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**WHO IS MOST RESPONSIBLE FOR ENSURING  
THE MEAT WE EAT IS SAFE?**

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# WHO IS MOST RESPONSIBLE FOR ENSURING THE MEAT WE EAT IS SAFE?

## **Abstract**

We report results of an analysis of the attribution of relative responsibility across the stages of the food chain for ensuring food safety. Specifically, we identify perceptions of the share of the overall responsibility that each stage in the food chain has to ensure that the meat people cook and eat at home does not cause them to become ill. Results are reported for two groups of stakeholders: consumers and farmers, and for two types of meat: chicken and beef.

The stakeholders' opinions regarding the relative degrees of responsibility of the sequential food chain stages (feed supplier, farmer, livestock transportation, abattoir,... consumer) are elicited via surveys using the Maximum Difference technique (best-worst scaling). The data are analyzed using mixed logit models estimated via Bayesian techniques.

We find that consumers and farmers both tend to allocate a relatively low share of responsibility to their own food safety role. So, consumers tend to think farmers are more responsible for ensuring meat safety than farmers do. Similarly, farmers tend to think consumers have a greater degree of responsibility than consumers themselves believe. Thus, there is a consistent pattern of downplaying the extent of one's own responsibility.

Further, consumers tend to allocate the highest shares of responsibility to the middle stages of the meat food chain. This contrasts with farmers who tend to allocate the highest shares of responsibility to the latter stages of the chain towards consumers, believing that the earlier stages of the chain (until the livestock arrive at the abattoir) have a relatively low share of responsibility. In the conclusion, we elaborate on the implications of our findings for further research into food safety economics.

*JEL codes:* Q18, Q51, D03, D12

## 1 Introduction

There has been increasing concern in recent years over the human health risks posed by biological, chemical, and physical hazards in the food chain. Consumers have become more aware of food quality and safety. Foodborne diseases and food poisoning outbreaks have strained the trust in the food chain. However, there is still a lack of awareness among stakeholders (e.g., consumers, processors) about the conditions under which food is safe. Accordingly, food safety concerns, as well as ineffective government regulations have become major issues.

Meat may become hazardous to human health at various points in the food chain and, similarly, steps can be taken at each of those stages to reduce the potential risk to humans. For example, in the case of BSE, both the feed cattle received and the techniques used in abattoirs and processing facilities created the hazard that ultimately led to deaths from CJD.

The willingness of food chain participants to take actions, which reduce hazards to human health, is influenced by many factors. These include their ability to take such actions, awareness of hazards, the extent to which they think their actions will reduce hazards, and the extent to which they believe that even if they do undertake risk reducing behaviours the effects of these are, or will be, reduced/eliminated by the actions of others in the chain.

For example, in the *E. coli* outbreak in South Wales in 2005, the contaminated meat was sold by a catering butcher who did not comply with several Food Safety Regulations, such as cleaning and separation of raw and cooked meats, and this caused many people to suffer from the pathogen. In this outbreak, although there were other parties involved (e.g. local council and schools) responsibility fell on the shoulders of the butcher.

The investigation of this outbreak touched on a very important point: responsibility for food safety and how it was distributed across stakeholders in the supply chain. General interviews performed by Aberdeen and Bangor Universities with various stakeholders in the food industry as part of the Rural Economy and Land Use Programme (RELU) *E. coli* project<sup>1</sup> showed that evidence of people in food chain tending to push responsibility onto next/later stages (e.g. farmers to consumers).

In the present paper, we investigate in detail how people in England and Wales allocate responsibility among the stages of the food chain for ensuring the meat they eat does not cause them to become ill.

More in particular, we have two main foci concerning the relative assessment of food safety responsibility: (1) among different stakeholder groups (i.e. consumers and farmers) and (2) how this differs between food types (chicken versus beef).

We proceed as follows. In section 2, we review the extant literature on the research issues and explain the contribution of this research. Section 3 introduces the methodology used, the survey design and the data collection processes. The models and results are explained in sections 4 and 5 respectively. We conclude with the main finding and future research plans in section 6.

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<sup>1</sup> <http://www.abdn.ac.uk/reluecoliproject/index.htm>

## 2 Literature and the Contribution of This Study

One of the challenges in food industry is the availability of information on the safety of food products we consume. Individuals usually do not have perfect information on whether foods they consume are safe enough to not make them ill. They become more aware of food safety when they suffer from it. Personal experiences with foodborne illnesses, an increase in the number of reported food poisonings and media coverage of public health call attention to the current safety practices, the need for better safety practices and information systems (Brown (1969); Dahlgran & Fairchild (1987); Johnson (1988); Lusk & Schroeder (2000); McKenzie & Thomsen (2001); Piggott & Marsh (2004); Robenstein and Thurman (1993); Smith, Ravenswaay and Thompson (1988); van Ravenswaay & Hoehn (1991)).

A study by Adak et al. (2005) estimated that, from 1996 to 2000, there had been 1,724,315 cases of indigenous foodborne diseases per year resulted in 21,997 hospitalizations and 687 deaths. There are various reasons for such foodborne cases and outbreaks some of which are (i) the lack of food safety awareness among stakeholders, (ii) ineffective food handling practices in the food supply chain, (iii) high cost of information on the conditions of foods and food productions, and (iv) other complexities in the chain, such as firms' ability to record information related to foods and their productions and then transfer such information to the other stages in the supply chain. However, the important reason lies under one's willing to take actions to reduce hazards.

For example, in the largest UK food poisoning, which occurred in Lanarkshire Scotland in 1996, a butcher shop sold unfit meat to the local public and neighbouring towns. This resulted in 496 cases of infection with *E. coli* O157, of which 272 were confirmed, 60 probable and 164 possible cases, and 18 deaths. Evidences indicated the butcher as the main source of the outbreak and the responsibility fell on the shoulders of the butcher. However, there was a possibility of other factors, such as cross contamination and person-to-person spread, having contributed to the outbreak, but due to the large scale of the outbreak, identification of other sources was difficult (The Pennington Group, 1998). Thus, willingness of food chain participants to take actions that reduce hazards to human health plays an important role in food safety. The extent to which people think their actions will reduce the hazard, and the extent to which they believe that even if they do undertake risk reducing behaviours, the effects of these are, or will be, reduced/eliminated by the actions of others in the chain are of extreme importance.

Similarly, the second largest outbreak in the UK occurred in South Wales in 2005 resulted in 157 identified cases. Of these, 31 were hospitalized, and one 5-year old child died. Cooked meats that had been contaminated at a butcher's shop caused the outbreak. The butcher, who also owned an abattoir, pleaded guilty and banned from any food services. According to the investigations, he was the main responsible person for the outbreak (Pennington Report, 2009, p.12).

The investigations also found that the local Council that is responsible for the inspection of the butcher had "insufficient focus on identifying and assessing working practices and procedures to ensure that the HACCP plan was being applied in practice" (p.13). Schools, on the other hand, had inadequate contracts with the butcher. Pennington Report also concluded that "the arrangements for the joint contract were inadequate, with a particular lack of clear and agreed roles and responsibilities between the organizations and key individuals" (p.14). They found that "the system for contract monitoring was not operated properly and the system for recording

complaints was seriously flawed”. As a result, in this outbreak, the responsibility for ensuring the meat safety lied on the shoulder of not only the butcher and abattoir, but also the other parties involved in this outbreak (e.g. local council and schools). The lack of food safety awareness and individual’s unwillingness to take an action to reduce hazards, as demonstrated by this example, have caused foodborne cases.

Personal responsibility and willingness to fulfil own responsibility show variations. People have different levels of knowledge and opinions on food safety, and thus have different levels of perceived responsibility. Kjaernes, Harvery and Warde (2007) asked a number of consumers to assess their perceptions about who they think is responsible for ensuring safety, nutrition, animal welfare, and promotion health diet. They performed a survey with Norwegians, Danes, Britons, Germans, Portuguese, and Italians. In the survey, they listed several statements and asked if the respondents agreed to these statements, using a qualitative scale (e.g. fully agree, partly agree, disagree, very important, quite important, or not important). In the first statement, consumers compared their own and government’s responsibility for the food safety. The study did not include the other stages of the chain. Italians were most likely to ”fully agreed” that consumers were more responsible than government for food safety (35%), followed by Britons (34%), Portuguese (30%), Danes (27%), Germans (25%), and Norwegians (13%). In another statement, authors asked if consumers were more responsible than manufacturers for nutrition. This question also addressed two stakeholder groups, more specifically, consumers and manufacturers, but not other stages of the food supply chain. Responses to this question showed much variation between countries. Italian agreed the statement with 61%, Portuguese 46%, Britons and Norwegians 39%, Danes 35%, and Germans 31%. Another interesting question asked to respondents (mainly consumers) was whether consumers were more responsible than farmers for improving animal welfare. Germans thought that, as consumers, they had more responsibility than farmers for ensuring animal welfare. This followed by Britons (19%), Italians (16%), Danes (11%), Portuguese (10%), and Norwegians (5%).

Similar to Kjaernes et al., Krystallis et al. (2005) investigated European consumers’ and experts’ opinions on responsibility for protections from food risks, along with other food issues, such as consumers’ awareness of food safety, satisfaction from food managements, priorities in food risk managements, and role of media. The surveys were conducted with consumers and experts. Consumers were asked whether “they should take more responsibility for protection from food risk” and experts were asked whether “it is the state’s responsibility to protect consumers from food risks”. The findings showed that both consumers and experts believed that responsibility for food safety was shared between consumers, states, and industry. Consumers focused more on self-protection, whereas experts had more emphasis on the role of state and the industry. Danish consumers stated that “if people want to stay healthy they have to check the safety of food they buy”. Greek consumers thought that “people should not blame each other, but take responsibility”. They also believed that consumers should take more responsibility as “there is no care (taken to protect consumers) on the part of the responsible authorities”. Danish consumers, on the other hand, questioned whether it was realistic to have self-protections. They thought that lay people were not as much knowledgeable as experts and “there were certain consumers whose limited budgets force them to buy foods that was not safe”.

In this research, we address different stakeholder groups’ perceptions of relative responsibility for ensuring food we consume is safe in the entire supply chain. The means by which this is done

is novel and differs from past responsibility studies in that it asks people directly regarding their relative assessments of the responsibility for food safety using a “best-worst” scaling, rather than using a Likert-type rating scale (e.g. strongly agree to strongly disagree) to reveal views on various statements (more discussion follows in Methodology).

We identify both consumers’ and farmers’ perception of the share of the overall responsibility that each stage in the meat chain has to ensure that the meat people cook and eat at home does not cause food poisoning. The stages included in the survey are: feed supplier, farmer, live animal transport, abattoir, meat transport, retailer (supermarket and local butcher), and consumers.

Past studies investigate previous outbreaks and critique who should (and could) have done to prevent the hazard. For example, Tuttle et al, (1999) investigated a large outbreak of *E. coli* that resulted in 700 cases and 4 deaths was associated with eating beef patties at restaurants of one fast food chain in the western USA. They reported that the contamination was possibly started on cattle farm and slaughtering animal caused surface contamination of meat. Mixing contaminated meat with meat from other sources and mishandling of hide and skinned carcass by employees at processing plant resulted in a large number of contaminated ground beef patties. Heuvelink et al. (2002), on the other hand, highlighted the risk of *E. coli* during at petting zoos, with a case study of *E. coli* in Netherlands in 2000. They concluded that good standards of hygiene in farm environment by the owner and the close supervision of visitors, especially young children, were the most important hazard preventive measures. Chapman et al. (2000) examined the presence of *E. coli* in 81 small butcher shops in Yorkshire, UK. They found *E. coli* O157 in 1.4% of all beef and lamb samples tested. They concluded that both beef and lamb were potential sources of the pathogen and it was very important to cook meat products thoroughly. Some other studies, on the other hand, examine consumers’ opinions on food safety responsibility at a specific stage, such as farm, processor, or consumer levels, but still lack dimensions in their analysis such that we only have general views on the responsibility of a specific stage (Krystallis et al. 2007, Kjaernes et al. 2007; Redmond and Griffith 2004).

In this research, we investigate different stakeholder groups’ perceptions of responsibility for ensuring the food safety in the entire supply chain, rather than at a specific stage, such as farm and consumer levels. The supply chain studied in the research is composed of ten stages. These stages are feed supplier, feed producer, farmer, livestock transportation, abattoir, processor, meat transporter, wholesaler, retailer (supermarkets and local butcher), and consumer. We also investigate different stakeholder groups’ perceptions of responsibility for food safety in the entire chain, as well as at a specific stage. This multi-dimensionality of the research provides us more information on the perceptions of food safety responsibility in the food chain, as well as on the expectations of these stakeholder groups from each other.

Additionally, this research goes beyond the existing studies and compares different stakeholders groups’ perceptions of responsibility for food safety in two different supply chains, namely beef and chicken supply chains. The recent foodborne outbreaks (e.g., *E. coli* and BSE in beef, Salmonella and Campylobacter in chicken at domestic kitchens) play an important role in the selection of food types in this research.

Methodologically, the research sheds light into the use of a fairly new technique, called Maximum Difference (MaxDiff), also known as “best-worst” scaling. MaxDiff is a form of conjoint analysis, which, although developed many years ago, is only recently gaining attention in the agricultural and environmental economics literature. We apply this technique on an abstract concept like “responsibility for food safety”, rather than on a product or a service that have been commonly investigated in the literature (Chrzan (2005); Chrzan and Griffiths (2005); Lusk and Briggeman (2009); Mueller et al. (2009); Hein et al.(2008); Goodman et al.(2005)).

Unlike a basic ranking task on a point scale, this technique provides us the responsibility rankings of each stage in the supply chain, as well as estimates of the relative size of the responsibility shares that people attribute to the food chain stages. This research, thus, contributes to the current literature with its structural methodological framework. Details on this technique are given in the next sections.

### **3 Methodology**

#### **3.1. Maximum Difference (MaxDiff) Scaling**

Maximum difference scaling (MaxDiff), also called Best-Worst Scaling (BWS), is a procedure invented by Jordan Louviere in 1987. It is a form of conjoint analysis that is recently gaining increased attention in the agricultural and environmental economics literature (see Lusk and Briggeman, 2009).

MaxDiff was developed as an extension of Thurstone’s (1927) Method of Paired Comparison (MPC), which is an established methodology in consumer science (e.g., Buck et al. (2001); Duineveld et al. (2000); Léon et al. (1999); Liem et al. (2004)). The main idea of MPC is to elicit trade-offs between paired items that describe attributes of a product, a service or a concept in a task (i.e. question). In MaxDiff, we are allowed to have more than two items in a task. A respondent chooses the “best” and “worst” (or “most” and “least”) items in a given subset that includes more than 2 items. The pair of items chosen (i.e. best/worst or most/least) shows the maximum difference in preferences/importances/utilities (therefore, it is called “MaxDiff”).

As an example of the MPC and the MaxDiff procedures, we consider a subset of 4 items, A, B, C, and D. In MPC, we can ask respondents to evaluate 6 pairs ( $4 \times 3 / 2 = 6$ ) in 6 choice tasks. From each task, we can only get 1 response, best or worst, most or least. Overall, from 6 tasks, we get 6 responses. Assume we now ask them to choose the best and worst items, rather than an item as in MPC case. Selecting best and worst (or most and least) items will provide us 12 responses ( $6 \times 2$ ). From this basic example, it is very clear that we get extra information from the selection of the second choice (best or worst) in MaxDiff experiment (Jaeger et al. (2008); Sawtooth Software (2007); Cohen and Orme (2004)).

The selections of “best” and “worst” items in a task shed light into the preferences for the each item of the survey. Assume the respondent chooses A as the “best” item and D as the “worst” item among given options (i.e. A, B, C, and D) (see Figure 1).



**Figure 1. An example of a MaxDiff task**

Best		Worst
✓	A	
	B	
	C	
	D	✓

Selecting best and worst informs us on five of six paired comparisons such that  $A > B$ ,  $C > D$  and  $B > D$ , where “>” means “more preferred/important than”. Here, we do not have information about B and D. However, just these two selections (i.e., best and worst or most and least) in a choice set give valuable information on the preference rankings of the items.

The alternative scaling approaches used in questionnaires are rating, ranking, or chip allocation (i.e. constant sum tasks). In a ranking task, respondents are asked to order the list of items from best to worst. This process can be extremely difficult for people when there are more than 7 items in a question (Cohen and Orme, 2004). Besides, not everyone has the same perception of ranking scale, thus we may have unreliable responses to questions that may not be useful in the analysis. In a rating task, respondents order the list of items using a point-scale (e.g., “0” meaning “not important at all” to a scale (e.g. 10) meaning “extremely important). The problem with this scaling is that there may be a tendency for respondents to use the scale inappropriate ways, such as showing a pattern in rating (e.g., mainly using the upper or lower part of the scale). Such a behaviour leads to a scale-use bias (Baumgartner and Steenkamp (2001)). In a constant-sum (or chip allocation) task, respondents allocate a certain number of chips (or points) across shown items. It may be difficult for respondents to allocate certain chips (or points) across several items and then to make sure the allocation sum makes up the required number. As in other tasks, when the number of items shown to respondents increases, this process may be even more difficult. Such a hurdle may not allow respondents to reflect their genuine preferences (Cohen and Orme, 2004).

MaxDiff questionnaires, on the other hand, are 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 MaxDiff scaling used in various areas.

### 3.2. Survey Design

The questionnaire design plays an important role in obtaining reliable responses from survey questions, especially when the survey concept involves a large number of items or attributes.

The number of items used in MaxDiff tasks varies with varying number of items describing the survey concept. 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 (Software, 2007). Furthermore, showing more items to respondents may result in confusion and fatigue, which may in turn cause unreliable responses. Sawtooth suggests using as many sets per respondents as possible such that each item appears in the survey 3-5 times per respondents. They generated a formulation for the suggested number of sets in a survey:

$$\frac{3K}{k} \leq \text{number of sets} \leq \frac{5K}{k} \quad (1)$$

where  $K$  is the total number of items in the study, and  $k$  is the number of items shown in each set.

The optimum design features that one should aim to have are frequency balance, orthogonality, and connectivity among tasks. Frequency balance ensures that each item appears an equal number of times in the questionnaire. Orthogonality ensures that each item appears approximately equal number of times with every other item. Finally, connectivity maintains that there are connections between tasks via items selected in surveys. Finding the optimum design is a challenging task, especially with many items in a survey. However, there are software generating cyclical algorithms to create optimal (or near-optimal) designs quite easily, such as SPSS and MaxDiff/Web. We used MaxDiff/Web to generate our survey designs.

In the surveys, we asked different stakeholder groups their perceptions of food safety responsibility in meat supply chain. The meat supply chain we referred to in the surveys includes 10 stages: feed supplier, farmer, live animal transport, abattoir, meat transport, retailer-butcher, retailer-supermarket, wholesaler, and consumers. The reason why we further classified retailer into two, i.e. retailer-supermarket and retailer-local butcher, is to see if people have different realizations of responsibility for these two stakeholder groups, given recent food poisoning outbreaks at the retailer level (e.g. Welsh *E. coli* case in 2005).

Another important point here is that we did not include the policy-maker in the food supply chains. We thought that the inclusion of the policy-maker in the food supply chain might lead people to overemphasize the role of the policy-maker by blaming them on for ineffectiveness they experienced or heard from media or other sources in the food chain. Such perceptions might lead to unrepresentative, and thus biased, responses in the questionnaires.

We investigate stakeholders' perception of food safety responsibility in two meat supply chains: beef and chicken. The reason for that is to investigate if stakeholders' perceptions of food safety responsibility differ by product types. Therefore, we have two versions of surveys to address this issue (thereafter called "beef" and "chicken" surveys).

We created eight versions of beef and chicken surveys using 10,000 iterations within Sawtooth Software. Each version features different stage combinations within the sets. The purpose of having multiple versions of survey is to “reduce psychological order and context effects that may occur if every respondent received the same combinations of items” (Sawtooth, 2007). In each survey, there were 8 sets (i.e. questions) and each set included 5 stages.

Given the total number of items (i.e. 10 stages) and the subset of items used in each set (i.e. 5 stages) the suggested number of sets used in the questionnaires are calculated using the formulation (1) which resulted in the number of sets between 6 ( $3 \times 10 / 5$ ) and 10 ( $5 \times 10 / 5$ ) in each survey. We used eight sets in each MaxDiff survey to get more information, given it is not cognitively burdensome on respondents to answer eight questions.

In each MaxDiff set, we show respondents different combinations of five stages for their assessment of the “most and “least” responsible stage in the meat chain with respect to the safety of the meat they eat does not make them sick or ill. Figure 8 shows how a MaxDiff survey question looks like.

The combinations of five items in MaxDiff sets satisfy the optimal design characteristics mentioned before. The one-way frequencies show that each item was displayed 32 times<sup>2</sup> across all versions of the questionnaires. Therefore, it is perfectly balanced. The two-way frequencies reveal that the survey had a nearly orthogonal main-effects design, in which each item appears 14 times on average with every other item with a standard deviation of 0.46. After ensuring a balanced and nearly orthogonal survey design, tasks (i.e. questions) were randomized and a participant was randomly assigned to a version.

We will now mention about the data collection before introducing the model and results.

### **3.3. Data Collection**

We conducted the paper-pen surveys with two stakeholder groups: farmers and consumers in England and Wales in June until early August of 2009. We collected the data at 5 agricultural shows (i.e. Cheshire, Royal Welsh, Nantwich, Garstang, and Romiley Young Farmers Shows), as well as in the city of Manchester. 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.

Overall, we contacted 267 respondents (110 consumers, 157 farmers) who were randomly assigned to one of two surveys: beef and chicken. Table 1 provides summary statistics for the respondents included in our analysis. Both samples are quite similar with respect to the variables, such as gender, age, and having children or not. Both samples are female dominated and most respondents have a completed degree as their highest qualification (28% consumers, 23% farmers). Consumers are higher in post-graduate education than in vocational education, whereas farmers are higher in vocational education than in post-graduate education.

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<sup>2</sup> 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 10 stages in total, each stage appears 4 times in each version. Across all 8 versions, each stage appears 32 times.

#### 4 Estimation

We model respondents' views on the most and least responsible stage of the supply chain using the Random Utility Theorem (RUT). RUT is a theory on human decision-making initiated by Thurstone (1927) and generalized by McFadden (1974). The general form of the RUT can be written as:

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

where  $U_{ij,t}$  is individual  $i$ 's utility from his/her selection of alternative  $j$  in a choice set  $t=\{1,2,\dots,K\}$ ,  $\beta_i$  is individual  $i$ 's utility parameter vector,  $X_{ij,t}$  is a vector for attributes 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 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:

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

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:

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

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

As an individual chooses a sequence of alternative best-worst (or most-least) pairs at each choice set of  $K$ , we can write the probability of the sequence of choices as the product of logit form in equation (3) as the following:

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

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

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

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

This is the probability of the individual's sequences of choices conditional on the parameters of the population distribution,  $\varphi(\beta_i | b, w)$ .

Hierarchical Bayes (HB) uses simulation for parameter estimation of the density function employing a technique called Gibbs Sampling. 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. Each iteration consists of the following steps (Sawtooth Software, 2003):

- Using the initial estimates for  $\beta$ s and  $w$ , generate a new estimate of  $b$ .  
We assume that  $b$  is distributed normally with a mean equal to the average of  $\beta$ s 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  $\beta$ s and  $b$ , draw a new estimate of  $w$  from the inverse Wishart distribution<sup>3</sup>.
- Using the present estimates of  $b$ ,  $w$ , and  $\sigma$ , generate new estimates of the  $\beta$ s.

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<sup>3</sup> Let  $p$  be the number of parameters estimated for each  $n$  individuals, and let  $N=n+p$ . The prior estimate of  $w$  is the identity matrix  $I$  of order  $p$ . Let matrix  $H$  combines the prior information with current estimates of  $\beta$ s and  $b$ :

$$H = pI + \sum_n (b - \beta_i)(b - \beta_i)'$$

The inverse of the matrix  $H$  can be written as:  $H^{-1} = \mathbf{TT}'$ . This is also called Cholesky decomposition. Next, multiplying  $T$ s with independent random values,  $u_i$ ; having zero mean and unit variance, and accumulating, we obtain the following function:

$$C = \sum_N (Tu_i) (Tu_i)'$$

The estimate of  $w$  is the inverse of this  $S$  function. For more details, please see Sawtooth CBC/HB technical paper, 2000.

Here  $\sigma$  is the standard deviation of the random error term in equation (1).

- Using the present estimates of  $b$ ,  $w$ , and  $\beta$ s, generate a new estimate of  $\sigma$ .

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.

Having provided the model used in the paper, we now turn to some results from the analysis.

## 5 Results

Stakeholders' allocation of responsibility for ensuring the meat consumed is safe is derived from their perceptions and knowledge of food safety in the supply chain. Thus, the results presented in this section purely represent their *beliefs* rather than *actual* measures for the responsibility in the food chain.

We present the analysis results in 4 parts. The first section gives the results of the analyses that investigate consumers' perceptions of responsibility for ensuring food safety in the meat supply chain. We also test whether their perceptions for food safety differs in different supply chains (as overall) and at a specific stage of these chains. Section 2 and 3 do this for farmers. And the final section compares the responsibility assessments of both consumers and farmers.

### 5.1. Who Do Consumers Believe is Responsible for Ensuring Food Safety in Beef and Chicken Supply Chains?

Table 2 shows consumers' allocation of responsibility for the safety of beef and chicken products in the meat chain. The scores provided in the table are rescaled logit scores from the mixed logit analysis using HB estimation (i.e. they sum to 100). The results of the analysis show that the processor is believed to be the most responsible stage in both chains, following farmer, abattoir, supermarket, local butcher, feed supplier, wholesaler, consumer, meat transport, and live animal transport.

We find a similar pattern in the allocation of shares of responsibility in both chicken and beef surveys. Having an initial naive assumption of equal shares of responsibility among 10 stages (i.e., 10% each), we see that consumers tend to allocate greater responsibility to feed supplier, farmer, abattoir, processor, retailers, and wholesaler (i.e. >10%) and less responsibility to feed supplier, live animal transport, meat transport, and themselves (i.e. <10%) in beef supply chain. Such perception is not surprising due to the recent foodborne outbreaks, such as Welsh *E. coli* case in 2005, second largest in the UK. Occurrences of similar foodborne outbreaks might lead to an increase in consumers' awareness of food safety and let them focus more on to the stages involved in a foodborne case.

Consumers follow the similar trend in the chicken supply chain, except that they allocate higher than an average of 10% responsibility to themselves and meat transporter for ensuring the chicken they eat does not make them ill. This is plausible given the higher occurrences of foodborne illness cases attributable to chicken products in domestic kitchens.

As seen from Figure 2, having an initial naive assumption of equal responsibility share among 10 stages (i.e., 10% each), consumers tend to allocate greater responsibility to farmer, abattoir, processor, and retailer-supermarket (i.e. >10%) and less responsibility to feed supplier, live animal transport, meat transport, wholesaler, and themselves (i.e. <10%) in the beef supply chain.

We also find that consumers tend to allocate their own share of responsibility higher in the chicken supply chain than in the beef chain. This is not surprising given the high number of foodborne cases attributable to chicken products in domestic kitchens.

Before testing whether consumers' perceptions of food safety, shown in Figure 2, are different in two supply chains, we would like to show how dispersed individual mixed logit scores are at each stage of the chains (see Figure 3 & Figure 4). As seen from the figures, the variations of scores differ for some stages of the chains. For example, scores for "feed supplier" are more dispersed in the beef supply chain than in the chicken supply chain. We now want to test whether these differences are statistically significant at the chain or stage level.

We performed the following linear regression for the hypotheses testing. We simply regress individual logit scores on stages and the interaction terms, as in the following model:

$$\text{scores} = \alpha + \gamma_i \text{stage}_i + \beta_i (\text{stage}_i \times \text{group}) + \varepsilon_i \quad i = 1, 2, \dots, 10 \quad (6)$$

where group (1=beef, 0=chicken),  $\alpha$  is intercept,  $\gamma_i$  are estimates for stage<sub>i</sub> scores from mixed logit,  $\beta_i$  are estimates for stage<sub>i</sub> scores at a specific group (e.g. beef).

**Hypothesis 1: Consumers' allocations of responsibility for the safety of beef and chicken products in both beef and chicken supply chains are the same.**

In this hypothesis, we investigate whether there is a significant difference between consumers' allocation of share of responsibility for food safety in beef and chicken supply chains. The null hypothesis we test is:  $H_0: \sum \beta_i = 0$  (overall distributions of scores in both systems are the same).

The hypothesis test result show that consumers' perception of food safety responsibility in beef and chicken supply chains are not the same at 10% significance level (Coefficient -8.15, Std error 5.02, t-value -1.62 significant at  $P > |t| < 0.10$ ).

Although consumers tend to have different views on responsibility for food safety in general, there may still be similarities in their views at a specific stage of the chain. Thus, we investigate this further in the following hypothesis.

**Hypothesis 2: Consumers' allocations of responsibility for the safety of beef and chicken products at a specific stage of the chains are the same.**

In this hypothesis, we now investigate whether there is a significant difference between consumers' allocation of share of responsibility for food safety at each stage of the beef and

chicken supply chains. The null hypothesis we test is the following:  $H_0: \beta_i = 0$  (distribution of scores at  $stage_i$  is the same in both systems).

The hypothesis test results in Table 3 show that consumers perceive food safety responsibility of “processor” and “supermarket” differently in beef and chicken supply chains. They think that processors are more responsible in the chicken chain than in the beef chain, but the supermarket is more responsible in the beef chain than in the chicken chain. Although test results of Hypothesis 1 revealed that consumers tend to have different perceptions of food safety for both supply chains, the test result of Hypothesis 2 shows that they have the same perceptions of food safety at specific stages of the supply chains (e.g. farmers). An interesting result from this is that consumers do not think feed supplier, farmer, or consumers themselves have different responsibility for food safety in beef and chicken supply system. This is a surprising as due to the recent food issues (e.g., *E. coli* and BSE in beef, Salmonella and Campylobacter in chicken at domestic kitchens), we would expect consumers having different allocation of responsibility in beef and chicken supply chains.

## **5.2. Who Do Farmers Believe is Responsible for Ensuring Food Safety in Beef and Chicken Supply Chains?**

This section investigates farmers’ perception of food safety responsibility in beef and chicken supply chains. The HB estimation results show that farmers have different views on responsibility of different stages of the chains Table 2 presents the average logit scores from mixed logit analysis using HB estimation.

The overall result of the analysis shows that farmers tend to allocate the less responsibility to initial stages of the chain, especially first 3 stages, namely feed supplier, farmer (themselves), and live animal transport (Figure 5). They believe that first 3 stages of the chain are less responsible than other stages for the safety of meat in the chain. In fact, they think that these initial stages and meat transporter have less than an average share of responsibility (i.e. 10%) in the chain.

In the survey, some farmers indicated that they grew their own animal feed and transported animals to abattoirs using their own sources. On the other hand, some said that they had business with their feed suppliers for a very long time and thus trusted them in regards to the safety of feeds they used on farm. Thus, farmers either associate these two stages (i.e. feed supplier and live animal transport) as one of them or simply trust them and allocate a low share of responsibility. This might be a reason why these first three stages go hand in hand in both chains.

On the other hand, farmers think that the greatest chance of something happening to consumers and making them sick or ill due to the consumption of unfit meat lies on mid (i.e. processor and abattoir) and final stages (i.e. retailer, wholesaler, and consumer) of the chain.

Another interesting result is that farmers’ tendency to allocate higher responsibility to supermarkets than to local butchers. During conducting the survey, some farmers expressed that supermarkets set the price and have the most of the power in the chain. They believe that the negotiation power supermarkets have lowers the price as well as the safety of meat products. Below are a couple statements from the surveys:



*“Supermarkets have too much power and do not enough regulations (food labelling, packaging, buying control).”*

*“Supermarkets set the price too low that we cannot compete with it. There is always someone willing to provide low quality low price meat to supermarkets. Therefore, I think supermarkets hold a significant responsibility for the safety.”*

The results also show that farmers perceive consumers’ responsibility for food safety in beef supply chain higher than in chicken supply chain. Although we do not have a strong explanation for this behaviour, we think that this may be due to the farmers’ sensitivity to food safety in beef chain as the majority of the farmers surveyed had livestock of which 82% was dairy cow, beef cow, goats, sheep, and pigs, and 17% was chickens. The dominance of red meat in these farms may be causing them prioritize the safety of red meat first. Moreover, outbreaks attributable to chicken products are generally happening at domestic kitchens. Thus, it is unexpected to see consumers having more responsibility scores in beef supply chain than in chicken supply chain.

Although we observe differences in farmers’ views of food safety responsibility in beef and chicken supply chains, we now would like to test if these differences are statistically significant. We do this using the regression model (6) mentioned above.

**Hypothesis 3: Farmers’ allocations of responsibility for ensuring the safety of beef and chicken products in the meat chain are the same.**

It is hypothesized that farmers’ allocation of responsibility in beef and chicken supply chains are not different from each other. Using the same test as in Hypothesis 1, we failed to reject the null hypothesis at any standard significance level ( $P > |t| = 0.94$ ).

Although we concluded that farmers’ perceptions of responsibility in both supply chains are the same, we would like to see if there are any similarities (or differences) in their perceptions at a specific stage. Hypothesis 4 below investigates this.

**Hypothesis 4: Farmers’ allocations of responsibility for ensuring the safety of beef and chicken products at a specific stage of the chains are the same.**

Farmers’ allocation of food safety responsibility in some stages of beef and chicken supply chains show similarities. However, the hypothesis test results show that farmers believe that “supermarket” and “consumer” have different share of responsibilities in beef and chicken supply chains (see Table 3). This is in accord with our expectations. However, the direction of the difference for “consumer” is unexpected (i.e. consumers more responsible for beef safety than chicken safety), as more than 25% of the indigenous foodborne cases are due to *Campylobacter* (Adak et al. 2005) that can be characterized to mishandled chicken products at domestic kitchens. Whereas, very well known food borne cases attributable to beef (e.g., *E. coli*) are due to the mishandling of beef at food services (e.g., butcher, restaurants, etc). Thus, we would expect consumers to have higher share of responsibility in chicken than in beef chains.

The results also imply that farmers think that other stages, such as feed supplier, farmer (themselves), and abattoirs, have no systematic differences with respect to the responsibilities for ensuring the safety in beef and chicken chains. For example, farmers feature their own

responsibility the same in chicken and beef chains. They also believe that abattoirs are approximately equally responsible for the safety of beef and chicken products. These results are unusual given a high trend in foodborne cases attributable to beef at farm and abattoir levels (e.g. *E. coli* Welsh case in 2005).

### **5.3. Do Farmers and Consumers Have Different Perceptions of Food Safety Responsibility in the Meat Supply Chain?**

The comparison of perceptions of food safety responsibility of the two stakeholder groups revealed significant differences. We now discuss the results under two sections: one for beef supply chain and the other for chicken supply chain in the following sections

#### ***Beef Supply Chain***

The comparison of the stakeholders' perception of responsibility shows both similarities and differences (see Figure 6). Both stakeholders believe that abattoir, processor, supermarket, and local butcher have higher than an average 10% share of responsibility, whereas live animal transport and meat transport have lower than an average 10% share of responsibility. However, as seen from the figure, we see that they do not agree on the allocation of food safety responsibility to feed supplier, farmer, and consumer.

The results also shows that consumers tend to allocate high responsibility to initial and mid-stages of the chain, whereas farmers tend to allocate higher responsibility towards the end of the chain. There are, in fact, big differences in the allocation of responsibility at first two stages of the chains, as well as at consumer stage.

From the figure, we also see that consumers feature their own share of responsibility less than what farmers believe it to be. Similar trend follows at feed supplier and farm stages of the chain.

As we did in the previous sections, we now test whether consumers and farmers overall have the same perceptions of responsibility in the beef supply chain. The first hypothesis we test is whether there is a significant difference between two stakeholders' perceptions of food safety responsibility in the beef chain. We then test this at each stage of the chain.

#### **Hypothesis 5: Farmers and consumers have the same perceptions of food safety responsibility in the beef supply chain.**

We used the same regression model (6) to test the hypothesis, where now "group" is a binary variable or the type of stakeholder (i.e. 1=farmer, 0=consumer).

The test result of the regression analysis in Table 4 reveals the rejection of the null hypothesis at a 5% significance level ( $P > |t| = 0.017$ ). We then conclude that consumers and farmers have different perceptions of responsibility for ensuring the beef in the supply chain is safe.

The result in Table 4 also indicates that farmers have been allocated higher share of responsibility than consumers in overall. This is not surprising due to the recent foodborne outbreaks attributable to beef and high media coverage on these issues during these outbreaks. These factors then may affect people's current agenda, as well as their perceptions (Frewer,

Howard, and Shepherd, 1995; Kalaitzandonakes, Marks, and Vickner, 2004; Schlender and Villas-Boas, 2009; Jonge et al., 2010).

**Hypothesis 6: Farmers and consumers have the same perceptions of food safety responsibility at each stage of the beef supply chain.**

We now hypothesize whether stakeholders' perceptions of responsibility for ensuring the safety of beef at a specific stage is the same.

As seen from Table 5, we reject the null hypothesis for only 3 stages of the chain: feed supplier, processor, and consumer. This implies that consumers and farmers have the different views on the safety of beef at these stages. The share of responsibility allocated by farmers for feed supplier is less than that of consumers. Farmers also allocate more responsibility to processor and consumers than consumers do.

An interesting result of this test is that although we see that both stakeholders have different views on the share of responsibility of farmers in Figure 6, the perceptions of food safety at farm level are the same. However, this is different at consumer level.

***Chicken Supply Chain***

Consumers and farmers display similar views on the share of responsibility in chicken and beef supply chains (see Figure 7). Similar to their assessment in the beef supply chain, we find that they both tend to allocate a relatively low share of responsibility to themselves in the chicken supply chain. Consumers tend to think farmers are more responsible for ensuring the meat safety than farmers do. While farmers tend to think consumers have a greater degree of responsibility than consumers themselves believe. Thus, there is a consistent pattern of downplaying the extent of one's own responsibility.

Analysis results also show that consumers tend to allocate the highest shares of responsibility to the middle stages of the meat food chain (e.g. processor (c.19%) and abattoir (c.12%)). This contrasts with farmers who tend to allocate the lowest shares of responsibility to first 3 stages of the chain (c.10%) and the highest shares of responsibility to the mid (c.35%) and later stages of the chain towards consumers (c.55%).

We now test whether consumers and farmers have the same perceptions of responsibilities in the chicken supply chain (Table 4). We used the same model and hypotheses used earlier. The result of the test shows that there is a significant difference between the perceptions of consumers and farmers in the chicken supply chain ( $P > |t| = 0.09$ ). The null hypothesis of "Farmers and consumers have the same perceptions of food safety responsibility in the chicken supply chain" is rejected at a 10% significance level.

We further test if their perceptions are the same at a specific stage of the chain. The test result shows that consumers and farmers have different allocation of responsibility for food safety at feed supplier, supermarket, and wholesaler levels. Although, as we discussed before, having different views at feed supplier or supermarket is plausible, we do not have an explanation as to why they have distinct views on the food safety at wholesale level.

The result also reveals that consumers and farmers tend to have the same perceptions of responsibility for “farmer” and “consumer” in the chicken supply chain, which is interesting.

## **6 Concluding Remarks**

In this paper, we have reported results of an analysis of the attribution of relative responsibility across the stages of the food chain for ensuring food safety. Specifically, we identified perceptions of the share of the overall responsibility that each stage in the food chain has to ensure that the meat people cook and eat at home does not cause food poisonings. We investigated how people in England and Wales allocate responsibility among the stages of the food chain for ensuring the meat they eat does not cause them to become ill, and how this differs between food types (i.e. chicken and beef) and across food chain stakeholders: consumers and farmers.

We constructed surveys employing a Maximum Difference (MaxDiff) Conjoint technique, also known as Best-Worst scaling. The elicitation process involves making choices between sets of items from which respondents identify the “best” and “worst”. In this case, the method is adapted so that, when faced with subsets of food chain stages, respondents are asked to identify the stage, which they think is “most” and “least” responsible for ensuring the meat people consume does not cause them to be ill. The stages included in the surveys are feed supplier, farmer, live animal transport, abattoir, meat transport, processor, wholesaler, retailer, and consumer.

The MaxDiff method is used here because we have a set of items (food chain stages) which we want respondents to rank yet there is evidence that people struggle to rank long lists, and hence the desire to break the task down into something more cognitively manageable. The Maximum Difference choice tasks are relatively easy for most people to understand as they face only (repeated) subsets of the full set of items. In addition, there is evidence that people cope better when they only need to evaluate the extreme preferences rather than the levels of their preferences. In addition to the responsibility rankings, we want estimates of the relative size of the responsibility shares that people attribute to the food chain stages. These shares are retrievable from mixed logit analysis of the best-worst choice data. We estimate the mixed logit model via hierarchical Bayes estimation techniques.

We find that consumers and farmers both tend to allocate a relatively low share of responsibility to themselves. Consumers tend to think farmers are more responsible for ensuring meat safety than farmers do. While farmers tend to think consumers have a greater degree of responsibility than consumers themselves believe. Thus, there is a consistent pattern of downplaying the extent of one’s own responsibility. Consumers allocate the highest shares of responsibility to the middle stages of the meat food chain (e.g. processor (c.19%) and abattoir (c.12%)). This contrasts with farmers who tend to allocate the highest shares of responsibility to the later stages of the chain towards consumers believing that the earlier stages of the chain (feed supplier, farmer, and live animal transport) have a relatively low degree of responsibility (c.10%) compared to the mid (c.35%) and later stages (c.55%).

We find a similar pattern of share of responsibility allocations for the chicken and beef surveys, however we do find that consumers tend to believe themselves to have a greater share of

responsibility in the case of chicken compared to beef. This is plausible given the higher occurrences of foodborne illness cases attributable to chicken products in domestic kitchens.

Using responses to debrief questions with survey participants we discuss some of the possible causes for the similarities and differences we see in the patterns of responsibility allocations across the stakeholder groups and meat products.

In future research, we plan to extend the current analysis to a third stakeholder group, abattoirs, representing a mid-chain group. It would give a better insight into how different groups of stages (initial, mid- and final) allocate the responsibility and perceive their own role in the chain. Another interesting group to interview would be food safety experts—the share allocation retrieved from these responses could be used to replace the naive assumption of equal shares of responsibility among the 10 stages (i.e., 10% each).

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**Table 1. Characteristics of Survey Respondents**

Variables	Consumers		Farmers	
	Mean	S.D.	Mean	S.D.
Gender (1=female, 0=male)	0.69	0.47	0.60	0.49
Age (age in years)	35.81	15.55	38.83	14.82
Income (annual household income (£))	43,274	26,405	38,611	29,379
Children (1=yes, 0=no)	0.39	0.49	0.43	0.50
Education (1=yes, 0=no)				
No GCSE level education	0	0	0.08	0.27
GCSE Level education (e.g. GCSE, O-Levels or Standards)	0.11	0.32	0.18	0.38
A-Level education (e.g. A, AS, S-Levels, Highers)	0.21	0.41	0.18	0.38
Undergraduate education (e.g. University examinations but not completed degree)	0.19	0.39	0.09	0.29
Degree or Graduate education (e.g. BSc, BA)	0.28	0.45	0.23	0.42
Post-graduate education (e.g. PhD, MSc, MA)	0.14	0.35	0.07	0.26
Vocational education (e.g. NVQ, HNC, HND)	0.07	0.25	0.17	0.37
Occupation (1=yes, 0=no)				
Student	0	0	0.08	0.27
Full time employed	0.11	0.32	0.18	0.38
Part time employed	0.21	0.41	0.18	0.38
Unemployed (looking for a job)	0.19	0.39	0.09	0.29
Unemployed (not looking for a job)	0.28	0.45	0.23	0.42
Self-employed	0.14	0.35	0.07	0.26
Retired	0.07	0.25	0.17	0.37
<i>Number of observation</i>	<i>110</i>		<i>157</i>	

**Table 2. Stakeholders' Allocation of Food Safety Responsibility in the Beef and Chicken Chains, (Rescaled MXL Scores, %)**

Stage	Beef Supply Chain		Chicken Supply Chain	
	Farmer	Consumer	Farmer	Consumer
Feed supplier	4.32	9.87	4.43	8.78
Farmer	4.73	14.62	3.49	12.06
Live animal transport	2.22	3.34	2.74	3.10
Abattoir	11.24	12.58	9.77	11.50
Meat transport	5.51	6.12	7.89	7.87
Processor	17.84	14.77	16.99	18.66
Retailer - supermarket	15.36	12.97	18.25	9.97
Retailer - local butcher	13.39	10.65	13.77	11.08
Wholesaler	11.42	9.21	13.06	8.50
Consumer	13.97	5.87	9.61	8.48
<i>Number of observation</i>	<i>46</i>	<i>53</i>	<i>47</i>	<i>57</i>



**Table 3. Differences in Stakeholders' Food Safety Responsibility Perceptions at a Specific Stage of Beef and Chicken Supply Chains**

<b>CONSUMERS</b>				
<b>Stage</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>t-value</b>	<b>P&gt; t </b>
Processor	-3.9	1.67	-2.33	0.02*
Supermarket	3.0	1.67	1.8	0.07**

<b>FARMERS</b>				
<b>Stage</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>t-value</b>	<b>P&gt; t </b>
Supermarket	-3.64	1.25	-2.92	0.004***
Consumer	4.63	1.25	3.72	0.000***

Statistically significant at \*\*\*p<0.01, \*\* p<0.10, \* p<0.05

**Table 4. Differences in the Food Safety Perceptions of Consumers and Farmers in the Beef and Chicken Supply Chains**

<b>BEEF</b>			
<b>Coef.</b>	<b>Std Err.</b>	<b>t-value</b>	<b>P&gt; t </b>
10.38	4.34	2.39	0.017*

<b>CHICKEN</b>			
<b>Coef.</b>	<b>Std Err.</b>	<b>t-value</b>	<b>P&gt; t </b>
7.54	4.45	1.69	0.09**

Statistically significant at \*\*\*p<0.01, \*\* p<0.10, \* p<0.05

**Table 5. Differences in the Food Safety Perceptions of Stakeholders at a Specific Stage of the Beef and Chicken Supply Chains**

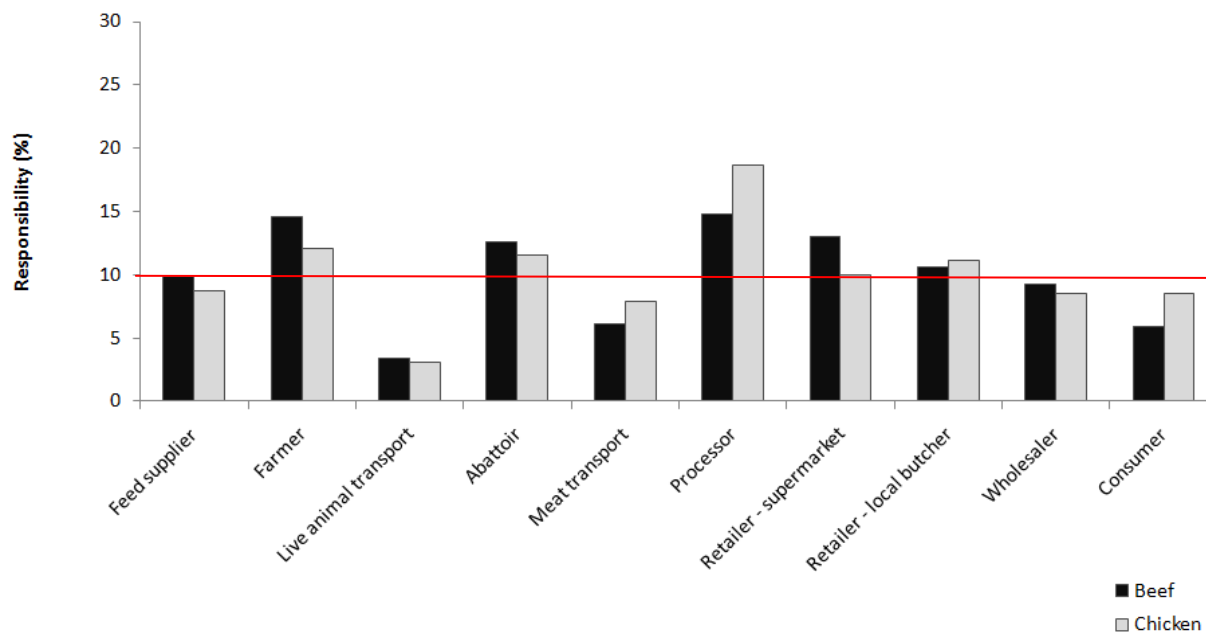
<b>BEEF</b>				
<b>Stage</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>t-value</b>	<b>P&gt; t </b>
Feed Supplier	-5.74	1.45	-3.97	0.000*
Processor	3.27	1.45	2.26	0.024*
Consumer	8.89	1.45	6.14	0.000*

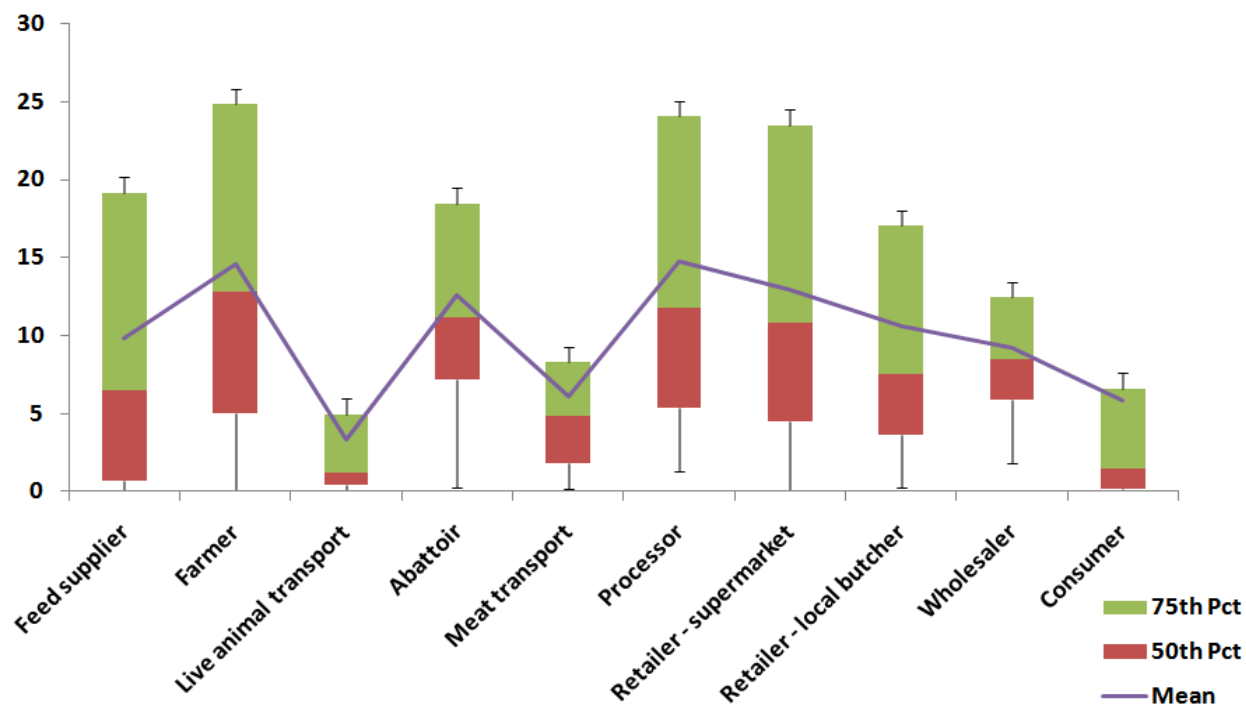
<b>CHICKEN</b>				
<b>Stage</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>t-value</b>	<b>P&gt; t </b>
Feed Supplier	-4.29	1.48	-2.89	0.004*
Supermarket	7.34	1.48	4.95	0.000*
Wholesaler	4.04	1.48	2.72	0.007*

Statistically significant at \*\*\*p<0.01, \*\* p<0.10, \* p<0.05

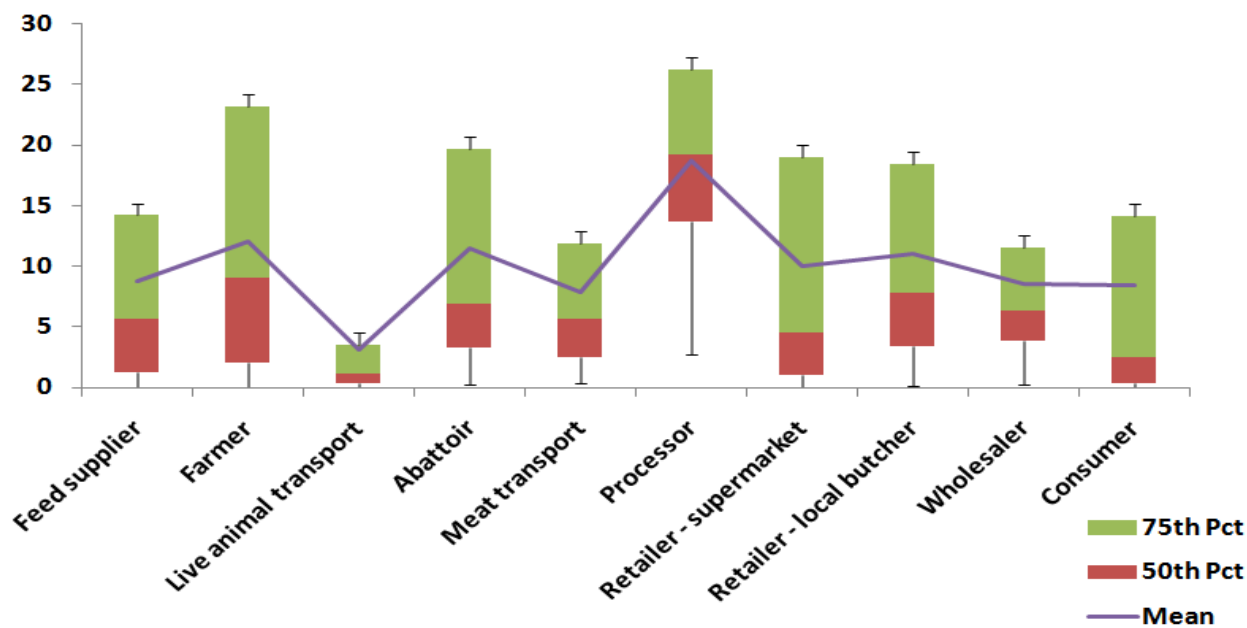
**Figure 2. Comparison of Consumers' Allocation of Food Safety Responsibility in the Beef and Chicken Supply Chains**



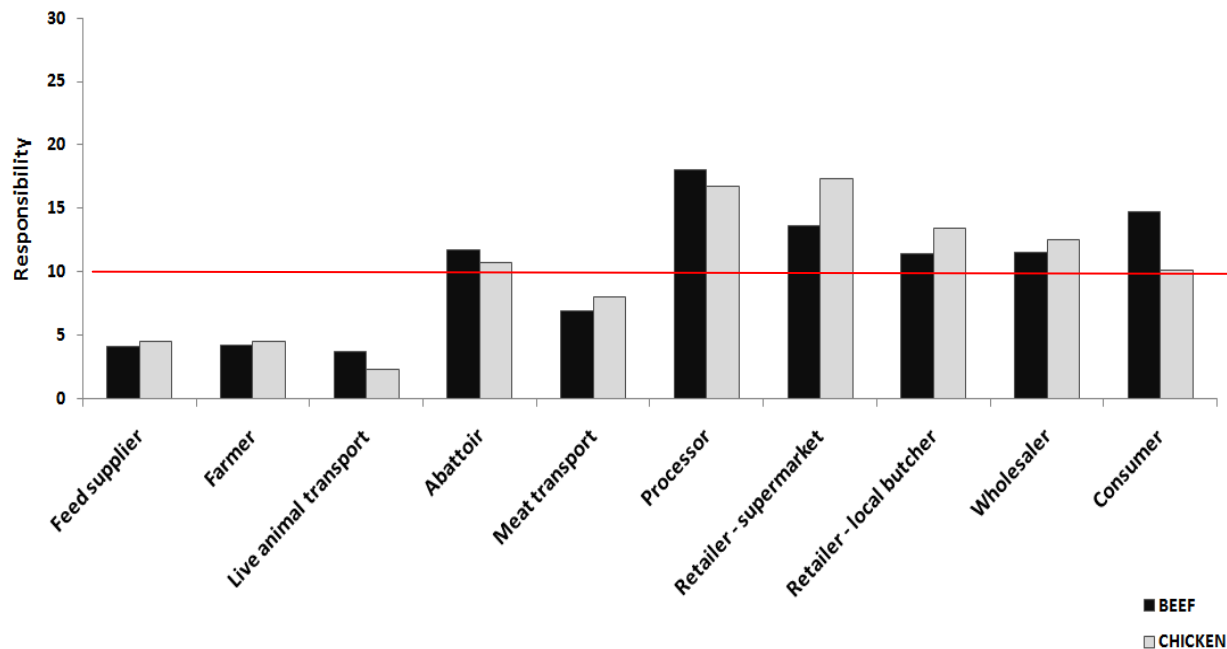
**Figure 3. Distribution of Consumers' Relative Responsibility in the Beef Supply Chain**



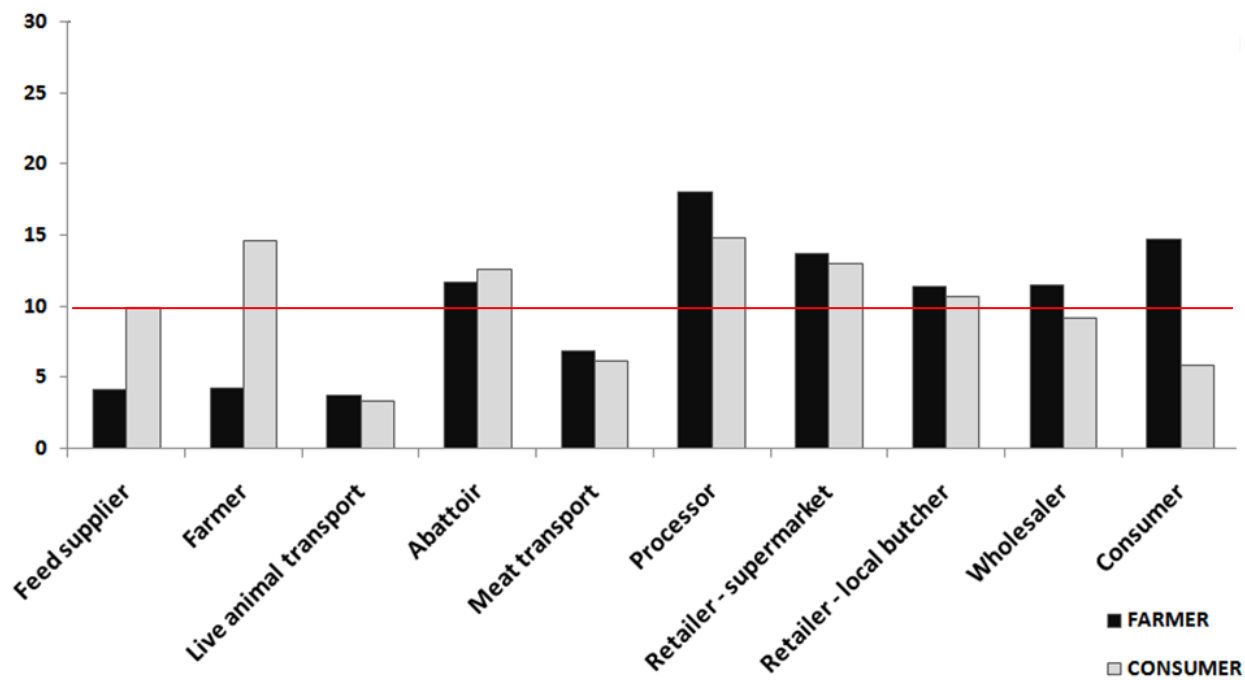
**Figure 4. Distribution of Consumers' Relative Responsibility in the Chicken Supply Chain**



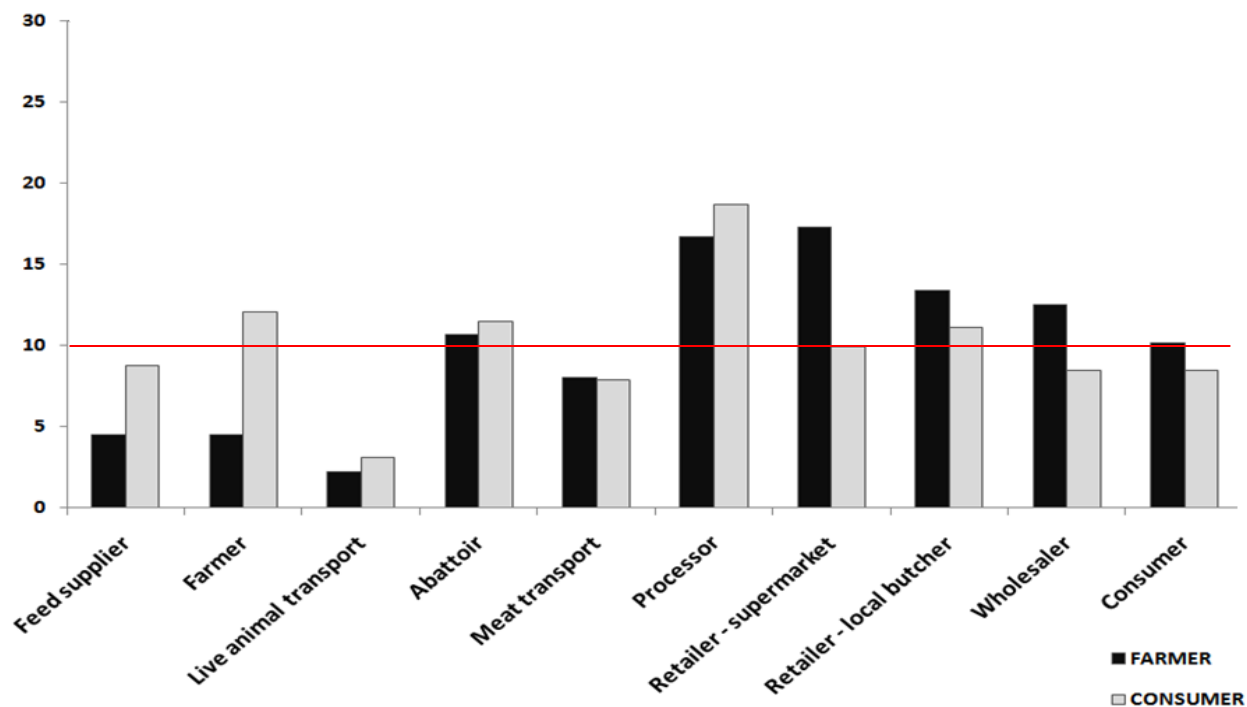
**Figure 5. Comparison of Farmers' Food Safety Allocation in the Beef and Chicken Supply Chains.**



**Figure 6. Consumers' and Farmers' Perceptions of Food Safety Responsibility in the Beef Supply Chain**



**Figure 7. Consumers' and Farmers' Perceptions of Food Safety Responsibility in the Chicken Supply Chain**



**Figure 8. An Example of a MaxDiff Question**

**Who is most responsible for beef safety?**

Consider the stages of the food chain shown below. Please indicate where you think lies the **greatest responsibility** and the **least responsibility** for ensuring the beef you eat is safe.

You might think of this as meaning at which stages are the **greatest risks** of the beef becoming unsafe and where are the **lowest risks** of the beef you eat becoming unsafe.

Most responsible		Least responsible
<input type="radio"/>	Consumer [i.e. you]	<input type="radio"/>
<input type="radio"/>	Live animal transport	<input type="radio"/>
<input type="radio"/>	Abattoir	<input type="radio"/>
<input type="radio"/>	Retailer - local butcher	<input type="radio"/>
<input type="radio"/>	Processor	<input type="radio"/>