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Beijing beef consumer consumption behaviours and product preferences: A Latent Class Analysis of New Zealand beef tenderloin

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Key Points

- The Agribusiness and Economics Research Unit (AERU) 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 beef tenderloin products by Beijing (China) 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 Discrete Choice Experiments was used. This involved an online survey of Beijing residents in October 2021.

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

    - Consumption frequency
    - Purchase frequency by beef cut, and by country-of-origin
    - Prices paid by beef cut
    - Country-of-origin quality ranking
    - NZ beef purchases by cut
    - Perceptions and attitudes related to beef production
    - Use of digital media and smart technologies for beef shopping

- The average respondent ate 3.8 meals a week containing beef. Everyone in the survey purchased beef tenderloin at least monthly, and they paid on average ¥149/kg which was the highest price paid of the sixteen cuts considered. Looking more closely at prices usually paid for beef tenderloin, half of respondents usually paid more than ¥150/kg, with one fifth of consumers paying more than ¥200/kg. Beef slices were the next most purchased beef cut (60 per cent), with average price of ¥122/kg. The least purchased beef product was minced beef (25 per cent), and this had the lowest average price at ¥92/kg. The majority of expenditure on beef products was through supermarkets (22 per cent), online domestically (15 per cent), and specially stores (14 per cent).

- Many respondents purchase NZ beef products, with 49 per cent frequently purchasing, and a further 21 per cent purchasing occasionally. New Zealand has the second highest purchase frequency overall, significantly behind domestically raised Chinese beef, and marginally ahead of Australian beef. New Zealand beef has the second highest quality ranking overall, highest by 29 per cent of respondents, and in the top three by 54 per cent of respondents. New Zealand quality is ranked moderately lower than Chinese beef, and significantly higher than Australian beef.

- Almost the entire sample had purchased some New Zealand beef products, even if only rarely (95 per cent). Within the previous month, the most purchased New Zealand beef cut was tenderloin (55 per cent), followed by porterhouse steak (40 per cent).

- Many consumers are using digital media in relation to beef products. 60 per cent of respondents often use online media sources for information related to beef products. The types of digital media used to search for information about how a product is produced are generally different from those used when deciding on which product to purchase.

- Consumers are using mobile device smart technologies such as QR codes for purchasing (29 per cent Often, 35 per cent Sometimes) and barcodes for information searching (41 per cent Often, 34 per cent Sometimes). There is a relatively high use of mobile applications, particularly related to health (60 per

cent), purchasing (51 per cent), discounts/coupons (41 per cent), and product reviews (41 per cent). Further, there is high interest in potential use of smart technology, even where current use is relatively low, such as for product delivery (44 per cent) and loyalty programmes (43 per cent).

- Two thirds of respondents purchased some beef online, with many purchasing online from overseas. This is mainly because they like being able to order products not locally available (23 per cent), the greater variety (20 per cent) and convenience of home delivery (19 per cent). Consumers use a large range of online retailers with supermarkets (28 per cent) and hypermarkets (27 per cent) most often used. 16 per cent often used international retailers, and another 29 per cent sometimes.

- The survey included a Discrete Choice Experiment to assess the willingness-to-pay by consumers for different attributes associated with beef tenderloin. The consumers were then segmented, using a Latent Class Model, into three classes each with different characteristics and preferences. Results demonstrate significant consumer support for the types of product attributes that can be considered as distinctively New Zealand. While the largest segment of consumers has the broadest set of attribute considerations of the three, their main preferences center on animal housing, and feed and additive claims. Consumers in this segment are more likely to live in a household as a couple with children and usually buy lower priced beef relative to other consumers. The second largest group of consumers has the highest WTP for Māori Production, and Grass-fed claims and are the only segment to value these claims. They are more likely to be willing to try unfamiliar foods and be more accepting of other cultures. While the third segment is the smallest of the three, they have high WTP for Organic produced beef and for attributes closely aligned with Organic practices including GM-free animal feed.

Beef tenderloin Attribute	Segment One 55% of consumers	Segment Two 33% of consumers	Segment Three 12% of consumers
Carbon Neutral	27% (8%, 46%)		
Biodiversity Enhancement	28% (12%, 44%)		95% (15%, 176%)
Water Quality Protection	22% (8%, 36%)	23% (19%, 28%)	
Organic Production	14% (1%, 28%)	33% (26%, 40%)	116% (5%, 232%)
Māori Production		48% (40%, 55%)	
Feedlot Raised	53% (21%, 85%)	54% (44%, 64%)	
100% Pasture Raised	38% (21%, 56%)	25% (21%, 29%)	
100% Grass-fed		40% (32%, 47%)	
Grain-fed	35% (17%, 53%)	32% (26%, 37%)	
No added antibiotics	30% (15%, 44%)	18% (11%, 26%)	66% (8%, 124%)
No added hormones	42% (21%, 64%)	26% (19%, 34%)	
Enhanced Animal Welfare	17% (11%, 23%)		31% (5%, 57%)
GMO-free	17% (9%, 26%)	11% (8%, 15%)	89% (25%, 154%)
Social responsibility	11% (3%, 21%)	15% (11%, 19%)	37% (1%, 73%)

Average marginal WTP/kg beef tenderloin.
95% Confidence Interval in brackets.

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. While NZ historically relied on key markets such as the United Kingdom for export trade, NZ has more recently significantly expanded its export markets and China has become established as an important beef 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 Beijing beef tenderloin 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 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 Discrete 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
Beef Consumer Survey Method

To understand how consumers value NZ credence attributes, this study used a structured self-administered online survey that included a Discrete Choice Experiment, conducted in Beijing in October 2021. The survey was administered through Qualtrics™, a web-based survey system, and focused on beef tenderloin consumers with purchase frequency of at least monthly.

The survey was developed by the research team drawing from a literature review on consumer trends for beef products, results from previous surveys examining consumer attitudes in overseas markets including China, and consultation with industry partners and stakeholders including the programmes 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.

2.1 Using Discrete Choice Experiments to examine consumer preferences

Discrete Choice Experiments are a survey-based economic 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 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 Discrete 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 beef tenderloin products are described by production practices and price (Table 2-1). Attribute selection was primarily informed by previous surveys, including scoping surveys that used a combination of open text and structured questions to identify which attributes Beijing consumers considered distinctive of NZ beef. Changes in beef attributes are described using the levels presented in (Table 2-2). Price levels were determined by market prices, and from what scoping survey respondents said that they usually paid.

Table 2-1 Beef tenderloin attribute descriptions used in the choice experiment

Beef tenderloin attributes	Attribute descriptions
Animal Feed	100% Grass-fed beef is lower in calories, contains more healthy omega-3 fats, vitamins A and E, beta-carotene and antioxidants. Grain fed beef have higher fat content and marbling which can produce a richer taste.
Environmental Sustainability	Environmentally sustainable farms actively minimise the environmental effects of beef production. The beef may be labeled as being produced using a system that is either Carbon Neutral, Enhances Biodiversity or Protects Water Quality.
Antibiotics & Hormones	Beef may be raised with or without added antibiotics and/or hormones.
Social Responsibility	Socially responsible farms actively include public interest into decision making.
GMO-Free	Beef raised are not genetically modified, and do not consume genetically modified feed.
Animal Housing	Animals can be raised mainly in feedlots, or mainly in pastures.
Māori Production	The beef may be labeled as being produced on Māori farms. Māori, New Zealand's indigenous people value sharing food with family, friends and visitors. For Māori, sharing food is more than just good hospitality but is viewed as an essential component of society and of individual prestige, with the food representing a gift that binds people together.
Organic Production	Beef is produced using a system with no synthetic fertilisers, hormones, antibiotics or animal by-product supplementation during the entire life of the animal including in their feed.
Animal Welfare	Animal welfare practices can be enhanced above the minimum legal standards.
Price	¥ per kilogram

Table 2-2 Beef tenderloin attribute levels used in the choice experiment

Beef tenderloin attributes	Attribute levels			
Enhanced Animal Welfare	No Label	Certified		
GMO-free	No Label	GMO-free		
Social Responsibility	No Label	Certified		
Additives	No Label	No Added Antibiotics	No Added Hormones	
Production System	No Label	Conventional	Organic	Māori
Animal Housing	No label	100% Pasture Raised	Feedlot raised	
Animal Feed	No label	100% Grass-fed	Grain-fed	
Environmental Sustainability	No Label	Carbon Neutral	Biodiversity Enhancement	Water Quality Protection
Price ¥ per kg beef tenderloin	¥80	¥130	¥180	

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 beef tenderloin products, while the third is a 'none of these' option. Each respondent answered ten choice sets. Product choices are statistically analysed using Latent Class Models to identify consumers preferences for each product attribute and to estimate consumers' WTP for each attribute. A more detailed description of the theoretical foundation and statistical procedure of Discrete Choice Experiments can be found in Appendix A.

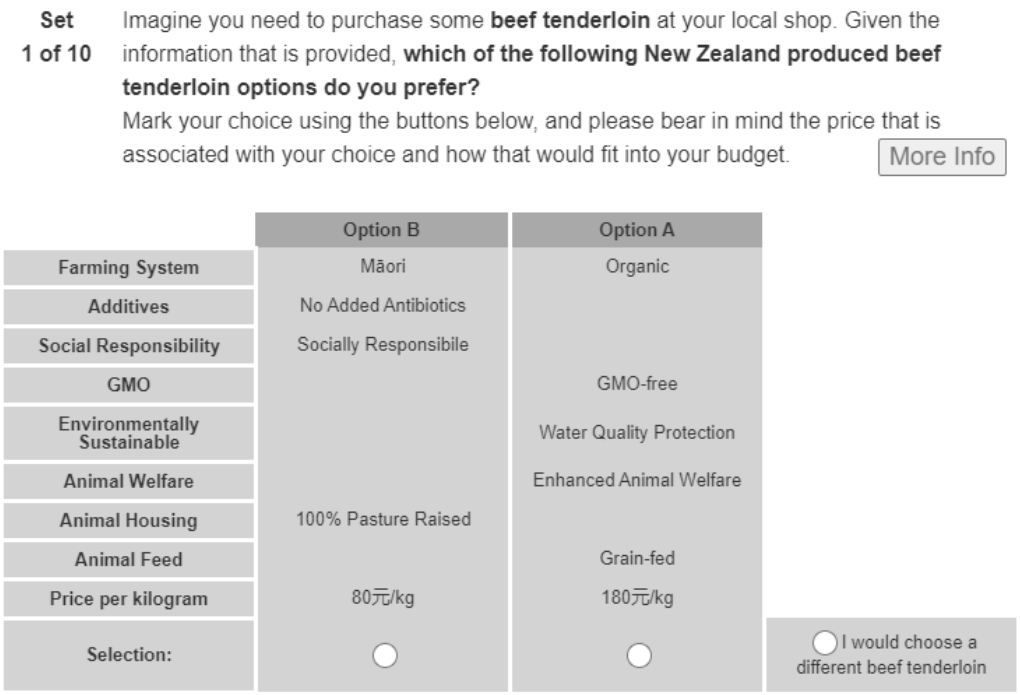
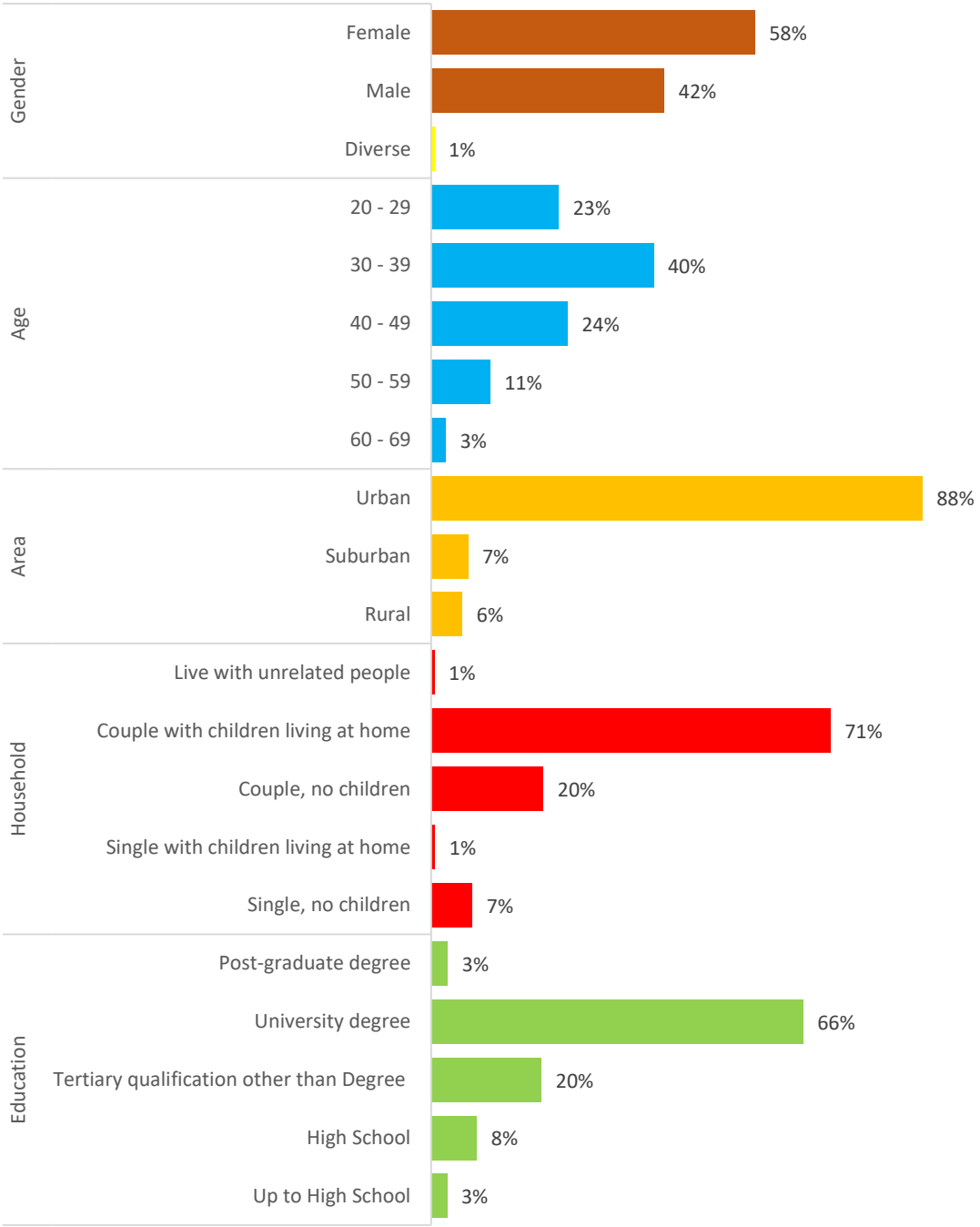


Figure 2-1 Example of a choice experiment question shown to respondents

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 broadly canvased the relevant population (Figure 3-1).
- It is important to note that we are not attempting to represent the overall Beijing population, but rather those that purchase beef tenderloin at least fortnightly.



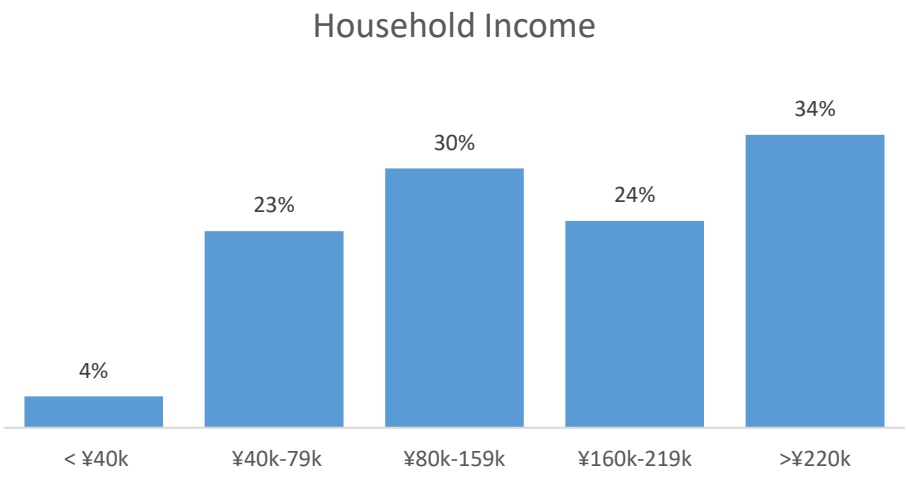


Figure 3-1 Sample demographics

3.2 Purchase and consumption behaviour

- On average, consumers ate 3.8 meals a week that contained beef (Figure 3-2).

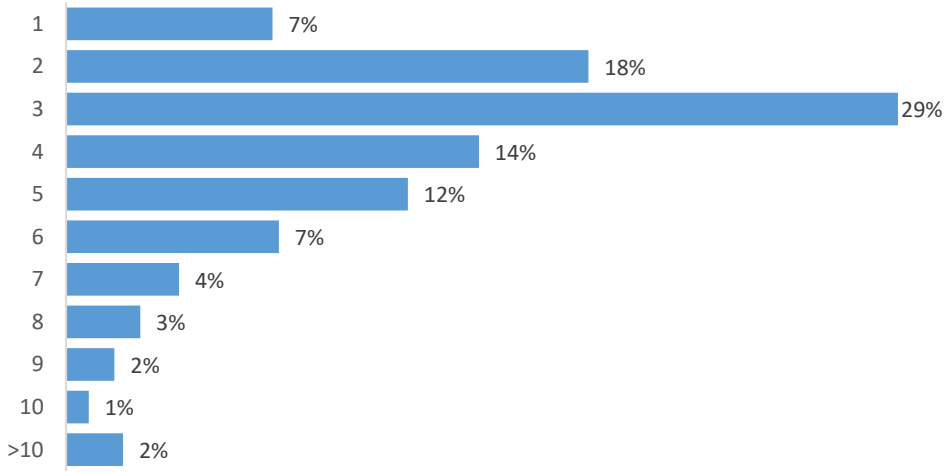


Figure 3-2 Number of meals per week containing beef

3.2.1 Alternative beef products purchased monthly

- Everyone invited to respond to the survey purchased tenderloin in the previous month (Figure 3-3). One in four consumers purchased minced beef in the last month, the lowest purchase level of the products considered here.

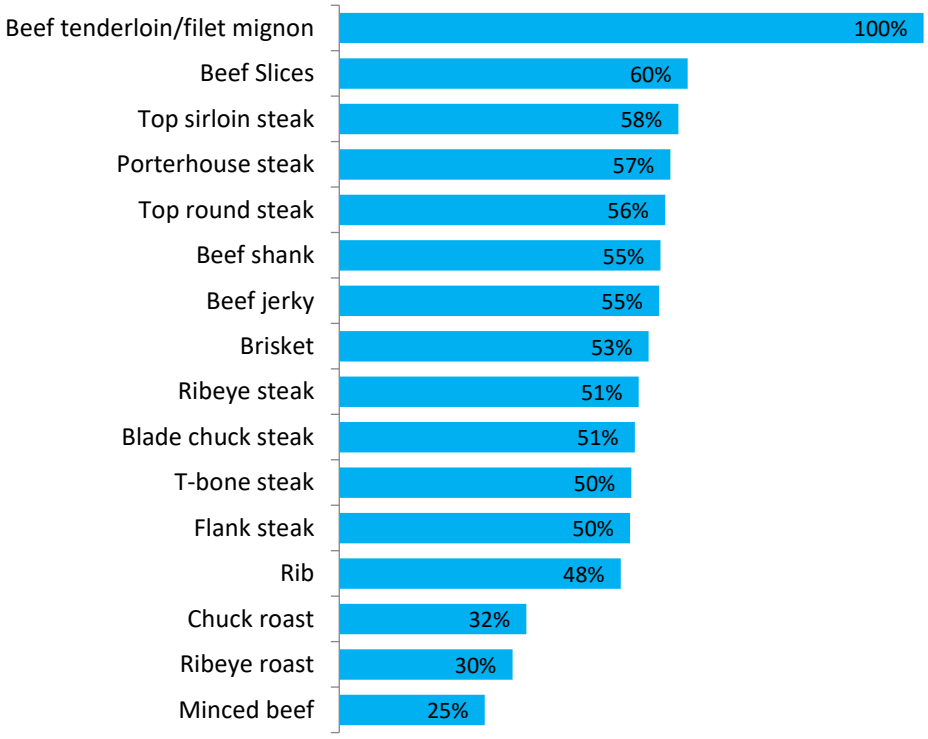


Figure 3-3 Beef product purchases in previous month

3.2.2 Prices usually paid for beef products

- Consumers were asked to indicate what they usually paid for the beef cuts that they had purchased in the last month.
- The average price per kilogram (kg) usually paid is highest for *beef tenderloin/filet mignon* and lowest for *minced beef* (Figure 3-4).

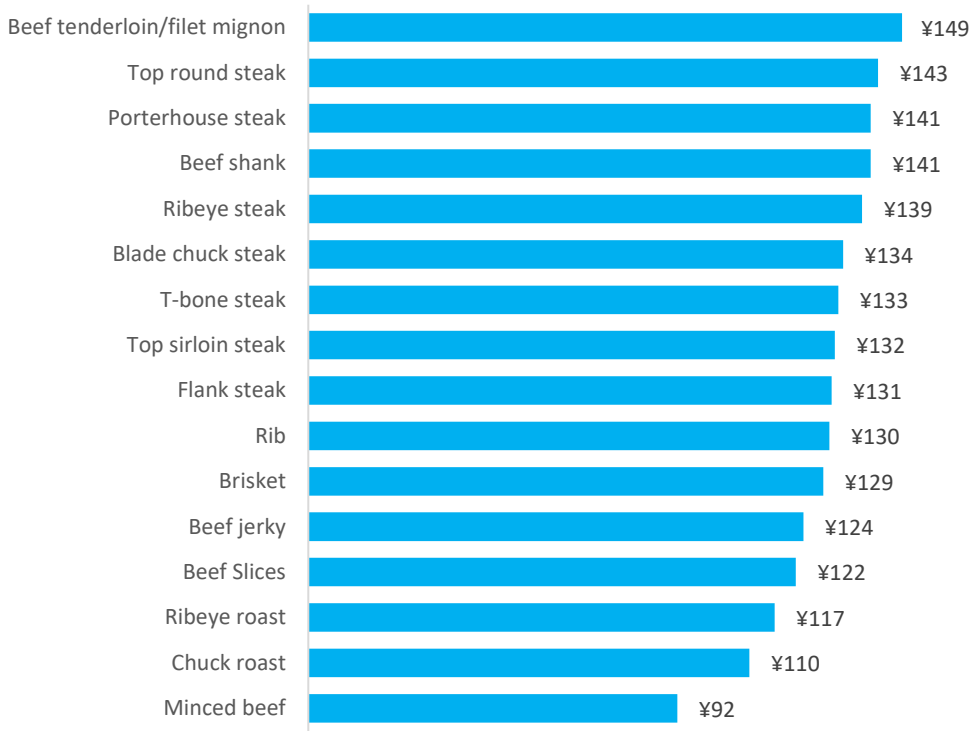


Figure 3-4 Average price per kg usually paid for beef cuts

- Looking more closely at prices usually paid for beef tenderloin, half of respondents usually paid more than ¥150/kg, with one fifth of consumers paying more than ¥200/kg (Figure 3-5).

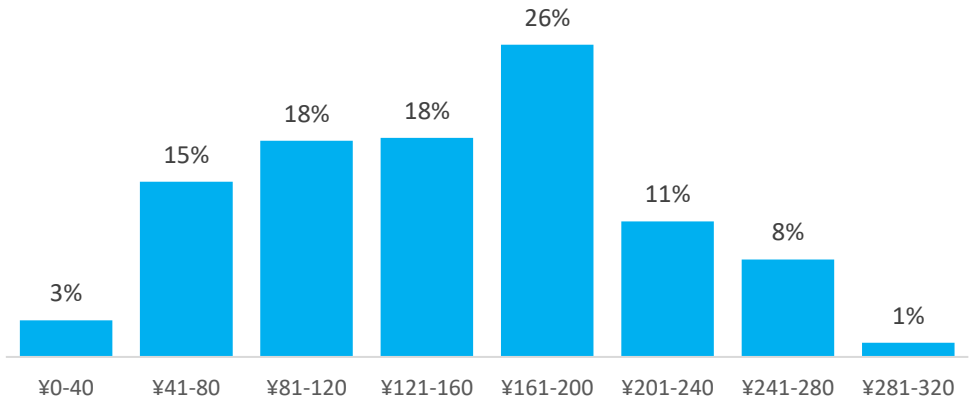


Figure 3-5 Price per kg usually paid for beef tenderloin

3.2.3 Country-of-origin beef purchase frequency

- Consumers were asked to indicate the country-of-origin of the beef that they purchased in last month (Figure 3-6).
- Looking at the country-of-origin for beef purchases, New Zealand has the second highest purchase frequency among consumers, behind domestically raised Chinese beef.

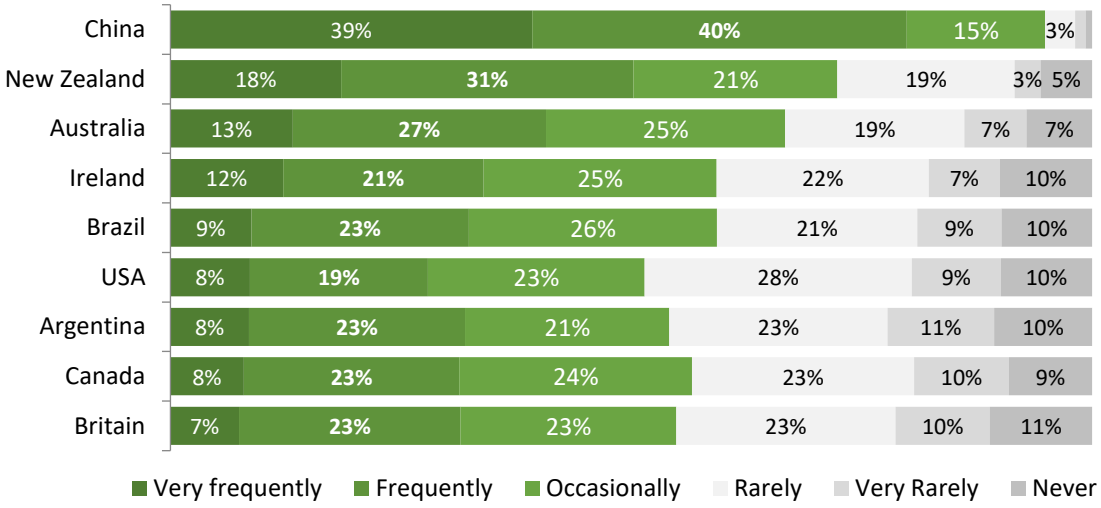


Figure 3-6 Country-of-origin purchase frequency in previous month

3.2.4 Country-of-origin beef quality ranking

- Consumers were asked to rank countries according to the quality of beef produced in that country (Figure 3-7). NZ beef has the second highest quality ranking overall, when compared with the other countries considered. The country is ranked highest by 29 per cent of respondents, and in the top three by 54 per cent of respondents.

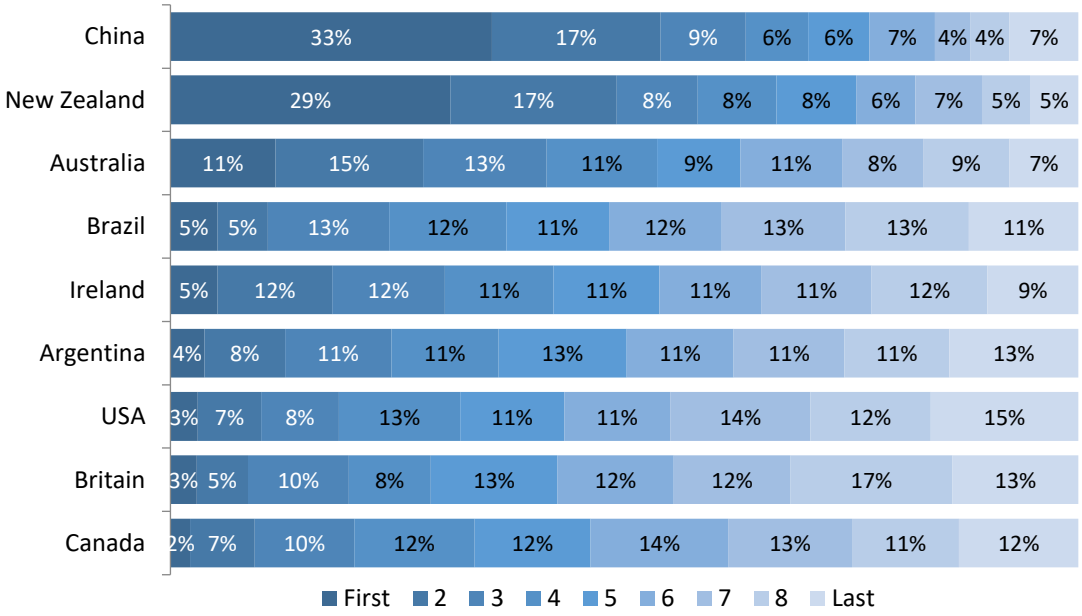


Figure 3-7 Beef country-of-origin ranking

3.2.5 New Zealand beef products purchased

- 55 per cent of respondents purchased a New Zealand produced beef cut in the previous month with *beef tenderloin/filet mignon* and *porterhouse steak* the most commonly purchased, and *minced beef* being the least. (Figure 3-8).

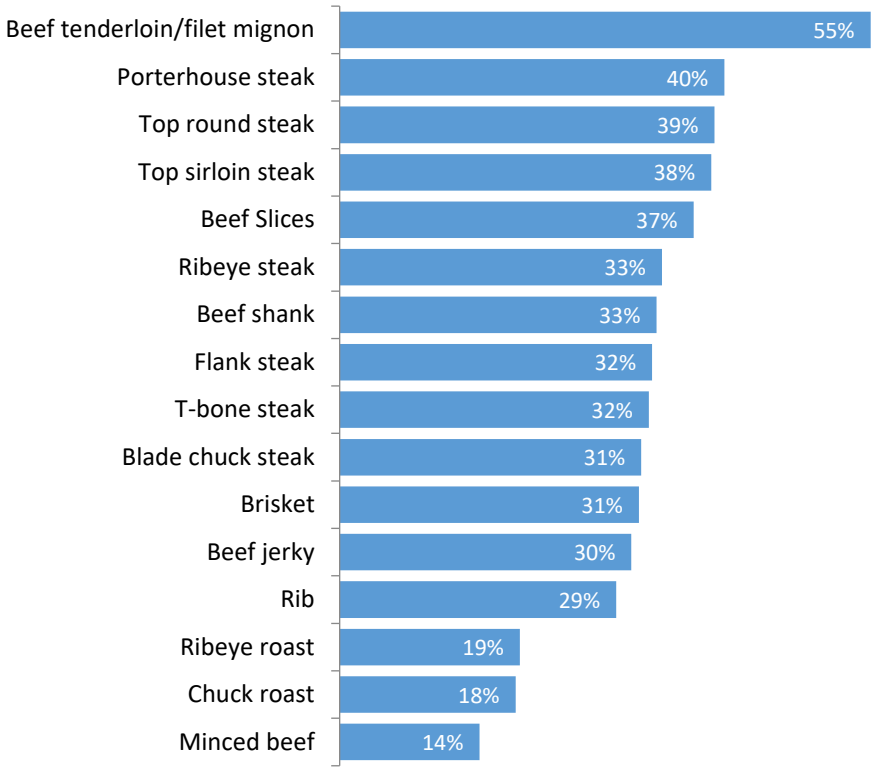


Figure 3-8 NZ beef cuts purchased in previous month

3.3 Use of digital media and smart technologies for beef shopping

3.3.1 Internet access by device and use

- Mobile devices such as smartphones are used more frequently to access the internet than home devices such as desktop computers (Figure 3.9).

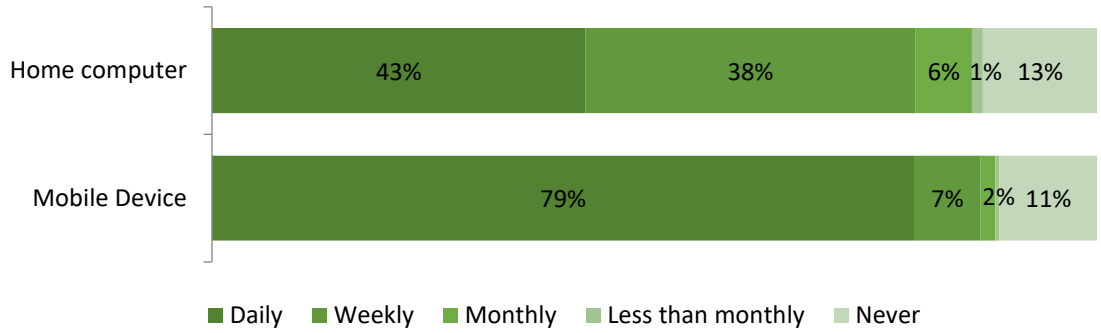


Figure 3-9 Frequency of internet access

- Considering the use of digital media related to beef, almost half of consumers often use digital media to purchase beef products, while just 22 per cent say they never use it in this way (Figure 3-10).

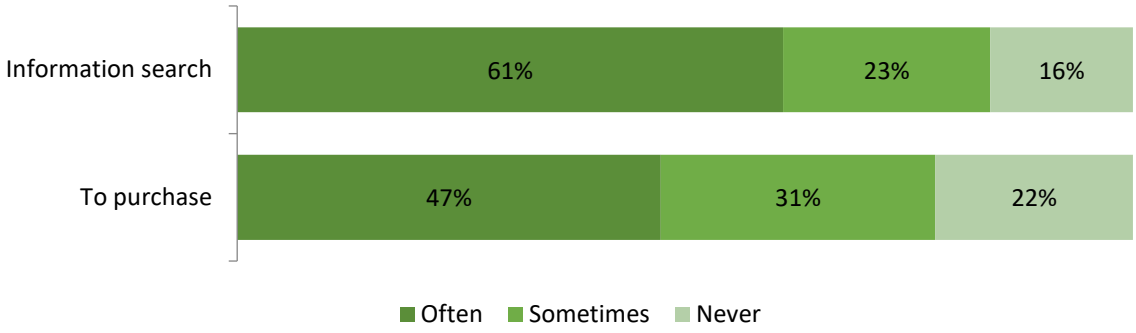


Figure 3-10 Use of digital media for information searching and purchase

3.3.2 Sources of digital media related to beef production and purchase

- Consumers were asked to indicate which sources of online digital media they used, either for information about how a product was produced, or for deciding which beef products to purchase (Figure 3-11).
- This reveals that, in general, the types of digital media used to search for information about *how a product is produced* are different from those used when deciding on *which product to purchase.*

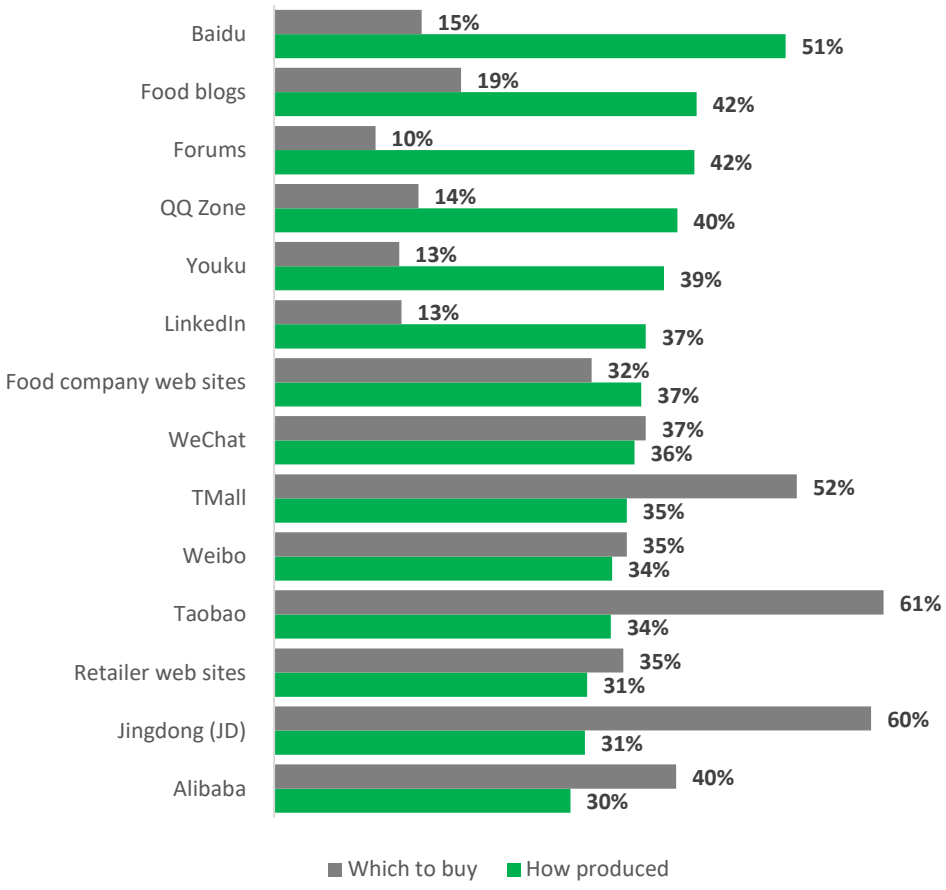


Figure 3-11 Use of digital media for information searching and product purchasing

3.3.3 Use of mobile device smart technologies in relation to beef

- Looking at the **use of mobile device smart technologies** shows that the use of bar codes for information searching is relatively high, with 75 per cent of consumers using this technology at least sometimes (Figure 3-12). While QR codes are slightly more popular for product purchasing.

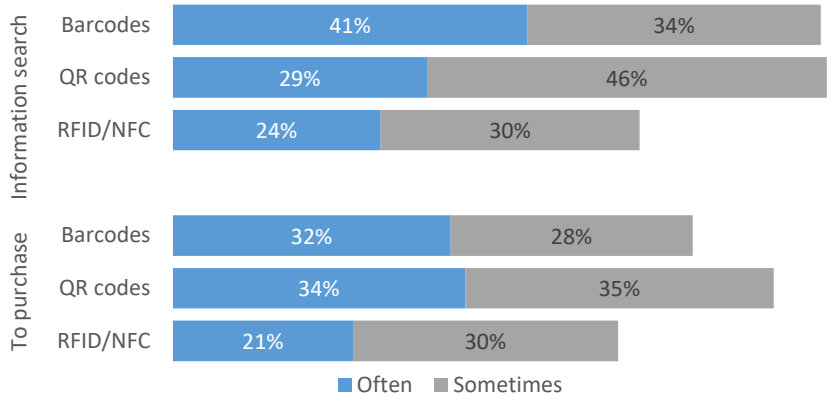


Figure 3-12 Use of smart technologies for information searching and purchasing

3.3.4 Mobile app use related to beef

- Consumers were asked if they currently use, or were interested in using mobile apps for a variety of beef related reasons (Figure 3-13). Health related apps were the most frequently used.

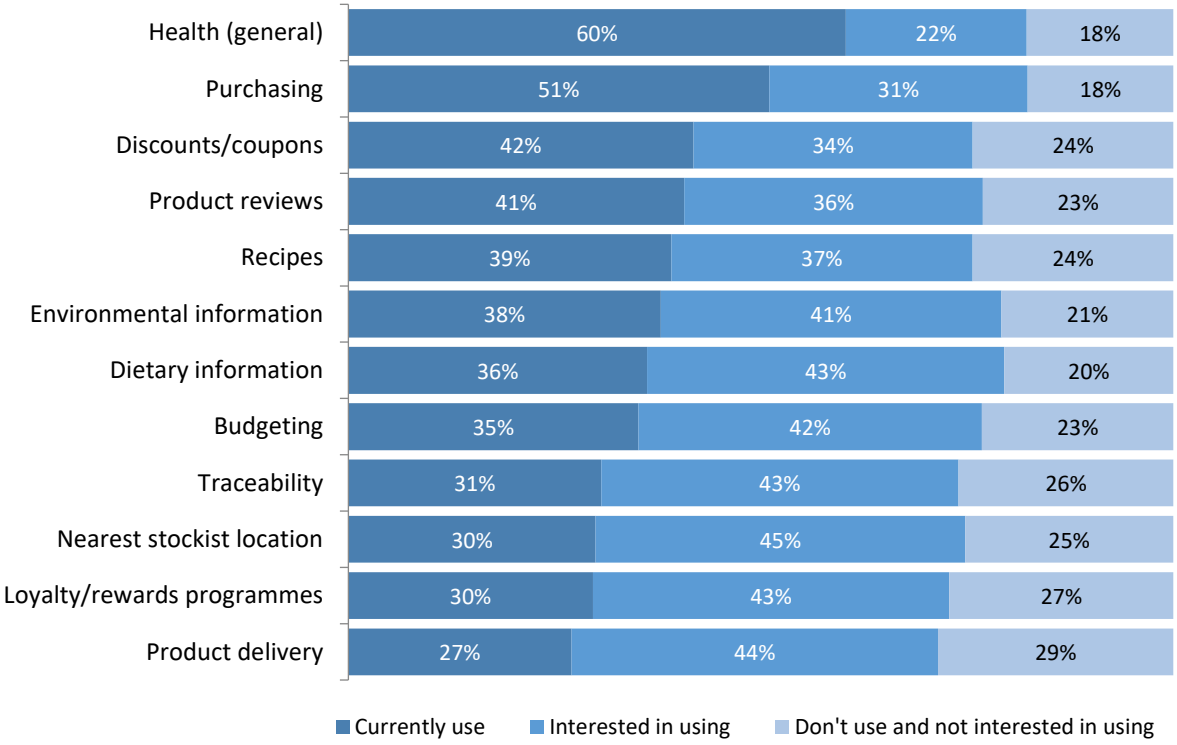


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Figure 3-13 Current and potential uses of mobile applications

3.3.5 Beef expenditure across retail channels

- Respondents were asked to allocate their beef expenditure across their usual purchase channels (Figure 3-14). The graph below shows the average expenditure for each channel. Supermarkets were the source of highest beef expenditure at 22 per cent, followed by online from domestic sources.

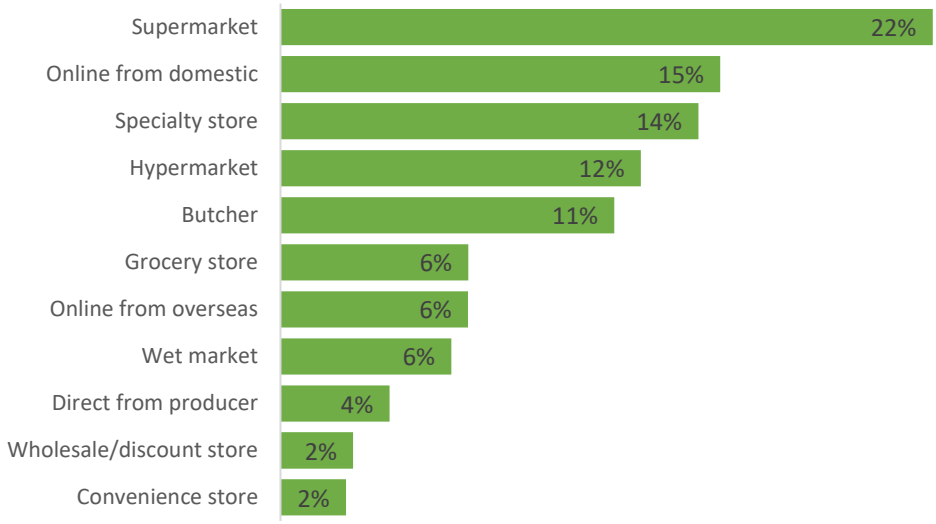

Figure 3-14 Percentage of beef expenditure by retail channel

- Almost two thirds of consumers purchased beef online. Supermarkets, hypermarkets, and specialty stores are the main online retail channels used by those purchasing beef online (Figure 3-15).

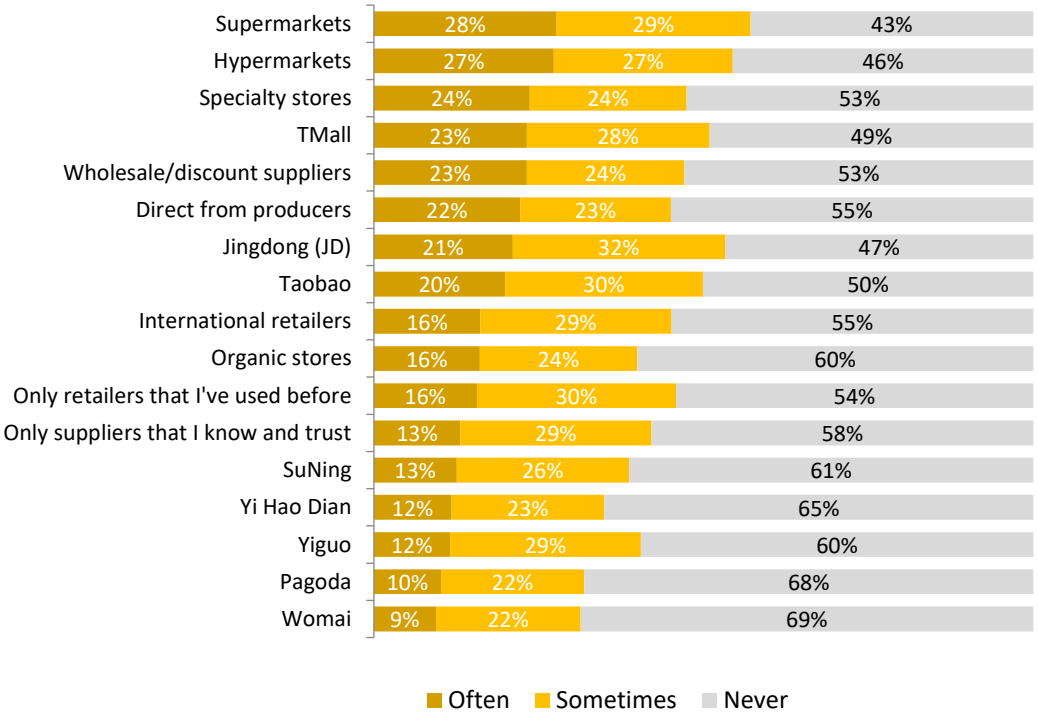

Figure 3-15 Use of online retail channels

- Access to products not available locally, and greater variety are the most important reasons for those choosing to shop online (Figure 3-16).

Figure 3-16 Main reason for shopping online for beef

3.4 Discrete Choice Experiment analysis of beef tenderloin choices

In this section we present findings of the Discrete Choice Experiment. Our objective is to identify which beef tenderloin attributes drive product choices, by how much, and by who. We do this using a statistical method called Latent Class Modelling that identifies consumer segments in the data based on which product offerings consumers preferred. The model parameter estimates can be found in Appendix B. Discrete 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, the choice task and product attribute understanding was high, respondents felt that they were able to express what was important to them concerning beef attributes, and most respondents felt certain that their responses reflected real-world choices if these beef tenderloin products were available (Figure 3-17).

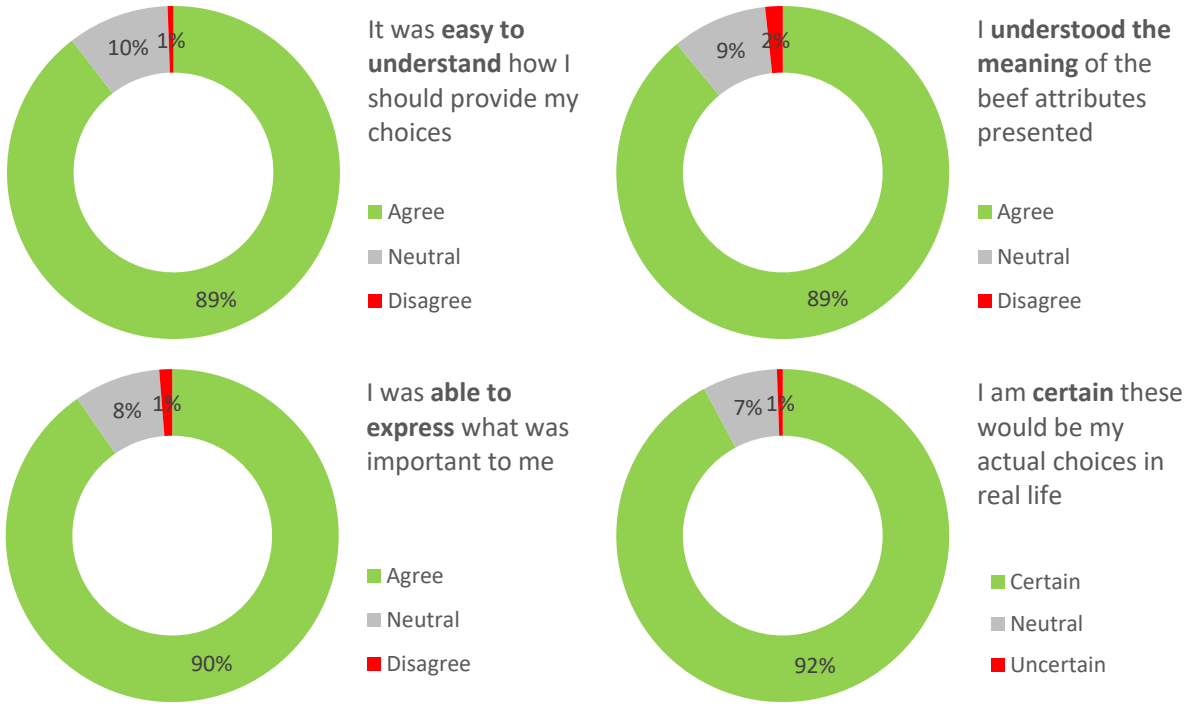

Figure 3-17 DCE debriefing questions: task and attribute understanding, ability to express preferences, choices certainty

3.4.1 Consumer willingness-to-pay values

Estimates of WTP tell us how much more the average consumer is willing-to-pay per kg of beef tenderloin product with a particular attribute, over one that does not have this attribute (Table 3-1, Figure 3-18). For example, members of Segment One are willing-to-pay, on average, ¥28.9 more for beef that is pasture raised, over one that is not. There is some uncertainty in WTP estimates, and the Confidence Intervals reported indicate that we can be 95 per cent sure that the true WTP falls within this interval, in this case between ¥8.4 and ¥49.

We can see that the Latent Class Modelling has identified three distinct consumer groups. Reported under each segment column heading is the size of each segment; Segment One has an estimated size of 32 per cent, the second segments size is 48 per cent and the third is 20 per cent. These segment sizes tell us the probability that a randomly selected Beijing beef mince purchaser is from that consumer group.

Table 3-1 Beef tenderloin attribute willingness-to-pay by consumer segment

Beef tenderloin Attribute	Segment One 55%	Segment Two 33%	Segment Three 12%
Carbon Neutral	¥40*** (12, 69)		
Biodiversity Enhancement	¥42*** (18, 66)		¥142** (23, 262)
Water Quality Protection	¥33*** (12, 54)	¥35*** (28, 42)	
Organic Production	¥21** (0.9, 41)	¥49*** (39, 60)	¥173*** (8, 345)
Māori Production		¥71*** (60, 82)	
Feedlot Raised	¥79*** (31, 127)	¥80*** (66, 95)	
100% Pasture Raised	¥57*** (32, 83)	¥37*** (31, 43)	
100% Grass-fed		¥59*** (48, 70)	
Grain-fed	¥52*** (26, 79)	¥47*** (39, 55)	
No added antibiotics	¥44*** (23, 66)	¥27*** (17, 38)	¥98** (12, 185)
No added hormones	¥63*** (31, 96)	¥39*** (29, 50)	
Enhanced Animal Welfare	¥26*** (17, 35)		¥46** (8, 85)
GMO-free	¥26*** (14, 39)	¥17*** (12, 23)	¥133*** (37, 230)
Social responsibility	¥17** (4, 31)	¥22*** (16, 28)	¥55** (2, 109)

Average marginal WTP/**kg** beef tenderloin ¥2021.
95% Confidence Interval in brackets.
***, **,* denote statistical significance at the 1%, 5% and 10% levels indicating that a willingness-to-pay estimate is significantly different from zero.

Beijing Beef Tenderloin Consumer Willingness-to-pay Segments

1. Animal Attentive — 54% of consumers

While the largest segment of consumers has the broadest set of attribute considerations of the three segments, their main preferences center on animal housing, feed and additives claims.

Consumers in this segment are more likely to:

- Live in a household as a couple with children
- Usually buy lower priced beef

2. Cultural Consumer — 34% of consumers

The second largest group of consumers have the highest WTP for Māori Production, and Grass-fed claims and are the only segment to value these claims.

Consumers in this segment are more likely to:

- Be willing to try unfamiliar foods
- Be more accepting of cultures other than their own

3. Organic Orientated — 12% of consumers

While this segment is the smallest of the three they have relatively high WTP for Organic produced beef. These consumers also have significant preferences for attributes closely aligned with Organic practices.

Consumers in this segment are more likely to:

- Have higher usual spend
- Have higher usual purchase frequency

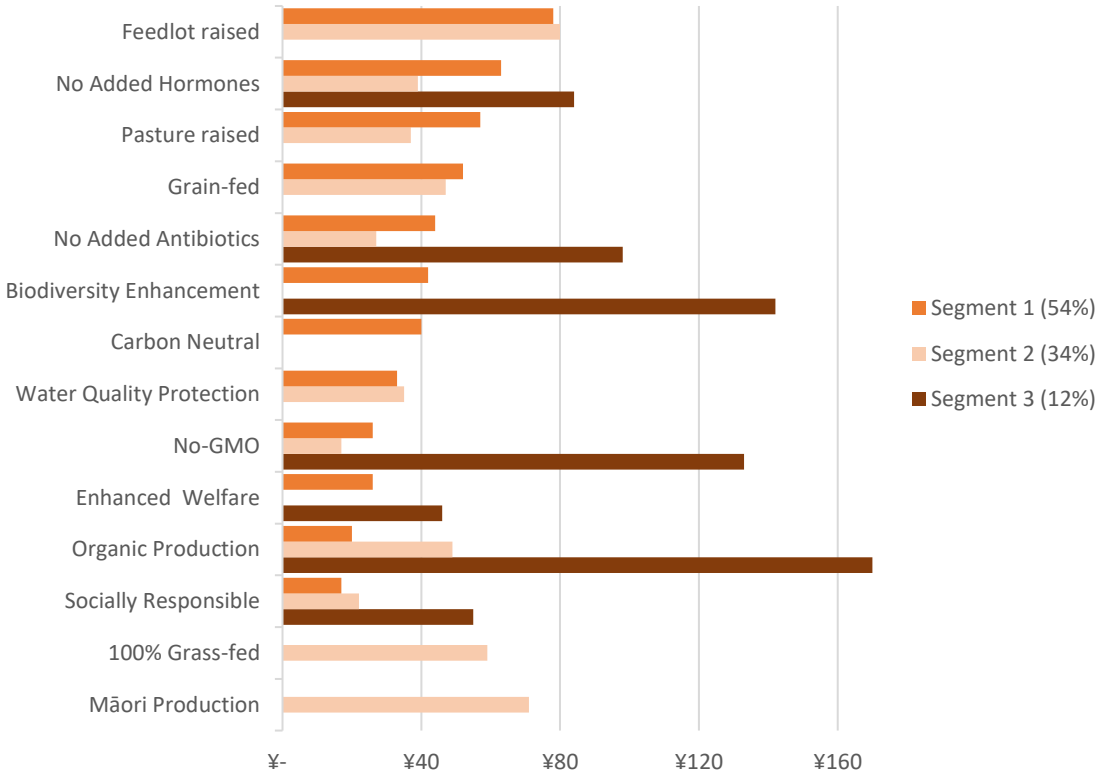

Figure 3-18 Beijing consumers' willingness-to-pay for beef tenderloin attributes

To provide an indication of the overall willingness-to-pay values an aggregate estimate is formed by weighting segment WTP values by their class size and summing across segments (Figure 3-19). This exercise indicates that beef attribute claims concerning 'Feedlot Raised', 'No added Hormones' and 'Organic Production', have the highest overall influence on tenderloin choices, and stand out as offering the greatest value to consumers.

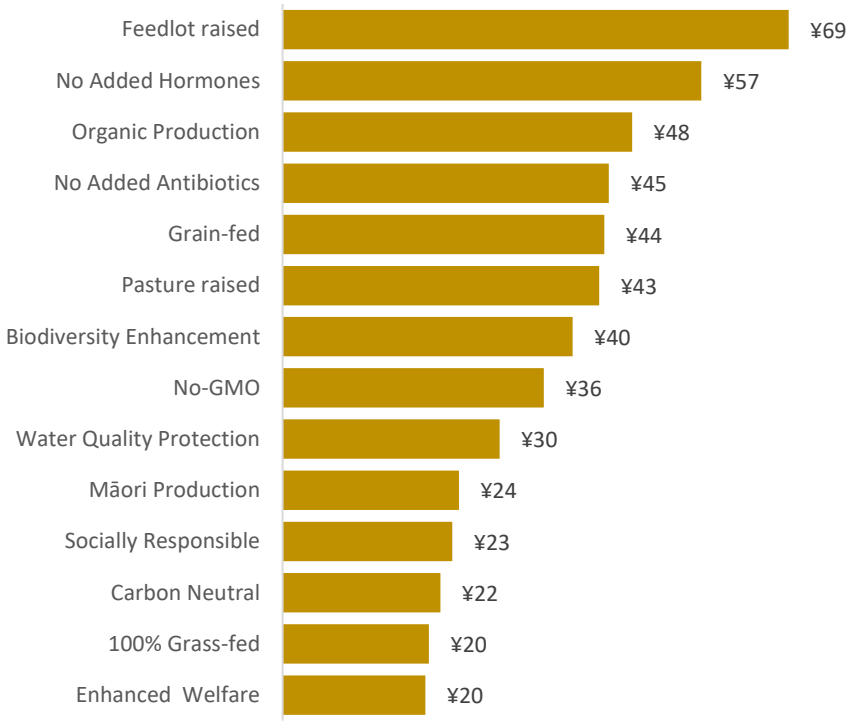

Figure 3-19 Segment weighted aggregate WTP

Chapter 4
Conclusions

This report presents the findings of a structured online survey of Beijing beef tenderloin consumers. The survey objective was to provide insights into consumers' purchase and consumption behaviours. The information gathered included examining perceptions of important drivers of product characteristics, the role of digital media and smart technologies, and consumers preferences for distinctively New Zealand credence attributes.

Overall, results clearly indicate that New Zealand beef is held in high regard as a high-quality offering, with characteristics that consumers prefer and value. The statistical analysis of consumers beef choices using the Discrete Choice Experiment and Latent Class Modelling provides a robust analytical framework to identify consumer segments with differing characteristics and product preferences. Profiling high value consumers informs marketing strategy aimed at engaging consumers with highest willingness-to-pay for the product attributes that New Zealand can deliver.

This survey is the second in the research programme to survey Beijing beef tenderloin consumers with the first survey in 2019. The two samples are consistent on demographic measures including income, gender, location, education, income, age, and household composition. Comparing results found here to the previous survey show that[1]:

- There is a signal that consumption frequency has increased. The average number of beef containing meals increased slightly from 3.7 in 2019 to 3.8. Two meals a week was the most common frequency in 2019 (28 per cent), that has increased to three meals a week in 2021 (29 per cent). With 20 per cent of consumers in 2019 eating three beef meals a week this indicates that about 10 per cent of consumers are eating an additional beef meal.
- Average prices paid are broadly consistent between survey years, with some minor movements in both directions across different cuts, and no systematic changes. Less premium cuts, including beef slices, average price increased from ¥112/kg (2019) to ¥121 (2021) and reduced for chuck roast from ¥114 to ¥110. Movements in premium cuts include ¥142 to ¥149 for tenderloin, and ¥146 to ¥141 for porterhouse steak.
- Country-of-origin frequency is unchanged with New Zealand beef the second highest country-of-origin, behind China and ahead of Australia. Seventy per cent of respondents buy New Zealand beef at least occasionally, another 22 per cent rarely, and just five per cent indicating that they had never bought New Zealand beef product. Purchases of different New Zealand beef cuts has increased moderately between surveys with the average number of cuts purchased increasing from four in 2019 to five in 2021.
- Consumers ranking of beef quality by country-of-origin remains consistent between 2019 and 2021, with New Zealand beef quality ranked relatively highly, and in the top three countries by 67 per cent (2019) and 63 per cent (2021) of consumers.

[1] Tait, Peter, Caroline Saunders, Paul Dalziel, Paul Rutherford, Timothy Driver and Meike Guenther (2020). *Beijing beef consumer consumption behaviours and product preferences: A Latent Class Analysis.* AERU Research Report No. 360, prepared for Unlocking Export Prosperity Research Programme. Lincoln University: Agribusiness and Economics Research Unit.

- There is an overall increase in the use and frequency of a range of digital media and smart technologies related to beef. Use of QR codes for information search and purchasing is about 15 per cent higher in 2021. Use of RFID/NFC technology to make purchases has increased by about 50 per cent.
- There is an increase in use of smartphone apps related to beef products of about 10 per cent. The top uses of apps including health, purchasing, and product reviews have remained unchanged. The relative use of a range of online digital media sources for product information is consistent between survey years.
- The proportion of consumers buying beef online is lower in the 2021 sample (67 per cent) than in 2019 (79 per cent).

Comparing consumer WTP estimates between survey rounds shows that overall consumer preferences have strengthened for a majority of the product claims assessed (**Error! Reference source not found.**). This graph presents the same weighted aggregate WTP estimate as in Figure 3-19 above, but measured as the percent of average prices usually paid (¥149/kg), compared with the same calculation for the 2019 results. At the time of the first survey in 2019, the COVID-19 pandemic had not taken hold in Beijing. The pandemic officially started in China in January 2020 when the first confirmed case was recorded. Covid-19 has significantly affected changes in consumers food and eating behaviours around the world. Food and nutrition now play a greater role in providing health benefits and in strengthening the immune system. Some of the changes in WTP between 2019 and 2021 estimates may be attributable to these factors. Demand for food that provides preventative health has increased, and this can have the effect of lifting overall WTP values across product attributes.

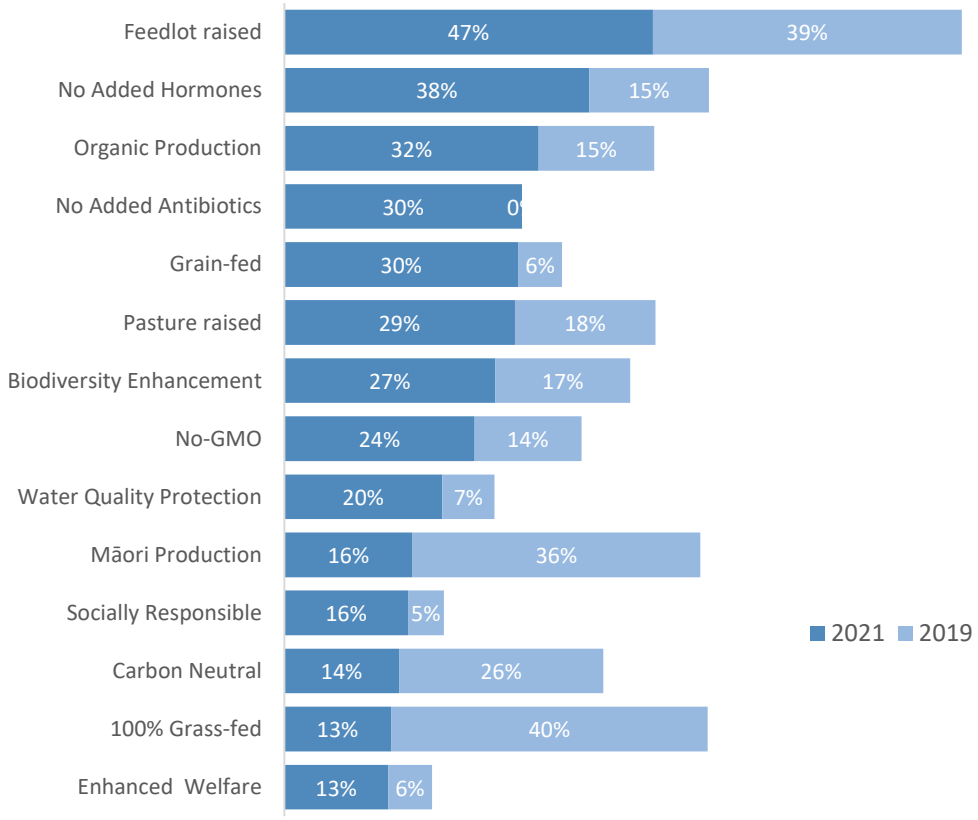

Figure 4-1 Comparing 2021 and 2019 WTP

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[2] *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[3] 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

[2] Related terminology used in psychology discipline is *the level of satisfaction* (Hensher et al. 2015).
[3] 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 Beef Tenderloin Choices

Table B-1 Latent Class Model of Beijing beef tenderloin consumer product choices

Utility parameters[1]	Segment 1	Segment 2	Segment 3
Carbon Neutral	0.50***(0.14)	0.31 (0.23)	0.94 (0.88)
Biodiversity Enhancement	0.53***(0.13)	- 0.16 (0.17)	3.00***(0.77)
Water Quality Protection	0.41***(0.07)	1.21***(0.15)	0.29 (0.31)
Organic production system	0.26***(0.10)	1.71***(0.20)	3.63***(0.63)
Māori production system	0.13 (0.10)	2.44***(0.24)	- 2.56***(0.58)
Feedlot raised	0.98***(0.17)	2.76***(0.37)	4.03 (4.58)
100% Pasture Raised	0.71***(0.07)	1.27***(0.17)	- 1.23***(0.46)
100% Grass-fed	0.18 (0.12)	2.04***(0.26)	- 2.28***(0.54)
Grain-fed	0.64***(0.07)	1.61***(0.17)	- 0.44 (0.37)
No added antibiotics	0.55***(0.08)	0.96***(0.14)	2.07***(0.42)
No added hormones	0.79***(0.09)	1.36***(0.09)	0.88** (0.35)
Enhanced animal welfare	0.33***(0.05)	0.13 (0.08)	0.98***(0.22)
No GM feed	0.32***(0.05)	0.60***(0.07)	2.81***(0.41)
Socially responsible	0.22***(0.06)	0.78***(0.07)	1.16***(0.25)
Price/kg	- 0.02***(0.00)	- 0.34***(0.00)	- 0.02***(0.00)
Opt-Out	- 2.70** (1.31)	- 4.22***(0.26)	- 2.93***(0.86)
Class Membership			
Food Neophobia score		- 0.12***(0.02)	
Ethnocentrism score	0.08***(0.02)	- 0.31***(0.08)	
Usual price paid	- 0.01***(0.00)	- 0.01***(0.00)	
Urban	1.23***(0.37)	1.25***(0.36)	
Has children	0.97***(0.31)		
Average class probability	0.54	0.33	0.12
Model Fit Statistics			
Log Likelihood function	- 6,087		
Log Likelihood chi^2 stat (74 d.f.)	7,247***		
McFadden Pseudo R^2	0.37		
Number of observations	8,840		
Number of respondents	884		

***, **,* 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

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373 In progress.

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