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United Kingdom lamb consumer consumption behaviours and product preferences: A Latent Class Analysis

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Research Report No. 362
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Key Points

- The Agribusiness and Economics Research Unit at Lincoln University with the support of research partners under the *Unlocking Export Prosperity from the Agri-food Values of Aotearoa New Zealand* research programme has estimated willingness-to-pay (WTP) values for selected credence attributes of lamb leg by United Kingdom consumers, with a focus on identifying preferences for attributes considered *distinctively New Zealand.*

- Preferences for many of the credence attributes considered here are not readily observable from market prices and so the non-market valuation method of Choice Experiments was used. This involved an online survey of United Kingdom residents in December 2019, using a research panel. The survey process achieved 1,005 responses with suitable representation of key population demographics.

- As well as WTP values, this survey reports on:

    - Purchase frequency by lamb cut, and by country-of-origin
    - Prices paid by lamb cut
    - Country-of-origin quality ranking
    - Substitute proteins purchase frequency
    - Lamb attribute importance

- New Zealand lamb was the second most purchased by country of origin behind English lamb. New Zealand was ranked the highest of the countries included for quality but this was very close to the rankings for both English and Welsh lamb. These qualities included taste, safety, no chemicals, higher animal welfare and no added hormones.

- The survey included a choice experiment to assess the Willingness to Pay by consumers for different attributes associated with lamb. The consumers were then segmented, using a latent class model, into 3 classes each with different characteristics and preferences.

- The results showed that consumer group one (the group at 20 per cent of the sample) were willing to pay the most for lamb from New Zealand, with a premium of nearly 46 per cent, but not for New Zealand lamb raised on Māori farms. Group one were more likely to be living in urban area, be male, have children and pay the least for their lamb. However, the demographic differences between the groups was low.

- Group two have a higher WTP English lamb at 52 per cent and 46 per cent for Welsh lamb and is also willing to pay a premium of 34 per cent for lamb produced on Māori farms. Group two also willing to pay 25 per cent for 100per cent grass fed, 21 per cent for no added growth hormones and 21 per cent for produced in New Zealand. Group three (the largest in the survey at 60 per cent) is willing to pay the highest premium for 100per cent grass fed lamb, prefers England and Wales as the countries of origin but also willing to pay for lamb raised on Māori farms.

- The average respondents percentage willingness-to-pay (WTP) was:

Lamb Leg Attribute	Group One 20% of consumers	Group Two 20% of consumers	Group Three 60% of consumers
Water Quality Protection	0	8	6
Organic	0	0	14
Enhanced Animal Welfare	14	8	14
No GM Feed	13	10	15
100% Grass Fed	21	25	34
100% Pasture Raised	12	18	22
No added antibiotics	0	20	24
No added growth hormones	18	21	24
Produced in New Zealand	46	21	16
Produced on Māori farms	0	34	34
Produced in Scotland	28	34	42
Produced in Wales	37	46	47
Produced in England	41	52	48

Chapter 1
Introduction

This study is part of a research programme entitled *Unlocking Export Prosperity from the Agri-food Values of Aotearoa New Zealand*. It is funded by the Ministry of Business, Innovation and Employment (MBIE) Endeavour Fund for science research programmes.

The research aims to provide new knowledge on how local enterprises can achieve higher returns by ensuring global consumers understand the distinctive qualities of the physical, credence and cultural attributes of agri-food products that are "Made in New Zealand".

Agricultural exports are an important contributor to the New Zealand (NZ) economy and the United Kingdom (UK) is established as an important lamb product destination. It is critically important for NZ exporters to understand export markets and the different cultures and preferences of those consumers to safeguard market access, and for realising potential premiums.

This report describes the application of a survey of UK lamb leg consumers that is designed to examine consumption behaviour and consumer willingness-to-pay (WTP) for credence attributes. While search attributes such as price or colour can be observed directly, and experience attributes such as flavour or texture can be assessed when consumed, credence attributes such as environmental sustainability cannot be immediately seen or experienced at the point of sale. For products promoting credence attributes, the role of verification including labelling is of significant importance.

Our approach is to apply a Choice Experiment economic valuation method, analysed using a statistical approach called Latent Class Modelling that describes profiles for different consumer segments identified in the data and provides estimates of attribute WTP across these segments.

Chapter 2
Lamb Leg Survey Method

To understand how consumers value NZ credence attributes, this study used a structured self-administered online survey that included the Choice Experiment, conducted in the UK in December 2019. The survey was administered through Qualtrics™, a web-based survey system, and had a sample size of 1,005 lamb leg consumers.

The survey was developed by the research team drawing from a literature review on consumer trends for animal proteins, results from previous surveys examining consumer attitudes in overseas markets, a scoping survey of 200 UK lamb consumers (November 2019) and consultation with industry partners and stakeholders, especially those on the AERU advisory board.

Sampling involved recruiting participants from an online consumer panel database provided by an international market research company (dynata.com). Panel members are recruited by online marketing across a range of channels and panels are profiled to ensure adequate representativeness. Panels are frequently refreshed, with the participation history of members reviewed regularly. Respondents for each survey are compensated with a retail voucher for completing a survey. Potential respondents were recruited by e-mail and were screened out if they purchased lamb less than monthly.

2.1 Using Choice Experiments to examine consumer preferences

Choice Experiments are a survey-based valuation approach that have been widely used to value consumer preferences for food product attributes. They are particularly useful for examining the role of new attributes, and attributes that that are not easily observable in market prices, such as the attributes explored in the current report. The ability of this method to identify which individual attributes are more important in consumer choices, and to estimate consumers' WTP for these, has seen this approach to valuation become increasingly favoured by researchers.

Designing a Choice Experiment survey involves deciding which product attributes are of interest, combining these into different product offerings, and asking consumers to pick which offering they prefer from a range of alternatives. In this study, alternative lamb leg products are described by production practices, origin and price (Table 2.1). Attribute selection was primarily informed by the scoping survey that used a combination of open text and structured questions to identify which attributes UK consumers considered distinctive of NZ lamb.

Table 2.1 Lamb attribute descriptions used in the choice experiment

Lamb attributes	Attribute descriptions
Country where the lamb was raised	The lamb may be labelled with the country where the lamb was raised.
Organic	The lamb may be labelled showing if production is Organic. Pasture is managed without using artificial fertilisers and pesticides. No added hormones, antibiotics or animal by-product supplementation including in or on the food they eat.
Environmental Sustainability	The lamb may be labelled showing if production employs a management system that is either Carbon Neutral, Enhances Biodiversity, or Protects Water Quality.
Enhanced Animal Welfare	The lamb may be labelled showing if production employs a management system that is above minimum welfare standards.
Animal Housing	The lamb may be labelled as being pasture raised where they are allowed to range free.
Animal Feed	The lamb may be labelled as being 100% grass-fed or GM free. Grass-fed lamb is lower in calories, contains more healthy omega-3 fats, vitamins A and E, beta-carotene and antioxidants.
Māori Production	The lamb may be labelled as being produced on Māori farms. Māori, New Zealand's indigenous people, produce 30% of NZ lamb. Like other indigenous peoples, they see themselves as belonging to the land. Māori seek to maintain and protect the health of their land for the welfare of current and future generations, and so to produce food that supports the health and wellbeing of their customers.
Production Additives	The lamb may be labelled as being raised without added hormones or antibiotics.
Price	The lamb is labelled with the price per kg.

Changes in lamb leg attributes are described using the levels in Table 2.2. Price levels were determined by market prices, and from what scoping survey respondents said that they usually paid. Countries of origin were selected based on volumes of sales in UK for 2019.

Table 2.2 Lamb attribute levels used in the choice experiment

Lamb attributes	Attribute levels					
Animal Housing	No Label	100% pasture raised				
Organic	No Label	Certified				
Enhanced Animal Welfare	No label	Certified				
Animal Feed	No label	100% Grass-fed	No GM feed			
Production Additives	No label	No added growth hormones	No added antibiotics			
Environmental Sustainability	No Label	Carbon Neutral	Biodiversity Enhancement	Water Quality Protection		
Country of Origin	No Label	England	Māori farm in NZ	NZ	Scotland	Wales
Price £/kg lamb leg	£7	£12	£13	£19		

An example of alternative product offerings presented to respondents is shown in Figure 2.1. Each set of offerings comprises three options, of which respondents chose their preferred one. Two options present alternative lamb legs, while the third is a 'none of these' option. Each respondent answered seven choice sets, generating 7,035 completed choice sets over the total sample.

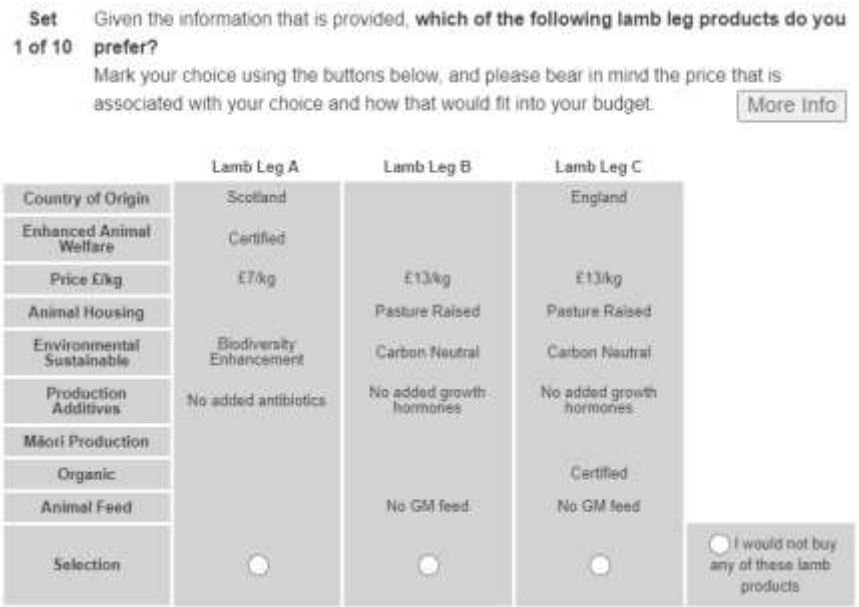


Figure 2.1 Example of a choice experiment question shown to respondents

Product choices are statistically analysed, and consumers' WTP for each attribute is estimated. A more detailed presentation of the theoretical foundation and statistical procedure can be found in Appendix A.

Chapter 3
Survey Results

3.1 Sample demographic description

- The sample comprised a wide range of demographics, which is important to ensure that the sampling process has broadly canvased the relevant population (Figure 3.1).
- It is important to note that we are not attempting to represent the overall UK population, but rather those that purchase lamb at least monthly.

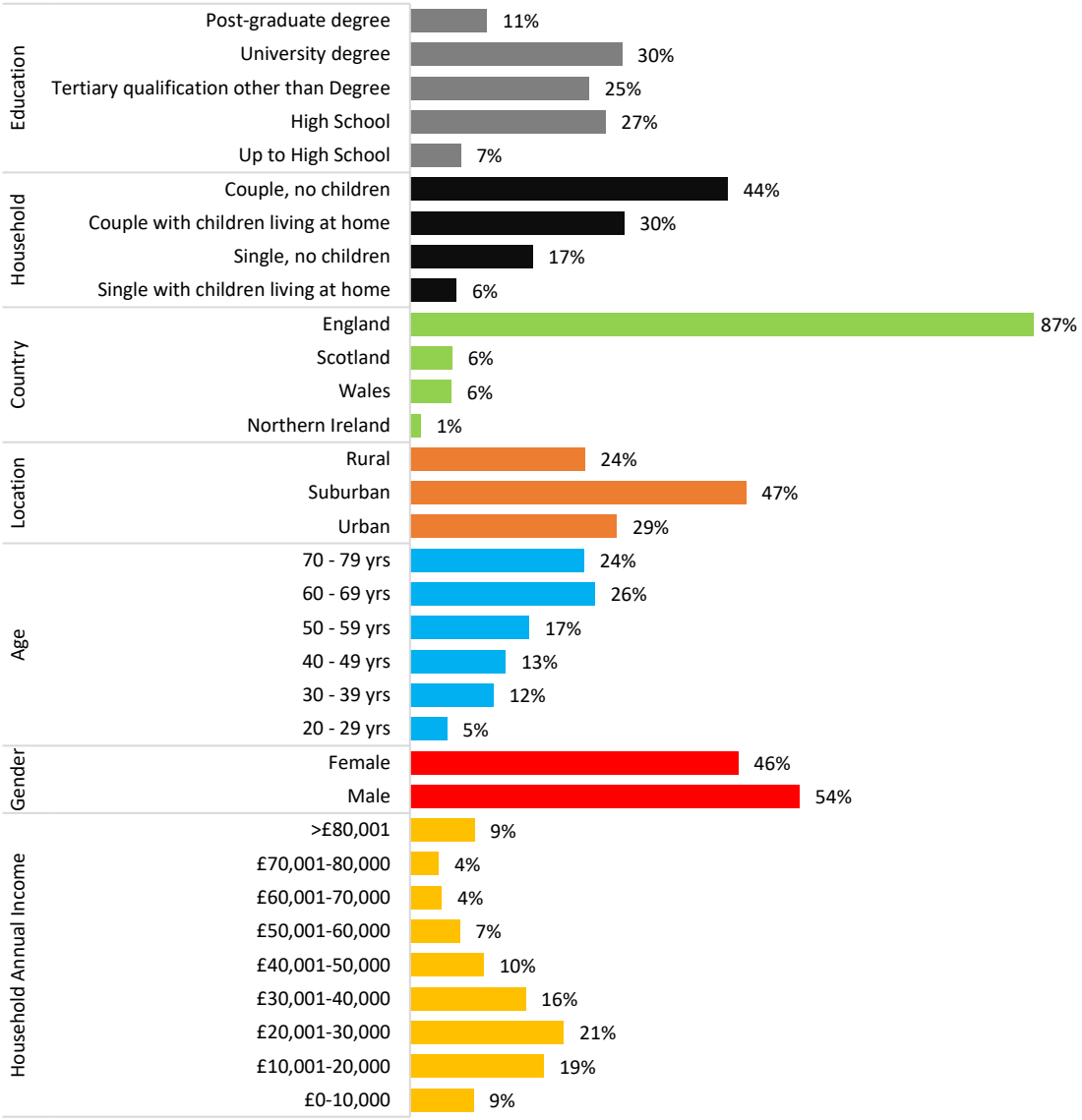


Figure 3.1 Sample demographics

3.2 Purchase and consumption behaviour

- Over a quarter of respondents purchase mince lamb each week, which is the highest weekly purchase rate out of the 14 products considered (Figure 3.2).
- 73 per cent of respondents purchase at least one lamb product on a weekly basis.

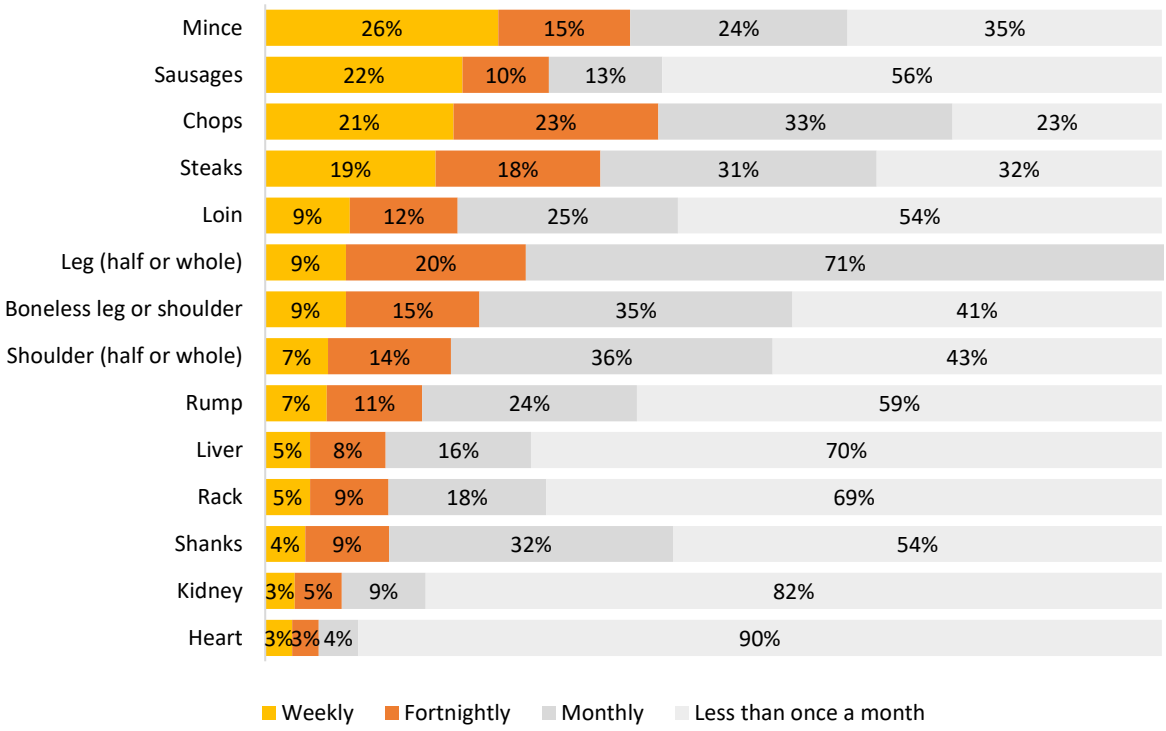


Figure 3.2 Lamb product purchase frequency

- Based on the same cuts as above, nearly all respondents purchase at least two different lamb cuts in a month (Figure 3.3).

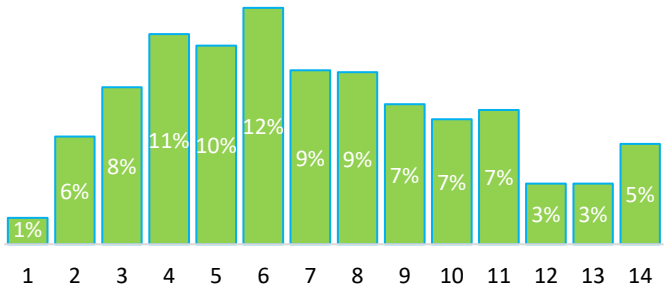


Figure 3.3 Number of different lamb cuts purchased monthly

- The highest average prices were paid for lamb leg, and the lowest were for liver (Figure 3.4).

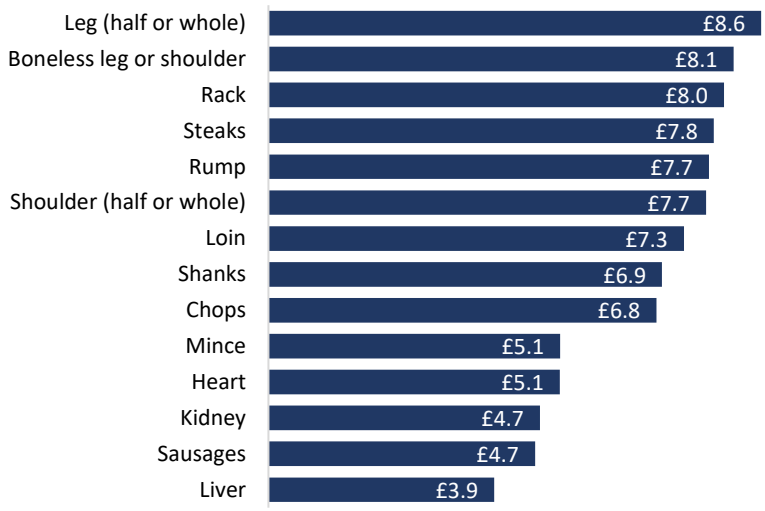


Figure 3.4 Average price usually paid per kg by cut

- Almost one in four respondents usually paid £12.00/kg or more for lamb leg (Figure 3.5). The most common price paid was £8.00/kg.

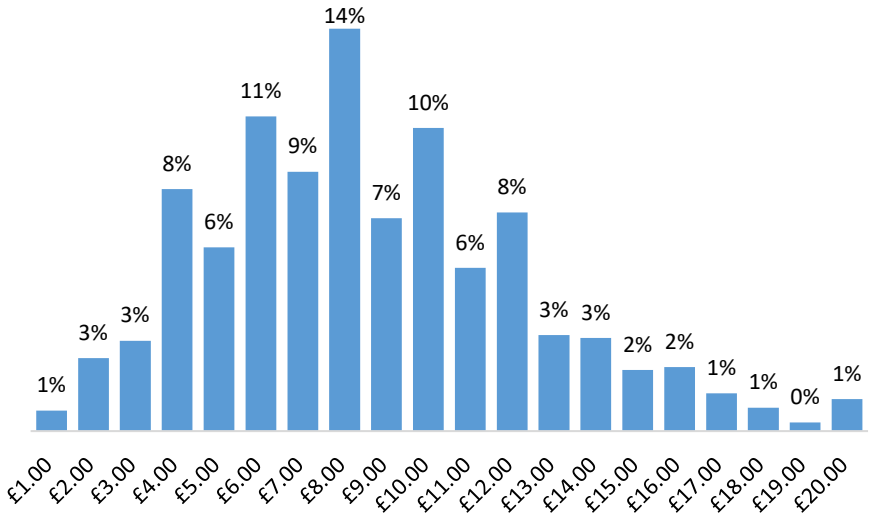


Figure 3.5 Range of prices usually paid per kg of lamb leg

- NZ has the second highest country-of-origin purchase frequency overall, however almost one in five respondents never purchase NZ lamb (Figure 3.6).

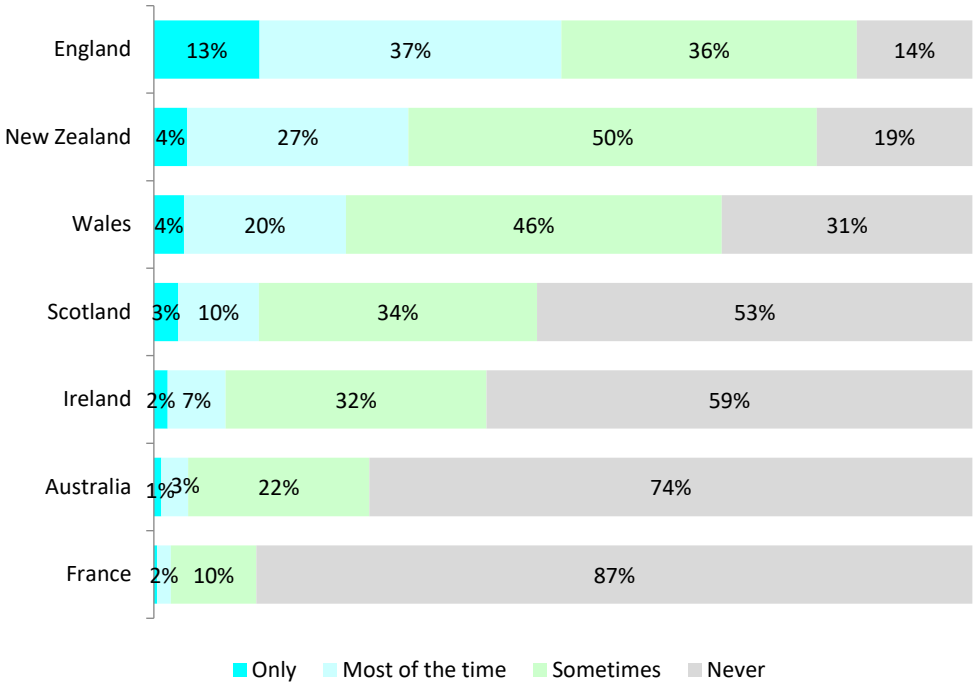


Figure 3.6 Country-of-origin purchase frequency

- 30 percent of respondents thought that NZ produced the best quality lamb compared to the other countries considered (Figure 3.7).
- Wales, England, and NZ are fairly evenly ranked overall.

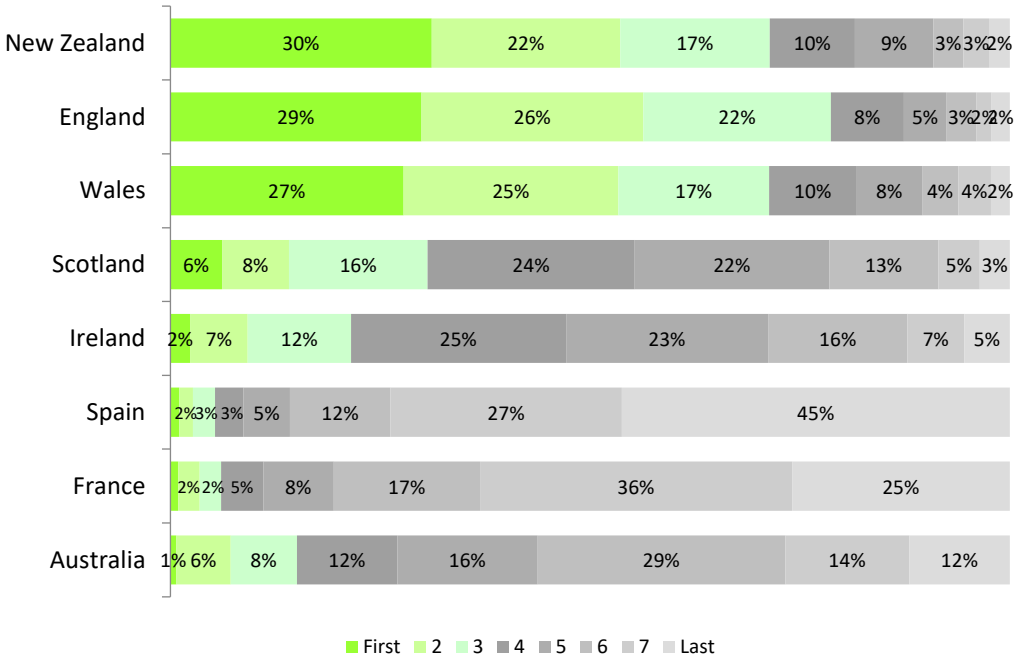


Figure 3.7 Country-of-origin quality ranking

- About two out of five respondents said that they purchased organic lamb at least sometimes (Figure 3.8).

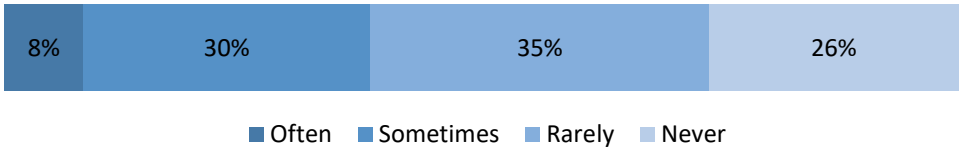


Figure 3.8 Organic lamb purchase frequency

- The main reason for buying Organic lamb was better animal welfare (Figure 3.9).

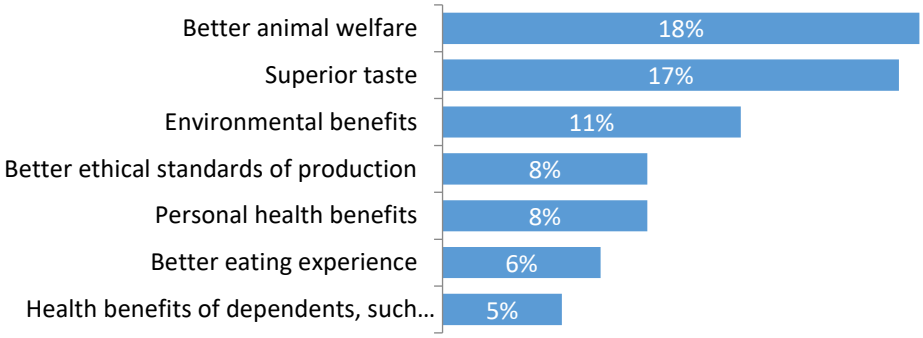


Figure 3.9 Main reasons for buying Organic lamb

- Chicken has the highest purchase frequency of the main alternative protein sources (Figure 3.10).

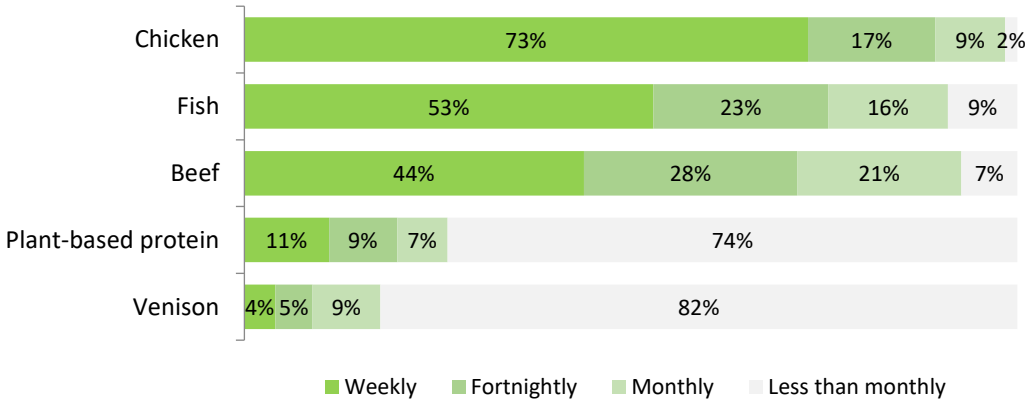


Figure 3.10 Alternative protein types purchase frequency

- For those purchasing alternative plant-based proteins, a balanced diet and environmental benefits are important reasons for consumption (Figure 3.11).

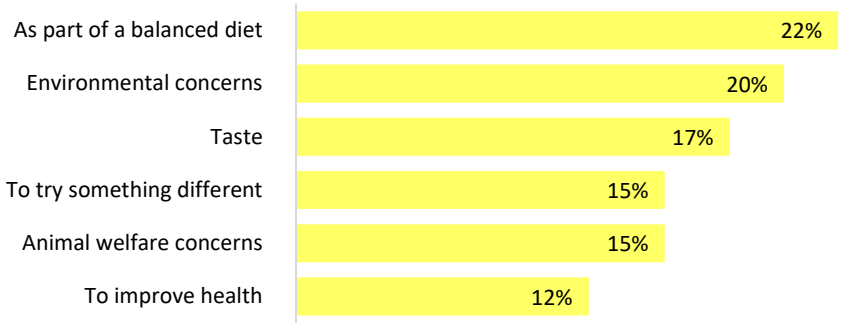


Figure 3.11 Reasons for consuming plant-based protein products

- An overall preference for animal proteins is the main reason given for not consuming plant-based protein products (Figure 3.12).

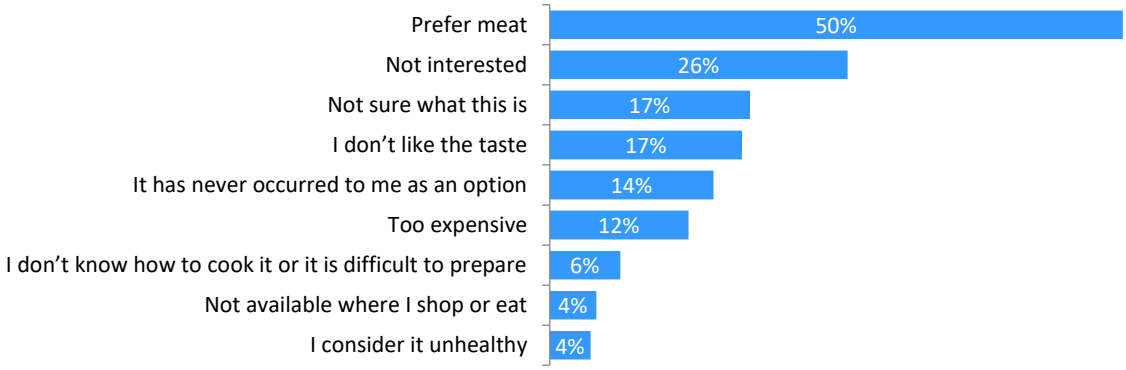


Figure 3.12 Reasons for not consuming plant-based protein products

- Supporting local producers is valued strongly by lamb leg consumers (Figure 3.13).

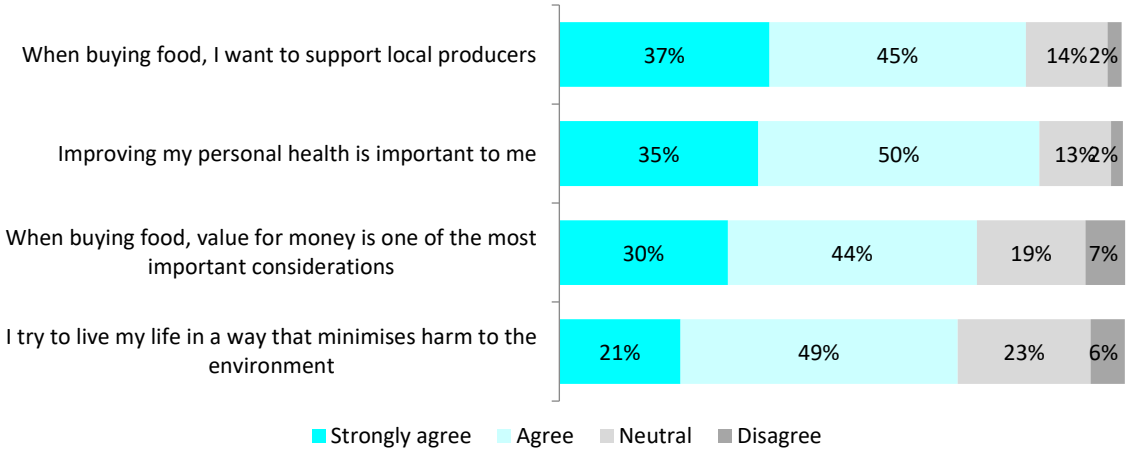


Figure 3.13 Personal value statements

- Overall, it is most important to consumers that lamb tastes good, is safe to eat, is natural and has high animal welfare standards (Figure 3.14).

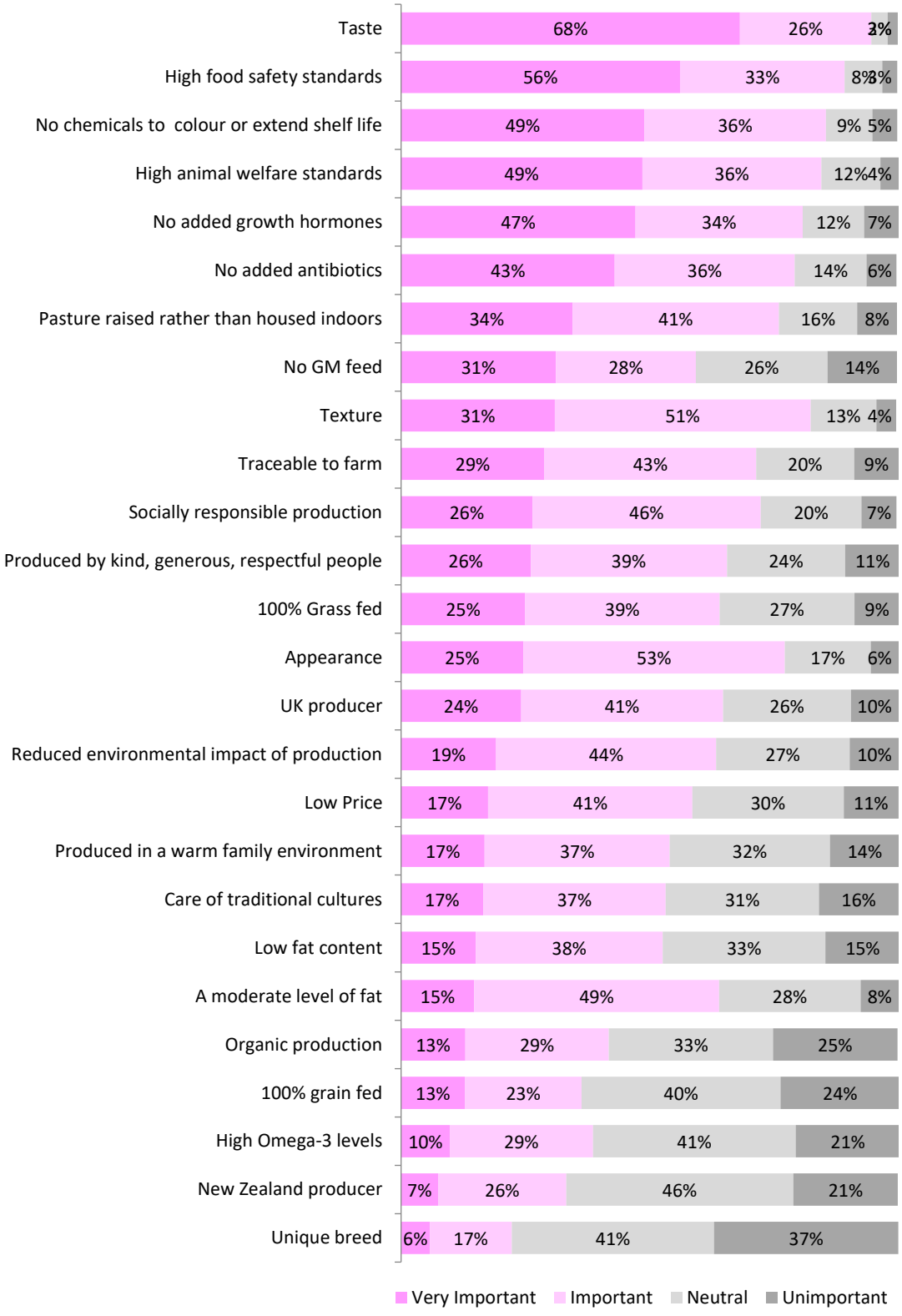


Figure 3.14 Importance of lamb product attributes when purchasing

3.3 Choice Experiment analysis of lamb leg choices

In this section we present findings of the Choice Experiment. Our aim is to identify which lamb attributes influence lamb choice, by how much, and by who. We do this by segmenting the sample of consumers into groups based on which product offerings they preferred (Appendix B).

Choice Experiments can be somewhat more difficult to answer compared with the usual question formats that people have typically seen before, so it is important to check whether respondents have been able to complete the exercise reliably. Overall, task and attribute understanding was relatively high, and most respondents felt certain that their responses reflected real-world choices if these types of lamb products were available (Figure 3.15).

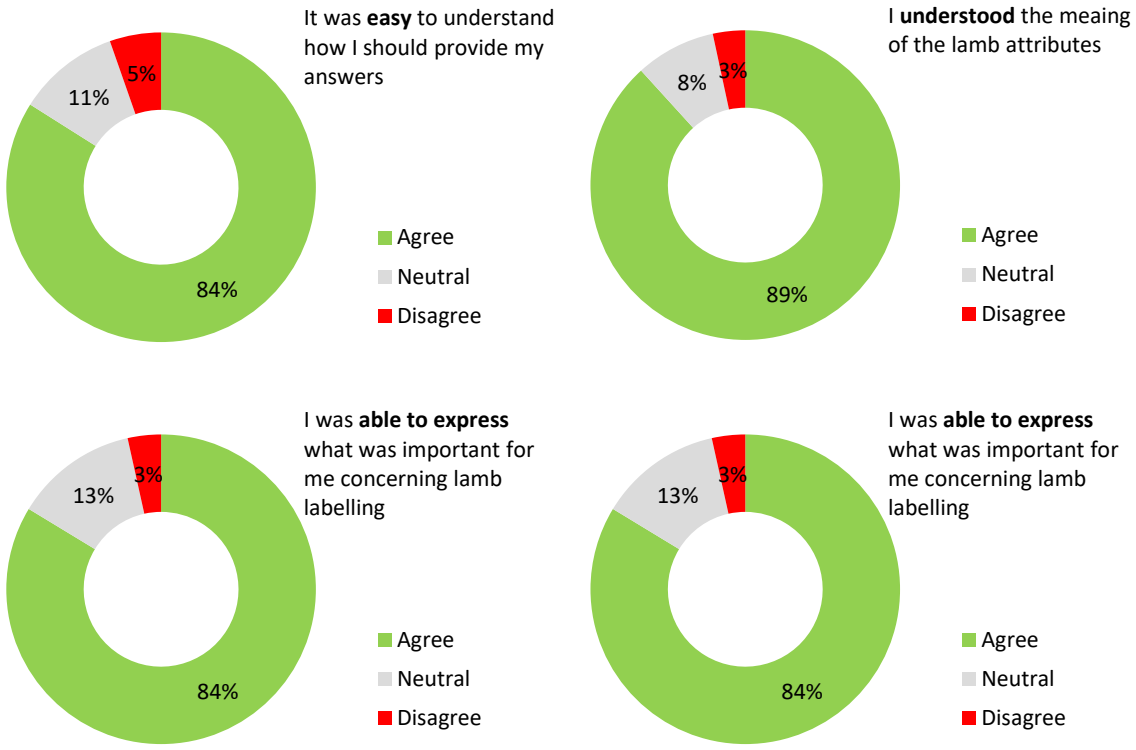


Figure 3.15 CE task and attribute understanding, ability to express, choice certainty

Therefore, the results present the Willingness to Pay by attribute for the three consumer groups. The WTP tell us how much more the average consumer is willing to pay for a kg of lamb leg with a particular attribute, over one that does not have this attribute (Table 3.1). For example, members of Group One are willing to pay, on average, £1.14/kg more for lamb leg that is produced with enhanced animal welfare standards over one that does not have this attribute. There is some uncertainty in WTP estimates, and the Confidence Intervals reported in Table 3.1 indicate that we can be 95 per cent sure that the true WTP falls within this interval.

In regard to country of origin group one are the most willing to pay for lamb sourced from New Zealand farms with a premium of 46 per cent. This was higher than the group's willingness to pay for English lamb at 41 per cent followed by welsh lamb at 37 per cent. This group was not willing to pay a premium for lamb sourced from Māori farms but group two were willing to pay 21 per cent and group three 16 per cent. Group one were also willing to pay a premium of 21 per cent for 100 per cent grass fed lamb, and 18 per cent for no added hormones.

Group two was willing to pay the most for English lamb at 52 per cent followed by Welsh lamb at 46 per cent. They also were prepared to pay more for 100 per cent grass fed at 25 per cent, no added growth hormones at 21 per cent and 100 per cent pasture raised 18 per cent. Group three preferred English and Welsh lamb with premiums of 48 and 47 per cent respectively. They were willing to pay the most for 100 per cent grass fed at 34 per cent and least willing to pay for New Zealand lamb.

In Table 3.1 this is reported under each group's column heading. We can see that three distinct consumer groups have been identified - the first group has an estimated size of 20 per cent, the second group's size is 20 per cent and the third is 60 per cent. These group sizes tell us the probability that a randomly selected UK lamb leg purchaser belongs to that consumer group.

Table 3.1 UK lamb leg attribute willingness-to-pay (WTP) by consumer group

Lamb Attribute	Group One 20%	Group Two 20%	Group Three 60%
Water Quality Protection		£0.70 (-0.11,1.55)	£0.53 (-0.1,1.07)
Organic			£1.18 (0.32,2.03)
Enhanced Animal Welfare	£1.14 (0.42,1.86)	£0.71 (0.11,1.32)	£1.23 (0.71,1.73)
No GM Feed	£1.06 (0.22,1.89)	£0.87 (-0.01,1.75)	£1.29 (0.63,1.93)
100% Grass Fed	£1.69 (0.16,3.23)	£2.21 (1.17,3.24)	£2.93 (1.51,4.35)
100% Pasture Raised	£0.97 (0.29,1.65)	£1.61 (0.94,2.27)	£1.92 (1.21,2.61)
No added antibiotics		£1.79 (0.96,2.63)	£2.05 (1.25,2.85)
No added growth hormones	£1.44 (0.14,2.75)	£1.83 (0.75,2.91)	£2.08 (0.96,3.18)
Produced in New Zealand	£3.69 (1.65,5.75)	£1.87 (0.27,3.46)	£1.37 (-0.12,2.87)
Produced on Māori farms		£3.02 (1.47,4.57)	£2.96 (1.36,4.55)
Produced in Scotland	£2.27 (0.98,3.57)	£2.99 (1.85,4.14)	£3.58 (2.36,4.78)
Produced in Wales	£3.01 (0.91,3.57)	£4.14 (2.71,5.57)	£4.09 (2.31,5.85)
Produced in England	£3.34 (1.02,5.66)	£4.67 (3.03,6.31)	£4.11 (2.24,5.99)

Average WTP per kg lamb leg 2019 (95% Confidence Interval)

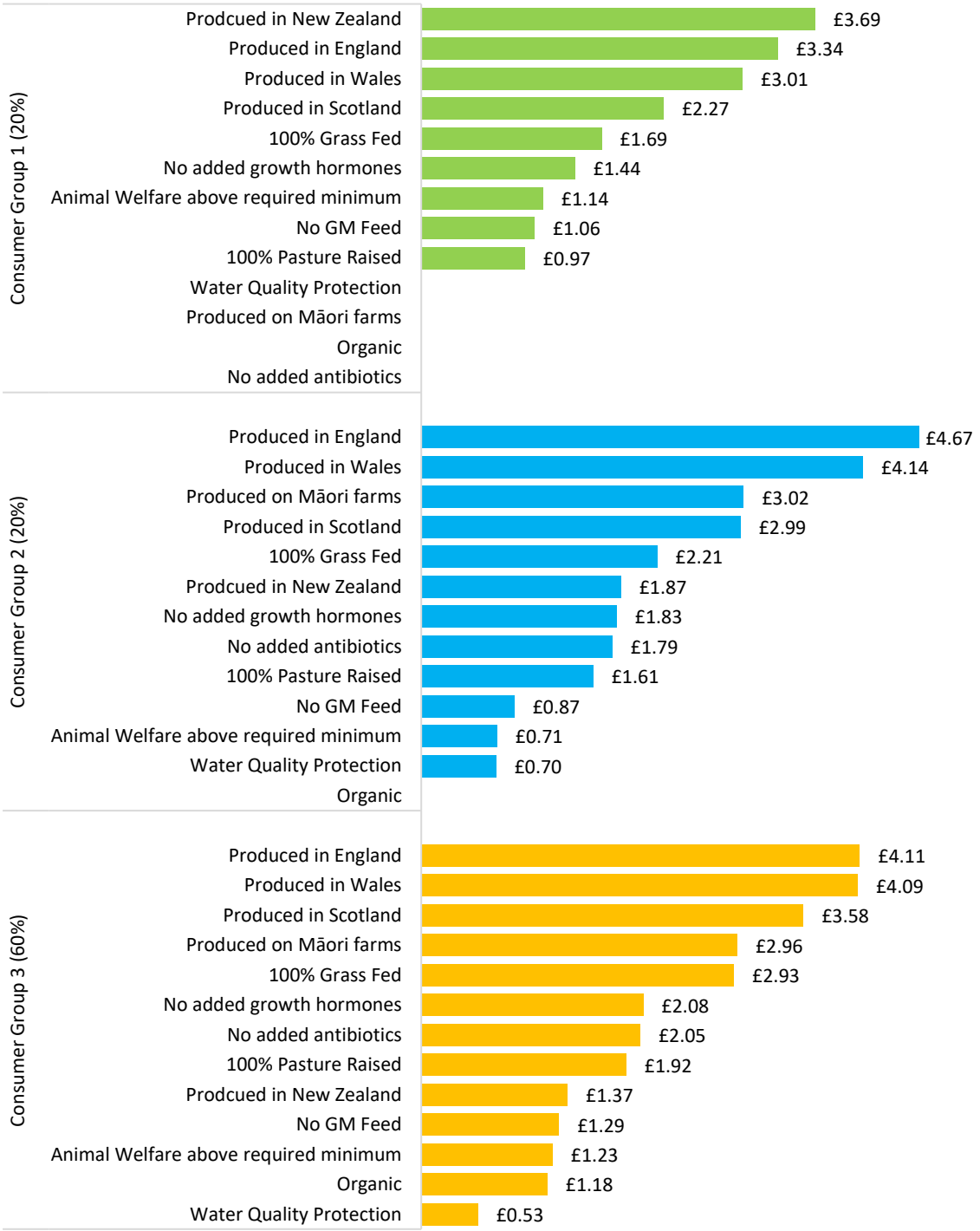


Figure 3.16 UK lamb attribute willingness-to-pay by consumer group

Where the lamb is raised is the most valued attribute for all three consumer groups.

- Consumers in Group One have the highest WTP for NZ lamb of the three groups (Figure 3.16).
- This group generally has lower WTP for other attributes compared with the other two consumer groups

- Consumers in Group Two have the strongest origin preferences of the three groups.
- They have the highest WTP for English, Welsh and Māori lamb of the three groups (Figure 3.16).
- Group Two members have the highest WTP for Māori origin of the three groups.

- Consumers in Group Three have the broadest set of preferences, exhibiting positive WTP for all of the attributes included in the Choice Experiment (Figure 3.16).
- This consumer group are the largest of the three at 60 per cent of consumers.
- They value England origin the highest.
- They value enhanced animal welfare, no GM feed, 100 per cent grass-fed, no added antibiotics or growth hormones higher than the other two groups.

3.4 Consumer group descriptions

This section describes each of the three consumer groups identified in the statistical analysis above, using the same questions we presented earlier. The objective is to highlight the differences and similarities between groups, which can be useful in identifying the types of consumers who are willing-to-pay for attributes relevant to an organisations objectives. For example, an organisation interested in applying enhanced animal welfare standards will be able to use the information below to describe the members of consumer Group Three, who are the group willing-to-pay the most for this attribute. As we go through the comparisons, the small bar charts on the right hand side will highlight the group with the largest values with a green bar.

- Most demographics are similar across consumer groups, however members of Group One are more likely to be male, from an urban location and have slightly higher income (Table 3.2). It is this group which is also willing to pay more for New Zealand lamb.

Table 3.2 Describing consumer groups: Demographics

Demographics	Group One	Group Two	Group Three
England	90%	89%	86%
Wales	5%	7%	5%
Scotland	2%	4%	7%
Northern Ireland	2%	0%	2%
Female	42%	48%	46%
< 44 years old	26%	26%	27%
> 65 years old	34%	39%	34%
Rural	14%	27%	25%
Have children	38%	32%	37%
University degree	41%	43%	39%
Income of lower quartile	£20,000	£30,000	£20,000
Median income	£40,000	£30,000	£40,000
Income of upper quartile	£60,000	£57,500	£50,000

- Supporting local producers is important to all groups (Table 3.3).

Table 3.3 Describing consumer groups: Personal values

Statements with **strong agreement**	Group One	Group Two	Group Three
When buying food, I want to support local producers	41%	38%	36%
Improving my personal health is important to me	33%	35%	35%
I try to live my life in a way that minimises harm to the environment	23%	20%	21%
When buying food, value for money is one of the most important considerations	30%	24%	31%

- Members of Group One have higher purchase frequency overall (Table 3.4).

Table 3.4 Describing consumer groups: Purchase frequencies

Purchase at least weekly	Group One	Group Two	Group Three
Chops	22%	19%	22%
Rump	10%	3%	8%
Mince	30%	24%	27%
Rack	6%	3%	5%
Loin	14%	8%	10%
Shoulder (half or whole)	7%	6%	7%
Leg (half or whole)	6%	8%	9%
Boneless leg or shoulder	10%	8%	9%
Steaks	26%	13%	19%
Sausages	27%	17%	22%
Shanks	6%	4%	5%
Liver	5%	2%	6%
Heart	6%	2%	2%
Kidney	3%	2%	4%

- Group Two members generally pay higher prices overall (Table 3.5).

Table 3.5 Describing consumer groups: Prices usually paid

Average usual price paid (£/kg)	Group One	Group Two	Group Three
Chops	£7.27	£7.13	£6.59
Rump	£7.10	£8.17	£7.70
Mince	£4.92	£5.45	£5.02
Rack	£7.98	£8.57	£7.82
Loin	£6.95	£8.18	£7.10
Shoulder (half or whole)	£7.28	£8.28	£7.57
Leg (half or whole)	£8.06	£8.92	£8.62
Boneless leg or shoulder	£8.38	£8.60	£7.96
Steaks	£7.78	£7.76	£7.80
Sausages	£4.73	£5.00	£4.54
Shanks	£6.94	£7.32	£6.76
Liver	£4.47	£4.27	£3.76
Heart	£5.23	£5.60	£5.01
Kidney	£5.52	£6.00	£4.35

- Members of Group Three are more likely to purchase NZ lamb (Table 3.6).

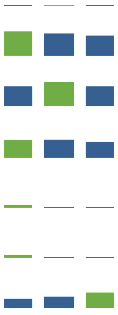
Table 3.6 Describing consumer groups: New Zealand purchasing

	Group One	Group Two	Group Three
Buy NZ lamb most of the time	23%	23%	29%
Buy NZ lamb most of the time or sometimes	71%	72%	79%
NZ produces the best lamb	32%	29%	30%
Rank NZ in top three best lamb	68%	69%	70%

- Organic lamb purchase frequency is similar across the three groups (Table 3.7).

Table 3.7 Describing consumer groups: Organic purchasing

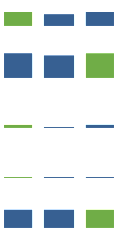
	Group One	Group Two	Group Three
Purchase Organic kiwi often	7%	11%	8%
Purchase Organic kiwi at least sometimes	44%	39%	37%
% of Benefits to myself	30%	34%	29%
% of Benefits to family	28%	27%	24%
% of Benefits to public locally	12%	8%	11%
% of Benefits to public globally	12%	10%	10%
% of Benefits to plant and animals	19%	21%	25%



- The proportion of each protein type purchased is consistent across all consumer groups (Table 3.8).

Table 3.8 Describing consumer groups: Alternative proteins purchasing

Purchase **at least weekly**	Group One	Group Two	Group Three
Beef	46%	36%	45%
Chicken	71%	69%	74%
Alternative plant-based protein	12%	8%	11%
Venison	4%	2%	3%
Fish	53%	56%	56%



- Taste and food safety are the most important lamb characteristics for all consumer groups (Table 3.9). All groups consider that the most important characteristics to be those that reflect a preference for what can be considered to embody a 'natural' product, including no added growth hormones or antibiotics, no chemicals to artificially colour or extend shelf life, and high animal welfare standards.

Table 3.9 Describing consumer groups: Product characteristics considered important

Characteristic considered **very important**	Group One	Group Two	Group Three
Taste	65%	67%	69%
Texture	32%	32%	30%
Low Price	21%	18%	17%
Reduced environmental impact of production	14%	18%	20%
High food safety standards	49%	58%	57%
Socially responsible production	22%	27%	27%
100% Grass fed	28%	26%	24%
Pasture raised rather than housed indoors	34%	37%	34%
No added growth hormones	46%	51%	46%
No added antibiotics	42%	48%	42%
High animal welfare standards	45%	47%	49%
Halal production	6%	7%	4%
No GM feed	36%	34%	29%
No chemicals to artificially colour or extend shelf life	48%	52%	48%
Organic production	8%	18%	12%
Traceable to farm	32%	33%	27%
High Omega-3 levels	9%	11%	10%
Unique breed	4%	9%	5%
Care of traditional cultures	14%	19%	16%
Lambs are born indoors	5%	7%	5%
Appearance	29%	31%	22%
100% grain fed	14%	14%	12%
Low fat content	16%	18%	14%
UK producer	19%	28%	24%
European producer	4%	6%	6%
New Zealand producer	8%	7%	8%
A moderate level of fat	14%	16%	14%
Produced by kind, generous, and respectful people	22%	29%	26%
Produced in a warm family environment	17%	18%	16%

Chapter 4
Conclusions

This report presents the results of a survey of lamb consumption in the UK. The survey was of just over 1,000 respondents who were selected as purchasing beef at least once a month.

The survey assessed purchase behaviour and the reasons for purchasing lamb by country of Origin. New Zealand lamb was the second most purchased by country of origin. New Zealand was ranked the highest of the countries included for quality but this was very close to the rankings for English and Welsh lamb. These qualities included taste, safety, no chemicals, higher animal welfare and no added hormones.

The survey included a choice experiment to assess the Willingness to Pay by consumers for different attributes associated with lamb. The consumers were then segmented, using a latent class model, into 3 classes each with different characteristics and preferences.

The results showed that consumer group one (the group at 20 per cent of the sample) were willing to pay the most for lamb from New Zealand, with a premium of nearly 46 per cent, but not for New Zealand lamb raised on Māori farms.

Group two have a higher WTP English lamb at 52 per cent and 46 per cent for Welsh lamb and is also willing to pay a premium of 34 per cent for lamb produced on Māori farms. Group two also willing to pay 25 per cent for 100 percent grass fed, 21 per cent for no added growth hormones and 21 per cent for produced in New Zealand. Group three (the largest in the survey at 60 per cent) is willing to pay the highest premium for 100 percent grass fed lamb, prefers England and Wales as the countries of origin but also willing to pay for lamb raised on Māori farms.

Appendix A
Statistical Method

This appendix provides technical details of statistical analysis of choice data. The appendix includes a brief description of the theoretical foundations of choice analysis followed by statistical probability estimation approaches, focusing on contemporary models applied in this report. Lastly, the method used in generating monetary estimates is described.

A.1 Conceptual Framework

In Choice Experiments (CEs), researchers are interested of what influences, on average, the survey respondents' decisions to choose one alternative over others. These influences are driven by people's preferences towards the attributes but also the individual circumstances such as their demographics or perceptions of the choice task (e.g., the level of difficulty or understanding) (Hensher et al. 2015).

Each alternative in a choice set is described by attributes that differ in their levels, both across the alternatives and across the choice sets. The levels can be measured either qualitatively (e.g., poor and good) or quantitatively (e.g., kilometres). This concept is based on the characteristics theory of value (Lancaster 1966) stating that these attributes, when combined, provide people a level of utility[1] *U* hence providing a starting point for measuring preferences in CE (Hanley et al. 2013; Hensher et al. 2015). The alternative chosen, by assumption, is the one that maximises people's utility[2] providing the behavioural rule underlying choice analysis:

$$U_j > U_i \tag{0.1}$$

where the individual *n* chooses the alternative *j* if this provides higher utility than alternative *i*. A cornerstone of this framework is Random Utility Theory, dated back to early research on choice making (e.g., Thurstone 1927) and related probability estimation. This theory postulates that utility can be decomposed into systematic (explainable or observed) utility *V* and a stochastic (unobserved) utility ε (Hensher et al. 2015; Lancsar and Savage 2004).

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{0.2}$$

where *j* belongs to a set of J alternatives. The importance of this decomposition is the concept of utility only partly being observable to the researcher, and remaining unobserved sources of utility can be treated as random (Hensher et al. 2015). The observed component includes information of the attributes as a linear function of them and their preference weights (coefficient estimates).

$$V_{nsj} = \sum_{k=1}^{K} \beta_k x_{nsjk} \tag{0.3}$$

with *k* attributes in vector x for a choice set s. Essentially, the estimated parameter β shows "the effect on utility of a change in the level of each attribute" (Hanley et al. 2013, p. 65). This change can be specified as linear across the attribute levels, or as non-linear using either dummy coding or effect coding

[1] Related terminology used in psychology discipline is *the level of satisfaction* (Hensher et al. 2015).
[2] In choice analysis, utility is considered as *ordinal utility* where the relative values of utility are measured (Hensher et al. 2015).

approaches. The latter coding approach has a benefit of not confounding with an alternative specific constant (ASC) when included in the model (Hensher et al. 2015).

A.2 Statistical Modelling of Choice Probabilities

The statistical analysis aims to explain as much as possible of the observed utility using the data obtained from the CE and other relevant survey data. In order to do so, the behavioural rule (eq. 1.1) and the utility function (eq. 1.2) are combined (Hensher et al. 2015; Lancsar and Savage 2004) to estimate the probability of selecting an alternative *j*:

$$\Pr_{nsj} = \Pr\left(U_{nsj} > U_{nsi}\right) = \Pr\left(V_{nsj} + \varepsilon_{nsj} > V_{nsi} + \varepsilon_{nsi}\right) = \Pr\left(\varepsilon_{nsi} - \varepsilon_{nsj} < V_{nsj} - V_{nsi}\right) \forall j \neq i \quad (0.4)$$

where the probability of selecting alternative *j* states that differences in the random part of utility are smaller than differences in the observed part. A standard approach to estimate this probability is a conditional logit, or multinomial logit (MNL) model (McFadden 1974). This model can be derived from the above equations (1.2 and 1.3) by assuming that the unobserved component is independently and identically distributed (IID) following the Extreme Value type 1 distribution (see e.g. Hensher et al. 2015; Train, 2003). Although the MNL model provides a "workhorse" approach in CE, it includes a range of major limitations (see e.g. Fiebig et al. 2010; Greene and Hensher 2007; Hensher et al. 2015):

- Restrictive assumption of the IID error components
- Systematic, or homogenous, preferences allowing no heterogeneity across the sample
- Restrictive substitution patterns, namely the existence of independence of irrelevant alternatives property where introduction (or reduction) of a new alternative would not impact on the relativity of the other alternatives
- The fixed scale parameter obscures potential source of variation

Some or all of these assumptions are often not realised in collected data. These restrictive limitations can be relaxed in contemporary choice models. In particular, the random parameter logit (RPL) model (aka, the mixed logit model) has emerged in empirical application allowing preference estimates to vary across respondents (Fiebig, et al. 2010; Hensher et al. 2015; Revelt and Train, 1998). This is done by specifying a known distribution of variation to be parameter means. The RPL model probability of choosing alternative *j* can be written as:

$$\Pr_{nsj} = \frac{\exp(\beta_n' x_{nsj})}{\sum_J \exp(\beta_n' x_{nsj})} \quad (0.5)$$

where, in the basic specification, $\beta_n = \beta + \eta_n$ with η being a specific variation around the mean for *k* attributes in vector *x* (Fiebig, et al. 2010; Hensher et al. 2015). Typical distributional assumptions for the random parameters include normal, triangular and lognormal distributions, amongst others. The normal distribution captures both positive and negative preferences (i.e., *utility* and *disutility*) (Revelt and Train, 1998). The lognormal function can be used in cases where the researcher wants to ensure the parameter has a certain sign (positive or negative), a disadvantage is the resultant long tail of estimate distributions (Hensher et al. 2015). The triangular distribution provides an alternative functional form, where the spread can be constrained (i.e., the mean parameter is free whereas spread is fixed equal to mean) to ensure behaviourally plausible signs in estimation (Hensher et al. 2015). Further specifications used in modelling include parameters associated with individual specific characteristics (e.g, income) that can

influence the heterogeneity around the mean, or allowing correlation across the random parameters. The heterogeneity in mean, for example, captures whether individual specific characteristics influence the location of an observation on the random distribution (Hensher et al. 2015). In this study, the frequency of visits to rivers, streams and lakes was used to explain such variance.

Another way to write this probability function (in eq. 1.4) (Hensher et al. 2015) involves an integral of the estimated likelihood over the population:

$$L_{njs} = \int_{\beta} \Pr_{nsj}(\beta) f(\beta|\theta) d\beta \tag{0.6}$$

In this specification, the parameter θ is now the probability density function conditional to the distributional assumption of β. As this integral has no closed form solution, the approximation of the probabilities requires a simulation process (Hensher et al. 2015; Train, 2003). In this process for data *X*, *R* number of draws are taken from the random distributions (i.e. the assumption made by the researcher) followed by averaging probabilities from these draws; furthermore these simulated draws are used to compute the expected likelihood functions:

$$L_{nsj} = E(\Pr_{nsj}) \approx \frac{1}{R} \sum_{R} f(\beta^{(r)}|X) \tag{0.7}$$

where the $E(\Pr_{nsj})$ is maximised through Maximum Likelihood Estimation. This specification (in eq. 1.6) can be found in Hensher et al. (2015). In practice, a popular simulation method is the Halton sequence which is considered a systematic method to draw parameters from distributions compared to for example, pseudo-random type approaches (Hensher et al. 2015).

A.3 Econometric Extensions

Common variations of the RPL model include specification of an additional error component (EC) in the unobserved part of the model. This EC extension captures the unobserved variance that is alternative-specific (Greene and Hensher 2007) hence relating to substitution patterns between the alternatives (Hensher et al. 2015). Empirically, one way to explain significant EC in a model is SQ-bias depicted in the stochastic part of utility if the EC is defined to capture correlation between the non-SQ alternatives (Scarpa et al., 2005).

Another extension which has gained increasing attention in recent CE literature, is the Generalized Mixed Logit (GMXL) model (Czajkowski et al. 2014; Hensher et al. 2015; Juutinen et al. 2012; Kragt 2013; Phillips 2014). This model aims to capture remaining unobserved components in utility as a source of choice variability by allowing estimation of the scale heterogeneity alongside the preference heterogeneity (Fiebig et al. 2010; Hensher et al. 2015). This scale parameter is (inversely) related to the error variance, and in convenient applications such as MNL or RPL, this is normalised to one to allow identification (Fiebig et al. 2010; Louviere and Eagle 2006). However, it is possible that the level of error variance differs between or within individuals, due to reasons such as behavioural outcomes, individual characteristics or contextual factors (Louviere and Eagle 2006).

Recent GMXL application builds on model specifications presented in Fiebig et al. (2010), stating that β_n (in eq. 1.4) becomes:

$$\beta_n = \sigma_n \beta + \gamma \eta_n + (1-\gamma)\sigma_n \eta_n \tag{0.8}$$

where σ is the scale factor (typically = 1) and $\gamma \in \{0,1\}$ is a weighting parameter indicating variance in the residual component. In the case the scale factor equals 1, this reduces to the RPL model. The importance of the weighting parameter is the impact on the scaling effect on the overall utility function (population means) versus the individual preference weights (individual means): when *γ* parameter approaches zero the scale heterogeneity affects both means, whereas when this approaches one the scale heterogeneity affects only the population means (Hensher et al. 2015; Juutinen et al. 2015). Interpretation of these parameters includes

- If *γ* is close to zero, and statistically significant, this supports the model specification with the variance of residual taste heterogeneity increases with scale (Juutinen et al. 2012); and
- If *γ* is not statistically significant from one, this suggests that the unobserved residual taste heterogeneity is independent of the scale effect, that is the individual-level parameter estimates differ in means but not variances around the mean (Kragt, 2013)

The scale factor specification (eq. 1.7) can also be extended to respondent specific characteristics associated with the unobserved scale heterogeneity (Hensher et al. 2015; Juutinen et al. 2015):

$$\sigma_n = \exp\{\bar{\sigma} + \tau\omega_n\} \tag{0.9}$$

where $\bar{\sigma}$ *is* the mean parameter in the error variance; and ω is unobserved scale heterogeneity (normally distributed) captured with coefficient *τ* (Hensher et al. 2015; Juutinen et al. 2015; Kragt, 2013). Juutinen et al. (2012), for example, in context of natural park management found that respondents' education level and the time spent in the park explained the scale heterogeneity ($\tau > 0$, p-value < 0.01). In this study, the respondents indicated levels of choice task understanding and difficulty were used to explain scale heterogeneity.

A.4 Estimation of Monetary Values

Typically the final step of interest in the CE application is the estimation of monetary values of respondent preferences for the attributes considered in utility functions. These are commonly referred to as marginal willingness-to-pay (WTP). WTP estimation is based on the marginal rate of substitution expressed in dollar terms providing a trade-off between some attribute k and the cost involved (Hensher et al. 2015) and is calculated using the ratio of an attribute parameter and the cost parameter. WTP can take into account interaction effects, if statistically significant, such as with the respondent demographics. WTP of attribute *j* by respondent *i* is calculated as the ratio of the estimated model parameters accommodating the influence of the random component (Cicia et al. 2013) as:

$$WTP_i^j = -\left(\frac{\beta_j + \varepsilon_{ij}}{\beta_{price} + \varepsilon_{ip}}\right) \tag{0.10}$$

The estimated mode parameters can also be used to estimate compensating surplus (CS) as a result of policy or quality change in a combination of attributes, using (Hanemann, 1984):

$$\mathbf{CS} = \frac{-1}{\beta cost}\left[\ln\sum_{j=1}^{J}\exp\left\{V_j^0\right\} - \ln\sum_{j=1}^{J}\exp\left\{V_j^1\right\}\right] \tag{0.11}$$

which calculates the difference in utilities before the policy or quality change (V_0) and after the policy or quality change (V_1) (Hanley et al. 2013; Lancsar and Savage 2004). Similar to WTP, the monetary estimation of this change is possible by using the estimate for the monetary attribute $\beta_{cost.}$. Lastly, there are some challenges associated with the empirical estimation of the WTP in the RPL based models. One approach is to use a fixed cost, which simplifies the WTP estimation (Daly et al. 2012) but which may not be as behaviourally a plausible consideration as allowing heterogeneous preferences towards the cost attribute (Bliemer and Rose, 2013; Daziano and Achtnicht, 2014). Conceptually, the estimated cost parameter is a proxy for the marginal utility of income for respondents and economic theory suggests individuals will respondent differently to varying income levels. The use of a random cost parameter however, presents complications in deriving population distribution moments from the ratio of two random parameters.

Appendix B
Latent Class Model of Lamb Leg Choices

Table B.1 United Kingdom lamb leg choice Latent Class model

Utility parameters[1]	Class 1	Class 2	Class 3
100% Grass fed	0.68** (0.0)	0.64***(0.16)	0.57***(0.09)
GM free	0.43***(0.16)	0.25* (0.13)	0.25***(0.05)
Carbon Neutral	- 2.05 (0.16)	0.12 (0.19)	-0.03 (0.11)
Biodiversity Enhancement	- 0.58 (0.49)	0.08 (0.21)	-0.03 (0.13)
Water Quality Protection	0.11 (0.16)	0.20* (0.12)	0.10* (0.05)
100% Pasture raised	0.39***(0.14)	0.47***(0.09)	0.37***(0.04)
Organic	- 0.24 (0.23)	0.19 (0.13)	0.23***(0.08)
Enhanced Animal Welfare	0.46***(0.13)	0.21** (0.08)	0.24***(0.04)
No added hormones	0.58** (0.26)	0.53***(0.15)	0.40***(0.08)
No added antibiotics	0.14 (0.15)	0.52***(0.11)	0.39***(0.05)
Raised in England	1.35***(0.45)	1.36***(0.22)	0.80***(0.13)
Raised in Wales	1.22***(0.31)	1.20***(0.20)	0.79***(0.12)
Raised in Scotland	0.92***(0.23)	0.87***(0.16)	0.69***(0.06)
Raised in NZ	1.49***(0.39)	0.54** (0.24)	0.27* (0.14)
Raised on Maori farms in NZ	0.24 (0.39)	0.88***(0.21)	0.57***(0.13)
Price per kg of leg	- 0.40***(0.08)	- 0.29***(0.03)	- 0.19***(0.03)
Class Membership			
Purchase Frequency	- 0.22***(0.04)	0.00 (0.19)	
Purchase Price	0.04** (0.00)	0.01***(0.00)	
Age	- 0.01***(0.00)	0.01***(0.00)	
Average class probability	0.20	0.20	0.60
Model Fit Statistics			
Log Likelihood function	- 7,363		
Log Likelihood chi^2 stat (70 d.f.)	4,486***		
McFadden Pseudo R^2	0.24		
Number of observations	9,950		
Number of respondents	1,005		

***, **,* denote statistical significance at the 1%, 5% and 10% levels respectively for the null hypothesis that a parameter estimate is not significantly different from zero.

Standard errors in brackets.

[1] Parameter mean estimates indicates the estimated average value in the model for each different parameter