficients**	
	Model 1	**Model 2**
(Constant)	(2.8)	(3.4)
Benefit	.26	.40
Risk	-.16	-.28
Female	-.11	-.11
College education	.05 (ns)	.05 (ns)
Biology knowledge	.02	.02
Trust	.13	.13
Technology optimism	.05	.05
Risk*Benefit interaction	-	-.04
R^2	.270	.273