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

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Abstract

This research locates a series of risks or hazards within a framework characterized 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 asks people directly regarding their relative assessments of the levels of control and worry regarding the risks presented. The cognitive burden associated with people ranking and scaling items in large sets is notoriously heavy and 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 4 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, in this paper we analyze 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

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1 Introduction

Concern 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 skeptical view of the safety of food. In addition to novel risks and hazards, high profile cases of familiar food hazards such as *E. coli* also cause concern to some. For example, the *E. coli* outbreak at Godstone Farm in the UK and *cases involving* pre-packaged cookie dough in the US, both in 2009. However, the level of concern people have regarding such risks varies from individual to individual. Their concerns and attitudes to prevent risks centered around their understanding and knowledge of risks, experience with them, and their moods at the evaluation of risks. Other factors, such as media, trust to food handlers, and people in their environment (e.g. family and friends) 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 characterized by the level of control respondents believe they have over the risks, and the level of worry the risks prompt. To act as a frame of reference, non-food risks are also added to the list of risks or hazards analyzed. The means by which this is done is novel and differs from past risk perception analyses in that it asks people directly regarding their relative assessments of the levels of control and worry regarding the risks presented. The cognitive burden associated with people ranking and scaling items in large sets is notoriously heavy and 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, in this paper we analyze the relative assessments of farmers and consumers with a particular orientation on *E. coli*.

The outline of this paper is as follows. Section 2 mentions about common methods used in the literature for assessing the risk perceptions. It summarizes different frameworks and theorems used in various disciplines. It also discusses the past research and links the current study with the past work. This is followed by Section 3, which outlines the contribution of this research. Section 4 introduces the methodology and explains the data collection. Section 5 introduces the model. Section 6 presents the results, and the final section summarizes the research.

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 political science perspective, according to Wildavsky and Dake (1990), risk perception theories involve knowledge, personality, economic, cultural, and political theories. In psychology, for example, risk perception is modeled around heuristics (Tversky and Kahneman, 1974), risk-as-feeling (Loewenstein, et al., 2001), and psychometric approaches (Fischhoff, et al., 1978).

Heuristics in decision-making, originated in a psychological research by Tversky and Kahneman, involves mental strategies during decision-making of risky events, such as representativeness of events and their relations to each other, availability of the risky events to individuals (i.e. how obvious a risky event to me?), and individuals' ability to imagine the event. *Risk-as-feeling*, discussed by Louwenstein et al. (2001) emphasizes the importance of feelings in decision-making of risky choices.

> *"Feelings maybe 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 behavior 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 analyze risk perception have found that each hazard, whether it is food-related or not, is multidimensional and can be analyzed 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 pointed out that 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, technological items that delayed the consequences of risks for many people, and thus they called this factor as "technological risk". When "technological risk" is high on the scale, it means that the consequences of the risks are unknown in short run. On the other hand, when risks are low on this factor, it means that the risks are familiar, taken in voluntary activities, and their consequences are immediate at the individual level. The second component identified was associated with events that resulted in fatal consequences. They called this component as "severity" (see Figure 1).

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

Building on this approach, but using Factor Analysis, Sparks and Shepherd (1994) consider risks in food production and consumption. They analyze food consumers' perception of 25 food-related hazards (e.g. genetic manipulation, food colorings, 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 related to "concern", "seriousness for future generations", "threatening widespread disastrous consequences", "dread", and "becoming more serious". The second factor related with risk variables, such as "known by the people exposed," "known to science," and "accuracy of assessments". The third factor, called "number of people exposed"

These axes were very similar to the ones in Fischhoff et al. However, in this study, Sparks and Shepherd found a third factor that was absent in Fischhoff et al. Nonetheless, they did not present this on their two-dimensional risk space. Instead, they only presented two factors, "severity" and "unknown", on their two-dimensions (see Figure 2).

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 risks 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 the study of Sparks and Shepherd and some were adopted from past researches. For example, they included new risk characteristics to their analysis, such as 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 has 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. 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 characterization of the risks in a small factor (usually 2) of fundamental characteristics. For example, Raats and Shepherd (1996) analyzed individuals' perception of chemical hazards in foods, such as pesticide and antibiotic residues using the Repertory Grid Method and found two risk factors which were similar to the ones in other studies mentioned before: "dread" and "unknown" (see Figure 3).

Using a similar approach, Frewer et al. (1998), in a study of public attitudes to various technologies, such as nuclear power, food irradiation, and GM food, identified two main principal factors. They interpreted the first factor as the component describing risks associated with technologies, such as "accidents", "dangerous", "severe", "risky", "unknown", "unnatural", and "worrying". The second factor was interpreted as describing the perception of benefits, such as "beneficial", "good", "interesting", "knowledgeable", and "necessary" (see Figure 4). One of the intriguing results was that subjects perceived the technological processes in food industry, such as GM food, food additives, food irradiation and pesticide use in agriculture harmful, threatening, and risky and they reflected this heavily on the X-axis, while ranged from medium to high on Y-axis of their two-dimensional risk space.

In summary, there is an extensive literature on the elicitation and analysis of risk perceptions. Some of these studies focus only on food domain, while some focus on both food and non-food domains. The "risk" referred in these studies also show variations with respect to the focus of the study. For example, while some studies analyze 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 but there is a common structure and output from most of the studies. Typically, the researches elicit perceptions of many risks in terms of many characteristics. This information is then reformulated so that the risks are characterized, usually via Factor Analysis or 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 perception of various risks and hazards, have analyzed 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, analyze and characterize risk perceptions.

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

The approach is similar to other analyses of risk and risk perceptions which have located risks in a two dimensional space characterized 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 in order to score the risks in terms of these underlying dimensions (e.g. 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 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. 2009 *E.coli* outbreak in Godstone Farm in Surrey that resulted in 35 cases (12 children seriously ill) and 2000 *E. coli* outbreak in a camping field in Aberdeenshire, UK that 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 perception 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, majority of studies focus on one domain only, such as on 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 addressed previously.

4 Methodology

4.1 Best-Worst Scaling (BWS)

We used Best Worst Scaling (BWS) to locate people's perception of various risks or hazards characterized by the level of control they believe they have over the risks, and the level of worry the risks prompt. For example, Figure 5 presents two examples of BWS sets from the research. Presented with repeated subsets of 5 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".

The selections of "most" and "least" controllable/worrying risks in these repeated tasks then reveal participants' ranking of the risks and allow estimation of scores (for example "control" scores") for each risk and so a scaled ranking is derived (more detail 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 now explain the fundamentals of the approach, which allows us to do all 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 (e.g., 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 "MaxDiff" experiment).

The main advantage of BWS over MPC is that it provides more information from respondent's selections. The selections of "best" and "worst" (or "most" and "least") items in a task shed light into the preferences for the each item of the survey. For example, in the example 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 7 of 10 (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 than”.

Here, we do not have information only about 3 risks, “eating food containing pesticide residues”, “getting avian flu (bird flu)”, and “becoming depressed”. However, just these 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 more cognitively manageable size, rather than asking people to rank a full set of items. Additionally, there is an evidence that people use a better judgment when they only need to evaluate the extreme preferences rather than preferences with the 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). Such an approach eliminates the possibility of scale-based biases and reduces the cognitive burden on respondents. Such advantages contribute to the use of this technique from academia to industry in a wide range of applications, such as 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, such as 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 elderly’s valuation of quality of life in terms of different levels of attributes, such as attachment, security, role, enjoyment and control. Mueller et a (2009), Louviere and Islam (2008) and Flynn et al. (2008) are some other recent examples of BWS scaling used in various areas.

4.2 Survey Design

We created 2 types of surveys having the same design: the first asked people to assess various risks in terms of “control”, and the second asked people to assess them in terms “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), some are more common and established risks (e.g. heart attack, additives).

We created 8 versions of surveys. In each survey, there were 8 sets (i.e. questions) and each set included 5 items (i.e. risks). Given the total number of items used in the survey (i.e. 20), it is plausible to use 5 items in each set as showing more than 5 items to respondents may result in confusion and fatigue, which may in turn results in unreliable responses. For example, 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 (MaxDiff Tech Paper, Sawtooth, 2007).

In each BWS set, we show respondents different combinations of 5 risks for their assessment of the “most” and “least” controllable/worrying risk (see Figure 5). The combinations of 5 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 randomized 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 in the summer of 2009. Overall, we contacted to 270 (165 farmers, 105 consumers) respondents who were randomly assigned to one of two treatments, the first asked people to assess the risks in terms of “control”, and the second treatment used the “worry” criterion.

Majority of the respondents were female (63%) and had a degree or graduate education (24%). Average age was about 38, and average annual household income was about £40,500 (c. $65,000). Thirty-five percent of the respondents were full-time employed, and 42% percent of the respondent had children.

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 generalized by McFadden (1974). In RUT, “the basic idea is that the assumption of utility maximization 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 maximizes his/her utility.

A simple Random Utility model can be mathematically written as:

$$U_{ij,t} = \beta_i X_{ij,t} + \varepsilon_{ij,t} \quad (1)$$

[1] As we presented 5 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 2 times in each version. Across all 8 versions, each stage appears 16 times.

where $U_{ij,t}$ is individual i's utility from his/her selection of alternative j in a choice set $t=\{1,2,...K\}$, 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 maximize the utility differences in his/her best and worst choices. 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 $\varepsilon_{ij,t}$ is distributed i.i.d. type 1 extreme value, then this probability can be written in a simple logit form:

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

Given that individuals have different tastes (i.e. heterogeneous individuals), 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 & Train (1998); McFadden and Train (2000). It is a highly flexible model that can approximate any random utility model (Train, 2003; McFadden & Train, 2000).

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

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

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:

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

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 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.

We now turn to results from the analysis.

6 Results

The results we present here concern relative assessments of the levels of control and worry people have over various risks. Hence, they concern *views*, rather than actual risk measures. We present the results in 4 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 this for food and non-food risks. The third section investigates how people perceive *E. coli* in a broader perspective. And the final 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 shows people's allocation of the level of control and worry for various food and non-food risks. The scores provided in the table are rescaled logit scores from the mixed logit analysis using HB estimation (i.e. they sum to 100). Having an initial naive assumption of equal levels of control/worry among 20 risks (i.e., each 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 shows this in a 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 felt they had an extremely low level of control. “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 lurid) coverage and warning of the threat of avian flu in 2005 and 2007. Climate change features as 17th out of 20 in terms of the level of control people feel they have over it and 8th 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.

One of the emerging food technologies identified by the UK Food Standards Agency (FSA, 2009) as requiring further research on public perceptions of it was cloning. 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. This 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[2] remains, despite it 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, “climate change” in terms of the worry it caused.

6.2 Comparison of Perceptions of Food and Non-Food Risks

Table 3 shows the distribution of food and non-food risks in each quadrant of the control-worry space in Figure 7. The general comparison of the risks in the control-worry space shows that people seem to locate more risks in Quadrants 1 and 3 (more worry–more control and less worry–less control, respectively), followed by Quadrants 2 and 4 (more worry–less control and less worry–more control, respectively). They tend to allocate more risks into a quadrant when the levels of concern and control move in the same direction (i.e. more–more or less–less).

Table 3 reveals that more than half of the risks (55%) are believed to be less controllable (Quadrants 2 & 3) and more worrying (Quadrants 1 & 4) by people.

As for the distribution of food and non-food risks, we observe that 40% of the food risks are on the “more worry” region of the graph, while 70% of non-food risks are distributed in the same part of the plot. This clearly indicates that people tend to have high level of concern over non-

[2] Or to be more accurate in this case: variant Creutzfeldt-Jakob disease (vCJD) the human illness linked to BSE in cattle.

food risks. On the contrary, people think that they have slightly more control over food risks than non-food risks: 5 of 10 food risks and 4 of 10 non-food risks lie in the “more control” region of the plot.

Within food risks, from Figure 6, we observe that people believe they have more than an average (i.e. 5%) “control” *and* “worry” over 30% of the food-risks (i.e. Salmonella, *E. coli*, hormones, GM, additives). This becomes 40% for the non-food risks (i.e. being run over, heart attack, fire at home, and becoming depressed). Now, we will discuss the results with a particular orientation 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 think that they have an extremely low level of concern (see Figure 6). 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 the product is “additive free” with big fonts. In such cases, people have the option of “not buying” the product, which is a way of exerting control. Particularly for “additives”, people also have little concern. Being able to avoid the use of a food product that includes additives in it, intuitively, results in less concern in people. However, there is always a possibility of missing information (e.g. on additives) on food labels. Also, due to the credence attributes of foods, people may still build up some concerns regarding these issues. In such cases, “additives” may prompt high level of concern and little control for people.

The results also show that people believe they have more than average control (i.e. 5%) over GM, Salmonella, *E. coli*, and hormones, in descending order. However, the level of control people think they have over BSE, pesticides, cloned animal, bird flu, and getting food allergy are less than the average level (i.e. 5%). 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 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* 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 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 behavior (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).

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 high risk of being contaminated by Salmonella (e.g., chicken) relative to food 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, allergy related illnesses.

Food pathogens are also regarded as more worrying than, *inter alia*, BSE, pesticide residues on, or hormones in, foods as well additives, allergies, and GM ingredients. Especially "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 (see Figure 7). This is the region where the high level of concern about risks leads to an action, i.e. in this case controlling the risk when they are highly able to do so. For example, people believe that "getting diabetes" is as much worrying as "getting ill from *E. coli*" but their perception of these risks may differ in terms of the level of action they take, i.e. "control" they have on them. This difference may be either due to the nature of the risks, for example, one may have diabetes because it may be genetically transferred from the family and s/he has nothing to do to prevent it (although s/he may reduce the impact of the risk), or due to the difficulty in practice, such as his/her life style may not allow him/her to prevent it easily. Another possibility is that the 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 (i.e. worried) *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 results of various things, such as:

- little familiarity to emerging risks (i.e.. not having a personal experience with it),
- low level of knowledge about emerging risks,
- difficulty in conceptualizing the probability of having such risks to be happening to them, and
- belief of having the less chances of having 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 somewhat not surprising as people may not be familiar with the risk at the beginning of the 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 since the first occurrence of *E. coli* in the UK in 1980s. This may be one of the reasons why we observe high level of concern and control over *E. coli*, as compared to other food risks.

We 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

The comparison of risk perceptions of the two stakeholder groups, consumers and farmers, revealed significant differences.

We rejected the null hypothesis that the perceptions of risks in both social groups are not statistically different from each other with respect to both the "control" and "worry" aspects of the risks at 1% and 5% significance levels, respectively (t-value=3.41 and p-value=0.001 for control, t-value=3.37 and p-value=0.025 for worry).

Although consumers and farmers tend to have different views on risks in general, there may still be similarities (or differences) in their views on some specific risks. Thus, we hypothesize whether consumers and farmers have the same perceptions for a specific risk. According to the test results, consumers' and farmers' allocations of the level of control *and* worry for BSE and pesticides on foods are not statistically different from each other. On the other hand, farmers and consumers have different perceptions on some risks, such as *E. coli*, GM, and eating meat or milk from a cloned animal (see Table 4).

In terms of the particular focus on food pathogens, it is clear that farmers believe that they have more control over the risk posed by *E. coli* than consumers, and consumers believe that they have more control over Salmonella than farmers (see Figure 8 and Figure 9). This result is intuitive as the majority of food cases that are attributable to Salmonella are associated with the consumption of mishandled foods (e.g. chicken) in domestic kitchens. On the other hand, food cases attributable to *E. coli* can be associated with poor handling and hygiene practices at production facilities, such as farms and abattoirs. The recent *E. coli* outbreaks on farms (e.g. Godstone Farm outbreak in 2009) and at abattoirs (Welsh outbreak in 2005) 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 concern about *E. coli* more than consumers (see Figure 9).

7 Summary

This research locates a series of risks or hazards within a framework characterized 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 asks people directly regarding their relative assessments of the levels of control and worry regarding the risks presented. The cognitive burden associated with people ranking and scaling items in large sets is notoriously heavy and 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 4 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. 7 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 specific (*E coli*) risk within a larger set of (20) risks. These two dimensions of risk (control, 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, as we explain below, the method used to elicit the risk perceptions in this paper is novel.

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 recently 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 5 risks, participants were asked to identify those they thought they had most/least "control" over and those that prompted most/least "worry". There are 20 risks included in the survey: half concern food hazards, the other half concern non-food hazards.

The advantages of this technique include its 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 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 characterized 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 in order to score the risks in terms of these underlying dimensions (e.g. Slovic, 1993; Henson et al., 2008; Hohl and Gaskell, 2008). 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*.

We conducted the surveys in-person in the summer of 2009 in England. The sample size was 270 (165 farmers, 105 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 treatment used the "worry" criterion. The choice data were analyzed 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.

The results show that, 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 felt they had an extremely low level of control. 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 lurid) coverage and warning of the threat of avian flu in 2005 and 2007. Climate change features as 17^{th} out of 20 in terms of the level of control people feel they have over it and 8^{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.

One of the emerging food technologies identified by the UK Food Standards Agency (FSA, 2009) as requiring further research on public perceptions of it was cloning. 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. This 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[3] remains, despite it 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 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 are more worrying than other food risks. "Getting ill from *E. coli*" is the most worrying food risk, followed closely by Salmonella. These are 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 find that people believe that they have 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 food from cloned animals, swine flu, bird flu, and climate change are located at the low end of the control scale. People may think that the occurrences of novels risks are out of their control. This may be due to the lack of knowledge regarding the issues involved in emerging risks. Among all novel risks, people believe that they have the least control over Swine Flu, which was a high profile issue at the time of the surveys, followed closely by Climate Change, Bird Flu, and Cloned Animals. Among food risks, the novel risks tended to be located in the "low control" region of the parameter space. The general lack of knowledge regarding the risks and uncertainties regarding the health outcomes may contribute to such perceptions.

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 high risk of being contaminated by Salmonella (e.g., chicken) relative to food 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, allergy related illnesses.

The comparison of risk perceptions of the two stakeholder groups, consumers and farmers, revealed significant differences. 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 indicates that consumers are more concerned about issues such as BSE and Salmonella than farmers, whilst the latter perceived pesticide residues on food as more worrying.

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[3] Or to be more accurate in this case: variant Creutzfeldt-Jakob disease (vCJD) the human illness linked to BSE in cattle.

References

Adamowicz, W., et al. "Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation." *American Journal of Agricultural Economics* 80, no. 1(1998): 64-75.

Anders, W., and L. Sjoberg. "Risk perception and the media." *Journal of Risk Research* 3, no. 1(2000): 31 - 50.

Baumgartner, H., and J.-B. E. M. Steenkamp. "Response Styles in Marketing Research: A Cross-National Investigation." *Journal of Marketing Research*, no. 38, May (2001): 143-156.

Brownstone, D., and K. Train. "Forecasting new product penetration with flexible substitution patterns." *Journal of Econometrics* 89, no. 1-2(1998): 109-129.

Buck, D., et al. "Predicting paired preferences from sensory data". *Food Quality and Preference* 12, no. 5-7(2001): 481-487.

Burton, M., and T. Young. "The impact of BSE on the demand for beef and other meats in Great Britain." *Applied Economics* 28, no. 6(1996): 687-693.

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

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

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

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

Craig, C. S., and S. P. Douglas. *International marketing research*. Chichester: Wiley, 2000.

Duineveld, C. A. A., P. Arents, and B. M. King. "Log-linear modelling of paired comparison data from consumer tests." *Food Quality and Preference* 11, no. 1-2(2000): 63-70.

Fife-Schaw, C., and R. Gene. "Public Perceptions of Everyday Food Hazards: A Psychometric Study." *Risk Analysis* 16, no. 4(1996): 487-500.

Fischhoff, B., et al. "How Safe is Safe Enough? A Psychometric Study of Attitudes towards Technological Risks and Benefits." *Policy Sciences* 9(1978): 127-152.

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

Frewer, L. J., C. Howard, and R. Shepherd. "Understanding public attitudes to technology." *Journal of Risk Research* 1, no. 3(1998): 221 - 235.

Frewer, L. J., R. Shepherd, and P. Sparks. "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, no. 1(1994): 19-40.

Gower, J. "Generalized procrustes analysis". *Psychometrika* 40, no. 1(1975): 33-51.

Gutman, J. "A Means-End Chain Model Based on Consumer Categorization Processes." *Journal of Marketing* 46, no. 2(1982): 60-72.

Henson, S., et al. "Understanding Consumer Attitudes toward Food Technologies in Canada". *Risk Analysis* 28, no. 6(2008): 1601-1617.

Hohl, K., and G. Gaskell. "European Public Perceptions of Food Risk: Cross-National and Methodological Comparisons." *Risk Analysis* 28, no. 2(2008): 311-324.

Jaeger, S. R., et al. "Best-worst scaling: An introduction and initial comparison with monadic rating for preference elicitation with food products." *Food Quality and Preference* 19, no. 6(2008): 579-588.

Jaeger, S. R., and J. M. Rose. "Stated choice experimentation, contextual influences and food choice: A case study." *Food Quality and Preference* 19, no. 6(2008): 539-564.

Jonge, J. d., et al. “Consumer Confidence in the Safety of Food and Newspaper Coverage of Food Safety Issues: A Longitudinal Perspective.” *Risk Analysis* 30, no. 1(2010): 125-142.

Kalaitzandonakes, N., L. A. Marks, and S. S. Vickner. “Media Coverage of Biotech Foods and Influence on Consumer Choice.” *American Journal of Agricultural Economics* 86, no. 5(2004): 1238-1246.

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

Kirk, S. F. L., et al. “Public perception of a range of potential food risks in the United Kingdom”. *Appetite* 38, no. 3(2002): 189-197.

Lee, W., et al. “Bias in psychiatric case-control studies: Literature survey.” *The British Journal of Psychiatry* 190, no. 3(2007): 204-209.

Léon, F., et al. “Measuring food liking in children: a comparison of non verbal methods.” *Food Quality and Preference* 10, no. 2(1999): 93-100.

Liem, D. G., M. Mars, and C. de Graaf. “Consistency of sensory testing with 4- and 5-year-old children.” *Food Quality and Preference* 15, no. 6(2004): 541-548.

Loewenstein, G. F., et al. “Risk as Feelings.” *Psychological Bulletin* 127, no. 2(2001): 267-286.

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

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

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

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

Lusk, J. L., J. Roosen, and J. A. Fox. “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.” (2003): vol. 85, pp. 16-29.

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

Mcfadden, D., and K. Train. “Mixed MNL models for discrete response.” *Journal of Applied Econometrics* 15, no. 5(2000): 447-470.

Miles, S., and L. J. Frewer. “Investigating specific concerns about different food hazards.” *Food Quality and Preference* 12, no. 1(2001): 47-61.

Petersen, A., et al. “Opening the black box: scientists' views on the role of the news media in the nanotechnology debate.” *Public Understanding of Science* 18, no. 5(2009): 512-530.

Piggott, N., and T. Marsh. “Does Food Safety Information Impact U.S. Meat Demand?” *American Journal of Agricultural Economics* 86, no. 1(2004): 154-174.

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

Revelt, D., and K. Train. “Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level.” *Review of Economics and Statistics* 80, no. 4(1998): 647-657.

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

Savadori, L., et al. “Expert and Public Perception of Risk from Biotechnology”. *Risk Analysis: An International Journal* 24, no. 5(2004): 1289-1299.

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

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

Schlenker, W., and S. B. Villas-Boas. “Consumer and Market Responses to Mad Cow Disease.” *American Journal of Agricultural Economics* 91, no. 4(2009): 1140-1152.

Slovic, P. “Perception of Risk”. *Science* 236(1993): 280-285.
Slovic, P. “Perception of Risk - Reflections on the Psychometric Paradigm”. *Social Theories of Risk* (1992): 117-152.
Slovic, P. “Psychology of Protective Behavior “*Journal of Safety Research* 10, no. 2(1978): 58-68.
Slovic, P., B. Fischhoff, and S. Lichtenstein. “Perceived Risk and Quantitative Safety Goals for Nuclear-Power.” *Transactions of the American Nuclear Society* 35, no. NOV(1980): 400-401.
Slovic, P., B. Fischhoff, and S. Lichtenstein. “Why Study Risk Perception?” *American Association for the Advancement of Science Abstracts of Papers of the National Meeting* 148(1982): 102.
Slovic, P. “Informing and educating the public about risk”, *Risk Analysis*, (1986): Vol.6 No. 4, pp. 403-415.
Slovic, P. “Perceived risk, trust and democracy”, in Lofstedt, R and Frewer, L (Eds.), *Risk and Modern Society.* (1998). Earthscan, London.
Slovic, P. and Lichtenstein, S. (1968), “Relative importance of probabilities and payoff in risk taking”, *Journal of Experimental Psychology Monograph*, Vol. 78.
Slovic, P., Fischhoff, B. and Lichtenstein, S. (1980), Facts and fears: understanding perceived risks, in Schwing, R. and Albers, W. Jr. (eds.) *Societal Risk Assessment: How safe is safe enough?* Plenum, New York, pp.181-216.
Sparks, P., and S. Richard. “Public Perceptions of the Potential Hazards Associated with Food Production and Food Consumption: An Empirical Study.” *Risk Analysis* 14, no. 5(1994): 799-806.
Thurstone, L. L. “A law of comparative judgment.” *Psychological Review* 34(1927): 278–286.
Tversky, A., and D. Kahneman. “Judgment under Uncertainty: Heuristics and Biases.” *Science* 185, no. 4157(1974): 1124-1131.
Verbeke, W., and R. W. Ward. “A fresh meat almost ideal demand system incorporating negative TV press and advertising impact.” *Agricultural Economics* 25, no. 2-3(2001): 359-374.
Wildavsky, A., and D. Karl. “Theories of Risk Perception: Who Fears What and Why?” *Daedalus* 119, no. 4 (1990): 41-60.
Wind, Y., and P. Green. *Marketing research and modeling: progress and prospects: a Tribute to Paul Green*. MA, USA: Kluwer Academic Publishers, 2004.
Yeung, R. M. W. “Food Safety Risk: Consumer Food Purchase Models.” Cranfield University Silsoe, 2002.

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

Table 2. Allocation of Control and Worry over Various Food and Non-food Risks.

Risks	**Control Scores (%)**	**Worry Scores (%)**
Getting ill from Salmonella	7.69	5.57
Getting ill from E. coli	6.87	7.08
Getting BSE (mad cow disease)	4.32	4.94
Getting avian flu (bird flu)	2.42	3.67
Eating food containing pesticide residues	4.38	5.11
Eating foods containing hormones	5.09	5.29
Eating rice or cereal (e.g. bread) that is genetically modified (GM)	7.78	1.94
Eating meat or milk from a cloned animal	3.56	2.04
Getting swine flu	0.90	4.14
Eating foods containing additives (e.g. E numbers)	11.17	1.99
Climate change	0.90	5.54
Being run over	7.21	6.31
The health effects of using mobile phones	8.57	1.27
Getting diabetes	3.35	7.01
Having a heart attack	4.42	11.42
A fire at my home	7.71	10.63
Being burgled	4.88	7.29
Becoming depressed	6.54	5.34
Getting a food allergy	1.90	2.09
Being struck by lightning	0.33	1.31

Table 3. Distribution of Food and Non-food Risks in Control-Worry Space

QUADRANT 2: more worry, less control	QUADRANT 1: more worry, more control
Food : 1 Non-food: 4	Food: 3 Non-food: 3
QUADRANT 3: less worry, less control	**QUADRANT 4: less worry, more control**
Food: 4 Non-food: 2	Food: 2 Non-food: 1

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

	Control		Worry	
RISKS	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Getting ill from Salmonella	3.03	6.02*	0.19	0.34
Getting ill from E. coli	2.21	4.40*	3.33	6.14***
Getting BSE (mad cow disease)	-0.34	-0.67	-0.77	-1.43
Getting avian flu (bird flu)	-2.24	-4.44*	-0.87	-1.60
Eating food containing pesticide residues	-0.27	-0.54	0.51	0.94
Eating foods containing hormones	0.44	0.87	1.17	2.16*
Eating rice or cereal (e.g. bread) that is genetically modified (GM)	3.12	6.21*	-3.00	-5.53***
Eating meat or milk from a cloned animal	-1.09	-2.17*	-2.65	-4.90***
Getting swine flu	-3.76	-7.47*	0.14	0.27
Eating foods containing additives (e.g. E numbers)	6.52	12.95*	-2.54	-4.70***
Climate change	-3.76	-7.47*	0.53	0.98
Being run over	2.56	5.08*	0.13	0.23
The health effects of using mobile phones	3.91	7.77*	-3.38	-6.23***
Getting diabetes	-1.31	-2.61*	3.05	5.63***
Having a heart attack	-0.24	-0.48	6.69	12.35***
A fire at my home	3.06	6.07*	5.56	10.26***
Being burgled	0.22	0.43	2.17	4.00***
Becoming depressed	1.88	3.74*	-0.79	-1.46
Getting a food allergy	-2.76	-5.49*	-1.92	-3.54***
Being struck by lightning	4.66	35.42*	4.79	0.34***

Statistically significant at * p<0.05, ** p<0.01, *** p<0.001

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

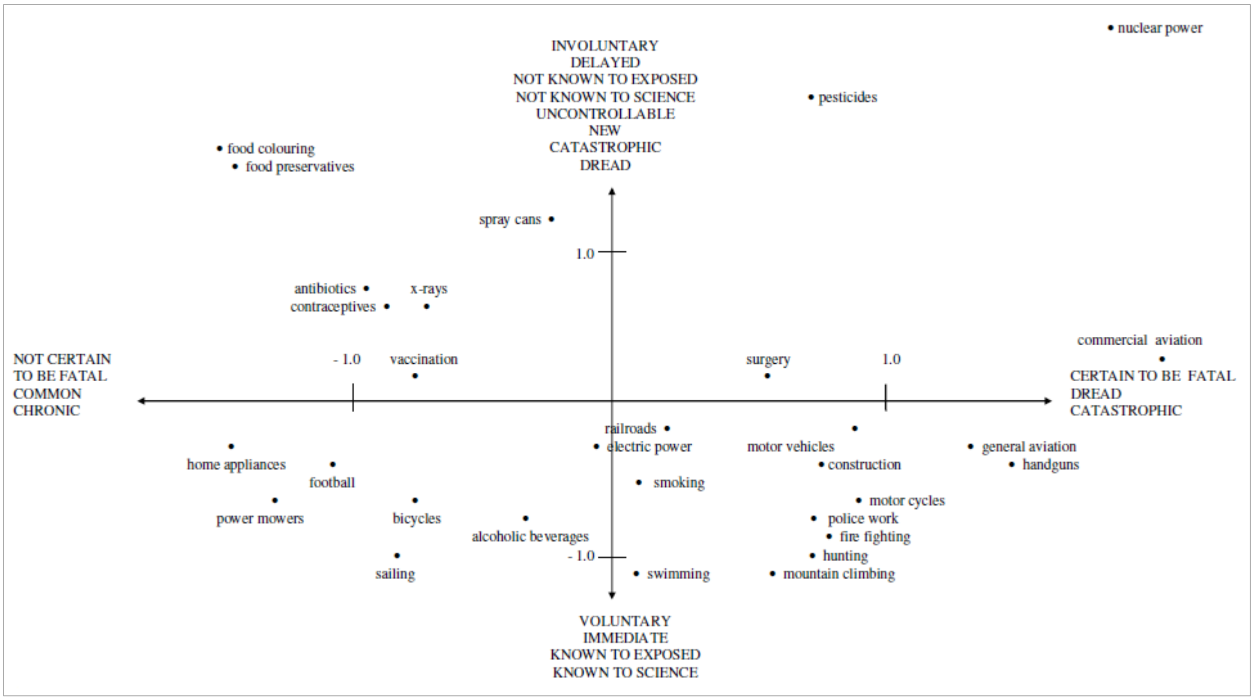

Figure 2. Location of food-related hazards within the two-component space (Sparks and Shepherd 1994)

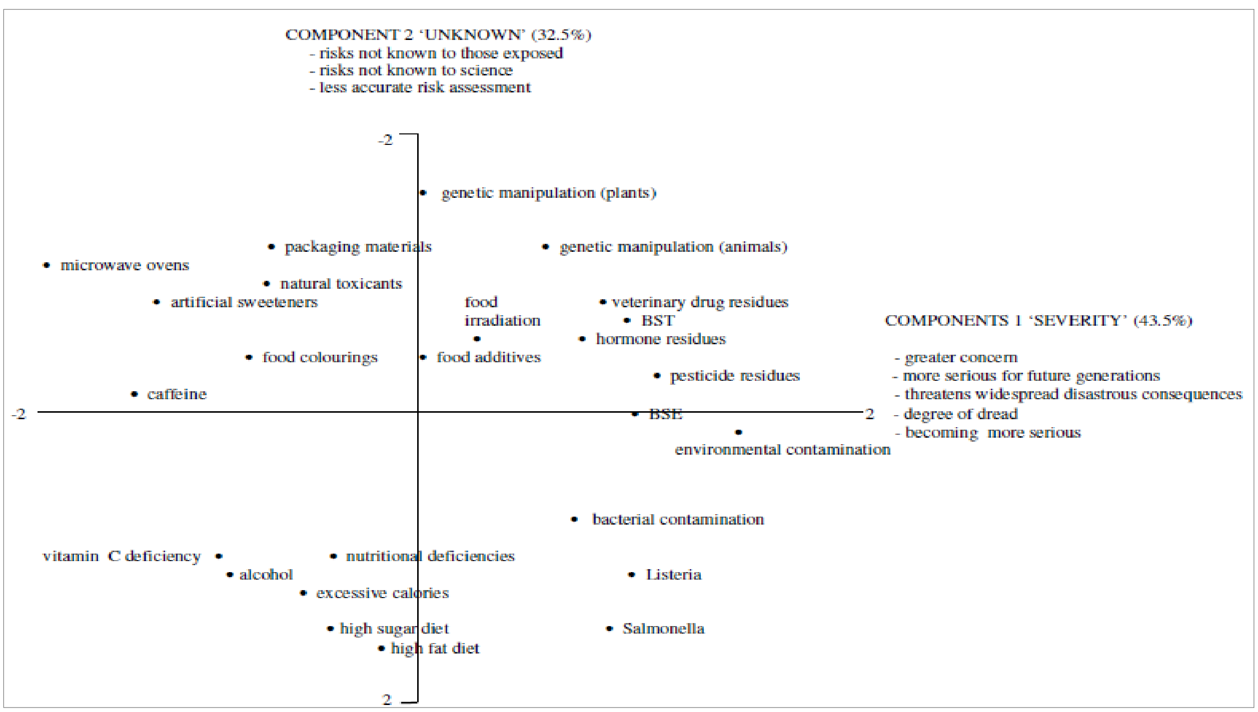

Figure 3. Location of chemical hazards within the two components space (Raats and Shepherd 1996)

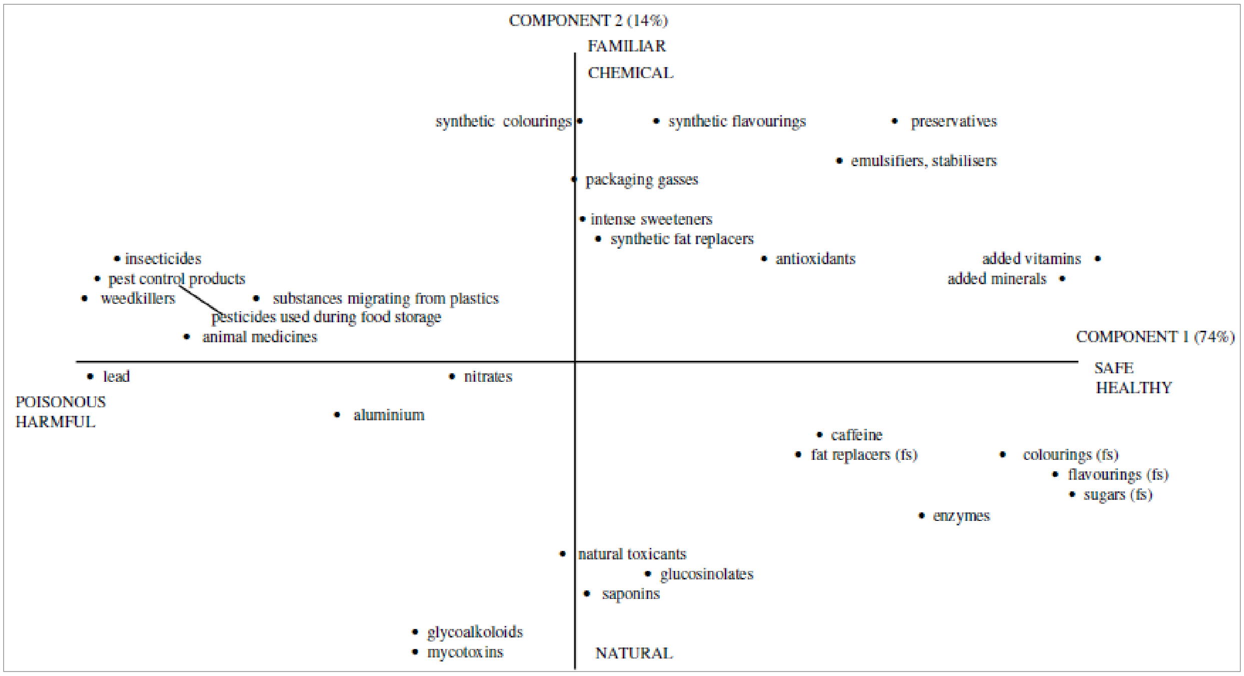

Figure 4. Location of technological risks within the two-component space (Frewer, Howard and Shepherd 1998)

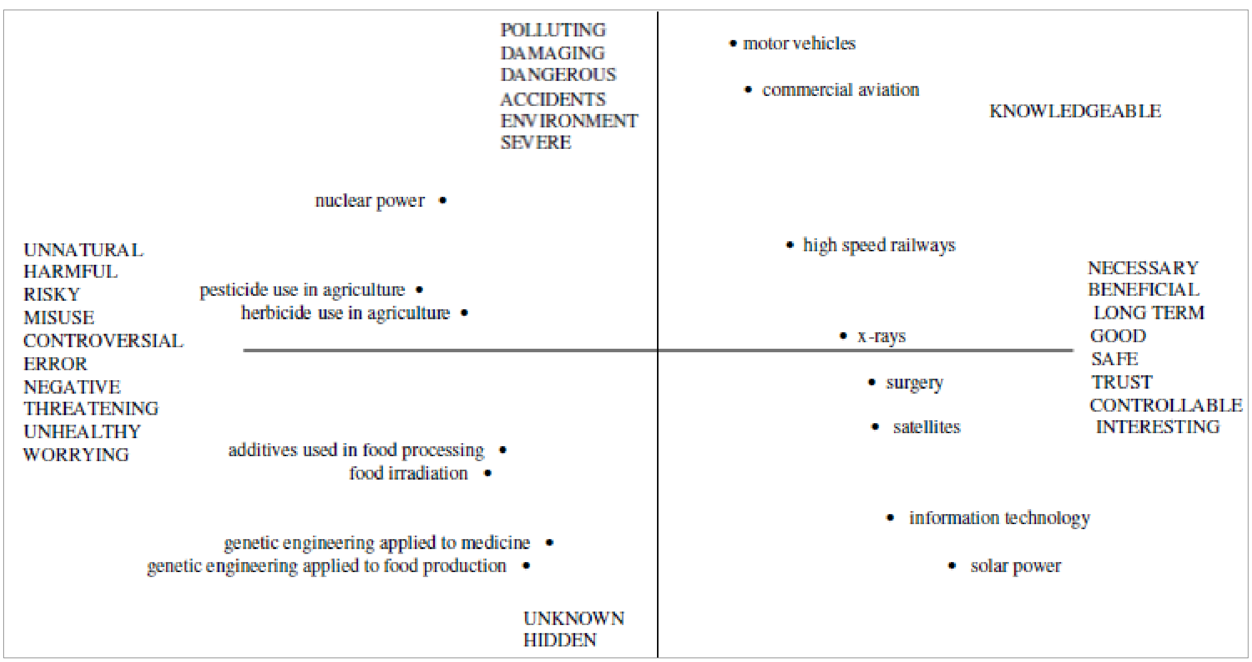

Figure 5. Examples of a BWS Survey Questions

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

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

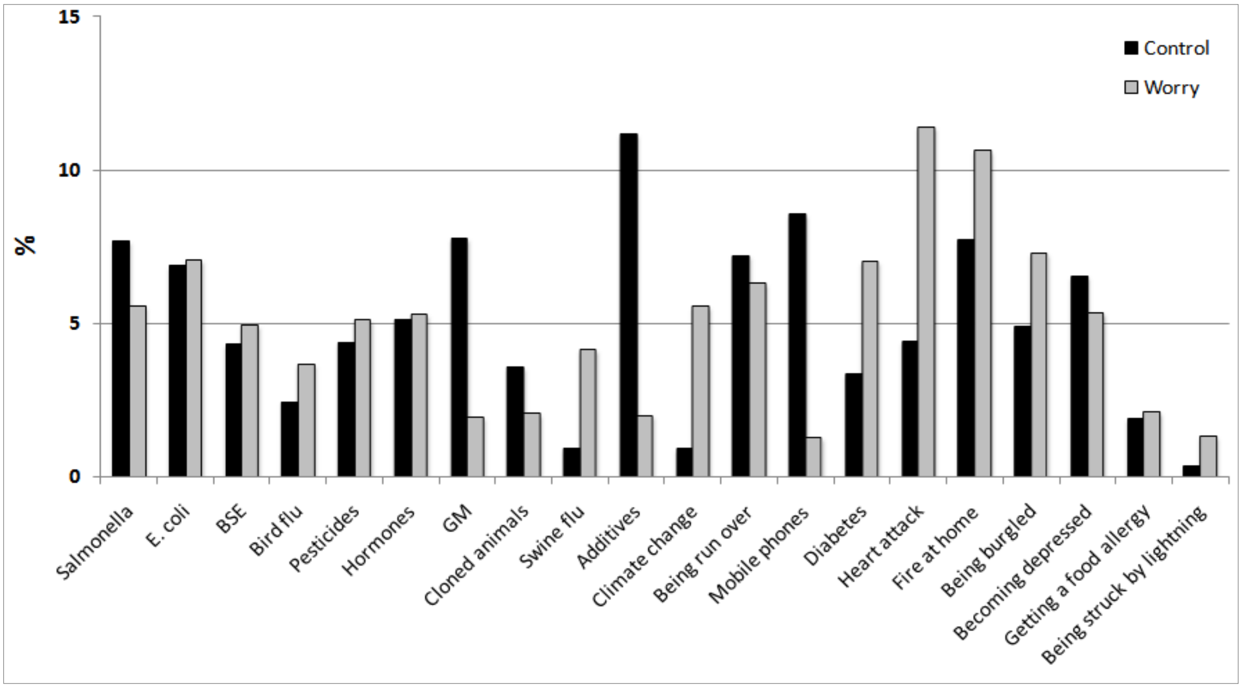

Figure 7. Location of Risks within Two-component Space (given in terms changes from a normal score of 5% for each risk).

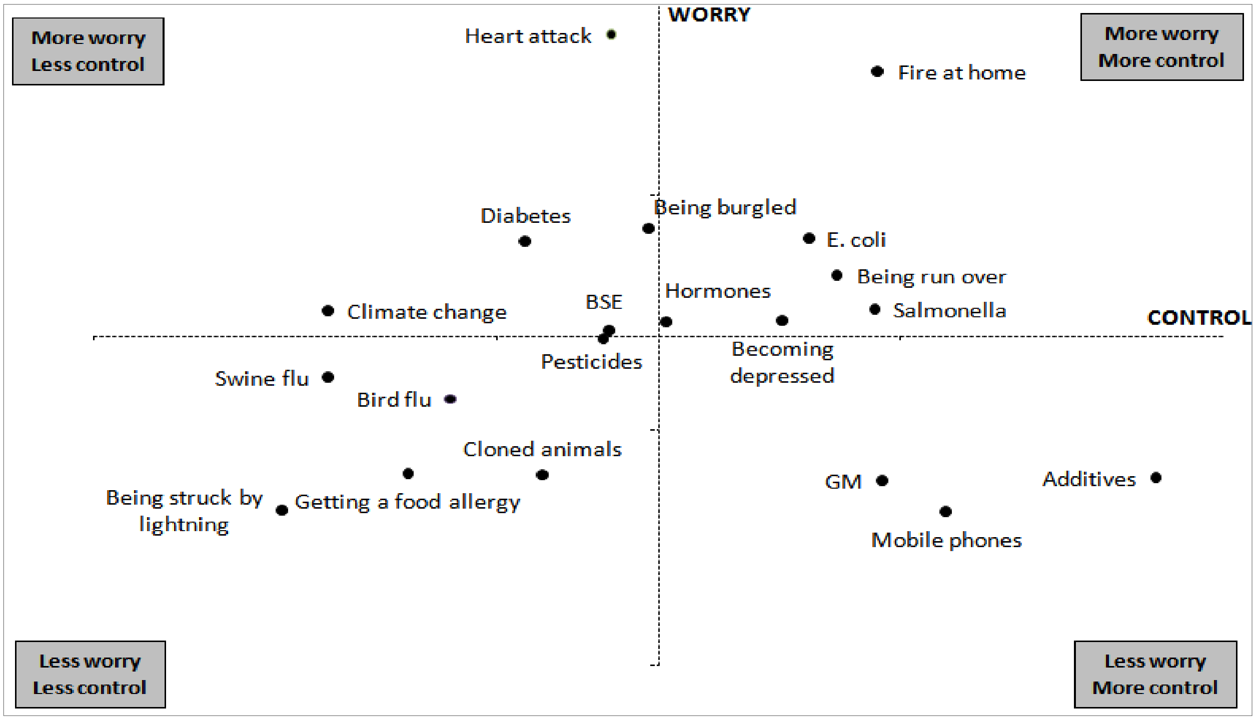

Figure 8. Consumers' and Farmers' Control Over Various Risks

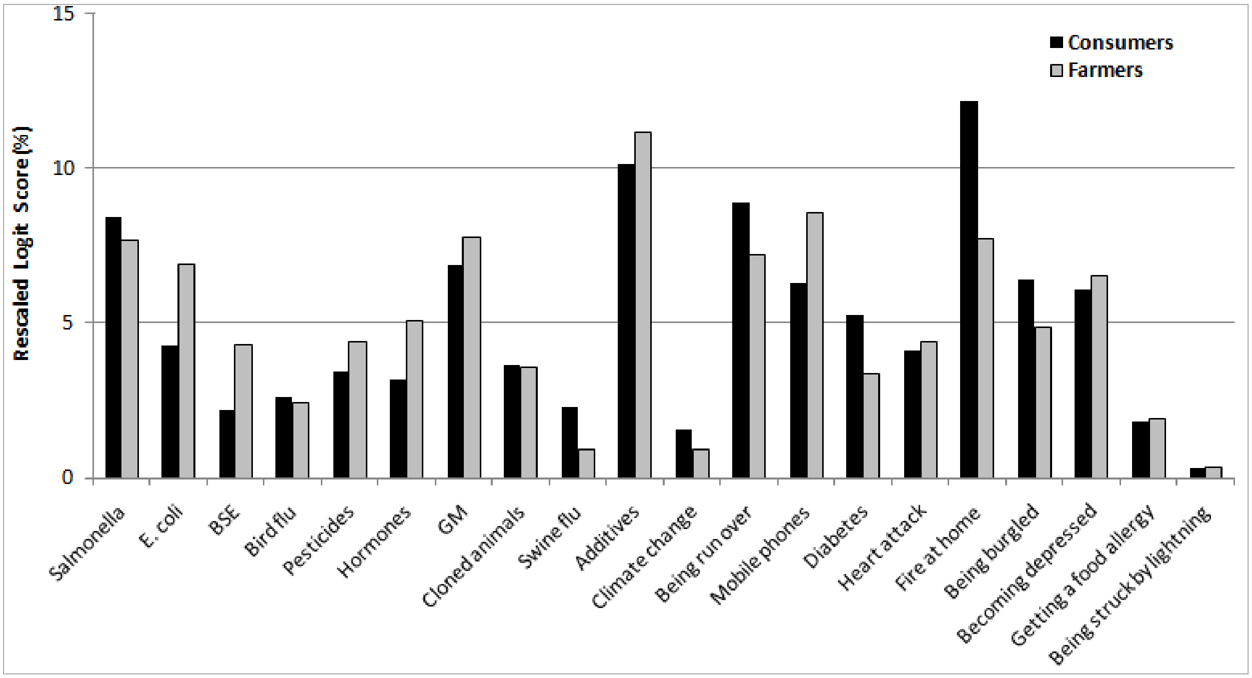

Figure 9. Consumers' and Farmers' Concern Over Various Risks