85th Annual Conference of the Agricultural Economics Society

Warwick University

18 - 20 April 2011

Using Best Worst Scaling to Investigate Perceptions of Control & Concern overFood and Non-food Risks

Seda Erdem*, University of York, UK

Dan Rigby, University of Manchester, UK

* Corresponding author.

USING BEST WORST SCALING TO INVESTIGATE PERCEPTIONS OF CONTROL & CONCERN OVER FOOD AND NON-FOOD RISKS

Abstract

This research locates a series of risks or hazards within a framework characterised by the level of control respondents believe they have over the risks, and the level of worry the risks prompt. It does this for a set of both food and non-food risks. The means by which this is done is novel, and differs from past risk perception analyses in that it questions people directly regarding their relative assessments of the levels of control and worry over the risks presented. The cognitive burden associated with people ranking and scaling items in large sets is notoriously heavy, so this study uses an elicitation method designed to make the process intuitive and cognitively manageable for respondents.

The substantive analysis of the risk perceptions has four main foci concerning the relative assessment of (i) novel as opposed to more familiar risks (e.g. swine flu vs. heart attack), (ii) food risks as opposed to non-food risks, (iii) perceived levels of control over the risks versus how worrying the risks are considered to be, (iv) differences in the risk perceptions across social groups, as in this paper we analyse the relative assessments of farmers and consumers with a particular orientation on *E. coli*.

Keywords: Best-worst scaling; risk; perception; novel technology; *E. coli,* UK.

1 Introduction

Concerns over food risks and food safety have increased in many developed countries in recent years. This has in part been prompted by high-profile scandals and hazards within the food chain. In the UK, the origins and subsequent management of BSE damaged trust in the food production process and encouraged a more sceptical view of food safety. In addition to novel risks and hazards, high profile cases of familiar food hazards such as *E. coli* also caused concern to some. The 2009 *E. coli* outbreak at Godstone Farm in the UK and cases involving pre-packaged cookie dough in the US are two such examples. However, the level of concern people have regarding these risks varies from individual to individual. Their concerns and attitudes to prevent risks are centred around their understanding and knowledge of risks, their experiences with them, and their mood at the time of evaluating the risks. Other factors, including media, trust in food handlers, and people in their environment (e.g. family and friends) can also affect their "concern" and "attitude" towards risks. As Slovic, Fischhoff, and Lichtenstein (1982) mentioned in their seminal paper, "risk means different things to different people." Thus, it is inevitable to observe different views on risk and any events involving risks.

This research explores people's perception of various food risks within a framework characterised by the level of control that respondents believe they have over the risks, and the level of worry that the risks prompt. To act as a frame of reference, non-food risks are also added to the list of risks or hazards analysed. The means by which this is done is novel and differs from past risk perception analyses in that it questions people directly regarding their relative assessments of the levels of control and worry over the risks presented. The cognitive burden associated with people ranking and scaling items in large sets is notoriously heavy, so this study uses an elicitation method designed to make the process intuitive and cognitively manageable for respondents.

In this research, we have four main foci concerning the relative assessment of risk perception; (i) novel as opposed to more familiar and established risks/events (e.g. swine flu vs. heart attack) (ii) food risks as opposed to non-food risks (e.g. BSE vs. lightning strike), (iii) perceived levels of control over the risks versus how worrying the risks are considered to be, (iv) differences in the risk perceptions across social groups, as in this paper we analyse the relative assessments of farmers and consumers with a particular orientation on *E. coli*.

The outline of this paper is as follows: Section 2 covers the common methods used in the literature for assessing the risk perceptions, and summarises different frameworks and theorems utilised in various disciplines. It also discusses the past research, and links the current study with past work. This is followed by Section 3, which outlines the contribution of this research. Section 4 introduces the methodology and explains the survey design and data collection. The model and results are then discussed in Section 5 and Section 6, respectively. Finally, a summary of the research is presented in the last section.

2 Literature Review

Assessing risk perception is a challenging task due to the complex nature of risks. The methodologies used in risk perception studies are not limited to a general theorem or model (Anders and Sjoberg, 2000). In fact, there is no one model or a theorem that addresses risk perception alone. The risk perception studies in the literature borrow information from various fields, such as psychology, economics, and political sciences. Depending on the research area, the definition and the methodology used differ. For example, from a political science perspective, according to Wildavsky and Dake (1990) risk perception theories involve knowledge, personality, economic, cultural, and political theories. In psychology, risk perception is modelled around heuristics (Tversky and Kahneman, 1974), risk-as-feeling (Loewenstein, et al., 2001), and psychometric approaches (Fischhoff, et al., 1978).

Psychological research by Tversky and Kahneman (1974) defined the role of heuristics as involving mental strategies during the decision-making process of risky events; these strategies include the representativeness of events and their relations to each other, the availability of the risky events to individuals, and the individuals' ability to imagine the event. *Risk-as-feeling*, as discussed by Louwenstein et al. (2001), emphasises the importance of feelings in the decision-making process of risky choices.

> *"Feelings may be more than just an important input into decision making under uncertainty; they may be necessary and, to a large degree, mediate the connection between cognitive evaluations of risk and risk-related behavior" (p. 15).*

The psychometric approach, pioneered by Fischhoff and colleagues, is a more common approach in the literature (Slovic, 1978; Slovic et al., 1980; Yeung, 2002). It uses "psychophysical scaling and multivariate analysis techniques to produce quantitative representations or 'cognitive maps' of risk attitudes and perceptions (Slovic, 1987, p.281)". Slovic (1987) describes the process involved in the psychometric paradigm as:

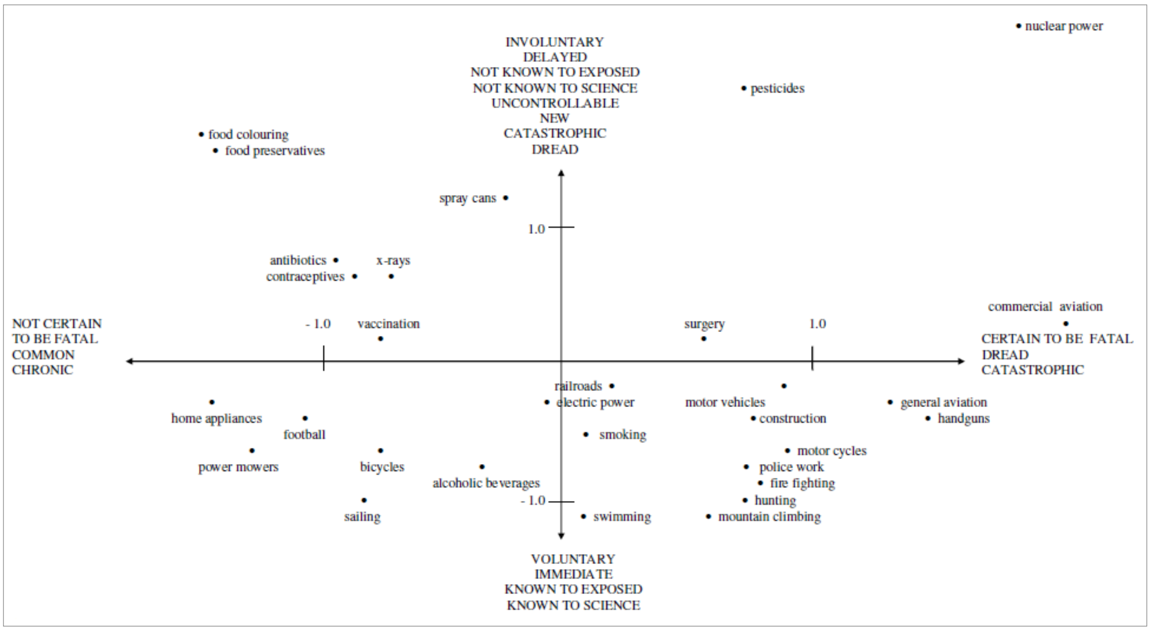
> *"Within the psychometric paradigm, people make quantitative judgments about the current and desired riskiness of diverse hazards and the desired level of regulation of each. These judgments are then related to judgments about other properties, such as (i) the hazard's status on characteristics that have been hypothesized to account for risk perceptions and attitudes (for example, voluntariness, dread, knowledge, controllability), (ii) the benefits that each hazard provides to society, (iii) the number of deaths caused by the hazard in an average year, and (iv) the number of deaths caused by the hazard in a disastrous year."*

There have been extensive studies on people's risk perception and behaviour using the psychometric methods (Slovic, 1993; Sparks and Shepherd, 1994; Frewer and Shepherd, 1995; Fife-Schaw and Gene, 1996; Raats and Shepherd, 1996; Saba, Rosati and Vassallo, 2000; Savadori et al., 2004; Henson et al., 2008; Hohl and Gaskell, 2008). While some studies focus only on the food domain (e.g. Frewer, Shepherd and Sparks, 1994; Frewer and Shepherd, 1995; Raats and Shepherd, 1996; Saba, Rosati and Vassallo, 2000; Savadori et al. 2004; Henson et al., 2008), others focus on both food and non-food domains (Frewer et al., 1998; Henson et al., 2008).

Researchers who analyse risk perception have found that each hazard, whether it is food-related or not, is multidimensional and can be analysed within the dimensions of risk characteristics. For example, in their seminal paper, Fischhoff et al. (1978) used quantitative methods to investigate how people evaluated 30 different activities and technologies, such as pesticides, smoking, mountain climbing, and nuclear power, with respect to a number of psychological risk characteristics, such as common-dread, severity of consequences, immediacy of effect, chronic-catastrophic, newness, familiarity of risk to the scientific world, control people have over them, and voluntariness of risk.

Fischhoff et al. (1978) pointed out that the inter-correlations among these numerous risk characteristics were sufficiently high, such that they could be reduced to a small number of dimensions of risk underlying these many characteristics. They identified two uncorrelated factors (or components) representing the characteristics of risks by using Principal Component Analysis (PCA). The first component they identified was highly associated with new, involuntary, and technological items that delayed the consequences of risks for many people, and thus they termed this factor as "technological risk". When "technological risk" is high on the scale, it means that the consequences of the risks are unknown in the short run; when the risks are low on this factor, it means that they are familiar, voluntary, and/or have immediate consequences at the individual level. The second component that Fischhoff et al. identified was associated with events which result in fatal consequences, and thus they termed this factor as "severity" (see Figure 1).

Figure 1. Factor Structure of Perceived Risks (Fischoff et al. 1978)



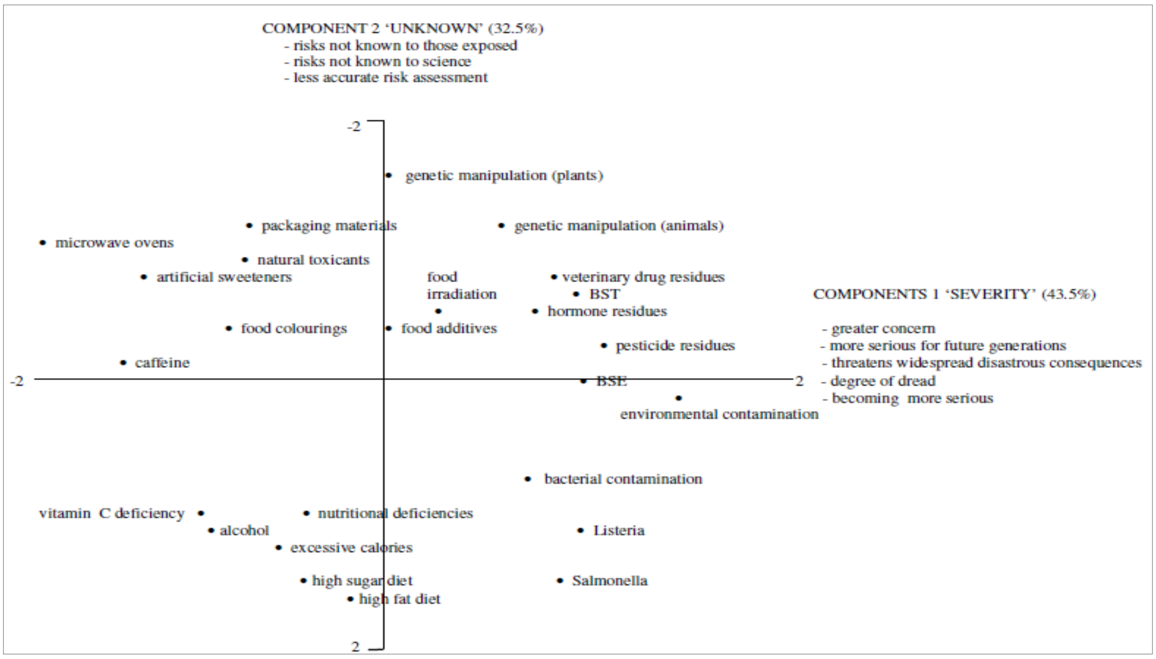
Using a similar approach, Slovic (1987) identified and replaced the first factor as “unknown” instead of “technological risk” and “dread” for degree of “severity”. The factor of “dread” included risk characteristics that were uncontrollable, globally catastrophic, having fatal consequences, of high risk to future generations, not easily reduced, risk increasing, and involuntary.

Building on this approach with Factor Analysis, Sparks and Shepherd (1994) consider risks in food production and consumption. They analyse food consumers’ perception of 25 food-related hazards (e.g. genetic manipulation, food colourings, bacterial contamination, pesticide residues). They used the same risk characteristics as in Slovic et al. (1980). Using the principal component analysis, they identified three factors: “severity”, “unknown”, and “number of people exposed”. The first factor is related to “concern”, “seriousness for future generations”, “threatening widespread disastrous consequences”, “dread”, and “becoming more serious”. The second factor is related to risk variables, such as “known by the people exposed,” “known to science,” and “accuracy of assessments”. The third factor is related to “number of people exposed” to risks.

The axes presented by Sparks and Shepherd were very similar to the ones in Fischhoff et al., but with the addition of a third factor that was absent in their predecessors’ work. Nonetheless, Sparks and Shepherd did not present this third factor on their two-dimensional risk space, choosing instead to present only the first two factors, “severity” and “unknown” (see Figure 2).

Figure 2. Location of Food-Related Hazards Within the Two-Component Space

(Sparks and Shepherd 1994)



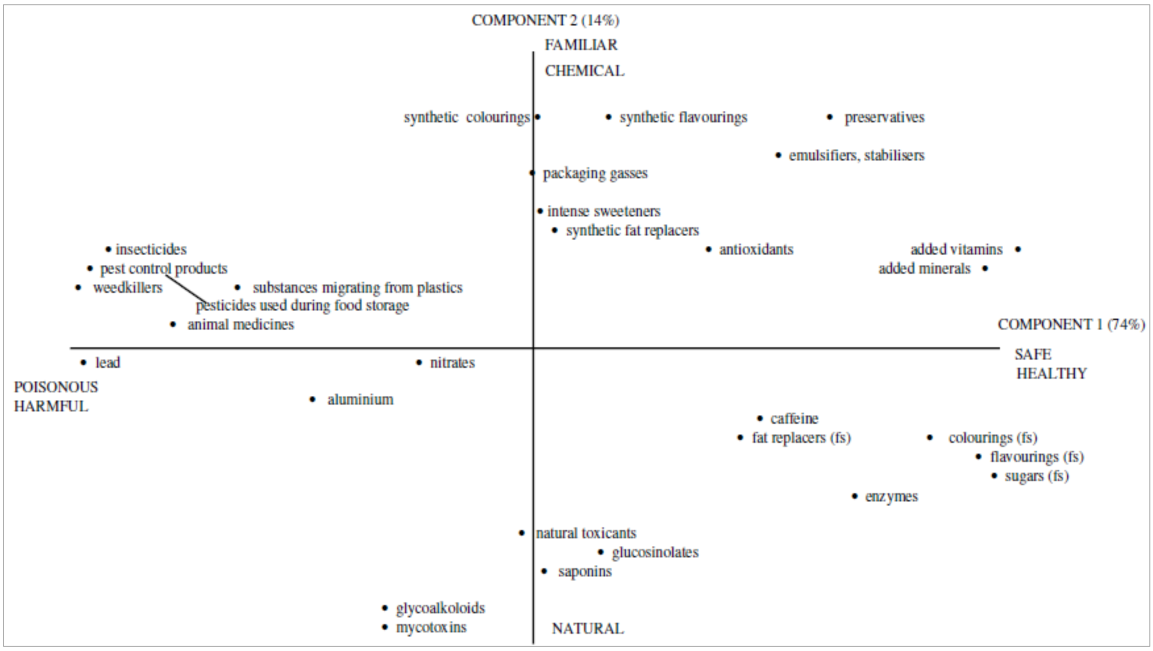
Following Sparks and Shepherd (1994), risk perception studies in the context of food have become more popular (Fife-Shaw & Rowe, 1996, 2000; Miles and Frewer, 2001; Kirk et al., 2002; Gaskell, 2008, Henson et al., 2008; Savadori et al., 2008). Fife-Schaw and Rowe (1996) extended the work of Spark and Shepherd conceptually and methodologically. They modified the type of risks and risk characteristics used in their research with the help of a focus-group study. They identified 22 food risks and 20 risk characteristics, some of which were new to Sparks and Shepherd's study (1994), and some of which had been adopted from past researches. For example, they included new risk characteristics in their analysis, such as the naturalness of hazards, whether hazards are perceived as harmful in large or small quantities, the perceived adequacy of regulations, and whether hazards are perceived to have instant or delayed effects. Although they used a number of new risk characteristics, they obtained a similar structure that had two factor components: the "severity" and "awareness" of the hazard.

In order to reduce the burden on respondents and to have more accurate responses, they constructed two types of surveys, one of which included half of risks and risk characteristics, and the other included the other half of the risks and risk characteristics. This issue of the number of risks for which perceptions can be reliably elicited is addressed regarding the contribution of this paper (see Section 3).

Other studies have differed in term of the methods used in risk perception analysis (e.g., Webster et al., 2010; Raats and Shepherd, 1996; Howard and Shepherd, 1998; Frewer, Howard and Shepherd, 1998, Henson et al., 2008; Miles and Frewer, 2001). However, while the methods have differed, they have, like the previous studies reviewed, arrived at a characterisation of the risks in a small factor (usually 2) of fundamental characteristics. For example, Raats and Shepherd (1996) analysed individuals' perceptions of chemical hazards in foods, such as pesticides and antibiotic residues, using the Repertory Grid Method. They found two risk factors which were similar to ones mentioned in previous studies: "dread" and "unknown" (see Figure 3).

Figure 3. Location of Chemical Hazards Within the Two Components Space

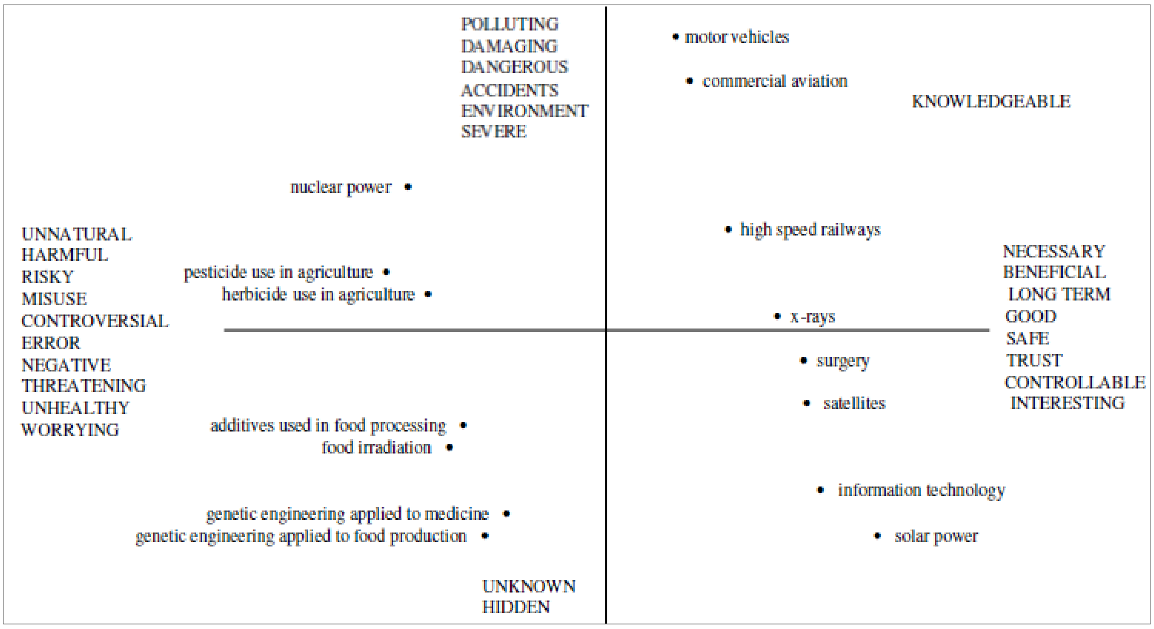
(Raats and Shepherd 1996)



In a study of public attitudes to various technologies – nuclear power, food irradiation, GM food, etc. – Frewer et al. (1998), identified two main principal factors using a similar approach. They interpreted the first factor as the component describing risks associated with technologies, e.g., “accidents”, “dangerous”, “severe”, “risky”, “unknown”, “unnatural”, and “worrying”. The second factor was interpreted as describing the perception of benefits, namely “beneficial”, “good”, “interesting”, “knowledgeable”, and “necessary” (see Figure 4). One of the intriguing results was that subjects perceived the technological processes of GM food, food additives, food irradiation and pesticide use in agriculture within the food industry as being harmful, threatening, and risky.

Figure 4. Location of Technological Risks Within the Two-Component Space

(Frewer, Howard and Shepherd 1998)



In summary, there is extensive literature on the elicitation and analysis of risk perceptions. Some of these studies focus only on the food domain, while some focus on both food and non-food domains. The “risk” referred to in these studies also show variations with respect to the focus of the study. For example, while some studies analyse the perception of food hazards associated with products (e.g., pesticide, Salmonella, additives), some investigate technological or production risks associated with foods (e.g., genetic modification, irradiation).

While the papers comprising this literature differ in some methodological respects, there is a common structure and output from most of the studies. Typically, the researches elicit perceptions of numerous risks in terms of numerous characteristics. This information is then reformulated so that the risks are characterised, usually via Factor Analysis or Principal Component Analysis (PCA), in terms of a small number of fundamental dimensions. This allows the risks to be located within the space defined by those dimensions.

We will now introduce the contribution of this research.

3 Contributions of the Research

Previous risk studies, which have commonly employed "rating scales" to elicit people's perceptions of various risks and hazards, have analysed the perception data using PCA to identify the primary risk characteristics. These studies generally reveal two principal components, which represent the main characteristics of the risks. In this study, we use an alternative approach to elicit, analyse, and characterise risk perceptions.

This research addresses the risk perceptions for various food and non-food risks or hazards by using a novel technique, Best-Worst Scaling (Louviere, 1993; Marley and Louviere, 2005), which is a form of conjoint analysis (also called Maximum Difference [MaxDiff] Scaling). While developed many years ago, this method is currently gaining attention in the agricultural and environmental economics literature (see Lusk and Briggeman, 2009).

The approach used is similar to other analyses of risk and risk perceptions, which have located risks in a two-dimensional space characterised by control and variants of worry/fear/dread. However, it differs in that, unlike other studies, we directly elicit from respondents their assessments of the risks in terms of these dimensions. Other studies typically seek to identify all possible concerns and then to undertake a Factor or Principal Components Analysis in order to score the risks in terms of these underlying dimensions (Slovic, 1993; Sparks and Shepherd, 1994; Fife et al., 1996; Savadori et al., 2004; Henson et al., 2008; Hohl and Gaskell, 2008).

Additionally, this research - which derives its origins from a project that investigates perceptions and management of *E. coli* risk in rural communities - specifically focuses on the risk perceptions of farmers and consumers. The non-farming public typically perceives *E coli* as being a food-borne illness, yet for rural workers/residents and visitors there are direct transmission paths from livestock waste and/or water. Recent outbreaks in the UK (e.g., the 2009 *E. coli* outbreak in Godstone Farm in Surrey that resulted in 35 cases, 12 children seriously ill; and an earlier *E. coli* outbreak in 2000, at a camping field in Aberdeenshire, UK which caused 20 cases) have highlighted the risks that the non-farming public can be exposed to from direct contact with livestock. Hence, we investigate how these two stakeholder groups, consumers and farmers, differ in their perceptions of *E. coli* risk and how this relates to other food and non-food risks.

The research also investigates the risk perceptions for novels hazards (e.g. swine flu, cloning animals, and climate change) as opposed to more familiar and established risks/events (e.g. heart attack, diabetes, additives) that were studied in the past. It does this within a broader perspective. That is, the research includes both food and non-food related risks/hazards so that we have a wider picture of where a specific risk (e.g. *E. coli*) lies in a two-dimensional risk space among a wide range of risks. In the literature, the majority of studies focus on one domain only, such as food (Fife-Shaw & Rowe, 1996; Sparks & Shepherd, 1994; Miles and Frewer, 2001; Kirk et al., 2002; Savadori et al., 2004). On the other hand, there are a few studies using both food and non-food risks in their analysis (e.g., Frewer et al., 1998; Henson et al., 2008; Hohl and Gaskell, 2008). Thus, we believe that our research will also contribute to the literature by filling the gaps in regards to the type of risks previously addressed.

4 Methodology

4.1 Best-Worst Scaling (BWS)

Best Worst Scaling (BWS) was used to locate people’s perceptions of various risks or hazards, characterised by the level of control they believe they have over the risks and the level of worry that the risks prompt; Figure 5 presents two examples of BWS sets from the research. Presented with repeated subsets of five items or risks, participants were asked to identify the risks they thought they had most/least "control" over and the risks that prompted most/least "worry".

Figure 5. Examples of a BWS Survey Questions

How much control do you have over events?

Please look at the sets of events below.

For each set please indicate:

• the event you think you would have the **most** control over
(i.e. the most control over preventing the event happening)

• the event you think you would have the **least** control over
(i.e. the least control over preventing the event happening)

Most control over		Least control over
O	Eating food containing pesticide residues	O
O	Getting ill from Salmonella	O
O	Becoming depressed	O
O	Getting avian flu (bird flu)	O
O	Being run over	O

What are the events that cause most & least worry for you?

Please look at the sets of events below.

For each set please indicate:

• the event that worries you **most**
• the event that worries you **least**

Most worrying		Least worrying
O	Eating food containing pesticide residues	O
O	Getting ill from Salmonella	O
O	Becoming depressed	O
O	Getting avian flu (bird flu)	O
O	Being run over	O

The selection of "most" and "least" controllable/worrying risks in these repeated tasks reveals participants' ranking of the risks and allows an estimation of scores (for example, "control" scores”) for each risk, and so a scaled ranking is derived (more detail on this can be found in Section 5). As a result, we will be able to locate risks in a two-dimensional risk space (i.e., control and worry) similar to other risk perception studies discussed earlier.

We will now explain the fundamentals of the approach, which allows us to do all of this.

BWS was developed as an extension of Thurstone's (1927) Method of Paired Comparison (MPC) (e.g., Buck et al., 2001; Duineveld et al., 2000; Leon et al., 1999; Liem et al., 2004). The main idea of MPC is to elicit tradeoffs between paired items shown in each set (e.g., risks). In BWS, there can be more than two items in a choice set (see Figure 5). The pair of items chosen in a set (i.e., best/worst or most/least) is the one which shows the maximum difference in preferences or importances or views (Louviere, 1993) (therefore it is also called a “MaxDiff” experiment).

The main advantage of BWS over MPC is that it provides more information from respondents' selections. The choice of “best” and “worst” or “most” and “least” items in a task sheds light into the preferences for each item of the survey. For example, as shown in Figure 5, assume the respondent chose “being run-over” as the “least” worrying and “getting ill from Salmonella” as the “most” worrying risk among all 5 options.

Selecting most and least informs us on seven of ten (i.e., 5x4/2) paired comparisons, such that:

- “getting ill from Salmonella” > “eating food containing pesticide residues”, “getting avian flu (bird flu)”, “becoming depressed”, “being run-over”, and
- “eating food containing pesticide residues”, “getting avian flu (bird flu)”, “becoming depressed” > “being run-over”

where “>” means “more worrying (or controllable) than”.

Here, as presented, we lack information about three of the risks: “eating food containing pesticide residues”, “getting avian flu (bird flu)”, and “becoming depressed”. However, even just two selections (i.e., most and least) in a set give valuable information on the rankings of the risks.

BWS questionnaires are also relatively easy for most respondents to understand. It breaks tasks into a more cognitively manageable size, rather than asking people to rank a full set of items. Additionally, there is evidence that people use better judgment when they only need to evaluate extreme preferences rather than preferences with levels (Louviere, 1993; Marley and Louviere, 2005). As there is no scale involved in the selection process, this process is also considered as a "scale-free" approach (Cohen and Markowitz, 2002); it eliminates the possibility of scale-based biases and reduces the cognitive burden on respondents. These advantages contribute to the use of the technique from academia to industry in a wide range of applications, including agriculture, environment, transport, health, and marketing. For example, a seminal paper by Finn and Louviere (1992) used this approach to address the level of concern for food safety relative to other issues, like cost of living and preserving the environment. Auger et al. (2007) examined the attitudes of consumers towards social and ethical issues, e.g., recycling and human rights, across six countries. Flynn et al. (2007) examined the elderly's evaluation of quality of life in terms of different levels of attributes, e.g., attachment, security, role, enjoyment and control. Mueller et al. (2009), Louviere and Islam (2008) and Flynn et al. (2008) are some other recent examples of BWS scaling used in various areas of research.

4.2 Survey Design

We created two types of surveys of the same design: the first asked people to assess various risks in terms of "control", and the second asked people to assess risks in terms of "worry" criterion. These two dimensions of risk were chosen as they have featured heavily in other risk analyses (Fischoff et al., 1978; Slovic, 1993; Sparks and Shepherd, 1994; Fife-Shaw and Rowe, 1996; Kirk et al., 2002; Henson et al., 2008; Hohl & Gaskell, 2008).

Overall, there are 20 risks included in the BWS surveys: half concern food hazards, the other half concern non-food hazards (see Table 1). Of these risks, some are novel (e.g., swine flu and cloned animals), and some are more common/established risks (e.g., heart attack, additives).

Table 1. Food and Non-food Risks Used in Surveys

Getting ill from Salmonella
Getting ill from *E. coli*
Getting BSE (mad cow disease)
Getting avian flu (bird flu)
Eating food containing pesticide residues
Eating foods containing hormones
Eating rice or cereal (e.g. bread) that is genetically modified (GM)
Eating meat or milk from a cloned animal
Getting swine flu
Eating foods containing additives (e.g. E numbers)
Climate change
Being run over
The health effects of using mobile phones
Getting diabetes
Having a heart attack
A fire at my home
Being burgled
Becoming depressed
Getting a food allergy
Being struck by lightning

We created eight versions of the surveys. In each survey, there were eight sets (i.e., questions) and each set included five items (i.e., risks). Given the total number of items used in the survey (20), it is plausible to use five items in each set. Showing more than five items to respondents may result in confusion and fatigue, which may in turn result in unreliable responses. Cohen and Orme (2004) suggested that asking respondents to evaluate more than five items within a set might not be useful. For studies involving up to 30 total items, the gains in precision of the estimates are minimal when using more than five items at a time (Sawtooth Software, 2007).

In each BWS set, we show respondents different combinations of five risks for their assessment of the "most" and "least" controllable/worrying risk. Figure 5 shows an example task used in the questionnaires. The combinations of five risks in these sets satisfy the optimal design characteristics: *frequency balance*, *orthogonality*, and *connectivity among tasks*. That is, the one-way frequencies reveal that the survey design is perfectly balanced as each item in the survey was displayed 16 times[1] across all versions of the surveys. The two-way frequencies show that the survey had a nearly orthogonal main-effects design, in which each item appears 3.56 times on average with every other item, with a standard deviation of 0.53.

After ensuring a balanced and nearly orthogonal survey design, tasks were randomised, and a participant was randomly assigned to a version.

We will now explain the data collection before introducing the statistical model used in the analysis and associated results.

4.3 Data Collection

We conducted the surveys with two stakeholder groups: farmers and consumers in England and Wales in the summer of 2009. We collected the data at five agricultural shows (Cheshire, Royal Welsh, Nantwich, Garstang, and Romiley Young Farmers Shows), as well as in the city of Manchester. We sampled farmers at agricultural shows that have high coverage and consumers in the city of Manchester[2]. The Cheshire and Royal Welsh Shows are the biggest agricultural summer events in the UK. There were approximately 80,000 and 220,000 visitors in the Cheshire and Royal Welsh Shows, respectively. We screened respondents in the questionnaires whether they work on farm or involved in farming practices and helped friends and family on farm (see sample questionnaire in the Appendix). By this way we identified respondents who were consumers that attended to the shows. We did not include these groups in our analysis as we believe that, given the nature of the questionnaires, responses we get from consumers who are in agricultural shows may result in biased responses. Their reactions to questions regarding the safety of meat they eat may be

[1] As we presented five items in each set, there were overall 40 items shown in every version (i.e., 5 items x 8 tasks). As there are 20 stages in total, each stage appears twice in each version. Across all eight versions, each stage appears 16 times.

different when they are in agricultural shows, as compared to a case when they are not in such an environment, but in their daily routine.

Overall, we contacted 280 (166 farmers, 114 consumers) respondents who were randomly assigned to one of two treatments. The first treatment asked people to assess the risks in terms of "control", and the second used the "worry" criterion.

The majority of the respondents were female (63%) and had a degree or graduate education (25%). The average age was about 38, and the average annual household income was about £40,500 (c. $65,000). Thirty-five percent of the respondents were employed full-time, and 42% percent of the respondents had children. A comparison with 2001 UK census data shows that people in our sample were not very different from the UK population with respect to age, gender, and employment status (e.g., the majority were 30-44 years old (23%), female (51%), and full-time employed (41%) in the population).

5 Model

We model people's perception of risks using the Random Utility Theorem (RUT). RUT is a theory on human decision-making initiated by Thurstone (1927) and was generalised by McFadden (1974). In RUT, "the basic idea is the assumption of utility maximisation combined with distributional assumptions on the unobserved errors" (Wind and Green, 2004, p.154). In this research, we use RUT for decisions, views or opinions (i.e., control and worry over risks), rather than for a good or a service from which someone maximises his/her utility.

A simple Random Utility model can be mathematically written as:

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

where $U_{ij,t}$ is individual i's utility from his/her selection of alternative j in a choice set t={1,2,...K}, $V_{ij,t}$ is the deterministic part of the model which can be written as:

$$V_{ij,t} = \beta_i X_{ij,t}$$

where β_i is individual i's utility parameter vector, $X_{ij,t}$ is a vector for attributes (i.e., risks) associated with alternative j, and $\varepsilon_{ij,t}$ is the stochastic (random) component, which allows researchers to make probabilistic statements about consumers' behaviour (Adamowicz et al., 1998 ; Lusk, 2003).

The respondent will choose a pair of attributes i.e., risks, that maximise the utility differences in his/her best and worst choices. For the sake of example, we assume the respondent chooses attribute *j* over attribute *k*, as the best and worst, respectively, out of a choice set with *J* items. Then the probability that the respondent i chooses attribute j over attribute k is the probability that the difference in utility $U_{ij,t}$ and $U_{ik,t}$ is greater than all other *J(J-1)-1* possible differences in the choice set. Assuming that $\varepsilon_{ij,t}$ is distributed i.i.d. type 1 extreme value, then this probability can be written in a simple logit form:

$$Prob(j \text{ is chosen best and k is chosen worst}) = \frac{e^{V_{ij,t}-V_{ik,t}}}{\sum_{l=1}^{J}\sum_{m=1}^{J} e^{V_{il,t}-V_{im,t}}} \quad (2)$$

Given that individuals are heterogeneous and therefore have different tastes, the logit form of the probability can be further specified using Mixed Logit (MXL) formulation. MXL, sometimes also called Random Parameter Logit, is widely used in the literature that acknowledges the heterogeneity of consumers in nature (Revelt and Train, 1998; Brownstone and Train, 1998; McFadden and Train, 2000). It is a highly flexible model that can approximate any random utility model (Train, 2003; McFadden and Train, 2000).

Substituting equation (1) into (2) gives the following simplified form:

$$Prob(j \text{ is chosen best and } k \text{ is chosen worst}) = \frac{e^{\beta_i X_{is,t}}}{\sum_{r=1}^{J} e^{\beta_i X_{ir,t}}} \quad (3)$$

Here, the parameters belong to the utility difference function, not to the individual best-worst utilities.

Now, consider a sequence of alternative best-worst pairs chosen at each choice set of *t={1,2,...,K},* then the individual's probability of making a sequence of choices is the product of logit forms in equation (3). We can write this as:

$$Prob(\text{sequence of choices}) = L_i(\beta_i) = \prod_{t=1}^{K} \frac{e^{\beta_i X_{is,t}}}{\sum_{r=1}^{J} e^{\beta_i X_{ir,t}}} \tag{4}$$

The mixed logit probability is then the weighted average of the logit formula evaluated at different values of β, with the weights given by the density function of $\varphi(\beta)$. We assume that β is distributed normally with mean b and covariance w.

The choice probability in equation (4) can be written as:

$$P_i = \int L_i(\beta_i)\varphi(\beta_i|b,w)d\beta_i \tag{5}$$

This is the probability of the individual's sequences of choices, conditional on the parameters of the population distribution, $\varphi(\beta_i \mid b, w)$. Generally, the integral in (5) does not have a closed form (Brownstone and Train, 1998); therefore, we approximate it through simulations.

We use a Hierarchical Bayes (HB) simulation method for parameter estimation of the density function. HB simulation follows an iterative procedure that uses each individual's choices along with information about the distribution of part worths for all respondents to estimate individual-level parameters[3]. We now turn to results from the analysis.

---

[3] Each iteration consists of the following steps (Sawtooth Software, 2003):

- Using the initial estimates for βs and w, generate a new estimate of b.

6 Results

The results we present here concern relative assessments of the levels of control and worry people have over various risks. Hence, they represent *views*, rather than actual risk measures. We present the results in four parts. The first section gives the results of the analysis of people's perception of novel and familiar (or more established) risks. The second section does the same for food and non-food risks. The third section investigates how people perceive *E. coli* in a broader perspective. Finally, the fourth section addresses the differences in the risk perceptions of farmers and consumers, again with a particular orientation on *E coli.*

6.1 Comparison of Perceptions of Novel and Familiar Risks

Table 2 presents raw scores, i.e., weights, resulting from the MXL estimation. These weights consist of negative and positive values which are on an interval scale. To make interpretation of the results easier, we converted these scores to ratio-scaled probabilities that range from 0 to 100 (thereafter called "rescaled" scores). These rescaled Mixed Logit scores are shown in

Table 3. Figure 6 presents them graphically.

Having an initially naive assumption of equal levels of control/worry among 20 risks (i.e., each at 5%), we find that people believe they have less than average control (i.e., 5%) over recently emerged risks, such as swine flu, eating meat from cloned animals, climate change, and bird flu (see Figure 6). They also tend to worry less than average for these risks. **Figure 7** presents this in a

---

We assume that b is distributed normally with a mean equal to the average of βs and a covariance matrix equal to w divided by the number of respondents. A new estimate of b is drawn randomly from that distribution.

- Using the present estimates of βs and b, draw a new estimate of w from the inverse Wishart distribution.
- Using the present estimates of b, w, and σ, generate new estimates of the βs. Here σ is the standard deviation of the random error term in equation 0(1).
- Using the present estimates of b, w, and βs, generate a new estimate of σ.

The final estimated parameters are obtained by averaging the parameter values retrieved from further iterations after convergence is attained. They are then used to rank attributes with respect to their importance or desirability.

two-dimensional risk space, in which scores were zero-centered. Thus, the axes in this graph represent the average (e.g., above zero means above average).

Regarding novel risks, we see that “swine flu”, which was an emerging and high profile issue at the time of the surveys, is seen as a cause of relatively little concern (less worrying than hormones in food, Salmonella, or BSE) and something over which people feel they had an extremely low level of control. “Swine flu” is seen as little different from “bird flu” even though the latter was receiving relatively little coverage at the time. This may be a result of “flu fatigue” with some people having become insensitive to warnings of flu epidemics following some arguably lurid coverage and warnings regarding the threat of avian flu in 2005 and 2007. Climate change features as 19th out of 20 in terms of the level of control people feel they have over it and 11 th in terms of how worrying it is, being regarded as less worrying than, *inter alia*, the risks of getting Salmonella, being hit by a car, or getting diabetes.

Cloning was one of the emerging food technologies identified by the UK Food Standards Agency (FSA, 2009) as requiring further research on public perceptions of it. The consumption of meat or milk from cloned animals prompted low levels of concern, on a par with additives in food. It is also notable that the consumption of GM foods was regarded as worthy of very little concern. In terms of the 10 food risks, it ranked as one of the least worrying to respondents, only being surpassed in terms of a lack of concern by the risk of getting a food allergy. Given the contentious history that the (non) production and consumption of GM food has had in the UK, this is quite remarkable. It may be a result of continued exposure to the idea of GM food (in many ways it might be seen as no longer a novel food technology), the absence of hard evidence of environmental or health effects of the use of GM foods, or the repeated calls in the preceding 18 months, at the height of the boom in world food prices, for the use of GM technologies to address global food needs. In contrast to this, it is notable how worrying the risk of getting BSE remains, despite having largely disappeared from the news media for many years and there having been only 8 deaths from vCJD in the UK between 2007 and 2009. Contracting BSE/vCJD was seen as more worrying than “swine flu” and on a par with “bird flu” and “climate change” in terms of the worry it caused.

Table 2. Raw MXL Scores

Risks	Control Mean	Control t-value	Worry Mean	Worry t-value
Getting ill from Salmonella	4.17	14.23	2.86	9.87
Getting ill from *E. coli*	3.45	10.65	3.16	9.57
Getting BSE (mad cow disease)	2.60	9.22	2.14	6.26
Getting avian flu (bird flu)	2.28	9.21	2.14	7.76
Eating food containing pesticide residues	2.72	7.95	2.39	6.83
Eating foods containing hormones	2.62	8.06	2.44	6.98
Eating rice or cereal (e.g. bread) that is genetically modified (GM)	3.93	11.33	0.21	0.53
Eating meat or milk from a cloned animal	2.19	7.24	0.62	1.87
Getting swine flu	1.22	4.39	1.92	6.47
Eating foods containing additives (e.g. E numbers)	5.40	16.31	0.60	1.62
Climate change	0.23	0.94	2.35	6.64
Being run over	4.10	11.15	2.86	10.82
The health effects of using mobile phones	4.01	15.35	-0.18	-0.52
Getting diabetes	2.72	9.96	3.25	12.75
Having a heart attack	2.61	9.26	5.20	16.91
A fire at my home	4.85	18.16	4.94	19.18
Being burgled	3.00	11.59	3.27	11.24
Becoming depressed	3.40	13.39	2.39	6.76
Getting a food allergy	1.39	5.10	0.83	3.07
Number of observations	*142*		*138*	
Root Likelihood[4]	*0.25*		*0.26*	

4 Root Likelihood measures the goodness of fit. As we have 5 alternatives in each choice set, the null probability of each alternative to be chosen is 0.20 (i.e.1/5). This is the expected RLH value for a chance model. The actual value of 0.25 (or 0.26) would be interpreted as just better than 1.13 times the chance level. .Here, we compute RLH by simply taking the nth root of the likelihood, where n is the total number of choices made by all respondents in all tasks. RLH is therefore the geometric mean of the predicted probabilities (see Sawtooth Software Technical Paper. Available at: 2008 . http://www.sawtoothsoftware.com/download/techpap/cbctech.pdf).

Table 3. Rescaled MXL Scores (%)

Risks	**Control**	**Worry**
Getting ill from Salmonella	9.14	6.26
Getting ill from *E. coli*	5.91	7.56
Getting BSE (mad cow disease)	3.08	3.67
Getting avian flu (bird flu)	2.34	3.68
Eating food containing pesticide residues	3.41	4.46
Eating foods containing hormones	3.14	4.66
Eating rice or cereal (e.g. bread) that is genetically modified (GM)	8.01	0.64
Eating meat or milk from a cloned animal	2.17	0.95
Getting swine flu	0.88	3.06
Eating foods containing additives (e.g. E numbers)	14.36	0.93
Climate change	0.34	4.35
Being run over	8.80	6.26
The health effects of using mobile phones	8.39	0.44
Getting diabetes	3.40	8.00
Having a heart attack	3.10	15.78
A fire at my home	12.25	15.07
Being burgled	4.27	8.10
Becoming depressed	5.71	4.46
Getting a food allergy	1.04	1.16
Being struck by lightning	0.27	0.52
Sum	*100*	*100*

Figure 6. Control and Worry over Various Food and Non-food Risks.

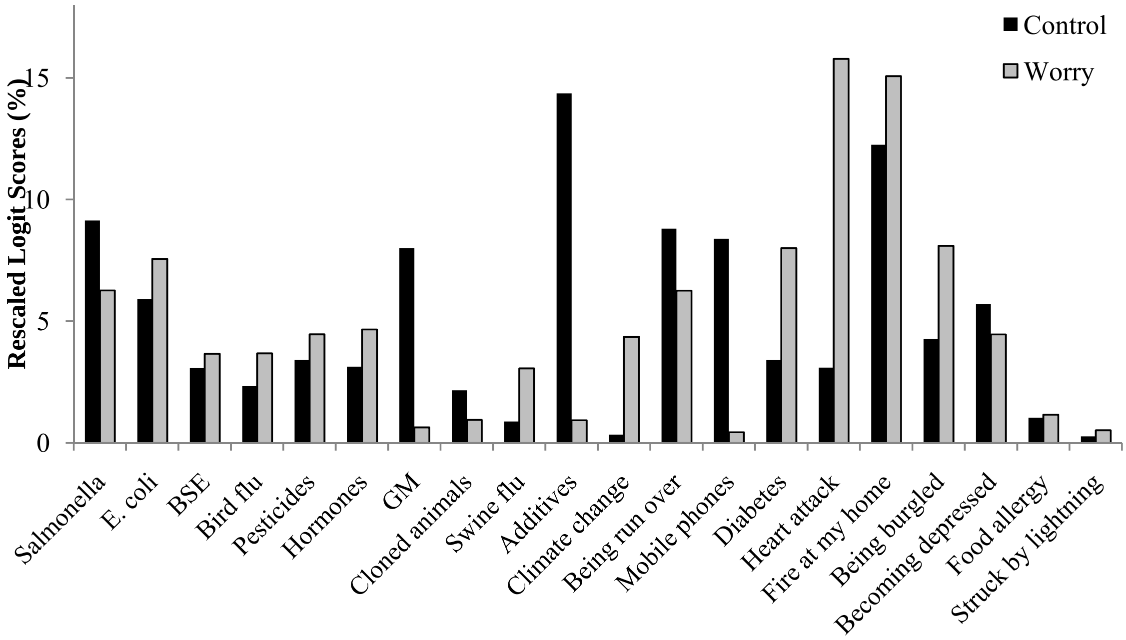
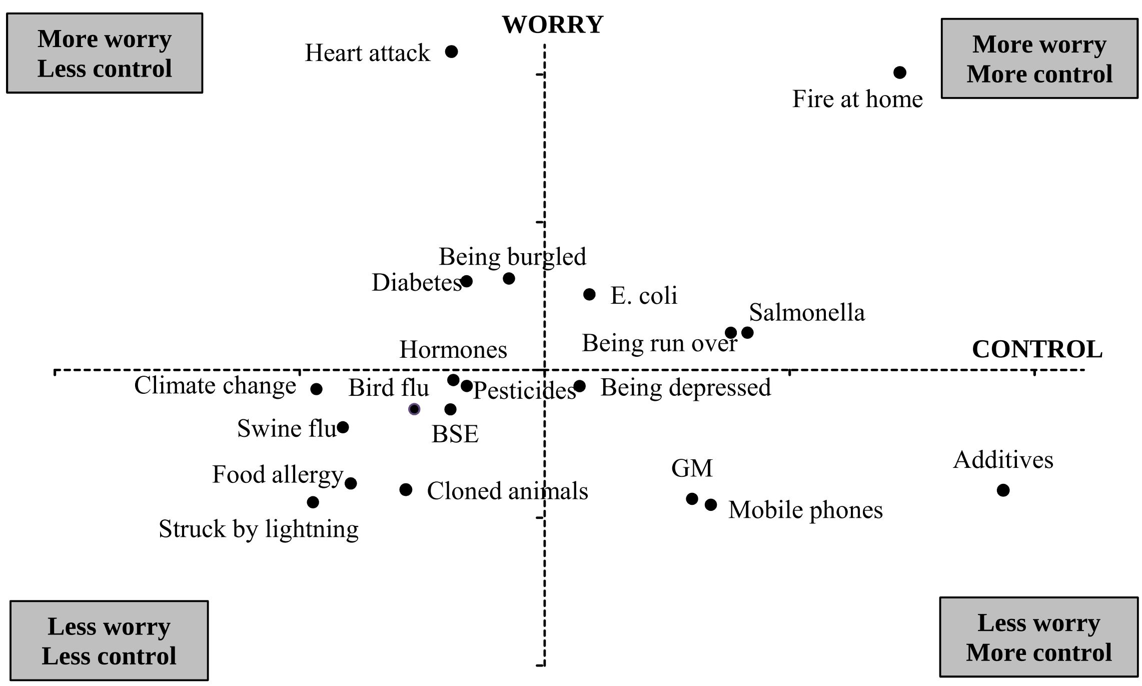


Figure 7. Location of Risks within Two-component Space



6.2 Comparison of Perceptions of Food and Non-Food Risks

The general comparison of the risks in the control-worry space shows that people seem to locate most risks in Quadrant 3 of the control-worry space in **Figure 7**. In this quadrant, people think that they have less than average control and concern over risks. The majority of risks located in this region are foodborne risks (e.g., BSE, cloned animals, and pesticides).

As seen from **Figure 7**, more than half of the non-food and food risks (60%) are located in “less control” quadrants. People feel that more controllable risks are “eating foods containing additives”, “fire at home”, “Salmonella”, “being run over”, “mobile phones”, and “GM foods”, in descending order.

Figure 7 also shows that people tend to worry less over food risks than over non-food risks. More than half of the food risks (80%) are located in “less worry” quadrants of the risk space. The most worrying risk for them is “having a heart attack”, followed by “fire at home”, “getting diabetes”, and “being burgled”.

Climate change is featured as one of the least worrying non-food risks, on a par with “becoming depressed”.

We now discuss the results with a particular focus on food risks.

Perceptions of Food Risks

Regarding food risks, we see that “additives” is seen as a cause of high control and something over which people feel that they have an extremely low level of concern (see Figure 6). The perception of a high level of control may be due to the food labels that indicate whether the product has additives in it or not. In fact, some packages in the UK specifically state that a given product is “additive free” in large fonts. People feel that they have the option of “not buying” the product, which is a way of exerting control. Particularly for “additives”, people also show little concern. Being able to avoid the use of a food product that includes additives in it intuitively results in less concern, although there is always a possibility of missing information (e.g., on additives) on food labels. Also, due to the credence attributes of foods, some people may still build up some concerns regarding these issues. In such cases, "additives" may prompt high levels of concern and feelings of limited control.

The results also show that people believe they have more than average control (i.e., 5%) over Salmonella, GM, and *E. coli*, in descending order. However, the levels of control people think they have over BSE, pesticides, hormones, cloned animal, bird flu, and getting food allergies are less than the average level. This may be partly because of the practicality of the preventive methods of these risks or the lack of information, either on the nature of food products (e.g., whether it includes pesticides), or on how to avoid them. For example, people may believe that they can prevent Salmonella in chicken if they properly handle the meat. However, controlling the risk may be very difficult (or not even possible) if they do not know anything about the risk.

One of the interesting results is that BSE still features strongly in people's minds despite this issue having had little coverage in the press for many years since the height of the fears, and despite government action to address the risks posed by BSE and vCJD.

Another intriguing result is that pathogens and hormones concern people more than other risks. Particularly, people perceive *E. coli* as more worrying than Salmonella. Similar results are also observed in other studies, such as Sparks and Shepherd (on Salmonella and hormones), Fife-Schaw and Rowe (on Salmonella and hormones), Henson et al. (on hormones), and Kirk et al. (on hormones and Salmonella). We believe that the recent food scares (e.g., *E. coli* outbreak in Godstone Farm in 2009) and subsequent media coverage on these issues play an important role in such perceptions. The risk profile in the public imagination develops over time and may change with the information in the press, broadcast media, and internet. This relationship has been investigated in the literature previously. For example, researchers have sought to identify the impact of media stories on observed purchasing or consumption behaviour (see Young and Burton on BSE, Kalaitzandonakes, Marks, and Vickner on biotech foods, van Ravenswaay and Hoehn on Alar scare, Verbeke and Ward on hormones in meat, Piggott and Marsh on Listeria, Salmonella, *E. coli*, and BSE), as well as confidence in the safety of foods (de Jonge et al., 2010).

6.3 *E. coli* in a Broader Perspective

In terms of the particular focus on *E. coli*, food pathogens were perceived to be more controllable than other food risks. People believe that they have marginally more control over Salmonella than over *E. coli*. This may be caused by consumers believing that they have more control in cooking and preparation of products that have the highest risk of being contaminated by Salmonella (e.g., chicken) relative to foods that pose an *E. coli* risk. It may reflect the higher frequency (and hence profile) of Salmonella cases (74,000 cases/year), as compared to *E. coli* cases (1,026 cases/year). Pathogen risks were seen as more controllable then pesticide, hormone, and allergy-related illnesses.

Food pathogens are also regarded as more worrying than all other food risks – such as BSE, allergies, GM ingredients, and pesticide residues on, or hormones in, foods as well as additives. Particularly, "getting ill from *E. coli*" is the most worrying food risk, followed closely by Salmonella.

From a broader point of view, *E. coli* falls into the "more worry-more control" region of the risk space in **Figure 7**. This is the region where the high level of concern about risks leads to an action; in this case, controlling the risk when they are highly able to do so. For example, people believe that "getting diabetes" is as worrying as "getting ill from *E. coli*" but their perception of these risks may differ in terms of the level of action they take, or the "control" they have over them. This difference may be due to the nature of the risks; for example, one may have diabetes because it was genetically transferred from the family and s/he has no ability to prevent it aside from reducing the impact of the risk. Alternatively, this may also be due to the difficulty in practice, as his/her life style may not allow him/her to prevent it easily. Another possibility is that the person in question has only a limited level of knowledge on how to prevent the risk.

The comparison of perceptions of novel risks and *E. coli* risks reveals that people are more concerned about *E. coli* than about emerging risks, such as "swine flu" and consuming meat or milk from cloned animals. They also believe that they have less control over emerging risks than over *E. coli*. Such perceptions may be the result of various things, for example:

- little familiarity with emerging risks, such as not having a personal experience with it;
- a low level of knowledge about emerging risks;
- difficulty in conceptualising the probability of those risks occurring to them,; and
- belief in having a lower chance of experiencing the risk or hazard as compared to other people (i.e., optimistic bias).

Another reason may be the media coverage of risks. For example, during the period we conducted the survey, the H1N1 Swine Influenza scare was underway. Although there was high media coverage on this scare during the survey period, the concern people had over Swine Flu was not high. This is not altogether surprising as people may not be familiar with a risk at the beginning of a scare. This is because the profiles of risks in the public imagination evolve over time and are influenced by, and reflected in, coverage in the press, broadcast media and – more recently – the internet. However, in the *E. coli* case, the awareness among the general public has been increasing ever since the first occurrence of *E. coli* in the UK in 1980s. This may be one of the reasons why we observe a high level of concern and control over *E. coli*, as compared to other food risks.

We will now give some results on the comparison of relative risk perceptions of farmers and consumers in the next section.

6.4 Relative Risk Assessments of Farmers and Consumers

In this section, we compare the relative risk assessments of consumers and farmers. We present the analysis results in two parts. The first part investigates the relative risk assessments in "control" space, and the second part does this in "worry" space. Each part tests two hypotheses:

H1: Risk assessments of consumers and farmers are the same in both "control" and "worry" spaces (i.e., overall distribution of risk scores in both systems are the same).

H2: Risk assessments of consumers and farmers for a specific risk are the same in both "control" and "worry" space (i.e., distribution of scores at $risk_i$ is the same in both systems).

In order to test these hypotheses, we perform the following linear regression. We simply regress individual logit scores on risks and the interaction terms, as in the following model:

$$\text{scores} = \alpha + \gamma_i \, \text{risk}_i + \beta_i \, (\text{risk}_i \text{ x group}) + \varepsilon_i \quad i = 1,2,\ldots 10 \qquad (6)$$

where group (1=farmer, 0=consumer), α is intercept, γ_i are estimates for risk_i scores from mixed logit, β_i are estimates for risk_i scores at a specific group (e.g., farmer). The null hypotheses for H1 and H2 mentioned above can then be written as followings:

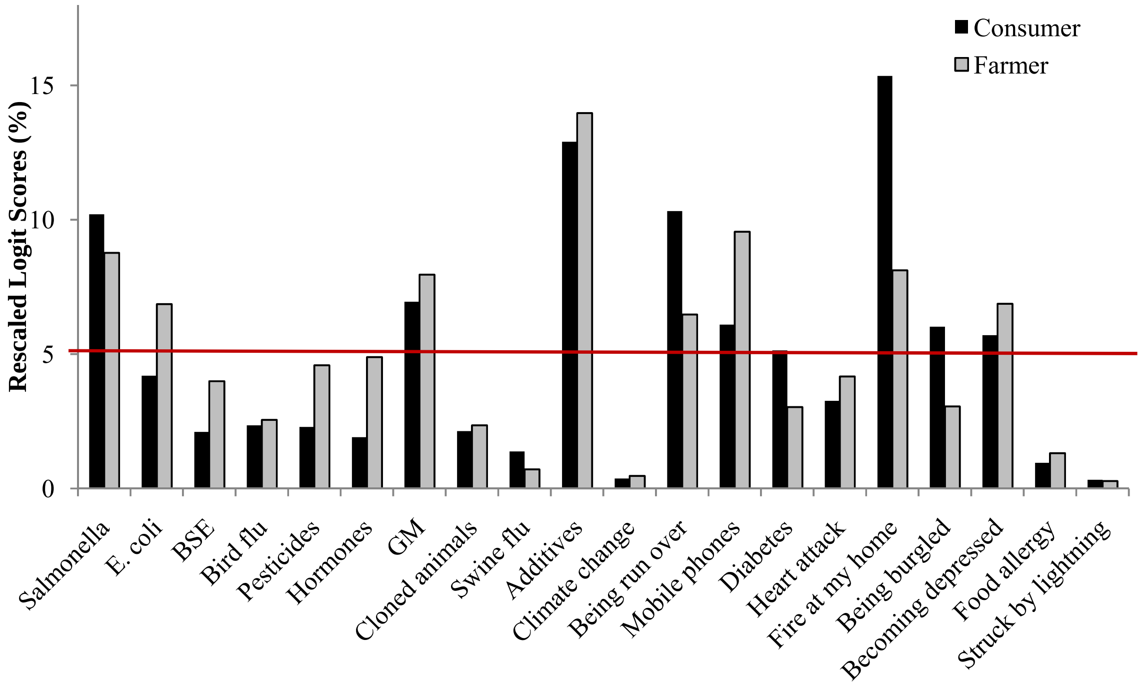
- H_1: $\sum\beta_i$= 0 (overall distributions of scores in both systems are the same).
- H_2: β_i= 0 (distribution of scores at risk_i is the same in both systems).

We now turn to the results from the hypothesis tests.

Control Space

Figure 8 provides a comparison of the analysis results for consumers and farmers. The results of the test for Hypothesis 1 did not reveal significant differences. We failed to reject the null hypothesis that the perceptions of risks in both social groups are not statistically significantly different from each other at 1% significance level (t-value=-0.14 and p-value=0.89). In other words, consumers and farmers in our sample have similar views on the level of control they think they have over risks in general. However, although consumers and farmers tend to have similar views on risks in general, there may still be differences in their views on some specific risks. Thus, we investigate this further by the second hypothesis. According to the test results, consumers and farmers have different perceptions for 10 of 20 risks, which are presented in Table 4.

Figure 8. Consumers' and Farmers' Control Over Various Risks



In terms of the particular focus on food pathogens, consumers and farmers perceive "*E. coli*" risk differently. Farmers believe that they have more control over risks posed by *E. coli* than consumers. This is not surprising as food cases attributable to *E. coli* can be associated with poor handling and poor hygiene practices at production facilities, such as farms and abattoirs. The recent *E. coli* outbreaks on farms (e.g., 2009 Godstone Farm outbreak in the UK) and at abattoirs (2005 Welsh outbreak in the UK) may be the cause of such beliefs among people. Thus, people may believe that farmers have more control over preventing illnesses from *E. coli* than consumers. This may then create tensions for farmers, such that they may have more concern about *E. coli* than consumers (see in the next section).

Table 4. Differences in the Perceptions of Consumers and Farmers for Individual Risks in Control Space

	Control	
RISKS	**Coef.**	**t-value**
Getting ill from Salmonella	-0.010	-1.48
Getting ill from E. coli	0.025	3.71***
Getting BSE (mad cow disease)	0.019	2.81***
Getting avian flu (bird flu)	0.000	-0.04
Eating food containing pesticide residues	0.009	1.36
Eating foods containing hormones	0.020	3.01***
Eating rice or cereal (e.g. bread) that is genetically modified (GM)	0.006	0.84
Eating meat or milk from a cloned animal	0.000	0.01
Getting swine flu	-0.014	-2.16**
Eating foods containing additives (e.g. E numbers)	0.012	1.77*
Climate change	-0.006	-0.86
Being run over	-0.015	-2.27**
The health effects of using mobile phones	0.022	3.37***
Getting diabetes	-0.018	-2.66***
Having a heart attack	0.001	0.16
A fire at my home	-0.044	-6.68***
Being burgled	-0.015	-2.24**
Becoming depressed	0.005	0.75
Getting a food allergy	0.000	-0.03
Being struck by lightning	0.004	0.60

Statistically significant at * $p<0.10$, ** $p<0.05$, *** $p<0.001$

The risk perceptions for Salmonella, however, are not statistically different from each other when comparing consumers and farmers. We would expect higher control scores for consumers than for farmers as the majority of food cases that are attributable to Salmonella are associated with the consumption of mishandled foods (e.g., chicken) in the domestic kitchen. However, the majority of farmers surveyed had livestock, of which 82% was dairy – cow, beef, cow, goats, sheep, and pigs – and 17% were chickens. The dominance of red meat in these farmers may be causing such a result. In other words, farmers in our sample may consider themselves to be chicken consumers, therefore weighting the level of control they have over Salmonella as same as consumers in the sample.

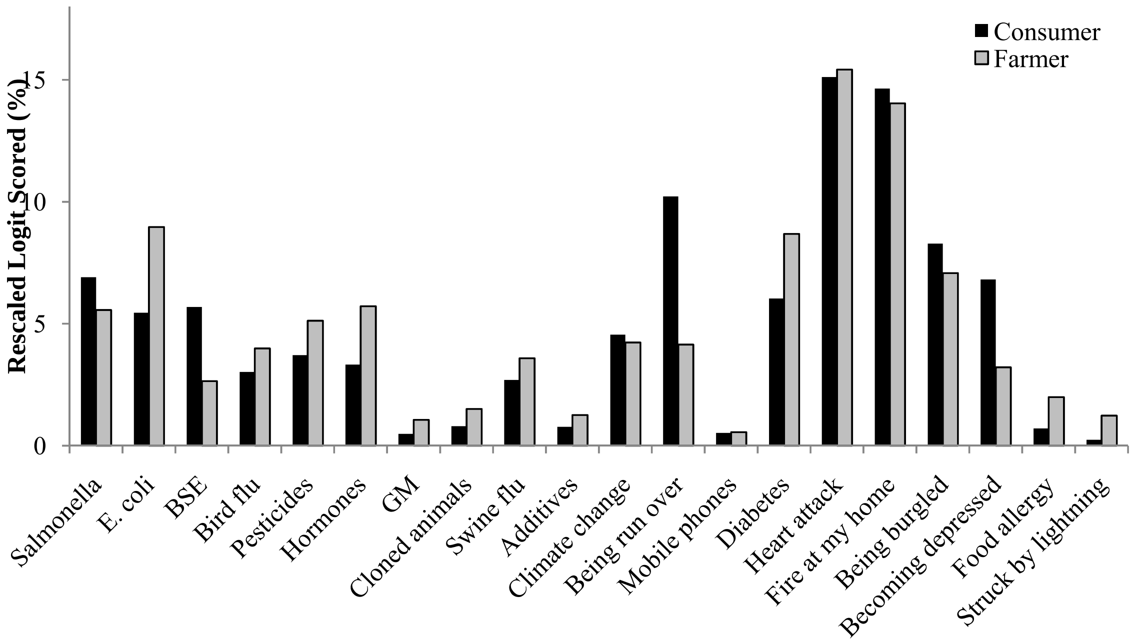
The results also show that farmers believe that they have more control over risks posed by BSE, and eating foods containing hormones and additives. This may be partly due to the fact that farmers have access to better information about the condition of foods they grow as compared to consumers, who may have less information about the safety of foods they purchase at stores.

Worry System

Figure 9 shows a comparison of the analysis results for consumers and farmers. The results of the test for Hypothesis 1 did not reveal significant differences. We failed to reject the null hypothesis that the consumers and farmers in our sample have the same level of worry over risks in general (t-value=-0.50 and p-value=0.62).

Although consumers and farmers tend to have similar views on risks in general, there may still be differences in their views on some specific risks. Thus, we hypothesise whether consumers and farmers have the same perceptions for a specific risk (Hypothesis 2). The results of the test are shown in Table 5.

Figure 9. Consumers' and Farmers' Concern Over Various Risks



In terms of particular foci on food risks, according to the test results consumers and farmers perceive risks posed by Salmonella, *E. coli*, BSE, Hormones, Additives, and Food Allergy differently (see Table 5).

It is also clear from Figure 9 that consumers believe that they have more concern over the risk posed by Salmonella and farmers believe that they have more concern over the risk posed by *E. coli*. This result is intuitive due to the trend in food cases attributable to Salmonella in domestic kitchens and food cases attributable to *E. coli* at production facilities, such as farms and abattoirs (e.g., Godstone Farm outbreak in 2009 and Welsh outbreak in 2005).

In terms of particular foci on non-food risks, the results show that farmers tend to have more concerns over Swine Flu, Diabetes, and Struck by Lightning. Although Swine Flu was a high profile issue at the time of the surveys, farmers tend to worry more than consumers. This may be because farmers may be more exposed to risks posed by Swine Flu, not only due to the possibility of getting ill, but also due to potential economic losses caused by unhealthy livestock.

Another interesting result is that risk assessments of consumers and farmers for some of the novel risks, such as Cloned Animals, Climate Change, and GM, do not reveal significant differences and are less than an average level of concern (i.e., 5%). As discussed before, this may be due to various reasons including poor familiarity with the emerging risks, a low level of knowledge about them, and difficulty in conceptualising the probability of those risks occurring to them.

Table 5. Differences in the Perceptions of Consumers and Farmers for Individual Risks in Worry Space

	Worry	
RISKS	**Coef.**	**t-value**
Getting ill from Salmonella	-0.014	-2.09**
Getting ill from *E. coli*	0.017	2.51***
Getting BSE (mad cow disease)	-0.024	-3.52***
Getting avian flu (bird flu)	0.010	1.42
Eating food containing pesticide residues	0.005	0.77
Eating foods containing hormones	0.013	1.95**
Eating rice or cereal (e.g. bread) that is genetically modified (GM)	-0.001	-0.13
Eating meat or milk from a cloned animal	0.004	0.61
Getting swine flu	0.018	2.74***
Eating foods containing additives (e.g. E numbers)	0.011	1.62*
Climate change	-0.006	-0.88
Being run over	-0.036	-5.41***
The health effects of using mobile phones	0.004	0.62
Getting diabetes	0.016	2.34**
Having a heart attack	-0.004	-0.65
A fire at my home	-0.002	-0.37
Being burgled	-0.008	-1.25
Becoming depressed	-0.035	-5.20***
Getting a food allergy	0.019	2.77***
Being struck by lightning	0.014	2.16**

Statistically significant at * $p<0.10$, ** $p<0.05$, *** $p<0.001$

7 Summary

This research locates a series of risks or hazards within a framework characterised by the level of control that respondents believe they have over the risks, and the level of worry the risks prompt. It does this for a set of both food and non-food risks. The means by which this is done is novel and differs from past risk perception analyses in that it questions people directly regarding their relative assessments of the levels of control and worry over the risks presented. The cognitive burden associated with people ranking and scaling items in large sets is notoriously heavy and time-consuming, so this study uses an elicitation method designed to make the process intuitive and cognitively manageable for respondents.

The substantive analysis of the risk perceptions has four main foci concerning the relative assessment of (i) novel as opposed to more familiar and established risks/events (e.g. swine flu vs. heart attack), (ii) food risks as opposed to non-food risks (e.g., BSE vs. lightning strike), (iii) perceived levels of control over the risks versus how worrying the risks are considered to be, (iv) differences in the risk perceptions across social groups, in this paper we analyze the relative assessments of farmers and consumers with a particular orientation on *E. coli* (for reasons explained below).

Researchers are often interested in rankings over large sets, yet there is ample evidence of the cognitive load this places on survey participants, and the frequency of associated anomalies, when the number of items ranked exceeds even quite low numbers (e.g., seven items according to Cohen and Orme, 2004). The problems are amplified if a scaled, rather than simply ordinal ranking, is required.

The research from which this paper derives was concerned with the perception and management of *E coli* risk for both farmers and consumers. To this end, whilst working on the specifics of measures to reduce the risk of *E coli* infection to farmers, rural residents/visitors and food consumers, we sought to locate this risk in a broader context. Specifically, we sought to locate the levels of concern and perceived control of this particular (*E coli*) risk within a larger set of twenty risks. These two dimensions of risk (control and worry) were chosen as they have featured heavily in other risk analyses (Fischoff et al., 1978; Slovic, 1993; Sparks and Shepherd, 1994; Fife-Shaw and Rowe, 1996; Kirk et al., 2002; Henson et al., 2008; Gaskell, 2008), although the method used to elicit the risk perceptions in this paper is novel, as explained below.

The approach elicited relative risk scores in terms of both worry and control and allowed the risks to be located in worry–control space. The process by which this was done was Best-Worst Scaling (Louviere, 1993; Marley and Louviere, 2005), a form of conjoint analysis, which, although developed many years ago, is gaining attention in the agricultural and environmental economics literature (see Lusk and Briggeman, 2009). Best-Worst Scaling (BWS) is a method designed to generate scaled rankings across (large) item sets via cognitively bearable choice tasks.

Presented with repeated subsets of five risks, participants were asked to identify those they thought they had most/least "control" over and those that prompted most/least "worry". There are twenty risks included in the survey: half concern food hazards, the other half concern non-food hazards.

The advantages of this technique include its function of breaking the task into more cognitively manageable sets via the use of repeated subsets, and the fact that people are asked only to identify options at the extreme (e.g., most/least) rather than rank a full set. In addition to the revelation of the participants ranking of the risks, the analysis of the choice data allows for the estimation of scores (for example, 'control scores') for each risk, and so a scaled ranking is derived.

The approach used in the study is similar to other risk perception studies, which locate risks in a two dimensional space characterised by control and variants of worry/fear/dread. It differs in that, unlike other studies, we directly elicit from respondents their assessments of the risks in terms of these dimensions. Other studies typically seek to identify all possible concerns and then undertake a Factor or Principal Components Analysis (PCA) in order to score the risks in terms of these underlying dimensions (e.g., Slovic, 1993; Henson et al., 2008; Hohl and Gaskell, 2008).

The surveys were conducted personally in the summer of 2009 in England. The sample size was 280 (166 farmers, 114 consumers). Respondents were randomly assigned to one of two treatments; the first asked people to assess the risks in terms of "control", and the second used the "worry" criterion. The choice data were analysed using a mixed logit model estimated via Bayesian methods to retrieve estimates of participants' (control and worry) 'scores' that best explain the pairs of "least" and "most" selections they made. We turn now to some of the substantive issues addressed in the paper: novel versus more familiar risks, food versus non-food risks, differences in the risk perceptions between farmers and consumers, with a particular focus on *E. coli*.

In regards to novel risks, the results show that Swine Flu – an emerging and high profile issue at the time of the surveys – was seen as a cause of relatively little concern, less worrying than hormones in food, Salmonella, or BSE, and something over which people felt they had an extremely low level of control over. Swine Flu was seen as little different from Bird Flu even though the latter was receiving relatively little coverage at the time. This may be a result of 'flu fatigue' with some people having become insensitive to warnings of flu epidemics following some arguably lurid coverage and warnings of the threat of avian flu in 2005 and 2007. Climate change features as 19th out of 20 in terms of the level of control people feel they have over it and 11th in terms of how worrying it is, being regarded as less worrying than, *inter alia*, the risks of getting Salmonella, being hit by a car, or getting Diabetes.

Cloning was one of the emerging food technologies identified by the UK Food Standards Agency (FSA, 2009) as requiring further research on public perceptions of it. The consumption of meat or milk from cloned animals prompted low levels of concern, on a par with additives in food. It is also notable that the consumption of GM foods was regarded as worthy of very little concern. In terms of the ten food risks, it ranked as one of the least worrying to respondents, only being surpassed in terms of a lack of concern by the risk of getting a food allergy. Given the contentious history that the (non) production and consumption of GM food has had in the UK, this is quite remarkable. It may be a result of continued exposure to the idea of GM food (in many ways it might be seen as no longer a novel food technology), the absence of hard evidence of environmental or health effects of the use of GM foods, or the repeated calls in the preceding 18 months, at the height of the boom in world food prices, for the use of GM technologies to address global food needs. In contrast to this, it is notable how worrying the risk of getting BSE remains, despite having largely disappeared from the news media for many years and there having been only eight deaths from vCJD in the UK between 2007 and 2009. Contracting BSE/vCJD was seen as more worrying than "swine flu" and on a par with "bird flu" and "climate change" in terms of the worry it caused.

In terms of the particular focus on *E. coli*, it is clear that food risks from food pathogens were more worrying than other food risks. “Getting ill from *E. coli*” was the most worrying food risk, followed closely by Salmonella. These were more concerning to the sample than issues related to BSE, pesticide residues on, or hormones in, food as well additives, allergies, and GM ingredients.

As for the other dimension of the risk assessment, control, we found that people believed that they had the most control over “eating foods containing additives (e.g. E numbers)” and the least control over “getting a food allergy.” Novel risks, such as Cloned Animals, Swine Flu, Bird Flu, and Climate Change were located at the low end of the control space. People might think that the occurrences of novels risks were out of their control. This might be due to various reasons, such as little familiarity to emerging risks and the lack of knowledge regarding the issues involved in such risks. Among all novel risks, people believed that they had the least control over Climate Change, followed closely by Swine Flu, which was a high profile issue at the time of the surveys, Food Allergy, Cloned Animals, and Bird Flu.

In terms of the particular focus on *E. coli*, food pathogens were perceived to be more controllable than other food risks. People believed that they had marginally more control over Salmonella than over *E. coli*. This might be caused by consumers believing that they had more control in cooking and preparation of products that have the highest risk of being contaminated by Salmonella (e.g., chicken) relative to foods that pose an *E. coli* risk. It may reflect the higher frequency (and hence profile) of Salmonella cases (74,000 cases/year), as compared to *E. coli* cases (1,026 cases/year). Pathogen risks were seen as more controllable then pesticide, hormone, and allergy-related illnesses.

The comparison of risk perceptions of the two stakeholder groups, consumers and farmers, did not reveal significant differences. However, they did show different perceptions for some specific risks, such as *E. coli*, Salmonella, BSE, and Hormones. For example, farmers viewed *E. coli* much more worrying than consumers did, yet they also believed it was more under their control. The comparison of results also indicated that consumers were more concerned about issues such as BSE and Salmonella than farmers, whilst the latter perceived Hormones as more controllable and yet more worrying.

Overall, the assessments of various risks in a broader perspective for different social groups shed light on how policymakers properly mitigate issues posed by these risks, and can help them with establishing priorities and in matters of resource allocation.

As a further work, we would like to explore risk perceptions with different social groups, such as food experts. The shared allocation retrieved from their responses could be used to replace the naive assumption of equal shares of "control" and "worry" among twenty risks. Furthermore, as an extension to the current study, we are exploring the effects of socio-demographic and psychometric characteristics of people on their risk perceptions.

References

Adamowicz, W., Boxall, P., Williams, M., & Louviere, J. (1998). Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. *American Journal of Agricultural Economics, 80*(1), 64-75.

Anders, W., & L. Sjoberg. (2000). Risk perception and the media. *Journal of Risk Research* 3(1), 31 – 50.

Auger, P., Devinney, T.M., & Louviere, J.J. (2007). Using Best-Worst Scaling Methodology to Investigate Consumer Ethical Beliefs Across Countries. *J. Business Ethics, 70*(3), 299-326.

Baumgartner, H., & Steenkamp, J.B.E.M. (2001). Response Styles in Marketing Research: A Cross-National Investigation. *Journal of Marketing Research*, 38, 143-156.

Brownstone, D., & Train, K., (1998). Forecasting new product penetration with flexible substitution patterns. *Journal of Econometrics* 89(1-2), 109-129.

Buck, D., et al. (2001). Predicting paired preferences from sensory data. *Food Quality and Preference* 12(5-7), 481-487.

Burton, M., & Young, T. (1996). The impact of BSE on the demand for beef and other meats in Great Britain. *Applied Economics,* 28(6), 687-693.

Cohen, S., & Markowitz, P. (2002). Renewing Market Segmentation: Some New Tools to Correct Old Problems. Amsterdam, the Netherlands, pp. 595-612.

Cohen, S., & Neira., L. (2003) Measuring Preference for Product Benefits Across Countries: Overcoming scale usage bias with Maximum Difference Scaling.

Cohen, S., & Orme, B. (2004) Asking Survey Respondents About Their Preferences Created New Scaling Decisions. *Marketing Research*.

Cohen, S.H., & SHC Associates. (2003). Maximum Difference Scaling: Improved Measures of Importance and Preference for Segmentation.

Craig, C. S., & Douglas. S.P. (2000). *International marketing research*. Chichester: Wiley.

de Jonge, J., van Trijp, H., Renes, R. J., & Frewer, L. J. (2010). Consumer confidence in the safety of food and newspaper coverage of food safety issues: A longitudinal perspective. *Risk Analysis, 30*(1), 125-142.

Duineveld, C.A.A., Arents, P., &King, B.M. (2000). Log-linear modelling of paired comparison data from consumer tests. *Food Quality and Preference* 11(1-2), 63-70.

Fife-Schaw, C., & Gene, R. (1996). Public Perceptions of Everyday Food Hazards: A Psychometric Study. *Risk Analysis* 16(4), 487-500.

Fischhoff, B., Slovic P., Lichtenstein S., Read S., Combs B.. (1978). How Safe is Safe Enough? A Psychometric Study of Attitudes towards Technological Risks and Benefits. *Policy Sciences* 9, 127-152.

Florkowski, W. J., Elnagheeb, A.H., &Huang, C.L. (1998) Risk perception and new food production technologies. *Applied Economics Letters* 5(2), 69 – 73.

Flynn, T. N., Louviere, J. J., Peters, T. J., & Coast, J. (2007). Best-worst scaling: What it can do for health care research and how to do it. *Journal of Health Economics., 26*(1), 171-189.

Flynn, T. N., Louviere, J. J., Peters, T. J., & Coast, J. (2008). Estimating preferences for a dermatology consultation using Best-Worst Scaling: Comparison of various methods of analysis. *BMC Medical Research Methodology, 8*(76).

Frewer, L. J., Howard, C., & Shepherd, R. (1995). Genetic engineering and food: what determines consumer acceptance? *British Food Journal* 97, 31-36.

Frewer, L. J., Howard, C., & Shepherd, R. (1998). Understanding public attitudes to technology. *Journal of Risk Research* 1(3), 221 - 235.

Frewer, L. J., Shepherd, R., &Sparks, P. (1994). The Interrelationship between Perceived Knowledge, Control and Risk Associated with a range of Food-Related Hazards Targeted at the Individual, Other People and Society. *Journal of Food Safety* 14(1), 19-40.

Gower, J. (1975). Generalized procrustes analysis. *Psychometrika* 40(1), 33-51.

Gutman, J. (1982). A Means-End Chain Model Based on Consumer Categorization Processes. *Journal of Marketing* 46(2), 60-72.

Henson, S., Annou, M., Cranfield, J., & Ryks, J. (2008). Understanding Consumer Attitudes Toward Food Technologies in Canada. *Risk Analysis, 28*, 1601-1617.

Hohl, K., and Gaskell, G. (2008). European Public Perceptions of Food Risk: Cross-National and Methodological Comparisons. *Risk Analysis* 28(2), 311-324.

Jaeger, S.R., et al. (2008). Best-worst scaling: An introduction and initial comparison with monadic rating for preference elicitation with food products. *Food Quality and Preference* 19(6), 579-588.

Jaeger, S. R., Jørgensen, A. S., Aaslyng, M. D., & Bredie, W. L. P. (2008). Best-worst scaling: An introduction and initial comparison with monadic rating for preference elicitation with food products. *Food Quality and Preference, 19*(6), 579-588.

de Jonge, J., Van Trijp, H., Renes, R. J., & Frewer, L. J. (2010). Consumer Confidence in the Safety of Food and Newspaper Coverage of Food Safety Issues: A Longitudinal Perspective. *Risk Analysis, 30*, 125-142.

Kalaitzandonakes, N., Marks, L.A., & Vickner, S.S. (2004). Media Coverage of Biotech Foods and Influence on Consumer Choice. *American Journal of Agricultural Economics* 86(5), 1238-1246.

Kelly, G.A. (1955). *The Psychology of Personal Constructs A Theory of Personality*. Vol. I, II. Norton, New York

Kirk, S. F. L., Greenwood, D., Cade, J. E., & Pearman, A. D. (2002). Public perception of a range of potential food risks in the United Kingdom. *Appetite, 38*(3), 189-197.

Lee, W., et al. (2007). Bias in psychiatric case-control studies: Literature survey. *The British Journal of Psychiatry* 190(3), 204-209.

Léon, F., Couronne, T., Marcuz, M. C., & Koster, E. P. (1999). Measuring food liking in children: a comparison of non verbal methods. *Food Quality and Preference, 10*, 93-100.

Liem, D. G., Mars, M., & de Graaf, C. (2004). Consistency of sensory testing with 4- and 5-year-old children. *Food Quality and Preference* 15(6), 541-548.

Loewenstein, G.F.,Weber, E.U., Hsee, C.K., Welch, N. (2001). Risk as Feelings. *Psychological Bulletin* 127(2), 267-286.

Louviere, J.J. (1993). The Best-Worst or Maximum Difference Measurement Model: Applications to Behavioral Research in Marketing. Phoenix: Arizona.

Louviere, J.J., & Woodworth, G.G. (1990). Best-Worst Scaling: A Model for Largest Difference Judgments. Alberta, Canada: University of Alberta.

Louviere, J.J., & Islam, T. (2008). A comparison of importance weights and willingness-to-pay measures derived from choice-based conjoint, constant sum scales and best-worst scaling. *Journal of Business Research, 61*(9), 903-911.

Lusk, J. L., Roosen, J., & Fox, J.A. (2003). Demand for beef from cattle administered growth hormones or fed genetically modified corn: A comparison of consumers in France, Germany, the United Kingdom, and the United States, *American Journal of Agricultural Economics,* Vol. 85, pp. 16-29.

Marley, A., & Louviere, J. (2005). Some probabilistic models of Best, Worst, and Best-Worst choices. *Journal of Math Psychology* 49, 464-480.

Lusk, J.L., & Briggeman, B.C. (2009). Food Values. *American Journal of Agricultural Economics* 91, 184-196.

Lusk, J. L., Roosen, J., & Fox, J. A. (2003). Demand for beef from cattle administered growth hormones or fed genetically modified corn: A comparison of consumers in France, Germany, the United Kingdom, and the United States, *American Journal of Agricultural Economics,* 85, 16-29

McFadden, D. 1974). *Conditional logit analysis of qualitative choice behavior. In Frontiers in Econometrics* Academic Press. Edited by P. Zarembka. New York

Mcfadden, D., & Train, K. (2000). Mixed MNL models for discrete response. *Journal of Applied Econometrics* 15(5), 447-470.

Miles, S., & Frewer, L.J. (2001). Investigating specific concerns about different food hazards. *Food Quality and Preference* 12(1), 47-61.

Petersen, A., Anderson, A., Allan, S., Wilkinson, C. (2009). Opening the black box: scientists' views on the role of the news media in the nanotechnology debate. *Public Understanding of Science* 18(5), 512-530.

Piggott, N., & Marsh, T. (2004). Does Food Safety Information Impact U.S. Meat Demand? *American Journal of Agricultural Economics* 86(1), 154-174.

Raats, M. M., & Shepherd, R. (1996). Developing a Subject-Derived Terminology to Describe Perceptions of Chemicals in Foods. *Insurance: Mathematics and Economics* 18, 227-227.

Revelt, D., & Train, K. (1998). Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level. *Review of Economics and Statistics* 80(4), 647-657.

Saba, A., Rosati, S. (2000), & Vassallo, M. (2000). Biotechnology in agriculture. Perceived risks, benefits and attitudes in Italy. *British Food Journal* 102, 114-121.

Savadori, L., Savio, S., Nicotra, E., Rumiati, R., Finucane, M., & Slovic, P. (2004). Expert and Public Perception of Risk from Biotechnology. *Risk Analysis, 24*, 1289-1299.

Sawtooth Software. (2003). The CBC/HB System for Hierarchical Bayes Estimation Version 4.0 Technical Paper. Sequim, WA, Sawtooth Software.

Sawtooth Software, (2007). The MaxDiff/Web v6.0 Technical Paper.

Schlenker, W., & Villas-Boas, S.B. (2009). Consumer and Market Responses to Mad Cow Disease. *American Journal of Agricultural Economics* 91(4), 1140-1152.

Slovic, P. (2010). *The Feeling of Risk: New Perspectives on Risk Perception*: Earthscan

Slovic, P. (1993). Perception of Risk. *Science* 236, 280-285.

Slovic, P. (1992). Perception of Risk - Reflections on the Psychometric Paradigm. *Social Theories of Risk,*pp. 117-152.

Slovic, P. (1978). Psychology of Protective Behaviour. *Journal of Safety Research* 10(2), 58-68.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1980). Perceived Risk and Quantitative Safety Goals for Nuclear-Power. *Transactions of the American Nuclear Society* 35(1), 400-401

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1982). Why Study Risk Perception? *American Association for the Advancement of Science Abstracts of Papers of the National Meeting* 148, 102
Slovic, P. (1986). Informing and educating the public about risk, *Risk Analysis*, 6(4), 403-415
Slovic, P. (1998). Perceived risk, trust and democracy, in Lofstedt, R., & Frewer, L. (Eds.), *Risk and Modern Society.* Earthscan, London.
Slovic, P. & Lichtenstein, S. (1968). Relative importance of probabilities and payoff in risk taking *Journal of Experimental Psychology Monograph,* 78
Slovic, P., Fischhoff, B. & Lichtenstein, S. (1980). Facts and fears: understanding perceived risks, in Schwing, R., & Albers, W., Jr. (eds.) *Societal Risk Assessment: How safe is safe enough?* Plenum, New York, pp.181-216
Sparks, P., & Richard, S. (1994). Public Perceptions of the Potential Hazards Associated with Food Production and Food Consumption: An Empirical Study. *Risk Analysis* 14(5), 799-806
Thurstone, L.L., (1927). A law of comparative judgment. *Psychological Review* 34, 278–286
Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. *Science* 185(4157), 1124-1131.
Verbeke, W., & Ward, R.W. (2001). A fresh meat almost ideal demand system incorporating negative TV press and advertising impact. *Agricultural Economics* 25(2-3), 359-374.
Webster, K., Jardine, C., Cash, S. B., & McMullen, L. M. (2010). Risk Ranking: Investigating Expert and Public Differences in Evaluating Food Safety Hazards. *Journal of Food Protection* 73(10), 1875-1885.
Wildavsky, A., & Karl, D. (1990). Theories of Risk Perception: Who Fears What and Why? *Daedalus* 119(4), 41-60.
Wind, Y., & Green, P. (2004). *Marketing research and modeling: progress and prospects: a Tribute to Paul Green*. MA, USA: Kluwer Academic Publishers
Yeung, R.M.W. (2002). Food Safety Risk: Consumer Food Purchase Models. Cranfield University: Silsoe