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Pesticides, Preference Heterogeneity and Environmental Taxes

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Abstract

In this paper we present results from two Choice Experiments (CE) designed to take account of the different negative externalities associated with pesticide use in agricultural production. For cereals production the most likely impact of pesticide use is a reduction in environmental quality. For fruit and vegetable production, the negative externality is on consumer health. Using latent class models we find evidence of the presence of preference heterogeneity regarding pesticide reduction in the population. With respect to consumer health, respondents' WTP for a 100 percent reduction in the use of pesticides in the UK is a 105 percent increase in the weekly fruit and vegetable food bill. For the environmental quality the WTP for a 100 percent reduction in the pesticide use in the UK is a 184 percent increase in the price of a loaf. To place our WTP estimates in a policy context we convert them into an equivalent pesticide tax by type of externality. Our tax estimates suggest that pesticide taxes based on the primary externality resulting from a particular mode of agricultural production are a credible policy option that warrant further consideration.

Key Words: Choice Experiments, Pesticides, WTP, Latent Class Models, Pesticide Taxes

1. Introduction

The impacts of pesticides on society continue to be a subject of intense debate. A great deal of research identifies that pesticides have a significant range of impacts on human health, aquatic and terrestrial ecosystems. However, there are still significant differences of opinion expressed about the actual impacts of pesticides. Many in society share the views expressed by Carson (2000) in her book *Silent Spring* first published in 1962, that pesticides are "*elixirs of death*". The negative externalities resulting from pesticide use are why the Pesticide Action Network (PAN) has called for a 50 percent reduction in pesticide use over 10 years.[1] These views are supported by a large scientific literature. For example, Benton *et al.* (2003) observe an obvious impact on the agricultural landscape from the impact of pesticide use is the facilitation of intensification of agricultural production and the associated loss of farmland biodiversity. There are also numerous examples in the literature explaining how agricultural land use has impacted wildlife. Take birds as an example. Key amongst the factors cited by Evans (2004) for a dramatic effect on bird populations are pesticides applications. The impact of pesticides is typically indirect. Pesticides, specifically insecticides and herbicides, either kill invertebrate prey and or remove insect host plants and reduce the quantity of seed available as feed. However, despite the wealth of scientific evidence there still remains a degree of scientific uncertainty regarding the overall impacts of pesticides e.g., Royal Commission on Environmental Pollution (2005). Other researchers express a view summarised by Lomborg (2001), who argues that there is little evidence linking the existence of pesticides in food and the incidence of cancer. Indeed, when annual reports of the UK Pesticide Residue Committee (2003, 2004) are examined, the levels of

[1] For more details of the pesticide reductions demanded by PAN visit their website www.pan-uk.org.

pesticides detected as a result of an extensive sampling of all food types, that exceed Maximum Residue Levels are less than one percent. At the same time, taking bread as an example, of the ten surveys conducted between January 2000 and December 2005, some 60 percent of all samples yielded a detectable level of pesticide residues.

Regardless of which position is scientifically correct, there are many policies designed to minimise the potential negative impact of pesticides. Current examples include pesticide taxes in Denmark and Norway and the Voluntary Initiative in the UK (OCED, 2005). Economic research has played an important role in informing the choice and design of these policies that aim to deal with pesticide externalities. One particularly important facet of economic research has been the attempts to estimate consumers' willingness to pay (WTP) to reduce or avoid the negative impacts of pesticides (e.g., Foster and Mourato, 2000, Florax *et al.*, 2005, Travisi *et al.,* 2006, and Balcome *et al.,* 2007). The WTP estimates for environmental and human health improvements that result from changes in current pesticide usage provide an important input into cost-benefit studies of policy design and pesticide use. Given the potential importance of such estimates to policy makers, it is necessary to ensure that WTP estimates are consistent and meaningful.

In this paper we present WTP estimates derived from a choice experiment (CE) that examines food purchase decisions and reductions in pesticide use. An important feature of our CE is that we have attempted to delineate the key negative externality associated with two specific types of agricultural production. Thus, we divided our CE into two parts, so as to identify WTP to avoid environmental impacts and the WTP to avoid human health impacts. As has been noted by Travisi *et al.* (2006) no single payment vehicle appropriately captures the all known externalities that occur in food production. Specifically we used an 800g sliced loaf of white bread and a weekly basket of fruit and vegetables for our choice arenas. For the bread CE, the main impact of pesticide use is on the environment as a result of intensive cereals production. In the case of fruit and vegetables it is human health via pesticide residues. This approach to the CE allowed us to estimates a WTP to reduce the main impact of pesticide use associated with that form of production activity. We are of the opinion that our CE and resulting WTP estimates better capture public preferences for pesticide reduction than existing research, because of the specific focus of each of the CEs that differentiate between the impact of pesticides based on the agricultural production system and the resulting use of the crops produced.

Another important aspect of this study is that because of the scientific uncertainty and polarised views expressed about the precise impacts of pesticide use, we have not explicitly quantified the impacts of pesticide use in the design of our survey instrument. Instead we presented respondents with neutral information consistent with current scientific knowledge and asked them to choose across a range of active ingredient reductions.

Overall this research makes several contributions to the literature. First, we add to a small body of literature in the UK on WTP for pesticide reduction. Previous studies are Foster and Mourato (2000), Mourato *et al.* (2000) and Balcombe *et al.* (2007). Our research differs from these existing studies both in the design of the CE as well as econometric methods employed. The data from our CE are estimated using a conditional logit (CL) and a latent class model (LCM) to take account of heterogeneity. Our results indicate evidence of the presence of preference heterogeneity. The use of the LCM is growing in the agricultural and resource economics literature (e.g., Boxall and Adamowicz, 2002, Scarpa *et al.,* 2003, Hu *et al*., 2004, Scarpa and Thiene, 2005, and Milon and Scrogin, 2006). It is also the case that the use of the LCM to capture preference heterogeneity, as opposed to other econometric models such as the mixed logit, has been strongly supported by Louviere (2006). The reason for this support is that, as Louviere argues, the LCM avoids some of the simple but serious limitations of the other methods currently employed in the literature that attempt to capture preference heterogeneity.

Second, as we have already indicated, because of the design of our CE we present results that start to untangle the relationship between specific pesticide uses, and their potential external effects. In doing this we are able to present context specific WTP estimates. The evidence in the literature for differential environmental quality and human safety WTPs is mixed. Florax *et al.* (2005), summing WTPs already in the literature for the elimination of pesticide risks to both soil and biodiversity, found that they are larger than their elimination with respect to human health (yearly cases of poisoning). Indeed the WTP for the full abatement of soil contamination alone is higher than for human health. Conversely a UK study by Foster and Mourato (2000) suggests the opposite; that respondents are WTP higher premiums for human safety than environmental quality. More recently Balcombe *et al.* (2007) found that after accounting for mis-reporting[2], WTP for pesticide-free food is higher for environmental quality than for food safety concerned individuals. However, both Foster and Mourato, and Balcombe *et al.* did not specifically delineate food safety and environmental concerns.

Third, we employ our WTP estimates to calculate equivalent pesticide taxes. Our tax estimates contribute to a small literature (i.e., DEFRA, 2000 and Mourato *et al.,* 2000) that has previously attempted to estimate the appropriate level of a pesticide tax in the UK. Unlike the earlier studies, the tax estimates we present here are with respect to particular types of externality. Our estimates make a useful contribution to the literature, as the use and potential magnitude of a pesticide tax in the UK has been the subject of much debate. Currently, the UK approach to minimising the negative externalities is via an industry program, the Voluntary Initiative, which attempts to bring about best practice in pesticide use by initiating research, training, communication and stewardship (Voluntary Initiative, 2006). The Voluntary Initiative was introduced in April 2001 after a long debate about the appropriate policy mechanism to employ to deal with pesticide externalities. The Voluntary Initiative was initially meant to last for 5 years but it has recently extended on a two year rolling basis. However, there are still strong reasons to assume that a pesticide tax will be considered again, given the Voluntary Initiatives two year rolling window of continued operation.

The structure of the paper is as follows. We begin by reviewing the economic valuation literature on pesticides. Next, in Section 3 we describe the econometric models we use to estimate WTP. We then describe the CE survey instrument. In Section 5 we present our

[2] Mis-reporting is the term used in this paper to describe the situation when survey respondents, for whatever reason, provide a survey response that is inconsistent with their utility function.

WTP results and in Section 6 we calculate out pesticide tax estimates. Finally, in Section 7 we conclude.

2. Review of the Literature

There currently exist a number of non-market studies that have considered what consumers might be WTP to reduce pesticide impacts as well as the reasons for this reduction. A useful summary and meta-analysis of the literature to date that places in context existing WTP estimates is provided by Florax *et al.* (2005). In general the estimates presented in the literature attempt to measure WTP for pesticide risk reduction. In year 2000 annual dollar prices they report that society is WTP US$ 262 per annum to reduce the impact of pesticides on farmers, US$ 289 per annum to reduce the impact on the aquatic environment, US$ 246 per annum to reduce the impact on terrestrial ecosystems, and US$ 42 per annum to reduce impacts on consumers health. However, they also note that the WTP distributions are skewed such that mean is significantly greater than the median. Further, they are cautions in terms of interpreting these results as they acknowledge there are intrinsic heterogeneity effects of pesticide usage for various target types.

In related research Travisi *et al.* (2006) use a multidimensional classification method, 'decision tree induction', in order to explain the disparities in empirical estimates of WTP for reduced pesticide risks. Their comprehensive review of the pesticide valuation literature shows an increasing reliance on the use of multi-attribute stated preference (SP) CEs. These studies are appealing in that they can capture the 'non-use' existence value of public goods, while revealed preference (RP) are only able to elicit their 'instrumental-related worth'. What is apparent from both reviews of the literature is that the justification used to motivate non-market valuation of pesticides is complex, and that there exist significant differences in the estimates generated. These differences depend to a greater extent on a multitude of factors, from the type of valuation technique to the nature and availability of the data on pesticide risks.

In terms of studies that focus on the UK there are only two to date Foster and Mourato (2000) and Balcombe *et al.* (2007). Foster and Mourato estimated WTP by employing a contingent ranking methodology. The survey used to derive the data focused on very specific impacts of pesticide use. The impact on biodiversity was proxied by the decline in farmland bird species and the impact on human health related to farm operator exposure to pesticides during agricultural activity. As is acknowledged by the authors, these only represent a subset of the many potential impacts of pesticide use and that increasing the number of impacts increases the complexity of the choice task faced by survey respondents. They estimated that UK consumers are WTP £ 1.15 (or 191 percent extra) for a "green" loaf of bread in order to reduce to zero cases of ill health per year and the number of declining farmland bird species jointly.

In related research Mourato *et al.* (2000) employed the same data as Foster and Mourato (2000) to derive an estimate of a pesticide tax for the UK. They estimated a uniform tax of £12.59 per kg of pesticide. This tax estimate is based on a reduction of one case of human illness and the protection of one bird species. To place this estimate in context DEFRA (2000) estimated that a 30 percent reduction in pesticide use would require a tax of £6 per kg. These estimates can be compared to actual taxes employed in practice in other countries. For example, in Noway (Spikkerud, 2005) the base rate tax is approximately EUR 2.5 per hectare. The tax charged varies by band, reflecting human and environmental impacts. The highest band takes the base tax and multiplies by 150 (EUR 375 per hectare). These values are then adjusted by product specific standard area doses to yield a tax per kg. In the case of Denmark, Larsen (2005) explains how various taxes on agriculture are levied, including various pesticide taxes. The current tax system employs an *ad valorem* tax that in 1998 prices was set at approximately 50 percent of the retail price for insecticides and combined pesticides and slightly lower for fungicides and herbicides. If we follow Mourato *et al.* and assume that the price of pesticide in the UK is £20 per kg, then this 50 percent tax implies that the estimates presented by Mourato *et al.* are credible.

A more recent examination of the WTP to consume food produced without the use of pesticides is Balcombe *et al.* (2007). In this CE survey respondents had to make a choice between a basket of food produced using standard farming methods and those that do not employ pesticides. Employing Bayesian methods Balcombe *et al.* were able to derive socioeconomic specific WTP estimates for the change in food production technology and the associated reductions in negative externalities associated with pesticide use. For example, they found that older females who classified themselves as either food safety aware or environmentally sensitive were WTP 150 percent more for the non-pesticide food. In contrast young males who described themselves as price sensitive yielded a WTP of almost zero. Overall, the sample average was 90 percent. This percentage increase is significant but less than that estimated by Mourato *et al* (2000).

Finally, there exist other non-market valuation research on UK farming pratices and the reduction of chemical use. For example, Burton *et al.* (2001) employed a CE to estimate consumers WTP to avoid genetically modified produce. As part of the choice set offered they drew attention to some of the costs and benefits of chemicals. Burton *et al.* found that infrequent, occasional and committed purchasers of organic food were found ready to increase their food bills by 13 percent, 42 percent and 103 percent respectively for a 10 percent reduction in chemical usage.

Taken collectively, these studies suggest a large WTP for reductions in pesticide usage, whether motivated by human health, or concern for wildlife or the natural environment. However, we would regard some of these valuations as being on the upper end of our own prior subjective distributions. Furthermore, the existing UK studies only employed a single CE to derive estimates of the WTP to avoid and reduce the externalities associated with pesticide use. As we explained in the Introduction these effects are complex and they vary significantly by production system and type of good being produced. As a result the analysis we present attempts to further clarify the meaning of WTP in this context. It is also the case that the resulting tax estimates we present should better reflect the specific type of externality being considered.

3. Model specification, econometric estimation and existing research

Until recently it has been common practice to estimate a CL model when dealing with CE data. The typical way to modify CL estimates to take account of heterogeneity is by incorporating socio-demographic and/or other attitudinal parameters in the model (Boxall and Adamowicz, 2002). But since these characteristics are individual-specific and are invariant across choices, it is necessary to interact them with choice attributes, which requires *a priori* selection of both a limited number of socio-economic variables and attributes. Alternative approaches include the mixed (or random parameters) logit (ML) (McFadden and Train, 2000, and Train, 2003) and the LCM (Greene and Hensher, 2003). The ML assumes a continuity of preferences over some range of parameter values. Allowing parameters of the utility function to vary according to continuous parametric distributions enables the researcher to approximate complex preference structures. However, data based identification of groups having more or less homogenous preferences, may be more desirable in order to answer pertinent research and policy questions. In fact Boxall and Adamowicz suggest that the LCM explains heterogeneity, as opposed to only accounting for it. We do not completely concur with this interpretation. However, the LCM will outperform other models in circumstances where individuals preferences cluster in a way that cannot be explained by conventional classifications such as age, gender etc. While the use of these variables are widespread, the actual distribution of preferences may contain multiple modes that cannot be well modelled without an accurate prior knowledge of the factors which determine these modes. For this reason we employ the LCM in this paper.

The LCM assumes an underlying parametric distribution for taste parameters across individuals, approximating a discrete distribution, whereby segment probabilities and segment-specific utility functions are simultaneously estimated. The LCM allows for market segment probabilities to be explained by individual characteristics, by conditioning them on as set of variables that can either be socio-demographic or attitudinal.

Formally, assuming the existence of S segments in the population, and that individual n belongs to segment s, the multinomial conditional logit model (McFadden, 1973) for the probability of choosing alternative i on choice occasion t from the respondent n's choice set is:

$$p_{nit|s} = \frac{e^{\beta_s' X_{nit}}}{\sum_{s=1}^{S_n} e^{\beta_s' X_{nit}}} \qquad (1)$$

where $p_{nit|s}$ is the probability that individual n chooses option i given his membership to class s, X_{nit} is a vector of attributes of i and β_s a vector of parameters to be estimated. Next let Z_n be a vector of individual-specific variables, λ_s a vector of parameters to be estimated, and ζ_{ns} a vector of error terms. Segment membership is a random variable, and assuming that error terms are i.i.d. across individuals and segments, and Type I extreme value, or Gumbel, distributed, allows us to specify the joint probability p_{ns} for a given individual n to belong to a given segment s, as a multinomial logit:

$$p_{ns} = \frac{e^{\lambda_s' Z_n}}{\sum_{s=1}^{S} e^{\lambda_s' Z_n}} \qquad (2)$$

where $\sum p_{ns}$ must be equal to one, and $0 \le p_{ns} \le 1$. Thus, the joint probability of an individual n selecting an alternative i on occasion t, conditional on membership to segment s is $p_{nsit} = p_{ns} \cdot p_{nit|s}$, and the unconditional choice probability can therefore be characterised as follows:

$$p_{nit} = \sum_{s=1}^{S} p_{ns} \cdot p_{nit|s} = \sum_{s=1}^{S} \left(\frac{e^{\lambda_s' Z_n}}{\sum_{s=1}^{S} e^{\lambda_s' Z_n}} \right) \cdot \left(\frac{e^{\beta_s' X_{nit}}}{\sum_{s=1}^{S_n} e^{\beta_s' X_{nit}}} \right) \tag{3}$$

Thus, the LCM allows the parameters for individual-specific characteristics and choice attributes, represented by λ and β respectively, to be simultaneously estimated, and subsequently for them to jointly explain individual choices. Substituting the membership and choice equations for the probability terms p_{ns} and $p_{nit|s}$ respectively, we obtain the following log-likelihood function that modifies that of the standard CL model to accommodate segment membership probabilities:

$$\log L(\beta_s, \lambda_s) = \sum_{n=1}^{N} \sum_{t=1}^{T_n} \sum_{s=1}^{S_n} y_{nit} \cdot \log \left[\sum_{s=1}^{S} \left(\frac{e^{\lambda_s' Z_n}}{\sum_{s=1}^{S} e^{\lambda_s' Z_n}} \right) \cdot \left(\frac{e^{\beta_s' X_{nit}}}{\sum_{s=1}^{S_n} e^{\beta_s' X_{nit}}} \right) \right] \tag{4}$$

where N is the number of sampled respondents, T_n the number of the respondent's choice sets and y_{nit} an indicator variable that equals one if respondent n chooses option i and zero otherwise. This specification assumes that the multiple choices made by each individual are independent. The parameters are estimated using maximum likelihood estimation (MLE). It also takes as given the number of segments S, which therefore have to be selected *a priori* by the researcher. Choosing the 'optimal' number of segments is done by means of statistical information criteria that weight the benefits of improved model fit against the undesirable effect of adding new parameters. Two such criteria are commonly used in the literature: the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC).

Finally, attribute specific WTP estimates (i.e., Marginal Rate of Substitution) are typically estimated as follows:

$$WTP_n = -\sum_{s=1}^{S} p_{ns} \cdot \left(\frac{\beta_{as}}{\beta_{ps}} \right) \tag{5}$$

where β_{as} is a segment-specific non-monetary coefficient and β_{ps} is a monetary coefficient. But, our WTP estimates are ratios of sums of parameters assumed to be drawn from a multivariate normal distribution they are complex non-linear functions of the estimated parameters. As a result we employ simulation methods (i.e., bootstrapping) for both CL and LCM models following Hensher and Greene (2003) whereby we generate empirical distribution of WTP which yield point and confidence intervals.[3]

4. Survey Design and Choice Experiment

In the literature it is understood (e.g., Travisi *et al.,* 2006) that no single payment vehicle will appropriately capture the documented food safety and environmental safety effects that are known to occur as a result of food production. As a result we decided to employ two CEs for two different types of food with fundamentally different production systems, pesticide risks and payment vehicles. In the case of bread, the impacts of pesticide use are almost all environmental. There is a significant body of scientific evidence that shows that the extensive application of pesticides in large-scale arable farming, to facilitate mono-cropping, has contributed directly and indirectly to the decline of farmland bird species (e.g., Benton et al., 2003 and Evans, 2004). In the case of fruit and vegetables the issue of food safety, in the form of pesticide residues, is foremost. This occurs because of the intensive nature of pesticide applications and the relative importance of insecticide and moluscicides in horticultural crops (PRC, 2004). On the other hand, the environmental effects of fruit and vegetable production, are considered negligible compared to arable crops, not least since they are carried out over a much smaller surface area than is the case in sprayed or conventional arable agriculture (Garthwaite *et al.*, 1999, 2000, 2002 and 2004).

In our CEs we employed the food purchase decision as the payment vehicle by which individuals would express their WTP for reduced or no pesticide usage. To do this we employed the price of bread and the cost of a weekly household basket of fresh fruit and vegetables. To ensure that these payment vehicles were credible we needed survey respondents to understand the link between pesticide use in different agricultural production contexts and the relationship to specific types of food purchase. We also needed to ensure that respondents were informed about the current state of knowledge on pesticide potential risks and impacts.

4.1 The Survey Design

For the two CEs the attributes and associated levels employed are shown in Tables 1 and 2

{Approximate Position of Tables 1 and 2}

In each CE respondents were presented with three choice cards, each consisting of three agricultural production practices:

- *Policy A:* current farming practices and national levels of pesticide applications
- *Policy B:* a green policy employing less pesticides than under the status quo
- *Policy C:* a nationwide ban on pesticide use

[3] Segment-membership probabilities are considered to be non-stochastic in the bootstrapping exercises, they are assumed to be fixed estimate. The reason for that is that these probabilities must add up to one. Introducing an error term to the bootstrapping exercise would compromise this condition.

The payment levels for both experiments were carefully selected to be typical of the current levels of consumer prices and expenditures in the UK. The level describing the price of the 'Standard' loaf was chosen following an overview of price ranges as advertised in store and on the websites of the main UK grocers. The same applies for the 'No Pesticides' loaves, who's price range more or less matched that of typical organic loaves. For the fruit and vegetable basket, the level of price of the 'Standard' basket was based on the 2002-2003 national average weekly expenditure on fresh fruits and vegetables in the UK, following a governmental report by the Office for National Statistics (2004). The price levels of both the 'Green' and the 'No Pesticides' baskets were then chosen to cover realistic ranges.

The alternatives and choice sets were constructed by developing a fractional factorial main impacts design of the 'Green' alternatives. This yielded 27 attribute bundles. The full profile of 'No Pesticides' options, consisting of three attributes bundles, was replicated nine times, again giving 27 alternatives. Finally, we combined alternatives from both profiles, plus the 'Standard' baseline option, which gave 27 choice sets. To balance the design, we made sure that in the 'Green' profile, each of the three proposed prices was combined three times with each of the three prices for the 'No Pesticides' alternatives. The initial choice sets profile was then reduced to 24 sets to account for dominant alternatives. These sets were grouped in blocks of three choice cards and numbered one to eight.

The survey instrument was presented to two focus groups and piloted before finally being distributed. We posted the survey out to 3,000 households. The sample was stratified according to age, income and county of residence and was purchased from a commercial company. The total number of respondents was 467 (response rate of 15.8%). The final number of analysable questionnaires was 420. Comparing the sample to the national average figures, our sample is reasonably representative of the UK population. Finally, the survey also collected data on various socio-demographic, behavioural and attitudinal characteristics and these variables are presented in Table 3.

{Approximate Position of Table 3}

5. Analysis and Results

We begin our analysis of the data by examining the basic pattern of survey responses. This provides useful information regarding the validity of our data. Having screened the data for irrational responses and removing a number of survey returns we are then in a position to present econometric estimates for the CL and LCM.[4] Subsequently, we estimate a seemingly unrelated regression model using Generalised Least Squares (GLS) to explain the segment membership. Finally, we present simulated point and confidence interval estimates of WTP for both CEs.

5.1. Initial Analysis

[4] A LCM with more than three classes was not examined as the number of segments should preferably not be larger than the number of choice sets presented to each respondent (Greene, 2002b).

The survey returns for both CEs provided some interesting initial results in terms of choices made. These results are shown in Table 4.

{Approximate Position of Table 4}

First, we found there to be an absence of a *status quo* bias in the responses. There is a strong preference for the 'Green' and 'No Pesticides' options despite their high prices/costs. Second, the probability of choosing 'Green' options only drops with the highest price/cost level (0.95 £/loaf and 9.50 £/week fruits and vegetables). On the other hand, the probability of choosing the 'No Pesticides' option increases from the lowest price/cost level (0.85 £/loaf and 8.50 £/week) to reach a plateau at the two higher payment levels. The impact of these irrational responses on the LCM estimates was immediately obvious. For both CEs we found that the LCM estimated using two or three segments contained one segment with a positive and significant payment parameter.[5] This indicates a preference for higher prices, an apparently irrational response. We can potentially explain this result as follows. What motivates this commitment to 'No Pesticides' options, is the strong bias on the part of some respondents to a technology change i.e., zero pesticide applications. In contrast, the 'Green' option always relates to a decrease in current pesticide use for the existing agricultural technology. This suggests that improvements within the context of the current technology are more likely to be weighed against price increases, while a change in technology is more likely to dominate the price effect. Thus, the correlation between positive price parameters in one latent segment and a certain survey response pattern is symptomatic of protest responses, yea-saying and/or lexicographic responses. In light of this finding we removed these responses from our data used to conduct our analysis and estimation of WTP.[6]

5.2. Model Results

For both CEs we estimated the standard CL and LCMs with two and three classes. We found that for the Bread CE, a three segment LCM performed best, whereas for the Fruit and Vegetable CE a two segment LCM was preferred. For each model we included a payment variable, the Green alternative specific constant and the three pesticide variables included in the CEs. The resulting parameter estimates for the best performing models are shown in Table 5.

{Approximate Position of Table 5}

Overall the results in Table 5 show that both models have negative and significant payment parameters in all their segments as we would expect. Furthermore, membership probabilities are statistically significant for all segments in both CEs. To aid interpretation, we have normalised the Payment parameter estimates to one in each segment to enable comparison of the magnitudes of partworths across segments. We have also adjusted the remaining attributes and standard errors proportionately.

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[5] These results and more extensive of analysis of the motivation of the respondents is available from the authors on request.

[6] Milon and Scrogin (2006) using a LCM, obtain WTP estimates for one class that are inconsistent with economic theory, a positive price parameter. These results are omitted from the analysis presented in the paper.

5.2.1. Bread CE

Starting with the Bread CE the majority of respondents (51.7 percent) belong to segment one. For this segment, all pesticide partworths are positive and statistically significant, and more or less evenly balanced across the three pesticide categories. This suggests that respondents view all pesticide classes negatively and wish them to be reduced. An interpretation of segment membership may be that these respondents wish to see across the board reductions in pesticide use. On average, members of this group are WTP an extra 61, 44 and 75 percent, for the elimination of Insecticides, Herbicides and Fungicides from cereal production, respectively.[7] This amounts to a total premium of 180% for the elimination of all pesticides i.e., approximately 90 pence.

For segment two there is a much smaller membership i.e., 19.8 percent. First, all partworths are highly statistically significant. Second, the partworth for 'Green' (21 percent of baseline price) is lower in value relative to all the pesticide partworths. This is the reverse of the other two segments. This indicates that respondents in this segment have a lower preference for food produced using reduced levels of chemical inputs, compared to the other two segments. Also the negative partworth for Insecticide indicates a preference for increases in insecticide applications. Thus, respondents in this segment will require that the price of a loaf of bread be reduced by 72.4 percent if pesticides are to be eliminated from UK cereal production. So, respondents in this segment potentially value Insecticide use. However, more likely is that this negative partworth reveals that choice cards answers were informed by the respondents' prior beliefs about pesticides, with little influence from the background information provided. Overall respondents in this segment are WTP a premium of 52.2 percent of the baseline price for an all-out elimination of pesticide use from cereal production.

Finally, the third segment contains the remaining 28.4 percent of the sample. The partworth for 'Green' indicates that respondents in this segment seem to be comparably motivated by reduced input farming. All parameter estimates are statistically significant except for Fungicide. As with segment two we have a negative partworth, although this time it is for Herbicide. However, unlike segment two the negative partworth almost cancels out the other pesticide partworths. This suggests that respondents in this segment place a near zero WTP on pesticide reduction.

5.2.2. Fruit and Vegetable CE

We now examine the results for our Fruit and Vegetable CE. The preferred model specification was for two segments, with membership split roughly into one third to two thirds. For the first segment the highest partworth is for 'Green'. The premium for Green is equivalent to 99.4 percent of the baseline weekly cost of the fruit and vegetable basket. Partworths for Insecticide and Herbicide are both significant and positive at 51.7 percent and 54.2 percent respectively. Finally, the partworth for Fungicide, though negative, is insignificant. Overall, this segment's respondents were willing to increase their weekly expenditure on fruits and vegetables by 88.7 percent (i.e., £5.30) if pesticide use were to be eliminated from UK fruit and vegetable production.

[7] For example, we derive 61 per cent for insecticides in segment 1 as 0.307/0.5 x 100.

Turning to the second segment the results are somewhat different. First, most partworths are lower compared to segment 1. Second, the partworths for all pesticides are greater than for 'Green'. Third, the partworth for Fungicide is positive, statistically significant and relatively large. This indicates concern about Fungicide use. Fourth, the partworth for Insecticide is negative indicating that respondents likely to be in this segment require that their weekly expenditure on fruits and vegetables be reduced in price in order to purchase insecticide-free food. This result might reflect respondent's prior beliefs about the impact of Insecticides on the quality, and lack of insect contamination, of the fruit and vegetables they buy. Finally, the partworth for Herbicide was positive and statistically significant, but much lower in value than that for Fungicide reduction. Overall, these results indicate that respondents in this segment are WTP 10 percent more for their weekly expenditure on fruit and vegetables produced under pesticide free conditions. This estimate is much lower than compared to the first segment, suggesting that respondents in this segment are indifferent to pesticide reduction and its potential safety implications in fruits and vegetables.

The results for the Fruit and Vegetable CE, for both segments, provide important insights into the way in which the information on particular pesticide impacts provided in the survey was understood by respondents. We informed respondents that Fungicide use and Insecticide use are the pesticide classes most likely to leave harmful residues. We also explained that Insecticides pose the greater health risk. Because of the link between pesticide type and human health we expected that Insecticide reduction would have the highest partworth, followed by Fungicides and then Herbicide. This outcome has not been found for either segment. As a result we are of the opinion that respondents relied to a greater extent on their pre-conceptions of pesticides in order to make their trade off between different attributes.

5.3. Explaining Segment Membership

Following Greene (2002a) we now employ a seemingly unrelated regression equations (SURE) model using Generalised Least Squares to facilitate the interpretation of the segments. Both SURE models are estimated to explain segment membership in terms of socioeconomic and attitudinal characteristics. Are results are presented in Table 6.

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{Approximate Position of Table 6}

For Bread, CE membership of segment one is positively related to individuals who are occasional purchasers of organic food (Occasional Organic). This could be because Occasional Organic consumers are more functional in their organic purchasing and would consider food with reduced pesticides as a substitute. We also find that 'Conservative' respondents are less likely to belong to this segment. Two characteristics that are almost statistically significant at the 10 percent level are Income and Food Safety. While respondents with higher incomes are less likely to belong to this segment, people with food safety as their main concern are more likely to belong to it.

Turning to segment two, the statistically significant parameters were Conservative and Occasional Organic. The Conservative parameter is in this case positive, meaning that Conservative voters are more likely to belong to this segment. Also Female and Age are nearly significant. The first has a positive parameter that is a rather surprising result and it needs to be reconciled with women's generally stronger concern over food safety. One could argue that insecticides are associated with visible 'bugs' in the food, the elimination of which is desired, especially by members of the household who are most likely to handle food. The second result is expected, with age comes experience, and probably better understanding of pesticide risks. Hence, older respondents are less likely to have such extreme attitudes towards pesticides.

For the third segment we find significant and negative parameter estimates for Frequent Organic, Occasional Organic and Environment. These three characteristics directly or indirectly pertain to environmental awareness. Therefore, we can argue that respondents who are environmentally aware are less likely to be members of this segment.

Turning to the Fruit and Vegetable CE our statistical results attempting to explain segment membership are weak. This is partly because the model constrains parameters in both segments to be equal in absolute value but opposite in sign. Thus, a parameter significant for one segment has to be equally significant for the second. Overall, the only parameter that is nearly significant at the 10% significance level is Int. Education which appears positively correlated with membership of the less doctrinal group two.

5.4. WTP estimates

We now examine the WTP estimates for a number of pesticide reduction levels. We only consider pesticides as a whole rather than by specific type. This is because our results indicate that survey respondents have, on the whole, replied consistently only with respect to pesticide reductions in general. For both CEs, all the WTPs estimates are based on the payment vehicles. These are a standard 800g sliced loaf of white bread in the case of the Bread CE, and a weekly basket of fresh fruits and vegetables for the Fruit and Vegetables CE. For the sake of comparison we present WTP for the CL and LCM specifications. For the LCM, segment-specific estimates are also presented. Our results are presented in Table 7.

{Approximate Position of Table 7}

The most obvious feature of Table 7 is that the WTP estimates increase with increasing pesticide reduction levels. We can also see that both LCMs consistently yielded larger WTPs than the CL models. For the Bread CE, the LCM estimates were larger than the CL estimates by 18.6 percent. For the Fruit and Vegetables CE, estimates increased by 71.8 percent.

Looking at the Bread CE, consumers in segment one have the highest WTPs compared to the other segments. The WTP premium is worth 45 pence if pesticide applications in the UK were halved, and 90 pence if they were eliminated. In contrast, segment two consumers had lower WTPs, whereby consumers' WTP is 13 pence and 26 pence respectively. Finally, and as we would anticipate from the results reported in Table 5 the WTP estimates are not statistically different from zero.

How do these results compare to those previously reported in the literature? These WTP estimates can be compared to Foster and Mourato (2000) CE. Both employ the same payment vehicle (i.e., a standard 800g sliced loaf of white bread). However, Foster and

Mourato considered both human health and environmental quality. Thus, comparing the WTP magnitudes for these two scenarios yields some valuable insights. The WTP Foster and Mourato obtain for an elimination of pesticide risks to farmland birds in the UK, amounts to a premium of 79 percent. In comparison, the WTPs derived here are similar in magnitude with the LCM yielding an estimate of 102 percent and the CL giving an estimate of 83 percent.

For the Fruit and Vegetables CE, segment one consumers are WTP a premium that amounts to £2.07 if pesticide application in UK horticultural production were halved and £5.35 if they were eliminated. Contrast these values with those for segment two where consumers are only WTP 26 pence and 51 pence respectively.

Finally, comparing the two CEs, an interesting observation can be noted. Both the CL and LCM WTPs show that consumers' WTP is higher, in percentage terms, for the environment than food safety. Again, this observation assumes that the survey design succeeded in restricting the respondents' attention to the environment in the first CE, and then to food safety in the second. Also, it is assumed that the difference in the order of magnitude between the payment vehicles in both CEs have no impact on the relative premiums.

6. WTP and Pesticide Taxation

We now present estimates for various forms of a pesticide tax based on the WTP estimates reported in the previous section. Our estimates add to those of Mourato *et al.* (2000) and DEFRA (2000) discussed earlier. Like the earlier studies we do not consider a 100 percent reduction in pesticide use. Instead we assume a 5 percent reduction. For both CEs we have derived the relative WTP for this level of pesticide reduction.

Like Mourato *et al.* our pesticide tax estimates are calculated assuming several important simplifications. Beginning with the Bread CE, first, we assume that UK wheat production can be divided equally between that used to make bread and other uses such as animal feed (HGCA, 2006). In turn we assume that only half of the annual pesticide applications that are used on wheat crops relate to bread production. Second, the environmental impact of each loaf of bread is assumed to be equal to one. Third, we assume that imports and exports of milling wheat and bread are small relatively to size of production and bread consumption. This assumption is supported by industry statistics (e.g., Federation of Bakers, 2005, and HGCA, 2006). Fourth, we assume that the bread consumption remains unchanged. We could follow Mourato *et al.* and adjust demand assuming an own price elasticity of demand. However, estimates in the literature suggest that bread is highly inelastic being less than -0.1. This approach is also consistent with random utility theory, whereby the effect of a price increase on utility is offset by the desirable reduction in pesticide use.

Turning to the Fruit and Vegetable CE, first, we make the same assumption regarding imports and exports. Second, we assume that all fruit and vegetables produced are consumed via the basket. Third, the potential health impacts are equal to one for each basket. Clearly, the assumptions we make for the Fruit and Vegetable CE are strong but are required to allow us to derive our pesticide tax estimate.

We begin with the Bread CE and Environmental quality. We assume a target level of 5 percent pesticide reduction used in cereal production. From the analysis performed to construct Table 7 this yields an individual WTP 2.15 p/loaf. Next we assume that there are 25 million households (Office of National Statistics, 2004) in the UK each consuming 86 loaves of bread per annum (Federation of Bakers, 2005). These figures produce an aggregate WTP of approximately £46 million per annum. In terms of wheat production, annual applications of pesticides used in cereal crops in 2004 amounted to approximately 13 million kg of active ingredient (a.i.) (Central Science Laboratory, 2006). However, only half the wheat produced in the UK are used to make bread so only 6.5 million kg a.i. are applicable for the tax calculation. Employing the same approach as Mourato *et al.* (2000) we calculate the tax, applied uniformly to all pesticide classes, as being equal to £7.07 per kg a.i. to be added to the price of pesticides.

We compute the pesticide tax for the Fruit and Vegetable CE in much the same way. From our WTP calculations we find a weekly WTP of £0.12 per household for a 5 percent reduction in pesticide use. For the number of households nationwide, the yearly WTP for the UK population would amount to £156 million. The annual volume of pesticide applications for all fruit and vegetable in the UK is 1.5 million kg a.i. (Central Science Laboratory, 2006). However, unlike for bread a significant proportion of fruit and vegetables consumed in the UK is sourced overseas (DEFRA, 2005). For example, for fresh vegetables in 2005 some 40 percent by value was imported which is an increase of 10 percent over 10 years. For fresh fruit 90 percent by value was imported in 2005. These figures require us to employ only a proportion of the total WTP to calculate the tax. As the total value of supply from the two sectors is similar this implies that domestic production constitutes 35 percent. Thus, the pesticide tax for this form of agricultural production in the UK is equal to £36.4 per kg a.i. which is higher than the environmental quality tax.

These two pesticide tax estimates raise an interesting issue. Our pesticide tax estimates capture differences in agricultural production systems and the associated damages. To date pesticide tax estimates have been based on rates of applications, as well as the chemicals' likely damage effects. What we have identified here are the potential differences in a tax based on the production system and the associated negative externalities. Although the difference in the estimates might appear unrealistic it is interesting to recall that in Norway the base rate for tax can be multiplied by up to 150 for pesticides considered to have significant impact on human health and the environment.

We can also consider if a taxes of this magnitude will achieve the target reduction of 5 percent of pesticide use. Focusing on the Bread CE, ideally, our tax estimate needs to result in a decrease in pesticide applications that is exactly equal to 5 percent if welfare is to be optimized. This means that the price-elasticity of demand for pesticides needed to achieve this reduction level should be equal to -0.18.[8] In the case of wheat production, this elasticity is ballpark. The DEFRA (2000) study in a review of the applied econometric literature found that this elasticity to be in the range of -0.2 to -0.8. Thus, the WTP estimate for reduced pesticide use in wheat appears credible.

[8] We calculate this as the percentage change in quantity (i.e., 5 per cent) divided by the percentage change in price, which is equal to the WTP estimate 7 divide by the price of kg of standard pesticide 25 times 100.

7. Summary and Conclusions

In this paper we present the results for two CEs conducted simultaneously and looking into the public's WTP to reduce pesticide use in food production. Our WTP estimates contribute to the literature on pesticide valuation in general and the UK in particular. We would argue that because of the use of two CEs that differentiate between the impact of pesticides (i.e., environmental vs. human health) that our WTP estimates potentially more accurately capture public preferences than existing research. In general our WTP estimates are lower, in terms of percentage increases from the status quo, than those reported by Foster and Mourato (2000) and Mourato *et al.* (2000) for the bread experiment. This result is also true in absolute terms, though this can partly be attributed to the fact that the baseline price chosen for 'standard' loaves in their experiment is higher than the one in the experiment presented here.

Our WTP estimates have also been used to calculate pesticide tax estimates. Our estimates add to a small but important literature that informs policy design. Given the nature of pesticide policy design in the UK our estimates provide further important empirical evidence with which to examine the feasibility of adopting a pesticide tax as opposed to the current Voluntary Initiative.

We also find strong evidence for the presence of heterogeneity in public attitudes towards reductions in pesticide categories, with respect to environmental quality and food safety. Indeed the latent class analysis identifies the presence of 3 preference groups in the Bread CE and 2 in the Fruits and Vegetables CE. Unfortunately, explaining these segments proved to be problematic, as the parameter estimates rarely reflected the information provided to respondents on the potential negative impacts of different pesticide categories prior to the choice tasks.

Finally, our results suggest that beyond the values that the public attaches the reduction of pesticides as a whole, any attempt to decompose these values along different use-categories will result in irrational associations. Although a rather disappointing result it does indicate that in future research more attention needs to be directed toward increasing the understanding of survey respondents. An examination of the literature suggests that the approaches recently employed by MacMillan *et al.* (2006) and Svedsater (2007) warrant further investigation to deal with this issue of information, understanding and preference formation. It is also the case that in designing future experiments to examine pesticide use that we follow the approaches adopted by Alberini *et al.* (2003) or Evans *et al.* (2004), and explicitly ask respondents to reveal their degree of response uncertainty and then use that information when estimating WTP.

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Table 1: Attributes and Levels Used in the Bread CE

Attribute		Type of bread loaf		Levels
PAY_B	Price of a loaf in £	Standard	(A)	£ 0.50 per loaf
		Green	(B)	£ 0.60 per loaf £ 0.75 per loaf £ 0.95 per loaf
		No Pesticides	(C)	£ 0.85 per loaf £ 1.05 per loaf £ 1.35 per loaf
INS_B	Proportion reduction in the usage of insecticide active ingredients in the UK arable production	Standard	(A)	0.00
		Green	(B)	0.20 0.50 0.80
		No Pesticides	(C)	1.00
HER_B	Proportion reduction in the usage of herbicide active ingredients in the UK arable production	Standard		0.00
		Green	(B)	0.20 0.50 0.80
		No Pesticides	(C)	0.00
FUN_B	Proportion reduction in the usage of fungicide active ingredients in the UK arable production	Standard	(A)	0.20
		Green	(B)	0.50 0.80 1.00
		No Pesticides	(C)	100 %
GRN_B	ASC accounting for 'Green' options			1 if type is 'Green' 0 otherwise

Table 2: Attributes and Levels Employed in the Fruit and Vegetable CE

Attribute		Type of fresh fruit & vegetable basket		Levels
PAY_FV	Weekly cost of a household basket of fresh fruits and vegetables	Standard	(A)	£ 6.00 per week
		Green	(B)	£ 6.50 per week £ 7.50 per week £ 9.50 per week
		No Pesticides	(C)	£ 8.50 per week £ 10.50 per week £ 13.00 per week
INS_FV	Proportion reduction in the usage of insecticide active ingredients in the UK horticultural production	Standard	(A)	0.00
		Green	(B)	0.20 0.50 0.80
		No Pesticides	(C)	1.00
HER_FV	Proportion reduction in the usage of herbicide active ingredients in the UK horticultural production	Standard		0.00
		Green	(B)	0.20 0.50 0.80
		No Pesticides	(C)	1.00
FUN_FV	Proportion reduction in the usage of fungicide active ingredients in the UK horticultural production	Standard	(D)	0.00
		Green	(B)	0.20 0.50 0.80
		No Pesticides	(C)	1.00
GRN_FV	ASC accounting for 'Green' options			1 if type is 'Green' 0 otherwise

Table 3: Socioeconomic Variables

Variable	Description
Fem	Dummy variable which takes the value of '1' if the respondent is a female, and '0' if a male
Inc	Respondent's household income before tax (£ / year)
Env	Dummy variable which takes the value of '1' if the effects of pesticides on the environment is the main aspect relating to food that affected the respondent's choices, and '0' otherwise
Food	Dummy variable which takes the value of '1' if the effects of pesticide residues on the food safety is the main aspect relating to food that affected the respondent's choices, and '0' otherwise
Age	Respondent's age (years)
Coup	Dummy variable which take the value of '1' if the respondent is married or lives with a partner, and '0' otherwise
Chil	Dummy variable which take the value of '1' if the respondent's household has dependents, and '0' otherwise
Int_Edu	Dummy variable which take the value of '1' if the respondent holds an A-level or college qualification, and '0' otherwise
Hi_Edu	Dummy variable which take the value of '1' if the respondent holds a university degree, and '0' otherwise
Org_Occ	Dummy variable which take the value of '1' if the respondent buys organic or green products more than once a month but less than once a week, and '0' otherwise
Org_Freq	Dummy variable which take the value of '1' if the respondent buys organic or green products at least once a week, and '0' otherwise
Lab	Dummy variable which take the value of '1' if the respondent's highest affinity is with the Labour Party, and '0' otherwise
Cons	Dummy variable which take the value of '1' if the respondent's highest affinity is with the Conservative Party, and '0' otherwise
Lib_Dem	Dummy variable which take the value of '1' if the respondent's highest affinity is with the Liberal Democratic Party, and '0' otherwise
GW_Less	Dummy variable which take the value of '1' if the respondent thinks that the impacts of pesticides less important than global warming, and '0' otherwise

Table 4: Break Down of Survey Returns

Bread and Environmental Safety				Fruits and Vegetables and Food Safety			
Price (£/loaf)	Standard	Green	No pesticides	Weekly cost (£/week)	Standard	Green	No pesticides
0.50	17.4%	-	-	6.00	18.6%	-	-
0.65	-	20.1%	-	6.50	-	20.9%	-
0.75	-	20.3%	-	7.50	-	21.1%	-
0.95	-	12.5%	-	9.50	-	14.1%	-
0.85	-	-	7.3%	8.50	-	-	6.4%
1.05	-	-	11.3%	10.50	-	-	9.4%
1.35	-	-	11.0%	13.50	-	-	9.5%
Total	*17.4%*	*52.9%*	*29.7%*	*Total*	*18.6%*	*56.1%*	*25.3%*

Number of observations (N) = 1260

Table 5: LCM estimates for the Bread CE and Fruits and Vegetables CE

	Bread CE			Fruits and Vegetables CE		
Variable	Coeff.	SE	P-value	Coeff.	SE	P-value
Payment I 1	-1.000	0.151	0.000	-1.000	-0.170	0.000
Green I 1	0.495	0.042	0.000	5.963	-0.316	0.000
Insecticide I 1	0.307	0.090	0.001	3.101	-0.972	0.001
Herbicide I 1	0.220	0.089	0.013	3.252	-1.028	0.002
Fungicide I 1	0.373	0.090	0.000	-1.034	-0.951	0.277
Payment I 2	-1.000	0.148	0.000	-1.000	-0.102	0.000
Green I 2	0.104	0.019	0.000	0.508	-0.115	0.000
Insecticide I 2	-0.362	0.070	0.000	-0.860	-0.385	0.026
Herbicide I 2	0.483	0.071	0.000	0.722	-0.333	0.030
Fungicide I 2	0.140	0.058	0.016	1.740	-0.373	0.000
Payment I 3	-1.000	0.254	0.000	-	-	-
Green I 3	0.456	0.051	0.000	-	-	-
Insecticide I 3	0.917	0.189	0.000	-	-	-
Herbicide I 3	-1.111	0.181	0.000	-	-	-
Fungicide I 3	0.201	0.154	0.192	-	-	-
Pr(Segment 1)	0.517	0.051	0.000	0.678	0.038	0.000
Pr(Segment 2)	0.198	0.038	0.000	0.322	0.038	0.000
Pr(Segment 3)	0.284	0.055	0.000	-	-	-
Pseudo R^2		*0.2843*			*0.3369*	
Log likelihood		*-796.51*			*-751.09*	
Respondents (N)		*338*			*344*	
Observations (T)		*1014*			*1032*	

Table 6: GLS estimates for the system of logistically transformed individual segment

Bread CE

	Segment 1		Segment 2		Segment 3	
Variable	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value
Constant	-0.855	0.278	-2.517	0.004	-1.239	0.008
Female	-0.007	0.983	0.533	0.118	-0.165	0.372
Income	-1.47E-05	0.128	1.627E-06	0.878	6.008E-06	0.298
Environment	0.396	0.313	0.338	0.432	-0.488	0.037
Food Safety	0.495	0.140	-0.087	0.812	-0.135	0.499
Age	0.011	0.276	-0.018	0.119	0.005	0.418
Couple	0.235	0.505	-0.249	0.518	-0.099	0.636
Dependents	-0.221	0.501	-0.027	0.941	0.274	0.161
Int. Education	-0.169	0.624	0.092	0.808	0.154	0.452
High Education	0.197	0.659	-0.026	0.957	-0.037	0.890
Occasional Organic	0.587	0.056	-0.679	0.044	-0.328	0.074
Frequent Organic	0.476	0.324	0.015	0.978	-0.816	0.005
Labour	-0.170	0.649	0.504	0.220	-0.198	0.375
Conservative	-0.696	0.076	1.099	0.011	0.098	0.675
Liberal Democrat	-0.178	0.701	0.798	0.117	-0.239	0.388
Global Warming	0.217	0.514	-0.066	0.856	0.038	0.848
Log Likelihood			*-2035.325*			

Number of respondents (N) = 338

Fruits & Vegetables CE

	Segment 1		Segment 2	
Variable	Coeff.	P-value	Coeff.	P-value
Constant	1.652	0.066	-1.652	0.066
Female	-0.375	0.286	0.375	0.286
Income	-1.197E-05	0.282	1.197E-05	0.282
Environment	-0.218	0.627	0.218	0.627
Food Safety	0.344	0.369	-0.344	0.369
Age	0.006	0.621	-0.006	0.621
Couple	0.511	0.205	-0.511	0.205
Dependents	-0.185	0.620	0.185	0.620
Int. Education	-0.634	0.102	0.634	0.102
High Education	-0.015	0.976	0.015	0.976
Occasional Organic	0.361	0.303	-0.361	0.303
Frequent Organic	-0.113	0.835	0.113	0.835
Labour	0.021	0.961	-0.021	0.961
Conservative	-0.126	0.774	0.126	0.774
Liberal Democrat	-0.293	0.577	0.293	0.577
Global Warming	0.155	0.685	-0.155	0.685
Log Likelihood		*1418.354*		

Number of respondents (N) = 344

Table 7: WTP Point and Interval Estimates

Welfare Estimates and 90% confidence intervals for the Bread CE

WTP (£/loaf)	Reduction in pesticide usage (%)					
	10%	30%	50%	70%	90%	100%
CL	0.04 *(0.04 – 0.05)*	0.13 *(0.11 – 0.14)*	0.21 *(0.19 – 0.24)*	0.30 *(0.26 – 0.33)*	0.39 *(0.34 – 0.43)*	0.43 *(0.38 – 0.48)*
LCM-3						
All	0.04 *(0.04 – 0.06)*	0.15 *(0.11 – 0.19)*	0.26 *(0.19 – 0.32)*	0.36 *(0.27 – 0.44)*	0.46 *(0.34 – 0.57)*	0.51 *(0.38 – 0.63)*
Segment 1	0.09 *(0.07 – 0.11)*	0.27 *(0.23 – 0.33)*	0.45 *(0.38 – 0.54)*	0.64 *(0.53 – 0.76)*	0.82 *(0.69 – 0.98)*	0.91 *(0.76 – 1.08)*
Segment 2	0.03 *(0.02 – 0.03)*	0.08 *(0.06 – 0.09)*	0.13 *(0.10 – 0.16)*	0.18 *(0.14 – 0.22)*	0.23 *(0.18 – 0.28)*	0.26 *(0.20 – 31)*
Segment 3	0.00 *(-0.03 – 0.02)*	-0.01 *(-0.11 – 0.06)*	-0.02 *(-0.19 – 0.09)*	-0.02 *(-0.27 – 0.13)*	-0.03 *(-0.35 – 0.17)*	-0.04 *(-0.39 – 0.19)*

Number of respondents (N) = 338

Welfare estimates and 90% confidence intervals for the Fruits and Vegetables CE

WTP (£/week)	Reduction in pesticide usage (%)					
	10%	30%	50%	70%	90%	100%
CL	0.24 *(0.18 – 0.29)*	0.72 *(0.55 – 0.88)*	1.21 *(0.91 – 1.47)*	1.69 *(1.28 – 2.05)*	2.17 *(1.65 – 2.64)*	2.41 *(1.83 – 2.93)*
LCM-2						
All	0.41 *(0.35 – 0.49)*	1.24 *(1.05 – 1.46)*	2.07 *(1.75 – 2.44)*	2.90 *(2.45 – 3.41)*	3.72 *(3.14 – 4.38)*	4.14 *(3.49 – 4.87)*
Segment 1	0.54 *(0.44 – 0.64)*	1.61 *(1.32 – 1.93)*	2.68 *(2.21 – 3.21)*	3.75 *(3.08 – 4.50)*	4.81 *(3.97 – 5.77)*	5.35 *(4.41 – 6.42)*
Segment 2	0.05 *(0.O3 – 0.07)*	0.15 *(0.09 – 0.22)*	0.26 *(0.15 – 0.37)*	0.36 *(0.21 – 0.52)*	0.46 *(0.28 – 0.67)*	0.51 *(0.31 – 0.75)*

Number of respondents (N) = 344

University of Kent

http://www.kent.ac.uk/kbs/research-information/index.htm