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# On the Economic Preferences towards Farm Animal Health and Welfare

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Submitted in fulfilment of the requirements for the
Degree of Doctor of Philosophy

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# Abstract

In this thesis, I study consumer and producer preferences towards farm animal health and welfare (FAHW), in the context of two endemic diseases Bovine Viral Diarrhoea (BVD) in cattle and lameness in sheep. Whilst BVD is an infectious disease, lameness is primarily a disease of management and as such, perceived and managed differently by farmers. Throughout the animals' lifetime, these diseases are a source of several health issues, leading to early death in the case of BVD and are also costly for the farmer. Thus, both of these two endemic diseases have emerged high on the priorities list in the Agricultural Act 2020. However, each country has different legislation regarding disease management in livestock. Whilst England has an industry led voluntary scheme for the eradication of BVD (in cattle) that started in 2016, Scotland has in place a mandatory BVD eradication Scheme set out in the Bovine Viral Diarrhoea (Scotland) Order 2019. The fact that both of these endemic diseases have severe health implications for the infected livestock but are not known to have any adverse effects for humans consuming their products, makes them apt objects for studying consumers and farmers preferences towards FAHW.

I have modelled consumer and producer preference towards FAHW using discrete choice experiments. For each respondent type (i.e. farmer and consumer) I run two surveys. The analysis for the consumer study uses hypothetical stated preference experiments related to four products: beef and milk, and lamb and wool. The first consumer study finds that UK respondents care about farm animal health and welfare independently of the sickness level in herds/flocks, when the sickness levels are known not to compromise the safety of the products consumed, as shown by their willingness to pay (WTP) to ensure it. The second consumer study was conducted a year later at the height of the COVID19 pandemic. My study aimed to model again consumer preferences towards FAH and FAW only this time in the presence of information asymmetry regarding food/product safety as well as increased financial uncertainty stemming from the ongoing pandemic. Respondents were divided into two sub-groups. The first treatment group (information treatment group) was given explicit food/product safety information whilst the second treatment group (no-information treatment group) was not given any food/product safety assurances. The results show that neither the COVID19 pandemic nor the presence of information asymmetry altered respondents' preferences towards FAHW. Respondents showed a strong preference for higher animal health whilst also preferring higher animal welfare. However, the magnitude for WTP estimates for FAH and FAW although positive were found to be dependent on the food/product safety information. Yet, the WTP coefficients for the two treatment groups were not found to be statistically different.

Next, I modelled farmers' preferences towards farm animal health and welfare in England and Scotland, using a discrete choice experiment. Respondents were divided into Cattle and Sheep

farmers depending on their main source of agricultural income. A hypothetical farm management scenario was used to model farmers' choices and the trade-offs they were willing to make in the presence of disease risk and financial uncertainty. Once again, the disease risk was studied in the context of two endemic diseases, Bovine Viral Diarrhoea (BVD) in cattle and lameness in sheep. The study found that farmers have statistically significant preferences for improvements in livestock health after controlling for expected returns and income uncertainty. Both English and Scottish farmers displayed a positive and separable benefit for lower levels of disease prevalence, however the magnitude of this result is disease specific. Interestingly enough, cattle farmers in England did not have statistically different preferences to cattle farmers in Scotland. However, sheep farmers in Scotland and sheep farmers in England were found to have statistically different preferences with regards to disease risk and financial uncertainty.

Finally, I also examined farmers' cattle purchasing behaviour at auctions. The proposed discrete choice experiment (DCE) models buyer preferences towards cattle purchases at auction markets in England and in Scotland, in the context of BVD in cattle. The experiment is tailored according to each country's individual legislation regarding BVD. This meant that English farmers' preferences were modelled with respect to BVD disease status whilst Scottish farmers preferences were examined in terms of the different BVD testing measures available. I found that cattle farmers in England preferred purchasing BVD free cattle. Similarly, Scottish farmers also exhibited strong preference for BVD tests that were administered to the whole herd thus, minimising disease risk. Farmers in both countries seem aware of the consequences of BVD still, they were willing to engage in risky behaviour through the purchase of cattle with either unknown BVD status in England or with purchasing cattle that came from a herd where a sub-sample of calves only were tested. The study also found that farmers purchasing behaviour was influenced by seller characteristics.

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# List of Abbreviations

| | |
|---|---|
| **AIC** | Akaike Information Criterion |
| **ASC** | Alternative Specific Constants |
| **BIC** | Bayesian Information Criterion |
| **bTB** | Bovine Tuberculosis |
| **BVD** | Bovine Viral Diarrhoea |
| **BVDV** | Bovine Viral Diarrhea Virus |
| **CAIC** | Consistent Akaike Information Criterion |
| **CAP** | Common Agricultural Policy |
| **CODD** | Contagious Ovine Digital Dermatitis |
| **CPI** | Consumer Price Index |
| **CVM** | Contingent Valuation Method |
| **DCE** | Discrete Choice Experiment |
| **DEFRA** | Department for Environment, Food and Rural Affairs |
| **EU** | European Union |
| **FAH** | Farm Animal Health |
| **FAW** | Farm Animal Welfare |
| **FAHW** | Farm Animal Health and Welfare |
| **FIELD** | Farm-level Interdisciplinary approaches to Endemic Livestock Disease |
| **FMD** | Foot Mouth Disease |
| **IID** | Independent and Identically Distributed |
| **IIA** | Independence from Irrelevant Alternatives |
| **ICLV** | Integrated Choice and Latent Variable |
| **LCA** | Latent Class Analysis |
| **LL** | Log-Likelihood |
| **LR** | Log-Likelihood Ratio |
| **MNL** | Multinomial Logit Model |
| **MU** | Marginal Utility |
| **OIE** | World Organisation for Animal Health formerly Office International des Epizooties |
| **ONS** | Office of National Statistics |
| **PI** | Persistently Infected |
| **RP** | Revealed Preference |
| **RPL** | Random Parameter Logit |
| **RSPCA** | Royal Society for the Prevention of Cruelty to Animals |
| **RUT** | Random Utility Theory |
| **SP** | Stated Preference |
| **UK** | United Kingdom of Great Britain and Northern Ireland |
| **UDAW** | Universal Declaration on Animal Welfare |
| **US** | United States of America |
| **VAT** | Value Added Tax |
| **WTP** | Willingness to Pay |
| **5PP** | Five Point Plan |

# Dedication

This thesis is lovingly dedicated to my father Mr Severino Rodrigues whose hard work for the family provided me with the opportunity to pursue my dream.

I also dedicate this thesis to my father-like figure the late Mr Inacio Rodrigues who was one of my biggest cheerleaders throughout my life.

# Acknowledgements

First and foremost, I would like to express my deepest gratitude to my supervisor Professor Nick Hanley for the guidance he provided throughout my studentship. His brilliance, knowledge, generosity with time and especially patience with me, made my time pursuing my doctoral studies much smoother than I had expected. I am immensely indebted for all he has taught me thus far, and continues to this day. Without him, I could not have undertaken this journey, so my sincerest thank you to my Professor.

I would also like to thank my second supervisor, Professor Rowland Kao. His advice and critique were invaluable. They helped me improve my understanding of the topic and grow as researcher. I really appreciate him for providing me with comprehensive, detailed feedback and insightful suggestions. I hope to have many more collaborations together and look forward to the future.

I would like extend my special thanks to Dr Keila Meginnis who was my supervisor for a period of time. I am grateful for all the help and support that Dr Meginnis gave me during the early days, especially for all the time she devoted to me. I would also like to thank Dr. Souvik Datta and Dr Zhaoyang Liu, who were briefly part of my supervisory team. Next, I want to extend my gratitude to Professor Mikołaj Czajkowski for the time he took answering my questions and helping me with my project as well as Professor Michiel Bliemer for his guidance on constructing discrete choice experiment designs in NGene. I would like to give a special thanks to Professor John Rolfe and Professor Robert Fraser for all the time spent providing me with useful suggestions and feedback.

I am also grateful to the FIELD researcher team: Professor Abigail Woods, Professor Karen Sayer, Sue Bradley, Dr Amy Proctor, Dr Lewis Holloway as well as the ECR's Nicole Gosling, Dr. James Brown, Dr Niamh Mahon, Dr Andrew Black for their guidance and collaboration during the last four years. I am also grateful to Dr Beth Clark and Dr Ewan Coleman for proof reading my work and providing me with constructive feedback.

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I am grateful to the Welcome trust for funding my research as well as all the participants in the survey/focus groups that made my study possible. I am also thankful to the attendees at the AES conference 2021 and Scottish graduate programme conference 2021 for their invaluable feedback on my work. I would to thank Newcastle University for inviting me to give a seminar on my work as well as the participants for providing me with feedback.

As well as those that helped me with the practical aspects of my thesis directly, there are those who helped me get through my studies with their moral support. I would be remiss in not mentioning my family and friends. I would like to acknowledge all my friends and my little brothers Rueben Rodrigues and Jessio Rodrigues for their support. Especially, Jessio for always being there for me whenever I needed a family. My father Severino Rodrigues for providing me with the opportunity to pursue my dream, believing in me and encouraging me to be the best I can. My late grandmother Maria Piedade Fernandes for instilling values in me that shape the person I am today.

And finally, and most importantly, I would like to thank my partner Vasileios Rafail Karaferis who has been my rock and his mother Areti Grammenopoulou for their love and support, for being the family I needed during all the difficult moments, for encouraging me and taking me in their warm embrace.

**Thank you.**

# Declaration

This thesis, and the work contained within it, was conducted from October 2018 to October 2022 by myself, unless stated otherwise. No part of this thesis has been submitted for another degree.

Signature

Maria Suella Rodrigues

# Chapter 1

# Introduction

## 1.1 Overview

Chapter 1 of my thesis is designed to provide an introduction to my thesis. Section 1.2 begins by presenting the background and motivation, delving briefly into the two key animal conditions considered in the context of my studies: Bovine Viral Diarrhoea (BVD) in cattle and lameness in sheep. Section 1.3 outlines the research aims and objectives and finally, in section 1.4 I provide a road map to the rest of the thesis.

## 1.2 Background and Motivation

Animal products such as meat, milk, wool, eggs for human consumption came from numerous breeds of animals through the process of domestication over the past 15,000 years of human history (Diamond J. (2002), MacHugh et al. (2017)). Today excellent, intriguing research is available investigating the prehistory of modern technological societies we live in and the food we consume. Selokar and Keus (2018), state that it is selective breeding that contributed to both “animal health and high production performance” through the breeding out of disease-causing traits thereby reducing the susceptibility to infectious diseases.

The advent of agriculture also brought with it an increased threat to human life through zootonic diseases (McNeill, 1976; Diamond J., 1997). All these studies focus on the contribution of animal health for the benefit of human health and welfare- with food safety being the primary focus-animal health and welfare are but a side note. Only recently we have started to consider the health and welfare of these animals as a society. This thesis, therefore, tries to redirect the reader to focus on the nexus of Farm Animal Health (FAH) and Farm Animal Welfare (FAW) instead. What do contemporary humans think of a such a topic? Recent times have seen the emergence of organic farming and questions are raised about the impacts of industrialised systems in conventional agriculture. The shift in focus to more sustainable practices was made possible only because of the rising demands from consumers. It has gained much attention not only amongst directly interested groups such as the members of the food production industry (for instance, meat producers and retailers) but also in a broad range of academic disciplines.

Over time, there have been extensive debates regarding animal health and welfare [1] however, we struggle as a scientific community to agree on one definition. Although my research is not aiming to solve this problem, I hope to contribute to this ever-growing literature on animal health and welfare in livestock production by understanding current consumer and farmer perceptions in the United Kingdom of Great Britain and Northern Ireland (UK) [2] for two specific, endemic livestock diseases. I model farmer and consumer preferences towards Farm Animal Health and Welfare (FAHW) using economic theories and methods. I employ discrete choice experiments to model two endemic diseases (BVD in cattle and Lameness in sheep) to understand the choices that the British public is willing to make to ensure high FAHW. However, since consumers cannot control the method of production, I investigate the different signals (i.e. attributes) they rely to make informed decisions.

Before Brexit, UK along with other European Union (EU) nations collaborated to set and implement legislation to improve and manage livestock diseases. The early 1990s saw most of the European community thrive with lower real prices, safer food and with a wide range of quality available (Swinbank A., 1994). For fifty years, since 1973, the UK was part of the EU's Common Agricultural Policy (CAP). This however changed of course with the UK's exit from the EU. A historic new opportunity in the form of the Agriculture Act 2020 [3] now allows the policymaker to design a more bespoke policy for its market. A notable feature of this new proposal is the inclusion of payments to farmers for increasing public good supply (e.g. enhancing biodiversity) rather than focusing on farm productivity alone. As such the new Agricultural Act of 2020 shifts the focus on the delivery of "Public goods". The term "Public good" [4] refers to a good/commodity that is non-excludable and is non-rival in consumption. And in this context, the government could incorporate varied outcomes from environmental benefits to improved FAHW. This promising new goal seeks to improve animal health and welfare by treating it as a public good.

My thesis also looks at preferences for farm animal disease management in the context of increasing consumer prices for food. According to the Office of National Statistics (ONS, 2021), with a population of 67.22 million and 23 million households in the UK, consumer spending increased to 359,983 GBP Million in the fourth quarter of 2021 from 353,212 GBP Million in the third quarter of 2021. We see a sharp decline in spending in early 2020 as a culmination of several factors including the COVID19 pandemic that saw large scale disruptions in the economies around the world, labour shortages and disruptions in the supply chains.

So, if we restrict our attention to the last 12 quarters, during which time my surveys for this thesis were designed and implemented, it becomes evident that this period is characterised by high volatility in both prices and consumer spending (See Figure 1.1 ). The right panel of figure 1.1[5], clearly demonstrates that consumers spending was still less volatile than inflation indicating the presence of a strong consumption smoothing motive and/or strong consumption habits[6].

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[1] Chapter 2 discusses some of the definitions and literature in this regard.

[2] In chapter 2, I provide a comprehensive review of the key literature.

[3] Separate provisions are made for Wales and Northern Ireland. https://www.legislation.gov.uk/ukpga/2020/21/contents/enacted

[4] Chapter 8 discusses "Public goods" extensively in the context of the results found in my thesis.

[5] Figure 1.1 was constructed using data on CPI and consumer spending from the ONS (2021).

[6] See Ravn et al., (2006) and Leith et al., (2012) for a discussion on consumption habits.

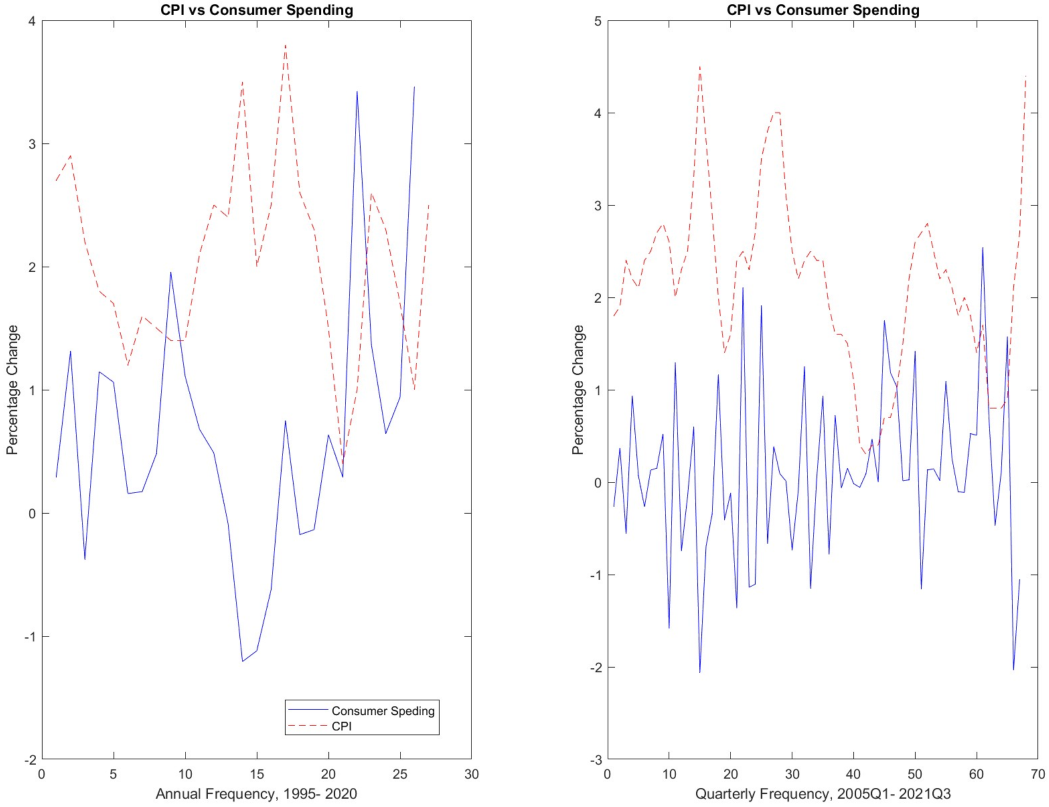
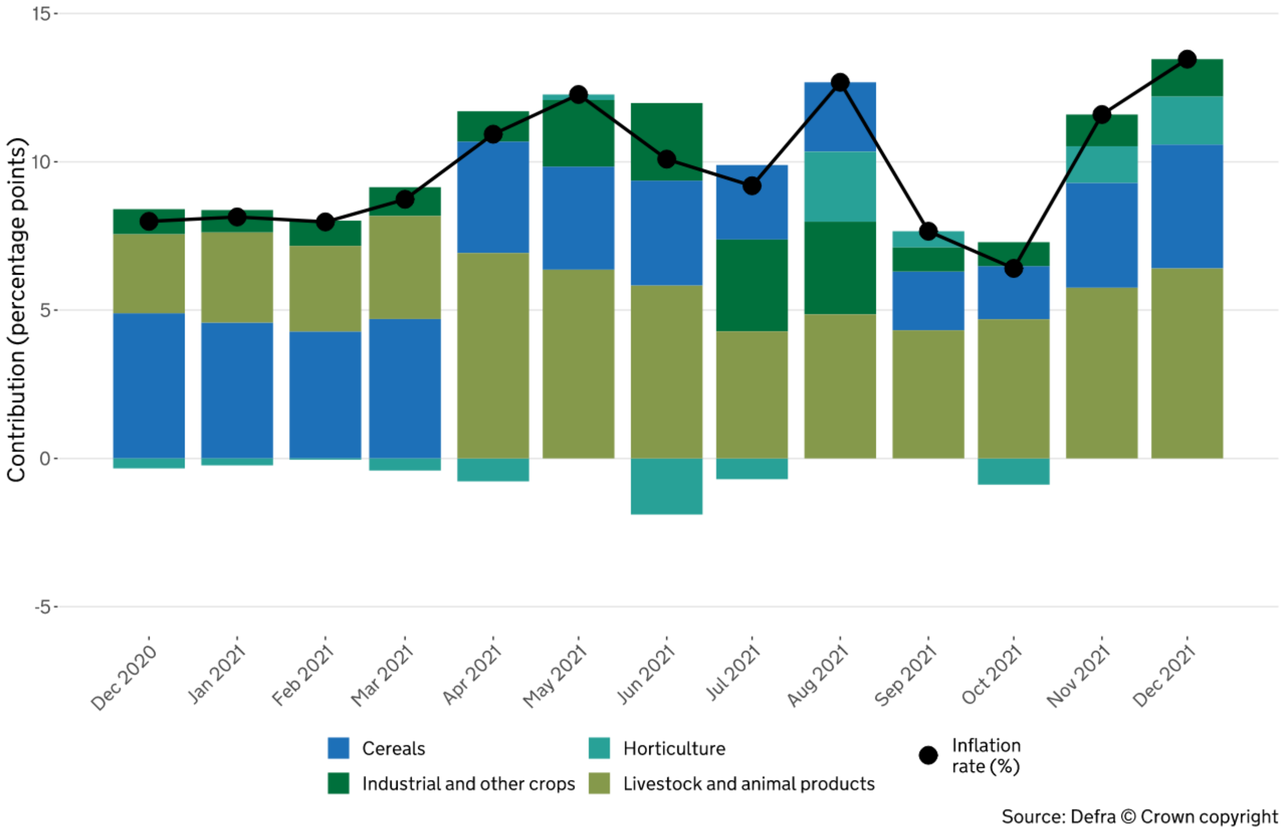


Figure 1.1: UK consumer spending and consumer price index (Source: Author)



Source: Defra © Crown copyright

Figure 1.2: Contributions to the 12-month inflation rate in agricultural outputs, UK (Source: DEFRA)

With prices on the rise, cost of food in the EU increased 4.70 percent in January of 2022 over the same month in the previous year (Eurostat, 2022). According to the ONS, UK on the other hand saw an increase of 5.10 percent in February 2022 over the same month in the previous year. In fact, we observe that inflation in agricultural outputs has increased steadily from February 2021 with the main driver behind this increase being the price surge in livestock and animal products (Figure 1.2).

Figure 1.3 shows a comparison of food inflation between the UK and the EU from 2005 to 2020[7]. Furthermore, I chose to deconstruct this index and look in isolation inflation that comes from beef, milk and lamb. I chose to focus on inflation coming from these products because they act as proxies for gauging consumer preferences to FAHW while simultaneously are important components of the agricultural commodity price index. One can easily observe that from 2008 onwards, the UK has experienced consistently higher food inflation than the EU average. Additionally, it also presents us with evidence that there is a clear positive trend in the food inflation data for both the UK and the EU.

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[7] The data for Figure 1.3 was taken from the Agricultural commodity price index in the Eurostat, 2020.

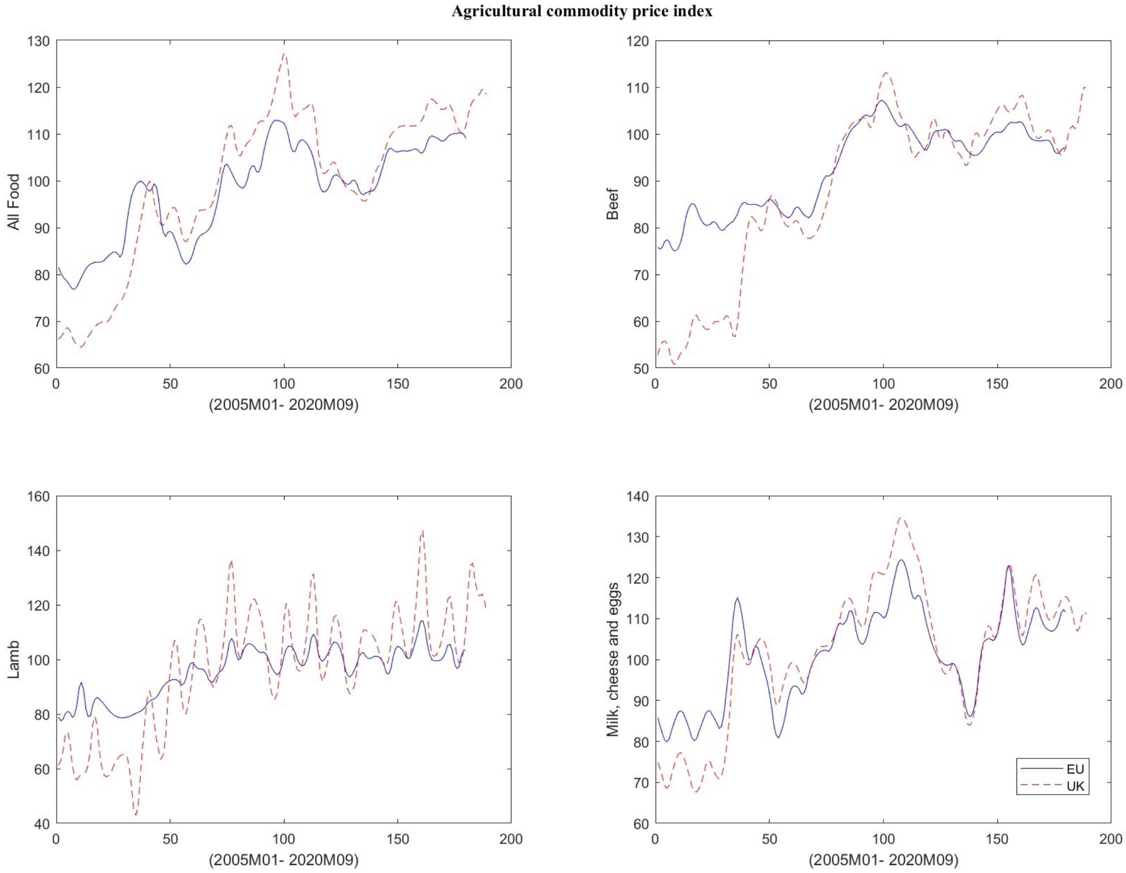

Figure 1.3: UK versus EU food inflation (Source: Author)

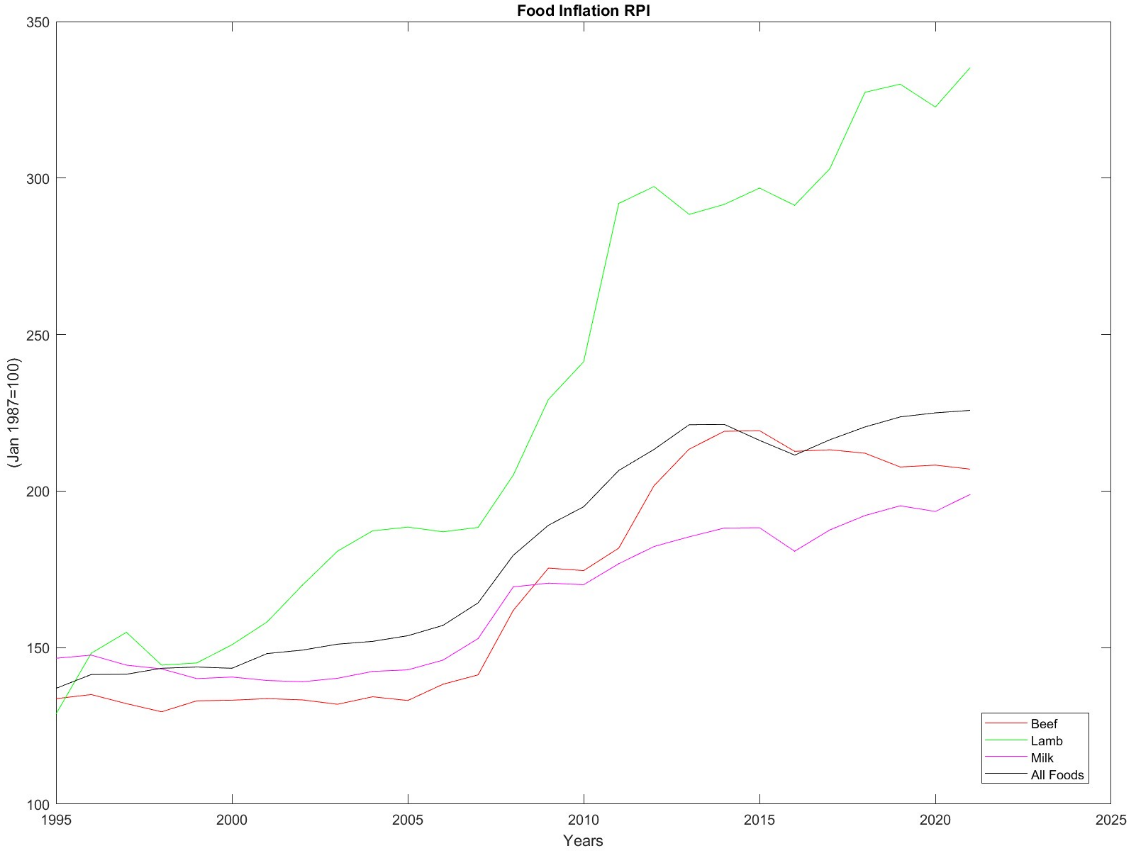

Figure 1.4: Evolution of Food Inflation (UK) (Source: Author)

In Figure 1.4, I illustrate the evolution of food inflation as a whole and by breaking it down to the components relative to my research. Just by glancing at Figure 1.4 [8], it becomes apparent that in the last fifteen years there has been a clear upward trend in food inflation in the UK. Inflation in 'Milk, Cheese, eggs' and in 'Beef' seem to follow one- to-one change in food inflation. On the other hand, inflation in "Lamb/ Sheep" meat has increased in this period by a lot more.

According to a report by the Department for Environment, Food and Rural Affairs (DEFRA) (2021) update report, agriculture contributed to 0.51 percent of GDP towards the UK economy in 2021 with the total income from farming of £6 billion (increase of £0.8 billion from 2020) as shown in Figure 1.5 which is adjusted to account for inflation. The agricultural sector employs 472,000 (decrease of 0.8 percent). There are livelihoods depending on this industry. The supply of our food and drink sector contributing £127 billion to the economy depends on agriculture. 71 percent of UK land is managed by farmers and land managers. In this respect, we can see that given agriculture plays a major role in our lives, dietary trends, changing ideologies can influence

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[8] The data for Figure 1.4 uses Food Inflation RPI: Food data from ONS.

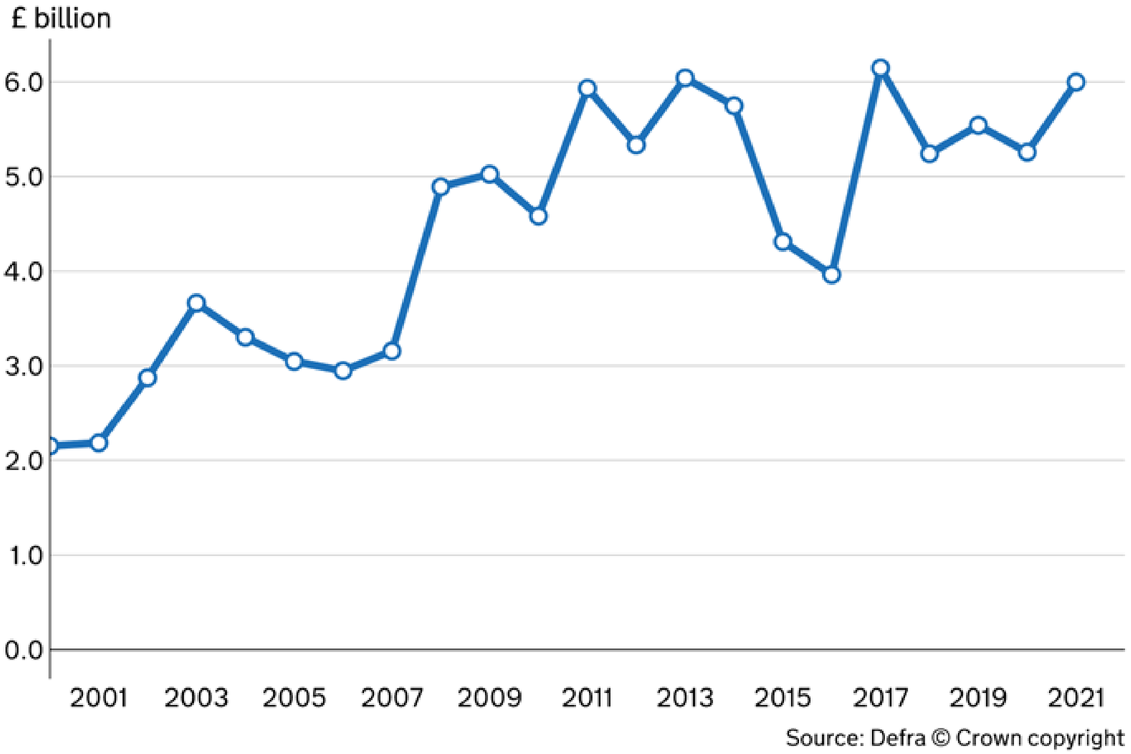

Figure 1.5: Long term trends in TIFF, 2000 to 2021 (Source: DEFRA 2021)

the outcomes of farm animal health and welfare and the way we broach the subject.

Emerging high on the priorities list in the Agricultural Act 2020 are Bovine Viral Diarrhoea (BVD), lameness and mastitis in cattle [9] and lameness, mastitis, and iceberg diseases in sheep[10]. The two endemic conditions considered in my thesis are Bovine Viral Diarrhoea (BVD) in cattle and lameness in sheep. While BVD is an infectious disease, lameness on the other hand is primarily a disease of management and therefore, viewed and treated differently by farmers. These conditions are a source of numerous health complications throughout the life of the animals, leading to early death in the case of BVD as well as tremendous economic costs (Gunn et al., 2005). The characteristics of these conditions make them apt objects for studying perceptions of these diseases as consuming animal products from sheep and cattle affected by these conditions induce no adverse health effects in consumers.

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[9] Since our study is solely based in the UK, I will use the meaning of cattle as defined in the UK as either specialist beef or dairy breeds (AHDB, 2012).

[10] Sheep are all ovine stock, and an animal under 6 months of age is considered to be a lamb, a mature female sheep is a ewe and mature male a ram. Classification of breeds is based on geographical location as well as purpose of breeding for example for milk, wool and meat production (AHDB, 2012).

### 1.2.1 Bovine Viral Diarrhoea

Cattle and calf populations in the UK, with an expected population of 9.36 million in 2020, are decreasing, according to Statista (2022). Despite a small increase in their population in 2014- 2015, the cattle and calves population has decreased by more than 1 million since 2005. Bovine Viral Diarrhoea (BVD) a highly contagious viral disease that spreads as easily as the common cold was first identified in 1946 in North America (Stalder et al., 2018). As Hanon et al. (2012) described, there are two types of infections caused by this disease: a transient infection and a persistent infection. Transient infections are temporary and result in poor fertility, low production of milk and immunosuppression which makes cattle more susceptible to diseases. Infection occurs after the birth of a cattle. On the other hand, a persistent infection (PI) is a lifelong infection where cattle are born with the disease. Most die within 18-24 months whilst spreading the virus infecting cattle that come in contact with them (Hoar, 2004). Some of the symptoms as reported by farmers were nasal discharge, fever, sporadic diarrhoea, respiratory symptoms, reduction in milk yield and sudden deaths in dairy cows and calves (Gethmann et al., 2015). PI cattle are the main source of spread of the virus (Houe, 1999). Transmissions may occur from infected dams to unborn calves, through direct contact with infected animals, indirectly by visitors or contaminated equipment and through the semen from infected bulls. The economic costs of BVD in the UK were estimated at £61 million per year (Bennett and Ijpelaar, 2005).

There is considerable variation in the management and policy responses to BVD in the UK. Scotland begun its eradication programme the so called ‘Scottish BVD Eradication Scheme’ - in 2010 with several phases introduced over the years (voluntary since 2010, compulsory testing since 2013 and movement restrictions since 2014). According to Haw (2019) in their report for the Scottish government, they estimated that an average-sized cattle herd will save £2000 to £14,000 per year if that herd is negative. If all farms eradicated BVD from their herds, Scotland could see farm business income to be around £2.4 million. Estimated upfront costs to an average farm to manage BVD range from £2000 - £6000. The Scottish scheme restricts movements of BVD positive herds and enforces compulsory testing of high-risk animals before they leave breeding herds. So far, this scheme was able to reduce BVD prevalence from 40% prior to the introduction of the scheme to 16% in 2019. Northern Ireland has had legislation in place since 2016 (previously pursued a voluntary phase from 2013) aimed at BVD eradication involving tag and testing and restriction of movement of PI cattle [11]. According to Strain et al. (2021), there was a 56% fall in incidence of BVD virus positive calves since the start of the legislation. Wales, however, has taken a voluntary industry led approach since 2017 (The Gwaredu BVD Eradicating program) with some funding provided by the Welsh government. Lastly, England launched an industry led voluntary scheme in 2016 (BVDFree England). According to Shortall and Calo (2021), the devolved nations’ adoption of distinct eradication plans whilst important, also prevented any conceivable form of cooperation to form a common plan to eradicate BVD. The author argued that countries within the UK “were motivated by the prospect of potential future EU- trade barriers or regulation around BVD” thus, the observed variation in the management of BVD within the UK.

Given BVD virus is widespread across the world, let us briefly appraise the global outlook. Some countries across Europe have successfully eradicated the disease with many countries boasting

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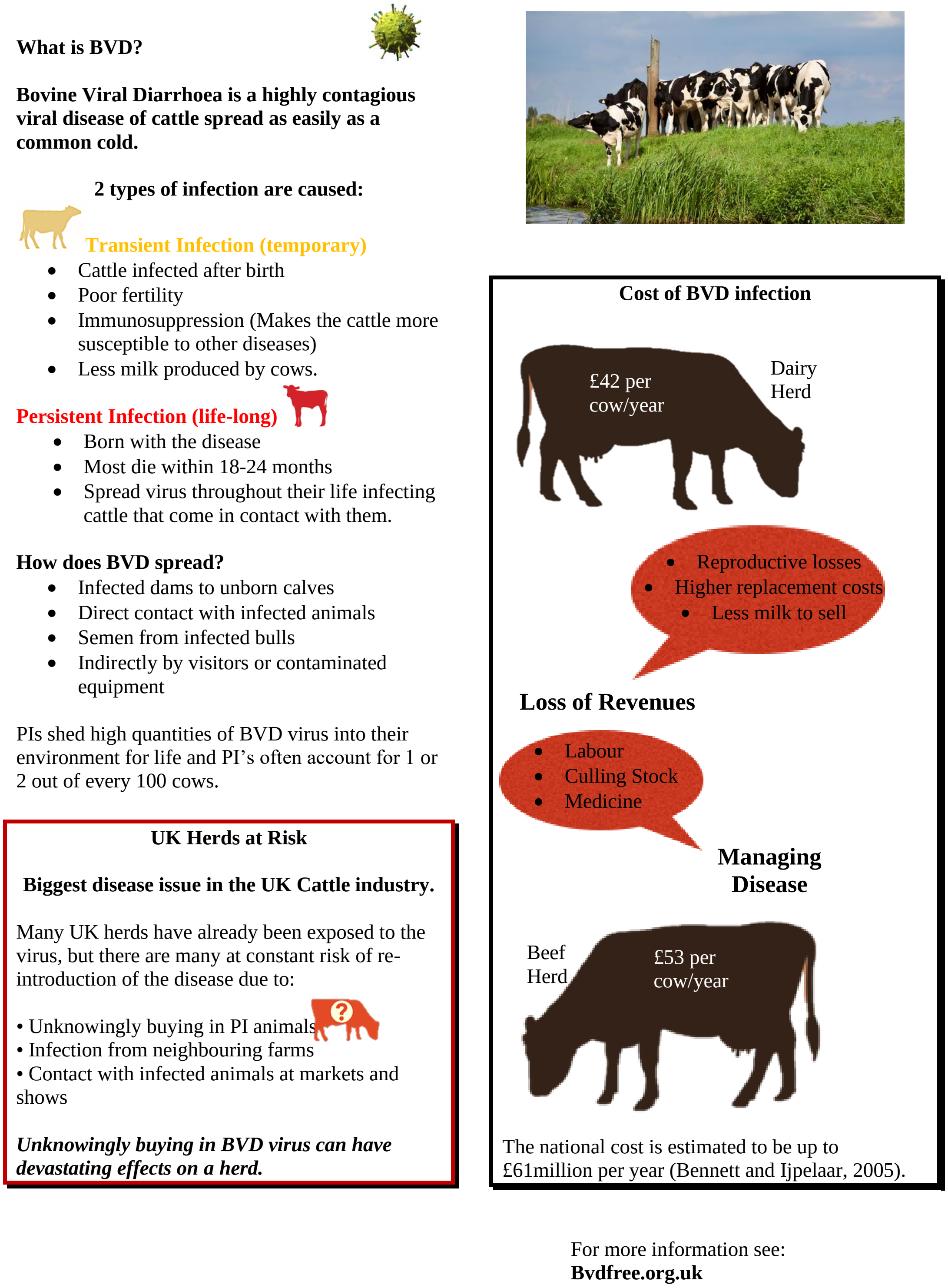
[11] Information on the Northern Ireland BVD eradication programme can be found at AFBI, 2022.

a BVD free status like Sweden, Norway, Finland and Denmark while others like Austria, Germany and Switzerland have implemented systematic control programmes with varying success rates (Scharnbock et al., 2018). Germany reduced their PI animals from 3.44% in 2011 to 0.16 % in 2016 (Wernike et al., 2017), Switzerland in two years went from 1.8% to under 0.2% in 2010 (Presi et al., 2011) and Austria reduced PI prevalence's at animal level from 0.13% in 2006 to 0.00% in 2017 (Scharnbock et al., 2018). In a recent study by Scharnbock et al. (2018), the authors provided a comprehensive look at BVD around the globe through their meta-analysis involving 325 studies in 73 countries. They found that while PI prevalence decreased over time in Europe, North America saw an increase. They identified that the highest prevalence at animal level in west and east Asia could be attributed primarily to shortcomings in the implementation process of any form of national eradication controls or vaccination programmes.

All in all, according to the European Union Thematic Network, given the success seen in many European countries, it was agreed that systematic approaches such as biosecurity, elimination of PI animals and surveillance of the progress were effective measures needed in the sustainable reduction of BVD in Europe (Lindberg et al., 2006). Figure 1.6 is the infographic used in the surveys in this thesis.



**What is BVD?**

**Bovine Viral Diarrhoea is a highly contagious viral disease of cattle spread as easily as a common cold.**

**2 types of infection are caused:**

**Transient Infection (temporary)**

- Cattle infected after birth
- Poor fertility
- Immunosuppression (Makes the cattle more susceptible to other diseases)
- Less milk produced by cows.

**Persistent Infection (life-long)**

- Born with the disease
- Most die within 18-24 months
- Spread virus throughout their life infecting cattle that come in contact with them.

**How does BVD spread?**

- Infected dams to unborn calves
- Direct contact with infected animals
- Semen from infected bulls
- Indirectly by visitors or contaminated equipment

PIs shed high quantities of BVD virus into their environment for life and PI's often account for 1 or 2 out of every 100 cows.

**UK Herds at Risk**

**Biggest disease issue in the UK Cattle industry.**

Many UK herds have already been exposed to the virus, but there are many at constant risk of re-introduction of the disease due to:

- Unknowingly buying in PI animals
- Infection from neighbouring farms
- Contact with infected animals at markets and shows

***Unknowingly buying in BVD virus can have devastating effects on a herd.***

**Cost of BVD infection**

£42 per cow/year

Dairy Herd

- Reproductive losses
- Higher replacement costs
- Less milk to sell

**Loss of Revenues**

- Labour
- Culling Stock
- Medicine

**Managing Disease**

Beef Herd

£53 per cow/year

The national cost is estimated to be up to £61million per year (Bennett and Ijpelaar, 2005).

For more information see:
**Bvdfree.org.uk**

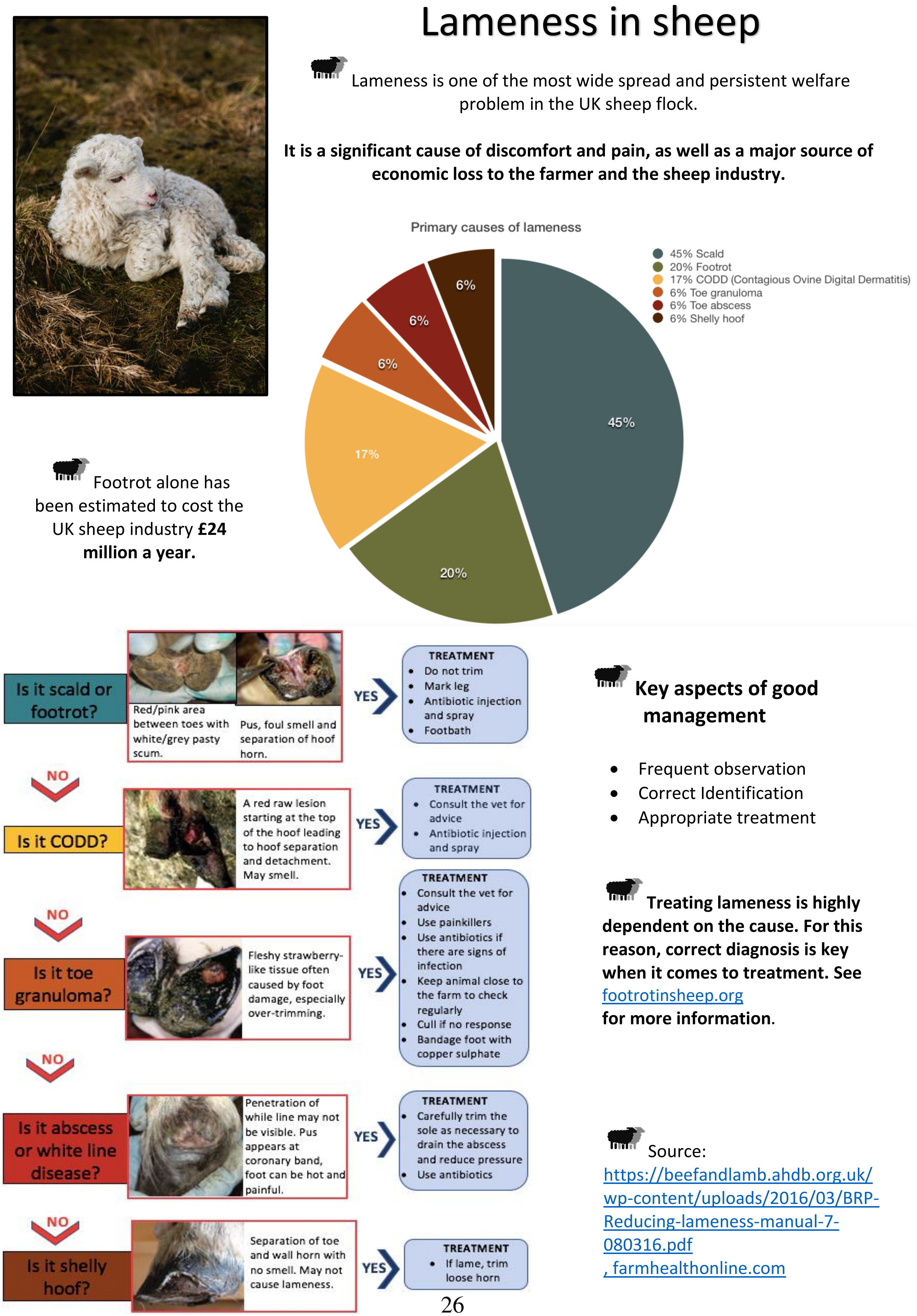
Figure 1.6: Infographic for BVD included in the surveys (Source: Author)

### 1.2.2 Lameness

The second case study condition used in my thesis is Lameness in sheep. According to the Statista database, the UK is estimated to have 21.85 million sheep and lamb livestock in 2021. Lameness is one of the most widespread and persistent welfare concerns in the UK as well as in the rest of the world (Farm Animal Welfare Council, 2011).

It is a significant cause of discomfort and pain as well as a major source of economic loss to farmers as well as the sheep industry. The estimated cost to the sheep industry in the UK is £80-£85 million per year (Winter and Green, 2017). The causes of lameness are widespread ranging from infections to environmental conditions (Winter, 2004). Footrot made up approximately 70% of lameness and is present in over 95% of flocks (Prosser et al., 2020). Contagious ovine digital dermatitis (CODD) is reported to affect 58% of flocks in 2013, an increase from 53% in 2004 (Dickins et al., 2016). On the other hand, a study by Angell et al. (2014) estimated flock prevalence of CODD at 35%. Although mainland Europe enjoys very few incidents of lameness - Germany for instance saw its first CODD outbreak in 2018 (Bernhard et al., 2021); in Greece estimated prevalence was at 9.0% (Moschovos et al., 2021) - it still struggles to manage outbreaks with a much higher prevalence. Although prevalence of lameness is hard to measure, studies have attempted to approximate prevalence levels on average in a country by generalising results presented in their studies. However, the pitfall of this approach is that these authors tend to employ very small samples whose outcomes should not be considered representative of the economy as a whole.

According to the Animal Welfare guidance (DEFRA, 2013), British legislation prohibits the transport of unfit animals, specifically those that are “injured or present physiological weaknesses or pathological processes, unable to move independently without pain or to walk unassisted”. The code of recommendations by the Farm Animal Welfare Council (2011) also requires chronically lame sheep not responding to remedial treatment to be culled. As discussed in Best et al. (2020), a national strategy, the so- called five point plan (5 P P) was launched in 2014 in order to tackle lameness on UK sheep farms. The strategy lists five points: culling lame sheep, quarantining stock as they come in, treating clinical signs promptly, avoiding transmission and vaccinating in the case of footrot. The authors found that the uptake of the 5 P P had not been promising, since only 5.8% farmers seemed to have adopted the plan even partially despite the efficacy of the plan being well documented. Lack of money, facilities as well as intrinsic factors like attitude and opinions played a major role (Best et al., 2021). A study in Australia found that only a few cases of mild lameness were treated immediately by farmers attributing this disengagement potentially to lack of labour, cost, time constraints and even skills (Munoz et al., 2019). Winter (2008) highlights the importance sheep lameness not just due to its economic implications in sheep production but also due to its animal health and welfare consequences. Figure 1.7 provide the infographic used in the surveys in this thesis.



# Lameness in sheep

Lameness is one of the most wide spread and persistent welfare problem in the UK sheep flock.

**It is a significant cause of discomfort and pain, as well as a major source of economic loss to the farmer and the sheep industry.**

Primary causes of lameness

- ● 45% Scald
- ● 20% Footrot
- ● 17% CODD (Contagious Ovine Digital Dermatitis)
- ● 6% Toe granuloma
- ● 6% Toe abscess
- ● 6% Shelly hoof

Footrot alone has been estimated to cost the UK sheep industry **£24 million a year.**

Is it scald or footrot?

Red/pink area between toes with white/grey pasty scum.

Pus, foul smell and separation of hoof horn.

YES

TREATMENT
- Do not trim
- Mark leg
- Antibiotic injection and spray
- Footbath

NO

Is it CODD?

A red raw lesion starting at the top of the hoof leading to hoof separation and detachment. May smell.

YES

TREATMENT
- Consult the vet for advice
- Antibiotic injection and spray

NO

Is it toe granuloma?

Fleshy strawberry-like tissue often caused by foot damage, especially over-trimming.

YES

TREATMENT
- Consult the vet for advice
- Use painkillers
- Use antibiotics if there are signs of infection
- Keep animal close to the farm to check regularly
- Cull if no response
- Bandage foot with copper sulphate

NO

Is it abscess or white line disease?

Penetration of while line may not be visible. Pus appears at coronary band, foot can be hot and painful.

YES

TREATMENT
- Carefully trim the sole as necessary to drain the abscess and reduce pressure
- Use antibiotics

NO

Is it shelly hoof?

Separation of toe and wall horn with no smell. May not cause lameness.

YES

TREATMENT
- If lame, trim loose horn

## Key aspects of good management

- Frequent observation
- Correct Identification
- Appropriate treatment

**Treating lameness is highly dependent on the cause. For this reason, correct diagnosis is key when it comes to treatment. See** footrotinsheep.org **for more information**.

Source: https://beefandlamb.ahdb.org.uk/wp-content/uploads/2016/03/BRP-Reducing-lameness-manual-7-080316.pdf , farmhealthonline.com

Figure 1.7: Infographic for lameness as shown in the surveys

## 1.3 Research aims

The literature on animal welfare is rife with papers investigating farm animal health and welfare from veterinary to sociology journals. Our main deficit comes from the limited economic research relating to animal welfare. The only exceptions are interdisciplinary projects (for example, FIELD[12] 2018- 2023), who attempt to provide answers to these questions from different scopes (typically including economics, as well). However, my approach differs from many of those which came before me in that I try to provide answers from an economic perspective and seek to shed some light on farmers' and consumers' attitudes towards their livestock.

This thesis therefore (as explained above) seeks to understand these current perceptions of UK consumers and producers towards farm animal health and welfare in the context of two livestock diseases BVD in cattle and lameness in sheep. I do not attempt to define improvement in animal welfare, whatever that maybe, but instead separate animal health and animal welfare as two different objectives to consider.

A straightforward example that illustrates monetary and non-monetary motives comes from the disease status of the animal. More specifically diseases that cause no harm to the public when the meat is consumed, and where there is no significant effect on productivity, would farmers still be willing to incur costs for the benefit of the animals themselves? In other words, do farmers derive utility directly from the health and well-being of their livestock, or is the source of utility only stemming from the implications of healthier animals to farm incomes?

To this end, the two main questions we seek to address are as follows:

1. What are the preferences of English and Scottish farmers with respect to animal health and welfare?

    - Animal welfare as it affects farm income.

    - Animal welfare independent of farm income.

    This question aspires to investigate farmers' attitudes towards their livestock. The central idea is to investigate trade-offs between risks and return as part of the farmer's decision-making process. Those decisions could come in various stages from the time that cattle is purchased until the end of its life.

2. What are the preferences of British consumers with respect to farm animal health and welfare? In terms of consumers, I will be looking to measure consumers attitudes towards the

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[12] FIELD is an interdisciplinary project funded by the Wellcome Trust made up of a team of social scientists, historians, economists and epidemiologists who research how livestock disease is influenced by nature and culture, science and society, and the actions of humans and livestock. For further details see https://field-wt.co.uk/.

health of the animals independent of food safety.

My research builds on existing literature on Willingness to pay (WTP) for food attributes (See Nocella et al., 2010; Sundstrom and Andersson, 2009; Loureiro and Umberger, 2007), while trying to identify a set of factors involved in the decision- making process. However, it needs to be acknowledged that literature on Willingness to pay (WTP) in the relation to livestock welfare, is quite scarce. Bennet and Balcome (2012) attribute this to the historic dominance of veterinary scientists in the area of animal health and disease with relatively low involvement from economists.

I extend the literature by differentiating between farm animal health (FAH) and farm animal welfare (FAW) and modelling the perceptions separately from both the farmer as well as the consumer point of view by focusing on trade-offs. Given scarce resources we have to make choices. So the question is, given certain constraints how much of attribute A are you willing to trade for an increase in attribute B? We want to improve animal health and welfare but how much income are we willing to give up? And it is this trade-off that my thesis attempts to measure addressing questions pertaining to whether or not UK consumers are concerned with the quality of life of an animal or whether price is the sole determinant of behaviour, when it comes to purchasing animal products. Similarly, what role does farm income play in decisions farmers make with respect to farm animal health and welfare?

Therefore, my thesis seeks to model farmer and consumer preferences towards farm animal health and welfare using economic theories and methods in the context of two endemic diseases BVD and lameness to work out trade-off's stakeholders are willing to make in their day to day lives and what that means for FAH and FAW.

My research objectives are as follows :

**RO1** Model and evaluate consumer perceptions towards farm animal health and welfare and how they influence consumption behaviour in the UK. Specifically, an objective is to see whether separate preferences for lower animal disease levels exist for UK consumers relative to preferences for farm animal welfare more generally.

**RO2** Assess whether consumer preferences shift in the absence of product safety information or in times of heightened uncertainty (information asymmetry).

**RO3** Evaluate trade-offs which farmers are willing to take between expected farm income, income volatility and animal health

**RO4** Analyse the attributes explaining heterogeneity in farmers' preferences for higher livestock health, using the context of purchasing behaviour in auctions.

## 1.4 Road map

The material in this thesis is structured into eight chapters. The thesis adds to the literature on discrete choice experiments in agricultural economics. There have been no studies modelling farmer and consumer preferences for farm animal health and welfare in the UK using discrete choice experiments that specifically study livestock disease. Contributions of the thesis are discussed in depth in each of the chapters.

- **Chapter 1** brief introduction to the thesis providing a background and an overview of the research aims.
- **Chapter 2** presents a review of existing literature on consumer and farmer behaviour to farm animal health and welfare in the UK and appraises the global outlook on farm animal health and welfare.
- **Chapter 3** gives an overview of the main methodology used for the economic analysis. We highlight the use of discrete choice experiment (DCE) in various valuation studies, explain the basic concept and the models employed in this thesis. Key stages involved in conducting a DCE are also outlined.
- **Chapter 4** is a study on the consumer preferences for farm animal health and welfare in the UK. The chapter discusses the separable preferences for sickness levels and animal welfare.
- **Chapter 5** continues on from the previous chapter. I test whether information asymmetry has any influence on consumer perceptions for farm animal health and welfare in the UK.
- **Chapter 6** presents the findings from the DCE that looks at producers' preferences when risky monetary returns and infection risks are part of the decision-making process.
- **Chapter 7** Preferences over disease risks are modelled for buying livestock in Scotland and England in the context of auctions.
- **Chapter** 8 summarises the overall findings of the thesis and considers potential future research avenues.

# Chapter 2

# Literature review

## 2.1 Overview

Chapter 2 of my thesis aims to review relevant literature in the area of farm animal health and welfare. The chapter is structured as follows. I start by providing a background to the topic of FAHW in section 2.2. In section 2.3, I review the various definitions used in the literature and consider some of the studies on cattle and sheep welfare. Section 2.4 then discusses the point of view of consumers and producers and how the two stakeholders differ and resemble in their attitudes and finally section 2.5 concludes.

## 2.2 Background

In recent years, there have been extensive debates about farm animal health and welfare (FAHW). This topic has gained much attention not only among a broad range of academic disciplines but also consumers and directly interested groups such as the members of the food production industry (for instance, meat producers and retailers). Although the bulk of the existing research in this topic has been conducted by biologist, animal scientists, veterinarians, philosophers, anthropologists, very little has been written by economists. Seamer (1998) attributes the rise in interest in the public to a large extent to the prosperity of the western world. To quote Vanhonacker et al. (2007) "Food supply has largely exceeded food demand". So, when an economy is hit by an adverse demand shock, the goal of trading turns to a marketing goal of creating new or rather, better meeting consumers needs and shaping preferences. This is coupled with the rising impact of post-materialistic ideals, where awareness of farm animal well-being is just an aspect of, for example, food choice decision-making. This thesis aims to contribute to the ever-growing literature on animal health and welfare in livestock production by understanding current consumer and farmer perceptions from an economics perspective.

### Method

In this chapter, I provide a review of the literature on "Farm Animal Health" (FAH) and "Farm Animal Welfare" (FAW). Although I identified and reviewed scientific research coming from different disciplines (from food science to history), my main focus has been identifying relevant research output stemming from economics. Through citation chasing, filtering and keyword searches limited to the title and abstract, I compiled a list of essential papers. The key words used in my search were “farm animal health” OR “farm animal welfare ” OR “farm animal health and welfare” AND economics.

## 2.3 What is animal health and welfare?

Animal health and welfare has been defined in several contexts with scientific, economic, ethical, political, social and cultural as well as religious perspectives emphasising various aspects of the concept. When we talk about “animal welfare”, Norwood and Lusk, (2011) argue that for all practical purposes we mean “farm animals’” welfare since, there are empirical estimates (US case study) showing that 98 percent of animals who are in contact with humans are farm animals. Farm animals, for the most part, are treated as valuable commodities so that welfare levels are established by the demands and preferences of our society (McInerney, 1998).

This view is also shared by Webster (2001) who defines farm animal welfare as an animal’s ability to sustain fitness and avoid suffering and argues that the responsibility of the farmer is to make provision for good welfare through good husbandry and that the farmer itself cannot ensure “good welfare”. The paper argues that the consumer is responsible for welfare outcomes since they are the ones expressing a desire for higher welfare standards. In this regard, Webster (2001) argues in favour of a free-market approach that places value on farm animals through consumer demand, thus ensuring their welfare whilst also advocating for welfare legislation which may or may not be consistent with the free market approach. This explains the reasoning behind the different care for the treatment of pets as opposed to a cow for example, in and at the end of her milking period. The market determines what is acceptable and what is not. However, government intervention is necessary to ensure high FAHW since there exists (potentially) a market failure due to information asymmetry. Note that if the consumer cannot observe the production process then, they cannot distinguish between high welfare farm output and low welfare output and this can lead to a market failure. Although most countries also impose regulatory standards which set minimum requirements for farm animal welfare, consumer demands can raise welfare standards and practices pertaining to welfare above these regulatory standards (minimum requirements), but not below. The UK for example, through the new Agricultural Act of 2020, “nudges” farmers to take actions that improve or rather ensure “high farm animal health and welfare”. Although there is no law demanding it, producers are obliged to comply in order to receive any form of government subsidy[1]. Thus, the regulation defines the acceptable threshold of suffering with market forces raising standards above this including state agencies, industry lobby groups and animal advocates.

Let us briefly look at some of the existing descriptions provided by various organisations. Because of differing interpretations of FAH and FAW (often defined jointly), there has been no consensus on the definition. The Brambell Committee report of 1965 proposed five minimal behaviours or activities that farmed animals should be afforded namely to stand up, lie down, turn around, stretch

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[1] The new system has moved away from subsidising farms that fulfil productivity objectives to a system that rewards producers that achieve environmental goals, with clear provisions for enhancing FAHW.

their limbs, and groom all parts of the body. This report was in response to a book published by Ruth Harrison in 1964, "Animal Machines" that prompted a parliamentary enquiry and hence the report. The book shed light on some of the realities of intensive farming and the livestock production systems of the time. Then in 1993, realising the lack of welfare concerns addressed in these freedoms, John Webster as part of the UK Farm Animal Advisory Committee proposed an update and the new five freedoms with provisions were introduced.

These were the

"

- Freedom from thirst, hunger, and malnutrition
  - By ready access to a diet to maintain full health and vigour

- Freedom from thermal and physical discomfort
  - By providing a suitable environment including shelter and a comfortable resting area

- Freedom from pain, injury, and disease
  - By prevention or rapid diagnosis and treatment

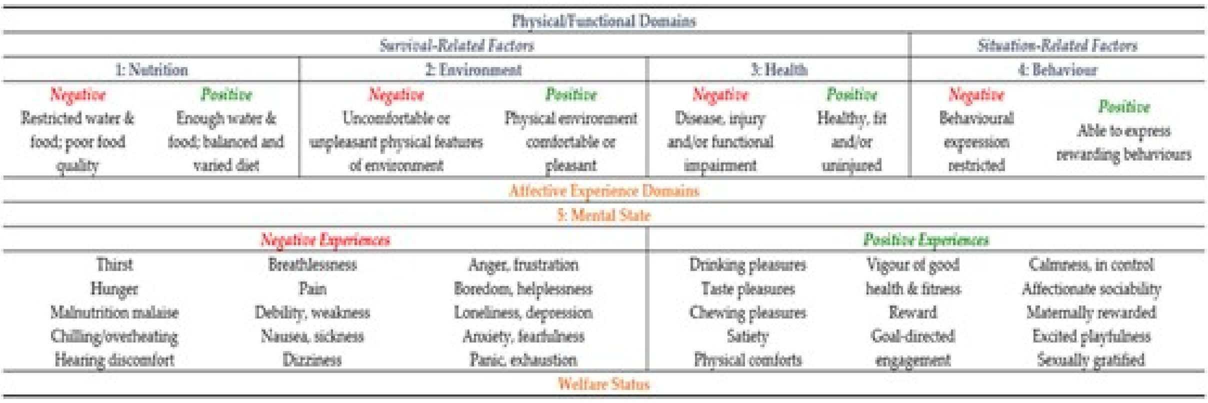
- Freedom from fear and distress
  - By providing sufficient space, proper facilities, and the company of the animal's own kind

- Freedom to express normal behaviour
  - By ensuring conditions which avoid mental suffering

  "

This general framework that aims to assess the quality of life has since been taken up by professional groups such as veterinarians, various organisations across the world such as the World Organisation for Animal Health, the Universal Declaration on Animal Welfare (UDAW) (a group comprised of the Royal Society for Prevention of Cruelty to Animals (RSPCA), World animal Protection and others), the Royal Society for the Prevention of Cruelty to Animals, the American Society for the Prevention of Cruelty to Animals and governments as foundations to build on and modify as required.

Hewson (2003) provides a comprehensive breakdown of definitions that focus solely on the body for example physiological measures such as endorphins, plasma cortisol and heart rate, the physical environments that determine the welfare of the animal and those that also incorporate feelings and behavioural signs such as display of fear or frustration. Following on from the debates on the definition of FAHW, Mellor (2016) expanded on the five freedoms and developed his own five



<table>
<tr><th colspan="24">Physical/Functional Domains</th></tr>
<tr><th colspan="18">Survival-Related Factors</th><th colspan="6">Situation-Related Factors</th></tr>
<tr><th colspan="6">1: Nutrition</th><th colspan="6">2: Environment</th><th colspan="6">3: Health</th><th colspan="6">4: Behaviour</th></tr>
<tr><td colspan="3">Negative<br>Restricted water & food; poor food quality</td><td colspan="3">Positive<br>Enough water & food; balanced and varied diet</td><td colspan="3">Negative<br>Uncomfortable or unpleasant physical features of environment</td><td colspan="3">Positive<br>Physical environment comfortable or pleasant</td><td colspan="3">Negative<br>Disease, injury and/or functional impairment</td><td colspan="3">Positive<br>Healthy, fit and/or uninjured</td><td colspan="3">Negative<br>Behavioural expression restricted</td><td colspan="3">Positive<br>Able to express rewarding behaviours</td></tr>
<tr><th colspan="24">Affective Experience Domains</th></tr>
<tr><th colspan="24">5: Mental State</th></tr>
<tr><th colspan="12">Negative Experiences</th><th colspan="12">Positive Experiences</th></tr>
<tr><td colspan="4">Thirst<br>Hunger<br>Malnutrition malaise<br>Chilling/overheating<br>Hearing discomfort</td><td colspan="4">Breathlessness<br>Pain<br>Debility, weakness<br>Nausea, sickness<br>Dizziness</td><td colspan="4">Anger, frustration<br>Boredom, helplessness<br>Loneliness, depression<br>Anxiety, fearfulness<br>Panic, exhaustion</td><td colspan="4">Drinking pleasures<br>Taste pleasures<br>Chewing pleasures<br>Satiety<br>Physical comforts</td><td colspan="4">Vigour of good health & fitness<br>Reward<br>Goal-directed engagement</td><td colspan="4">Calmness, in control<br>Affectionate sociability<br>Maternally rewarded<br>Excited playfulness<br>Sexually gratified</td></tr>
<tr><th colspan="24">Welfare Status</th></tr>
</table>

Figure 2.1: Five domains model abbreviated (Mellor, 2016)

domains: nutrition, environment, health, behaviour, and mental[2] arguing that the original [3] did not consider the differentiation between physical and “affective” elements of animal welfare (See Figure 2.1 for a comprehensive breakdown). Numerous such tools have been developed to measure health and welfare outcomes each with their own strengths and limitations, each with their own understanding [4] of what should and should not constitute good farm animal health and welfare.

Consider for instance the World Organisation for Animal Health (OIE) formerly Office International des Epizooties, with a total of 182 member countries defines animal welfare as ‘the physical and mental state of an animal in relation to the conditions in which it lives and dies’. The United Nation (UN) convention on animal health and protection (UNCAHP) 2018, defines animal health as ‘ the state of the individual regarding its attempts to cope with pathology, including physical, mental and social factors and not just the impact of sickness or ailments’ and animal welfare as ‘the state of the individual animal, regarding attempts to cope with its environment, including the absence of physical and psychological suffering, as well as the satisfaction of its biological, including physiological, ethological and social needs’. They state that their standards are guided by the five freedoms as well as the ‘three Rs’ [5].

Nevertheless, the interpretation of farm animal health and welfare varies substantially amongst several types of market participants and the way it is perceived is greatly affected by different group’s (or individual’s) belief system, ethics, norms, motives (Te Velde et al., 2002), knowledge, culture and even geography making it complex and multi-faceted . Therefore, measuring health and welfare in animals poses such a challenge and specific indicators measuring the outcomes consequently vary widely.

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[2] By “mental”, Mellor (2016), refers to the individual negative affects identified and their cumulative impact on animal welfare as a whole.

[3] I refer to the five freedoms proposed by Webster in 1993 as the “original freedoms” or “original” for short.

[4] Webster (2016), in his opinion paper discusses the five freedoms, five domains and Quality of Life (Green and Mellor, 2011). Botreau et al. (2007) also introduced four principles and eleven criteria in categorising the elements of farm animal welfare.

[5] The three R’s is a principle advocating reduction, refinement and replacement introduced by Russell and Burch in the Principles of Humane Experimental Technique published in 1959.

Browning (2020) argues that part of animal welfare are also the negative and positive experiences of animals where we might endeavour merely to decrease suffering and/or increase pleasure for animal and as such ‘suffering calculators’ intending to calculate the total suffering produced by production systems have been emerging using length of life, number of animals, and sentience multiplier as guides (Warren, 2018; Tomasik, 2018). ‘Animal Life Years Suffered’ is another such welfare index designed by Scherer et al. (2018). So, though there are physical traits that can be easily identified to recognise good or bad welfare like lesions on body or the way an animal walks, many measures are much harder to identify to the naked eye like behavioural traits of distress or compromised immune function. Some, while measurable like increased heart rate or stress hormones are then difficult to interpret (Dawkins, 2006). Having captured public attention, academic research, according to Fraser (2008) has focused on topics regarding space allowances, types of flooring, air quality, and abnormal behaviour. Not only has the interest in FAHW induced regulation changes but it has also led to the development of new technology such as sensors, ear tags, drones, GPS monitoring and others designed to operate on a wide scale while still addressing important animal welfare issues associated with confinement systems. Herlin et al. (2021) review some digital tools utilised in monitoring and managing cattle and sheep and discuss their potential in improving animal welfare.

On the other hand, we see a number of assurance programmes used to label finished products, signalling to the consumers a guarantee that farm animal welfare criteria are satisfied, as a way of addressing the information asymmetry responsible for the market failure. For example, the Royal Society for Prevention of Cruelty to Animals (RSPCA) in England and Wales lays out a succinct checklist of criteria which must be complied with in regard to transportation, housing, food, slaughter and management for different species including beef cattle, dairy cattle and sheep with regular updates and amendments. Such farm assurance schemes not only encourage buyer confidence but also facilitate farmers credibility for using acceptable production processes for farm outputs and allow validation of quality standards and provenance of their product through independent verification and certification. Other such schemes led by retailers, producers or private entities (non-governmental) are also common pushing the welfare needs beyond those stipulated by their governments. From two main typologies, organic farming as opposed to conventional agricultural farming systems are generally thought to hold higher welfare standards due to their distinct approaches [6]. According to the Farm Animal Welfare Council report (2005) on welfare implications of farm assurance schemes, organic certification schemes do not explicitly set out welfare criteria but instead utilise an ‘input-oriented approach’ that necessitates animals are treated and kept in a specific way. It is through this implementation of specified requirements that welfare outcomes are ascertained.

What about the European Union (EU)? In the treaty of Rome, 1957 animals were referred to as “goods” where welfare was not part of legislation, however, in the subsequent 1997 Treaty of Amsterdam a unique legally “binding protocol” on animal welfare was included for the first time recognising animals as “sentient beings” ( Caporale et al., 2005). In 1974, the first EU legislation on slaughter of animals was adopted. Following discussions over the last 40 years many modifica-

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[6] Numerous research explore the outcomes of organic versus conventional farming with organic farming described to take a holistic approach with synthetic chemicals typically forbidden while conventional or industrial farming is seen less sustainable due to the heavy reliance on mechanisation (Rozzi et al., 2007; Rodriguez-Bermudez et al., 2019; Durham and Mizik, 2021).

tions in animal welfare led to a string of mandates safeguarding animals. According to Veissier et al. (2008) the safeguards called for more spacious lodging areas, more opportunity for social contacts, nutrition standards, more sanitary environment in an effort to accommodate new findings and the market demand. Although, no formal link was established it was postulated that the first European regulations to protect animals were adopted just after the Brambell report and were consistent with the inferences of the report suggesting that the report was influential, not only in the United Kingdom but also in the rest of Europe. However, animal welfare legislation differs across Europe with Northern states having stricter legislation (Veissier et al., 2008). According to the 2012-15 EU Strategy for Protection and Welfare of Animals evaluation, improving compliance across member states remains paramount in order to optimise the resources available to improve animal welfare standards. Thorough guidelines have been laid out to keep and transport animals, with utmost care, avoiding any form of abuse and maltreatment. However, usually lengthy legislation's translate into higher costs for EU farmers than their non-EU counterparts who are either not faced with stringent animal protection laws or even if they are, the laws may not be enforced. As a result, the EU in an effort to simultaneously promote animal welfare and eliminate (or rather minimise) EU farmers disadvantage foster trade agreements that level the playing field which then could positively affect farmer preferences towards animal welfare as the cost of welfare and meeting market demands balance out without having to lessen the already slim profit margins. According to Bartussek (2000), in Austria, an "Animal Needs Index" a legal requirement is in place to certify high welfare standards on organic farms for cattle, hens, fattening pigs, and pregnant sows. The criteria for each species are laid out and graded by points mainly assessing the housing and production environment. Much like the UK, the EU countries also have various farm production schemes facilitating farm animal health and welfare independent of government legislation. The packaging and logos may signal high welfare thus transferring these standards to the consumer. However, Veissier et al. (2008) suggest that premium prices maybe be driving farmers participation in such schemes with some farmers citing ethical reasons.

Interest in animal welfare, however, has been slow on the other side of the Atlantic. Mench (2008) discusses the evolution of farming practices and their slow uptake in the US since the Brambell Report was published owing much to the awareness campaign fuelled by growth in research and teaching. The legislative drive in Europe appears much more compared to the US which saw very little change in legislation in the last 50 years to protect farm animal welfare. Mench (2008) argues that without a doubt, there exists a niche in the market for humanely produced or organically produced animal products which are growing, but demand continues to be towards sustaining a cheap food supply even by increasing the intensification of farm animal production. There is no uniformity between states on acceptable practices, nonetheless, Wise (2003) emphasises that all US states being in possession of some form of animal cruelty legislation, strictly enforce these laws imposing substantial fines for violations.

Hence, while Europe went through cultural changes including those concerning the quality of life of animals, other nations around the world did not see the same progress (Fraser, 2001; Fraser 2005). Evaluating the global perspective, we find that desire for improvement in animal welfare in one part of world may not be easily transferable across the globe. In OIE (2005), global guidelines for the first time for animal welfare, in regard to transport, slaughter of animals for human consumption and killing of animals for disease control, animal welfare in production systems were issued. The initiative took animal welfare centre stage at an international scale drawing the attention of developing nations as well (Bayvel et al., 2005).

Fraser (2008) observes that since the 20th century, countries outside the European and Anglophile nations while experiencing rapid growth in animal production through large-scale confinement systems still continue to hold traditional small-scale systems at the fore front of their production citing China and India as examples of such practices despite being responsible for the majority of the worlds meat consumption. The author concludes that regulations and other schemes designed to promote animal welfare in industrialised nations may not fit well with the traditional production systems of the less industrialised. He suggests however, that there is still ample space for enhancing such traditional varied small-scale systems identifying three main avenues that may be useful in attaining high welfare standards through provision of economic incentives emphasising losses caused by injury stress and malnutrition, disease control programs and international collaborations.

Buller (2018) provides five recommendations to drive the global cause of farm animal welfare and sustainability: integration of the farm animal welfare as an integral part of sustainability, articulation of the concerns, representation of the animal welfare community in international governance structures, legitimisation through robust and comparable standards at an international level and innovation in addressing the issues avoiding the more reactionary approaches we tend to follow. A global endeavour on the subject of animal welfare if successful may not only facilitate innovative solutions to intensification demands that risk FAHW going backwards but drive improvements in the life of the livestock on a larger scale.

## 2.4 Consumer versus Producer – the predicament

Although the supply chain consists of intermediaries like food retailers, service, processing and manufacturing, my thesis focuses on the producer and the final consumer. Now, let us briefly compare the literature on the interpretations and attitudes of consumers and producers of animal products.

According to Kendall et al. (2006) producers have a tendency to perceive themselves as rational (well-informed) agents, whilst they dismiss the animal well-being concerns of the general public labelling them too sensitive and uninformed. On the other hand, consumers frequently associate the farmers' interest in animal welfare as being solely returns motivated with their own concerns being ethically driven. These concerns were further echoed in the outcomes of the study by Vanhonacker et al. (2008), where consumers typically attributed greater weight compared to farmers when evaluating the significance of farm animal welfare. The authors identified several conflicting beliefs between citizens and farmers. Consumers typically attributed higher weight compared to farmers when evaluating the significance of farm animal welfare. It could be assumed that citizens mainly answer this particular question from a perceptual perspective, while the farmer grounds his answer possibly more on expertise and knowledge.

However, one should use caution when using knowledge alone to explain observed disparities as has been criticised by Hansen et al. (2003) and is referred to as the knowledge deficit model. The authors note that the viewpoint of the farmer in regard to animal welfare may be judged by the two issues farmers relate to "good" animal welfare i.e. fast growth and satisfactory food conversion. It was shown that farmers typically associate animal welfare with animal health. According to the farmer, healthy animals develop quickly, indicating that their welfare is "good" and that they are in good health.

As in Webster (2001), we would expect costs of imposing higher welfare standards to the farmer to be considerably higher as compared to the consumer. Switching to farming that allows animals the facility to behave "naturally" would involve considerable investments and may even threaten economic performance forcing farmers to shut down. A study by Te Velde et al. (2002) found that farmers do not have a great deal of knowledge about potential additional components of animal well-being, such as the ability to exhibit "natural" behaviour placing very little importance to it, nor do they show much interest in alternative agricultural practises that pay particular attention to animal welfare. Although farmers attached importance to aspects of space, pain, and stress, they alleged to find little to no opportunity to make improvements without facing serious economic obstacles.

In contrast, according to the consumer's in the study issues of transport, suffering, space, fresh air, light and the ability to engage in natural behaviour were characteristics that were judged negatively with a more positive appraisal given to attributes relating to feed and water as well as the relationship between the farmer and its animals. When it came to the ability of livestock to engage in "natural" behaviour, there was an indication of concern from consumers. These divergent perceptions, consequently, sets off many of the debates we encounter in the literature. Rawles (2017) in 'The Meat Crisis' reasons that animal welfare should not be classed as a luxury only afforded during time of economic booms, a compromise when prioritising environmental and economic concerns but a rather pivotal part of the production system. The rising concerns range from food safety, environmental concerns and animal health and welfare concerns are ultimately all related to each other (Worsely et al., 2015). The true costs to farmers and consumers must be investigated since improvements in animal welfare directly affect the health and welfare of the animals (Webster, 2001). McInerny (1998) explored whether there should exist restrictions that are enforced by the EU or the WTO due to the existing market failure. They estimated the costs -to farmers and consumers- of five radical changes to husbandry system, imposed and enforced by the EU would include

1. Legislation to permit recombinant bovine growth hormone (rGH or BST)

2. Implantation of anabolic hormones in beef cattle

3. Ban on confining sows in individual stalls

4. Recommended improvements to minimum standards ban on broilers (effectively an increase in age at slaughter from six weeks to eight weeks)

5. A ban on the battery cage

Latacz-Lohmann and Schreiner (2019) looked at both the farmer as well as consumer preferences for farm animal welfare and reported consumers' willingness to pay to be significant in several aspects of animal welfare including less surgical interventions, more space per pig, more bedding and shorter transportation. It could then be argued that the market alone may not suffice in bringing about these improvements and therefore there is a need for state policies [7].

To explain consumer buying behaviour scholars have tried to classify behaviour by dividing consumer preferences for food into two quality attributes: extrinsic credence cues and intrinsic search cues (Zanoli et al., 2013). Extrinsic credence cues are related to the physical aspect of the products which could include price, colour, and visible fat, whilst credence attributes include country of origin, and environmental impact. Animal welfare was classed as a credence attribute. Credence attributes are not directly observable to the consumer. It has also been argued that consumer choices may be influenced by food category (Maehle et al., 2015). The authors make a distinction between food consumed for pleasure versus that for nutritional value. They discover that for both hedonistic and utilitarian products, taste and price were important. This outcome becomes considerably more compelling when consumers are grouped by their product preferences with environmental friendliness and healthfulness being more important to certain segments of the society. However, the binary distinction may often not be possible to classify consumer behaviour. Vanhonacker et al. (2007) in their paper shed some light on the citizen-consumer duality and discuss how targeted marketing perhaps could make high welfare products relevant to different consumers.

Next, I discuss the recent literature on modelling consumer and producer preference towards farm animal health rather than animal welfare. Sok et al. (2018) used a discrete choice experiment (DCE) in order to estimate farmer preferences for vaccination schemes to control bluetongue disease applying hybrid models like the integrated choice and latent variable (ICLV) approach. They tried to measure the choices respondents made, their social- psychological constructs and the socio-demographic characteristics of respondents from the Netherlands. In addition, they measured perceived attitudes and norms of the study participants. Since the Netherlands was free from bluetongue disease at the time of the study, the authors created a hypothetical scenario where bluetongue was detected within 100 kilometres from the premises of the respondent. They concluded that the farmers participation to such schemes could be increased through the provision of information and subsidies- the two policy implications. A similar study by Raily et al. (2018) in Tanzania on 432 households attempted to elicit preferences for vaccinations for foot- and- mouth disease (FMD). The authors attempted to bridge the gap between the parameters that contribute to decisions of vaccinations and how they relate to perceived risks. The target groups chosen were cattle owning households, since they wished to gauge behavioural responses and improve precision of responses. The purpose of the survey was to determine the households' preferences towards FMD vaccinations that were not available at the time of the study. The cross-sectional survey included questions pertaining on demographics, livestock management practices and knowledge and history of FMD. The study used a double bounded dichotomous choice contingent valuation method that jointly analyses willingness to pay (WTP) for a particular product as well as gauging the reasons

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[7] Chapter 8 Discussion of my thesis addresses whether there is a market failure and how it could be solved in the context of the results from my thesis.

respondents had for being in the market. Some of the main findings of the study include decisions of routine and emergency vaccinations depended heavily on income, diversity of income boosted the uptake of vaccination and emergency vaccinations had higher WTP than routine vaccinations.

Another study, by Bennett and Balcombe (2012), on farmers attitudes and WTP for Bovine Tuberculosis (bTB) cattle vaccine utilised both contingent valuation and choice experiment methods. The survey questionnaires were conducted through telephone interviews on a sample of 300 farmers in targeted bTB tested areas in England and Wales. They found that farmers were concerned and believed there was a high risk of their cattle getting diseased. The WTP estimates were a lot higher than was expected, indicating that farmers in the high risk bTB ‘hotspot’ areas deemed buying these vaccines very important. The authors decided to use a choice experiment since the policymaker’s required information on how people perceived the different attributes of the vaccines and which attributes were given higher value or deemed more important. The contingent valuation method was then used to compare and contrast the WTP estimates from the study, checking their credibility. As illustrated such studies illicit information on various management options from vaccine developments to prevention strategies and inform policies. Scarpa et al. (2003) used choice experiments to value farmers WTP for disease resistance in pigs in Mexico. Similarly, Roessler et al. (2008) using choice experiments assessed smallholder farmers’ preferences for pig breeding traits in different production systems in North–West Vietnam. Scarpa et al. (2003) examined preferences for cattle traits in Kenya. Such studies concerning valuing livestock traits are in plenty. However, when it comes to preferences in relation to livestock disease control relatively few studies using discrete choice experiments and contingent valuation methods are available. These include Swallow and Mulatu (1994) in Ethiopia and Bennett and Willis (2008) in England and Wales.

## 2.5 Summary

This chapter has reviewed the literature on farm animal health and welfare both from an economics and non-economics point of view. I start by laying out the challenges in defining FAHW and the evolution over time. We saw that many studies attempt to understand preferences for farm animal health and welfare and the ever-changing perceptions towards it, but we also saw the lack of one all-encompassing clear definition of the term. This led me to conclude that there is an appetite for improvement of livestock health and welfare, however, what constitutes this improvement is dynamic based on the time and place. Over time various methodologies have been utilised to model these preferences both from farmer and consumer perspectives. There exists a growing literature on modelling these preferences in various contexts, and by employing different methodologies. I also briefly reviewed some of the key papers in order to provide an overview of the current available knowledge and investigate the preference gap. The methodology used in this thesis is described in the subsequent chapter.

# Chapter 3

# Methodology

## 3.1 Overview

This chapter lays out the methodology used in the thesis - Discrete Choice Experiments (DCE). Firstly, I discuss the rationale behind my choice of methodology reminding the reader of my research aims. I then provide a brief introduction of available valuation methods. Discrete Choice Experiments are defined in section 3.3, along with their families and the theoretical underpinnings in consumer theory. The procedures involved in developing and implementing a DCE are described in Section 3.4. Section 3.5 reviews relevant literature in agriculture using DCE's and finally, section 3.6 concludes by summarising the groundwork laid down in this chapter.

## 3.2 Choice analysis

From the very moment of conception, we have been making decisions, we choose to do or we choose not to. As individuals, as a community, as economic agents we make choices and these choices eventually shape our lives and those around us. Choices can be based on habits, repetition, randomness, necessity, maintaining the status quo or even experience. These choices can be postponed, brought forward or made immediately. The study of choices is not a new area of research. In fact, there are several theories and schools of thought in pursuit of understanding the choices economic agents make. At the heart of the study of choice analysis is why and how we make these choices at individual and aggregate levels which may initiate search and learning allowing us to find solutions in markets where conditions change rapidly.

The standard neoclassical model of consumer choice behaviour states that consumers are aware of their preferences, that they act with full information and make rational decisions in order to maximise utility. In other words, choices are made based on for example, product attributes as well as the consumers' preferences for these attributes. Another common assumption influencing decision is of non-satiability i.e. consumers prefer more rather than less. New information can also influence decisions. Several studies have shown how information dissemination can affect the choices we make in various contexts (Zhang et al., 2014; Berninghaus and Ehrhart, 2001; Bundorf et al., 2009; Waaswa et al., 2021). However, this neoclassical model can sometimes fail due to its rigid assumptions. This is where behavioural studies contribute to modelling choices. Consumers do not always make rational decisions[1] and consumers do not always have full information.

Choice analysis looks at the choice outcomes and postulates choice behaviour. It is a way of explaining variation in the behaviour of a sample of individuals or variation in the behaviour of one person across different choice tasks. We will look at a formal definition at a later stage but for now let us understand the core characteristics of choices. Because of the heterogeneity in behavioural decision making, choice analysis attempts to try and explain preferences across a sample population. When we make a choice, we are faced with an alternative. An individual decision problem will, therefore, consist of a set of all but finite possible mutually exclusive alternatives say, $J$, which may not necessarily be binary. So essentially, there should exist at least two choices so we can pick one, even if the choice is not to choose and maintain status quo- it is a choice we make. These set of alternatives contain all the possible choices we can make given the decision problem. The researcher may for the purpose of an experiment limit the number of choices to suit the experimental design. A choice outcome is the selection of an alternative by comparing all those available to the individual. A sequence of events, information acquisition steps, and/or decisions eventually lead to an outcome (Pendyala and Bricka, 2006).

We can thus summarise that choice studies are characterised by three key characteristics, the attributes, the alternatives available and the choice response. Finding a meaningful relationship between these characteristics has been the age-old challenge faced by researchers given the behavioural variability, inconsistency and unpredictability in the recognition of the decision process. Given the implications of choices in terms of social welfare there appears to be great merit in understanding these decision processes.

To reiterate, the key questions I address in this thesis:

1. Are animal health and animal welfare separable properties of utilities? What is the consumer willingness to pay (WTP) for animal products when considering animal health and welfare?
2. Does changing information on the safety of the product change consumers preferences towards FAH and FAW?
3. What are farmer preferences to FAH and FAW when monetary returns and sickness levels are part of the operational decision making process?
4. Would farmers risk buying animals that could potentially introduce disease risk in their farms where we control for effects on income? How do farmers trade off expected income and livestock disease risks?

Choice modelling is therefore, considered the most appropriate method when the researcher seeks to estimate the willingness to pay for a product or service whilst considering multiple attributes with varying levels. In other words, it assists us in identifying improvements in product or service across several product qualities.

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[1] A rational household (i.e. consumer) is assumed to have access to public information and make decisions/choices that are not consistently incorrect.

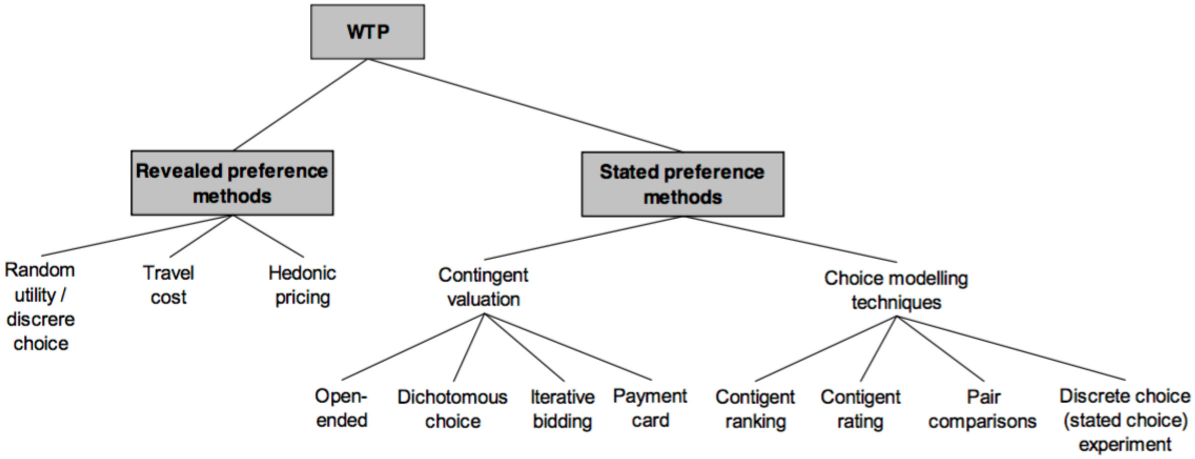

Figure 3.1: Willingness to pay methods. Source: (Kjaer, 2005) and (Bateman et al., 2002)

There are however, several methods we could use for estimating willingness to pay. Why then did I choose DCEs? The next section describes these valuation methods and their uses.

### 3.2.1 Valuation methods

There has been a significant amount of literature developed around survey methods to estimate Willingness-to-pay (WTP) especially when revealed market variation is absent. These methods are frequently used to model demand functions, market reactions to price changes, and other aspects of pricing strategies. WTP estimates are also a way of shedding light on the economic valuations of product and services that do not have a market value. We may accrue benefits from an improvement but these benefits may not have a market price attached and WTP is a way of valuing this latent price. Methods for calculating these latent prices can be classified into the two major sub-categories, revealed and stated preference methods. See Figure 3.1 for a breakdown. Let us briefly compare revealed preference and stated preference methods.

Observing behaviour under a wide range of conditions can aid the development of robust models. When the preferences are observed (revealed) through actual behaviour and essentially represent real-world choices that individuals make, we call such methods Revealed Preferences (RP). On the other spectrum, when behaviour is difficult to observe or data is just not available, hypothetical situations are created whereby judgements are made based on the responses of individuals. Preference information is gathered by questioning individuals on hypothetical situations through the provision of alternatives comprising of attributes. Individuals then state which alternative they prefer. Such methods are called Stated Preference (SP) methods.

The study by Stephens (2010), for the Competition Commission, asserted that stated preference data was the most popular choice when conducting market research mainly because of the unavailability of data or that the markets desired change (or improvement) just did not exist. As a result, a wider range of attributes can be studied than available in present systems. The most common experiments used are the discrete choice experiment and contingent valuation experiment. Revealed preference methods, on the other hand, employ hedonic pricing methods among others. RP methods use real goods and services whereas SP methods create hypothetical goods/services (Kjaer, 2005).

Each of these approaches has benefits and drawbacks of its own. In terms of the disadvantages, SP methods may not represent actual behaviour due to a number of reasons, for example, lack of incentive to provide accurate answers, or incentive to behave strategically. Additionally, the costs involved in conducting such surveys are can be considerable, besides, the complexity of designing a suitable survey. Nonetheless, RP methods come with its own set of drawbacks including lack of information, high cost of acquiring the data, non-quantifiable information and the fact that the natural experiment is difficult to control due to unexpected variations in human behaviour that stem from idiosyncratic shocks.

Note, however, that RP methods provide external validity as the choices observed are real market choices with the individuals having committed time and money to participate. Yet, SP methods fill in the gaps by providing information that would otherwise be impossible to replicate in real-life. Given the nature of my questions coupled with the specific product attributes used to illicit information on consumer/producer choices, I was not able to find data of either actual purchasing behaviour or farm management and therefore stated preference method was a more suitable choice.

SP methods measure economic value of both non-use and use value. This has far-reaching potential as its implications provide rich results when valuing future interventions. As was seen in Figure 3.1, SP methods branch out into Contingent Valuation Methods (CVM) ( Mitchell and Carson, 1989) and Choice Modelling (CM) techniques, more specifically choice experiments (Louviere et al., 2010).

Both techniques are widely used when analysing data, however, choice modelling methods seem to be favoured as they are able to valuate attributes of goods or services and provide information on marginal changes in these attributes. This is helpful since I want to estimate consumers and farmers WTP for farm animal health and welfare. The CVM approach involves asking respondents for their WTP for a good given a set scenario of a hypothetical market. The CM technique, in contrast, offers respondents different alternatives made up of sets of attributes grouped together at varying levels. The respondent then picks the alternative that they prefer the most. In contrast to the CVM approach, which only offers the value of the entire good, CM helps estimate trade-offs between attributes allowing attributes to be measured separately.

Referring again to Figure 3.1, we can see that there are number of Choice Modelling techniques at our disposal. All of these techniques assume goods and services can be defined in terms of their attributes or characteristics. I focus on the value respondent's place on these attributes. These techniques are classified into four categories - that describe their theoretical assumptions, the methods of analysis and procedures used for experimental design - namely, paired comparisons, contingent ranking, contingent rating and discrete choice experiments (DCE).

Discrete choices are taken when we choose or don't choose, for example. They appear to be more positively received in the general literature precisely due to this feature which as I mentioned before is closer to real-life decisions. In addition, they allow for WTP estimations. All the different techniques, however, do have over-lapping assumptions and data collection procedures. For example, all require a systematic experimental design that has been rigorously planned out and executed.

DCE's run on the main assumption that respondents choose (from a number of alternatives) the alternative that provides the highest perceived utility. In doing so, the decision-maker must implicitly trade off several attributes of the available options. First developed by Louviere and Hensher (1982) respondents were given a set of choices. The choices were defined in terms of their attributes or characteristics. By making these decisions, respondents thereby revealed the relative utility (values) received from each attribute and dis-utility of higher prices (Hanley, 2001).

All in all, DCE's outplay contingent valuation methods (dependent on the research question) because they are able to estimate the value for each of the attributes described in the questionnaire and, hence, estimate the value for a control programme that changes these attributes simultaneously. A very detailed account of stated choice methods can be found in Louviere et al. (2000).

RP methods and SP methods appear to be used interchangeably in the literature contingent on data availability and the research question in hand. They can be thought of as substitutes of each other. Both have their merits and shortcomings, therefore, contrary to their classification as substitutes using them in conjunction with each other, perhaps, could decrease the discrepancies created by them (complements rather than substitutes)[2]. Moreover, there is empirical evidence backing SP methods, along with the fact that the RP methods have strengths that if jointly used could improve the validity of SP methods. This would conveniently combine the desirable features of both methods. Naturally, it is not an easy process, given the complexity, the unavailability of software that could support the combination of the differences in behaviour of individuals under the two conditions, the potential challenges in collecting the data and the fairly newness of this technique. According to Kroes and Sheldon (1988), RP data may contain a high degree of attribute collinearity, which makes it challenging to estimate the variance in an attribute. SP methods can resolve this issue by tailoring the survey accordingly. As we have seen there exists several alternative approaches and often time complimentary approaches that we have touched on briefly. Regardless, my thesis will use DCE's based on SP data due to its ability to estimate preferences and willingness to pay for changes in attributes which are not easy to uncover from market data.

## 3.3 What are Discrete Choice Experiments?

Discrete Choice experiments are a WTP technique used to ascertain a respondents valuation of attributes of a good or service underpinned by the seminal work of Lancasters' 1966 consumer demand theory and McFaddens Random Utility Theory (RUT), 1974 in economics (see the following sub-sections 3.2.1 and 3.2.2 respectively for further details). Prior to its theoretical development, the basic intuitions underlying choice modelling can be traced to the founding work of L.L. Thurnstone in the 1920s on food preferences using categorical judgement that leads to binary Probit model (Kornbrot, 1978). As previously mentioned, DCE's when administered as a survey are a sequence of hypothetical scenarios where a respondent is faced with a choice between a finite number

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[2] See for example the work of Brownstone et al. (2000) or Resano-Ezcaray et al. (2010) for the merits of combining RP and SP methods.

of mutually exclusive alternatives. They fall under the umbrella of quantitative research methods primarily used in measuring trade-offs and the strength of preferences in both use and non-use values. This method has been getting popular among researchers and policymakers with many fields increasingly utilising this method. Initially prevalent in market research and transport literature, it was quickly introduced in environmental literature in the 1990s (Louviere and Timmermans, 1990; Adamowiczs et al., 1994).

### 3.3.1 Consumer Demand theory

Lancaster (1966) realised traditional consumer behaviour theory that assumed goods are a direct object of utility ignored intrinsic properties of goods. He therefore, recommended a new approach where it is the attributes or characteristics of goods or combination of goods from which utility is derived. He argued "that goods possess, or give rise to, multiple characteristics in fixed proportions and that it is these characteristics, not goods themselves, on which the consumer's preferences are exercised". The key assumptions made in this theory are as follows: 1. It is the characteristics of the goods that provide utility and not the good itself. 2. Each good will possess more than one characteristic and many characteristics will be shared by multiple goods. 3. A combination of goods may possess characteristics different to those exhibited by the goods separately.

### 3.3.2 Random Utility Theory (RUT)

We must first clarify that the type of data used in choice analysis admits in its entirety preferences of the individuals over a discrete set of mutually exclusive alternatives in a discrete categorical form. Examples include health status, educational level and marital status. Given the categorical nature of the data we will work with, the commonly used OLS regression models fail to capture the true data generating process. The dependent variable is often stated in this data as a dummy variable. This should not come as a surprise as making a choice essentially involves selecting an option from a set of possible alternatives. So we choose one or the other of the available alternatives. In my analysis for example, a possible question would be " Are you willing to pay to ensure high animal health and welfare?" the answer can be summarised by a simple "yes" or "no" i.e. 0 or 1. The independent variables would include personal characteristics among other variables. The main focus in developing a model is to explore causes of heterogeneity in the factors shaping the respondents' decision making process. Thus, RUT posits that respondents will choose based on the characteristics of a good (i.e. the deterministic component) plus some stochasticity (i.e. a random component) which allows us to bridge the gap between theory and observed choice. The stochastic component stems from either the presence of incomplete information or due to some randomness in the preferences of the individual.

### 3.3.3 Utility Model

The preferences we intend to model are not as straightforward as we may like them to be. It is important to note here that preferences have an ordinal property and not cardinal one, in that they only provide us with the relative preferences for the set of alternatives we model. This means that only the ranking of the alternatives will matter. Cardinal preferences on the other hand assign a numerical score to alternatives. For example, a cardinal measurement would be when an individual scores, say their preferences over oranges (5), mangoes (4) and bananas (3). The result is a preference order with a precise number. However, in ordinal measurements, rankings are based on relativity to the alternatives. So oranges are strictly preferred ($\succ$) over mangoes and mangoes are strictly preferred ($\succ$) over bananas.

These preferences represent latent continuous variables that we normally call "Utilities" [3]. In order to formalise choice situations, a utility function with the aim to maximise utility is defined. Utility is maximised when the individual chooses the option that yields the highest possible utility realisation.

$$u(x) \geq u(y), \quad \text{for all } x, y \in X \qquad (3.1)$$

In other words, let $u_i$ be the utility for individual $i = 1, \ldots, n$. Given two alternatives, 0 or 1, if an individual chooses alternative 0, they receive utility $u_{i0}$ and utility $u_{i1}$ otherwise. Let's assume (without loss of generality) that

$$u_{i0} > u_{i1} \tag{3.2}$$

then the obvious choice would be to choose alternative 0. Alternatively, we could rewrite this statement as

$$u_{i0} - u_{i1} > 0 \tag{3.3}$$

This suggests that the choice we make may be expressed as the distinction between the utility realisations. So, let $y_i$ take the form:

$$y_i = u_{i0} - u_{i1} \tag{3.4}$$

Note, $y_i$ here is our dependent variable. Unlike the commonly used linear regression models, our dependent variable is a difference in utilities between two choices and hence requires appropriate treatment.

A choice experiment is a survey based method that can help derive marginal utilities of the attributes included in the choice cards. The utilities derived from the choices made are the sum of the utilities from the choice attributes (Lancaster, 1966). It is then presumed[4] that the respondent chooses the option that is likely to give them the highest utility realisation or at least minimises that the dis-utility/loss of an action/behaviour/policy. To account for heterogeneity in preferences we would include a random component within utility, alongside observable components of choice such as the characteristics of products, and the socio- economic characteristics of people (Hensher, Rose and Greene, 2015).

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[3] The term "Utilities" refers to the realisation of the Utility function associated with a particular preference/choice.

[4] Typically but not always as people could be satisficing. This means that a respondent in a stated choice experiment utilises simplifying heuristics and this behaviour is not in line with RUT (Sandorf and Campbell, 2007).

The preferences we intend to model are ordinal preferences in the sense that they only provide us with the relative ranking for the set of alternatives we model.

A key focus in developing this model is to explore causes of heterogeneity in the respondents' observed and unobserved influences in decision making.
In order to formalise choice situations, we rely on the standard random utility expression:

$$U_{isj} = V_{isj} + \varepsilon_{isj} \tag{3.5}$$

Where $U_{isj}$ be the utility for individual i in choice situation $s$ given alternative $j$. This utility is a sum of a deterministic i.e. observable component $V_{isj}$ that depends on the regressors, the unknown parameters $\beta$ and the unobserved random component $\varepsilon_{isj}$ [5], which is treated as a random variable (Bhat et al., 2008). As always when agents' preferences are expressed by a utility function, the objective is for the agent to choose a plan [6] that maximises utility.

As in Hensher, Rose and Greene (2015), the probability of alternative $j$ being selected by individual i in choice situation s will have the maximum utility, assuming that some joint density $\varepsilon_{is} = \langle \varepsilon_{is1}, ..., \varepsilon_{isJ} \rangle$ exists which is a vector of J unobserved effects for the complete choice set, is given by equation 3.6.

$$\begin{aligned} Pr_{isj} &= \Pr(U_{isj} > U_{isk}) = \Pr(U_{isj} - U_{isk} > 0) \\ &= \Pr((V_{isj} + \varepsilon_{isj} > V_{isk} + \varepsilon_{isk}, \forall k \neq j) \end{aligned} \tag{3.6}$$

Therefore,

$$Pr_{isj} = \Pr(\varepsilon_{isj} - \varepsilon_{isk} > V_{isk} - V_{isj}), \qquad \forall k \neq j \tag{3.7}$$

Meaning that eq.(3.7) reduces to an expression where the probability of alternative $j$ being selected by individual i in choice situation s will have the maximum utility depending only on the difference in the random components being less than the difference in the deterministic components. We can then claim that it is only the differences in the utility that really matter. Equations 3.6 and 3.7 reflect the "translation between the categorical dependent variable and the latent utility". The utility functions of the j alternatives are connected through the characteristics of the probabilities. That is to say, if the utility of one alternative rises, everything else being equal, the likelihood of that alternative being chosen increases while the probabilities of other alternatives being chosen decreases.

Given the nature of my data, the individual chooses from a number of different and mutually exclusive options (multinomial choices), choosing the plan that they believe would yield the highest utility realisation. This option is subjective and determined by the respondent's individual attitudes

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[5] The randomness could stem from uncertainty on the part of the respondents for example, the respondents may not be fully aware of the ramifications of each of their choices. It could also be that the analyst is unaware of all the factors responsible for the decision outcome.

[6] In economics the most commonly used proxy to measure utility is consumption. Thus agents need to choose the "consumption plan" or "plan" for short that maximises their utility.

and characteristics.

To account for this, I make use of discrete regression models, namely, models in which the dependent variable assumes discrete values. In the simplest version of these models, the dependent variable $y$ is binary, meaning that it can only assume two values (which for convenience and without any loss of generality, we denote by 0 and 1).

All of the models considered in this section are selected due to the nature of our data. As documented by Train and Weeks (2005), specification that allows for both preference heterogeneity and scale heterogeneity induces correlation among the observed attributes and this should be accounted for.

In this study, three types of modelling techniques are developed for comparison purposes in light of investigating respondents' preferences. First, we employ a Multinomial Logit model (MNL). Next, we make use of a Random Parameter Logit (RPL) model to account for the nature of the data and the unobserved preference heterogeneity between respondents. Subsequently, Latent class analysis (LCA) is used to estimate class membership among respondents based on their willingness-to-pay (WTP) for different options. We will now describe each of our models to understand their underlying theoretical implications, focusing on the approaches that will be used in my data chapters.

### 3.3.4 Multinomial Logit Model (MNL)

The **Multinomial Logit Model** (MNL) model is an extension of the simple logit model for dichotomous variables. The taste parameters for each attribute is assumed to be fixed for all respondents. It is characterised by constant variances and zero co-variances. Multinomial logit is preferred over probit models, due to the latter being more cumbersome to compute. The probabilities for the MNL model are considerably simpler to obtain compared to most probit models and can be computed in closed form. Confusingly, both models are sometimes referred to as MNL models.

#### Conditional (Fixed-effects) Logit Model

The approach was developed by McFadden, (1974). The model is characterised by using conditional- i.e. fixed effects logistic regression and ignoring random effects and/or non-independence in the data. The conditional logit model is an extension of the MNL model. It is a particularly appropriate choice when it comes to modelling choice behaviour, especially when the explanatory variables include attributes of the choice alternative. Below, I provide a brief discussion of the key assumptions.

Again, let $U_{isj}$ be the utility for individual $i$ in choice situation $s$ given alternative $j$. As discussed above, this utility is a sum of a deterministic i.e. observable component $V_{isj}$ that depends on the regressors, the unknown parameters $\beta$ and the unobserved random component $\varepsilon_{isj}$ since choice depends on random utilities. This can be represented by a standard utility expression:

$$U_{isj} = V_{isj} + \varepsilon_{isj} \tag{3.8}$$

Now, let us define $Y_i$ by a discrete choice from among the $j$ alternatives.

But first we need to assume rationality. Meaning that respondents will consistently make choices in order to maximise their perceived utility subject to their expenditure constraints. When an individual faces $j$ choices, we will define a latent variable $Y_i^*$ which indicates the level of indirect utility from the $i$-th choice. $Y_i$ can therefore be defined as [7]:

$$
\begin{aligned}
& Y_i = 1 \qquad if \qquad Y_i^* = Max(Y_1^*, Y_2^*, ..., Y_j^*) \\
\text{and} \qquad & \mathrm{Y}_i = 0 \qquad\qquad otherwise.
\end{aligned}
\tag{3.9}
$$

Provided that the probability density function is given as

$$f(\varepsilon) = \exp(-\varepsilon - \exp(-\varepsilon)) \tag{3.10}$$

Then, the probability that alternative $j$ is chosen is shown to be (See Train, 2009),

$$\mathrm{Pr}_{isj} = \frac{\exp(V_{isj})}{\sum \exp(V_{isk})}, \qquad \mathrm{j}= 1,2,..\mathrm{J} \tag{3.11}$$

which defines the multinomial logit model.

The expected utilities $V_{ij}$ are modelled on the characteristics of the individuals. Hence,

$$\mathrm{V}_{ij} = x_i^{'}\beta_j, \tag{3.12}$$

where, $\beta_j$ represents the utilities of various choices or the likelihood of making a specific choice as influenced by the covariates (Rodriguez, 2007). Consequently, relevant quantities are then plugged in into the formula with no approximations required.

Despite the clear benefits of MNL models, other alternative specifications are considered due to its limitations, particularly the assumptions of no preference heterogeneity amongst respondents and the equally strong assumption of independence from irrelevant alternatives (IIA) which leads to unrealistic predictions. The classic example by McFadden (1974) about the red bus/blue bus paradox illustrates where the MNL model does not work. Assume you can choose your mode of transport between a train or a red bus. Suppose you choose between the options with equal probability since you are indifferent. Hence, your probabilities are train 0.50, red bus 0.50. Suppose now an additional blue bus has been introduced. You are indifferent between the two buses as you do not care about the colour of the bus. Hence, we would expect you to have a 1:1 split between the red bus and the blue bus which means the probabilities would be 0.50 train, 0.25 blue bus, 0.25 red bus. However, the MNL model predicts the probabilities to be 0.33 for a train, 0.33 for a red bus, 0.33 for a blue bus, increasing the total bus share to 67%. The Independence from Irrelevant

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[7] See full proof in (Maddala, 1983).

Alternatives (IIA) axiom was first introduced by Luce (1959). The IIA axiom states that for a specific individual, the ratio of the choice probabilities of choosing one alternative over another, given that both alternatives have a non-zero probability of choice, is entirely unaffected by the presence or absence of any additional alternatives in the choice set (Louviere et al., (2010), ch. 3, p.44). In other words, when presented with a choice for example between two alternatives, it is assumed that the probability will depend only on the attributes of the two alternatives and will be unaffected by the presence of a third alternative. Although claiming that the IIA axiom holds is a strong assumption, for robust discrete choice modelling constitutes a necessary condition (Train, 2003). This is because the violation of the IIA axiom translates to the unobserved component $\varepsilon$ being correlated. To ensure $\varepsilon$ is uncorrelated, we need the independent variables to capture all the observable characteristics. Hence, we need to rely on the Hausman-McFadden test (1984) test to examine whether the IIA assumption holds. If it fails, we would need to rely on alternative models (i.e. the Random Parameter Logit model).

Regardless of the choice model considered, the utility maximisation process itself suffers from certain drawbacks. There are bound to be errors in the decision making process due to imperfect information, optimisation as well as the fact that we cannot measure exactly all the relevant variables.

Following Thurstone (1927), McFadden (1974) assumed utility to be a random function and further suggested modelling expected utilities as characteristics of the alternatives. Thus, we now denote by $z_j$ a vector of characteristics of the $j$-th alternative and by $\eta$ the corresponding matrix of case-specific coefficients.

Hence, giving us the conditional logit model

$$V_{ij} = z_j^{'}\eta \tag{3.13}$$

This model is equivalent to a log-linear model where the main effect is defined as the covariates $z_j$. Note here that, such models are generally used when the number of available choices is large.

Combining the above two models, we can generate a more general model- a mixed conditional logit model also referred to as (again confusingly) the conditional logit model.

Suppose, we have a set of $N$ respondents facing $j$ choices,

$Y_{ij}^{*}$ = indirect utility for the i-th respondent making the $j$- th choice
$Y_{ij} = 1$ if the $i$-th respondent makes the $j-$th choice, and $Y_{ij} = 0$ otherwise.

Therefore, we have:

$$Y_{ij}^{*} = x_i^{'}\beta_j + z_{ij}^{'}\eta + \varepsilon_{ij} \tag{3.14}$$

Where $x_i$ are individual-specific variables that are constant across choices and $z_{ij}$ is the $i$th respondents vector of values of the attributes of the $j$-th alternative which represents characteristics varying across the choices. Hence, this model incorporates dependence on both -characteristics of the individuals as well as the choice attributes.

The probability of choice (i-th respondent making the j-th choice) is thereby defined as:

$$Pr_{ij} = \Pr(Y_{ij} = 1) = \frac{\exp(x_i'\beta_j + z_{ij}'\eta)}{\sum_j \exp(x_i'\beta_j + z_{ij}'\eta)}$$

where $\gamma_1 = 0$ (3.15)

See Greene (2012) for a straightforward textbook description of conditional logistic regression from an economist's point of view, as well as a brief description of choice models. In conditional logit analysis, the data is grouped and the conditional likelihood is calculated relative to each group (StataCorp., 2021). Note that multinomial logit and conditional logit both constitute special cases of a more general discrete- choice model from which we can derive each of them by setting different elements to zero. As such they employ the "same statistical assumptions about the relationship between choice and the variables used to explain the choice" (Hauber et al., 2016). Models that link choices to the characteristics of the respondents are referred to as multinomial logit models i.e. using case-specific data. On the other hand, conditional logit models associate decisions to the characteristics of the alternatives that respondents choose i.e. alternative-specific data. Often the two terms are used interchangeably in literature. However, I have employ the "multinomial logit" model.

### 3.3.5 Mixed Logit/Random Parameter Logit Model

The random parameter logit model (RPL), or the mixed logit model relaxes the IIA assumption, thus allowing its parameters to vary across decision makers overcoming the limitations of the MNL model. This implies that different respondents may have different preferences. Additionally, RPL models also allow for error correlation across each person's multiple choices.

The RPL model varies from the MNL model as it assumes at least some of its parameters are random following a certain probability distribution. We assume these random parameter distributions are continuous over the sample. More than one parameter can be treated as random which contributes to the practicality of such models. Therefore, we find that the choice probabilities now depend on the random parameters.
We define the probability of choice following Hensher, Rose and Greene (2015) as:

$$\Pr(Y_{is} = j) = \frac{\exp(V_{isj})}{\sum_{j=1}^{J_{is}} \exp(V_{isj})} \tag{3.16}$$

Where,

$$\mathrm{V}_{isj} = \beta_i' x_{isj}$$

The model takes the form of:

$$\beta_i = \beta + \Delta z_i + \gamma v_i \tag{3.17}$$

$x_{isj} = K-$ attributes of alternative $j$ pertaining to individual $i$, in choice situation $s$ .

$z_i =$ Set of $M$ aspects of individual $i$ affecting the mean of the taste parameters.

$v_i =$ a vector of $K$ of random variables, with mean zero, unit variance and zero covariances.

$\Delta z_i =$ captures the observed heterogeneity in the preference parameter of individual i.

$\gamma v_i =$ captures the unobserved heterogeneity in the preference parameter of individual i. The

estimated parameters are $\beta$, K x M matrix of parameters $\Delta$ and the non-zero elements of the lower triangular Cholesky matrix $\gamma$. These models were especially developed to account for the presence of unobserved heterogeneity in preferences by relaxing the assumption that the coefficients are fixed rather than random (Hensher, Rose and Greene, 2015). A number of parametric distributions can be accommodated by this technique, however the literature tend to assume coefficients are normally distributed with the price/monetary attributed assumed fixed (Kruk et al., 2010).

### 3.3.6 Latent Class Analysis

The latent structure analysis has been around since the 50's and was introduced in order to identify a latent categorical variable by Paul Lazarsfeld in 1950. He mainly developed the conceptual foundation and only following that several attempts were made to develop the models and methods (Anderson, 1982). Lazarsfeld and Henry (1968) proposed the **Latent Class Analysis** (LCA) models identifying categorical latent classes measured by a number of observed response variables.

The primary motive is to categorise individuals into classes using the observed variables, and in turn find variables that best group these classes and understand them.

The underlying theory posits that behaviour of individuals hinges on observable attributes and on latent heterogeneity that contrasts with elements that are unobserved. LCA helps us identify and better understand these unobserved sub-groups within categorical data. Since then several extensions have been presented allowing for interesting applications in different directions.

There are several references on these techniques in the literature. Recent development has made it possible to incorporate various combinations of outcomes (binary, ordinal, nominal, count and continuous). They contrast with the more traditional **Factor Analysis Model** (FA) widely used. Here, however, the factors correlate with each other, so the subsets are linearly associated. FA is normally used to measure continuous latent variables.

The model we discuss in this chapter is characterised by having categorical latent variable rather than continuous. The groups may be individuals with different buying preferences, consumers with different patterns of behaviour, education status classifications, health status classifications etc.

The model posits that each respondent belongs to one of a set of mutually exclusive and exhaustive latent classes. When the MNL model fails to address heterogeneity in the model, latent class modelling is a possible alternative approach (Uebersax, 1999). The latent class model is a semi-parametric variant of the MNL model, in that it does not require making specific assumptions about the distributions of parameters across individuals.

The approach assumes that parameter vectors $\beta_i$, are distributed among individuals with a discrete distribution rather than continuous that lies behind the RPL model. We work with the assumption that the population consists of a finite number, $Q$, of groups of individuals distributed heterogeneously with a discrete distribution in a population. Each of these groups are different from one and another however, there is a common parameter $\beta_q$ for each members of the group. This then implies that different parameter estimates distinguish the classes. So, when individuals are sorted into a set of $Q$ classes, we do not know which class will contain any particular individual, it is irrelevant whether the individual on the other hand may or may not know of this. Thus making the class assignment unknown. Two sets of parameters are estimated: class/group membership probabilities (which are analogous to factor scores) and variable response probabilities conditional on group membership indicating the likelihood of class members responding differently to each category variable (Lanza and Cooper, 2016). Heckman and Singer (1984) provide a good theoretical background and Greene (2001) provides an early survey of literature. Swait (1994) and Bhat (1997) are early examples of the application of LCA to the analysis of discrete choice among multiple alternatives.

The main model is framed as a logit model for individual i observed in $s_i$ independent choice situations with a discrete choice among $j_i$ alternatives, given by:

$$\Pr(\text{choice } j \text{ by individual } i \text{ in choice situation } s |\text{ class } q) = \frac{\exp(x'_{is,j}\beta_q)}{\sum_{j-1}^{j_i}\exp(x'_{is,j}\beta_q)}, \text{ with}$$

$$\frac{\exp(x'_{is,j}\beta_q)}{\sum_{j-1}^{j_i}\exp(x'_{is,j}\beta_q)} = F(i,s,j|q) \tag{3.18}$$

Where, $\beta_q$ is the common parameter.

In each choice situation, the number of observations and the size of the choice set may very well influence the choice set. Note here that each individual $i$ is observed over several choice situations $s$, helping us give a wholesome view of individual choice behaviour.

For a class $q$ for individual $i$, let $P_{iq}$ define the prior probability. It can be shown in the MNL model form as:

$$\Pr_{iq} = \frac{\exp(v'_i\theta_q)}{\sum_{q=1}^{Q}\exp(v'_i\theta_q)} \tag{3.19}$$

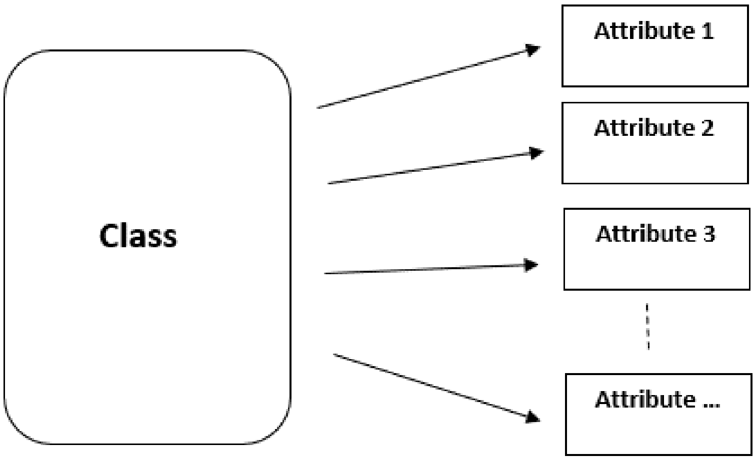

Figure 3.2: Latent Class Analysis model diagram. Source: Author

$$q = 1, \ldots, Q \text{ and } \theta_Q = 0$$

Where $v_i$ is a set of observable characteristics that enter the model for class membership. $\theta_Q$ is a latent class parameter vector. We then decide the number of classes $Q$ we want to assign. There are numerous ways we can decide on the number of classes in LCA.

We try several classes to analyse which model fits best. The general indices used are Bayes IC and bootstrap ratio test. A study by Nylund et al. (2007) and Lin and Dayton (1997) compare and contrast in length several data analysis techniques in a simulation study that examines the performance of likelihood-based tests. Their findings showed that the Bayesian Information Criterion (BIC) performed best among the IC's, while the bootstrap likelihood ratio test also showed consistent results. This is in agreement with Roeder et al. (1999) who suggested using BIC. The prime way would be to test down to determine the appropriate amount of classes suitable in the model being considered. We will on the other hand receive invalid results if we were to test up for a small $Q$ as the estimates obtained would be inconsistent. In addition Consistent Akaike IC (CAIC) is also employed (Pacifico and Yoo, 2013).

Using Bayes theorem, we can obtain a posterior estimate of the latent class probabilities using:

$$\hat{P}_{q|i} = \frac{\hat{H}_{q|i} P_{iq}}{\sum_{q=1}^{Q} \hat{H}_{q|i} P_{iq}} \tag{3.20}$$

$\hat{P}_{q|i}$, is defined as the respondent-specific estimate of the class probability, conditional on their estimated choice probabilities.

When we estimate the model, we cannot predict which observation belongs to which class (therefore, the term latent). We are defining each class to have a specific behavioural meaning, thus, these classes essentially can be referred to as a probabilistic decision rule.

Generally, LCA modelling has a variety of potential uses, it helps understand heterogeneity to better direct and target interventions (perhaps more effectively), campaigns, marketing etc. In figure 3.2, class is a discrete latent grouping variable. The respondent can be in either one group or another and that group determines the respondents profile of responses. It then takes the patterns of responses and identifies prototypical sub-grouping latent classes.

When we fit an LCA model, we specify the number of classes and then estimate the probabilities of class membership. The parameters estimated are allowed to vary across the classes.

We then estimate the probability of being in each class using the multinomial logit regression:

$$\Pr(C=1) = \frac{e^{-\gamma_1}}{e^{-\gamma_1} + e^{-\gamma_2}} \tag{3.21}$$

$$\Pr(C=2) = \frac{e^{-\gamma_2}}{e^{-\gamma_1} + e^{-\gamma_2}} \tag{3.22}$$

$\gamma_1$ and $\gamma_2$ are the intercepts in the multinomial logit model. The first class is always treated as the base, therefore $\gamma_1 = 0$.

The key assumptions are as follows:

1. Non- parametric- LCA model does not adopt any assumptions related to linearity, normal distributions or homogeneity.
2. Data level – Only categorical or ordinal data can be utilised.
3. Identified model – Models should be just or over identified. The number of equations must be greater than the number of estimated parameters.
4. Conditional independence – Observations in each class need to be independent.

The model can be extended to allow for heterogeneity both within and across groups, i.e. variation in parameter vector within classes as well as between classes. The extended model combines RPL and LCA models.

In general, the fit of a model with a given number of latent classes to the data will be underestimated. New LCA methods, called mixed latent trait (MLT) models, that overcome this limitation for dichotomous and ordered category data can used for more complex analysis.

### 3.3.7 Willingness to Pay

In order to gauge how much respondents value the attributes of the choices, we commonly use measures to estimate the **Willingness to Pay** (WTP).

We compute the marginal WTP so we can ascertain the significance of a unit change in an attribute and accordingly postulate the respondents WTP.

The WTP estimates for marginal changes are calculated for all the attributes using:

$$WTP = \frac{-\beta_{attributes}}{\beta_{costs}} \tag{3.23}$$

the individual-specific preference parameter $\beta$ and and the choice specific constants $\alpha$ vary around their means and are not fixed for all respondents. The parameter distributions of $\alpha_{ij}$ and $\beta_{ik}$ have means that are allowed to be heterogeneous with $z_i$ with weights $\delta_j$ and $\delta_k$ (Sheremet et al., 2017). The Krinsky and Robb (1986) procedure is undertaken in order to compute confidence intervals. Several studies have shown how WTP estimates can be influenced by unobserved factors. For example, Czajkowski et al. (2015) argued how experience can influence respondents' preferences and hence how their choices can influence the willingness to pay estimates. Therefore, a different approach would be to estimate models in the WTP space. They also suggested that learning could affect both means and variances of random taste parameters and as a result, the mean and variance of willingness to pay. Of course, there are a number of techniques that could be utilised to compute WTP. Moore et al. (2011) for instance showed categorical income variables' response ranges and used them to allow for testing of the hypothesis that household income shifts the WTP function.

Although I estimate my models in the preference space and not directly in the WTP space, it is an important class of models. These models allow us to relax the assumption of fixed price, therefore, the attribute coefficient is interpreted as the marginal WTP directly (Carson and Czajkowski, 2013, Scarpa and Willis, 2010). The debate over which method is superior is still ongoing. Balcombe et al. (2009) report that the WTP space estimates appear to be more stable and reasonable. Train and Weeks (2005) find that the model fit decreases possibly when commonly used distributions (e.g. normal distribution) are employed. On the other hand, Hole and Kolstad (2012) found that models estimated in the preference space have a somewhat better fit whilst delivering more realistic WTP estimates. Thus, I have decided to pursue the estimation of the WTP in the preference space.

## 3.4 Key Stages to conducting a DCE

Now let us confine our attention in the remainder of this chapter to how a DCE as a framework for data and its analysis can be set-up. Setting-up a DCE appropriately and conducting rigorous checks to ensure its suitability can mitigate some of the limitations often cited in literature (see section 3.6 for a brief discussion on the limitations of DCE's).

## A. Identification

The most important part of conducting a DCE before choosing the modelling framework is characterising the decision problem. Before pursuing a DCE its suitability must be assessed. We first need to identify our utility function that can be estimated from a given experiment. The utility in theory must be separable that is to say, that it is comprised of a deterministic and additively separable stochastic component. While DCE's can assume complete separability of utility, it is possible to have interactions between attributes.

Since DCE's are an attribute based measure, they assume choices are made with regard to a good or service depending on the attributes (i.e. characteristics) of that good and service. Attributes and their levels can be identified using a number of techniques. This will typically be based on the question you want answered. The first line of inquiry may be literature searches and reviewing studies and their applications. Many times consulting experts in the field can prove fruitful and assist in making an informed decision or at the very least with the initial selection of attributes and their levels. For a thorough search, one can use interviews and/or focus groups shedding further light on the experiment ensuring its suitability and identification of any flaws. In order to obtain the WTP, a monetary attribute is required. I will need the choice cards to be mutually exclusive from the perspective of the respondents as well as exhaustive offering all the possible finite number of alternatives (Train, 2009).

Collins and Vossler (2009) suggest using incentive compatibility as an apparatus where respondents cannot attain a better outcome from any action other than revealing their true preferences. Czajkowski et al. (2017), provide evidence that a SP survey should be incentive compatible, meaning that there is no strategic advantage for agents to be dishonest but instead a respondent obtains the maximal reward/happiness for truthful preference revelation. One of the central conditions behind this mechanism is the concept of "consequentiality". Johnston et al. (2017) describes it as " a condition in which an individual faces or perceives a nonzero probability that their responses will influence decisions related to the outcome in question and they will be required to pay for that outcome if it is implemented". As in Carson and Groves (2007), we need two conditions to ensure valid SP data. Incentivising respondents to reveal their true preferences can be achieved by including a binary choice format which would discourage respondents to deviate from truth-telling and using consequentiality as discussed above. In my case, there are no incentive compatibility concerns as respondents both farmers and consumers will have no gains by employing strategic behaviour. My choice experiments were conducted on familiar goods to both consumers and farmers. These are goods they would purchase on a regular basis and hence are aware of the prices of the goods and their budget constraints. Hence, I can conclude that my respondents choices reveal their true demand for the good(s) in question. Furthermore, since my studies focus on relative magnitudes of the WTP rather than absolute, the lack of incentive compatibility is not a primary concern.

## B. Design

A sequence of choice scenarios (cards) are presented consecutively to each respondent with the block (choice sets) assigned randomly (see Figure 3.3). The number of such choice scenarios and the number of blocks in the experiment are dependent on the researcher.

Each choice card is made up of a certain number of attributes (e.g., price, quality, colour). The attributes serve the purpose of describing possible scenarios or characteristics based on which the respondents may make their choices. These attributes will also have varying attribute levels (e.g., attribute price may have levels £1, £2 , attribute colour may have attribute levels red, yellow, blue) that will allow us to create various combinations of scenarios to choose from the specified number of choice alternatives.

The most appropriate experimental design is selected at the discretion of the researcher and hence choice sets are selected from a universal set of all possible choice sets satisfying specific statistical properties. Louviere et al. (2010) suggest that the key statistical properties are identification and precision along with non-statistical properties such as realism and complexity that require careful attention. I focus on selecting the most efficient design. Efficiency here refers to those combinations of attributes and their levels that provide us with the most information when respondents make their choices. Meaning that this approach will result in having the lowest possible standard errors. The experiment designs for my thesis were coded on NGene software. If the attributes and their levels are sufficiently small, full factorial designs can be employed. A full factorial design is one which incorporates the full range of attribute levels and all possible combinations of these. Otherwise, fractional factorial designs may be employed. These designs take a sub-set of choice scenarios. These sub-sets are selected in a way that enable utility to be inferred despite the limited range of scenarios. The widely accepted approach for linear models is to take on an orthogonal design where variations of attributes and alternatives may be uncorrelated and integrate these into the experimental designs.

## C. Pilot

At this point, appropriate levels must be established for the monetary attribute as well as the other attributes and their levels inviting respondents to suggestions or modifications. Analysing data from pilot studies can provide information on the attributes and their significance. Therefore, a pilot study can provide both qualitative and quantitative information on a study ensuring a robust design. The pilot study can also be used to test interactions between attributes.

Prior to conducting a pilot study we can assume zero priors for our attributes when extracting an experimental design. A pilot study then aids us in providing attribute preference directionality, making our final experimental design much richer. At the initial point, the pilot study for my thesis used fractional factorial D-efficient MNL experiment design which was extracted from NGene. Priors and standard errors were then obtained from estimating my parameters from the pilot data. The experimental design method employed is specifically structured to increase the statistical performance of the models when applied to small samples than are required for other less efficient (statistical) designs such as orthogonal designs (Rose et al., 2008).

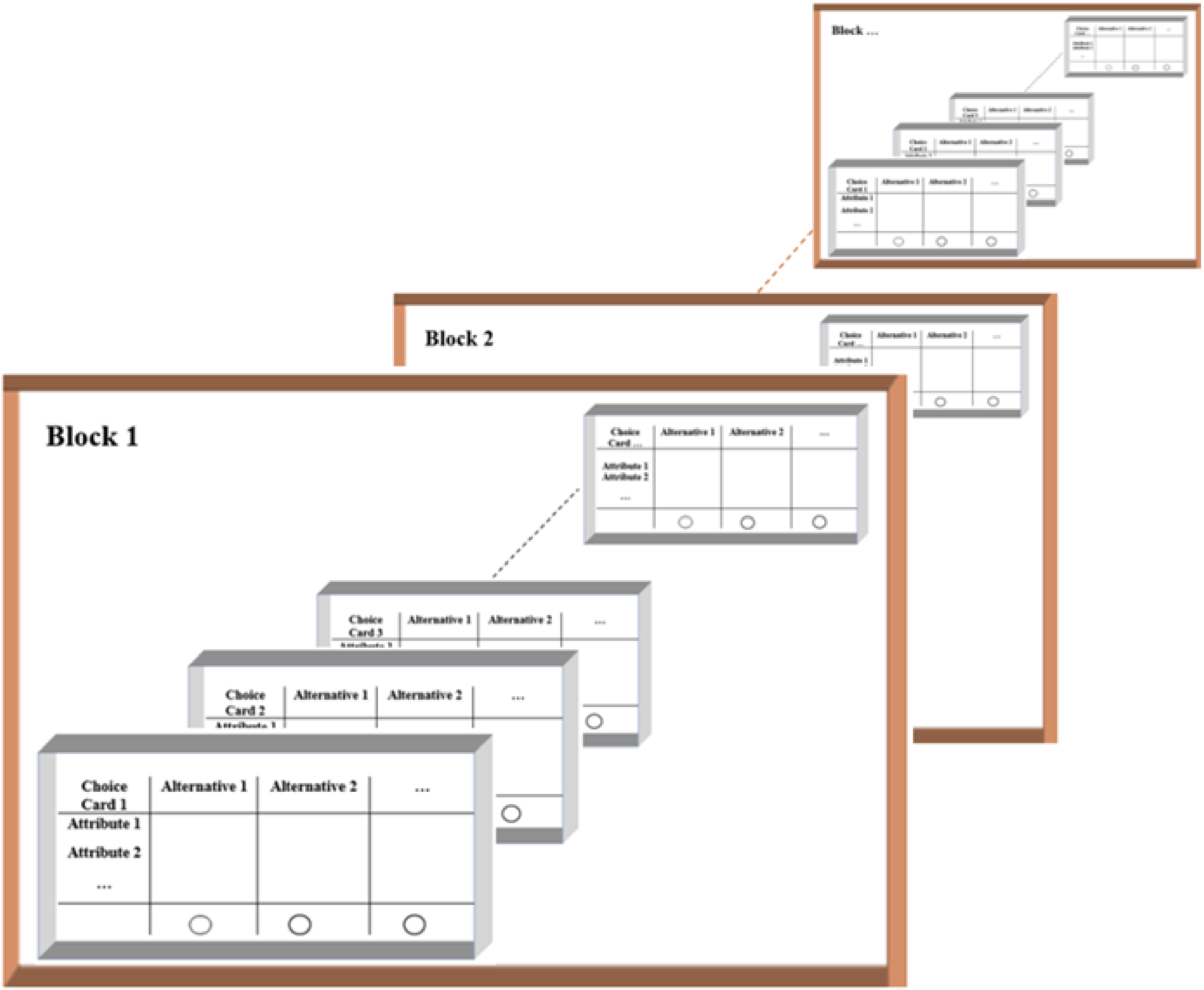

Figure 3.3: Choice experiment design Scheme. Source: Author

The surveys for my thesis were designed on Sawtooth software. Market research companies were then be used to administer the online survey to the sample specification of researchers choice. The econometric analysis of the data collected was conducted using Stata and Matlab.

## 3.5 Related literature

Given my research questions fall under agricultural economics, in this section I provide a brief exposition on the literature of stated preferences applied to the field of agricultural economics with a specific focus on livestock disease and health. A more targeted literature review is provided in each of the data chapters.

According to Hanley et al. (2001) “choice experiment (CM) is a family of survey-based methodologies for modelling preferences for goods, where goods are described in terms of their attributes and of the levels that these take”. A discrete choice experiment (DCE) falls under the umbrella of stated preference method typically employed to estimate non-monetary costs and benefits associated with changes in environmental policy (Hanley et al., 2001; Bennett and Balcombe, 2012). It is a technique that allows us to efficiently model multidimensional problems. In the last two decades, this approach has been widely recognised by academics and (policy) practitioners alike as a key approach for estimating the non- marketed as well as monetary value of policy changes (in agriculture and environment). The appropriateness of this methodology becomes even more evident when one considers the change in the UK Agricultural policy (DEFRA, 2020) and the move towards a PES (payments for environmental services) system. Thus, in this section I present a review of the recent literature in agricultural and resource economics that employ this technique.

There is emerging evidence that the choice of policy mechanisms may be important in influencing value estimation (Czajkowski and Hanley, 2009; Johnston and Duke, 2009; Rolfe and Windle, 2013), however, there is not much tested in relation to farm animal health and welfare. Questions like whether there exist trade-offs that decision makers go through when deciding between animal products as they pick one option over the other have been explored but very little is said in the context of farm animal health and welfare.

Sok et al. (2018) used a DCE in order to estimate farmer preferences for vaccination schemes to control bluetongue disease applying hybrid models like the integrated choice and latent variable (ICLV) approach. The authors tried to measure the choices respondents made, their social-psychological constructs and the socio-demographic characteristics of respondents from the Netherlands. In addition, they measured perceived attitudes and norms of the study participants. Since the Netherlands was free from bluetongue disease at the time of the study, the authors created a hypothetical scenario where bluetongue was detected within 100 kilometres from the premises of the respondent. Next, they specified the probability of infection and the preparation of vaccination schemes they could choose in order to reduce the probability of infection at the farm to zero. Using a fractional factorial main effects design, the authors collected data from 280 farmers and found that farmers were willing to participate in a vaccination scheme that minimises the probability of herd infection. They also concluded that the farmers participation to such schemes could be increased through the provision of information and subsidies- the two policy implications.

A similar study by Railey et al. (2018) in Tanzania on 432 households attempted to elicit preferences for vaccinations for foot- and- mouth disease (FMD). The authors attempted to bridge the gap between the parameters that contribute to decisions of vaccinations and how they relate to perceived risks. The target groups chosen were cattle owning households, since they wished to gauge behavioural responses and improve the precision of responses. The purpose of the survey was to determine the households preferences towards FMD vaccinations that were unavailable to these farmers prior to the time of the study. The cross sectional survey included questions pertaining on demographics, livestock management practices and knowledge and history of FMD. The study used a double bounded dichotomous choice contingent valuation method that jointly analyses willingness to pay (WTP) for a particular product as well as gauging the reason for this decision. Some of the main findings of the study include decisions of routine and emergency vaccinations depended heavily on income, diversity of income boosted the uptake of vaccination and emergency vaccinations had higher WTP than routine vaccinations.

Another study by Bennett and Balcombe (2012) on farmers attitudes and WTP for Bovine Tuberculosis (bTB) cattle vaccine utilised both contingent valuation and choice experiment methods. The survey questionnaires were conducted through telephone interviews on a sample of 300 farmers in targeted bTB tested areas in England and Wales. They found that farmers were concerned and believed there was a high risk of their cattle getting diseased. The WTP estimates of bTB cattle vaccine were a lot higher than was expected indicating that farmers in the high risk bTB 'hotspot' areas deemed buying these vaccines very important. The authors decided to use a choice experiment since the policymakers required information on how people perceived the different attributes of the vaccines and which attributes were given higher value or deemed more important. The contingent valuation method was then used to compare and contrast the WTP estimates from the study, checking their credibility.

As illustrated such studies illicit information on various management options from vaccine developments to prevention strategies and inform policies. Scarpa et al. (2003) used choice experiments to value farmers WTP for disease resistance in pigs in Mexico. Similarly, Roessler et al. (2008) assessed preferences for pig breeding traits in Veitnam and Ouma et al. (2006) examined preferences for cattle traits in Kenya. Such studies concerning valuing livestock traits are in plenty. On the other hand, CV method was used to estimate consumers WTP to reduce the risk of salmonella in Sweden by Sundstrom and Andersson (2009). Loureiro and Umberger (2007) explored consumer preference for meat attributes in the US using choice experiments. Nocella et al. (2010) looked at consumer WTP and the issue of trust and animal welfare. There are, however, few studies using choice experiments and contingent valuation techniques to elicit preferences in connection to livestock disease prevention. These include Swallow and Woudyalew (1994) in Ethiopia and Bennett and Willis (2008) in England and Wales.

A study by LaRiviere, et al. (2014) showed that the WTP estimates are a function of not only the true states of information but also of the individuals belief sets. They conducted a field experiment by feeding positive information on cold water corals sites off the coast in Norway to a group of subjects and identified a causal effect of objective signals of a consumers knowledge on the mean and precision of WTP estimates. Their study was different to previous work that mainly showed for example that agents do not update negative signals in the same way as they would positive signals as well as that over confident posterior beliefs are more common (Grossman and Owens, 2012) which are consistent with the findings of Eil and Rao (2011). Additionally, there is considerable literature that models the effects of past choices, expectation and learning through inspection on choices and preferences in the current period (Louviere and Meyer, 2008). Much like my thesis, a study by Xuan and Sandorf (2020) examine both supply and demand side using DCE's however they focus on sustainable aquaculture production in Vietnam.

## 3.6 Summary

The preceding discussion all but confirms that DCE's are a suitable method of preference examination for FAH and FAW in this thesis. This chapter gave an overview of the theoretical background, a primer to setting up a DCE and the estimation strategies that may explain individuals preferences. Starting with the 1workhorse' model MNL we looked at its key benefits and discussed its shortcomings which led us to consider more flexible alternatives like the random parameter logit model. We then considered the Latent Class analysis model and its potential uses. These techniques we discussed are well- established estimation methods.

In the random parameter logit model the parameters are assumed to vary from one individual to another. Thus, it allows us to randomise attributes to account for any preference heterogeneity. The results of the RPL model will contribute to our knowledge by providing mean value estimates across the population samples and show the relative importance of other explanatory variables. The RPL model trumps other available techniques due to the fact that it produces broadly flexible functional forms that can match behavioural modelling to empirical specification and estimation (Greene, 2018).

On the other hand, the LCA models highlight the different groups of respondents and their relative preferences. LCA models can be developed to specify the identification of several classes of respondents who have heterogeneous preferences towards the attributes. This approach has great merit as a framework within which to represent multiple decision processes whilst also allowing a comparison of preferences for relative changes. All three models have their limitations and strengths.

Controlling for preference heterogeneity can improve the fit of models estimating WTP. Aldrich, et al. (2007) use cluster analysis and latent class analysis as methods to account for unobserved heterogeneity; Provencher and Bishop (2004) perform a similar comparison between random parameters logit and a latent class model. Other studies rely on socio-demographic variables or answers to attitudinal and behavioural questions to serve as proxies for unobserved preference heterogeneity (Moore, et al., 2011). Example, Johnston et al. (2011) asks respondents about the importance of some environmental concerns to model preference heterogeneity in decisions to purchase eco-labelled seafood. Holmes and Kramer (1996) and Jenkins et al. (2002) use questions about recreation behaviour to help explain differences in WTP for forest conservations.

Several recent studies have eluded to the scope of introducing more complex methods like the random parameter latent class models which can be advantageous. They conclude that the inclusion of these random parameters improves the model fit (Hess, et al., 2012; Hensher, et al., 2015). However the crux of the matter is DCE can help us identify appropriate policy responses to addressing farm animal health and farm animal welfare giving us quantitative measures of the relative importance of different attributes. This is where I contribute to the existing literature predominantly led by qualitative surveys that do not necessarily provide us with quantitative measures and that go beyond the traditional qualitative assessments guiding us to better understand and therefore implement more informed strategies. Policymakers can look at preferences and plan schemes to incentivise agents. So while qualitative studies provide us with rich understanding and importance of certain variables, DCE's give us the strength of preference, trade-offs between given attributes and in many cases probability of take-up.

I have also highlighted the stages involved in conducting a DCE and how perhaps improved information that can affect economic decisions like the willingness to pay for specific goods. To this end, several studies have emphasises the importance of context and how direct experience with a good can influence individuals outlook on that good (Nelson, 1970; Erdem and Keane, 1996). Economic decision making is also influenced by the provision of objective information on a good or even expert advice (Grossman and Owens, 2012; Eil and Rao, 2011).

Therefore, given the literature, the research aims, the questions I want answered and the non-existence of actual data make DCE's the most suitable method for my thesis. This thesis aims to examine the preferences of consumers and farmers to FAH and FAW, their WTP and whether information asymmetry has any influence on the WTP.

# Chapter 4

# Disentangling farm animal health from farm animal welfare

## 4.1 Abstract

Do consumers care about the health of farm animals? Using a sample of n = 515 consumers, I assess the relationship between consumers preferences, herd sickness levels and farm animal health (FAH) and farm animal welfare (FAW) by analysing UK consumers purchasing decisions in the context of two endemic livestock conditions Bovine Viral Diarrhoea (BVD) in cattle and lameness in sheep. The analysis uses discrete choice experiments related to four products: beef and milk, and lamb and wool. The study provides robust evidence that UK consumers care about farm animal health and welfare independently of the sickness level in herds/flocks, when sickness levels do not compromise the safety of the products consumed.

The chapter is structured as follows: Section 4.2 introduces the main premise of the chapter and highlights the question I seek to answer. The experimental design is described in section 4.3, which also gives a summary of the data I use. The outcomes of the investigation utilising multinomial logit models and random parameter logit models are presented after this in section 4.4. Following this, I present the results from a latent class variable approach and finally in section 4.6 I conclude with a discussion and potential extensions and variations of the study.

## 4.2 Introduction

In ‘A new approach to consumer theory’, Kelvin Lancaster (1966), laid the foundations for what is now a well-studied methodology of discrete choice experiments (DCE henceforth). Lancaster’s characteristics demand theory postulates that it is the characteristics of the goods in the basket rather than the goods itself that contribute to the utility consumers derive. Therefore, in this study I look at products with specific characteristics and their relative significance to consumers when making purchases.

Markets offer consumers a wide variety of products, such that I can pick and choose the product characteristics that most appeal to us. This study attempts to look at preferences for such product characteristics, contrasting attributes such as price and place of origin with animal health and welfare attributes to markets in the UK. Importantly, the study considers two livestock diseases where there is no link between disease prevalence and food safety or product quality. The main research focus is on whether consumers have separable preferences for reductions in livestock disease relative to broader animal welfare considerations, since “farm animal welfare” is a much broader concept than livestock disease status or animal health. I compare preferences for these attributes across four animal products, beef steak and milk from cattle and lamb chops and pure wool from sheep.

In the study, lameness and bovine viral diarrhoea (BVD) are used as reference conditions. Lameness in sheep and BVD in cattle were chosen for simplicity as well as because governments prioritise these diseases specifically in cattle and sheep [1]. BVD is a highly contagious viral disease that spreads as easily as common cold. There are two types of infections caused by this disease: a transient infection and a persistent infection. Transient infections are temporary and are characterised by poor fertility, low production of milk and immunosuppression which makes cattle more susceptible to diseases. This type of infection is caused after the birth of a cattle. On the other hand, a persistent infection is a lifelong infection where cattle are born with the disease. Most die within 18-24 months and during their life spread the virus infecting cattle that come in contact with them (Hoar, 2004). BVD can spread from infected dams to unborn calves through direct contact with infected animals, indirectly by visitors or contaminated equipment and through the semen from infected bulls. The economic costs in the UK were estimated at £61 million per year at the national level (Bennett and Ijpelaar, 2005). Lameness is one of the most widespread and persistent welfare concern in the UK sheep flock. It is a significant source of discomfort and pain for animals as well as a major source of economic loss to farmers and the sheep industry. The estimated cost to the sheep industry is £80-£85 million per year (Winter and Green, 2017). The causes of lameness are widespread ranging from infections to environmental conditions (Winter, 2004). Chapter 1 offers more details on the two conditions.

Lameness and BVD both contribute to a variety of health issues in animals throughout their lives, leading to early death in the case of BVD as well as significant (but only for some farmers) economic costs (Gunn et al., 2005). The characteristics of these conditions make them apt objects

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[1] Similar to the other devolved administrations, the Welsh government has priority diseases for the Animal health and welfare Steering Group, these include for beef animals - BVD, Johne’s disease and liver fluke; for dairy cattle - Johne’s disease, lameness, mastitis, VD and liver fluke; and for sheep - sheep scab, liver fluke, lameness and lambing losses. See FAWC report on farm animal welfare: health and disease, 2012

for studying perceptions of these diseases. However, consuming animal products from sheep and cattle affected by these conditions induces no adverse health effects in consumers [2]. This led me to ask the question whether consumers care about the sickness level of farm animals independently of the overall animal welfare grading assigned to the farm. Do people care about sickness levels in farm animals when such sickness has no direct implications for food safety? This is a significant question as it contributes to the debate of whether farm animal health and welfare should be a public good. In chapter 1, I presented a brief explanation of the term ”public good”. An extensive definition as well as a discussion of this subject are provided in the last chapter (Chapter 8: Discussion) where I summarise the key results from each of my data chapters and examine their ramifications for the discussion of public goods.

Research has shown that consumers value improvement in farm animal welfare and are willing to pay for approaches that address animal welfare and the environment. A study by Van Osch et al.(2017) found that the Irish public was willing to pay a Price premium for farming sustainable salmon and preferred locally produced salmon. They made a case for eco-labelling that broadly rated the impacts of aquaculture with each scale on the label indicating a 10% increase in sustainability. Although not explicitly stating, the study shows a positive consideration by the public for farm animal welfare. In contrast, a study in Germany looked at not just the public but the producers preferences for FAW in the context of pig farming (Latacz-Lohmann and Schreiner, 2018). Interestingly, the authors chose to include actual FAW initiatives that existed in Germany at the time for instance the surface area per pig, supply of bedding straw, manipulable material, tail docking and castration and duration of transport to abattoir. Comparing the willingness to pay of the consumers to the willingness to accept of the producers, the authors found some discrepancy in the preferences. While consumers preferred enhanced standards in all FAW attributes, producers saw surface area per pig and the amount of bedding material to be the most crucial. This discrepancy can be a sign that customers are unaware of the implications of the particular requirements. It may also imply that the producers find the expense of the programmes unsustainable, which would explain why they demand higher prices in the study than the average consumer was prepared to pay. Additionally, consumers are unable to observe the production process as farmers can.

While studies in FAW are plenty, my study analyses consumer preferences for farm animal welfare and health in England, Scotland, Wales, and Northern Ireland in the context of infection levels. Drawing from the literature, the study also investigates consumer preferences and WTP for farm animal health and welfare using a combination of hedonic and utilitarian goods with search and credence cue attributes. I seek to understand the extent to which consumers are willing to trade-off one attribute against the other, and their willingness to pay for increases in desired attributes. The key distinction the study makes is the separation of animal health from animal welfare. Together with the multinomial model and random parameter logit model, I also utilise the a latent class modelling framework to explain the heterogeneity in consumer choices.

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[2] Bovine Viral Diarrhea Virus (BVDV) that causes BVD is a pestivirus and “pestiviruses do not infect humans”. (See https://www.gov.scot/publications/bovine-viral-diarrhoea-bvd-eradication-scheme-phase-4-vets-guidance/pages/9/, Varshney et al., 2009 ). According to FAWC: health and Disease report, 2012 the government is monitoring diseases that have an impact on human health and endemic diseases like lameness which affect FAHW only receive minimal surveillance.

## 4.3 Methodology

### 4.3.1 Experiment design and data

I use a discrete choice experiment for the empirical analysis on the attitudes of $n = 515$ UK consumers. The survey was conducted in July 2020. Qualtrics, a market research company, was commissioned to collect the data in a manner that ensured the sample was representative according to geographical distributions and key demographic characteristics of the UK population. The online choice experiment survey was developed using Sawtooth software and the experimental design was generated in NGene.

Prior to running the main survey, a pre-test and two pilot surveys were conducted. The pre-test involved small focus group and online interviews that took place in April and May 2020 with members of the public that provided us with qualitative data. Originally, an in-person focus group meeting was arranged at the Hillhead Library in Glasgow. However, COVID-19 restrictions forced me to move the meeting online. The group consisted of six participants. The purpose of the focus group was to discuss consumer perceptions and product characteristics that consumers value when making their purchasing decisions. I asked participants to rank the most important attributes they consider when purchasing products as well as attributes not included in the survey. Participants were not aware of the two endemic conditions: BVD and lameness and their impact on farm animal health and welfare. This inspired me to create the infographics that were included in the survey capturing key facts about the two diseases. The online interviews with five members of the public were held after the group meeting and had a more technical aspect to them. These interviews with each participant lasted approximately 1 hour and helped me finalise the final form of the survey. They were mainly focused on whether the survey was fit for purpose, the length was sufficient to cover the key research questions and the level of complexity was suitable for a broad spectrum of consumers to comfortably answer it. Visual cues, jargon and attributes included in the choice experiment were discussed at length.

This data along with existing literature fed into the identification of the attributes and its levels. The first pilot enlisted $n = 50$ respondents and was used to fine-tune the survey. The second pilot employed a D-efficient design with zero priors in order to generate $n = 48$ participants data. This facilitated the generation of the final choice sets that incorporated a homogenous Bayesian efficient design. A bayesian efficient design is one where instead of fixed priors I use random priors that are characterised by random distributions. Given that I can not know the priors fully, the uncertainty about the parameter priors is addressed by this method. It is a homogenous design because I use a single design for the different respondent segments i.e. the four choice sets as described below.

The survey included four choice sets, one for each product (Cattle product:-beef steak, milk and Sheep product:- lamb chops and pure wool). Each respondent received two choice sets combining a product from each animal in a random order, together with questions that sort information on socio-demographics with the intention to use them to determine their effects on the preferences. However, an exemption was made for vegetarian respondents who were limited to only milk and wool choice sets.

In the survey, respondents were presented with short summaries on the two infections prior to starting the choice experiment. Importantly, respondents were explicitly informed that “These diseases/conditions may undermine farm animal health and welfare. However, they do not cause any ill effect to humans when they consume the animal products”. It is important to emphasise that we reiterated several times throughout the experiment that “all the products displayed in the choice scenarios were completely safe to consume”. These choice sets comprised of six choice cards with each choice card having three alternatives, two products and one opt- out alternative. The experimental design was composed of three blocks of six choice scenarios each. The respondents had to choose one of these alternatives. An example choice card is displayed in figure 4.1. The choice cards for milk, lamb chops and wool followed a similar design.

The attributes in the choice sets (origin, animal welfare grading, herd infection level for BVD or lameness as appropriate, and price), along with the levels for each of the four attributes are summarised in table 1. These attributes were chosen in accordance with the question at hand and focus group feedback. As shown below, they are also in line with those from the relevant literature

1. Price levels - This pecuniary attribute was determined based on the current market prices in budget chain supermarkets, premium supermarkets and private butchers’ shops.

2. Origin – Product origin was used as a proxy for food mileage/ traceability distinguishing products produced locally, within the UK and outside the UK. Zanoli et al. (2013) found domestic breed origin was one of the most important attributes in their survey (based in Italy). Country of origin was found to be the most requested attribute in Cicia and Colantouni (2010), in their meta-analysis for WTP on meat traceability along with food safety and animal welfare playing a crucial role. Although my survey accounts for place of production within the UK, it abstains from looking at either the significance of breeds or tracing countries of origin outside the UK. For example, locally produced suggested the product came from less than 50 miles from where the consumer purchases the product; produced elsewhere in UK indicated that the product is produced within the UK but outside the 50 miles radius; and produced outside the UK indicates an imported product.

3. Animal welfare grading- This attribute grades the product as coming from a high, medium or low welfare farm that distinguishes farms based on the overall quality of the farm. Our experiment uses an ecolabel scale from A- C sorting animal welfare from highest to lowest with “C” being the base in our estimation signifying lowest welfare while “A” signifying highest welfare. These animal welfare ratings were graded with the presumption that they might be based on a certification from any organisation trusted by consumers, such Red Tractor or the RSPCA Animal welfare is a fairly well-established attribute of importance for consumers. However, what animal welfare means differs widely, with previous work using different proxies to measure it making its importance highly dependent on the definition of animal welfare in the study. Zanoli et al. (2013), looked at whether the cattle were ”allowed

Which of the following three options of beef steak (500 grams) would you choose?

| | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| **Origin** | Produced outside the UK | Locally produced | |
| **Infection level (farm)** | 0% herd infected by BVD | 30% herd infected by BVD | NONE: I wouldn't buy any of these. |
| **Animal welfare** | C<br>LOW | A<br>HIGH | |
| **Price** | £14 | £14 | |

Figure 4.1: An example choice card for beef

to range freely or were they confined and chained?" as their proxy for animal welfare and found that animal welfare did play a role in influencing consumers when making organic meat purchases. This study, however, did not use a representative sample. Caracciolo et al. (2010) showed that generally consumers, in Europe, seem to take account of animal welfare attribute more than other intrinsic product characteristics. Van Osch et al. (2017) used eco-labels to indicate sustainability levels in their study on Irish consumers' willingness to pay[3]. We steered clear of ambiguous labels that are linked to various production methods like organic, animal welfare and consumer health as Pouta et al.(2010) showed labels may offset the impact of the production method.

4. Herd/flock infection level – This attribute specifies the prevalence rates for BVD or lameness in the herd/flock that the product comes from. The levels were determined based on a survey conducted by the FIELD team on farmers in the North of the UK as well as literature.

---

[3] This paper was the source of inspiration for the welfare gradings used in my study.

Table 4.1: Attributes and their levels in the choice experiment

| Attributes | Description | Levels | |
|---|---|---|---|
| **Price** | Beef steak (fillet) | £11, £14, £17 | 500 grams i.e., 2 steaks |
| | Milk | £0.40, £0.90, £1.40 | 1 litre = 1.75 pints |
| | Lamb chops | £4.50, £7.50, £10.50 | 500 grams |
| | Wool (pure) | £7, £9, £11 | 100 grams |
| **Animal welfare (Grading)** | High | A | |
| | Medium | B | |
| | Low | C | |
| **Infection level in the herd** | Beef steak | 0%, 10%, 20%, 30% | BVD |
| | Milk | 0%, 10%, 20%, 30% | BVD |
| **Infection level in the flock** | Lamb chops | 0%, 10%, 20%, 30% | Lameness |
| | Wool (pure) | 0%, 10%, 20%, 30% | Lameness |
| **Origin** | | Locally produced | < 50 miles from shop |
| | | Produced elsewhere in the UK | |
| | | Produced outside the UK | |

Categorical choice attributes were dummy coded, with the base levels indicated in italics in table 4.1. The opt out alternative i.e. don't want to buy either was also dummy coded which meant that rejecting the products as presented in the two other alternatives would gives us the relative utility.

The other components of the survey included socio-demographics. Table 4.2 summarises the demographic characteristics of our sample and compares them to the UK population as a whole. It is worth noting here that the UK population census was last conducted nearly 10 years ago so we expect variations in the statistics in regards to socio-demographic characteristics. Table A1 in the appendix includes the demographics for the lamb, wool and milk samples. Overall, our sample is representative of the UK population. Men made up 47% of the sample. The age distribution matched that of the UK except for consumers over 55 years where our sample had 31% compared to the UK population of 37%. The average family size was 3 persons. The median education level is A-levels or equivalent with the modal education level being an undergraduate degree[4]. Similarly, I report that the median monthly household (pre-tax) income in my sample was found to be between £2000- £2500, consistent with the observed annualised median income of £30,762 according to the ONS for 2019/20.

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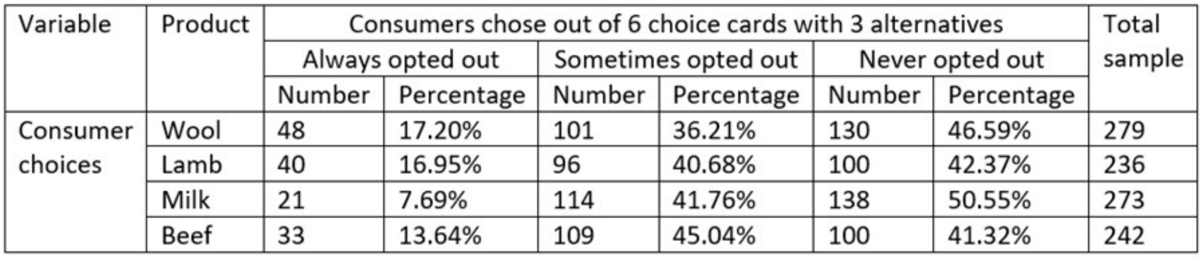
[4] The statistics for the UK population are from ONS (Office of National Statistics) and the UK 2011 census.

Table 4.2: Socio- demographic characteristics of the respondents

| **Variables** | **Sample (n = 515)** | **Beef (n = 242)** | **UK Population** |
|---|---|---|---|
| Share of males (%) | 0.47 | 0.54 | 0.49 |
| Average family size (*n*) | 2.67 | 2.67 | 2.3 |
| Age (years) (%) | | | |
| 18 – 24 | 0.12 | 0.13 | 0.11 |
| 25 - 34 | 0.18 | 0.13 | 0.17 |
| 35 - 44 | 0.17 | 0.17 | 0.16 |
| 45 - 54 | 0.20 | 0.22 | 0.19 |
| 55 and Over | 0.31 | 0.32 | 0.37 |
| Age (mean) | 45 years | 46 years | |
| Age (median) | 50 years | 50 years | 40 years |
| Age (mode) | 50 years | 50 years | |
| Education level | | | |
| Median | A-levels or advance GVNQ or equivalent | A-levels or advance GVNQ or equivalent | 41% adults have college degrees |
| Mode | Undergraduate degree | Undergraduate degree | |
| Income distribution (monthly after tax) | | | |
| Median | £2001 – £2500 | £2001 - £2500 | £1700 |
| Mode | £1001 - £1500 | £1001 - £1500 | |
| Covid19 impact on expected future earnings (%) | Yes = 0.32 No = 0.68 | Yes = 0.34 No = 0.66 | |

Table 4.3: Consumers distribution of the choices.



| Variable | Product | Consumers chose out of 6 choice cards with 3 alternatives | | | | | | Total sample |
|---|---|---|---|---|---|---|---|---|
| | | Always opted out | | Sometimes opted out | | Never opted out | | |
| | | Number | Percentage | Number | Percentage | Number | Percentage | |
| Consumer choices | Wool | 48 | 17.20% | 101 | 36.21% | 130 | 46.59% | 279 |
| | Lamb | 40 | 16.95% | 96 | 40.68% | 100 | 42.37% | 236 |
| | Milk | 21 | 7.69% | 114 | 41.76% | 138 | 50.55% | 273 |
| | Beef | 33 | 13.64% | 109 | 45.04% | 100 | 41.32% | 242 |

Table 4.3 provides a distribution of consumer choices to opting- out for each of the four products. In the case of beef, for example, 13.64% of the respondents always opted out, whereas 41.32% never opted- out. Similar trends can be seen in the table for the rest of the products. During model estimation, these observations remained as part of the sample and were not treated differently. The reason I left these observations in the sample was because respondents provided clear explanations for their choice to opt-out for example their preferences for only "grade A beef with 0 infection level".

### 4.3.2 Econometric estimation

It is presumed the respondent would choose the option that is likely to give them the highest utility. To account for heterogeneity in preferences I include a random component within utility, alongside observable components of choice such as the characteristics of products, and the socio-economic characteristics of people (Hensher, Rose and Greene, 2015).

The preferences I want to simulate have an ordinal characteristic in that they only provide us the relative ranking for the set of alternatives we model. The main focus in developing this model is to explore causes of heterogeneity in the respondents' observed and unobserved influences in decision making. In order to formalise choice situations, I then define a utility function with the aim to maximise utility.

Let $U_{isj}$ be the utility for individual $i$ in choice situation $s$ given alternative $j$. This utility is a sum of a deterministic i.e., observable component $V_{isj}$ that depends on the regressors, the unknown parameters $\beta$ and the unobserved random component $\varepsilon_{isj}$. This can be represented by a standard random utility expression based on Mcfadden, (1974):

$$U_{isj} = V_{isj} + \varepsilon_{isj}$$

We can go further and conclude that the probability of alternative j being selected is given by the following:

$$
\begin{aligned}
Pr_{isj} = \Pr(U_{isj} > U_{isk}) = \Pr(U_{isj} - U_{isk} > 0) \\
= \Pr((V_{isj} + \varepsilon_{isj} > V_{isk} + \varepsilon_{isk}, \forall k \neq j)
\end{aligned} \tag{4.1}
$$

Therefore,

$$
Pr_{isj} = \Pr(\varepsilon_{isj} - \varepsilon_{isk} > V_{isk} - V_{isj}), \qquad \forall k \neq j \tag{4.2}
$$

Meaning that the probability that the difference in the random components is less than the difference in the deterministic components. We can then claim that it is only the differences in the utility that really matter. Therefore the multinomial logit (MNL) model specification given by a linear specification with no preference heterogeneity is the observable component $V_{isj}$ which is an additive function of the attributes $x_{isj}$ that determine utility and the constant term.

$$
V_{isj} = \beta_i' x_{isj} + \alpha_j
$$

The random parameter logit (RPL) model has been developed as one method to allow for unobserved heterogeneity of preferences (Train, 2009). Preference heterogeneity in the sample is incorporated into the model by treating the coefficients as random rather than fixed allowing attribute coefficients to vary across respondents around their mean, thus improving the realism of the model and interacting consumer characteristics with the constant (opt-out) given that these do not vary across alternatives (Hanley et al., 2001). The random parameters model, or the mixed logit model relaxes the IIA assumption by allowing its parameters to be normally distributed. We also assume that these random parameter distributions are continuous over the sample. More than one parameter can be treated as random which contributes to the practicality of such models. Therefore, we find that the choice probabilities now depend on the random parameters.

We define the probability of choice as

$$
\Pr(y_{is} = j) = \frac{\exp\left(V_{isj}\right)}{\sum_{j=1}^{is} \exp\left(V_{isj}\right)}
$$

where,

$$
V_{isj} = \beta_i' x_{isj} + \alpha_j
$$

The model therefore takes the form:

$$
\beta_{ik} = \beta_k + \Delta_k z_i + \gamma \vartheta_{ik}
$$

$$\alpha_{ij} = \alpha_j + \Delta_j z_i + \gamma\vartheta_{ij}$$

$\alpha_j$ is the alternative specific constant, $x_{isj}$ are the $K$ attributes of alternative $j$ pertaining to individual $i$, in choice situation $s$, $z_i$ are the set $m$ characteristics of individual $i$, a vector of $k$ random variables, with mean zero, unit variance and zero covariance is given by $\vartheta_{ik}$- it is the individual specific heterogeneity of a taste parameter. Heterogeneity of choice specific constants, with normal distribution (with zero mean) is represented by $\vartheta_{ij}$ and $\beta_k$ is the k- attribute coefficients of the population mean where the individual-specific preference parameter $\beta$ and and the choice specific constants $\alpha$ vary around their means and are not fixed for all respondents. The parameter distributions of $\alpha_{ij}$ and $\beta_{ik}$ have means that are allowed to be heterogeneous with $z_i$ with weights $\delta_j$ and $\delta_k$ (Sheremet et al., 2017). All the dummy variables are assumed to be random and normally distributed as well as opt out and price (continuous) i.e. varying across individuals. Assuming fixed prices may imply that there are no distortions in the market and all individuals have the same preference for price but this may not reflect reality. Price preferences may vary considerably depending on brands, companies, where the product is bought from etc.

Using the coefficient from both models, we derive the willingness to pay (WTP) estimates as a ratio of the coefficients of the attribute variables and the price variable.

$$WTP_x = \frac{-\beta_x}{\beta_{price}}$$

This gives us the marginal values of the attribute levels from preferences elicited from each respondent. These estimates shed light on consumers utility for changes in attribute levels. Confidence intervals were estimated using the delta method and by non-parametric bootstrapping since we model price as a random variable (Hole, 2007).

Given MNL models limitations particularly of its assumption of independence from irrelevant alternatives (IIA), it is not uncommon to use alternative specifications like the latent class models also known as discrete-mixture logit model. The latent class model is a semi-parametric variant of the MNL model, in that it does not require making specific assumptions about the distributions of parameters across individuals. These models do not require assumptions in the distributions of parameters unlike the random parameter logit model. The premise is that there exists a finite number of groups X.

Latent Class Analysis (LCA) models are used to estimate class membership among respondents based on their willingness-to-pay as prescribed in chapter 3. Lazarsfeld and Henry (1968) proposed the LCA models identifying categorical latent classes measured by a number of observed response variables. The primary motive is to categorise individuals into classes using the observed variables, in turn find variables that best group these classes and understand them. The underlying theory posits that behaviour of individuals hinges on observable attributes and on latent heterogeneity that contrasts with elements that are unobserved. LCA helps us identify and better understand these unobserved sub-groups within choice data.

The groups may be individuals with different buying preferences, consumers with different patterns of behaviour, education status classifications, age and so on. The model posits that each respondent belongs to one of a set of mutually exclusive and exhaustive latent classes although the class membership functions are probabilistic.

The latent class model assumes there are $X$ distinct "classes" of individuals with the probability that individual $i$ belongs to class $x$ is given by

$$\pi_{ix}(\Psi) = \frac{\exp(z_i \cdot \psi_x)}{1 + \sum_{l=1}^{X-1} \exp(z_i \cdot \psi_l)}$$

where $z_i$ is a row vector of the individual $i$'s characteristics . $\psi_x$ is a column vector of membership model coefficients for class $x$, with $\psi_X$ normalised to 0 for identification.
Finally, $\Psi = (\psi_1, \psi_2, \ldots, \psi_{X-1})$ denotes a collection of the $X-1$ identified membership coefficient vectors (Yoo, 2020).

## 4.4 Results

### 4.4.1 Socio-demographics

This section reports the results of the analyses that were carried out for each of the four products using Multinomial Logit (MNL) and Random Parameter Logit (RPL) regressions with and without interactions with socioeconomic variables. Section 4.5 summarises the results from the latent class approach also used to elicit preferences.

The results from the MNL and RPL models are reported in tables 4.4 and 4.5 for beef. Note throughout the chapter, the sign of the estimated standard deviations for the RPL models is irrelevant. Results for the other products can be found in the appendix and are largely qualitatively similar to the beef results. I started with the multinomial logit model in order to get an overall idea of the effects of the attributes and their respective magnitudes. When the marginal utilities are positive, we can conclude that there is an increase in utility relative to the base level, making purchase of the product more probable. I start with the multinomial logit model for its simplicity as it will allows me to interpret the resulting choice probabilities and elasticities.

All my attribute coefficients for beef were found to be statistically significant. Using a sample of $n = 242$ respondents I estimated multinomial logit models as presented in table 4.4. These indicate that any increase in the animal welfare is preferred by the respondents relative to the lower welfare alternative. Relative to low welfare (grade C), the estimates show positive and statistically significant effect on the UK consumers utility for increases in animal welfare. An increase in animal welfare from grade C (low welfare) to grade B (medium welfare) has a positive coefficient with the magnitude rising further as the grade goes up to A (high welfare).

When it comes to the origin of the product, consumers showed a strong preference for beef products produced within the UK compared to the base level of beef produced outside the UK. This result was even stronger for locally produced beef than for beef that originated within the UK but greater than 50 miles from their place of purchase indicating a strong preference for close proximity of production.

The attribute for BVD infection level was also found to be statistically significant and negatively increased in magnitude given that the base level was zero infection rate indicating that consumers preferred the beef product coming from farms with a lower prevalence of infection, given a constant rating of farm animal welfare. As a reminder to readers, BVD infection rate has no consequence to food safety of the product, hence, consumers placing importance to this attribute makes it significant and particularly interesting result.

The negative parameter estimate for monetary attribute price was in line with consumer theory. Unsurprisingly, higher price of beef yielded lower utility which is expected: higher costs decrease the likelihood of purchasing a product.

The alternative specific constant represents the opt out option where consumers have the option to choose purchasing neither of the products offered. This parameter was found to be negative and statistically significant indicating that people in the sample on average preferred to not opt out of the purchase.

The model includes demographic variables interacted [5] with the opt out option including place of residence, country of residence, age, income, education, gender, family size, number of children under the age of 18 and any expected changes in future income due to Covid- 19. Interacting these variables with status quo tells us how the likelihood of choosing the opt out option varies with a specific demographic. The model suggests that male respondents are more likely to purchase beef steak as presented in the choice experiment. Similarly, respondents with higher education level and higher income[6] choose making a purchase instead of opting out. Older respondents are more likely to opt out of buying. This result could be attributed to fact that as you grow older (usually above 50 years of age) your income tends to reduce therefore the older respondents appear unwilling to adjust their present consumption level to ensure high FAHW. Number of kids underage, family size and residency were found to be statistically insignificant. According to Duffy et al. (2005) urban consumers frequently feel disconnected from the food production process and are becoming more critical of contemporary agriculture. The results from my study show that urban consumers are more likely to opt out of purchasing beef from the presented scenarios than those living in rural or urban with significantly rural areas, however, this result was not statistically significant.

---

[5] Final model estimations are included after the following selection procedure. The interactions were added one at a time separately to the models. I did this in order to avoid multi-collinearity among the observed variables. Likelihood ratio test was applied as a criterion for selection.

[6] Income here refers to average income as I believed average income would give a better indication of wealth distribution

Table 4.4: Estimation results for Multinomial Logit Model with attribute level-dummy variable-Beef

| **Beef**<br>Variable | Coefficient |
|---|---|
| Opt-out | -2.084*** |
| | (0.474) |
| *Price* | -0.101*** |
| | (0.0142) |
| *Animal Welfare (Base level = Low)* | |
| High Welfare = 1 | 0.834*** |
| | (0.109) |
| Medium Welfare = 1 | 0.513*** |
| | (0.121) |
| *Origin (Base level = Produced outside the UK* | |
| Locally Produced = 1 | 0.663*** |
| | (0.107) |
| Produced elsewhere in the UK = 1 | 0.201* |
| | (0.112) |
| *Infection level (Base level = 0%)* | |
| 10% infection in the herd | -0.879*** |
| | (0.112) |
| 20% infection in the herd | -1.146*** |
| | (0.132) |
| 30% infection in the herd | -1.598*** |
| | (0.117) |
| **Interactions with Opt-Out alternative** | |
| Age | 0.0223*** |
| | (0.00401) |
| Income (average per household) | -0.000209** |
| | (9.61e-05) |
| Education | -0.121* |
| | (0.0662) |
| Male | -0.208* |
| | (0.122) |
| *Type of residences (Base level = Urban with significant rural)* | |
| Urban residents | 0.224 |
| | (0.166) |
| Rural residents | -0.119 |
| | (0.188) |
| Number of children below 18 years | -0.189** |
| | (0.0843) |
| Change in expected future income | -0.0206 |
| | (0.129) |
| England | 0.0777 |
| | (0.316) |
| N. Ireland | -0.505 |
| | (0.629) |
| Scotland | 0.110 |
| | (0.385) |
| **Information criteria** | |
| Number of observations | 4,356 |
| Number of respondents n | 242 |
| Log-likelihood | -1395 |
| AIC | 2830.025 |
| BIC | 2957.612 |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Next, I conduct a Hausman-McFadden (1984) specification test to examine whether the IIA assumption holds. The test statistic is given by $H = (b_r - b_f)'[v_r - v_f]^{-1}(b_r - b_f)$ where b is a column vector of parameter estimates and v is the variance- covariance matrix. I start by estimating the full model “f” with all J alternatives and then estimating the restricted “r” model by removing the ‘irrelevant alternative’. The test statistic follows a $\chi^2$ distribution with the degrees of freedom equal to the number of estimated parameters.

Table 4.5: Hausman test for IIA axiom

| **Multinomial Logit model** | | |
|---|---|---|
| Excluding alternative 3 | $\chi^2$(9 degrees of freedom) = 63.34 | Prob > $\chi^2$ = 0.0000 |
| Excluding alternative 2 | $\chi^2$(9 degrees of freedom) = 9.68 | Prob > $\chi^2$ = 0.3721 |
| Excluding alternative 1 | $\chi^2$(9 degrees of freedom) = 7.46 | Prob > $\chi^2$ = 0.5892 |

Table 4.5 shows the findings of the Hausman test statistic, which compares coefficient estimates after one of the alternative choices is removed. I examine the null hypothesis, which states that the difference in coefficients is not statistically significant. From the output of the Hausman test it can be inferred that excluding alternative 3 leads to the violation of the IIA assumption as the test value is higher than the critical value of 16.92. Therefore, since the Hausman statistic is large and statistically significant at 5% significance level, the null hypothesis has to be rejected. Dropping alternative 1 or 2 on the other hand, it can be seen that there is no evidence of the IIA assumption being violated.

Table 4.6: The results of the random parameter logit (RPL) model

| | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| | β (SE) | Standard deviation | β (SE) | Standard deviations | β (SE) | Standard deviations | β (SE) | Standard deviations |
| Random parameters | | | | | | | | |
| *Opt-out* | -5.070*** | 4.838*** | -6.288*** | 4.762*** | -5.331*** | 4.206*** | -8.661*** | 5.618*** |
| | (0.618) | (0.597) | (2.275) | (0.729) | (0.651) | (0.521) | (2.212) | (0.840) |
| *Price* | -0.269*** | 0.190*** | -0.281*** | 0.233*** | -0.108 | 0.229*** | -0.282*** | 0.254*** |
| | (0.036) | (0.040) | (0.0370) | (0.0411) | (0.0676) | (0.0315) | (0.0962) | (0.0386) |
| *Animal Welfare (Base level = Low)* | | | | | | | | |
| High Welfare = 1 | 1.992*** | 2.248*** | 1.908*** | 2.019*** | 3.099*** | 2.167*** | 3.877*** | 2.166*** |
| | (0.295) | (0.302) | (0.297) | (0.321) | (0.756) | (0.307) | (0.849) | (0.297) |
| Medium Welfare = 1 | 1.295*** | -1.202*** | 1.158*** | 0.931** | 1.442** | -1.067*** | 2.046*** | 1.118*** |
| | (0.252) | (0.394) | (0.235) | (0.415) | (0.645) | (0.357) | (0.735) | (0.396) |
| *Origin (Base level = Produced outside the UK* | | | | | | | | |
| Locally Produced = 1 | 1.442*** | 0.035 | 1.391*** | 0.0488 | 1.399** | 0.635* | 1.176* | 0.279 |
| | (0.239) | (0.905) | (0.243) | (0.413) | (0.623) | (0.351) | (0.665) | (0.466) |
| Produced elsewhere in the UK = 1 | 0.835*** | 1.498*** | 0.803*** | 1.610*** | 0.808 | 1.251*** | 1.012 | 1.518*** |
| | (0.266) | (0.394) | (0.285) | (0.407) | (0.693) | (0.366) | (0.783) | (0.372) |
| *Infection level (Base level = 0%)* | | | | | | | | |
| 10% infection in the herd | -2.059*** | 0.740** | -1.956*** | -0.662* | -1.701*** | -0.661* | -2.226*** | -0.878** |
| | (0.260) | (0.332) | (0.243) | (0.380) | (0.592) | (0.382) | (0.665) | (0.346) |
| 20% infection in the herd | -2.697*** | 1.823*** | -2.512*** | 1.460*** | -1.776** | 1.411*** | -2.829*** | -1.665*** |
| | (0.383) | (0.451) | (0.340) | (0.460) | (0.777) | (0.471) | (0.923) | (0.404) |
| 30% infection in the herd | -3.876*** | 1.385*** | -3.576*** | 1.159*** | -2.921*** | 0.848** | -3.603*** | -1.418*** |
| | (0.433) | (0.366) | (0.372) | (0.350) | (0.690) | (0.419) | (0.811) | (0.409) |
| **Interactions with Age** | | | | | | | | |
| Age*locally produced | | | | | -0.00001 | | 0.00848 | |
| | | | | | (0.0120) | | (0.0129) | |
| Age*produced elsewhere in the UK | | | | | 0.00127 | | 0.00118 | |
| | | | | | (0.0140) | | (0.0157) | |
| Age*high welfare | | | | | -0.0280* | | -0.0395** | |
| | | | | | (0.0145) | | (0.0162) | |
| Age*medium welfare | | | | | -0.00607 | | -0.0170 | |
| | | | | | (0.0132) | | (0.0146) | |
| Age*10% infection in the herd | | | | | -0.00493 | | 0.00330 | |
| | | | | | (0.0117) | | (0.0130) | |
| Age*20% infection in the herd | | | | | -0.0157 | | 0.00448 | |
| | | | | | (0.0158) | | (0.0181) | |
| Age*30% infection in the herd | | | | | -0.0128 | | -0.00667 | |
| | | | | | (0.0134) | | (0.0155) | |
| Age*price | | | | | -0.00360*** | | -0.000220 | |
| | | | | | (0.00135) | | (0.00197) | |
| **Interactions with Opt-Out alternative** | | | | | | | | |
| Age | | | 0.0544** | | | | 0.0434 | |
| | | | (0.0247) | | | | (0.0342) | |
| Income (average per household) | | | -0.00117 | | | | -0.000579 | |
| | | | (0.000729) | | | | (0.000433) | |
| Male | | | -0.865 | | | | -0.657 | |
| | | | (0.732) | | | | (0.652) | |
| Education | | | -0.318 | | | | -0.251 | |
| | | | (0.315) | | | | (0.319) | |
| *Type of residences (Base level = Urban with significant rural)* | | | | | | | | |
| Urban residents | | | -0.470 | | | | -0.417 | |
| | | | (1.222) | | | | (0.894) | |
| Rural residents | | | -0.0746 | | | | -0.383 | |
| | | | (0.904) | | | | (1.075) | |
| Number of children below 18 years | | | -0.767 | | | | -1.450*** | |
| | | | (0.541) | | | | (0.477) | |
| Change in expected future income | | | 0.248 | | | | -0.0466 | |
| | | | (1.375) | | | | (0.670) | |
| England | | | 1.483 | | | | 3.413** | |
| N. Ireland | | | (1.965) | | | | (1.463) | |
| | | | -2.076 | | | | -0.108 | |
| Scotland | | | (3.048) | | | | (2.566) | |
| | | | 0.260 | | | | 2.681 | |
| **Information criteria** | | | (2.408) | | | | (1.653) | |
| Number of observations | 4,356 | | 4,356 | | 4,356 | | 4,356 | |
| Number of respondents | 242 | | 242 | | 242 | | 242 | |
| Log-likelihood | -1103 | | -1099 | | -1101 | | -1087 | |
| AIC | 2242.165 | | 2255.604 | | 2254.808 | | 2247.525 | |
| BIC | 2356.992 | | 2440.604 | | 2420.67 | | 2483.559 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.6 lists the results of the random parameter logit (RPL) model. RPL models allow us to accommodate unobserved preference heterogeneity by letting parameters vary randomly over individuals on the assumption that there exists some continuous distribution (Hensher and Greene, 2003). Estimated coefficients were assumed to follow a normal distribution (Louviere et al., 2010). Following Garrido (2003), I relied on Sobol sequences with 1000 draws. This approach has been used widely in the discrete choice modelling literature as it overcomes the main problems of Halton sequences. Models 2, 3 and 4 are presented as a contrast to the main effects base model (i.e. model 1). These models capture the effects of socio-demographic characteristics on preference formation. All the attributes were specified as having a random component. All attribute variables were found to be statistically significant showing a similar pattern to the models specified in the multinomial logit model showing clear preferences. Price, opt out and high infection rates showed negative preferences whilst beef from within the UK and more specifically locally produced beef was found to have a positive preference. Preferences for animal welfare were positive and increased from grade C to A, that is from low to high animal welfare, indicating that high welfare was important to consumers when determining which product to buy.

The estimated standard deviations for the attribute variables were all found to be statistically significant with exceptions of locally produced attribute in specifications (1), (2) and (4). This suggests that there is statistically significant individual heterogeneity in attitudes towards purchasing beef. The preferences for origin, animal welfare and infection level vary significantly across the population. The heterogeneity in infection level is reduced when the UK demographic features are taken into account in models (3) and (4), but the random taste variation persists in other attributes. Respondents that were male and those with high income we were less likely to choose the opt out option, whereas older consumers were less likely to choose purchasing beef given the presented options. We also find that respondents who had a higher number of children under the age of 18 preferred making the purchases as presented. Younger consumers appear willing to pay more for beef that ensures higher welfare standards. These consumers are willing to accept the increased cost (higher prices) necessary to ensure high FAHW despite the fact that it may result in a decrease in demand.

To compare model fit I looked at the Akaike Information Criteria (AIC), Bayesian Information Criterion (BIC) and the log-likelihood for each of the models. The AIC and BIC for RPL models (2242 and 2356 respectively) are lower than for the MNL model (2830 and 2957, respectively). As for the log-likelihood the RPL models ( -1103) have higher log-likelihood than the MNL models (-1395). All three of the information criteria indicate the RPL models are preferred over the MNL models. Since the estimated standard deviations are statistically significant, we can conclude that there exists statistically significant unobserved heterogeneity in preferences.

### 4.4.2 Willingness to pay

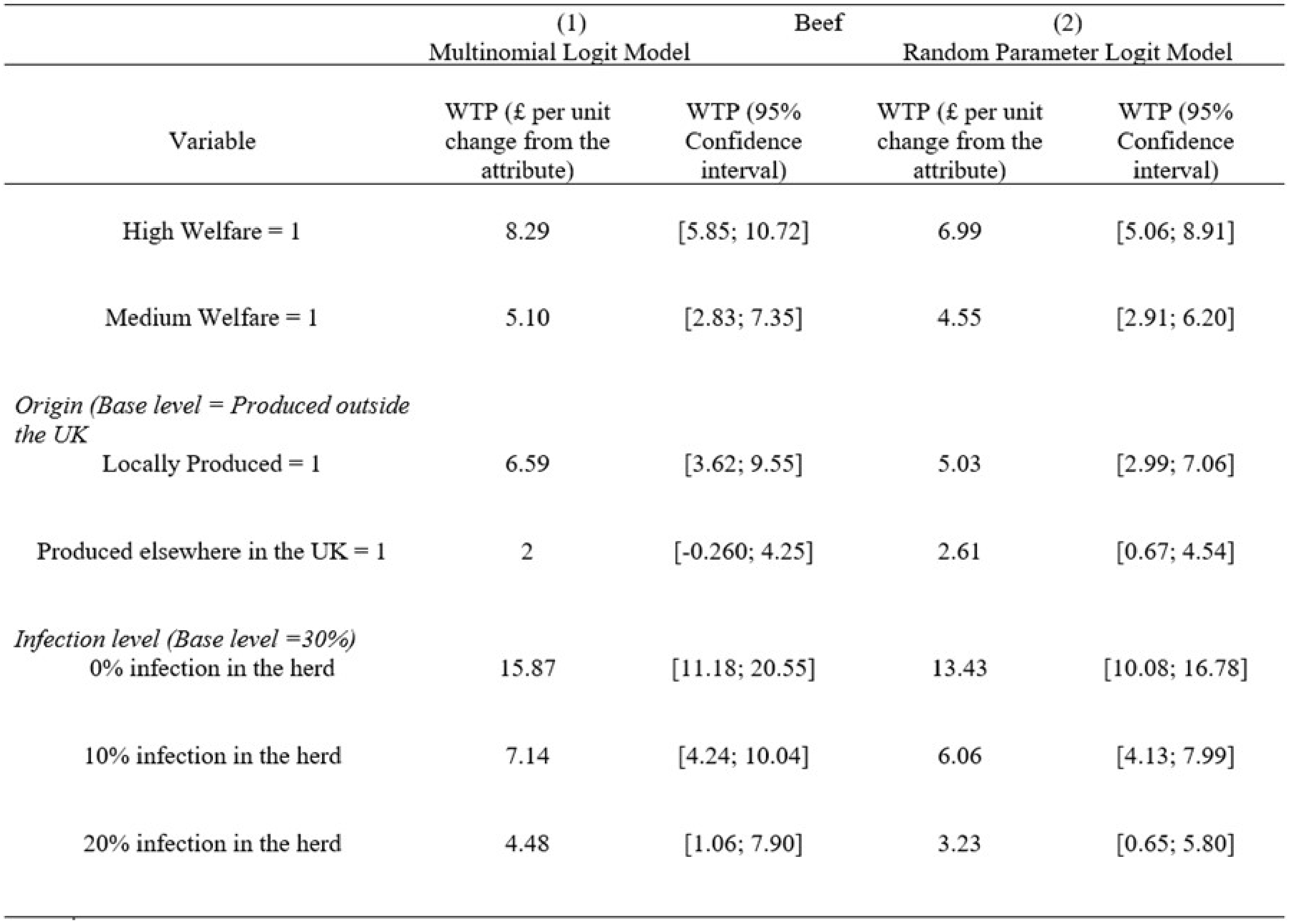
Next, I calculated the marginal willingness to pay (WTP) for discrete changes in the levels of each attribute. Results are shown in Table 4.7 and are also statistically significant in the 95% confidence interval. Given the attribute level dummies, the WTP in this case can be interpreted as the value of change from the base attribute level to an alternative level. The table includes the confidence intervals for WTP estimates for the Multinomial logit model (1) and the random parameter logit model (2) model, using the delta method. Both models have coefficients similar in size and sign.

An increase in animal welfare level leads to an increase in the marginal WTP by £5.10 for medium welfare product and £8.29 for high welfare product per 500 grams in the multinomial logit model. Whilst in the random parameter logit model, WTP estimates indicate that the UK consumer has a WTP of £4.64 per 500 grams for a medium welfare beed steak and £6.98 per 500 grams for high welfare beef steak. Both models indicate consumers are willing to pay the most for beef with 0% infection in the herd. A high value £15.87 per 500 grams was found for beef coming from farms with no infection at all according to model (1) and £13.44 per 500 grams according to model (2).

The WTP decreases as the prevalence of infection in the herd increases. Beef from farms with 10% infection in their herd had marginal WTP of £7.14 per 500 grams in model (1) and model (2) estimated this value as £5.81 per 500 grams. On the other hand, farms with 20% prevalence of infection in model (1) had values at £4.48 while model (2) estimated these to be £3.50 per 500 grams. The WTP for beef produced elsewhere in the UK is at the lower end of the range of WTP for both models. Generally, both models show comparable results given that their confidence intervals overlap in all attributes. The willingness to pay across all products is reported in table 4.8 this time using a non-parametric bootstrapping procedure. By comparing the results in table 4.7 and table 4.8 for beef, it is evident that the choice of the estimation method yield marginal discrepancies in the WTP. For reduced levels of disease in both sheep and cattle products the WTP is found to be higher, and this holds even for goods that are not classified as "food products" (i.e. wool). Locally produced items are preferable over those made elsewhere in the UK when it comes to the place of origin. For instance, the marignal WTP for beef that is locally produced was £5.04 where as beef produced elsewhere has marginal WTP of £3.04

In Table 4.9, I report the proportion of positive preference for attributes assuming a normal distribution for random parameters. I calculate the proportion of respondents for whom a beef attribute has a positive effect on preference for purchasing that product. It seems that every responded in our sample prefers consuming locally sourced beef.

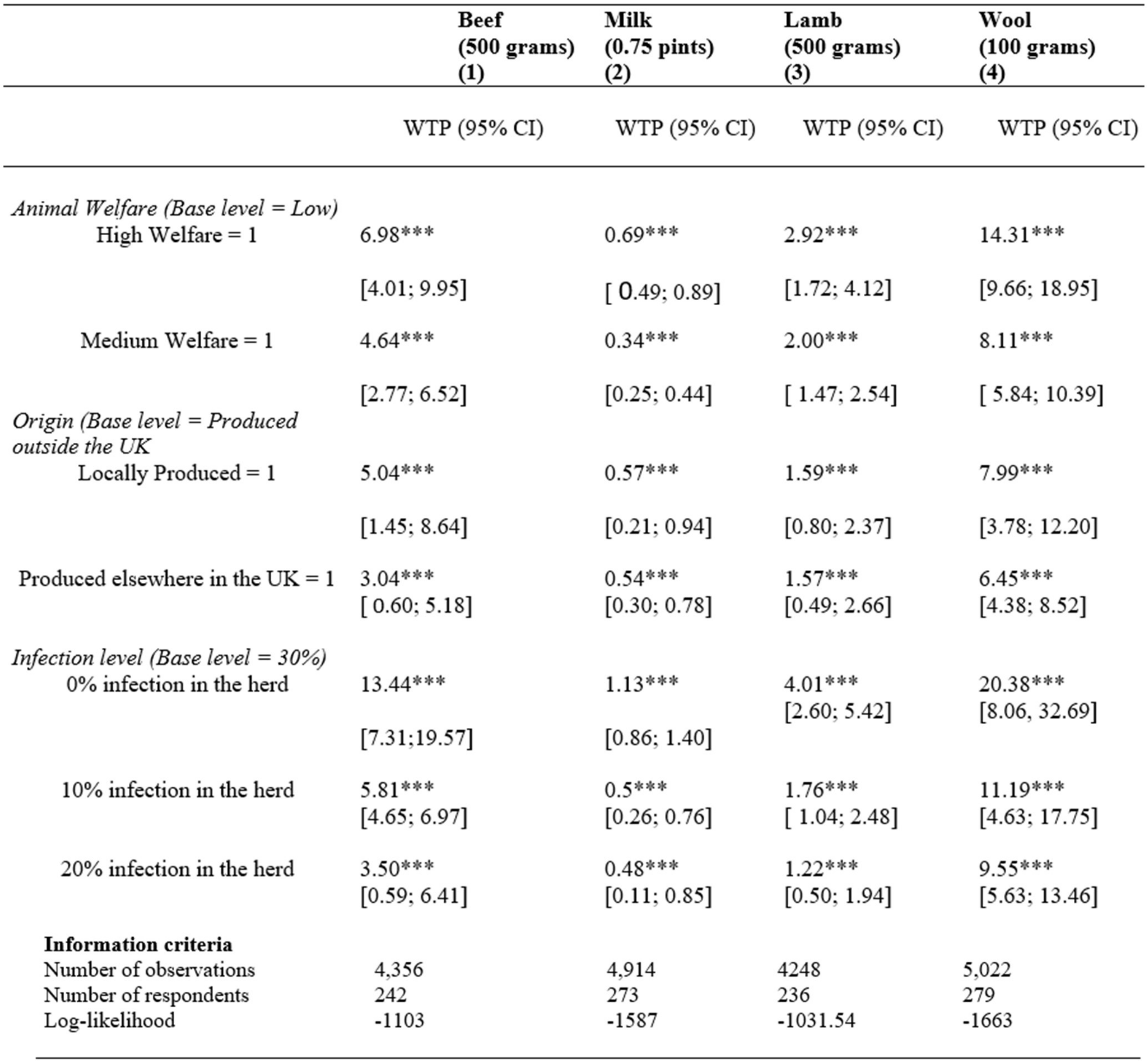
Table 4.7: Willingness-to-pay estimates: Beef



| | (1) Multinomial Logit Model | Beef | (2) Random Parameter Logit Model | |
|---|---|---|---|---|
| Variable | WTP (£ per unit change from the attribute) | WTP (95% Confidence interval) | WTP (£ per unit change from the attribute) | WTP (95% Confidence interval) |
| High Welfare = 1 | 8.29 | [5.85; 10.72] | 6.99 | [5.06; 8.91] |
| Medium Welfare = 1 | 5.10 | [2.83; 7.35] | 4.55 | [2.91; 6.20] |
| *Origin (Base level = Produced outside the UK* | | | | |
| Locally Produced = 1 | 6.59 | [3.62; 9.55] | 5.03 | [2.99; 7.06] |
| Produced elsewhere in the UK = 1 | 2 | [-0.260; 4.25] | 2.61 | [0.67; 4.54] |
| *Infection level (Base level =30%)* | | | | |
| 0% infection in the herd | 15.87 | [11.18; 20.55] | 13.43 | [10.08; 16.78] |
| 10% infection in the herd | 7.14 | [4.24; 10.04] | 6.06 | [4.13; 7.99] |
| 20% infection in the herd | 4.48 | [1.06; 7.90] | 3.23 | [0.65; 5.80] |

Note values are rounded to two decimal places.

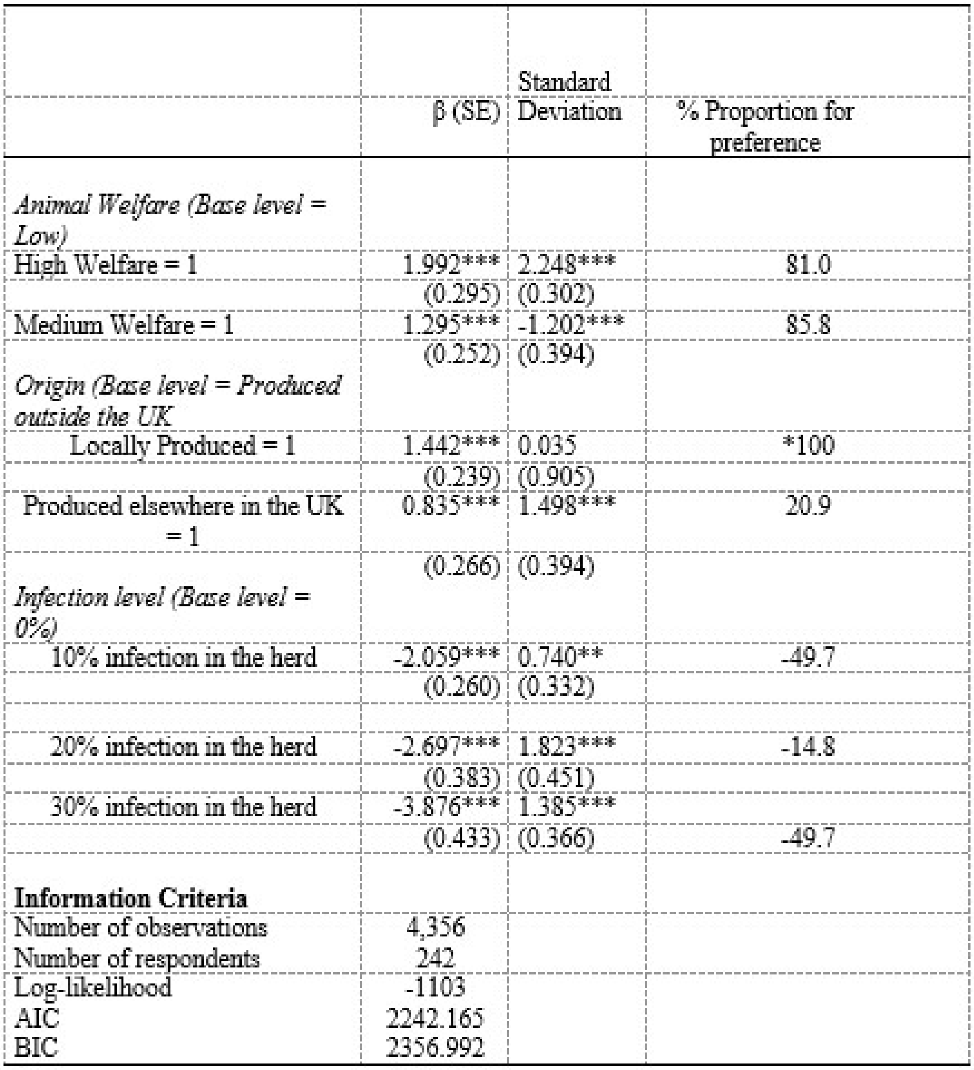
Table 4.8: Willingness to pay estimates across all products



| | **Beef (500 grams) (1)** | **Milk (0.75 pints) (2)** | **Lamb (500 grams) (3)** | **Wool (100 grams) (4)** |
|---|---|---|---|---|
| | WTP (95% CI) | WTP (95% CI) | WTP (95% CI) | WTP (95% CI) |
| *Animal Welfare (Base level = Low)* | | | | |
| High Welfare = 1 | 6.98*** | 0.69*** | 2.92*** | 14.31*** |
| | [4.01; 9.95] | [ 0.49; 0.89] | [1.72; 4.12] | [9.66; 18.95] |
| Medium Welfare = 1 | 4.64*** | 0.34*** | 2.00*** | 8.11*** |
| | [2.77; 6.52] | [0.25; 0.44] | [ 1.47; 2.54] | [ 5.84; 10.39] |
| *Origin (Base level = Produced outside the UK* | | | | |
| Locally Produced = 1 | 5.04*** | 0.57*** | 1.59*** | 7.99*** |
| | [1.45; 8.64] | [0.21; 0.94] | [0.80; 2.37] | [3.78; 12.20] |
| Produced elsewhere in the UK = 1 | 3.04*** | 0.54*** | 1.57*** | 6.45*** |
| | [ 0.60; 5.18] | [0.30; 0.78] | [0.49; 2.66] | [4.38; 8.52] |
| *Infection level (Base level = 30%)* | | | | |
| 0% infection in the herd | 13.44*** | 1.13*** | 4.01*** | 20.38*** |
| | | | [2.60; 5.42] | [8.06, 32.69] |
| | [7.31;19.57] | [0.86; 1.40] | | |
| 10% infection in the herd | 5.81*** | 0.5*** | 1.76*** | 11.19*** |
| | [4.65; 6.97] | [0.26; 0.76] | [ 1.04; 2.48] | [4.63; 17.75] |
| 20% infection in the herd | 3.50*** | 0.48*** | 1.22*** | 9.55*** |
| | [0.59; 6.41] | [0.11; 0.85] | [0.50; 1.94] | [5.63; 13.46] |
| **Information criteria** | | | | |
| Number of observations | 4,356 | 4,914 | 4248 | 5,022 |
| Number of respondents | 242 | 273 | 236 | 279 |
| Log-likelihood | -1103 | -1587 | -1031.54 | -1663 |

Note values are rounded to two decimal places. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 4.9: Random Parameter Logit model and standard deviations with calculated proportions of positive preference for beef attributes



| | β (SE) | Standard Deviation | % Proportion for preference |
|---|---|---|---|
| *Animal Welfare (Base level = Low)* | | | |
| High Welfare = 1 | 1.992*** | 2.248*** | 81.0 |
| | (0.295) | (0.302) | |
| Medium Welfare = 1 | 1.295*** | -1.202*** | 85.8 |
| | (0.252) | (0.394) | |
| *Origin (Base level = Produced outside the UK* | | | |
| Locally Produced = 1 | 1.442*** | 0.035 | *100 |
| | (0.239) | (0.905) | |
| Produced elsewhere in the UK = 1 | 0.835*** | 1.498*** | 20.9 |
| | (0.266) | (0.394) | |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd | -2.059*** | 0.740** | -49.7 |
| | (0.260) | (0.332) | |
| | | | |
| 20% infection in the herd | -2.697*** | 1.823*** | -14.8 |
| | (0.383) | (0.451) | |
| 30% infection in the herd | -3.876*** | 1.385*** | |
| | (0.433) | (0.366) | -49.7 |
| **Information Criteria** | | | |
| Number of observations | 4,356 | | |
| Number of respondents | 242 | | |
| Log-likelihood | -1103 | | |
| AIC | 2242.165 | | |
| BIC | 2356.992 | | |

Note: Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance

## 4.5 Consumers' preferences for product attributes: A latent class variable approach

In section 4.4.1 we confirmed the presence of unobserved heterogeneity in preferences. These latent sources of preference heterogeneity could stem from many different sources which means that there is a need to study the underlying causes of heterogeneity. In this section I account for the presence of heterogeneity through a latent class approach. I do this to deepen our comprehension of the underlying causes that could explain the disparity in consumer preference across attributes that we saw in the previous section. In the following sub-sections, I discuss the results with and without class membership where membership refers to socio-economic characteristics.

### 4.5.1 Results Without Class membership

The optimal number of latent classes selection for each product was decided using the Consistent Akaike Information Criterion (CAIC) and Bayesian Information Criterion (BIC) criterion. More specifically, it was found optimal to include for beef, and wool four (latent) classes, three classes for Lamb and five classes for milk. The table containing this information can be seen in Appendix A5. I do not rely on AIC criterion since studies have found that it favours the inclusion of more classes compared to BIC. However, the convergence of models with more classes is found to be extremely sensitive to the seed used for the estimation and is being questioned on the basis that their log-likelihood functions may not be concave at the supposed maximum (Oviedo and Yoo, 2017).

Table 4.10 presents the results from latent class model for beef and milk with four and five classes respectively. Beginning with beef we find class membership is approximately evenly distributed with classes 2 and 3 (31 percent) having the highest respondents assigned to them whilst the other two classes have smaller samples (14 percent for class 1 and 24 percent for class 4).

Consumers belonging to class 1 (14 percent membership) appear to not have a strong inclination towards any of the attributes including price. High welfare is statistically significant at 90% significance level and medium welfare at 95%. Price and product origin hold no importance. This is the "altruistic" class. For class 2, one of the biggest classes strongly prefer lower prices and lower infection levels. I call these "individualistic" class because they value cost minimisation over animal welfare improvements. However they still show concern regarding FAH. Class 3, on the other hand, much like class 2 is also one of the biggest classes appearing in my sample. This is the "economical FAHW-aware regionalist" class where lower prices, high welfare, low infection level and locally produced products are strongly preferred. And lastly, class 4 with 24% membership, the "FAHW-aware nationalist" class, deem higher welfare, lower infection levels and origin (as long as the product comes from within the UK whether locally produced or elsewhere) the most important.

Table 4.10: Latent class model parameters and class shares for UK consumers (beef and milk)

**Beef**
**n = 242**

| **Variable** | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | |
|---|---|---|---|---|---|---|---|---|
| Price | 0.028 | (0.12) | -0.339*** | (0.05) | -0.201*** | (0.06) | -0.012 | (0.08) |
| High welfare | 1.37* | (0.74) | -0.045 | (0.27) | 2.164*** | (0.42) | 3.396*** | (0.53) |
| Medium welfare | 1.705** | (0.86) | 0.334 | (0.23) | 0.773 | (0.51) | 1.408*** | (0.40) |
| Local | 13.767 | (253.43) | 0.468* | (0.25) | 1.381*** | (0.35) | 1.834*** | (0.50) |
| Elsewhere | 15.118 | (253.43) | -0.111 | (0.32) | 0.437 | (0.40) | 1.4** | (0.62) |
| 0% Infection | 16.881 | (253.43) | 1.13*** | (0.26) | 2.525*** | (0.46) | 3.318*** | (0.57) |
| 10% Infection | 0.976 | (0.62) | 1.215*** | (0.27) | 1.323*** | (0.46) | 1.874*** | (0.51) |
| 20% Infection | 1.297 | (0.86) | 0.648* | (0.35) | 1.013** | (0.49) | 1.671** | (0.78) |
| Opt-out | 17.32 | (253.47) | -5.97*** | (0.71) | 2.64*** | (0.93) | 2.26 | (1.56) |
| **Class share** | **0.14** | | **0.31** | | **0.31** | | **0.24** | |

**Milk**
**n = 273**

| **Variable** | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | | **Class 5** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Price | -33.45 | (227.17) | -0.56* | (0.29) | -0.28 | (0.42) | -1.199*** | (0.35) | 1.138* | (0.65) |
| High welfare | 14.52 | (113.59) | 0.93*** | (0.30) | 4*** | (0.83) | 0.805* | (0.46) | -0.856 | (0.57) |
| Medium welfare | 0.59 | (2.69) | 0.19 | (0.33) | 2.12*** | (0.68) | 0.748* | (0.41) | -1.205** | (0.57) |
| Local | -0.29 | (2.16) | 1.02*** | (0.27) | 0.64 | (0.52) | 2.33*** | (0.38) | 0.372 | (0.49) |
| Elsewhere | -1.12 | (1.95) | 0.32 | (0.31) | 0.62 | (0.52) | 1.649*** | (0.37) | 0.571 | (0.56) |
| 0% Infection | 15.14 | (113.58) | 3.65*** | (0.53) | 1.5*** | (0.37) | 1.143*** | (0.33) | 3.533*** | (0.98) |
| 10% Infection | 0.18 | (1.10) | 1.52*** | (0.53) | 1.48*** | (0.47) | 0.008 | (0.38) | 3.704*** | (1.02) |
| 20% Infection | 13.61 | (113.60) | 1.29** | (0.58) | 0.59 | (0.76) | 0.581 | (0.54) | 2.565** | (1.17) |
| Opt-out | -32.14 | (204.46) | 3.94*** | (0.63) | 2.14 | (0.82) | -0.79 | (0.62) | 0.99 | (1.37) |
| **Class share** | **0.13** | | **0.28** | | **0.23** | | **0.23** | | **0.13** | |

+Note values are rounded to two decimal places. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Next, let us look at consumer preferences for milk with five classes. Class 1 (13 percent of respondents) shows that no attribute was considered important by members of this class. Class 2 is the largest class with 28 percent membership for milk. Consumers belonging to this class place higher weight on the following attributes: high animal welfare, locally produced and low infection levels. In fact it is the only class that given the choice scenarios presented to them, they are more likely to opt out of purchasing. Class 3 and class 4 are the second largest classes with each of them having 23 percent membership. In class 3, respondents show a clear preference for higher animal welfare. This is reflected in the magnitude's of the coefficients for both high and medium welfare which are the largest across all classes. This class also values low infection levels. Next, consumers belonging to class 4 show the strongest preference towards low prices and place of origin favouring local produced milk. And finally, in class 5 with 13 percent membership we observe that these respondents were primarily concerned with the infection levels in the herd.

The results for consumer choices for lamb chops and wool are presented in table 4.11. The latent class model for lamb chops has three classes. Class 1 (41 percent membership) with highest membership had no statistically significant attributes. In class 2 (39 percent membership), members exhibited strong preference for lower prices, lower infection rates and lamb chops produced locally and elsewhere in the UK. Class 3 with 20 percent class membership, we see that the respondents belonging to this class place the highest weight on lower prices and high animal welfare with 0% infection levels in the flock. Interestingly enough, they seem to prefer lamb chops produced outside the UK.

The latent class model for wool has four classes. Class 1 (30 percent membership), we see that consumers belonging to this class care the most about wool with low prices, high welfare, locally produced and coming from a flock with no more than 10% infection levels. Class 2 on the other hand, had no statistically significant attributes with 20 percent of the respondents belonging to this class. In class 3 with 13 percent membership, consumers only appear to be motivated by high welfare. And lastly, for class 4 with 37 percent membership, the largest class for wool, consumers in this class value low prices, locally produced wool with low infection levels in the flock.

Table 4.11: Latent class model parameters and class shares for UK consumers (lamb and wool)

**Lamb**

n = 236

| **Variable** | **Class 1** | | **Class 2** | | **Class 3** | |
|---|---|---|---|---|---|---|
| Price | -0.25 | (0.05) | -0.13*** | (0.03) | -6.28*** | (38.69) |
| High welfare | 1.02 | (0.33) | 1.90*** | (0.23) | 16.24*** | (116.07) |
| Medium welfare | 0.897 | (0.36) | 1.30*** | (0.23) | 15.36** | (116.07) |
| Local | 0.8 | (0.28) | 0.74*** | (0.20) | -14.52*** | (116.07) |
| Elsewhere | 0.41 | (0.28) | 0.56*** | (0.20) | 0.75 | (1.07) |
| 0% Infection | 2.09 | (0.31) | 1.39*** | (0.19) | 18.88*** | (116.07) |
| 10% Infection | 0.42 | (0.40) | 1.12*** | (0.20) | 0.66 | (0.86) |
| 20% Infection | 0.48 | (0.43) | 0.14 | (0.30) | 1.51 | (1.04) |
| Opt-out | 2.20 | (0.48) | -0.65 | (0.40) | -47.35 | (290.18) |
| **Class share** | **0.41** | | **0.39** | | **0.20** | |

**Wool**

n = 279

| Variable | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | |
|---|---|---|---|---|---|---|---|---|
| Price | -0.23*** | (0.08) | -0.07 | (0.25) | 0.38* | (0.21) | -0.24*** | (0.06) |
| High welfare | 3.67*** | (0.44) | -0.88 | (0.86) | 2.79*** | (0.86) | -0.19 | (0.25) |
| Medium welfare | 2.09*** | (0.41) | -1.56 | (1.15) | 0.77 | (0.76) | -0.07 | (0.23) |
| Local | 1.08*** | (0.31) | 1.35 | (0.84) | 1.43* | (0.77) | 0.72*** | (0.2) |
| Elsewhere | 0.51* | (0.3) | 0.59 | (1.07) | 0.85 | (0.88) | 0.36* | (0.21) |
| 0% Infection | 1.44*** | (0.32) | -0.09 | (1.18) | 16.31 | (285.28) | 0.94*** | (0.19) |
| 10% Infection | 1.43*** | (0.29) | 0.15 | (0.86) | 10.71 | (285.270) | 0.74*** | (0.22) |
| 20% Infection | 0.57 | (0.4) | -0.3 | (1.18) | 10.08 | (285.27) | 0.8*** | (0.31) |
| Opt-out | 0.86 | (0.84) | 3.31 | (2.78) | 19.71 | (285.32) | -5.13*** | (0.69) |
| **Class share** | **0.30** | | **0.20** | | **0.13** | | **0.37** | |

+Note values are rounded to two decimal places. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

I estimate the utility coefficient associated with the marginal utility (MU) of price using the pecuniary attribute price. Tables 4.12 and 4.13 display the implied WTP measures converted from the estimated utility coefficients for the four products. Price here is the cost of acquiring a specific alternative, in my case each alternative is a product with certain attributes. The marginal utility of price measures how much each person in that class is willing to pay for each of these attributes. The MU of price is the estimate on the cost attribute. It allows us to express the preference parameters for each non-monetary attribute in terms of WTP. The tables only present the WTP values for classes where the price attribute was found to be statistically significant at least at the 95% significance level. The estimates are presented in pounds sterling.

Starting with beef, only class 3 is associated with positive WTP estimates for higher welfare, locally produced beef coming from a herd with low infection levels. This class is willing to pay the highest price premiums to ensure high FAHW. Also from the magnitude of the WTP estimates for infection levels, we see that as the percentage of infected cattle in the herd reduces these consumers are willing to pay progressively more. Respondents belonging to this class were previously classified as the "economical FAHW aware regionalist" class. Still these respondents were found to have positive and statistically significant preference for opting out from purchasing beef as it was presented in the choice cards. On the other hand, for class 2 opt out was found to be negative thus indicating that these consumers were likely to buy beef the way it was presented in the experiment. Members of this class are WTP more only to ensure low disease levels in the herd.

Next for milk only in class 4, prices were found to be statistically significant. As such I calculated the WTP only for this class. Members of this class displayed positive WTP for UK produced milk with low infection levels in the herd. Lamb chops had two classes where price was found to be statistically significant. In class 1, I find that consumers are WTP more to ensure FAW but only for locally produced lamb with 0% infection level in the flock. In class 2 on the other hand, I observe the highest positive WTP coefficients for all statistically significant estimates i.e. high FAW, UK produced lamb chops with lower infection levels in the flock. Lastly, class 2 and class 4 for wool had statistically significant prices. In class 1, consumers were WTP more for high FAHW and locally produced wool. Whereas in class 4, consumers were WTP only for locally produced wool with low infection levels.

In order to look at my model's capability to make in-sample predictions of the actual choice outcomes I consider the results presented in table 4.14. As in Pacifico and Yoo (2013) and Yoo (2020), I begin by assigning my respondents to some particular class 'x' provided that this class gives them the highest posterior membership probability. Then, I predict the unconditional probability of actual choice and the conditional probability of actual choice, for each subgroup of respondent, provided that they belong to the aforementioned class. I find that the average unconditional choice probability is above 30 percent given I have 3 alternatives per choice scenario. In the case of conditional probability, I observe that it is above 55 percent in all products and their respective classes. This implies that the choice behaviour is explained very well by my models.

## Table 4.12: Marginal willingness-to-pay estimates for beef and milk

| Beef | | | | |
|---|---|---|---|---|
| **Variable** | **Class 1** | **Class 2** | **Class 3** | **Class 4** |
| High welfare | | -0.13 | 10.76*** | |
| | | (-1.70, 1.43) | *(3.93, 17.59)* | |
| Medium welfare | | 0.98 | 3.85 | |
| | | (-0.32, 2.29) | *(-0.41, 8.10)* | |
| Local | | 1.38* | 6.86*** | |
| | | *(-0.21, 2.97)* | *(1.59, 12.14)* | |
| Elsewhere | | -0.33 | 2.17 | |
| | | *(-2.21, 1.55)* | *(-1.48, 5.83)* | |
| 0% Infection | | 3.33*** | 12.55*** | |
| | | *(1.77, 4.88)* | *(3.12, 21.98)* | |
| 10% Infection | | 3.58*** | 6.57*** | |
| | | *(1.99, 5.16)* | *(0.87, 12.28)* | |
| 20% Infection | | 1.91* | 5.04** | |
| | | *(-0.17, 3.99)* | *(-0.38, 10.46)* | |

| Milk | | | | | |
|---|---|---|---|---|---|
| **Variable** | **Class 1** | **Class 2** | **Class 3** | **Class 4** | **Class 5** |
| High welfare | | | | 0.69* | |
| | | | | *(-0.02, 1.39)* | |
| Medium welfare | | | | 0.63* | |
| | | | | *(0.04, 1.22)* | |
| Local | | | | 1.94*** | |
| | | | | *(0.83, 3.06)* | |
| Elsewhere | | | | 1.38*** | |
| | | | | *(0.63, 2.13)* | |
| 0% Infection | | | | 0.96*** | |
| | | | | *(0.25, 1.67)* | |
| 10% Infection | | | | 0.017 | |
| | | | | *(-0.61, 0.64)* | |
| 20% Infection | | | | 0.495** | |
| | | | | *(-0.43, 1.42)* | |

+Note values are rounded to two decimal places. Confidence intervals in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance. WTP coefficients are presented for attributes where price was significant ant 95% level.

Table 4.13: Marginal willingness-to-pay estimates for lamb and wool

**Lamb**

| **Variable** | **Class 1** | **Class 2** | **Class 3** |
|---|---|---|---|
| High welfare | 4.13***<br>*(1.57, 6.68)* | 14.15***<br>*(8.09, 20.20)* | |
| Medium welfare | 3.63**<br>*(1.16, 6.09)* | 9.73***<br>*(5.31, 14.13)* | |
| Local | 3.24***<br>*(0.90, 5.58)* | 5.49***<br>*(0.67, 10.31)* | |
| Elsewhere | 1.65<br>*(-0.57, 3.84)* | 4.16***<br>*(0.34, 7.97)* | |
| 0% Infection | 8.49***<br>*(4.67, 12.30)* | 10.28***<br>*(4.58, 15.98)* | |
| 10% Infection | 1.7<br>*(-1.40, 4.79)* | 8.27***<br>*(3.07, 13.44)* | |
| 20% Infection | 1.98<br>*(-1.40, 5.35)* | 1.01<br>*(-3.63, 5.65)* | |

**Wool**

| Variable | **Class 1** | **Class 2** | **Class 3** | **Class 4** |
|---|---|---|---|---|
| High welfare | 16.5***<br>*(6.5, 26.40)* | | | -0.81<br>*(-3.01, 1.40)* |
| Medium welfare | 9.4***<br>*(3.58, 15.21)* | | | -0.29<br>*(-2.16, 1.59)* |
| Local | 4.9***<br>*(0.37, 9.32)* | | | 3.01***<br>*(0.57. 5.43)* |
| Elsewhere | 2.3*<br>*(-0.67, 5.26)* | | | 1.49*<br>*(-.029, 3.25)* |
| 0% Infection | 6.5***<br>*(1.42, 11.48)* | | | 3.94***<br>*(1.85, 6.01)* |
| 10% Infection | 6.5***<br>*(1.39, 11.43)* | | | 3.1***<br>*(1.06, 5.13)* |
| 20% Infection | 2.6<br>*(-1.56, 6.68)* | | | 3.36***<br>*(0.31, 6.39)* |

+Note values are rounded to two decimal places. Confidence intervals in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance. WTP coefficients are presented for attributes where price was significant ant 95% level.

Table 4.14: Probability of actual choice being in a specific class

| | Observations | Class | Unconditional probability | Conditional probability |
|---|---|---|---|---|
| **Beef** | 222 | 1 | 0.466142 | 0.737605 |
| | 438 | 2 | 0.394395 | 0.603013 |
| | 426 | 3 | 0.380353 | 0.696319 |
| | 366 | 4 | 0.444027 | 0.710378 |
| **Milk** | 222 | 1 | 0.422606 | 0.884036 |
| | 450 | 2 | 0.356473 | 0.615824 |
| | 384 | 3 | 0.433813 | 0.6932 |
| | 348 | 4 | 0.44294 | 0.631424 |
| | 234 | 5 | 0.434019 | 0.744061 |
| **Lamb** | 570 | 1 | 0.390292 | 0.667064 |
| | 552 | 2 | 0.384609 | 0.561289 |
| | 294 | 3 | 0.42109 | 0.852411 |
| **Wool** | 510 | 1 | 0.417469 | 0.624888 |
| | 330 | 2 | 0.326073 | 0.931341 |
| | 222 | 3 | 0.416591 | 0.796449 |
| | 612 | 4 | 0.375114 | 0.580457 |

Table 4.15: Posterior probability of class membership

| | **Beef** | **Milk** | **Lamb** | **Wool** |
|---|---|---|---|---|
| **Mean** | 0.93 | 0.91 | 0.97 | 0.94 |
| **Observations** | 242 | 273 | 236 | 279 |

Next, following Pacifico and Yoo (2013), I want to quantitatively measure how well the models differentiate between different preference classes by predicting the probabilities of choosing each alternative in each choice scenario. This is accomplished by calculating the average of the highest posterior probability of class membership. Table 4.15 summarises the mean highest posterior probabilities for each of the product models and as can be seen the probability for beef is 0.93, milk is 0.91, lamb is 0.97 and wool is 0.94 indicating my models do very well to differentiate the different preference patterns given the observed choice behaviour. These are the posterior probabilities that an individual will belong to a particular class given their choice sequence.

### 4.5.2 With membership

In this subsection, I look at the demographic covariate *age* as an independent variable entering the logit model of class membership, since age was found to be consistently statistically significant across the different specifications. I test for differences in the attributes allowing the model to differ across groups and therefore, predicting the likelihood of respondents belonging to certain class given their socio-demographic information (i.e. age). Once again, I chose the optimal number of latent classes by relying on the BIC and CAIC criteria as shown in table 4.21 in the appendix. CAIC and BIC are minimised at 4 classes for all the products. Hence, I conclude that the inclusion of four classes is the optimal choice.

In table 4.22 of the appendix, I summarise the output of the latent class model with class membership for beef and milk. Here the class shares are averaged over respondents and they are allowed to vary according to the covariate *age*. Starting with beef, *age* was not found to be statistically significant for any class. Class 1 (with 15 per cent of respondents probabilistically assigned to it) had a strong preference for both high welfare and Medium welfare. For class 2 (30 percent of the sample) consumers display a strong preference for lower prices and low infection levels in the herd. The opt out coefficient was found to be negative and statistically significant, thus, indicating that consumers were more likely to accept buying beef as it was presented in the choice cards. Class 3 (31 per cent of the sample) is the largest class. Respondents belonging to this class show clear preferences for lower price, high welfare, locally produced beef from a herd with low infection levels. Contrary to the results from Class 2, the opt- out coefficient was found to be statistically significant and positive. Hence, consumers are more likely to opt out from buying the product as it was shown in the choice experiment. Finally, Class 4 (24 per cent of the sample) consumers exhibit a strong preference for beef coming from a herd with high (and medium) welfare, produced within the UK as well as coming from a herd with low infection levels.

Next, let us look at milk with 4 classes. This time *age* was found to be statistically significant predictor for class membership in all classes with the exception of class 2. The probability of class 4 membership was found to be increasing as the respondents grow older. On the other hand, the probability of belonging to either class 1 or class 2 was found to be decreasing with age. Note, that age is statistically significant for class 2 only at the 90% significance level. In contrast, we see that for class 3, the probability of belonging to this class increases with the respondents age.

Class 1 and class 4 were found to be the largest classes with 31 per cent of respondents in each. Class 1 valued milk with higher welfare that was produced anywhere in the UK. This class also displayed a strong preference for lower infection level. However, since the opt out estimate was found to be positive and statistically significant, the respondents are more likely to reject the product presented to them in the choice cards. For class 2 (with 12 per cent membership), we observe that consumers belonging to this class place weight only on the attributes pertaining infection levels and medium welfare in the herd. These respondent have clear preference for lower infection levels in the herd however, they do not seem to place high weight on animal welfare. In class 3 (with 26 per cent membership) prices and place of origin were found to be the most statistically significant attributes. These consumers have a strong preference for lower prices and also for milk which was produced elsewhere in the UK. Still they exhibit a preference for 0% infection level in the herd but not for high animal welfare. The opt out coefficient was fount to be negative and statistically significant, thus demonstrating that consumers are more likely to accept the product as it was shown to them in the choice cards. Finally, respondents belonging to class 4 (31 percent membership) exhibited quite different behaviour compared to consumers belonging to class 3. Here consumers do not seem to consider price of the milk as the coefficient is not statistically significant. These respondents care for high welfare milk that has been produced locally and comes from a herd with lower infections. The opt out coefficient is statistically significant and positive meaning that consumers are likely to reject purchasing milk as it was shown to them in the choice cards.

Table 4.23 in the appendix summarises consumer choices for lamb chops and pure wool. Beginning with lamb chops we see that for lamb only in class 1 the age covariate was found to be statistically significant and positive indicating that membership to this class increased as the respondents grow older. In class 4 on the other hand which acts as the baseline, the probability of class 4 membership was found to be decreasing with in increasing age. In contrast for wool, when looking at the effects of the age with the probability of belonging to a particular we observe that for class 1 and class 3 membership, the age covariate was found to be statistically significant and negative. This means that the probability of belonging to either class 1 or class 3, decreases as respondents grow older. Now, as for the probability of class 4 membership, we witness that the probability of class membership increases as the respondents grow older.

Let us discuss the results first for lamb chops and wool respectively. Respondents belonging to class 1 for lamb (the largest class), we see that they have prefer lower prices, high welfare lamb chops, originating from the UK. These consumers are not willing to accept any infection level in the flock. The opt out coefficient coefficient is positive and statistically significant indicating they are likely to opt out from buying the product as it was presented to them in the choice scenarios. Members belonging to the class 2 exhibit similar preferences. They care about lower prices in lamb, high welfare and low infection level. They do not seem to place any weight on the place of origin as the estimate of this attribute is not statistically significant and for the same reasons they are likely not to opt out. In class 3, none of coefficients are statistically significant. Finally, for class 4, respondents belonging to this class, find important only the pace of origin (i.e. produced in the UK) and low infection levels in the flock.

Lastly, I analyse the results for pure wool with 4 classes, the only non-edible product in my study. The age covariate played a statistically significant role in the membership determination. However, since these results are very similar to lamb, the results are presented in the appendix. Similarly, in tables 4.24 and 4.24 in the appendix I summarise the posterior probability of class membership for each product as well as the probability of an actual choice being in a specific class.

## 4.6 Discussion

In this chapter, I have investigated UK consumer preferences and the willingness to pay for high farm animal health and welfare using four different animal products.

The study provides robust evidence that the UK public cares about the sickness level of the animals even when controlling for variations in animal welfare as well as other characteristics. Given the utility trade-offs between choice attributes, consumers perceived infection levels as one of the most important attributes. Interestingly, as respondents were given strong reassurance that the products were completely safe to consume regardless of the infection level. I argue that consumers may still be apprehensive of buying products with some infection. Assuring them that it is safe to consume may not necessarily diminish or alter perceptions of safety. However, given that I found preferences for wool to be largely similar, it is safe to assume that consumers genuinely care about the conditions these animals are kept. As such, I find that consumers seem to care about sickness levels in farm animals even when this has no consequences for food or product safety. This result is particularly relevant given recent statements by DEFRA [7] on the direction of public funding for farming post-Brexit. In this new environment, farm animal health is seen as something which taxpayers should contribute to (since it can be argued to have some public good characteristics[8] ).

Additionally, I have also found that the value placed on high animal welfare and low infection rates varies with the participants' age and income. Younger consumers value *high animal welfare* and *low infection levels* more highly than older consumers, despite the fact that the average income of their household tends to be lower. Higher income consumers showed a greater preference for high animal welfare, ceteris paribus. Assuming a uniform effect, however, would be unrealistic. There I examined the data using RPL and found statistically significant latent preference heterogeneity in the results despite the inclusion of possible observed sources of such variation like *age*, *income*, and *education*. Furthermore, I have also tested preference heterogeneity for the *welfare* and *infection level* attributes by interacting them with control variables *age* and *income*. This was further verified using Latent class analysis to explore and profile of consumer categories based on socio-economic data.

During periods of increased uncertainty, especially one as unpredictable as the ongoing Covid- 19 pandemic has been, consumers tend to pessimistic and/or fearful regarding their future financial prospects. People tend to be more worried about their expected future income and although the majority of our sample (roughly 66 %) still retained their optimism, it is noteworthy to see that they still prioritise locally produced, disease free, high welfare products instead of substituting this consumption good with inferior substitutes. This could perhaps be related to the changing consciousness around livestock practices and zoonotic disease risks.

These preferences followed a similar pattern across all four products. This is an interesting result because I would not expect that even for products that humans do not actually ingest, consumers would be willing to pay as much to ensure high animal health and welfare. This outcome helps me solidify my position that consumers are willing to pay for high animal welfare and low sickness levels irrespective of the perceived effect it has on their health. It was expected that wool being a

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[7] See "The Path to sustainable farming: An Agricultural Transition Plan 2021 to 2024". https://www.gov.uk/government/publications/agricultural-transition-plan-2021-to-2024

[8] In chapter 8, I provide the reader with a lengthy discussion on FAHAW as a public good

luxury good as well as a non-consumable good would show indifference to infection levels in the flock. However, I find that this was not the case and consumers preferred their wool from animals that came from farms with lower sickness levels.

Several implications of the study can be considered. For example, there is a clear need for designing policy instruments to incorporate farm animal health and welfare. Next, information provision is also needed to ensure transparency and better labelling practices in order to increase the improve public trust. The information available or lack thereof on health and welfare of animals in the retail environment where people encounter livestock products, sees consumers increasingly relying on independent bodies to certify high welfare standards without fully understanding what welfare standards are and are not included. The fact that citizens have lower preference for purchasing products that are produced from diseased animals even when these infections cause no harm to the consumers essentially indicates that information labelling needs to be updated. Endemic conditions that compromise the health and welfare of farm animals needs to be eradicated and stricter measures put in place not just for the protection of public health but to facilitate sustainable and more importantly improve the health and welfare of farm animals.

Naturally, there is increasing attention given by consumers to what I eat and how it was produced, placing significant weight in the farm and food industry for better and improved methods of production valued by consumers (Pouta et al., 2010). Average spending trends in the UK like many other European countries on ethical and organic food products have soared, with 55% of the respondents opting to become vegetarian and vegan because of animal welfare concerns[9]. Animal welfare itself is not a well understood concept among consumers with households increasingly relying on independent organisations to assess suitability of product before it is brought to the supermarket shelves. It is not about companies ,in the mature animal product industry, gaining competitive advantage with pricing but through differentiation strategy that comes with delivering to the customer features that they value whilst persuading them to pay price premiums that cover the cost of this differentiation. This is especially important in the current market given the exponential rise of interest in what I consume by previously smaller market segments.

Finally, in this study, I employed a choice experiment with a parsimonious set of attributes to better understand the importance of certain characteristics whilst assessing the underlying beliefs that shape their significance. The results provide me with evidence of strong positive preference for farm animal health regardless of high animal welfare given that it has zero implications on human health. I have also tested the effect of place of origin and found that locally produced products increased the probability of consumer choice. This was not surprising given the rising attention to product origin as has been documented in many studies particularly with consumers attributing quality of product to place of origin[10].

It is without doubt difficult to quantify farm animal health and welfare. I attempt to understand the current UK consumer perceptions around farm animal health and welfare, and the key results is that consumers care about animal health and welfare regardless of food safety. So perhaps there is a need to redefine animal health and welfare regardless of whether or not it affects consumer health and safety.

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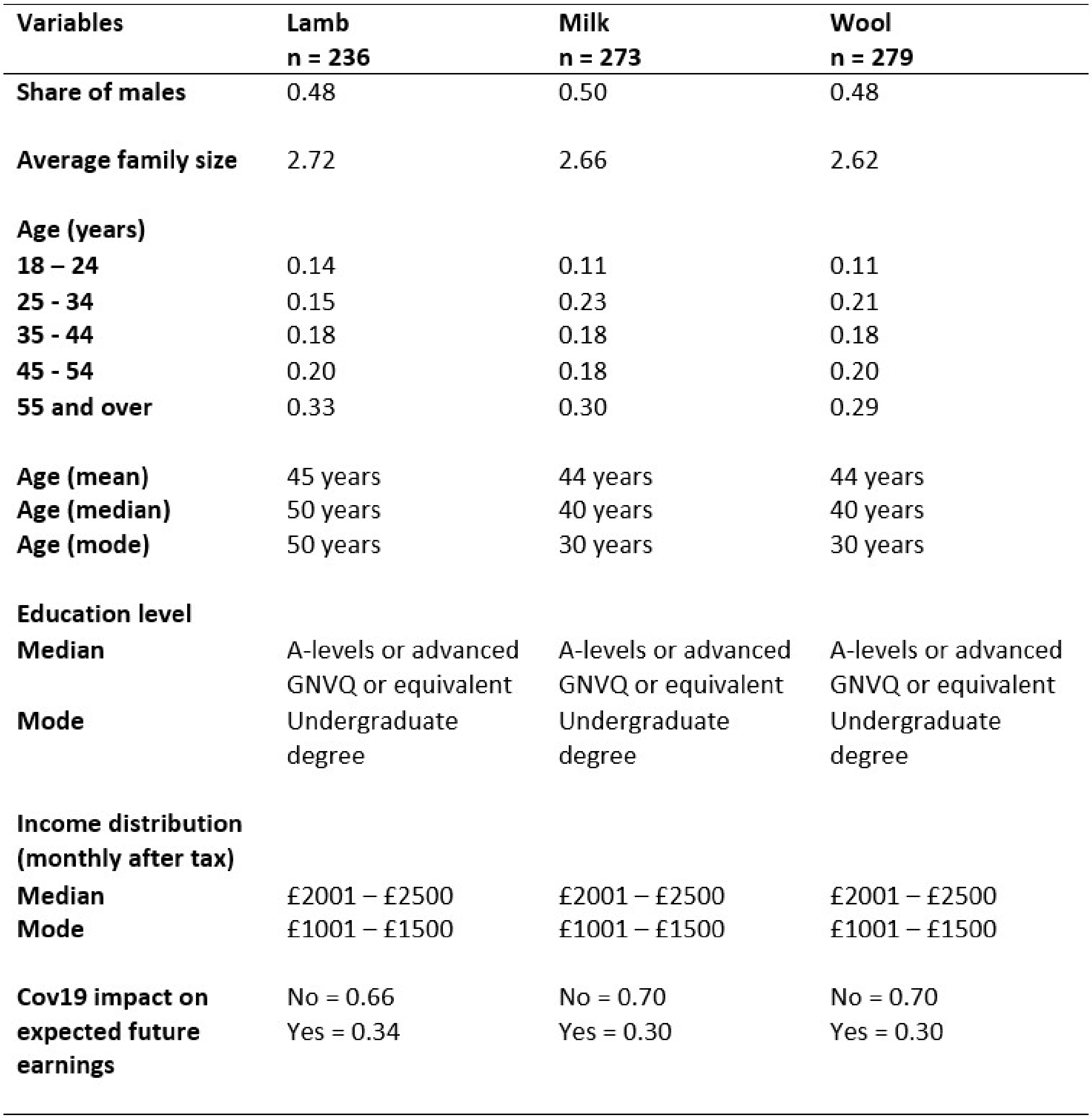
[9] Statista database:Health and wellness food trends in the United Kingdom, 2022.

[10] See the studies of Loreiro and Umberger, 2007; Bolliger and Reviron, 2008; Pouta et al., 2010; Cicia and Colantuoni., 2010; Zanoli et al., 2013 for a comprehensive exposition of this result.

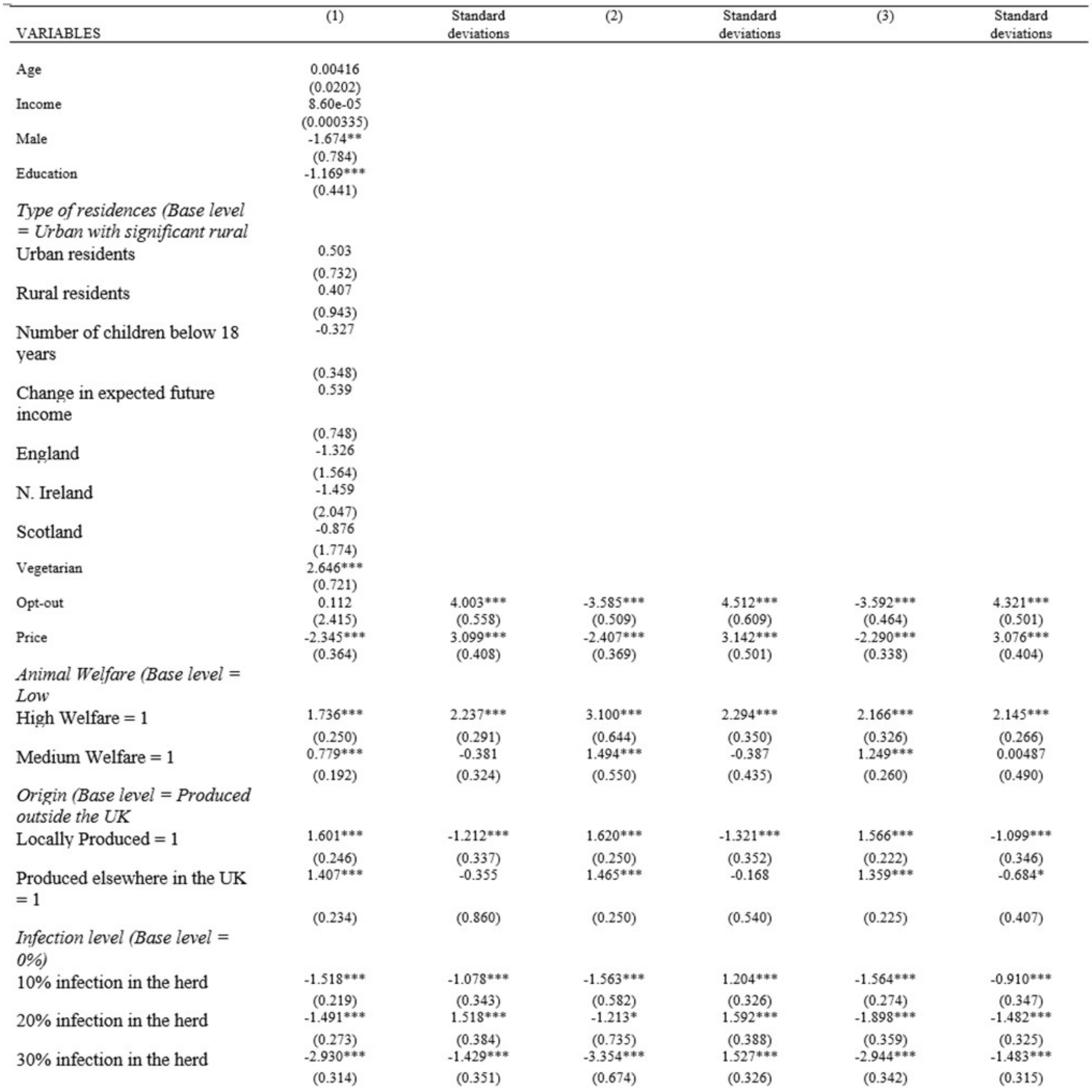
## 4.7 Appendix A

Table 4.16: (A1) Summary statistics

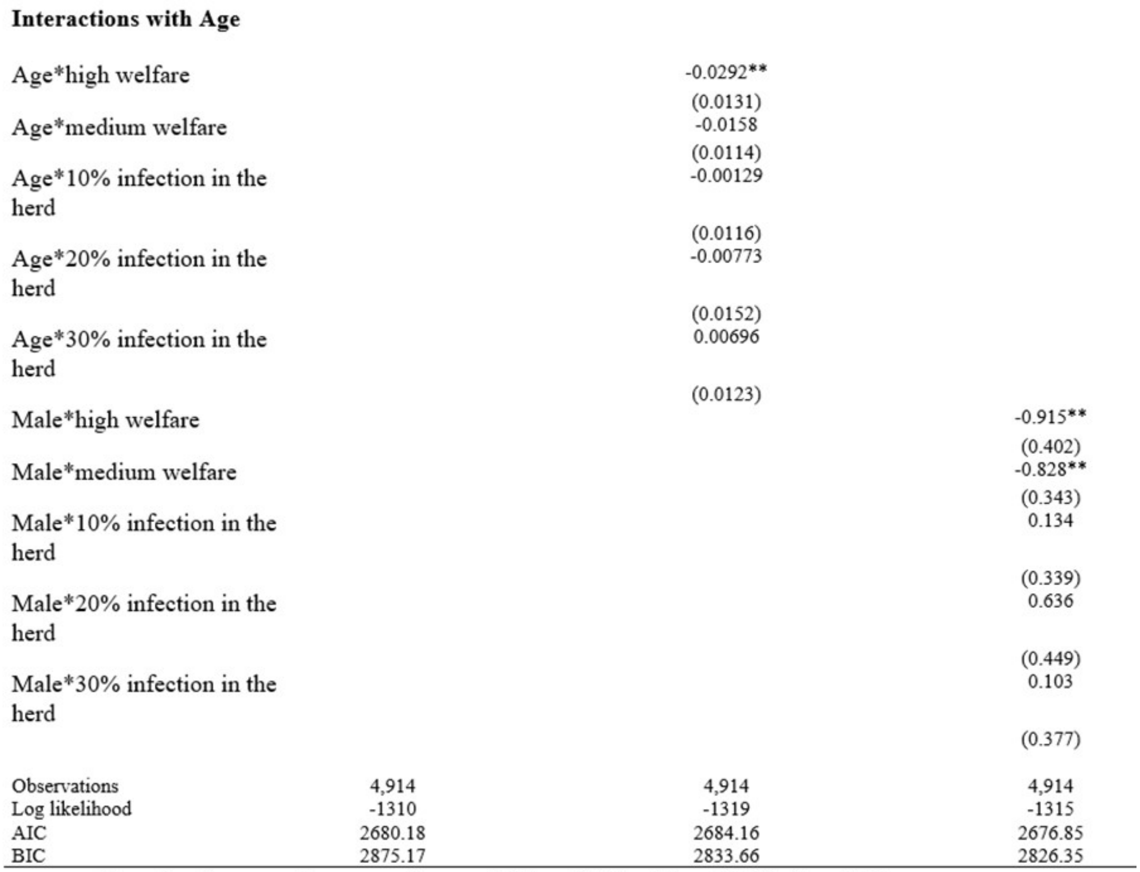


| Variables | Lamb<br>n = 236 | Milk<br>n = 273 | Wool<br>n = 279 |
|---|---|---|---|
| **Share of males** | 0.48 | 0.50 | 0.48 |
| **Average family size** | 2.72 | 2.66 | 2.62 |
| **Age (years)** | | | |
| **18 – 24** | 0.14 | 0.11 | 0.11 |
| **25 - 34** | 0.15 | 0.23 | 0.21 |
| **35 - 44** | 0.18 | 0.18 | 0.18 |
| **45 - 54** | 0.20 | 0.18 | 0.20 |
| **55 and over** | 0.33 | 0.30 | 0.29 |
| **Age (mean)** | 45 years | 44 years | 44 years |
| **Age (median)** | 50 years | 40 years | 40 years |
| **Age (mode)** | 50 years | 30 years | 30 years |
| **Education level** | | | |
| **Median** | A-levels or advanced GNVQ or equivalent | A-levels or advanced GNVQ or equivalent | A-levels or advanced GNVQ or equivalent |
| **Mode** | Undergraduate degree | Undergraduate degree | Undergraduate degree |
| **Income distribution (monthly after tax)** | | | |
| **Median** | £2001 – £2500 | £2001 – £2500 | £2001 – £2500 |
| **Mode** | £1001 – £1500 | £1001 – £1500 | £1001 – £1500 |
| **Cov19 impact on expected future earnings** | No = 0.66<br>Yes = 0.34 | No = 0.70<br>Yes = 0.30 | No = 0.70<br>Yes = 0.30 |

Table 4.17: (A2) Random Parameter Logit specifications for milk (Age and education)



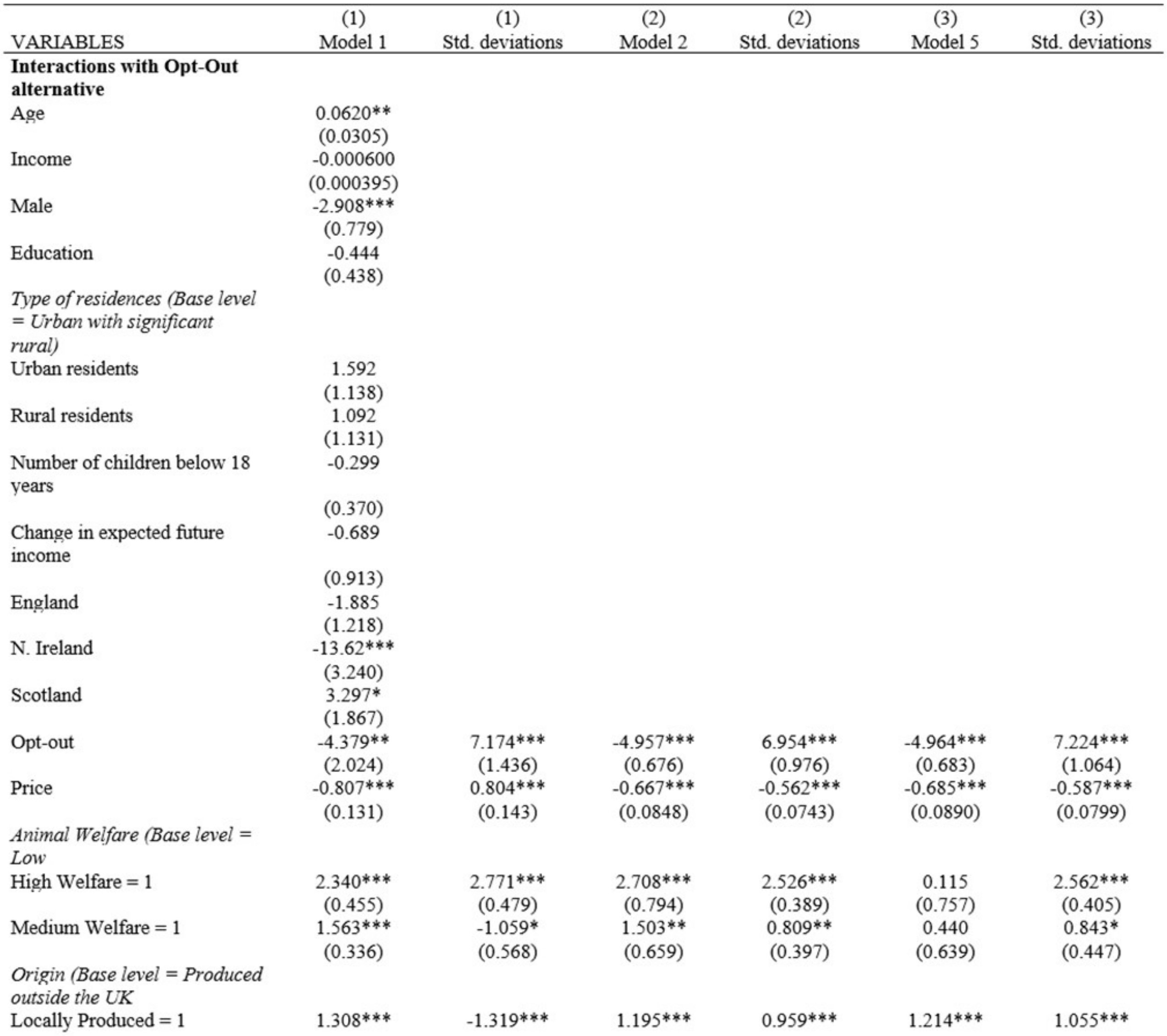
| VARIABLES | (1) | Standard deviations | (2) | Standard deviations | (3) | Standard deviations |
|---|---|---|---|---|---|---|
| Age | 0.00416 | | | | | |
| | (0.0202) | | | | | |
| Income | 8.60e-05 | | | | | |
| | (0.000335) | | | | | |
| Male | -1.674** | | | | | |
| | (0.784) | | | | | |
| Education | -1.169*** | | | | | |
| | (0.441) | | | | | |
| *Type of residences (Base level = Urban with significant rural* | | | | | | |
| Urban residents | 0.503 | | | | | |
| | (0.732) | | | | | |
| Rural residents | 0.407 | | | | | |
| | (0.943) | | | | | |
| Number of children below 18 years | -0.327 | | | | | |
| | (0.348) | | | | | |
| Change in expected future income | 0.539 | | | | | |
| | (0.748) | | | | | |
| England | -1.326 | | | | | |
| | (1.564) | | | | | |
| N. Ireland | -1.459 | | | | | |
| | (2.047) | | | | | |
| Scotland | -0.876 | | | | | |
| | (1.774) | | | | | |
| Vegetarian | 2.646*** | | | | | |
| | (0.721) | | | | | |
| Opt-out | 0.112 | 4.003*** | -3.585*** | 4.512*** | -3.592*** | 4.321*** |
| | (2.415) | (0.558) | (0.509) | (0.609) | (0.464) | (0.501) |
| Price | -2.345*** | 3.099*** | -2.407*** | 3.142*** | -2.290*** | 3.076*** |
| | (0.364) | (0.408) | (0.369) | (0.501) | (0.338) | (0.404) |
| *Animal Welfare (Base level = Low* | | | | | | |
| High Welfare = 1 | 1.736*** | 2.237*** | 3.100*** | 2.294*** | 2.166*** | 2.145*** |
| | (0.250) | (0.291) | (0.644) | (0.350) | (0.326) | (0.266) |
| Medium Welfare = 1 | 0.779*** | -0.381 | 1.494*** | -0.387 | 1.249*** | 0.00487 |
| | (0.192) | (0.324) | (0.550) | (0.435) | (0.260) | (0.490) |
| *Origin (Base level = Produced outside the UK* | | | | | | |
| Locally Produced = 1 | 1.601*** | -1.212*** | 1.620*** | -1.321*** | 1.566*** | -1.099*** |
| | (0.246) | (0.337) | (0.250) | (0.352) | (0.222) | (0.346) |
| Produced elsewhere in the UK = 1 | 1.407*** | -0.355 | 1.465*** | -0.168 | 1.359*** | -0.684* |
| | (0.234) | (0.860) | (0.250) | (0.540) | (0.225) | (0.407) |
| *Infection level (Base level = 0%)* | | | | | | |
| 10% infection in the herd | -1.518*** | -1.078*** | -1.563*** | 1.204*** | -1.564*** | -0.910*** |
| | (0.219) | (0.343) | (0.582) | (0.326) | (0.274) | (0.347) |
| 20% infection in the herd | -1.491*** | 1.518*** | -1.213* | 1.592*** | -1.898*** | -1.482*** |
| | (0.273) | (0.384) | (0.735) | (0.388) | (0.359) | (0.325) |
| 30% infection in the herd | -2.930*** | -1.429*** | -3.354*** | 1.527*** | -2.944*** | -1.483*** |
| | (0.314) | (0.351) | (0.674) | (0.326) | (0.342) | (0.315) |



| | | | |
|---|---|---|---|
| **Interactions with Age** | | | |
| Age*high welfare | | -0.0292** | |
| | | (0.0131) | |
| Age*medium welfare | | -0.0158 | |
| | | (0.0114) | |
| Age*10% infection in the herd | | -0.00129 | |
| | | (0.0116) | |
| Age*20% infection in the herd | | -0.00773 | |
| | | (0.0152) | |
| Age*30% infection in the herd | | 0.00696 | |
| | | (0.0123) | |
| Male*high welfare | | | -0.915** |
| | | | (0.402) |
| Male*medium welfare | | | -0.828** |
| | | | (0.343) |
| Male*10% infection in the herd | | | 0.134 |
| | | | (0.339) |
| Male*20% infection in the herd | | | 0.636 |
| | | | (0.449) |
| Male*30% infection in the herd | | | 0.103 |
| | | | (0.377) |
| Observations | 4,914 | 4,914 | 4,914 |
| Log likelihood | -1310 | -1319 | -1315 |
| AIC | 2680.18 | 2684.16 | 2676.85 |
| BIC | 2875.17 | 2833.66 | 2826.35 |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.18: (A3) Random Parameter Logit specifications for lamb (Age and education)



|  | (1) | (1) | (2) | (2) | (3) | (3) |
|---|---|---|---|---|---|---|
| VARIABLES | Model 1 | Std. deviations | Model 2 | Std. deviations | Model 5 | Std. deviations |
| **Interactions with Opt-Out alternative** |  |  |  |  |  |  |
| Age | 0.0620** |  |  |  |  |  |
|  | (0.0305) |  |  |  |  |  |
| Income | -0.000600 |  |  |  |  |  |
|  | (0.000395) |  |  |  |  |  |
| Male | -2.908*** |  |  |  |  |  |
|  | (0.779) |  |  |  |  |  |
| Education | -0.444 |  |  |  |  |  |
|  | (0.438) |  |  |  |  |  |
| *Type of residences (Base level = Urban with significant rural)* |  |  |  |  |  |  |
| Urban residents | 1.592 |  |  |  |  |  |
|  | (1.138) |  |  |  |  |  |
| Rural residents | 1.092 |  |  |  |  |  |
|  | (1.131) |  |  |  |  |  |
| Number of children below 18 years | -0.299 |  |  |  |  |  |
|  | (0.370) |  |  |  |  |  |
| Change in expected future income | -0.689 |  |  |  |  |  |
|  | (0.913) |  |  |  |  |  |
| England | -1.885 |  |  |  |  |  |
|  | (1.218) |  |  |  |  |  |
| N. Ireland | -13.62*** |  |  |  |  |  |
|  | (3.240) |  |  |  |  |  |
| Scotland | 3.297* |  |  |  |  |  |
|  | (1.867) |  |  |  |  |  |
| Opt-out | -4.379** | 7.174*** | -4.957*** | 6.954*** | -4.964*** | 7.224*** |
|  | (2.024) | (1.436) | (0.676) | (0.976) | (0.683) | (1.064) |
| Price | -0.807*** | 0.804*** | -0.667*** | -0.562*** | -0.685*** | -0.587*** |
|  | (0.131) | (0.143) | (0.0848) | (0.0743) | (0.0890) | (0.0799) |
| *Animal Welfare (Base level = Low* |  |  |  |  |  |  |
| High Welfare = 1 | 2.340*** | 2.771*** | 2.708*** | 2.526*** | 0.115 | 2.562*** |
|  | (0.455) | (0.479) | (0.794) | (0.389) | (0.757) | (0.405) |
| Medium Welfare = 1 | 1.563*** | -1.059* | 1.503** | 0.809** | 0.440 | 0.843* |
|  | (0.336) | (0.568) | (0.659) | (0.397) | (0.639) | (0.447) |
| *Origin (Base level = Produced outside the UK* |  |  |  |  |  |  |
| Locally Produced = 1 | 1.308*** | -1.319*** | 1.195*** | 0.959*** | 1.214*** | 1.055*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.325) | (0.431) | (0.264) | (0.356) | (0.273) | (0.361) |
| Produced elsewhere in the UK = 1 | 0.881*** | -1.923*** | 1.078*** | -1.068** | 1.091*** | -1.137*** |
| | (0.326) | (0.511) | (0.289) | (0.439) | (0.297) | (0.428) |
| *Infection level (Base level = 0%)* | | | | | | |
| 10% infection in the flock | -2.050*** | 0.928* | -1.484** | 0.572 | -1.856*** | 0.734 |
| | (0.406) | (0.480) | (0.659) | (0.527) | (0.640) | (0.454) |
| 20% infection in the flock | -2.538*** | -1.587*** | -1.494* | -1.475*** | -2.438*** | -1.374*** |
| | (0.516) | (0.450) | (0.834) | (0.416) | (0.718) | (0.428) |
| 30% infection in the flock | -3.438*** | -1.276** | -2.787*** | 1.062** | -2.456*** | 1.122*** |
| | (0.552) | (0.511) | (0.695) | (0.438) | (0.650) | (0.423) |
| **Interactions with Age** | | | | | | |
| Age*high welfare | | | -0.0139 | | | |
| | | | (0.0163) | | | |
| Age*medium welfare | | | -0.00323 | | | |
| | | | (0.0138) | | | |
| Age*10% infection in the flock | | | -0.00426 | | | |
| | | | (0.0136) | | | |
| Age*20% infection in the flock | | | -0.0108 | | | |
| | | | (0.0166) | | | |
| Age*30% infection in the flock | | | -0.00124 | | | |
| | | | (0.0138) | | | |
| Education*10% infection in the flock | | | | | 0.0434 | |
| | | | | | (0.241) | |
| Education *20% infection in the flock | | | | | 0.178 | |
| | | | | | (0.273) | |
| Education *30% infection in the flock | | | | | -0.194 | |
| | | | | | (0.240) | |
| Education*high welfare | | | | | 0.825*** | |
| | | | | | (0.301) | |
| Education*medium welfare | | | | | 0.403 | |
| | | | | | (0.248) | |
| Observations | 4,248 | | 4,248 | | 4,248 | |
| Log likelihood | -1015 | | -1027 | | -1023 | |
| AIC | 2088.52 | | 2100.46 | | 2091.6 | |
| BIC | 2272.79 | | 2246.61 | | 2237.74 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.19: (A4) Random Parameter Logit specifications for Wool

| VARIABLES | (1) Model 1 | (1) Std. deviations | (2) Model 2 | (2) Std. deviations |
|---|---|---|---|---|
| **Interactions with Opt-Out alternative** | | | | |
| Age | 0.0685** | | | |
| | (0.0320) | | | |
| Income | -0.000215 | | | |
| | (0.000428) | | | |
| Male | -2.353*** | | | |
| | (0.868) | | | |
| Education | -0.540 | | | |
| | (0.428) | | | |
| *Type of residences (Base level = Urban with significant rural)* | | | | |
| Urban residents | -0.403 | | | |
| | (1.237) | | | |
| Rural residents | -1.768 | | | |
| | (1.265) | | | |
| Number of children below 18 years | -0.628* | | | |
| | (0.369) | | | |
| Change in expected future income | -1.122 | | | |
| | (0.803) | | | |
| England | 0.781 | | | |
| | (2.028) | | | |
| N. Ireland | -4.094 | | | |
| | (3.007) | | | |
| Scotland | 0.343 | | | |
| | (2.260) | | | |
| Vegetarian | 4.089*** | | | |
| | (1.378) | | | |
| Opt-out | -3.500 | 6.525*** | -3.061*** | 7.077*** |
| | (3.415) | (0.903) | (0.534) | (0.897) |
| Price | -0.153*** | 0.195*** | -0.153*** | 0.179*** |
| *Animal Welfare (Base level = Low* | | | | |
| High Welfare = 1 | 2.284*** | 2.792*** | 3.886*** | 2.739*** |
| | (0.331) | (0.408) | (0.782) | (0.350) |
| Medium Welfare = 1 | 1.332*** | -0.0501 | 1.619*** | -0.401 |
| | (0.230) | (0.373) | (0.579) | (0.390) |
| *Origin (Base level = Produced outside the UK* | | | | |
| Locally Produced = 1 | 1.448*** | -1.362*** | 1.432*** | 1.166*** |
| | (0.265) | (0.377) | (0.250) | (0.312) |
| Produced elsewhere in the UK = 1 | 1.443*** | 0.238 | 1.448*** | -0.130 |
| | (0.294) | (0.686) | (0.270) | (0.439) |
| *Infection level (Base level = 0%)* | | | | |
| 10% infection in the flock | -1.383*** | -0.366* | -0.336 | -0.648* |
| | (0.232) | (0.727) | (0.554) | (0.392) |
| 20% infection in the flock | -1.639*** | 2.356*** | 0.865 | 2.085*** |
| | (0.364) | (0.470) | (0.832) | (0.403) |
| 30% infection in the flock | -3.271*** | 1.816*** | -2.169*** | 1.747*** |
| | (0.404) | (0.365) | (0.698) | (0.351) |

| | | |
|---|---|---|
| **Interactions with Age** | | |
| Age*high welfare | | -0.0386** |
| | | (0.0156) |
| Age*medium welfare | | -0.00718 |
| | | (0.0121) |
| Age*10% infection in the flock | | -0.0238** |
| | | (0.0117) |
| Age*20% infection in the flock | | -0.0568*** |
| | | (0.0184) |
| Age*30% infection in the flock | | -0.0251* |
| | | (0.0146) |
| Observations | 5,022 | 5,022 |
| Log likelihood | -1237 | -1237 |
| AIC | 2533.36 | 2520.72 |
| BIC | 2729.01 | 2670.72 |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.20: (A5) Optimal number of latent class selection with no membership

| | Classes | Log likelihood | Parameters | AIC | CAIC | BIC |
|---|---|---|---|---|---|---|
| **Beef** | 2 | -1173.01 | 19 | 2384.026 | 2469.316 | 2450.316 |
| | 3 | -1115.59 | 29 | 2289.171 | 2419.35 | 2390.35 |
| | 4 | -1076.89 | 39 | 2231.785 | 2406.854 | 2367.854 |
| | 5 | -1057.64 | 49 | 2213.273 | 2433.231 | 2384.231 |
| | 6 | -1031.83 | 59 | 2181.652 | 2446.499 | 2387.499 |
| **Milk** | 2 | -1398.05 | 19 | 2834.096 | 2921.676 | 2902.676 |
| | 3 | -1326.75 | 29 | 2711.496 | 2845.171 | 2816.171 |
| | 4 | -1289.55 | 39 | 2657.092 | 2836.862 | 2797.862 |
| | 5 | -1256.31 | 49 | 2610.615 | 2836.479 | 2787.479 |
| | 6 | -1232.62 | 59 | 2583.246 | 2855.204 | 2796.204 |
| **Lamb** | 2 | -1141.41 | 19 | 2320.812 | 2405.625 | 2386.625 |
| | 3 | -1060.12 | 29 | 2178.241 | 2307.692 | 2278.692 |
| **Wool** | 2 | -1345.22 | 19 | 2728.448 | 2816.442 | 2797.442 |
| | 3 | -1256.11 | 29 | 2570.226 | 2704.531 | 2675.531 |
| | 4 | -1197.47 | 39 | 2472.946 | 2653.563 | 2614.563 |
| | 5 | -1190.61 | 49 | 2479.212 | 2706.142 | 2657.142 |
| | 6 | -1134.02 | 59 | 2386.043 | 2659.284 | 2600.284 |
| | 7 | -1093.76 | 69 | 2325.524 | 2645.078 | 2576.078 |

Table 4.21: (A6) Optimal number of latent class selection with class membership

| | Classes | Log likelihood | Parameters | AIC | CAIC | BIC |
|---|---|---|---|---|---|---|
| **Beef** | 2 | -1167.537 | 21 | 2377.074 | 2471.342 | 2450.342 |
| | 3 | -1107.067 | 33 | 2280.135 | 2428.27 | 2395.27 |
| | 4 | -1066.468 | 45 | 2222.936 | 2424.938 | 2379.938 |
| | 5 | -1042.425 | 57 | 2198.849 | 2454.719 | 2397.719 |
| | 6 | -1032.392 | 69 | 2202.783 | 2512.52 | 2443.52 |
| **Milk** | 2 | -1397.91 | 20 | 2835.815 | 2928.005 | 2908.005 |
| | 3 | -1321.28 | 31 | 2704.562 | 2847.455 | 2816.455 |
| | 4 | -1284.41 | 42 | 2652.823 | 2846.421 | 2804.421 |
| | 5 | -1264.94 | 53 | 2635.887 | 2880.189 | 2827.189 |
| | 6 | -1224.94 | 64 | 2577.88 | 2872.886 | 2808.886 |
| **Lamb** | 2 | -1138.36 | 20 | 2316.715 | 2405.992 | 2385.992 |
| | 3 | -1055.96 | 31 | 2173.927 | 2312.306 | 2281.306 |
| | 4 | -1007.85 | 42 | 2099.693 | 2287.173 | 2245.173 |
| | 5 | -989.208 | 53 | 2084.417 | 2321 | 2268 |
| | 6 | -958.835 | 64 | 2045.671 | 2331.356 | 2267.356 |
| **Wool** | 2 | -1341.57 | 20 | 2723.13 | 2815.755 | 2795.755 |
| | 3 | -1251.73 | 31 | 2565.449 | 2709.017 | 2678.017 |
| | 4 | -1191.75 | 42 | 2467.501 | 2662.012 | 2620.012 |
| | 5 | -1181.73 | 53 | 2469.454 | 2714.908 | 2661.908 |

Table 4.22: (A7) Latent class model parameters and class shares for UK consumers (beef and milk) with class membership

| Beef n = 242 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | |
| **Price** | 0.04 | (0.12) | -0.34*** | (0.05) | -0.20*** | (0.04) | -0.02 | (0.07) |
| **High welfare** | 1.39** | (0.67) | -0.05 | (0.27) | 2.14*** | (0.27) | 3.33*** | (0.47) |
| **Medium welfare** | 1.66** | (0.76) | 0.32 | (0.24) | 0.81 | (0.24) | 1.40*** | (0.38) |
| **Local** | 15.86 | (252.83) | 0.42 | (0.26) | 1.34*** | (0.26) | 1.87*** | (0.48) |
| **Elsewhere** | 17.18 | (252.83) | -0.20 | (0.34) | 0.43 | (0.34) | 1.48** | (0.59) |
| **0% Infection** | 18.69 | (252.83) | 1.10*** | (0.26) | 2.46*** | (0.26) | 3.34*** | (0.53) |
| **10% Infection** | 0.79 | (0.57) | 1.24*** | (0.27) | 1.25*** | (0.27) | 1.87*** | (0.46) |
| **20% Infection** | 1.16 | (0.77) | 0.65* | (0.35) | 1.02** | (0.35) | 1.77** | (0.75) |
| **Opt-out** | 19.31 | (252.85) | -6.10** | (0.72) | 2.52*** | (0.94) | 2.03 | (1.41) |
| **Class share** | **0.15** | | **0.30** | | **0.31** | | **0.24** | |
| **Age** | 0.07 | (0.02) | 0.03 | (0.01) | 0.04 | (0.01) | a | |
| **constant** | -3.62 | (0.94) | -1.12 | (0.63) | -1.66 | (0.60) | a | |
| **Milk n = 273** | | | | | | | | |
| **Variable** | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | |
| **Price** | -0.25 | (0.28) | 1.13 | (0.69) | -3.65*** | 0.47) | -0.35 | (0.26) |
| **High welfare** | 2.99*** | (0.35) | -1.22* | (0.67) | 0.1 | 0.33) | 1.03*** | (0.27) |
| **Medium welfare** | 1.51*** | (0.33) | -1.70** | (0.71) | 0.53* | 0.31) | 0.15 | (0.30) |
| **Local** | 1.40*** | (0.31) | 0.44 | (0.54) | 1.39*** | 0.34) | 1.03*** | (0.25) |
| **Elsewhere** | 1.25*** | (0.34) | 0.38 | (0.64) | 1.33*** | 0.43) | 0.32 | (0.28) |
| **0% Infection** | 1.52*** | (0.28) | 3.49*** | (1.00) | 1.11*** | 0.34) | 3.10*** | (0.41) |
| **10% Infection** | 1.13*** | (0.33) | 4.26*** | (1.32) | 0.46 | 0.37) | 1.05*** | (0.40) |
| **20% Infection** | 1.07** | (0.49) | 3.20** | (1.35) | 0.72 | 0.54) | 1.12** | (0.45) |
| **Opt-out** | 1.38*** | (0.54) | 0.65 | (1.42) | -4.05*** | 0.62) | 3.61*** | |
| **Class share** | **0.31** | | **0.12** | | **0.26** | | **0.31** | |
| **Age** | -0.02** | (0.01) | -0.029* | (0.01) | 0.026** | (0.01) | a | |
| **constant** | 1.10** | (0.52) | 0.272 | (0.72) | -1.452** | (0.62) | a | |

+Note values are rounded to two decimal places. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance; a is used the baseline reference class to which others are compared.

Table 4.23: (A8) Latent class model results for UK consumers (lamb and wool) with class membership

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | **Lamb n = 236** | | | | |
| **Variable** | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | |
| **Price** | -0.25*** | (0.05) | -0.551*** | (0.17) | -6.807 | (36.72) | -0.051 | (0.04) |
| **High welfare** | 0.91*** | (0.33) | 7.1*** | (1.37) | 17.77 | (110.18) | 0.308 | (0.33) |
| **Medium welfare** | 0.91** | (0.36) | 4.679*** | (1.07) | 16.652 | (110.19) | 0.334 | (0.33) |
| **Local** | 0.96*** | (0.30) | -1.163 | (0.72) | -15.818 | (110.19) | 1.207*** | (0.27) |
| **Elsewhere** | 0.59** | (0.30) | -1.243* | (0.75) | 0.629 | (1.2013) | 0.555** | (0.26) |
| **0% Infection** | 2.07*** | (0.31) | 3.496*** | (0.79) | 20.525 | (110.18) | 1.092*** | (0.25) |
| **10% Infection** | 0.37 | (0.40) | 2.008*** | (0.53) | 0.687 | (0.88) | 0.822*** | (0.29) |
| **20% Infection** | -0.17 | (0.52) | -0.599 | (0.78) | 1.453 | (1.05) | -0.148 | (0.39) |
| **Opt-out** | 2.21*** | (0.488) | -0.47 | (1.27) | -51.21 | (275.46) | -1.66*** | (0.57) |
| **Class share** | **0.38** | | **0.18** | | **0.20** | | **0.24** | |
| **Age** | 0.025** | (0.01) | -0.003 | (0.01) | 0.014 | (0.01) | **a** | **a** |
| **constant** | -0.68 | (0.58) | -0.17 | (0.70) | -0.794 | (0.66) | a | a |
| | | | | **Wool n = 279** | | | | |
| **Variable** | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | |
| **Price** | -0.258*** | (0.06) | 0.201 | (0.18) | -0.488*** | (0.09) | 0.138 | (0.08) |
| **High welfare** | 3.68*** | (0.36) | -0.241 | (0.55) | -0.479 | (0.39) | 0.701* | (0.36) |
| **Medium welfare** | 2.174*** | (0.31) | -0.032 | (0.65) | -0.232 | (0.37) | -0.067 | (0.36) |
| **Local** | 0.978*** | (0.27) | 1.594** | (0.63) | 0.884*** | (0.32) | 0.763** | (0.31) |
| **Elsewhere** | 0.521* | (0.28) | 1.396** | (0.68) | 0.649* | (0.37) | -0.107 | (0.31) |
| **0% Infection** | 1.419*** | (0.24) | 3.345*** | (0.89) | 0.507* | (0.29) | 3.904*** | (0.66) |
| **10% Infection** | 1.224*** | (0.24) | 1.873*** | (0.51) | 0.649** | (0.31) | 1.328** | (0.66) |
| **20% Infection** | 0.303 | (0.37) | 0.278 | (0.82) | 2.06*** | (0.56) | 0.162 | (1.06) |
| **Opt-out** | 0.27 | (0.70) | -0.48 | (2.13) | -6.68*** | (1.18) | 6.30*** | (1.23) |
| **Class share** | **0.32** | | **0.14** | | **0.21** | | **0.33** | |
| **Age** | -0.027** | (0.01) | -0.007 | (0.01) | -0.031*** | (0.01) | a | |
| **constant** | 1.218** | (0.50) | -0.562 | (0.70) | 0.988* | (0.55) | a | |

+Note values are rounded to two decimal places. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance; a is used the baseline reference class to which others are compared.

Table 4.24: (A9) Posterior probability of class membership (with class membership)

| | Beef | Milk | Lamb | Wool |
|---|---|---|---|---|
| **Mean** | 0.93 | 0.92 | 0.95 | 0.94 |
| **Observations** | 242 | 273 | 236 | 279 |

Table 4.25: (A10) Probability of actual choice being in a specific class (with class membership)

| | Observations | Class | Unconditional probability | Conditional probability |
|---|---|---|---|---|
| **Beef** | 222 | 1 | 0.4706566 | 0.726494 |
| | 426 | 2 | 0.3954032 | 0.6062769 |
| | 426 | 3 | 0.3902399 | 0.6960484 |
| | 378 | 4 | 0.462842 | 0.7036286 |
| **Milk** | 474 | 1 | 0.4465762 | 0.6523206 |
| | 216 | 2 | 0.4375579 | 0.7555996 |
| | 432 | 3 | 0.4543657 | 0.7061936 |
| | 516 | 4 | 0.3560804 | 0.5745445 |
| | | | | |
| **Lamb** | 552 | 1 | 0.399072 | 0.685513 |
| | 258 | 2 | 0.411794 | 0.724222 |
| | 294 | 3 | 0.421489 | 0.853096 |
| | 312 | 4 | 0.371354 | 0.581684 |
| **Wool** | 522 | 1 | 0.4213073 | 0.6272684 |
| | 222 | 2 | 0.396206 | 0.7865558 |
| | 372 | 3 | 0.3690072 | 0.6917974 |
| | 558 | 4 | 0.3730472 | 0.7276101 |

# Chapter 5

# Information asymmetry and its influence on consumer perceptions for farm animal health and welfare

## 5.1 Abstract

In this chapter, I present the findings of a stated preference experiment conducted to determine whether information asymmetry on the safety of animal products might affect consumers' preferences for the health and welfare of farm animals. Farm animal health and welfare (FAHW) is studied from the perspective of Bovine Viral Diarrhoea (BVD) in cattle and lameness in sheep. These two endemic diseases are known to have an adverse effect on FAHW but they do not impact human health. Three animal products — beef, milk from cattle, and wool from sheep were used to measure the willingness to pay of the UK public to ensure high FAHW.

Respondents were divided into two treatment groups. The first treatment group was provided with explicit food/product safety information (n = 258) and the second treatment group was not given any food/product safety information (n = 269). The results indicate that i. despite the uncertainty caused by the ongoing COVID19 pandemic, the British public's preferences can still be captured by a separable utility for FAH and FAW. ii. that despite the inclusion or exclusion of the product/food safety information for human consumption and use, consumers preferred higher animal health whilst also preferring higher animal welfare. iii. the magnitude for WTP estimates for FAH and FAW although positive were dependent on the food/product safety information. However, upon testing it was found that there was no statistically significant difference in the willingness to pay coefficients between the two treatment groups.

The chapter is organised as follows: Section 5.2 provides an introduction to the topic and sets out the research questions. Section 5.3 outlines the design of the survey and describes the data. Section 5.4 presents the estimation results and section 5.5 provides a comparison of the willingness-to-pay estimates for the two treatment groups. Finally, in section 5.6 I discuss the findings and conclude.

## 5.2 Introduction

The motivation behind this chapter comes from the seminal work of LaRivere et al. (2014) who investigated how consumer preferences and the willingness to pay towards a public good are affected through exogenous changes in the agent's information set. This question is at the "intersection of stated preferences and behavioural economics" and I deemed it worth pursuing especially in an environment of heightened uncertainty like the ongoing pandemic.

Respondents were divided into two treatment groups. One group of respondents were provided information about the diseases but no product safety information for human consumption was included. This group was compared to a group that received explicit accentuated information on every choice card that the products -despite the farm sickness levels- were safe for human consumption. Thus, I refer to the former as "No information" treatment group and the latter group as "information" treatment group. As in the previous chapter, respondents were asked to make hypothetical but realistic purchasing decisions. They received information regarding the herd/flock sickness level and animal welfare grading. According to the results from the previous chapter, consumers tend to show strong preferences for low sickness levels in animals and high farm animal welfare. In order to determine if respondents' actions were motivated by fear and/or lack of knowledge regarding food safety, I re-ran a survey very similar to the one presented in the previous chapter.

Concerns regarding food safety especially due to scares in the UK such as the foot and mouth disease in 2001, Salmonella, and most recently avian influenza in 2021, unsurprisingly, can cause consumers to seek information or assurances on which to base their purchasing decisions. A multitude of information is communicated to consumers through labels on products. Mayfield et al. (2007) found that consumers did not feel well informed about animal welfare issues and that product labels were the preferred source of information. Labels provide consumers with a wealth of information and along with it, implicitly, the safety of the product is presumed. However, as documented by Aakkula et al. (2005) not all consumers are worried about food safety. Using a contingent valuation questionnaire in Finland the authors studied consumer perceptions to food safety concluding that different parties may take varying measures to ensure the safety of food, conditional on their individual characteristics and circumstances.

There is a burgeoning literature focusing on how households change their behaviour when they are given additional information or advice (Jensen, 2007; Duflo and Saez, 2003; Jessoe and Rapson, 2014). Eil and Rao (2011) and Grossman and Owens (2012), among others, find that giving economic agents more knowledge or guidance on a good may greatly affect their decision-making or rather their valuation for that product even when the agent does not have personal experience using or purchasing that good. However, the existence of different information sources (from scientific reports to neighbours) does not mean that all respondents place the same weight to or even use the same sources to inform themselves (Kornelis et al., 2007). As shown by Doherty and Campbell (2014) in their study that compares preferences of consumers in Great Britain and Republic of Ireland, the authors investigated the connection between consumer demand for enhanced food safety and place of origin attribute. Employing a DCE they find that consumers were willing to substitute enhanced food safety features for regional labels.

Nonetheless, much like Hoehn et al. (2010), I investigate the effect of additional information on shaping consumer preferences in the context of environmental goods. Unlike Needham et al. (2018) I am not examining "how information affects knowledge and how knowledge affects preferences" but rather, similar to Smith et al. (1988) or Boyle (1989) I assume that the group provided with the explicit information regarding food safety fully internalise it as a credible fact and that everyone in the information group updates their knowledge in the same way. This assumption can be easily justified. As documented in Clark (2022), despite the fact that the British public is supportive of the use of public funds to assure high farm animal health and welfare, the study finds that there is little trust and low recognition in Quality assurance labels. Additionally, as shown in Bruhn and Schutz (1999) consumers deem university scientists and health practitioners amongst the most dependable sources of food safety information compared to industry food labels. Hence, one can conjecture that there is credible information asymmetry between respondents belonging to different treatment groups. The group with no explicit product/food safety information receives a "safety" signal only through the market place labels in the form of the attribute animal welfare grading. Whilst the group with food/product safety information receives an additional explicit and independent signal of food safety.

The debate on food safety and consumers' willingness to pay for food safety is not a recent one. Lewis et al. (2017) investigates the willingness to pay of British and German consumers for labelled beef using safety attributes in a choice experiment. The authors use country of origin, quality assurance, and hormone-free label as proxies for safety attributes in beef. It was assumed that respondents who prioritised food safety issues would be willing to pay for beef products with such features. The study showed that consumers appeared to associate country of origin and hormone-free labels the most with food safety issues and thus, they reported high willingness to pay for domestic beef [1]. Becker et al. (2000) investigated the notions "quality" of fresh meat in Germany. According to the authors, consumers used "country of origin" to gauge both the safety and the quality of the food. Lusk and Schroeder (2004) established a choice format with posted prices[2] in various scenarios to examine the consumers' willingness to pay (WTP) for food quality attributes. Following their example, I rely on a similar model that uses posted prices, product origin, infection levels and farm animal welfare (FAW) gradings to elicit information on consumers' WTP to ensure high FAHW in the UK.

Therefore the main research questions considered in this chapter are as follows. Firstly, much like the previous chapter, I examine the separation of FAH and FAW however this time in the presence of information asymmetry as well as accounting for the interaction between FAH and FAW which are the novel and central contributions of this chapter. In other words, how information asymmetry regarding product safety is affecting the willingness to pay for high FAHW. Secondly, since this experiment took place during the height of the COVID19 pandemic, what is the willingness to pay for FAH and FAW during this period of increased uncertainty. Similar to chapter 4, preferences are studied in the context of two endemic diseases: Bovine Viral Diarrhoea (BVD) in cattle and lameness in sheep. Finally, I should mention that this study also complements the work of Balcombe et al. (2021) who use choice experiments to gauge the UK public's WTP towards FAHW but through

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[1] By domestic beef they refer to beef produced in Germany and UK. As both countries were part of the EU at the time, this classification implicitly assured lack of growth hormones as well.

[2] Posted prices are the prevailing market prices. They show the price level for a specific commodity at which households are willing to buy or sell a unit of that good.

the lens of prohibited production methods instead. The rest of the chapter is organised as follows. Section 5.3 presents the methodology used for this study. Next, I discuss the key results in Section 5.4. Section 5.5 contains the discussion regarding the willingness to pay estimates. Finally, section 5.6 summarises the key results and concludes this chapter.

## 5.3 Methodology

I use the discrete choice experiment (DCE) approach based on random utility theory to estimate the preferences of consumers for farm animal health and welfare with the same econometric estimation techniques as the previous chapter [3].

The experiment was organised as follows. I created two sets of discrete choice experiment surveys similar in every aspect except on information on food safety. The sample was split into two treatment groups with one set of respondents receiving food/product safety information ($n = 258$) and the other receiving no food/product safety information ($n = 269$). In the information treatment group, an explicit statement about the safety of the product was displayed on every choice card emphasising the safety of the products despite the sickness levels in the herd/flock. The statement included was " All products are safe to consume regardless of infection level". See Figure 5.1 for an example choice card for beef. The choice cards for milk, and wool followed a similar design. This information was reiterated in the disease overview section as well as in the section describing the attributes. On the other hand, the treatment sample with no product safety information did not receive any statement commenting on the safety of the product for human consumption. In the disease overview section while describing the diseases BVD and lameness presented before the choice experiment, no remark was made on the food safety or human health aspect of the diseases.

This survey unlike the one in chapter four used three animal products: beef and milk from cattle and pure wool from sheep. Wool the only non-edible product was included because firstly, in order to understand whether consumers are willing to pay for FAH and FAW when "food safety" and therefore effects on human health is not a concern and secondly, since not everyone in the UK consumes meat, including a non-edible animal product can help increase the representativeness of my sample when investigating consumers preferences towards FAWH. Lamb chops were dropped out of this study for simplicity as they did not provide information that was not present in the other animal products. Every respondent received two choice sets that included a product from each animal in a random order. Vegetarian respondents were limited to receiving the combination milk and wool. Three Bayesian efficient experimental designs was generated on NGene, one for each product. This allowed me to make comparisons between the two data sets with and without product safety information. The Bayesian priors used were those generated by the previous survey from chapter 4. The quantity of beef steak was halved to 250 grams which is approximately 1 steak and therefore the prices were halved as well. The price range for milk was also updated in line with market trends. The prices of wool were unchanged. The remainder of the attributes and attribute levels used in the experiment are summarised in Table 5.1, unchanged from the previous chapter. The experimental design was composed of three blocks of six choice scenarios each. Another differing feature of the experimental design compared to the previous chapter was the inclusion of the

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[3] I provide a full exposition of the estimation techniques in chapter 3 and chapter 4

interaction between the animal welfare and infection level attribute. This was done in order to test whether respondents consider FAH and FAW independently.

I developed the survey in Sawtooth and distributed it online using Qualtrics, a market research company in May 2021 on a representative [4] sample of consumers in the UK. The representativeness of each sample was based on key demographic characteristics of the UK population for example in terms of age, income, education and gender. A complete description of the socio-demographic data collected in the surveys is provided in table 5.15 in the appendix.

Table 5.2 describes the respondent characteristics and how they compare to the UK average. My treatment samples had 50% and 49% male respondents in the information and no information treatment groups respectively in line with the UK average of 49%. The age distribution was similar to that of the UK, with the exception of consumers over the age of 55, where our sample included 32% and 31% respondents in each of the respective samples versus the 37% in the UK population. The average household size was 3 people. The median education level was A-levels or equivalent. The median monthly household (pre-tax) income in my sample was between £2000 and £2500, which is similar to the ONS's reported annualised median income of £30,762 for 2019/20. Finally, I also report whether the participants believed that their expected future income is affected due to the restrictions caused by the COVID19 pandemic.

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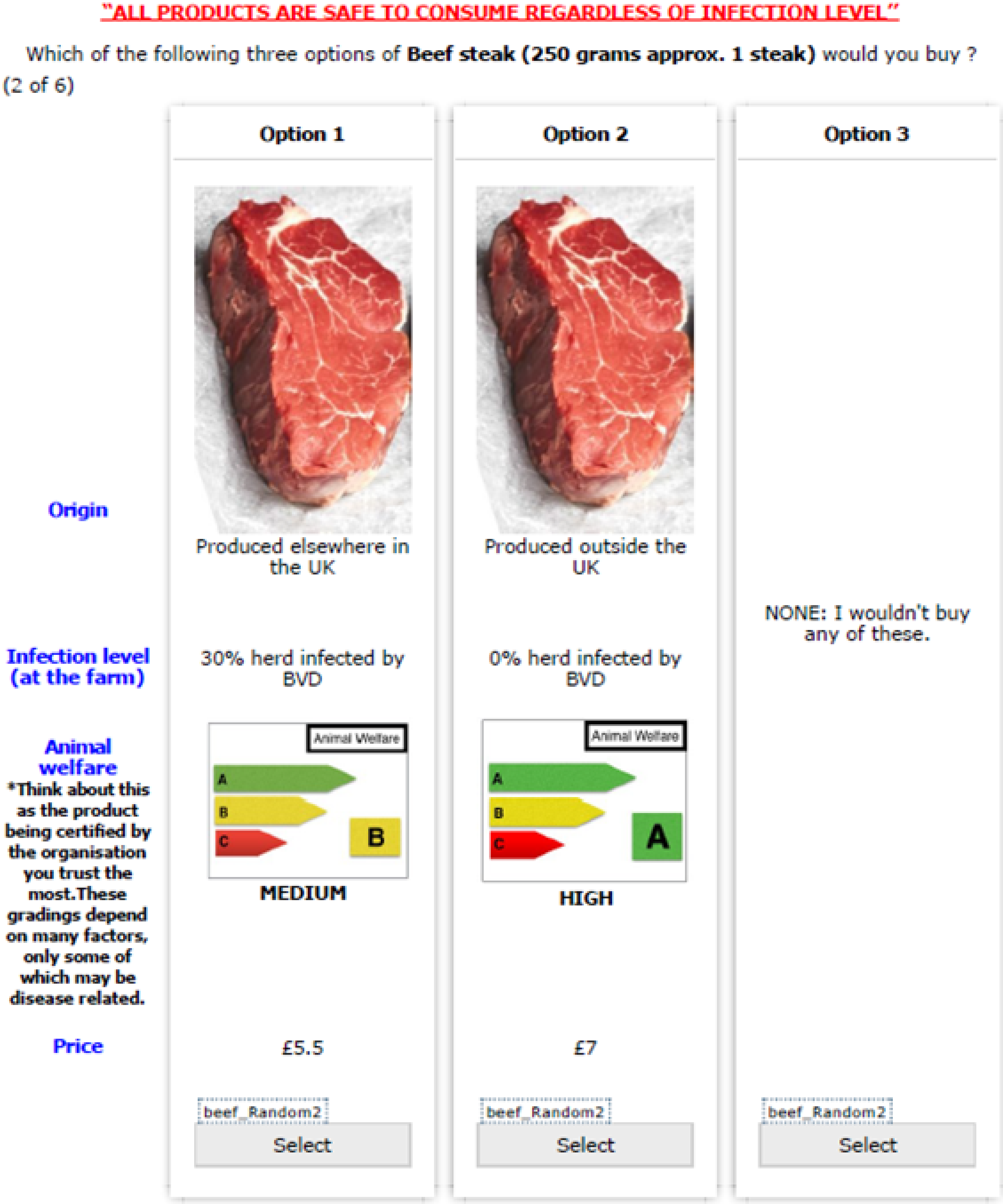
[4] The statistics for the UK population are from ONS (Office of National Statistics) and the UK 2011 census.



**"ALL PRODUCTS ARE SAFE TO CONSUME REGARDLESS OF INFECTION LEVEL"**

Which of the following three options of **Beef steak (250 grams approx. 1 steak)** would you buy ?
(2 of 6)

| | **Option 1** | **Option 2** | **Option 3** |
|---|---|---|---|
| **Origin** | Produced elsewhere in the UK | Produced outside the UK | NONE: I wouldn't buy any of these. |
| **Infection level (at the farm)** | 30% herd infected by BVD | 0% herd infected by BVD | |
| **Animal welfare** ***Think about this as the product being certified by the organisation you trust the most.These gradings depend on many factors, only some of which may be disease related.** | B<br>**MEDIUM** | A<br>**HIGH** | |
| **Price** | £5.5 | £7 | |

Figure 5.1: Example choice scenario with with safety text displayed on every choice scenario in the food safety information survey for beef

Table 5.1: Attributes and their levels in the choice experiment

| Attributes | Description | Levels | |
|---|---|---|---|
| **Price** | Beef steak (fillet) | £5.5, £7, £8.5 | 250 grams i.e., 1 steak |
| | Milk | £0.80, £1, £1.20 | 1 litre = 1.75 pints |
| | Wool (pure) | £7, £9, £11 | 100 grams |
| **Animal welfare (Grading)** | High | A | |
| | Medium | B | |
| | Low | C | |
| **Infection level in the herd** | Beef steak | 0%, 10%, 20%, 30% | BVD |
| | Milk | 0%, 10%, 20%, 30% | BVD |
| **Infection level in the flock** | Wool (pure) | 0%, 10%, 20%, 30% | Lameness |
| **Origin** | | Locally produced | $<$ 50 miles from shop |
| | | Produced elsewhere in the UK | |
| | | Produced outside the UK | |

Table 5.2: Socio- demographic characteristics of the respondents

| **Variables** | **Sample Information (n = 258)** | **Sample No Information (n = 269)** | **UK Population** |
|---|---|---|---|
| Share of males (%) | 0.50 | 0.49 | 0.49 |
| Average family size ($n$) | 2.56 | 2.64 | 2.3 |
| Age (years) (%) | | | |
| 18 – 24 | 0.10 | 0.11 | 0.11 |
| 25 - 34 | 0.18 | 0.20 | 0.17 |
| 35 - 44 | 0.17 | 0.17 | 0.16 |
| 45 - 54 | 0.21 | 0.20 | 0.19 |
| 55 and Over | 0.32 | 0.31 | 0.37 |
| Age (mean) | 46 years | 46 years | |
| Age (median) | 50 years | 50 years | 40 years |
| Age (mode) | 50 years | 50 years | |
| Education level | | | |
| Median | A-levels or advance GVNQ or equivalent | A-levels or advance GVNQ or equivalent | 41% adults have college degrees |
| Mode | Postgraduate degree | Undergraduate degree | |
| Income distribution (monthly after tax) | | | |
| Median | £2001 – £2500 | £2001 - £2500 | £1700 |
| Mode | £1001 - £1500 | £2001 - £2500 | |
| Covid19 impact on expected future earnings (%) | Yes = 0.28 No = 0.71 | Yes = 0.32 No = 0.68 | |

## 5.4 Results

The analyses were carried out for each of three products using multinomial logit (MNL) and random parameter logit (RPL) regressions comparing the two treatment [5] data sets. Note throughout the chapter, the sign of the estimated standard deviations for the RPL models is irrelevant.

### 5.4.1 Beef

Results from the MNL and RPL models for beef for both treatment groups are presented in tables 5.3 to 5.5. Tables 5.3 and 5.4 display the results from the MNL and RPL models capturing the effects of socio-demographics. The RPL model was estimated using Sobol sequences with 100 draws following Garrido (2003). This approach has been used widely in the discrete choice modelling literature as it overcomes the main problems of Halton sequences.All the attribute coefficients for beef were found be statistically significant across all models. An increase in *animal welfare* is preferred as well as a decrease in *infection levels* in both my treatment samples. Similar to the results in the previous chapter, the *origin* attribute that indicates the product traceability saw respondents preferring locally produced beef over beef produced outside the UK.

The opt-out option gives consumers the choice to buy none of the offered products, and is represented by the alternative specific constant. This parameter was negative and statistically significant, demonstrating that, on average, the participants did not opt to decline the purchase of beef that was offered to them. This was true for all estimated models for beef. Similarly, the price attribute was significant and negative in all models indicating higher prices of beef resulted in decreased utility.

Now let us look at the socio-demographic interactions with the opt out alternative in tables 5.3 and 5.4 to see the effects of consumer characteristics on purchasing decisions. In all models, older respondents were more likely to opt out of buying steak given the choices in both samples. It should also be noted that all the models also found respondents with higher number of kids under the age of 18 opting to make a purchase instead of choosing to not buy. Consumer purchasing decisions did not appear to be influenced by income as this parameter was not significant in all models. The results form the MNL model for both treatment groups show that higher education level meant the respondent was more likely to opt out of buying. Male respondents on the other hand were more likely to buy beef as presented to them in the choice experiment.

Next, one can also see that there exists significant preference heterogeneity as indicated by the estimated standard deviations. While *high welfare* beef exhibited considerable variation in consumer preferences in the treatment sample that did receive information about food safety, *medium welfare* beef displayed no preference heterogeneity. In contrast, I find significant heterogeneity in preferences for both *high welfare* and *medium welfare* beef in the sample that did not receive food safety information. Similarly, the attribute *infection level* saw variation in preferences in all the attribute levels for the sample with no food safety information. However, the sample that received food safety information saw no heterogeneity in preferences for *10% infection level*

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[5] The first group which I refer to as the information treatment group has received explicit food safety information whilst the other group has not being given any food safety information and thus, I refer to them as the no- information treatment group.

however *20%* and *30% infection levels* saw significant preference heterogeneity. The attribute *origin* in the sample with no safety information saw no variability in their preferences for *locally produced* products and those products *produced elsewhere in the UK* (greater than 50 miles from their place of purchase). On the other hand, one can easily observe that respondents from the sample that received food safety information displayed preference heterogeneity towards *locally produced* beef but not for beef *produced elsewhere in the UK* .

Table 5.5 the presents results of the main effects [6] model as well as a model with an interaction of animal welfare attribute with infection level attribute. The variable is coded as a continuous variable which is given by the interaction of animal welfare attribute (where 3 represents high animal welfare, 2 medium welfare, 1 low welfare and 0 indicating opt-out) and the attribute infection level (where 4 represents 30% infection level, 3 is 20% infection level, 2 is 10% infection level, 1 represents 0 infection level, and 0 for opt-out). In the no information treatment group, as respondents preferred *higher animal welfare*, we can see that their preference for *lower infection in the herd* decreased. However, significant preference heterogeneity was observed. Note also that the inclusion of this interaction variable, causes the heterogeneity in the low and medium infection level to become insignificant. The presence of heterogeneity is not surprising as in the absence of information consumers may try making educated guess based on the implicit information they receive on product attributes and their own personal experience. In both models (1) and (2), when looking at preferences towards animal welfare, consumers value higher welfare and lower infections- a result consistent across all models and treatment groups. From models (3) and (4) from the information treatment group, it is evident that although consumers care about the FAH and FAW independently; when interacting welfare and infection, the coefficient is not significant and as such one can infer that consumers consider the two attributes to be independent issues. Provision of safety information ensures that consumers treat assurance of high animal health and welfare as orthogonal problems.

To compare model fit I looked at the Akaike Information Criteria (AIC), Bayesian Information Criterion (BIC) and the log-likelihood for each of the models presented in tables 5.3 and 5.4. Starting with the treatment group that received no food safety information, the AIC and BIC for RPL model (1294.62 and 1432.44 respectively) is lower than for the MNL model (1480.70 and 1566.84 respectively). As for the log-likelihood the RPL model ( -623.61) has a higher log-likelihood than the MNL model (-725.41). As for the treatment group that received safety information, the AIC and BIC for RPL model (1307.09 and 1444.53 respectively) is lower than for the MNL model (1490.54 and 1576.47 respectively). As for the log-likelihood the RPL model ( -629.5) has a higher log-likelihood than the MNL model (-731.9). All three of the information criterion indicate the RPL model is a preferred model over the MNL model.

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[6] Refers to the primary independent attributes included in the study.

Table 5.3: Estimation results for Multinomial Logit Model with attribute level-dummy variable (Beef)

| **Beef** | **No Information** | **Information** |
|---|---|---|
| Variables | (1)<br>β (SE) | (2)<br>β (SE) |
| Opt-out | -4.174*** | -4.550*** |
| | (0.572) | (0.590) |
| *Price* | -0.351*** | -0.375*** |
| | (0.0504) | (0.0498) |
| *Animal Welfare (Base level = Low)* | | |
| High Welfare = 1 | 0.579*** | 0.740*** |
| | (0.175) | (0.172) |
| Medium Welfare = 1 | 0.443** | 0.626*** |
| | (0.177) | (0.173) |
| *Origin (Base level = Produced outside the UK* | | |
| Locally Produced = 1 | 0.312** | 0.316** |
| | (0.147) | (0.141) |
| Produced elsewhere in the UK = 1 | 0.351** | 0.290* |
| | (0.171) | (0.161) |
| *Infection level (Base level = 0%)* | | |
| 10% infection in the herd | -1.231*** | -0.848*** |
| | (0.199) | (0.196) |
| 20% infection in the herd | -1.153*** | -0.974*** |
| | (0.178) | (0.175) |
| 30% infection in the herd | -1.688*** | -1.202*** |
| | (0.175) | (0.166) |
| **Interactions with Opt-Out alternative** | | |
| Age | 0.0322*** | 0.0297*** |
| | (0.00573) | (0.00638) |
| Income | -8.73e-05 | -4.13e-05 |
| | (7.05e-05) | (7.44e-05) |
| Education | 0.307*** | 0.228** |
| | (0.0972) | (0.101) |
| Male | -0.595*** | -0.227 |
| | (0.176) | (0.179) |
| Number of kids | -0.515*** | -0.364*** |
| | (0.109) | (0.125) |
| Expected future income | -0.262 | -0.357 |
| | (0.198) | (0.223) |
| **Information criteria** | | |
| Number of observations | 2,304 | 2,286 |
| Number of respondents | 128 | 127 |
| Log-likelihood | -725.4 | -731.9 |
| AIC | 1480.70 | 1490.54 |
| BIC | 1566.84 | 1576.47 |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

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Table 5.4: Estimation results from Random Parameter Logit model- demographics (Beef)

| **Beef** | **No Information** | | **Information** | |
|---|---|---|---|---|
| | (1) | | (2) | |
| Variables | β (SE) | Standard deviation | β (SE) | Standard |
| Opt-out | -8.310*** | 2.647*** | -8.101*** | 2.658*** |
| | (1.869) | (0.490) | (1.635) | (0.410) |
| *Price* | -0.584*** | 0.236*** | -0.565*** | 0.0948 |
| | (0.0958) | (0.0756) | (0.0847) | (0.116) |
| *Animal Welfare (Base level = Low)* | | | | |
| High Welfare = 1 | 1.259*** | 1.648*** | 1.340*** | 1.601*** |
| | (0.353) | (0.405) | (0.325) | (0.361) |
| Medium Welfare = 1 | 0.984*** | 0.903* | 1.029*** | -0.261 |
| | (0.323) | (0.467) | (0.294) | (0.691) |
| *Origin (Base level = Produced outside the UK* | | | | |
| Locally Produced = 1 | 0.777*** | 0.290 | 0.642*** | 0.892*** |
| | (0.248) | (0.586) | (0.239) | (0.335) |
| Produced elsewhere in the UK = 1 | 0.584** | 0.0689 | 0.472** | -0.415 |
| | (0.262) | (0.680) | (0.236) | (0.473) |
| *Infection level (Base level = 0%)* | | | | |
| 10% infection in the herd | -2.108*** | -1.272** | -1.405*** | 0.632 |
| | (0.393) | (0.618) | (0.330) | (0.597) |
| 20% infection in the herd | -2.248*** | 2.368*** | -1.862*** | 1.685*** |
| | (0.422) | (0.653) | (0.372) | (0.510) |
| 30% infection in the herd | -3.431*** | 2.477*** | -2.206*** | 1.963*** |
| | (0.525) | (0.505) | (0.363) | (0.413) |
| **Interaction with opt-out alternative** | | | | |
| Age | 0.0625*** | | 0.0673*** | |
| | (0.0223) | | (0.0234) | |
| Income | 0.000207 | | -7.67e-05 | |
| | (0.000288) | | (0.000262) | |
| Education | 0.339 | | 0.138 | |
| | (0.367) | | (0.265) | |
| Male | -1.093 | | -0.470 | |
| | (0.672) | | (0.660) | |
| Number of kids | -1.307*** | | -0.879** | |
| | (0.458) | | (0.448) | |
| Expected future income | -0.352 | | -1.108 | |
| | (0.743) | | (0.903) | |
| **Information criteria** | | | | |
| Number of observations | 2,304 | | 2,286 | |
| Number of respondents | 128 | | 127 | |
| Log-likelihood | -623.6 | | -629.5 | |
| AIC | 1294.62 | | 1307.09 | |
| BIC | 1432.44 | | 1444.53 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance

Table 5.5: Estimation results from Random Parameter Logit model (Beef)

**Beef**

| | **No Information** | | | | **Information** | | | |
|---|---|---|---|---|---|---|---|---|
| Beef | **(1)** | | **(2)** | | **(3)** | | **(4)** | |
| Variables | β (SE) | Standard deviation | β (SE) | Standard deviation | β (SE) | Standard deviation | β (SE) | Standard deviation |
| Opt-out | -5.391*** | 3.029*** | -5.348*** | 2.839*** | -5.396*** | 3.143*** | -4.871*** | 2.611*** |
| | (0.855) | (0.565) | (1.041) | (0.583) | (0.740) | (0.508) | (0.860) | (0.496) |
| *Price* | -0.603*** | -0.277*** | -0.578*** | 0.231*** | -0.559*** | 0.171** | -0.540*** | 0.275*** |
| | (0.101) | (0.0834) | (0.107) | (0.0626) | (0.0802) | (0.0746) | (0.0914) | (0.0618) |
| *Animal Welfare (Base level = Low)* | | | | | | | | |
| High Welfare = 1 | 1.242*** | 1.672*** | 1.630*** | 0.982* | 1.302*** | 1.485*** | 1.747*** | 1.452*** |
| | (0.364) | (0.401) | (0.626) | (0.521) | (0.306) | (0.349) | (0.577) | (0.373) |
| Medium Welfare = 1 | 0.968*** | 0.280 | 1.067*** | -0.963** | 1.004*** | -0.141 | 1.415*** | -0.241 |
| | (0.314) | (1.197) | (0.414) | (0.473) | (0.277) | (0.601) | (0.362) | (0.758) |
| *Origin (Base level = Produced outside the UK* | | | | | | | | |
| Locally Produced = 1 | 0.743*** | -0.298 | 0.884*** | -0.659 | 0.647*** | 0.693** | 0.707*** | 0.713* |
| | (0.253) | (0.456) | (0.272) | (0.404) | (0.223) | (0.328) | (0.236) | (0.391) |
| Produced elsewhere in the UK = 1 | 0.551** | -0.0554 | 0.637** | -0.106 | 0.471** | -0.261 | 0.530** | 0.146 |
| | (0.263) | (0.521) | 0.884*** | -0.659 | (0.228) | (0.474) | (0.266) | (0.727) |
| *Infection level (Base level = 0%)* | | | | | | | | |
| 10% infection in the herd | -2.161*** | 1.474* | -1.069** | -0.655 | -1.304*** | 0.370 | -1.196*** | -0.435 |
| | (0.435) | (0.787) | (0.465) | (0.507) | (0.300) | (0.792) | (0.407) | (0.708) |
| 20% infection in the herd | -2.370*** | -2.449*** | -1.398** | 0.0532 | -1.720*** | 1.392*** | -1.727*** | 0.532 |
| | (0.458) | (0.741) | (0.682) | (0.591) | (0.328) | (0.486) | (0.614) | (0.618) |
| 30% infection in the herd | -3.529*** | 2.639*** | -2.825*** | -1.732*** | -2.089*** | 1.777*** | -2.406*** | -0.537 |
| | (0.585) | (0.642) | (0.944) | (0.491) | (0.332) | (0.404) | (0.814) | (0.726) |
| Welfare*infection level | | | -5.037** | 11.74*** | | | -0.527 | 6.042*** |
| | | | (2.517) | (2.135) | | | (1.531) | (1.000) |
| **Information criteria** | | | | | | | | |
| Number of observations | 2304 | | 2,304 | | 2,286 | | 2,286 | |
| Number of respondents | 128 | | 128 | | 127 | | 127 | |
| Log-likelihood | -637.7 | | -593.9 | | -641.9 | | -619.6 | |
| AIC | 1311.42 | | 1227.74 | | 1319.77 | | 1279.24 | |
| BIC | 1414.78 | | 1342.59 | | 1422.85 | | 1393.78 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01,** p<0.05, * p<0.1 indicate significance.

### 5.4.2 Milk

In this sub-section let us look at the results of the analysis for milk in tables 5.6 - 5.8. The appendix contains additional results for milk. Tables 5.6 and 5.7 show the results of the MNL and RPL models for milk for both treatment groups. All the attribute coefficients for milk were found be statistically significant across all models for both samples. Both an increase in animal welfare as well as a decrease in infection levels in both of the treatment samples are found to be preferable. Respondents also exhibited strong preference for locally produced milk over milk produced outside the UK preferring closer proximity of production. Table 5.7 presents results from the RPL model where, to allow for unobserved preference heterogeneity, all attributes were specified to have a random component. The pattern observed is similar to what is found in the multinomial logit models for both treatment samples.

Respondents have the option to choose not to purchase any of the available milk products displayed in the choice experiment, and this option is represented by the opt-out variable. The results indicate this parameter to be negative and statistically significant meaning that participants did not opt to decline the purchase of milk that was offered to them. This was true in all of the milk models. Similarly, the price attribute was also significant and negative across all models, demonstrating that higher prices of milk were associated with lower utility.

Now let us look at the socio-demographic interactions with the opt out alternative in tables 5.6 and 5.7. The MNL model shows age to be statistically significant variable indicating that older respondents were more likely to opt out of purchasing milk as was displayed on the choice cards. This was also the case in the RPL model for the sample that did not receive food safety information. However, the result was not significant for the information treatment group. In the MNL model, the no- information treatment group also saw respondents with a higher number of children under the age of 18 opting to make a purchase instead of opting out of buying. In the group that was provided with food safety information, male respondents were more likely to choose to buy milk as seen in the choice experiment in both MNL and RPL models whereas respondents whose expected future household income was affected due to the restrictions caused by the COVID19 pandemic, chose to buy milk as was presented to them. Additionally, in table 5.7 observe there was no preference heterogeneity in price, origin and 10% infection level for the no-information treatment group. On the other hand, in the information treatment group, attribute levels milk produced elsewhere in the UK and milk that comes from farms with 10% infection level has no variability in preferences.

Table 5.8 shows the results from the RPL model when allowing animal welfare attribute to interact with the infection level attribute. Models (1) and (3) are the base main effects models and models (2) and (4) capture the effect of interaction between animal welfare grading and infection level attribute. Overall both treatment groups, show similar preferences between FAH and FAW, with the exception of the interacted variable. Respondents in both groups seem to prefer lower prices, higher welfare levels in the herd as well as lower infection levels. The opt out attribute is found to be statistically significant and negative across groups and models, demonstrating that respondents are likely to accept the purchase of the proposed product. However, when looking at the interacted variable the results change across groups. In the no- information treatment group, the interacted attributes are not statistically significant and preference heterogeneity is detected. On the other hand, for the information treatment group this result is reversed, meaning that the attribute coefficient is found to be statistically significant, although preference heterogeneity amongst respondents still persists. The sign of the coefficient stems from the infection attribute showing us that lower infection levels with higher welfare is preferred. Respondents from the information treatment group are unable to fully distinguish FAH from FAW, while caring about higher FAW and lower infection levels (in isolation).

To examine model fit, I evaluated the Akaike Information Information Criterion (AIC), Bayesian Information Criterion (BIC), and log-likelihood for each of the models shown in tables 5.6 and 5.7. The AIC and BIC for the RPL model (1395.03 and 1535.16 respectively) in the treatment group that did not receive information on food safety are lower than for the MNL model (1660.98 and 1748.56 respectively). The log-likelihood of the RPL model (-673.5) is greater than that of the MNL model (-815.5). The AIC and BIC for the sample that received food safety information in the RPL model (1277.25 and 1415.62, respectively) are lower than for the MNL model (1565.57 and 1652.05 respectively). As for the log-likelihood the RPL model ( -614.6) has a higher log-likelihood than the MNL model (-765.5).The RPL model is recommended above the MNL model according to all three informational criteria.

Table 5.6: Estimation results for Multinomial Logit Model with attribute level-dummy variable (Milk)

| **Milk** | **No Information** | **Information** |
|---|---|---|
| | (1) | (2) |
| Variables | β (SE) | β (SE) |
| Opt-out | -2.578*** | -2.530*** |
| | (0.508) | (0.522) |
| *Price* | -1.476*** | -1.698*** |
| | (0.324) | (0.328) |
| *Animal Welfare (Base level = Low)* | | |
| High Welfare = 1 | 0.949*** | 0.930*** |
| | (0.148) | (0.149) |
| Medium Welfare = 1 | 0.448*** | 0.564*** |
| | (0.142) | (0.145) |
| *Origin (Base level = Produced outside the UK* | | |
| Locally Produced = 1 | 0.621*** | 0.473*** |
| | (0.136) | (0.136) |
| Produced elsewhere in the UK = 1 | 0.442*** | 0.445*** |
| | (0.139) | (0.140) |
| *Infection level (Base level = 0%)* | | |
| 10% infection in the herd | -0.900*** | -0.624*** |
| | (0.137) | (0.140) |
| 20% infection in the herd | -1.438*** | -1.072*** |
| | (0.172) | (0.172) |
| 30% infection in the herd | -1.670*** | -1.175*** |
| | (0.173) | (0.170) |
| **Interactions with Opt-Out alternative** | | |
| Age | 0.0199*** | 0.0162** |
| | (0.00560) | (0.00636) |
| Income | 0.000018 | 0.000103 |
| | (6.66e-05) | (6.89e-05) |
| Education | -0.085 | -0.150 |
| | (0.0901) | (0.0984) |
| Male | 0.217 | -0.811*** |
| | (0.170) | (0.194) |
| Number of kids | -0.314*** | -0.172 |
| | (0.119) | (0.130) |
| Expected future income | -0.239 | 0.436** |
| | (0.191) | (0.205) |
| **Information criteria** | | |
| Number of observations | 2,538 | 2,358 |
| Number of respondents | 141 | 131 |
| Log-likelihood | -815.5 | -765.5 |
| AIC | 1660.98 | 1565.57 |
| BIC | 1748.56 | 1652.05 |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 5.7: Estimation results from Random Parameter Logit model- demographics (Milk)

| **Milk** | **No Information** | | **Information** | |
|---|---|---|---|---|
| Variables | β (SE) | Standard deviation | β (SE) | Standard deviation |
| Opt-out | -7.349*** | 3.734*** | -7.995*** | 5.942*** |
| | (2.326) | (0.563) | (2.689) | (1.260) |
| *Price* | -2.901*** | 0.851 | -4.051*** | -2.181*** |
| | (0.569) | (0.929) | (0.699) | (0.704) |
| *Animal Welfare (Base level = Low)* | | | | |
| High Welfare = 1 | 1.686*** | -1.332*** | 1.985*** | 1.568*** |
| | (0.287) | (0.457) | (0.373) | (0.493) |
| Medium Welfare = 1 | 0.679*** | 1.261*** | 0.938*** | 1.481*** |
| | (0.234) | (0.400) | (0.283) | (0.432) |
| *Origin (Base level = Produced outside the UK* | | | | |
| Locally Produced = 1 | 1.046*** | 0.669* | 0.826*** | 1.135*** |
| | (0.219) | (0.380) | (0.247) | (0.334) |
| Produced elsewhere in the UK = 1 | 0.532** | 0.578 | 0.469** | 0.793* |
| | (0.225) | (0.581) | (0.239) | (0.410) |
| *Infection level (Base level = 0%)* | | | | |
| 10% infection in the herd | -1.362*** | 0.151 | -0.998*** | 0.0958 |
| | (0.214) | (0.491) | (0.222) | (0.333) |
| 20% infection in the herd | -2.383*** | 1.032** | -2.014*** | 0.838* |
| | (0.347) | (0.460) | (0.348) | (0.479) |
| 30% infection in the herd | -3.085*** | 2.114*** | -2.355*** | 2.975*** |
| | (0.447) | (0.557) | (0.497) | (0.699) |
| **Interactions with opt-out alternative** | | | | |
| Age | 0.0555** | | 0.0503 | |
| | (0.0263) | | (0.0388) | |
| Income | 8.57e-05 | | 0.000337 | |
| | (0.000347) | | (0.000442) | |
| Education | -0.129 | | -0.798 | |
| | (0.422) | | (0.706) | |
| Male | 0.561 | | -3.038*** | |
| | (0.842) | | (1.174) | |
| Number of kids | -0.313 | | -0.173 | |
| | (0.426) | | (0.797) | |
| Expected future income | -0.581 | | 1.007 | |
| | (1.023) | | (1.237) | |
| **Information criteria** | | | | |
| Number of observations | 2,538 | | 2,358 | |
| Number of respondents | 141 | | 131 | |
| Log-likelihood | -673.5 | | -614.6 | |
| AIC | 1395.03 | | 1277.25 | |
| BIC | 1535.16 | | 1415.62 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 5.8: Estimation results from Random Parameter Logit model (Milk)

| **Milk** | **No Information** | | | | **Information** | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| Variables | β (SE) | Standard deviation | β (SE) | Standard deviation | β (SE) | Standard deviation | β (SE) | Standard deviation |
| Opt-out | -4.996*** | 3.952*** | -5.141*** | 3.751*** | -9.286*** | 6.827*** | -8.048*** | 5.125*** |
| | (0.742) | (0.564) | (0.788) | (0.512) | (1.795) | (1.834) | (1.335) | (0.951) |
| *Price* | -2.997*** | 1.443*** | -3.098*** | 1.006 | -4.752*** | 3.615*** | -4.185*** | 2.116*** |
| | (0.559) | (0.518) | (0.587) | (0.659) | (0.902) | (1.023) | (0.791) | (0.695) |
| *Animal Welfare (Base level = Low)* | | | | | | | | |
| High Welfare = 1 | 1.752*** | 1.447*** | 1.825*** | 1.575*** | 2.112*** | -1.588*** | 1.648*** | -1.441*** |
| | (0.296) | (0.381) | (0.387) | (0.425) | (0.389) | (0.513) | (0.437) | (0.505) |
| Medium Welfare = 1 | 0.684*** | 1.471*** | 0.720*** | 1.096* | 0.888*** | 1.350*** | 0.707** | -0.892 |
| | (0.250) | (0.387) | (0.254) | (0.636) | (0.277) | (0.422) | (0.286) | (0.556) |
| *Origin (Base level = Produced outside the UK* | | | | | | | | |
| Locally Produced = 1 | 1.084*** | -0.734** | 1.140*** | -0.714* | 0.892*** | -1.156*** | 0.831*** | -0.924** |
| | (0.225) | (0.342) | (0.242) | (0.369) | (0.263) | (0.341) | (0.264) | (0.395) |
| Produced elsewhere in the UK = 1 | 0.558** | 0.648* | 0.548** | 0.639 | 0.461* | 0.959* | 0.416* | 0.914** |
| | (0.229) | (0.394) | (0.229) | (0.447) | (0.249) | (0.540) | (0.252) | (0.461) |
| *Infection level (Base level = 0%)* | | | | | | | | |
| 10% infection in the herd | -1.432*** | -0.0676 | -1.210*** | 0.0977 | -1.028*** | -0.140 | -0.346 | -0.118 |
| | (0.217) | (0.515) | (0.295) | (0.455) | (0.224) | (0.431) | (0.299) | (0.364) |
| 20% infection in the herd | -2.533*** | 1.066** | -2.230*** | 0.863 | -2.109*** | 0.912** | -1.029** | 0.0636 |
| | (0.364) | (0.444) | (0.515) | (0.532) | (0.353) | (0.389) | (0.488) | (0.706) |
| 30% infection in the herd | -3.161*** | 1.980*** | -2.956*** | 1.734*** | -2.405*** | 2.842*** | -1.396** | -2.210*** |
| | (0.442) | (0.479) | (0.662) | (0.611) | (0.473) | (0.652) | (0.699) | (0.678) |
| Welfare*infection level | | | -1.240 | 4.303*** | | | -3.361** | 8.191*** |
| **Information criteria** | | | | | | | | |
| Number of observations | 2,538 | | 2,538 | | 2,358 | | 2,358 | |
| Number of respondents | 141 | | 141 | | 131 | | 131 | |
| Log-likelihood | -675.9 | | -669.05 | | -616.6 | | -588.39 | |
| AIC | 1387.73 | | 1378.10 | | 1269.29 | | 1216.78 | |
| BIC | 1492.83 | | 1494.88 | | 1373.07 | | 1332.09 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01,** p<0.05, * p<0.1 indicate significance.

### 5.4.3 Wool

Tables 5.9 to 5.11 in this sub-section include the findings of the analysis for pure wool. Additional supporting results for wool can be found in the Appendix. Let us start by looking at table 5.9 that provides the results of the MNL models for both treatment groups. In the sample that did not receive product safety information, all attributes were found to be significant but locally produced wool. Wool produced elsewhere was found to be significant only at 90% significance level[7]. Similarly, in the sample that did receive product safety information, wool produced elsewhere in the UK was not significant and locally produced wool showed weaker preference at 90% significance level.

Moving on to the socio-demographic characteristics of the respondents, notice that age and number of kids under the age of 18 were found to be significant in all the models across both samples. Older participants were more likely to opt out of purchasing wool as was presented to them in the choice scenarios whereas participants with higher number of children under the age of 18 tended to purchase wool as was presented instead of opting out of buying. The income attribute was found to be significant and negative indicating that higher the income more likely were the participants to choose to buy wool. This was true in both the treatment samples. In the sample with no product safety information higher the education level more likely were the participants to opt out of purchasing wool in the choice scenarios presented. This variable was not significant in the sample with information on product safety. Sex of the participant also appears to have some influence on purchasing decisions with male respondents being highly likely to not opt out of buying wool.

In table 5.10 that presents the RPL models all attributes across both samples were found to be statistically significant. Therefore, it can be inferred that the respondents preferred higher welfare wool and lower infection levels. The findings also show that the opt-out parameter is statistically significant and negative in all the models across both treatment groups indicating that participants did not opt to decline the purchase of wool as was offered to them in the choice scenarios. Also significant and negative was the price attribute which showed higher prices of wool linked to decreased utility. As can be seen, there is preference heterogeneity in all attributes except medium welfare, wool produced elsewhere in the UK and 10% infection level but only in the sample that did not receive safety information. On the other hand, in the sample that did receive product safety information, the attributes wool produced elsewhere in the UK, 10% infection level and 20% infection level had no preference heterogeneity. Now let us look at the effects of the socio-demographic characteristics. Age and number of kids were found to be negative and significant in both models and across information groups. Whilst the income attribute which was negative and significant in both treatment groups in the MNL model, it is only significant in the information treatment group . in the RPL model.

For each of the models provided in tables 5.9 and 5.10, I calculated the log-likelihood, the Akaike Information Information Criterion (AIC), and the Bayesian Information Criterion (BIC) to assess model fit. In the treatment group that did not receive information on product safety, the AIC and BIC for the RPL model (2456.12 and 2611.76, respectively) are lower than for the MNL model (3188.45 and 3285.73 respectively). The log-likelihood of the RPL model (-1204) is greater than that of the MNL model (-1579). The AIC and BIC for the sample that received product safety information in the RPL model (2337.07 and 2491.91 respectively) are lower than for the MNL

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[7] I refer to the situation where a estimate is found to be significant only at 90% significance level as ”the respondents showing weak preference towards this attribute”

model (1565.57 and 1652.05 respectively). In terms of log-likelihood, the RPL model (-1145) is superior to the MNL model (-1549). According to all three informative criteria, the RPL model is advised above the MNL model.

Table 5.11 contains the results of the RPL estimations for wool, when interacting animal welfare with the infection level attribute. Although this attribute is not found to be statistically significant in any specification, including it reduces the magnitude of the heterogeneity observed in all statistically significant attributes. Compared with the results reported in table 5.10, we can observe that despite the change in the magnitudes of the reported coefficients, the same attributes are found to be statistically significant and the signs of the coefficients are retained.

Table 5.9: Estimation results for Multinomial Logit Model with attribute level-dummy variable - (Wool)

| **Wool** | **No Information** | **Information** |
|---|---|---|
| | (1) | (2) |
| Variables | β (SE) | β (SE) |
| Opt-out | -3.02*** | -2.622*** |
| | (0.364) | (0.351) |
| *Price* | -0.203*** | -0.228*** |
| | (0.0274) | (0.0277) |
| *Animal Welfare (Base level = Low)* | | |
| High Welfare = 1 | 0.612*** | 0.643*** |
| | (0.0955) | (0.0960) |
| Medium Welfare = 1 | 0.321** | 0.352*** |
| | (0.125) | (0.127) |
| *Origin (Base level = Produced outside the UK* | | |
| Locally Produced = 1 | 0.147 | 0.246** |
| | (0.121) | (0.122) |
| Produced elsewhere in the UK = 1 | 0.169* | 0.134 |
| | (0.0993) | (0.100) |
| *Infection level (Base level = 0%)* | | |
| 10% infection in the flock | -0.453*** | -0.467*** |
| | (0.114) | (0.117) |
| 20% infection in the flock | -0.885*** | -0.789*** |
| | (0.135) | (0.139) |
| 30% infection in the flock | -1.021*** | -0.708*** |
| | (0.121) | (0.120) |
| **Interactions with Opt-Out alternative** | | |
| Age | 0.040*** | 0.0299*** |
| | (0.00390) | (0.00402) |
| Income | -0.000202*** | -0.00012*** |
| | (0.00004) | (4.51e-05) |
| Education | 0.168*** | -0.0518 |
| | (0.06) | (0.0627) |
| Male | -0.3740.0510 | -0.263** |
| | (0.11) | (0.117) |
| Number of kids | -0.423*** | -0.528*** |
| | (0.072) | (0.087) |
| Expected future income | -0.199 | -0.0961 |
| | (0.127) | (0.134) |
| **Information criteria** | | |
| Number of observations | 4,842 | 4644 |
| Number of respondents | 269 | 258 |
| Log-likelihood | -1579 | -1549 |
| AIC | 3188.45 | 3127.62 |
| BIC | 3285.73 | 3224.27 |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 5.10: Estimation results from Random Parameter Logit model- demographics(Wool)

| **Wool** | **No Information** | | **Information** | |
|---|---|---|---|---|
| Variables | β (SE) | Standard deviation | β (SE) | Standard deviation |
| Opt-out | -11.75*** | 6.227*** | -9.085*** | 6.004*** |
| | (2.689) | (1.048) | (3.412) | (1.113) |
| *Price* | -0.505*** | 0.478*** | -0.468*** | 0.349*** |
| | (0.0703) | (0.0939) | (0.0587) | (0.0611) |
| *Animal Welfare (Base level = Low)* | | | | |
| High Welfare = 1 | 1.306*** | -2.110*** | 1.303*** | 1.739*** |
| | (0.260) | (0.359) | (0.221) | (0.329) |
| Medium Welfare = 1 | 0.661*** | 0.515 | 0.565** | -0.897** |
| | (0.225) | (0.641) | (0.229) | (0.410) |
| *Origin (Base level = Produced outside the UK* | | | | |
| Locally Produced = 1 | 0.461** | 0.766** | 0.561*** | 0.557* |
| | (0.204) | (0.350) | (0.199) | (0.311) |
| Produced elsewhere in the UK = 1 | 0.626*** | -0.130 | 0.469*** | 0.110 |
| | (0.174) | (0.342) | (0.167) | (0.348) |
| *Infection level (Base level = 0%)* | | | | |
| 10% infection in the flock | -0.972*** | -0.717 | -0.923*** | -0.548 |
| | (0.209) | (0.563) | (0.199) | (0.376) |
| 20% infection in the flock | -2.220*** | 0.852* | -1.841*** | -0.515 |
| | (0.295) | (0.442) | (0.272) | (0.498) |
| 30% infection in the flock | -2.494*** | -1.361*** | -1.807*** | 2.115*** |
| | (0.296) | (0.390) | (0.288) | (0.465) |
| **Interactions with opt-out alternative** | | | | |
| Age | 0.163*** | | 0.150*** | |
| | (0.0324) | | (0.0502) | |
| Income | -0.000235 | | -0.00104** | |
| | (0.000378) | | (0.000429) | |
| Education | 0.462 | | 0.039 | |
| | (0.447) | | (0.468) | |
| Male | -1.821*** | | -1.161 | |
| | (0.846) | | (0.805) | |
| Number of kids | -1.915*** | | -1.484*** | |
| | (0.633) | | (0.431) | |
| Expected future income | -0.720 | | 0.426 | |
| | (0.877) | | (1.132) | |
| **Information criteria** | | | | |
| Number of observations | 4,842 | | 4,644 | |
| Number of respondents | 269 | | 258 | |
| Log-likelihood | -1204 | | -1145 | |
| AIC | 2456.12 | | 2337.07 | |
| BIC | 2611.76 | | 2491.91 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance

Table 5.11: Estimation results from Random Parameter Logit model - (Wool)

| **Wool** | **No Information** | | | | **Information** | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (1) | | (2) | |
| Variables | β (SE) | Standard deviation | β (SE) | Standard deviation | β (SE) | Standard deviation | β (SE) | Standard deviation |
| Opt-out | -6.188*** | 7.245*** | -6.349*** | 6.130*** | -5.806*** | 6.448*** | -6.481*** | 6.066*** |
| | (0.875) | (0.957) | (0.889) | (1.057) | (0.731) | (0.812) | (0.807) | (0.764) |
| *Price* | -0.529*** | 0.522*** | -0.537*** | 0.454*** | -0.478*** | 0.359*** | -0.528*** | 0.412*** |
| | (0.0679) | (0.0783) | (0.0684) | (0.0652) | (0.0597) | (0.0658) | (0.0681) | (0.0652) |
| *Animal Welfare (Base level = Low)* | | | | | | | | |
| High Welfare = 1 | 1.275*** | 2.198*** | 1.292*** | 2.103*** | 1.312*** | 1.726*** | 1.139*** | 1.872*** |
| | (0.235) | (0.346) | (0.340) | (0.361) | (0.218) | (0.292) | (0.342) | (0.340) |
| Medium Welfare = 1 | 0.651*** | -0.687 | 0.589** | 0.113 | 0.519** | -0.710 | 0.254 | 0.628 |
| | (0.232) | (0.531) | (0.282) | (0.592) | (0.220) | (0.488) | (0.287) | (0.498) |
| *Origin (Base level = Produced outside the UK* | | | | | | | | |
| Locally Produced = 1 | 0.480** | 0.785** | 0.164 | 0.730** | 0.565*** | 0.609* | 0.360* | -0.404 |
| | (0.211) | (0.362) | (0.220) | (0.328) | (0.196) | (0.349) | (0.218) | (0.397) |
| Produced elsewhere in the UK = 1 | 0.647*** | -0.153 | 0.468** | -0.453 | 0.472*** | -0.0384 | 0.510*** | -0.0266 |
| | (0.174) | (0.332) | (0.192) | (0.345) | (0.167) | (0.444) | (0.195) | (0.448) |
| *Infection level (Base level = 0%)* | | | | | | | | |
| 10% infection in the herd | -1.018*** | 0.891*** | -0.729** | 0.904** | -0.888*** | -0.565 | -0.469 | -0.725* |
| | (0.209) | (0.338) | (0.295) | (0.365) | (0.192) | (0.365) | (0.294) | (0.397) |
| 20% infection in the herd | -2.316*** | -0.836** | -1.833*** | -0.364 | -1.814*** | -0.523 | -1.314*** | 0.166 |
| | (0.296) | (0.415) | (0.421) | (0.518) | (0.262) | (0.474) | (0.413) | (0.368) |
| 30% infection in the herd | -2.517*** | 1.388*** | -2.519*** | 1.032** | -1.729*** | 2.165*** | -1.088* | 1.882*** |
| | (0.291) | (0.344) | (0.596) | (0.490) | (0.277) | (0.377) | (0.595) | (0.570) |
| Welfare*infection level | | | -1.432 | 5.710*** | | | -1.972* | 5.239*** |
| **Information criteria** | | | | | | | | |
| Number of observations | 4,842 | | 4,842 | | 4,644 | | 4,644 | |
| Number of respondents | 269 | | 269 | | 258 | | 258 | |
| Log-likelihood | -1228 | | -1196 | | -1162 | | -1136 | |
| AIC | 2492.02 | | 2432.99 | | 2359.03 | | 2312.81 | |
| BIC | 2608.75 | | 2562.69 | | 2475.01 | | 2441.68 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01,** p<0.05, * p<0.1 indicate significance.

## 5.5 Willingness to pay (WTP)

In this section, I report the results of the the marginal willingness to pay (WTP) estimates that I calculated for each product using the delta method (Hensher and Greene, 2003) for discrete changes in the levels of each attribute. The WTP coefficients were derived from the output of the RPL model, where prices were fixed. There is large number of empirical studies investigating the frequency at which prices change. The consensus is that after excluding temporary price variations (i.e. sales), aggregate prices change approximately once every 11 months (Kehoe and Midrigan, 2015). Since I employ cross- sectional rather than time- series or panel data in my study, the assumption of fixed prices seems reasonable. The key WTP results are summarised in figures 5.2-5.4 for all animal products considered in this chapter. The majority of the attributes were found to be significant in the 95% confidence interval. I interpret the WTP as the price for a change from the base attribute level to an alternative level, given the attribute level dummies. However, in this section, the attribute infection level was modelled with 30% as the base attribute level.

In each graph, the shaded part shows the confidence intervals for the WTP estimates for the Random parameter logit (RPL) model along with the mean WTP estimates. The graph at the top of each figure displays the willingness to pay estimates for the information treatment group whilst the bottom graph of the figure demonstrates the willingness to pay for the same animal product from the no- information treatment group.

Let us start with figure 5.2 that reports the WTP estimates for beef. Both groups seem to have estimates that are close in size and sign. An increase in animal welfare level leads to an increase in the average marginal value by £2.33 for high welfare beef and £1.92 for medium welfare beef per 250 grams in the information treatment group. Whilst in the no information treatment group, the same increase in animal welfare leads to £1.88 per 250 grams for a high welfare beef steak and only £1.26 per 250 grams for medium welfare beef. In both groups consumers exhibit the highest WTP for beef with 0% infection in the herd. The WTP for the group that received food safety information was found to be £3.4 per 250 grams of beef coming from farms with no infection. For the other group, the estimated value for the same WTP coefficient was found to be £5.4 per 250 grams, instead. The lowest significant WTP estimate[8] was found to be beef produced elsewhere in both treatment groups (£0.85 in the information treatment group and £0.81 in the other).

The rest of the products (milk and wool) are shown in figures 5.3 and 5.4 respectively. They display a similar pattern to beef, where 0% infection level in the herd/flock had the highest WTP across both treatment groups. Milk much like beef had the lowest WTP for milk produced elsewhere in the UK for both groups. Whereas locally produced wool had the lowest WTP for the no information treatment group and wool produced elsewhere exhibited the lowest WTP for the information treatment group.

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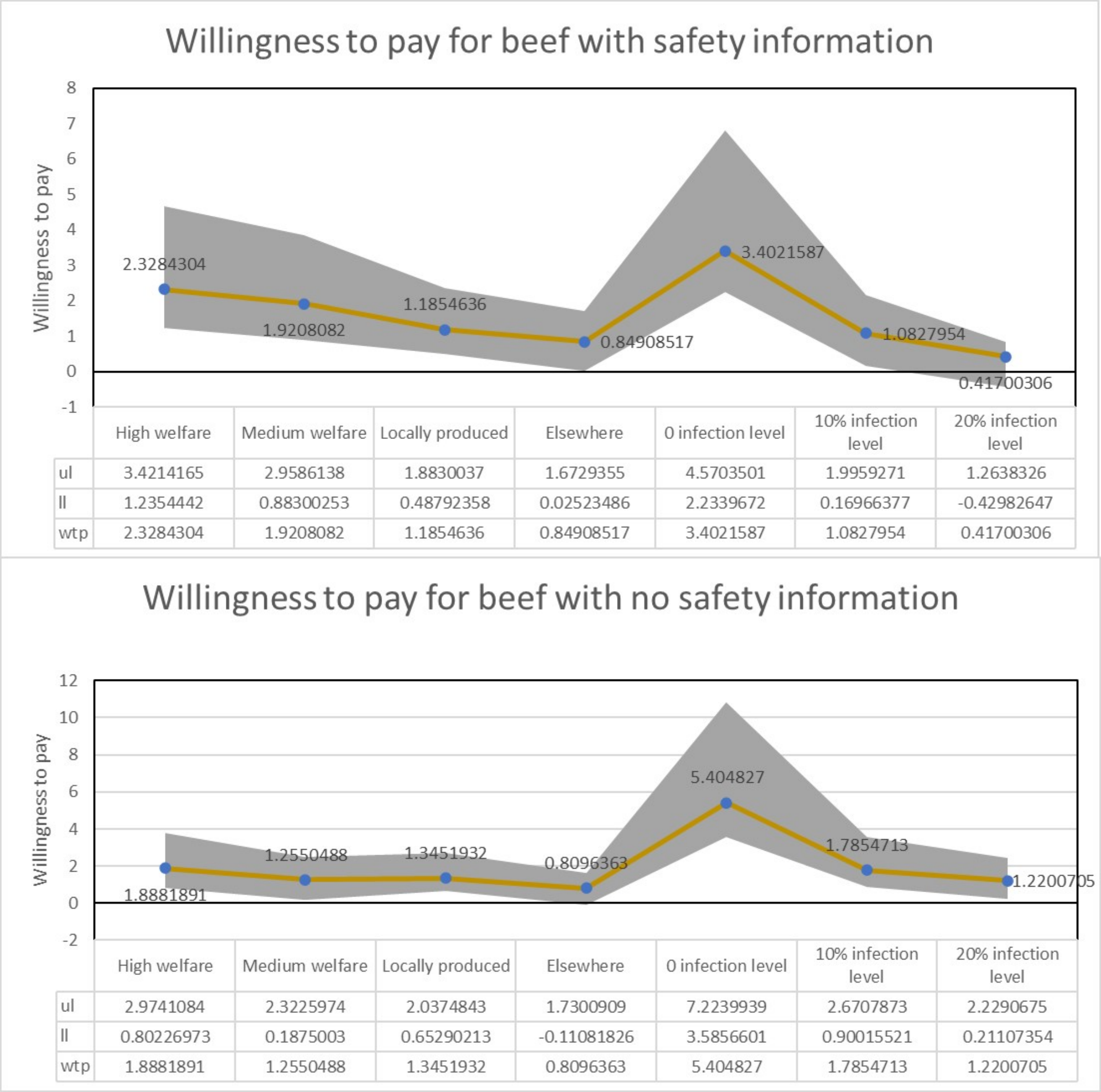
[8] Tables 5.12 to 5.14 report the coefficient and their significance level for all products.



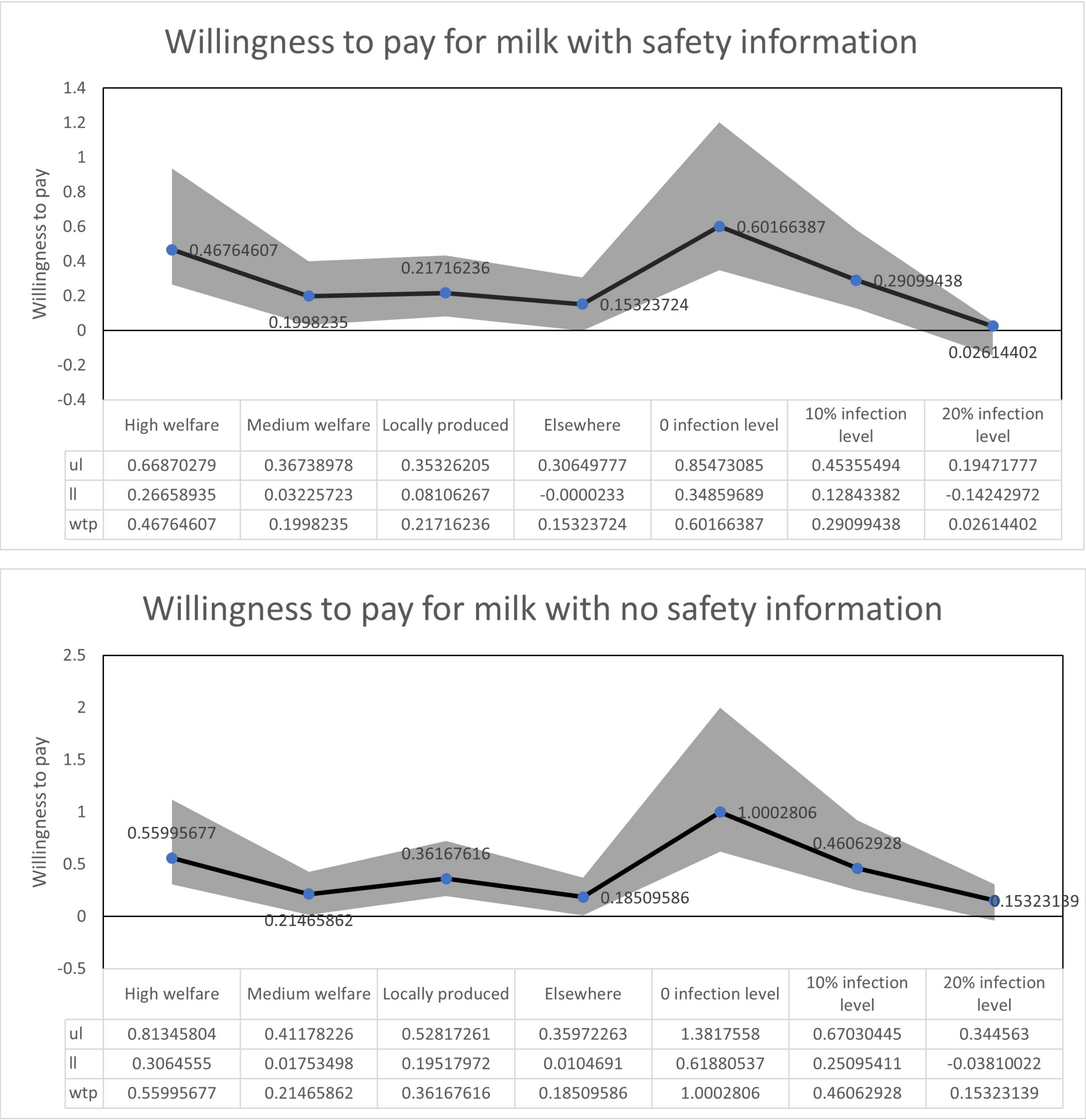
Willingness to pay for beef with safety information

| | High welfare | Medium welfare | Locally produced | Elsewhere | 0 infection level | 10% infection level | 20% infection level |
|---|---|---|---|---|---|---|---|
| ul | 3.4214165 | 2.9586138 | 1.8830037 | 1.6729355 | 4.5703501 | 1.9959271 | 1.2638326 |
| ll | 1.2354442 | 0.88300253 | 0.48792358 | 0.02523486 | 2.2339672 | 0.16966377 | -0.42982647 |
| wtp | 2.3284304 | 1.9208082 | 1.1854636 | 0.84908517 | 3.4021587 | 1.0827954 | 0.41700306 |

Willingness to pay for beef with no safety information

| | High welfare | Medium welfare | Locally produced | Elsewhere | 0 infection level | 10% infection level | 20% infection level |
|---|---|---|---|---|---|---|---|
| ul | 2.9741084 | 2.3225974 | 2.0374843 | 1.7300909 | 7.2239939 | 2.6707873 | 2.2290675 |
| ll | 0.80226973 | 0.1875003 | 0.65290213 | -0.11081826 | 3.5856601 | 0.90015521 | 0.21107354 |
| wtp | 1.8881891 | 1.2550488 | 1.3451932 | 0.8096363 | 5.404827 | 1.7854713 | 1.2200705 |

Figure 5.2: Willingness to Pay for Beef



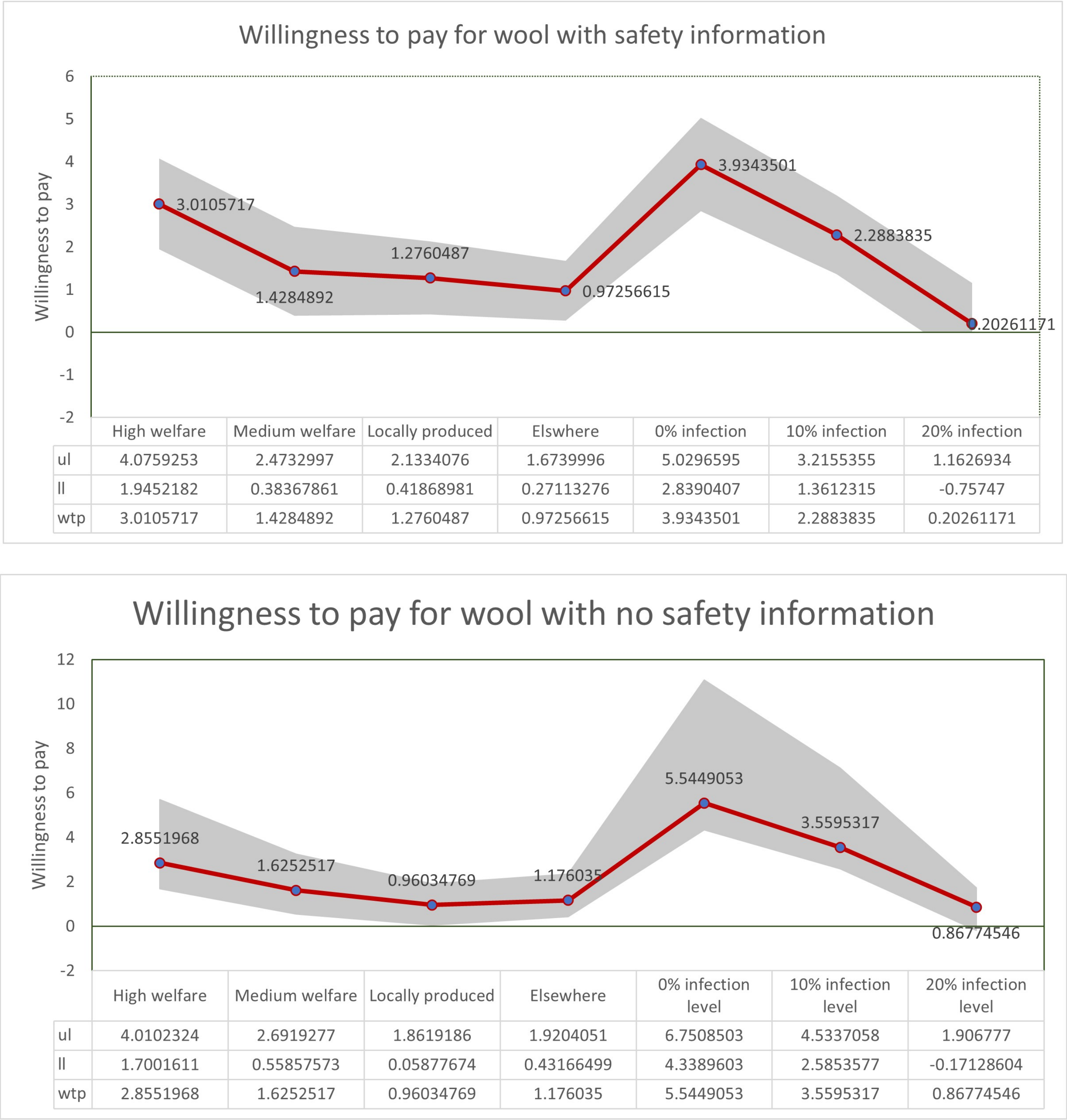
Willingness to pay for milk with safety information

| | High welfare | Medium welfare | Locally produced | Elsewhere | 0 infection level | 10% infection level | 20% infection level |
|---|---|---|---|---|---|---|---|
| ul | 0.66870279 | 0.36738978 | 0.35326205 | 0.30649777 | 0.85473085 | 0.45355494 | 0.19471777 |
| ll | 0.26658935 | 0.03225723 | 0.08106267 | -0.0000233 | 0.34859689 | 0.12843382 | -0.14242972 |
| wtp | 0.46764607 | 0.1998235 | 0.21716236 | 0.15323724 | 0.60166387 | 0.29099438 | 0.02614402 |

Willingness to pay for milk with no safety information

| | High welfare | Medium welfare | Locally produced | Elsewhere | 0 infection level | 10% infection level | 20% infection level |
|---|---|---|---|---|---|---|---|
| ul | 0.81345804 | 0.41178226 | 0.52817261 | 0.35972263 | 1.3817558 | 0.67030445 | 0.344563 |
| ll | 0.3064555 | 0.01753498 | 0.19517972 | 0.0104691 | 0.61880537 | 0.25095411 | -0.03810022 |
| wtp | 0.55995677 | 0.21465862 | 0.36167616 | 0.18509586 | 1.0002806 | 0.46062928 | 0.15323139 |

Figure 5.3: Willingness to Pay for milk



| | High welfare | Medium welfare | Locally produced | Elswhere | 0% infection | 10% infection | 20% infection |
|---|---|---|---|---|---|---|---|
| ul | 4.0759253 | 2.4732997 | 2.1334076 | 1.6739996 | 5.0296595 | 3.2155355 | 1.1626934 |
| ll | 1.9452182 | 0.38367861 | 0.41868981 | 0.27113276 | 2.8390407 | 1.3612315 | -0.75747 |
| wtp | 3.0105717 | 1.4284892 | 1.2760487 | 0.97256615 | 3.9343501 | 2.2883835 | 0.20261171 |

| | High welfare | Medium welfare | Locally produced | Elsewhere | 0% infection level | 10% infection level | 20% infection level |
|---|---|---|---|---|---|---|---|
| ul | 4.0102324 | 2.6919277 | 1.8619186 | 1.9204051 | 6.7508503 | 4.5337058 | 1.906777 |
| ll | 1.7001611 | 0.55857573 | 0.05877674 | 0.43166499 | 4.3389603 | 2.5853577 | -0.17128604 |
| wtp | 2.8551968 | 1.6252517 | 0.96034769 | 1.176035 | 5.5449053 | 3.5595317 | 0.86774546 |

Figure 5.4: Willingness to Pay for wool

Next let us look at the implication of the willingness to pay using beef data, since the results are similar across all products considered in this study. First, it is evident that both treatment groups are willing to pay to ensure high farm animal welfare and low infection levels. The animal welfare coefficients for the group that has additional information on food safety were higher than those reported for the no information group. The opposite result holds true for the infection level coefficients where no safety information group were willing to pay more. This outcome demonstrates that the group who had received the additional safety information that the endemic disease considered here does not pose a threat to human health, was willing to pay more to ensure high FAW. Still, the information treatment group exhibited higher WTP for locally produced animal products. This result is in line with the seminal work of Hassanein (2003) and Balcombe et al. (2021). The former argues that consumers affected by food issues should participate more in the discussion regarding the design of food safety policies whilst the latter who also investigates the WTP of the UK public towards high FAW reports the importance that British consumers' place on the country of origin and how much they value locally produced animal products.

On the other hand, one observes that the group that has no explicit information regarding how the endemic disease may affect their own health, seem to be willing to pay relatively less to ensure high FAW. As expected, this group has higher willingness to pay to ensure zero or at least low infection levels in the herd/flock and this is particularly clear when the animal product is locally produced. Nocella et al. (2010) showed the importance of consumer' trust towards stakeholders on the WTP for FAW. Although my estimates for locally produced animal products are high for both groups, one can notice that the WTP coefficient is higher in the group that did not receive explicit safety information. Thus, implying a that there is implicit trust towards local farmers regarding safe farming practices. A complementary explanation for this result stems from EUs' strategy to promote food products from areas reputed to produce high quality animal products. As documented in Loureiro and Umberger (2007), to support food production and production of agricultural goods in general from specific regions the EU has relied on food labelling policies. Thus, one can conjecture that even in the absence of formal quality assurance framework, the UK consumers given their experience they value and trust locally produced animal products.

### 5.5.1 Testing WTP parameters between groups

In this section, I am testing the following null hypothesis against the alternative hypothesis. The null hypothesis is that the WTP coefficients are statistically the same between the two treatment groups. Whereas, the alternative hypothesis states that they are statistically different.

I perform this test by directly comparing $\beta_1$ and $\beta_2$ using the test specified below. The coefficients $\beta_1$ and $\beta_2$ refer to the WTP coefficient for the same attribute coming from treatment group 1 (no-information treatment group) and treatment group 2 (information treatment group), respectively.

$$\begin{aligned} H_0 &: \beta_1 = \beta_2 \\ H_1 &: \beta_1 \neq \beta_2 \end{aligned}$$

First, I rewrite the hypothesis above using a new variable (w),

$$\begin{aligned} H_0 &: w = \beta_1 - \beta_2 = 0 \\ H_1 &: w = \beta_1 - \beta_2 \neq 0 \end{aligned}$$

Where w is the difference in estimates $\beta_1$ and $\beta_2$ that I compute based on the estimation results. Note in the event that either $\beta_1$ or $\beta_2$ were not found to be statistically significant, I took their value to be zero when constructing the w variable.

Next, I need to determine the standard error of w, which can be computed as:

$$SE(w) = \sqrt{Var(\beta_1) + Var(\beta_1) - 2 \cdot Cov(\beta_1, \beta_2)}$$

Where var is the variance, and cov is the covariance. However, since $\beta_1$ and $\beta_2$ come from different data sets their correlation and thus, their covariance is zero ($Cov(\beta_1, \beta_2) = 0$).

$$SE(w) = \sqrt{Var(\beta_1) + Var(\beta_1)}$$

Finally, I compute the relative confidence intervals as,

$$CI = \left[w \pm t_{(\alpha)} \cdot SE(w)\right]$$

where $t_{(\alpha)}$ is the critical t-value for significance level of 95%.

Once I construct the confidence interval for any of the w variables, I examine whether the value of w under null hypothesis (w = 0) falls within the confidence interval. If it does then, I fail to reject the null hypothesis. Interestingly enough, I failed to reject the null hypothesis in all instances as shown in tables 5.12- 5.14. Thus, I come to the conclusion that there is no statistically significant difference in the WTP estimates between the two treatment groups. Alternatively, this hypothesis could also be tested using the LR test or the convolutions test on the preference parameters between the two treatment groups (Poe et al., 1994).

Table 5.12: Comparison of Willingness to pay estimates (Beef)

| **Beef** | **(1)**<br>**No information** | **(2)**<br>**Information** | | | |
|---|---|---|---|---|---|
| | **β1 (SE)** | **β2 (SE)** | **w** | **CI (95%)** | **Significantly different** |
| *Animal welfare (base level= low welfare)* | | | | | |
| High welfare | 1.888*** | 2.328 *** | -0.44 | [-1.98, 1.1] | No |
| | (0.554) | (0.557) | | | |
| Medium welfare | 1.255** | 1.920*** | -0.665 | [-2.152, 0.822] | No |
| | (0.544) | (0.529) | | | |
| *Origin (base level- produced outside the UK* | | | | | |
| Locally produced | 1.345*** | 1.185*** | 0.16 | [-0.821, 1.41] | No |
| | (0.353) | (0.355) | | | |
| Produced elsewhere in the UK | 0.809* | 0.849** | -0.04 | [-1.274, 1.194] | No |
| | (0.469) | (0.420) | | | |
| *Infection level (Base level =30%)* | | | | | |
| 0% infection in the herd/flock | 5.404*** | 3.402*** | 2.002 | [-0.16, 4.164] | No |
| | (0.928) | (0.596) | | | |
| 10% infection in the herd/flock | 1.785*** | 1.082** | 0.703 | [-0.567, 1.973] | No |
| | (0.451) | (0.465) | | | |
| 20% infection in the herd/flock | 1.220** | 0.417 | 0.803 | [-0.096, 2.536] | No |
| | (0.514) | (0.432) | | | |

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance. Note: Estimates are rounded up to 3 d.p.

Table 5.13: Comparison of Willingness to pay estimates (Milk)

| Milk | (1)<br>No information | (2)<br>Information | | | |
|---|---|---|---|---|---|
| | **β1 (SE)** | **β2 (SE)** | **w** | **CI (95%)** | **Significantly different** |
| *Animal welfare (base level= low welfare)* | | | | | |
| High welfare | 0.559*** | 0.467*** | 0.092 | [-0.23, 0.414] | No |
| | (0.129) | (0.102) | | | |
| Medium welfare | 0.214** | 0.199*** | 0.015 | [-0.242, 0.272] | No |
| | (0.100) | (0.085) | | | |
| *Origin (base level- produced outside the UK* | | | | | |
| Locally produced | 0.361*** | 0.217*** | 0.144 | [-0.069, 0.357] | No |
| | (0.084) | (0.069) | | | |
| Produced elsewhere in the UK | 0.185** | 0.153** | 0.032 | [-0.122, 0.186] | No |
| | (0.010) | 0.078 | | | |
| *Infection level (Base level =30%)* | | | | | |
| 0% infection in the herd/flock | 1.000*** | 0.601*** | 0.399 | [-0.058, 0.856] | No |
| | (0.194) | (0.129) | | | |
| 10% infection in the herd/flock | 0.460*** | 0.290*** | 0.17 | [-0.093, 0.433] | No |
| | (0.106) | (0.082) | | | |
| 20% infection in the herd/flock | 0.153 | 0.026 | 0 | [-0.254, 0.254] | No |
| | (0.097) | (0.086) | | | |

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance. Note: Estimates are rounded up to 3 d.p.

Table 5.14: Comparison of Willingness to pay estimates (Wool)

| **Wool** | **(1) No information** | **(2) Information** | | | |
|---|---|---|---|---|---|
| | **$\beta_1$ (SE)** | **$\beta_2$ (SE)** | **w** | **CI (95%)** | **Significantly different** |
| *Animal welfare (base level= low welfare)* | | | | | |
| High welfare | 2.855*** | 3.010*** | -0.155 | [-1.725, 1.415] | No |
| | (0.589) | (0.543) | | | |
| Medium welfare | 1.625*** | 1.428*** | 0.197 | [-1.296, 1.69] | No |
| | (0.544) | (0.533) | | | |
| *Origin (base level- produced outside the UK* | | | | | |
| Locally produced | 0.960** | 1.276*** | -0.316 | [-1.558, 0.926] | No |
| | (0.459) | (0.437) | | | |
| Produced elsewhere in the UK | 1.176*** | 0.972*** | 0.204 | [-0.816, 1.224] | No |
| | (0.379) | (0.357) | | | |
| *Infection level (Base level =30%)* | | | | | |
| 0% infection in the herd/flock | 5.544*** | 3.934*** | 1.61 | [-0.018, 3.238] | No |
| | (0.615) | (0.558) | | | |
| 10% infection in the herd/flock | 3.559*** | 2.288*** | 1.271 | [-0.074, 2.616] | No |
| | 0.497 | (0.473) | | | |
| 20% infection in the herd/flock | 0.867 | 0.202 | 0 | [-1.413, 1.413] | No |
| | (0.530) | (0.489) | | | |

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance. Note: Estimates are rounded up to 3 d.p.

## 5.6 Discussion

Based on the feedback received on the previous chapter I decided to test the hypothesis whether food/product safety information or perception of food safety could have influenced our respondents preferences towards high animal welfare and low herd/flock sickness level as shown in the previous chapter. I controlled for this parameter by re-running the survey and splitting the sample into two sub-samples. Half the respondents received explicit food/product safety information and the other did not receive any such information. The aim was to investigate how this information asymmetry would affect the marginal WTP towards preferences for livestock health and welfare.

In this study, using three animal products: beef steak, milk and pure wool, I study UK consumer preferences towards farm animal health and welfare in the presence of information asymmetry regarding food/product safety. This study also addresses how the ongoing COVID19 pandemic may have affected the British public's willingness to pay for high FAHW.

Similar to the findings reported in chapter 4, I find that the UK public's preferences for FAH and FAW can still be modelled using a separable utility during times of heightened uncertainty. The results provide robust evidence that additional information on food/product safety of animal products has no significant impact on consumer preferences. In both groups respondents have strong preferences for high animal welfare and low sickness levels in the herd/flock. I still find that utility is separable for FAW and FAH in the presence of information asymmetry. The findings are in line with Needham et al. (2018). Although, I do not explicitly measure changes in knowledge and only apply two treatments which vary in terms of information provision, I assume that the respondents belonging to the information treatment group internalise the explicit message that these endemic diseases do not affect human health. This assumption is supported by the evidence from Bruhn and Schutz (1999) who find that consumers trust university researchers and health practitioners the most regarding food safety information in comparison to food labels used by the industry. As such, I conjecture that there is difference in the knowledge between members of each group. However, it is not known how people interpreted the additional information provided, and how much they used it to update their priors.

Although I find that there is marginal difference in the magnitudes of the WTP between treatment groups, consumers' attitudes towards FAH and FAW remain largely similar. The treatment group that received no additional information regarding product/food safety exhibited higher WTP to ensure low sickness in the herd/flock. However, upon performing a robustness test it was revealed that the WTP estimates were not statistically different between the two treatment groups. Hence, it can be concluded that the provision of additional information regarding food/product safety did not alter the respondents attitudes towards FAH and FAW.

When comparing the willingness to pay estimates with those reported in the previous chapter, I find them to be somewhat different. This discrepancy is present mostly in the willingness to pay estimates for beef, since the prices and product quantities used in the second experiment were substantially lower. Overall, I observe that willingness to pay preferences and attitudes towards farm animal health and farm animal welfare have remained relatively similar during the COVID19 pandemic. This result is in line with Hynes et al. (2021) who make a similar observation when examining preferences and willingness to pay for environmental objectives pre and during the

COVID19 shock.

Moreover, I find that respondents from both groups exhibit high willingness to pay for locally produced- animal products coming from farms with low infection levels. Both groups are presented with the same choice scenarios where they make hypothetical consumption choices based on origin, infection level in the herd/flock and animal welfare grading except the food safety disclaimer absent in the no -information treatment group. One can argue that the information included in the above attributes much like the quality assurance labels and country of origin attributes in Lewis et al. (2017) could act as a proxy for food safety[9] that could affect the respondents purchasing decisions. Still only the "information" treatment group received an explicit signal regarding food safety. Nevertheless, due to the high willingness to pay for locally produced animal products observed across groups, I can infer that as in Becker et al. (2000), the British public somewhat correlates food safety with place of origin - showing implicit trust to local farmers. This result is further confirmed by Duffy et al. (2005) who report that British consumers tend to prefer to buy food that is domestically produced, as they believe it to be safer and prepared in compliance with stricter standards for animal welfare.

Similar to Needham et al. (2018), it would be interesting to see how the purchasing behaviour of the respondents was affected by the safety information provided to them. How credible did they find it and whether they internalised the information provided to them. Another extension could be testing the stability of consumer preferences over time. Currently, we are going through a cost of living crisis which has significantly constrained the purchasing habits of households. Given this implicit loss of income, would consumers still be willing to pay for high FAW and FAH?

In periods of high inflation these results could be overturned since wages are relatively rigid and the cost of the consumption basket significantly increases. My survey was conducted at the height of the COVID19 pandemic where the government stepped in and helped people who were financially affected. As most of our respondents were optimistic about their expected future earnings and did not seem to be affected by the uncertainty caused by the COVID19 pandemic, it could be argued that the purchasing behaviour remained relatively unchanged. However, today we are experiencing the aftermath of the pandemic, where inflation is approximately at 10%, wages have not adjusted sufficiently and the country is experiencing a decline in the standard of living, therefore, the public's purchasing behaviour may have adjusted.

*The survey can be found in the appendix at the end of chapter 8.

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[9] See for instance Phan-Huy and Fawaz, (2003) for a discussion on how premium animal products are associated with higher animal welfare.

## 5.7 Appendix A

Table 5.15: (A1) Description of socio-demographic variables

| Variables | Description |
|---|---|
| **Age** | Respondents age described in categories.<br>Age was re-coded according to the midpoints of respective age ranges |
| **Income** | Total household income range before tax per month.<br>Income was re-coded according to the midpoints of respective income ranges |
| **Number of kids** | The number of children under the age of 18 currently residing in respondent household. |
| **Education** | Highest completed education level<br>GCSE or GNVQ or equivalent<br>A-levels or advanced GNVQ or equivalent<br>University undergraduate degree<br>Postgraduate degree or higher |
| **Sex** | Respondent sex |
| **Expected future income** | Expectations of future household income being affected due to current (at the time) restrictions caused by the COVID19 pandemic. (Yes/No) |

Table 5.16: (A2) Estimation from Random Parameter Logit model- Number of kids and Age (Beef)

| **Beef** | **No Information** | | | | **Information** | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| Variables | β (SE) | Standard deviation | β (SE) | Standard | β (SE) | Standard deviation | β (SE) | Standard deviation |
| Opt-out | -5.606*** | 2.995*** | -5.754*** | 3.040*** | -5.450*** | 3.036*** | -5.289*** | 2.913*** |
| | (0.845) | (0.611) | (0.897) | (0.556) | (0.744) | (0.514) | (0.737) | (0.496) |
| *Price* | -0.620*** | 0.253*** | -0.623*** | 0.256*** | -0.567*** | 0.175** | -0.555*** | 0.179** |
| | (0.105) | (0.0792) | (0.108) | (0.0890) | (0.0821) | (0.0786) | (0.0812) | (0.0853) |
| *Animal Welfare (Base level = Low)* | | | | | | | | |
| High Welfare = 1 | 1.010** | 1.895*** | 2.367** | 1.842*** | 1.221*** | 1.505*** | 1.328 | 1.517*** |
| | (0.422) | (0.467) | (0.982) | (0.431) | (0.338) | (0.348) | (0.902) | (0.354) |
| Medium Welfare = 1 | 0.849** | 0.834 | 1.130 | 0.539 | 0.903*** | -0.199 | 2.130*** | -0.0421 |
| | (0.366) | (0.614) | (0.891) | (0.799) | (0.308) | (0.572) | (0.809) | (0.515) |
| *Origin (Base level = Produced outside the UK* | | | | | | | | |
| Locally Produced = 1 | 0.774*** | -0.291 | 0.821*** | -0.245 | 0.638*** | 0.710** | 0.639*** | -0.652** |
| | (0.258) | (0.376) | (0.259) | (0.516) | (0.226) | (0.323) | (0.221) | (0.330) |
| Produced elsewhere in the UK = 1 | 0.555** | 0.196 | 0.599** | 0.221 | 0.435* | -0.251 | 0.469** | -0.183 |
| | (0.268) | (0.521) | (0.267) | (0.564) | (0.232) | (0.503) | (0.227) | (0.578) |
| *Infection level (Base level = 0%)* | | | | | | | | |
| 10% infection in the herd | -2.467*** | 1.458** | -0.577 | 1.517** | -1.548*** | 0.546 | -1.392* | 0.440 |
| | (0.451) | (0.716) | (0.978) | (0.702) | (0.346) | (0.582) | (0.840) | (0.637) |
| 20% infection in the herd | -2.964*** | 2.382*** | 1.429 | 2.430*** | -1.663*** | 1.418*** | -1.383 | 1.346*** |
| | (0.541) | (0.637) | (1.032) | (0.669) | (0.359) | (0.491) | (0.852) | (0.457) |
| 30% infection in the herd | -3.730*** | 2.642*** | -0.620 | 2.542*** | -2.245*** | 1.818*** | -1.970** | 1.760*** |
| | (0.586) | (0.578) | (1.037) | (0.586) | (0.379) | (0.403) | (0.901) | (0.415) |
| Number of kids*10% infection in the herd | 0.513* | | | | 0.385 | | | |
| | (0.291) | | | | (0.247) | | | |
| Number of kids*20% infection in the herd | 0.866** | | | | -0.0957 | | | |
| | (0.359) | | | | (0.273) | | | |
| Number of kids*30% infection in the herd | 0.388 | | | | 0.247 | | | |
| | (0.339) | | | | (0.296) | | | |
| Number of kids* High Welfare | 0.614* | | | | 0.132 | | | |
| | (0.332) | | | | (0.279) | | | |
| Number of kids* Medium Welfare | 0.275 | | | | 0.142 | | | |
| | (0.295) | | | | (0.267) | | | |
| Age* High Welfare | | | -0.0227 | | | | -0.000274 | |
| | | | (0.0193) | | | | (0.0180) | |
| Age* Medium Welfare | | | -0.00298 | | | | -0.0240 | |
| | | | (0.0181) | | | | (0.0160) | |
| Age*10% infection in the herd | | | -0.0350* | | | | 0.00201 | |
| | | | (0.0201) | | | | (0.0167) | |
| Age*20% infection in the herd | | | -0.0890*** | | | | -0.00649 | |
| | | | (0.0244) | | | | (0.0171) | |
| Age*30% infection in the herd | | | -0.0627*** | | | | -0.00173 | |
| | | | (0.0226) | | | | (0.0178) | |
| **Information criteria** | | | | | | | | |
| Number of observations | 2,304 | | 2,304 | | 2,268 | | 2,268 | |
| Number of respondents | 128 | | 128 | | 127 | | 127 | |
| Log-likelihood | -629.2 | | -623.5 | | -639.7 | | -640.4 | |
| AIC | 1304.34 | | 1293.05 | | 1325.47 | | 1326.78 | |
| BIC | 1436.41 | | 1425.12 | | 1457.18 | | 1458.5 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance

Table 5.17: (A3) Estimation results from Random Parameter Logit model- Number of kids and Age (Milk)

| **Milk** | **No Information** | | | | **Information** | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| Variables | β (SE) | Standard deviation | β (SE) | Standard | β (SE) | Standard deviation | β (SE) | Standard deviation |
| Opt-out | -4.852*** | 3.870*** | -4.960*** | 3.812*** | -7.460*** | 5.706*** | -7.529*** | 5.335*** |
| | (0.748) | (0.551) | (0.757) | (0.535) | (1.172) | (1.074) | (1.074) | (0.963) |
| *Price* | -2.892*** | 1.321** | -2.810*** | 0.811 | -3.893*** | 1.331** | -4.794*** | 2.708*** |
| | (0.558) | (0.561) | (0.534) | (0.761) | (0.639) | (0.538) | (0.926) | (0.800) |
| *Animal Welfare (Base level = Low)* | | | | | | | | |
| High Welfare = 1 | 1.551*** | 1.411*** | 2.419*** | -1.138*** | 1.897*** | -1.453*** | 3.085*** | 1.659*** |
| | (0.332) | (0.371) | (0.750) | (0.428) | (0.405) | (0.477) | (1.038) | (0.486) |
| Medium Welfare = 1 | 0.652** | 1.400*** | 0.377 | 1.224*** | 0.620** | 1.138*** | 2.094** | 1.848*** |
| | (0.292) | (0.395) | (0.682) | (0.419) | (0.315) | (0.440) | (0.977) | (0.532) |
| *Origin (Base level = Produced outside the UK* | | | | | | | | |
| Locally Produced = 1 | 1.059*** | -0.779** | 1.055*** | 0.653* | 0.915*** | 1.189*** | 0.872*** | -1.380*** |
| | (0.229) | (0.349) | (0.217) | (0.372) | (0.258) | (0.328) | (0.270) | (0.414) |
| Produced elsewhere in the UK = 1 | 0.555** | 0.670* | 0.522** | 0.757** | 0.457* | 0.986** | 0.519* | 1.417** |
| | (0.231) | (0.372) | (0.230) | (0.383) | (0.244) | (0.441) | (0.293) | (0.554) |
| *Infection level (Base level = 0%)* | | | | | | | | |
| 10% infection in the herd | -1.643*** | -0.131 | -0.355 | 0.0605 | -0.985*** | -0.187 | 0.788 | 0.185 |
| | (0.257) | (0.508) | (0.525) | (0.613) | (0.251) | (0.411) | (0.631) | (0.539) |
| 20% infection in the herd | -2.791*** | 1.084** | -0.965 | 1.066** | -1.745*** | 1.117** | -0.521 | 1.006** |
| | (0.441) | (0.491) | (0.778) | (0.442) | (0.380) | (0.445) | (0.925) | (0.505) |
| 30% infection in the herd | -3.524*** | 1.984*** | -2.406** | 2.093*** | -2.392*** | 2.951*** | -1.202 | 3.116*** |
| | (0.516) | (0.482) | (0.962) | (0.532) | (0.540) | (0.675) | (1.271) | (0.642) |
| Number of kids*10% infection in the herd | 0.342* | | | | 0.0515 | | | |
| | (0.195) | | | | (0.251) | | | |
| Number of kids*10% infection in the herd | 0.396 | | | | -0.548 | | | |
| | (0.291) | | | | (0.380) | | | |
| Number of kids*10% infection in the herd | 0.696** | | | | 0.145 | | | |
| | (0.348) | | | | (0.484) | | | |
| Number of kids* High Welfare | 0.414 | | | | 0.218 | | | |
| | (0.289) | | | | (0.399) | | | |
| Number of kids* Medium Welfare | 0.0903 | | | | 0.600* | | | |
| | (0.284) | | | | (0.345) | | | |
| Age* High Welfare | | | -0.0167 | | | | -0.0212 | |
| | | | (0.0157) | | | | (0.0200) | |
| Age* Medium Welfare | | | 0.00692 | | | | -0.0254 | |
| | | | (0.0148) | | | | (0.0200) | |
| Age*10% infection in the herd | | | -0.0233** | | | | -0.0434*** | |
| | | | (0.0116) | | | | (0.0140) | |
| Age*20% infection in the herd | | | -0.0330* | | | | -0.0405** | |
| | | | (0.0172) | | | | (0.0194) | |
| Age*30% infection in the herd | | | -0.0157 | | | | -0.0318 | |
| | | | (0.0199) | | | | (0.0257) | |
| **Information criteria** | | | | | | | | |
| Number of observations | 2,538 | | 2,538 | | 2,358 | | 2,358 | |
| Number of respondents | 141 | | 141 | | 131 | | 131 | |
| Log-likelihood | -670.3 | | -673.3 | | -615.8 | | -606.3 | |
| AIC | 1386.67 | | 1392.51 | | 1277.51 | | 1258.67 | |
| BIC | 1520.97 | | 1526.81 | | 1410.12 | | 1391.28 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 5.18: (A4) Estimation results from Random Parameter Logit model- Number of kids and Age- (Wool)

| **Wool 5** | **No Information** | | | | **Information** | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | β (SE) | Standard deviation | β (SE) | Standard | β (SE) | Standard deviation | β (SE) | Standard deviation |
| Opt-out | -6.245*** | 7.940*** | -6.298*** | 7.089*** | -6.102*** | 6.464*** | -6.010*** | 6.314*** |
| | (0.779) | (1.052) | (0.866) | (1.011) | (0.771) | (0.834) | (0.767) | (0.828) |
| *Price* | -0.592*** | 0.590*** | -0.537*** | 0.509*** | -0.493*** | 0.415*** | -0.490*** | 0.402*** |
| | (0.0786) | (0.0845) | (0.0696) | (0.0833) | (0.0632) | (0.0695) | (0.0641) | (0.0689) |
| *Animal Welfare (Base level = Low)* | | | | | | | | |
| High Welfare = 1 | 1.280*** | 2.267*** | 1.822*** | 2.350*** | 1.387*** | 1.666*** | 0.915 | 1.669*** |
| | (0.295) | (0.344) | (0.668) | (0.361) | (0.254) | (0.304) | (0.620) | (0.311) |
| Medium Welfare = 1 | 0.453 | -0.733* | 1.014 | -0.699 | 0.463* | 0.706 | 0.909 | 0.664 |
| | (0.277) | (0.432) | (0.619) | (0.504) | (0.252) | (0.495) | (0.595) | (0.511) |
| *Origin (Base level = Produced outside the UK* | | | | | | | | |
| Locally Produced = 1 | 0.532** | -1.003*** | 0.466** | 0.909*** | 0.605*** | 0.385 | 0.579*** | 0.489 |
| | (0.221) | (0.310) | (0.217) | (0.346) | (0.197) | (0.455) | (0.198) | (0.412) |
| Produced elsewhere in the UK = 1 | 0.657*** | 0.0350 | 0.648*** | -0.240 | 0.471*** | -0.0386 | 0.454*** | -0.118 |
| | (0.179) | (0.457) | (0.180) | (0.343) | (0.168) | (0.337) | (0.168) | (0.348) |
| *Infection level (Base level = 0%)* | | | | | | | | |
| 10% infection in the flock | -1.394*** | -0.885** | 0.539 | 0.934*** | -0.822*** | 0.628* | 0.116 | 0.664** |
| | (0.257) | (0.370) | (0.545) | (0.345) | (0.224) | (0.338) | (0.512) | (0.333) |
| 20% infection in the flock | -2.919*** | -1.015** | -0.508 | -0.900** | -2.084*** | 0.545 | -1.204* | 0.541 |
| | (0.385) | (0.399) | (0.669) | (0.429) | (0.321) | (0.455) | (0.652) | (0.463) |
| 30% infection in the flock | -2.992*** | 1.409*** | -0.860 | 1.406*** | -2.051*** | 2.337*** | 0.136 | 2.184*** |
| | (0.362) | (0.353) | (0.639) | (0.408) | (0.338) | (0.389) | (0.722) | (0.377) |
| Number of kids*10% infection in the flock | 0.557*** | | | | -0.112 | | | |
| | (0.190) | | | | (0.175) | | | |
| Number of kids*20% infection in the flock | 0.730*** | | | | 0.377 | | | |
| | (0.235) | | | | (0.263) | | | |
| Number of kids*30% infection in the flock | 0.515** | | | | 0.336 | | | |
| | (0.228) | | | | (0.263) | | | |
| Number of kids* High Welfare | 0.0812 | | | | -0.176 | | | |
| | (0.241) | | | | (0.216) | | | |
| Number of kids* Medium Welfare | 0.540** | | | | 0.0629 | | | |
| | (0.244) | | | | (0.195) | | | |
| Age* High Welfare | | | -0.0123 | | | | 0.00753 | |
| | | | (0.0146) | | | | (0.0132) | |
| Age* Medium Welfare | | | -0.00745 | | | | -0.00910 | |
| | | | (0.0131) | | | | (0.0126) | |
| Age*10% infection in the flock | | | -0.0361*** | | | | -0.0182* | |
| | | | (0.0121) | | | | (0.0108) | |
| Age*20% infection in the flock | | | -0.0418*** | | | | -0.0143 | |
| | | | (0.0148) | | | | (0.0134) | |
| Age*30% infection in the flock | | | -0.0390*** | | | | -0.0374*** | |
| | | | (0.0142) | | | | (0.0155) | |
| **Information criteria** | | | | | | | | |
| Number of observations | 4,842 | | 4,842 | | 4,644 | | 4,644 | |
| Number of respondents | 269 | | 269 | | 258 | | 258 | |
| Log-likelihood | -1218 | | -1220 | | -1157 | | -1157 | |
| AIC | 2482.49 | | 2486.03 | | 2360.50 | | 2359.31 | |
| BIC | 2631.65 | | 2635.19 | | 2508.70 | | 2507051 | |

The sign of the estimated standard deviations is irrelevant: interpret them as being positive. Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance

# Chapter 6

# Returns, uncertainty, infection risks, and their role in shaping producer preferences for farm animal health and welfare in England and Scotland

## 6.1 Abstract

I assess farmers' preferences towards farm animal health and welfare in England (n = 169) and Scotland (n = 104) using discrete choice experiments. Cattle and sheep farmers' choices and the trade-offs they make in the presence of monetary uncertainty and disease risk are assessed using multinomial logit and random parameter logit models. The disease risk is studied in the context of two endemic diseases, Bovine Viral Diarrhoea (BVD) in cattle and lameness in sheep.

The results suggest farmers have statistically significant preferences for improvements in livestock health controlling for monetary returns and income uncertainty. There is a positive and separable benefit for lower levels of disease prevalence both in English and Scottish farmers. In addition, I find that cattle farmers in England do not have statistically different preferences to cattle farmers in Scotland. However, sheep farmers is Scotland and sheep farmers in England were found to have statistically different preferences for potential income volatility and livestock disease risk. Scottish sheep farmers are more risk averse than their English counterparts. And finally, I also find that there is a preference for lower disease risk in farms by farmers, however, the magnitude of preference is disease specific.

The chapter is organised as follows: Section 6.2 begins with an introduction and outlines the research questions addressed in this chapter. The discrete choice experiment design, details of the survey and data are presented in section 6.3. Estimation results are presented in section 6.4. The trade-offs made between attributes are presented in section 6.5. Section 6.6 discusses the results and concludes.

## 6.2 Introduction

This chapter examines UK farmer behaviour as economic agents in a hypothetical scenario involving financial returns and uncertainty, and infection risk. Farmers consider several factors when making economic decisions from how to run their farms to buying machinery and culling. These decisions are shaped by the uncertainty (for instance, climate, market and financial) involved in running a farm. As a result, a clear understanding of their preferences towards livestock disease risk in these (or similar) situations is essential, if one wishes to identify farmer preferences towards farm animal health and welfare. The previous chapters focused on understanding the UK consumers perceptions towards FAH and FAW. Now, I examine these perceptions from the supply side of the economy.

As Economic agents, our decisions are the result of a complex cognitive mechanism. Economic decisions are the expected result (weighed average) of different scenarios (choices) weighted by the probability of them occurring. They are the final outcome of a cost- benefit analysis. A well-known result in economics is that agents want to smooth their consumption throughout their lifetimes and as a result they are averse to increased volatility in their earnings. As such, farmers like any other agent seek financial stability. Although, financial stability is sought by all agents, the need for a steady and smooth running of operations becomes absolutely paramount when running a farming business. Farming is a seasonal business with uneven returns across a calendar year. Large expenditures involving monthly bills, purchasing livestock, financing machinery and livestock shelter are vital aspects of farm management. As such, is income the sole determinant of farmers' decision and to what degree does income uncertainty shape them? How can the farms gross margins feed into farmers strategic choices between productivity and infectious disease control approaches? These are some of the questions addressed within this chapter.

Livestock disease management is a critical component of farm management, with farmers employing either proactive or reactive measures to control endemic diseases. This chapter takes one step forward in understanding farmers behaviour around livestock disease management and biosecurity. There is limited literature examining farmers' individual assessments towards farm animal health and welfare (FAHW). Lagerkvist et al. (2011) identify important concerns in the identification and empirical assessment of farmers' preferences towards farm animal welfare (FAW), stressing the significance of considering the trade-off between use and non-use values. This conclusion was further echoed in a study by Owusu-Sekyere et al. (2021) who found that dairy farmers favouring floor solutions were motivated by a complex mix use values referring to economic outcomes of profitability and productivity and non-use values derived from good ethical practices, high animal welfare and animal freedom. Austin et al. (2005) investigated the connection between high welfare farming practices and the farmers' personality and demeanour towards FAW. The authors created a "welfare attitude scale" to examine farmers' preferences. However, what these studies fail to consider is the business aspect of farming. As stated by Bock and Van Huik (2007), producers' attitudes regarding FAW must be viewed in the larger context of their farms' business aims because they can not be motivated only by compassion nor from ethical concerns. Fraser (2005) makes a similar argument that as the farm size increases, the amount of FAW observed in a farm is just the outcome of economic optimisation.

A number of studies have focused on illustrating how farmers investment incentives decrease for private disease control measures due to the presence of externalities. Perhaps the most important among them are the different spatial arrangements like neighbours' behaviour to infection control (Hennessy, 2005), government policies (Gramig and Horan, 2011), market failure (Zilberman et al., 2012) leading to an inefficient equilibrium. It is often argued that farmers would not willingly take steps to eradicate completely endemic diseases in an effort to maximise animal welfare as it is a costly option that would reduce farm profits. As argued by Lusk and Norwood (2011), farms' choices regarding inputs and outputs are the result of profit maximisation behaviour and thus, it is unlikely that they would deliver the maximal animal welfare. On the other hand, in the context of Lameness, a recent study by O'Kane et al. (2017) on English farmers finds that the farmers thoughts and feelings both towards the disease and towards FAW as well as their personality traits are the key determinants of whether or not they will adhere to good farming practices. Several such studies also attempt to explore risk behaviour and conclude that risk attitudes can be considered as greatly inconsistent due to various reasons including context (Reynaud and Couture, 2012; MacCrimmon and Wehrung, 1990), personality traits (Meraner et al., 2016; Deck et al., 2008) and even cognitive skills (Dave et al., 2010). Thus, influenced by the ongoing debate, I try to gauge if farmers operate only as profit maximising entrepreneurs or if animal health and welfare concerns shape their decisions.

According to DEFRA (2021) report[1]on agriculture in the United Kingdom, there was a decrease in the total number of cattle and calves by 0.1% to 9.6 million while the value of beef and veal increased by 10% to £3.3 billion. Sheep and lamb populations increased by 0.8% to 33 million while their value also increased by 12% to £1.5 billion. There was also an increase in the total income from farming (TIFF)[2] to 5.9 million which was an increase of 14% from 2020. Income volatility in the UK in the last 20 years has had year on year fluctuations of over 40%. As such, given the increased uncertainty observed in the economic environment in recent times, one would logically expect farmers to prioritise financial stability and be ready to accept lower rewards and higher certainty. In other words, we would expect farmers to avoid risky practices, making safer choices that might result in lower expected return but also lower income volatility.

As illustrated by the literature summarised above, farm animal health and welfare is the product of a complex decision making process. My study differs from those mentioned previously in certain key aspects. I conduct a survey based discrete choice experiment to elicit information on the trade-off between disease risk, and financial uncertainty, among cattle and sheep farmers in England and Scotland. Producers' choices are examined in a scenario where farmers decide to take on the management of a farm where expected income is linked to their decision-making process in the presence of disease risk. Therefore the research questions addressed in this chapter are as follows: i. Are farmers willing to forfeit higher expected gross margins for lower disease risk and lower income volatility? ii. What are the trade-offs farmers are willing to make in order to take up the management of a farm with lower infection rates? iii. Are preferences between cattle farmers from England different to cattle farmers from Scotland given the presence of different legislation governing the handling of BVD infected cattle[3]. iv. Are preferences between sheep farmers from England different to sheep farmers from Scotland in the context of lameness in sheep. I look at

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[1] Annual publication of the Agriculture in the United Kingdom 2020 (Published 27 July 2022).

[2] Total income from farming is calculated as the gross value added minus asset depreciation minus (tax, wages, rent, interest) plus subsidies.

[3] The two nations differing approach to handling BVD in cattle has been discussed in chapter 1.

attitudes of farmers towards these diseases because while lameness is primarily a management issue, BVD is an infectious disease. Therefore, farmers are expected to have differing preferences towards the management of these diseases. The remainder of this study is organised as follows. The following section presents the methodology and describes the data. This is followed by the results of the analysis in section 6.4. I present the results of the trade-offs ratios between between countries and farmer types in section 6.5 and finally, I discuss the results and conclude in section 6.6.

## 6.3 Methodology

### Experiment design and data

The study's main objective was to evaluate farm animal health and welfare preferences of farmers in the presence of income uncertainty and disease risk. A discrete choice experiment was the most appropriate choice given the research questions. The aim of the choice experiment was to ascertain the trade-offs farmers were willing to make between income fluctuation and disease level in the herd/flock as well as expected gross margins. These attributes help me better understand the decision's farmers would make in a hypothetical but realistic farm management scenario. The hypothetical scenario in this study was the takeover of the management of a farm that already came with a flock/herd. Of the three farms offered, farmers were asked to pick the farm they would most likely prefer to manage. The choices farmers make provide useful insight into the decision making process when expected income and herd/flock sickness levels are considered.

The choice experiment was delivered in the form of an online survey to cattle and sheep farmers across England and Scotland. The survey ran between February and October 2020 however there were periods of disruption in between due to the COVID19 pandemic. Farmer emails were identified from various farming websites that had them listed in their directories. The surveys were also advertised on agricultural charity websites as well. As an incentive to completing the surveys, a monetary donation to the charities was offered. For every completed survey, £5 was donated to the charities the Farming Community Network in England and the Royal Scottish Agricultural Benevolent Institution in Scotland. I had a response rate of 41.6% in England and 38.27% in Scotland [4]. Observations with missing values were excluded from the analysis (a total of seven responses were missing information on gross revenue, five from England and 2 from Scotland). Incomplete surveys were dropped giving us a final sample size of n = 169 for England and n = 104 for Scotland.

The surveys were constructed on Sawtooth software and an experimental design was generated from NGene. Six choice scenarios -with three alternatives each with differing levels- were presented consecutively. In all, I had 18 choice scenarios, which I divided into three blocks. An initial pilot survey was conducted on farmers in person at the Hexham auction mart in England. The pilot study used a D-efficient design with very small positive and negative prior values. Using the data from the pilot (n = 11) I implemented homogeneous[5] Bayesian- efficient pivot design in order to improve the robustness of the study. Such pivot designs are developed to ensure a more realistic layout for each respondent, taking into account the "cognitive and contextual point of view" that not all respondents face the same choice situations, thereby, converging to a sub-optimal equilibrium (Hensher et al., 2015). In my case, I employed a pivoted design centred on the socio-economic co-variate *gross revenue*. Farmers were stratified into three income categories depending on their overall reported agricultural gross revenue (see figure 6.1 for detailed breakdown). Those whose combined gross revenue from agricultural and non-agricultural sources annually was

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[4] The response rate was calculated as the total number of completed surveys/the total number of people who opened the link

[5] A single experimental design is created for all respondents based on the medium income farmers using levels 100, 250, and 500 (£). I simply replaced these levels with the lower or higher levels for the other farmers. I believed farmer income was too varied to allow a pivot design based on individual income, based on the data from the survey conducted by the FIELD team. At the time I was designing the study, I wanted to also compare different farmer types and therefore wanted to rule out the impact of different designs that a heterogeneous design produced.

less than £100,000 (low), between £100,000 and £500,000 (medium) and those with gross revenues over £500,000 (high) were pivot design references. When compared to other less effective (statistically) designs like orthogonal designs, the experimental design strategy utilised here was specifically structured to enhance the statistical performance of the models when applied to small samples (Rose, et al., 2008).

The survey was structured as follows: Section A started with some socio-economic questions on the farmer and their individual farming characteristics, these questions were divided across several sections. Section B presented the auction choice experiment as will be discussed in the following chapter (chapter 7). Section C collected some socio-economic questions. Section D was part of the survey related to the farm management choice experiment. Section E collected information on farmers risk preferences and attitudes and finally section F concluded with some more questions on farm characteristics.

Three attributes as listed in table 6.1 made up the choice experiment. The attribute expected gross margins was defined as the average income predicted from the new farm over the next five financial years subject to some uncertainty. This attribute was included in order to assess farmers preferences in the presence of expected income. Dependent on the gross revenue reported, the farmers were directed to the corresponding choice experiment where the expected gross margins changed based on the income category as defined above. For example, a farmer with reported annual gross revenue of say £300,000 would fall in the medium income category and therefore would complete the choice experiment with attribute expected gross margins of £100,000, £250,000 and £500,000.

Potential future income fluctuation was another key attribute that was employed. It showed the average percentage variation of income, which could fluctuate up or down in the ranges specified every year based on the previous five years. And lastly, I used percentage of herd/flock infection levels (this attribute has been consistently used in both the consumer and farmer surveys thus far). It gives an indication of the percentage of the flock/herd infected, for example, by lameness; so 10% infection level indicated 1 in 10 sheep are infected with lameness in the flock. The attributes were selected to reflect the uncertainty involving disease risk versus income risk. These attributes were described to the respondents before commencing the choice experiment in order to ensure all respondents had a common set of definitions of the terminology used in the experiment. The surveys were limited to cattle and sheep farmers only. In addition, I also ensured that farmers whose gross revenue is primarily derived from sheep farming were provided with the choice scenarios in the context of lameness in sheep, while farmers whose gross revenue is primarily derived from cattle farming completed the choice experiment in the context of BVD in cattle. The survey concluded with socio-economic questions about the farmer. The choice scenario describes a situation where people who are thinking of renting additional farm/land if they are tenant farmers or farmers who may be thinking about buying another farm to expand their business.

Figures 6.2 and 6.3 provide example choice scenarios. The question was presented as follows:

“ You are a farmer who is offered to take-over the management of some new farm. You have the following farms you could choose. Think about what characteristics of the farm are most important

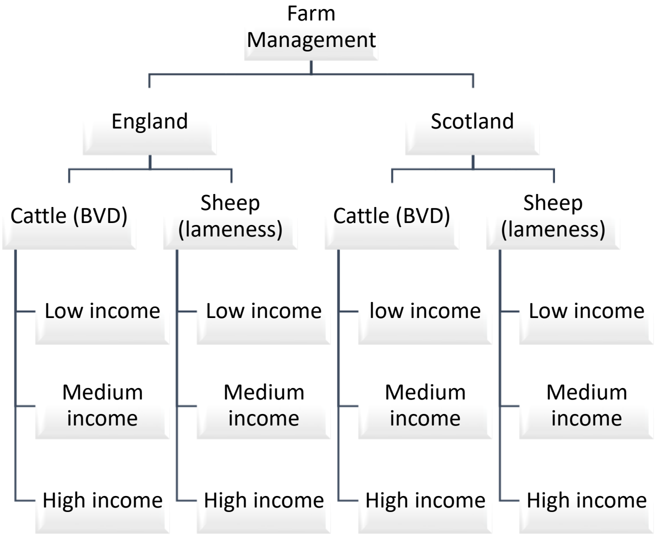
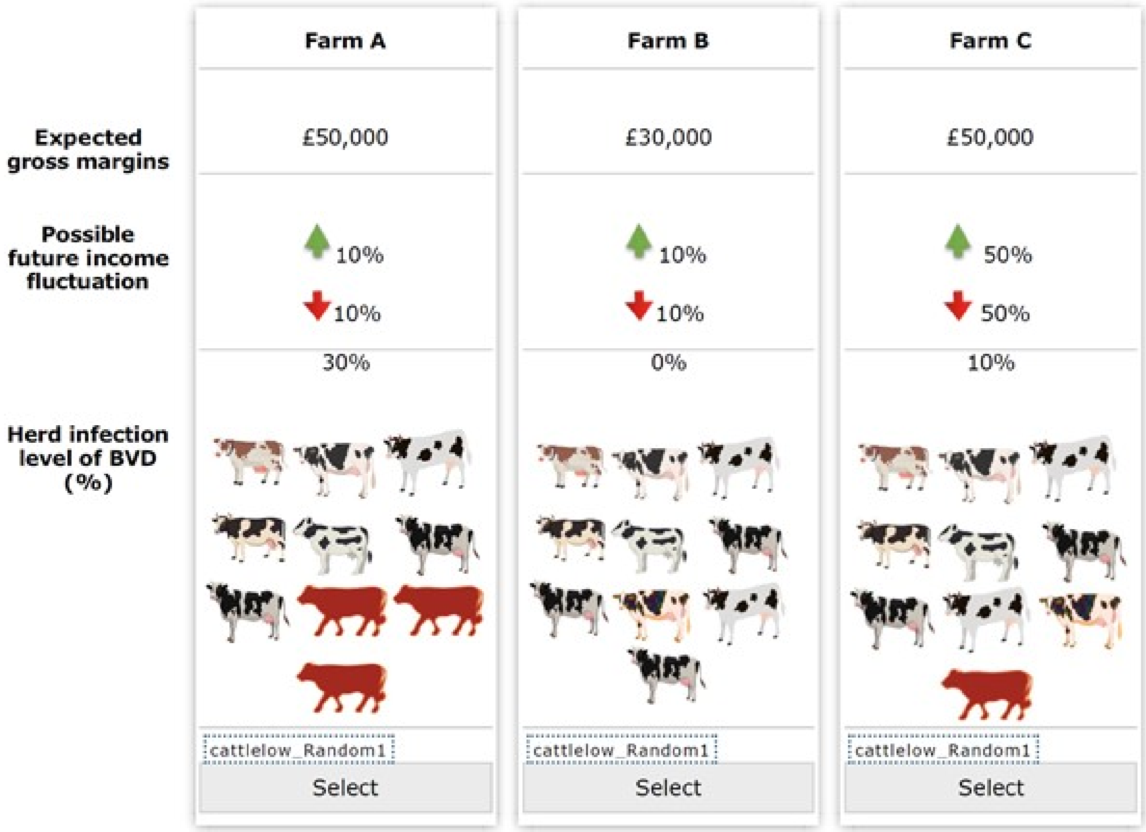


Figure 6.1: Pivot design

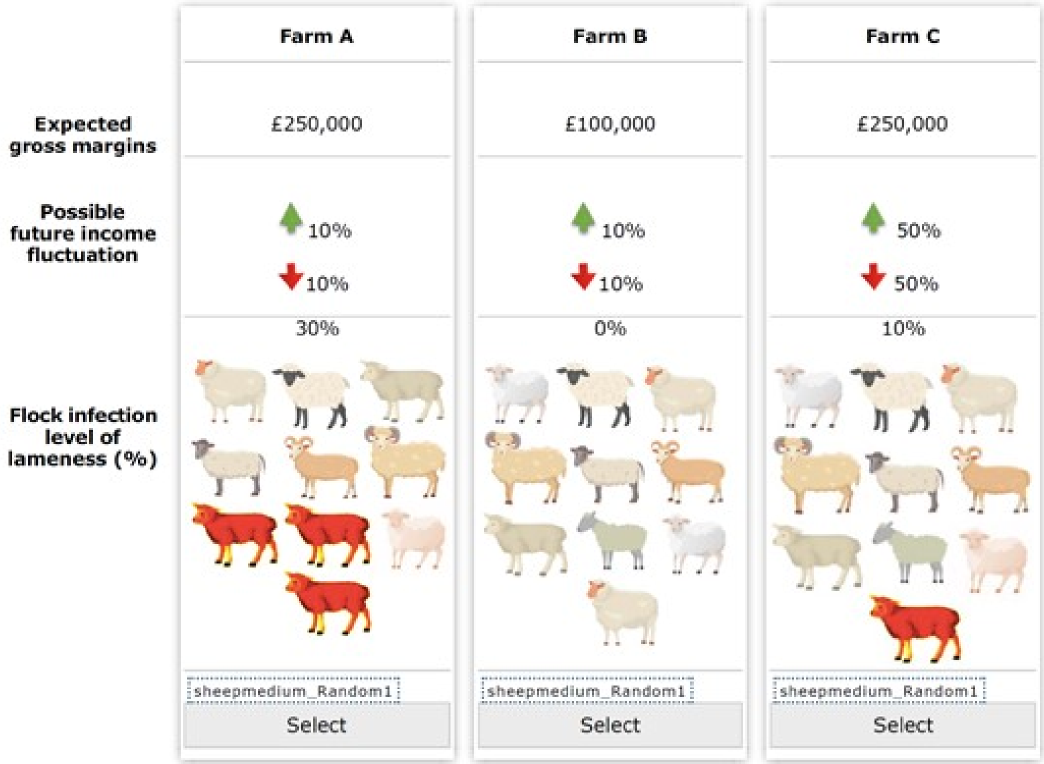
Table 6.1: Farm management attributes and attribute levels

| **Attributes** | **Pivot reference** | **Levels** |
|---|---|---|
| Expected gross margins | Low (gross revenue < £100,000) | £30,000 |
| | | £50,000 |
| | | £90,000 |
| | Medium (gross revenue between £100,000 - £500,000) | £100,000 |
| | | £250,000 |
| | | £500,000 |
| | High (gross revenue > £500,000) | £600,000 |
| | | £800,000 |
| | | £1,000,00 |
| Possible future income fluctuation (%) | | ± 10 |
| | | ± 30 |
| | | ± 50 |
| BVD infection level (%) | | 0, 10, 20, 30 |
| Lameness infection level (%) | | 0, 10, 20, 30 |



| | Farm A | Farm B | Farm C |
|---|---|---|---|
| Expected gross margins | £50,000 | £30,000 | £50,000 |
| Possible future income fluctuation | ↑ 10%<br>↓ 10% | ↑ 10%<br>↓ 10% | ↑ 50%<br>↓ 50% |
| Herd infection level of BVD (%) | 30% | 0% | 10% |

Figure 6.2: Example choice experiment – Low gross margins (Cattle)



| | Farm A | Farm B | Farm C |
|---|---|---|---|
| Expected gross margins | £250,000 | £100,000 | £250,000 |
| Possible future income fluctuation | ▲ 10%<br>▼ 10% | ▲ 10%<br>▼ 10% | ▲ 50%<br>▼ 50% |
| Flock infection level of lameness (%) | 30% | 0% | 10% |

Figure 6.3: Example choice experiment – Medium gross margins (sheep)

to you and choose a farm accordingly. **Each choice is independent of the others so a previous choice should not affect or influence future decisions.**

**Please pick one farm you are most likely to accept.**"

A sample interpretation of the choice scenario provided is as follows for figure 6.2:

"**Farm A** you predict the expected gross margins to be **£50,000** a year over the next 5 years, with a possible fluctuation in the future income being **10%** higher than your expected gross margins versus **10%** lower than your expected gross margins. The current testing of the herd suggests **30%** prevalence of PI cattle (i.e., **every 3 in 10 cattle are BVD positive**).

**Farm B** you predict expected gross margins of £30,000 a year over the next 5 years, with the possible fluctuation in the future income being **10%** higher than your expected gross margins versus **10%** lower than your expected gross margins. The current testing of the herd suggests **0%** prevalence of PI cattle (i.e., **every 0 in 10 cattle are BVD positive**).

**Farm C** you predict expected gross margins of **£50,000** a year over the next 5 years, with the possible fluctuation in the future income being **50%** higher than your expected gross margins versus **50%** lower than your expected gross margins. The current testing of the herd suggests **10%** prevalence of PI cattle (i.e., **every 1 in 10 cattle are BVD positive**)."

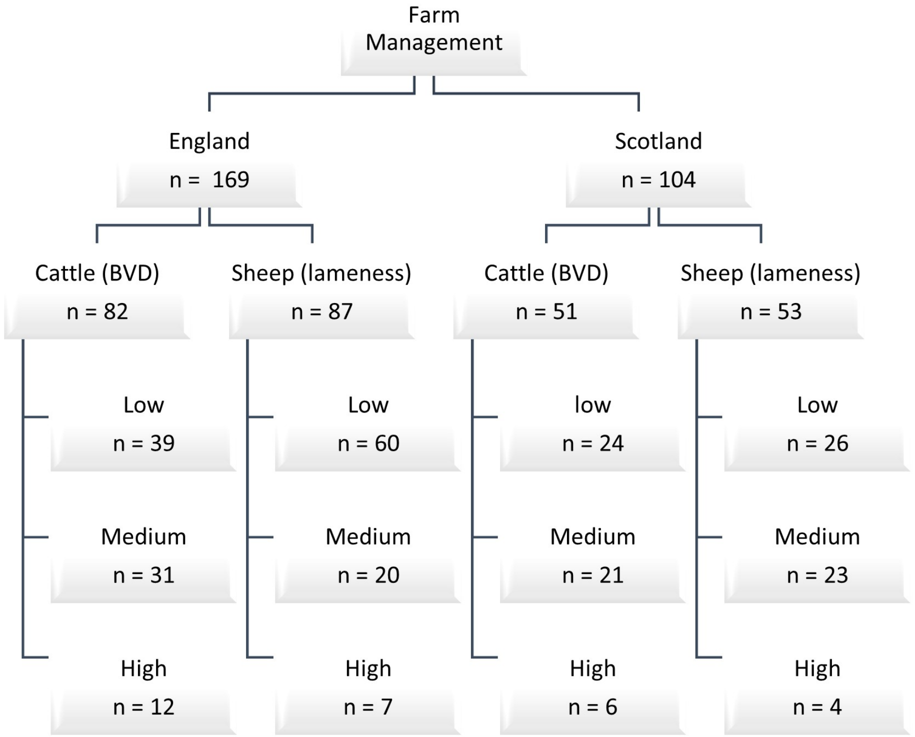


Figure 6.4: Sample size for each stratum

In contrast to all of the earlier choice experiments in this thesis, I employed a forced choice experiment to force the respondents to make a decision by removing the option to opt-out. The reasoning behind this decision was that while in a real-life buying situation a respondent may choose not to make a purchase, this scenario, however, differs in that respondents are asked to express a preference for an alternative rather than buying something. In several studies, results with and without no-choice alternatives have been compared using choice experiments and lab experiments to study how choices are formed when there is preference ambiguity, particularly when the alternatives are equally appealing and both offer advantages and disadvantages (Dhar and Simonson, 2003; Simonson, 1989).

An overview of the data distribution is shown in Figure 6.4. My sample is substantially skewed towards English farmers, with sheep farmers in both nations somewhat outnumbering cattle farmers. Additionally, there were more low-income farmers in the sample (approximately 58.6% in England and 48% in Scotland) than medium-income farmers (approximately 30% in England and 42% in Scotland). Farmers with gross revenue of more than £500,000 made up roughly 11% of the English sample and 9.6% of Scottish sample.

Tables 6.2 - 6.5 represent the descriptive statistics for alternatives in the choice experiments. They show the distribution of the farmers' farm choices. The second unlabelled alternative (actual choice share = 0.37) was picked more frequently than the first (choice share = 0.34), while alternative C (choice share = 0.27) was picked the least frequently, according to the analysis in table 6.2. This is true across all samples. On average notice alternative C has slightly better values for all three

Table 6.2: Descriptive statistics for alternatives in the English choice experiment for sheep farmers

| Choice shares | **Alternative A**<br>**34.6%** | | **Alternative B**<br>**37.8%** | | **Alternative C**<br>**27.6%** | |
|---|---|---|---|---|---|---|
| | Mean | Standard deviation | Mean | Standard deviation | Mean | Standard deviation |
| **Expected Gross margins** | 0.69 | 1.07 | 0.75 | 1.09 | 0.55 | 0.99 |
| **Possible future income fluctuation** | 0.67 | 1.06 | 0.73 | 1.07 | 0.53 | 0.97 |
| **Infection level in flocks** | 0.84 | 1.31 | 0.90 | 1.36 | 0.73 | 1.32 |

attributes, alternative A being the second best compared to alternative B which again was true across all samples. This gives no indication that there was any reason for the greater propensity of respondents to select alternative B over the other two alternatives.

## 6.4 Results

The results of the analyses are presented in three sub-sections. I estimate the models using the same econometric approaches described in detail in chapters 3 and 4. The analysis was conducted using the multinomial logit (MNL) and random parameter logit (RPL) models. The RPL model was estimated using Gauss quadrature with 3 draws instead of pseudo-random draws as it requires fewer simulations and as a result is able to evaluate a higher number of designs without a high computational cost. The standard deviations in the RPL model indicate the presence of preference heterogeneity, and the standard errors inform of the estimate uncertainty. Note throughout the chapter, the sign of the estimated standard deviations for the RPL models is irrelevant. The model fit is tested using Akaike Information Criteria (AIC), Bayesian Information Criterion (BIC) and log-likelihood information criterion. In every sub-section, I discuss the model fit for one of the key outputs.

As was highlighted in the introductory chapter, the approach towards managing BVD is different in England and Scotland. While England uses a voluntary scheme, Scotland has a compulsory eradication scheme where the BVD status of all breeding cattle must be known according to the Bovine Viral Diarrhoea (Scotland) order of 2019. Unlike Scotland, England has no such legislation requiring farms to have a BVD free status in order to trade cattle. Scottish farmers are prohibited from trading BVD-positive cattle and from keeping Persistently Infected (PI) cattle on their farms

Table 6.3: Descriptive statistics for alternatives in the English choice experiment for cattle farmers

| Choice shares | **Alternative A**<br>**31.30%** | | **Alternative B**<br>**40.65%** | | **Alternative C**<br>**28.05%** | |
|---|---|---|---|---|---|---|
| | **Mean** | **Standard deviation** | **Mean** | **Standard deviation** | **Mean** | **Standard deviation** |
| **Expected Gross margins** | 0.62 | 1.03 | 0.81 | 1.11 | 0.56 | 1.01 |
| **Possible future income fluctuation** | 0.60 | 1.02 | 0.78 | 1.09 | 0.55 | 0.99 |
| **Infection level in herds** | 0.79 | 1.310 | 0.99 | 1.42 | 0.70 | 1.25 |

Table 6.4: Descriptive Statistics for alternatives in the Scottish choice experiment for sheep farmers

| Choice shares | **Alternative A**<br>**34.6%** | | **Alternative B**<br>**37.8%** | | **Alternative C**<br>**27.6%** | |
|---|---|---|---|---|---|---|
| | Mean | Standard deviation | Mean | Standard deviation | Mean | Standard deviation |
| **Expected Gross margins** | 0.69 | 1.07 | 0.75 | 1.09 | 0.55 | 0.99 |
| **Possible future income fluctuation** | 0.67 | 1.06 | 0.73 | 1.07 | 0.53 | 0.97 |
| **Infection level in flocks** | 0.84 | 1.31 | 0.90 | 1.36 | 0.73 | 1.32 |

Table 6.5: Descriptive statistics for alternatives in the Scottish choice experiment for cattle farmers

| Choice shares | **Alternative A**<br>**32.35%** | | **Alternative B**<br>**42.48%** | | **Alternative C**<br>**25.16%** | |
|---|---|---|---|---|---|---|
| | **Mean** | **Standard deviation** | **Mean** | **Standard deviation** | **Mean** | **Standard deviation** |
| **Expected Gross margins** | 0.64 | 1.04 | 0.84 | 1.11 | 0.51 | 0.99 |
| **Possible future income fluctuation** | 0.61 | 1.01 | 0.82 | 1.11 | 0.50 | 0.95 |
| **Infection level in herds** | 0.81 | 1.31 | 1.03 | 1.44 | 0.62 | 1.20 |

for more than 40 days before declaring a BVD “not negative” herd until the animal has been tested. Therefore, the sub-sections are laid out as follows. The first sub-section discusses preferences of all respondents in England and Scotland. In the following two sub-sections, I segregate the findings for cattle and sheep farmers from each country, thus allowing comparisons between farmer types and across nations.

A comparison of Scottish and English farmers’ behaviour is provided in subsections 6.4.2 and 6.4.3. After reporting the estimated outputs, I provide kernel density plots [6] to illustrate the empirical distributions of individual-level coefficients derived from the RPL models (see Hensher, Rose and Greene, 2015, chapter 15). This gives us a graphical representation of the distributions of the individual-level coefficients, thus, providing us with a greater understanding of the parameter estimates across the sampled populations.

### 6.4.1 All data

Table 6.6 shows the estimation results for two specifications. Model 1 describes the multinomial logit model and model 2 addresses the random parameter logit model. Each model is estimated using the total farmer data set from both countries. The AIC for model 1 is 2956.137 and 2596.908 for model 2 and the BIC is 2995.136 and 2674.906 for model 1 and model 2 respectively, suggesting that model 2 fits the data better. The log-likelihood for model 1 is -1472 higher than model 2 that has -1286, once again confirming that model 2 is better suited.

Next, observe that higher expected gross margins (interchangeably used as mean income or mean

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[6] The kernel density estimates use Epanechnikov kernel function.

Table 6.6: Sheep and cattle farmers in England and Scotland

| **Variables** | **(1)**<br>**Model 1** | **(2)**<br>**Model 2** | |
|---|---|---|---|
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0306*** | 0.0978*** | 0.142*** |
| | (0.00272) | (0.0167) | (0.0217) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.575*** | -0.724*** | -0.274 |
| | (0.0891) | (0.126) | (0.292) |
| ± 50% | -0.230*** | -0.329*** | 0.712*** |
| | (0.0615) | (0.101) | (0.139) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -0.909*** | -1.325*** | 1.243*** |
| | (0.0883) | (0.164) | (0.178) |
| 20% infection in the herd/flock | -1.373*** | -2.020*** | 0.849*** |
| | (0.0946) | (0.165) | (0.180) |
| 30% infection in the herd/flock | -2.469*** | -3.843*** | 1.395*** |
| | (0.120) | (0.270) | (0.231) |
| **Information criteria** | | | |
| Number of observations | 4,914 | 4,914 | |
| Log-likelihood | -1472 | -1286 | |
| AIC | 2956.137 | 2596.908 | |
| BIC | 2995.136 | 2674.906 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6.7: Cattle farmers in England and Scotland

| | (1) | (2) | |
|---|---|---|---|
| **Variables** | **Model 1** | **Model 2** | |
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0259*** | 0.0394*** | 0.117*** |
| | (0.00402) | (0.0138) | (0.0301) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.577*** | -0.787*** | 0.639** |
| | (0.142) | (0.214) | (0.304) |
| ± 50% | -0.285*** | -0.397** | 1.047*** |
| | (0.0982) | (0.172) | (0.223) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -1.666*** | -2.228*** | 0.812*** |
| | (0.143) | (0.264) | (0.279) |
| 20% infection in the herd/flock | -2.212*** | -3.133*** | 0.742*** |
| | (0.164) | (0.304) | (0.280) |
| 30% infection in the herd/flock | -3.405*** | -4.787*** | 1.094*** |
| | (0.211) | (0.439) | (0.325) |
| **Information criteria** | | | |
| Number of observations | 2,394 | 2,394 | |
| Log-likelihood | -608.7 | -528.8 | |
| AIC | 1229.482 | 1081.554 | |
| BIC | 1264.166 | 1150.923 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6.8: Sheep farmers in England and Scotland

| Variables | (1)<br>Model 1 | (2)<br>Model 2 | |
|---|---|---|---|
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0441*** | 0.282*** | 0.287*** |
| | (0.00411) | (0.0424) | (0.0428) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.537*** | -0.760*** | 0.00746 |
| | (0.119) | (0.186) | (0.263) |
| ± 50% | -0.259*** | -0.710*** | 0.966*** |
| | (0.0852) | (0.164) | (0.182) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -0.401*** | -0.594*** | -1.032*** |
| | (0.121) | (0.222) | (0.284) |
| 20% infection in the herd/flock | -0.822*** | -2.013*** | 1.260*** |
| | (0.122) | (0.270) | (0.236) |
| 30% infection in the herd/flock | -1.977*** | -4.463*** | 2.129*** |
| | (0.155) | (0.515) | (0.379) |
| **Information criteria** | | | |
| Number of observations | 2,520 | 2,520 | |
| Log-likelihood | -785.2 | -650.8 | |
| AIC | 1582.351 | 1325.598 | |
| BIC | 1617.343 | 1395.582 | |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

returns) are preferred by the farmers. Model 2 reconfirms this result and also alerts us to the presence of preference heterogeneity. Possible future income fluctuations (also referred to as income uncertainty, income volatility) indicate that the farmers are risk averse. This was also evident in model 2 where farmers showed a greater preference for moderate risk. At 30% possible future income fluctuations, there was no observed preference heterogeneity but at 50% fluctuations, I note the existence of significant preference heterogeneity. Finally, respondents also exhibited negative preference for higher disease risk. In other words, farmers favoured managing farms with lower disease risk. Nevertheless, there was significant heterogeneity in preferences for this attribute. To understand this further, I study English and Scottish farmers separately in the following subsections. Before that let us see if there are any differences between cattle and sheep farmers. Table 6.7 considers all cattle farmers across the two nations. It is evident that although the farmers preferences have largely remained the same as the results reported in table 6.6, I observe significant preference heterogeneity in all the attributes. Table 6.8 helps draw an analogous conclusion for the sheep farmers from both countries. Similar to the case of the cattle farmers, there is significant heterogeneity in all attributes with the exception of moderate income fluctuations (30% income fluctuations).

Using table 6.6, I calculate the proportion of farmers who have specific (positive or negative) preference towards an attribute [7]. Notice that 32% of farmers would accept 50% fluctuations in income, 14% are ready to manage a farm with 10% disease risk, 0.89% prefer managing a farm with 20% disease risk and 0.3% would accept a disease risk of 30%. Comparing results between cattle and sheep farmers using tables 6.7 and 6.8, I find that 10% of cattle farmers would accept income fluctuations of 30%. This is in stark contrast to sheep farmers who had no preference heterogeneity for this attribute level. At 50% income volatility however, one can see that 35% of the cattle farmers were willing to take the risk compared to only 23% of sheep farmers. When it comes to infection levels, only 3% of cattle farmers preferred a farm with 10% infection level over no infection, with the number going to zero as the BVD infection level in the herd climbs to 20%. On the other hand, when considering lameness in a flock, 28% of farmers were willing to manage a farm with 10% infection level, 6% would choose farms with 20% infection level and only 2% would choose farms with 30% lameness levels. This difference in preference could be attributed to the fact that lameness unlike BVD has several different causes and is easily detectable and manageable depending on the causes.

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[7] To calculate proportions of preference figures, I use $100 \times \phi\left(\frac{-\beta_s}{SD_s}\right)$ where $\Phi$ is the cumulative standard normal distribution, $-\beta_s$ is the mean of the sth coefficient and $SD_s$ is the standard deviation of the $s^{th}$ coefficient. All figures are rounded to the nearest percentage.

### 6.4.2 Farmers in England

Table 6.9 reports the preferences of English sheep and cattle farmers. I refer to the estimation output using the multinomial logit model as model 1 whilst model 2 refers to the random parameter logit estimates. According to AIC, BIC and the log-likelihood information criteria, the random parameter model outperforms the multinomial logit model. The AIC and BIC for the RPL model (1526.848 and 1599.091, respectively) are lower than the multinomial logit model (1892.59 and 1928.712, respectively). The log likelihood of the RPL model (-751.4) is higher than the multinomial logit model (-940.3). All three of the information criteria indicates that the RPL model (model 2) better fit these data. The appendix reports the models with j-1 alternative specific constants (ASC's) (Hensher, Rose, Greene, 2015). The ACS's were not included in the final model since they were not statistically significant which means that they do not add to any useful behavioural explanation.

To begin with, let us look at the estimation output of the MNL model. Any positive marginal utilities imply an increase in utility relative to the base level. As anticipated, the marginal utility of the expected gross margins was positive implying that the higher the expected gross margins, the higher the utility. Moving on to attributes with base levels, notice that infection levels displayed a very similar pattern both in sign and magnitude to consumer preferences (see chapters 4 and 5). Both type of farmers (cattle and sheep farmers) had to consider taking up the management of farms with specific infection levels. For cattle farmers the infection level was in the context of BVD whilst for sheep farmers it was in the context of lameness. When appending the samples the infection levels are used in a broader setting of disease risk. The values are statistically significant and negatively increased in magnitude given the base level of 0% infection rate, signifying the farmers preferences to manage farms that had lower prevalence of infection. As a reminder, BVD is an infection that can be controlled within farms through vaccinations and strict mitigating controls within the farm (for example, by quarantining PI animals).

Lastly, the attribute of possible future income fluctuations also was statistically significant for income fluctuation of plus/minus 30%, however, fluctuation of 50% was not found to be significant. This was in contrast to the RPL model where all of the attributes were found to be significant including fluctuation in income of plus/minus 50%. This attribute level was found to be both negative and statistically significant, indicating that the lower the fluctuations more likely is the farmer to take up the management of the farm. In addition to the above, model 2 indicates the existence of unobserved heterogeneity in preferences. The statistically significant standard deviations generated by the RPL model demonstrates this. The only exceptions being possible income fluctuations of 30% (at 95% significance level) and 20% infection in the herd (at any significance level).

Moving on, let us examine sheep farmers in England as shown in table 6.10. Model 1 corresponds to the MNL model and model 2 to the RPL model. To compare the fit of the models notice that the AIC and BIC (798.8 and 863, respectively) for model 2 are lower compared to model 1 (997.46 and 1029.59, respectively). Model 2 also has a higher log likelihood (-387.4) than model 1 (-492.7). Thus, again, we conclude that the RPL model has a better model fit than the MNL model. This was also the case for table 6.11 that specified models for cattle farmers in England. Next, I provide a comparison between sheep farmers (table 6.10) and cattle farmers (table 6.11) from England.

Table 6.9: Models for all farmers in England (Sheep and cattle)

| | **(1)** | **(2)** | |
|---|---|---|---|
| **Variables** | **Model 1** | **Model 2** | |
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0252*** | 0.145*** | 0.403*** |
| | (0.00353) | (0.0176) | (0.0458) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.605*** | -0.754*** | 0.643* |
| | (0.112) | (0.198) | (0.363) |
| ± 50% | -0.113 | -0.345** | 1.494*** |
| | (0.0767) | (0.175) | (0.214) |
| *Infection level (Base level = 0%)* | | | |
| | -0.767*** | -1.587*** | 0.980*** |
| 10% infection in the herd/flock | (0.111) | (0.254) | (0.315) |
| | -1.210*** | -2.806*** | 0.501 |
| 20% infection in the herd/flock | (0.116) | (0.278) | (0.451) |
| | -2.147*** | -4.859*** | 1.869*** |
| 30% infection in the herd/flock | (0.145) | (0.471) | (0.377) |
| **Information criteria** | | | |
| Number of observations | 3,042 | 3,042 | |
| Log-likelihood | -940.3 | -751.4 | |
| AIC | 1892.59 | 1526.848 | |
| BIC | 1928.712 | 1599.091 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

As anticipated higher expected gross margins increased the likelihood of farmers both sheep and cattle choosing a proposed farm. However, the RPL model for cattle farmers shows that although there is variability in preferences for expected gross margins, the coefficient, nonetheless, although positive is not significant. Higher uncertainty in possible future income decreased the probability of choosing a farm to manage in the case of sheep farmers. This attribute showed preference heterogeneity only at income fluctuation of plus/minus 50%. At plus/minus 30% income fluctuation, sheep farmers preferences were homogeneous.

Cattle farmers on the other hand, exhibited a strong preference against 30% fluctuations in income with no heterogeneity in preferences. At 50% fluctuations of income the result although negative was not statistically significant. Lastly, the likelihood of farmers choosing the management of a proposed farm decreased as the infection risk for lameness in sheep and BVD in cattle increased. This result was significant, negative, and increased in magnitude as the infection risk increased. However, while there was variability in preferences for this attribute in sheep farmers, cattle farmers exhibited no heterogeneity in preference for 20% infection rate. Graphically in figure 6.5 and 6.6, we can observe the potential presence of heterogeneity in the attributes using the kernel density plots. The attribute coefficients that have (statistically) significant heterogeneity are more spread out whilst homogeneous attributes seem to concentrate around the mean.

Table 6.10: Sheep farmers in England

| **Variables** | **(1)**<br>**Model 1** | **(2)**<br>**Model 2** | |
|---|---|---|---|
| | β(SE) | β(SE) | Standard deviation |
| *Expected gross margins* | 0.0512*** | 0.350*** | 0.464*** |
| | (0.00596) | (0.0570) | (0.0748) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.539*** | -0.620** | -0.0299 |
| | (0.151) | (0.281) | (1.015) |
| ± 50% | -0.142 | -0.525** | 1.633*** |
| | (0.108) | (0.264) | (0.375) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -0.321** | -1.113*** | -1.035*** |
| | (0.152) | (0.345) | (0.394) |
| 20% infection in the herd/flock | -0.723*** | -2.405*** | 0.888** |
| | (0.151) | (0.397) | (0.452) |
| 30% infection in the herd/flock | -1.719*** | -5.265*** | 2.509*** |
| | (0.188) | (0.808) | (0.610) |
| **Information criteria** | | | |
| Number of observations | 1,566 | 1,566 | |
| Log-likelihood | -492.7 | -387.4 | |
| AIC | 997.459 | 798.8191 | |
| BIC | 1029.597 | 863.0945 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

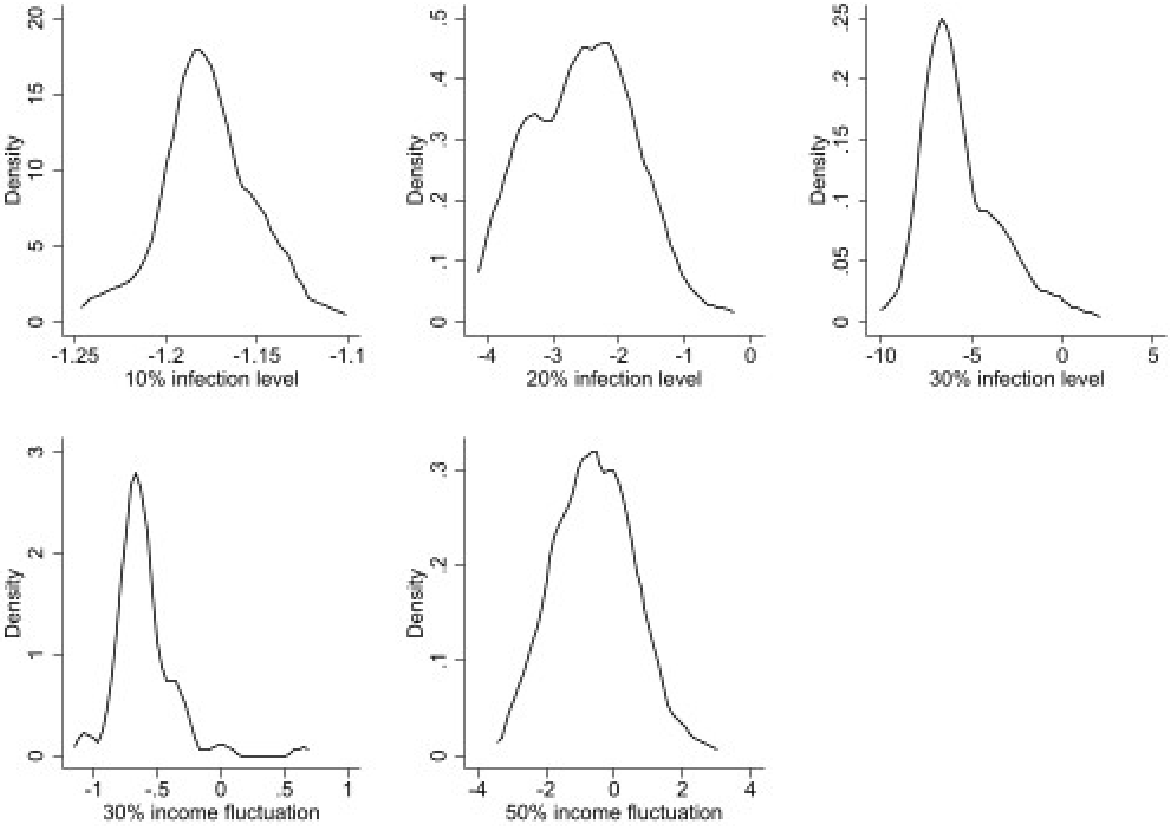

Figure 6.5: Kernel densities for individual-level attributes for English sheep farmers

Table 6.11: Cattle farmers in England

| | **(1)** | **(2)** | |
|---|---|---|---|
| **Variables** | **Model 1** | **Model 2** | |
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0176*** | 0.0304 | 0.143*** |
| | (0.00518) | (0.0272) | (0.0383) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.519*** | -0.754*** | 0.560 |
| | (0.180) | (0.287) | (0.533) |
| ± 50% | -0.152 | -0.230 | 1.164*** |
| | (0.124) | (0.238) | (0.286) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -1.661*** | -2.299*** | -1.142** |
| | (0.186) | (0.385) | (0.549) |
| 20% infection in the herd/flock | -2.119*** | -3.140*** | -0.00523 |
| | (0.208) | (0.412) | (0.749) |
| 30% infection in the herd/flock | -3.285*** | -4.773*** | 1.352*** |
| | (0.270) | (0.632) | (0.508) |
| **Information criteria** | | | |
| Number of observations | 1,476 | 1,476 | |
| Log-likelihood | -378.6 | -331.5 | |
| AIC | 769.287 | 686.9016 | |
| BIC | 801.0696 | 750.4667 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

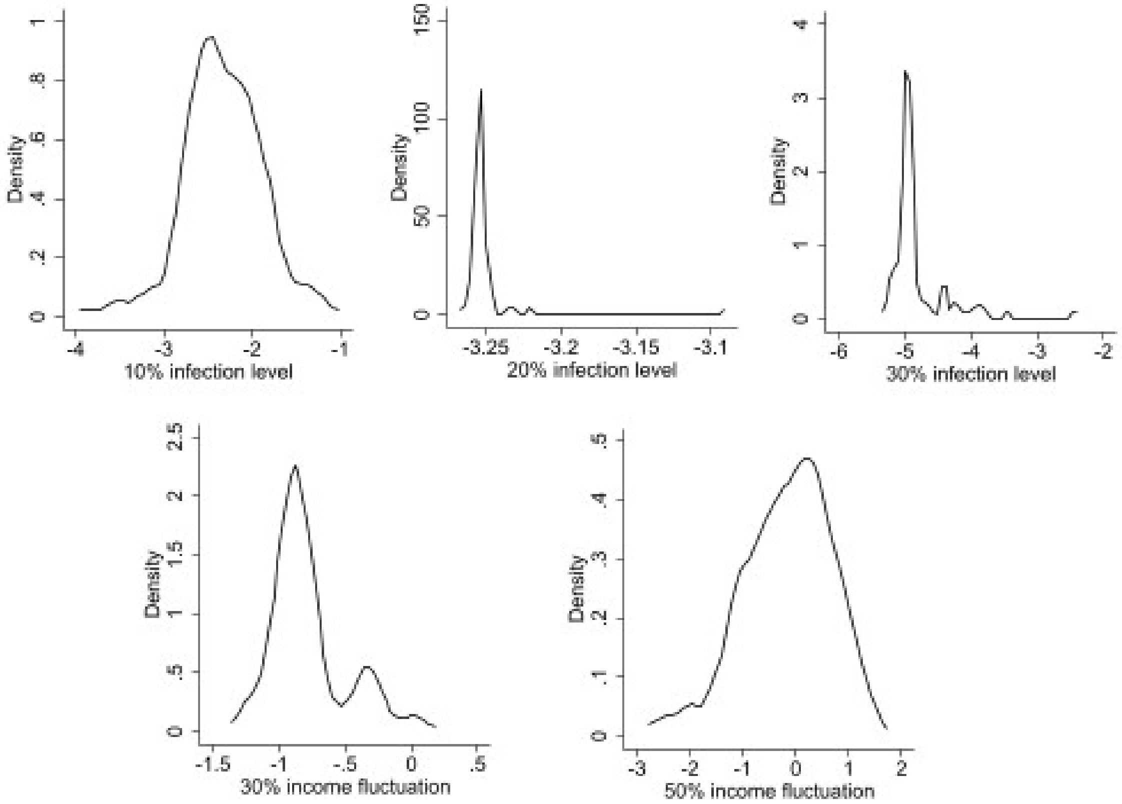

Figure 6.6: Kernel densities for individual-level attributes for English Cattle farmers

### 6.4.3 Farmers in Scotland

We now look at Scottish farmers. Once again, relying on the AIC, BIC and Log-Likelihood criteria, we see that the RPL model (model 2) outperforms the MNL model (model 1). The appendix reports the models with j-1 alternative specific constants (ASC's) (Hensher, Rose, Greene, 2015). There is a similar pattern in preferences across all farmers (see tables 6.12 - 6.14). Whether we look at cattle farmer data or sheep farmer data or even the aggregate farmer data for Scotland, it is evident that all attributes are significant for both models. Higher expected gross margins show higher utility, thus, farmers are more willing to take up the management of the proposed farm. Lower uncertainty in future income is preferred as well as lower disease rates in herd/flock.

The RPL model shows that all attributes with the exception of 30% future income fluctuation and 10% infection level in the herd/flock display significant preference heterogeneity amongst respondents. Although at 10% infection level the preferences of the Scottish farmers appear to be homogeneous, preferences varied as the infection risk increased. These results hold true whether I review aggregate Scottish data or even when examining each farmer type in isolation. Once again relying on the graphical apparatus of kernel density for individual-level attributes as shown in figures 6.7 and 6.8, we can visually assess the presence of heterogeneity in the attributes discussed above.

Next, let us compare the proportion of respondents with positive or negative preference for the attributes as were calculated in the previous sub-section. Whether we look at cattle or sheep farmers in England (table 6.10 and table 6.11) or cattle or sheep farmers in Scotland (table 6.13 and table 6.14), the farmers display no preference heterogeneity when it comes to income volatility of 30%. The coefficient was insignificant for 50% income volatility in cattle farmers in England. In Scotland, on the other hand, only 28% cattle farmers were willing to take on 50% uncertainty in income. Similarly, 37% sheep farmers in England preferred taking on farms with 50% income volatility and only 13% sheep farmers in Scotland were willing to do so. This indicates that Scottish farmers, perhaps, are more income risk averse. Next, let us compare disease risk. 2% cattle farmers in England were willing to choose a farm with 10% BVD infection risk. The probability is zero for higher disease risk. In Scotland, less than 1% of the cattle farmers were willing to take on any risk at all when it comes to BVD disease risk. This of course is expected given Scotland's BVD free legislation. Lastly, 14% sheep farmers in England would choose to manage a farm with 10% risk of lameness in the farm whilst no preference heterogeneity was observed in Scottish sheep farmers. At 20% risk of lameness, 3% sheep farmers in England would choose such farms while 12% of Scottish sheep farmers would be willing to choose to manage such farms with significant preference heterogeneity. And lastly, at 30% risk of lameness infection at the farm, 2% of English and Scottish farmers would choose such farms again with significant preference heterogeneity.

Table 6.12: Models for all farmers in Scotland (Sheep and cattle)

| | (1) | (2) | |
|---|---|---|---|
| **Variables** | **Model 1** | **Model 2** | |
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0396*** | 0.124*** | 0.192*** |
| | (0.00438) | (0.0273) | (0.0417) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.531*** | -0.752*** | -0.287 |
| | (0.150) | (0.263) | (0.998) |
| ± 50% | -0.448*** | -0.873*** | 1.007*** |
| | (0.104) | (0.216) | (0.296) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -1.153*** | -1.569*** | -0.0264 |
| | (0.148) | (0.284) | (0.606) |
| 20% infection in the herd/flock | -1.696*** | -3.330*** | 1.944*** |
| | (0.165) | (0.539) | (0.449) |
| 30% infection in the herd/flock | -3.080*** | -7.998*** | 4.415*** |
| | (0.218) | (1.468) | (1.194) |
| **Information criteria** | | | |
| Number of observations | 1,872 | 1,872 | |
| Log-likelihood | -521.9 | -425.8 | |
| AIC | 1055.812 | 875.6944 | |
| BIC | 1089.02 | 942.1116 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6.13: Sheep farmers in Scotland

| | (1) | (2) | |
|---|---|---|---|
| **Variables** | **Model 1** | **Model 2** | |
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0426*** | 0.180*** | 0.243*** |
| | (0.00612) | (0.0478) | (0.0597) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.489** | -0.760** | 0.0142 |
| | (0.199) | (0.339) | (0.510) |
| ± 50% | -0.475*** | -1.027*** | 0.918** |
| | (0.142) | (0.297) | (0.381) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -0.655*** | -0.771** | 0.0261 |
| | (0.204) | (0.371) | (0.458) |
| 20% infection in the herd/flock | -1.130*** | -2.562*** | 2.193*** |
| | (0.216) | (0.683) | (0.623) |
| 30% infection in the herd/flock | -2.664*** | -7.981*** | 3.885*** |
| | (0.291) | (2.141) | (1.002) |
| **Information criteria** | | | |
| Number of observations | 954 | 954 | |
| Log-likelihood | -281.6 | -223.3 | |
| AIC | 575.1328 | 470.5615 | |
| BIC | 604.2968 | 528.8895 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

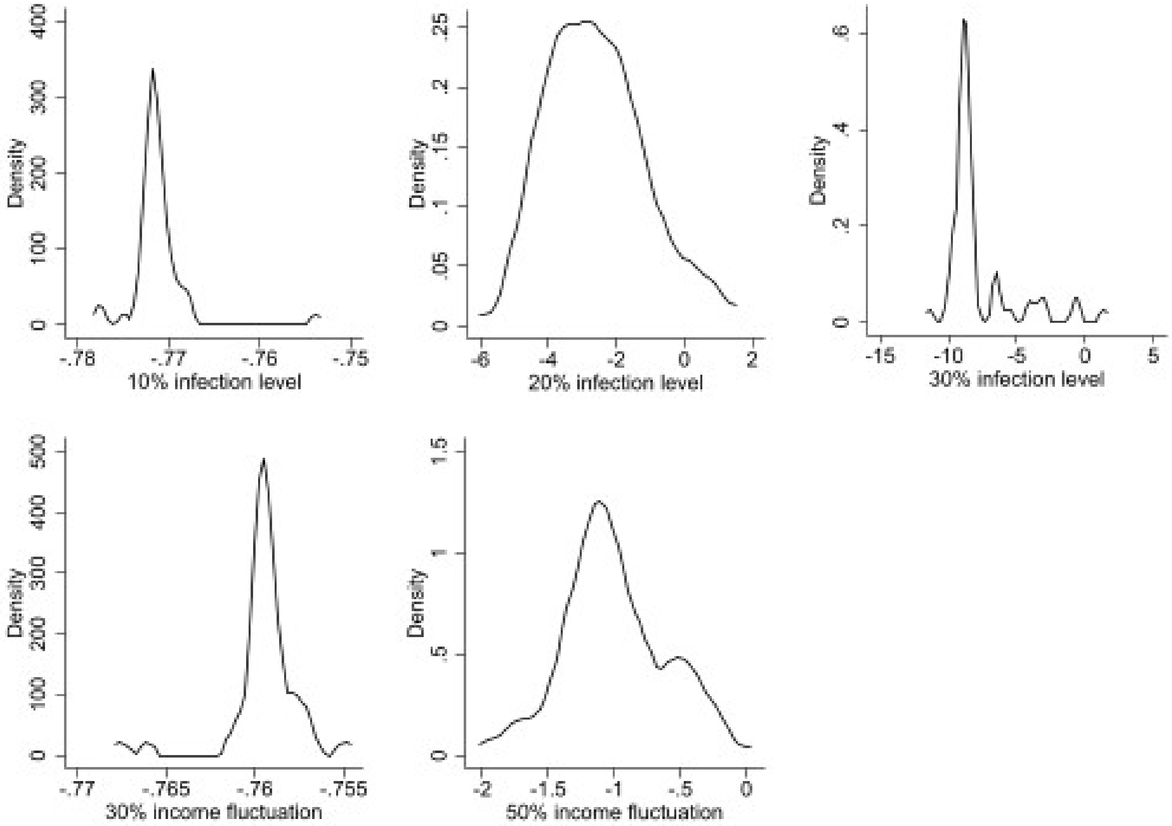

Figure 6.7: Kernel densities for individual-level attributes for Scottish sheep farmers

Table 6.14: Cattle farmers in Scotland

| | (1) | (2) | |
|---|---|---|---|
| **Variables** | **Model 1** | **Model 2** | |
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0387*** | 0.0929*** | 0.148*** |
| | (0.00653) | (0.0277) | (0.0459) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.670*** | -1.177** | 1.122 |
| | (0.235) | (0.473) | (0.712) |
| ± 50% | -0.500*** | -0.860** | 1.472*** |
| | (0.163) | (0.367) | (0.486) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -1.692*** | -2.695*** | 1.087 |
| | (0.226) | (0.572) | (0.694) |
| 20% infection in the herd/flock | -2.388*** | -4.452*** | 1.815*** |
| | (0.271) | (0.826) | (0.605) |
| 30% infection in the herd/flock | -3.616*** | -8.004*** | 2.785*** |
| | (0.346) | (1.779) | (0.829) |
| **Information criteria** | | | |
| Number of observations | 918 | 918 | |
| Log-likelihood | -225.7 | -186.4 | |
| AIC | 463.4119 | 396.7398 | |
| BIC | 492.3451 | 454.6062 | |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

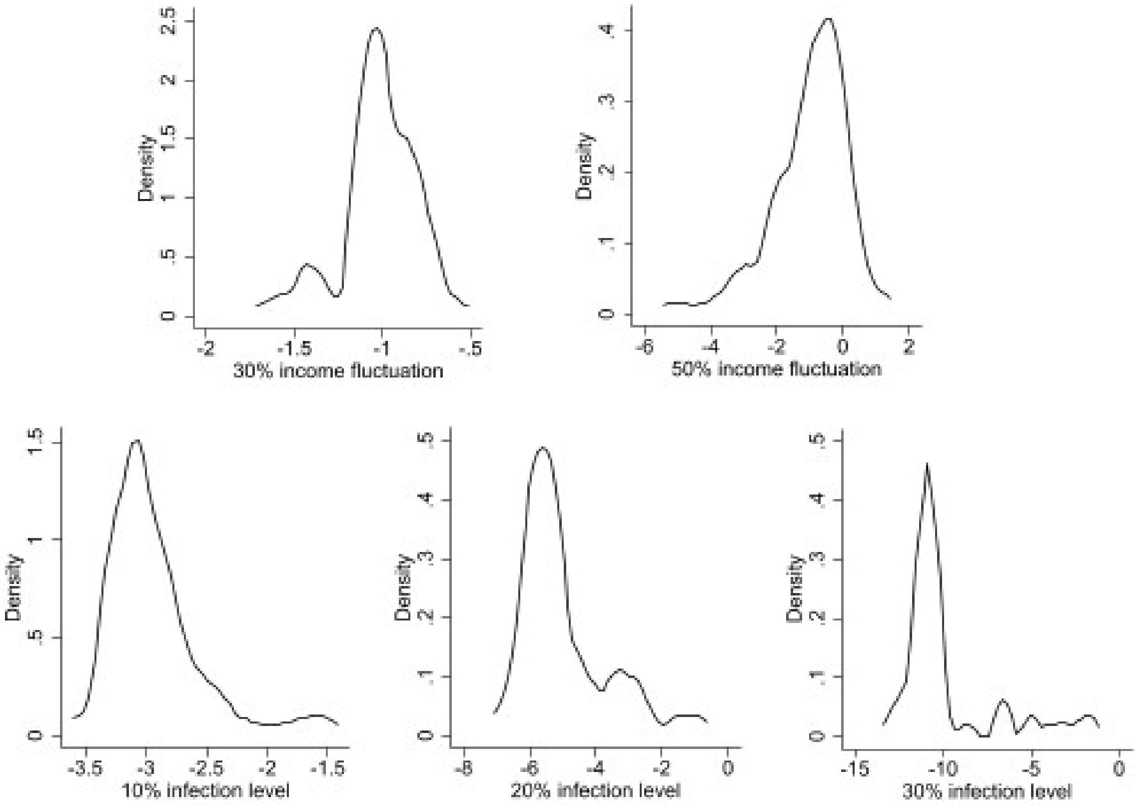

Figure 6.8: Kernel densities for individual-level attributes for Scottish Cattle farmers

## 6.5 Trade-off ratios

### 6.5.1 Testing the parameters for the trade-off ratios between countries and farmer types

In this section, I describe the robustness test for the trade-off ratios. Here, I compute the trade-off ratios- ($\beta_i/\beta_{GrossMargin}$) for English and Scottish farmers. The ratios are calculated using the delta method, similar to WTP calculations in the previous chapters ( Hole, 2007). These ratios represent the marginal value of a movement from the baseline case to the defined levels. The base level for income fluctuation is 10% whilst the base level for infection level is 30% in both herd and flock.

The null hypothesis is that the trade-off coefficients are statistically the same between the two groups. Groups here refer to each nation or type of farmer (cattle and sheep farmer). Whereas, the alternative hypothesis states that the coefficients are statistically different. A comparison is made between English and Scottish farmers who have the same main source of agricultural income as well as different farmer types from the same country.

I perform this test by directly comparing $\beta_1$ and $\beta_2$ using the test specified below. The coefficients $\beta_1$ and $\beta_2$ refer to the trade-off coefficient for the same attribute coming from each group.

$$\begin{aligned} H_0 &: \beta_1 = \beta_2 \\ H_1 &: \beta_1 \neq \beta_2 \end{aligned}$$

or equivalently,

$$\begin{aligned} H_0 &: \frac{\beta_1}{\beta_{GrossMargins}} = \frac{\beta_2}{\beta_{GrossMargins}} \\ H_1 &: \frac{\beta_1}{\beta_{GrossMargins}} \neq \frac{\beta_2}{\beta_{GrossMargins}} \end{aligned}$$

First, I rewrite the hypothesis above using a new variable (w),

$$\begin{aligned} H_0 &: w = \frac{\beta_1}{\beta_{GrossMargins}} - \frac{\beta_2}{\beta_{GrossMargins}} = 0 \\ H_1 &: w = \frac{\beta_1}{\beta_{GrossMargins}} - \frac{\beta_2}{\beta_{GrossMargins}} \neq 0 \end{aligned}$$

Where w is the difference in estimates $\frac{\beta_1}{\beta_{GrossMargins}}$ and $\frac{\beta_2}{\beta_{GrossMargins}}$ that I compute based on the estimation results. Note in the event that either $\beta_1$ or $\beta_2$ were not found to be statistically significant, I took their value to be zero when constructing the w variable.

Next, I need to determine the standard error of w, which can be computed as:

$$SE(w) = \sqrt{Var(\beta_1) + Var(\beta_1) - 2 \cdot Cov(\beta_1, \beta_2)}$$

Where var is the variance, and cov is the covariance. However, since $\beta_1$ and $\beta_2$ come from different data sets their correlation and thus, their covariance is zero ($Cov(\beta_1, \beta_2) = 0$).

$$SE(w) = \sqrt{Var(\beta_1) + Var(\beta_1)}$$

Finally, I compute the relative confidence intervals as,

$$CI = \left[w \pm t_{(\alpha)} \cdot SE(w)\right]$$

where $t_{(\alpha)}$ is the critical t-value for significance level of 95%.

Once I construct the confidence interval for any of the w variables, I examine whether the value of w under null hypothesis (w = 0) falls within the confidence interval. If it does then, I fail to reject the null hypothesis.

### 6.5.2 Results of the trade-off ratios

A comparison between the two countries is reported in table 6.15 for cattle farmers and table 6.16 for sheep farmers. And tables, 6.17 and 6.18 provide a comparison between cattle and sheep farmers within each country.

## Cattle farmers: English farmers versus Scottish farmers

Table 6.15 presents the trade-off ratios in the context of BVD in cattle. The base level for the income fluctuation is 10%. For moderate income fluctuations[8] (30%), English cattle farmers are less risk loving (financially) than their Scottish counterparts since the attribute is significant for both groups, but, English farmers have a much higher trade-off ratio. This outcome is reversed when considering high income fluctuation scenario (50%). The trade-off ratio is insignificant for English cattle farmers in the high income fluctuation scenario. In fact, it is the only insignificant estimate in table 6.15. Next, let us look at their trade-off ratios for taking up the management of a farm with lower infection levels. The baseline infection level is 30%. Observe that cattle farmers are willing to accept lower expected gross margins if that translates to managing a farm with lower infection levels. The majority of the respondents were low-to-medium income farmers, this is reflected in the magnitudes of the trade-off ratios[9]. Thus, as the BVD infection level in the proposed farm gets lower, farmers are willing to trade-off higher expected profit margins for lower disease risk. Interestingly enough, I failed to reject the null hypothesis in all instances for the cattle farmers, thus, I conclude that the preferences were not significantly different for cattle farmers across the two nations. This implies that although the estimated magnitudes are different between respondents from the two countries, statistically they demonstrate the same willingness to trade expected gross margins for a reduction in the expected uncertainty in income and disease risk.

## Sheep farmers: English farmers versus Scottish farmers

Now, let us look at the sheep farmers in table 6.16 across the two nations in the context of lameness in sheep. Once again, the only insignificant coefficient in the table is the trade-off ratio for 50% income fluctuation for English farmers. Sheep farmers from Scotland seem to exhibit higher risk aversion compared to English farmers as they have higher trade-off ratios when it comes to income fluctuation and lower trade-off ratios with respect to the infection level in the herd/flock. As expected, when sheep farmers are offered to manage a farm with lower infection levels, they are willing to accept an income reduction proportional to the proposed reduction in the infection rate. I also conclude that there is a statistically significant difference between sheep farmers across the two countries for most attributes. The only attribute that is not statistically different between the two groups is moderate (expected) income fluctuation. This could be explained by the fact that Scottish sheep farmers are demonstrably more risk averse than their English counterparts, as seen by the comparison of the trade-off coefficients. Thus, the trade-off estimates are significantly different between the two groups, reflecting the difference in their willingness to adopt risky behaviour in exchange for potentially higher expected gross margins.

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[8] I refer to 30% and 50% income fluctuations as moderate and high income fluctuations, respectively in this section.

[9] The expected gross margin coefficients are very small, thus, translating into larger magnitudes for the trade-off ratios.

## England: Cattle farmers versus sheep farmers

Table 6.17 shows a comparison between Cattle farmers and Sheep farmers in England. Observe both farmer types in England exhibit positive and significant trade-off ratios for moderate income fluctuation (30%) but the trade-off ratios for high income fluctuation ( 50%) are not significant. English farmers show the same willingness (statistically) to assume financial risk given the potential increase in their expected future income. However, when it comes to the infection level in the herd/flock, they display statistically different trade-off ratios. As expected all coefficients were found to be negative and significant, demonstrating that farmers are willing to forego higher expected compensation for managing a farm with lower infection level in the herd/flock. Yet, their respective trade-off ratios were significantly different with the exception of 20% infection level. Cattle farmers have a higher willingness to trade-off with respect to infection levels. This result is understandable given the different requirements for managing each disease.

## Scotland: Cattle farmers versus sheep farmers

Lastly, let us look at the Scottish farmers in table 6.18. All trade-off ratios were found to be significant here. Both farmer types are willing to trade-off the base level income fluctuation of 10% for higher income variability. Consistently, I find that the magnitude of the trade-off ratios is higher for cattle farmers in Scotland. Once again, when looking at the disease risk Scottish farmers have significant and negative trade-off ratios showing their willingness to accept lower expected compensation for lower infection levels in the herd/flock. All estimates between the two farmer types were not significantly different except at 0% infection level. Here I find that there exists a significant difference in preference between the two groups.

In summary,

1. English cattle farmers do not have significantly different preferences to Scottish cattle farmers.
2. English sheep farmers have significantly different preferences to Scottish sheep farmers in all but possible 30% future income fluctuation.
3. It is evident that English sheep farmers tend to have significantly different trade-off ratios from English Cattle farmers when it comes to disease control/management at 0% and 20% infection level.
4. On the other hand, Scottish cattle and sheep farmers do not have significantly different trade-off ratios in all but one attribute which is 0% infection level.

Table 6.15: Trade-off ratio of Cattle farmers (English vs Scottish Farmers)

| **Cattle** | **(1) English Farmers** | **(2) Scottish Farmers** | | | |
|---|---|---|---|---|---|
| | **$\beta_1$ (SE)** | **$\beta_2$ (SE)** | **w** | **CI (95%)** | **Significantly different** |
| *Income fluctuation (Base level =10%)* | | | | | |
| 30% income fluctuation | 30.358541** | 13.492133** | 16.866 | [-8.85; 42.58] | No |
| | (11.95503) | (5.407901) | | | |
| 50% income fluctuation | 12.174126 | 16.910818*** | -16.911 | [-33.84; 0.02] | No |
| | (7.51446) | (4.259213) | | | |
| *Infection level (Base level =30%)* | | | | | |
| 0% infection in the herd/flock | -182.59575*** | -100.67164*** | -81.924 | [-185; 21.17] | No |
| | (49.24128) | (18.48972) | | | |
| 10% infection in the herd/flock | -68.798929*** | -42.025555*** | -26.773 | [-68.17; 14.62] | No |
| | (19.84125) | (7.240549) | | | |
| 20% infection in the herd/flock | -41.016*** | -22.447*** | -18.569 | [-48.95; 11.81] | No |
| | (14.48292) | (5.5277227) | | | |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 6.16: Trade-off ratio of Sheep farmers (English vs Scottish Farmers)

| | (1) | (2) | | | |
|---|---|---|---|---|---|
| **Sheep** | **English Farmers** | **Scottish Farmers** | | | |
| | **$\beta_1$ (SE)** | **$\beta_2$ (SE)** | **w** | **CI (95%)** | **Significantly different** |
| *Income fluctuation (Base level =10%)* | | | | | |
| 30% income fluctuation | 6.7238307 ** | 9.6413852** | -2.9175545 | [-12.1; 6.25] | No |
| | (2.387974) | (4.01885) | | | |
| 50% income fluctuation | 2.7326841 | 13.170584*** | -13.170584 | [-21.45; -4.89] | Yes |
| | (2.235855) | (3.582124) | | | |
| *Infection level (Base level =30%)* | | | | | |
| 0% infection in the herd/flock | -28.279796*** | -52.52245*** | 24.242654 | [5.75; 42.73] | Yes |
| | (4.617862) | (8.229791) | | | |
| 10% infection in the herd/flock | -19.127937*** | -40.064131*** | 20.936194 | [6.79; 35.08] | Yes |
| | (3.940066) | (6.04676) | | | |
| 20% infection in the herd/flock | -12.796351*** | -26.701497*** | 13.905146 | [2.25; 25.56] | Yes |
| | (2.530697) | (5.382745) | | | |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 6.17: Trade-off ratio of English Farmers (Cattle vs Sheep Farmers)

| **England** | **(1)**<br>**Cattle Farmers** | **(2)**<br>**Sheep Farmers** | | | |
|---|---|---|---|---|---|
| | **$\beta_1$ (SE)** | **$\beta_2$ (SE)** | **w** | **CI (95%)** | **Significantly different** |
| *Income fluctuation (Base level =10%)* | | | | | |
| 30% income fluctuation | 30.358541** | 6.7238307 ** | 23.64 | [-0.26; 47.53] | No |
| | (11.95503) | (2.387974) | | | |
| 50% income fluctuation | 12.174126 | 2.7326841 | 0 | [-15.37; 15.37] | No |
| | (7.51446) | (2.235855) | | | |
| *Infection level (Base level =30%)* | | | | | |
| 0% infection in the herd/flock | -182.59575*** | -28.279796*** | -154.32 | [-251.25; -57.38] | Yes |
| | (49.24128) | (4.617862) | | | |
| 10% infection in the herd/flock | -68.798929*** | -19.127937*** | -49.67 | [-89.32; -10.02] | Yes |
| | (19.84125) | (3.940066) | | | |
| 20% infection in the herd/flock | -41.016*** | -12.796351*** | -28.22 | [-57.04; 0.6] | No |
| | (14.48292) | (2.530697) | | | |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 6.18: Trade-off ratio of Scottish Farmers (Cattle vs Sheep Farmers)

| | (1) | (2) | | | |
|---|---|---|---|---|---|
| **Scotland** | **Cattle Farmers** | **Sheep Farmers** | | | |
| | **β1 (SE)** | **β2 (SE)** | **w** | **CI (95%)** | **Significantly different** |
| *Income fluctuation (Base level =10%)* | | | | | |
| 30% income fluctuation | 13.492133** | 9.6413852** | -2.9175545 | [-9.36; 17.06] | No |
| | (5.407901) | (4.01885) | | | |
| 50% income fluctuation | 16.910818*** | 13.170584*** | -13.170584 | [-7.17; 14.65] | No |
| | (4.259213) | (3.582124) | | | |
| *Infection level (Base level =30%)* | | | | | |
| 0% infection in the herd/flock | -100.67164*** | -52.52245*** | 24.242654 | [-87.82; -8.48] | Yes |
| | (18.48972) | (8.229791) | | | |
| 10% infection in the herd/flock | -42.025555*** | -40.064131*** | 20.936194 | [-20.45; 16.53] | No |
| | (7.240549) | (6.04676) | | | |
| 20% infection in the herd/flock | -22.447*** | -26.701497*** | 13.905146 | [-10.87; 19.38] | No |
| | (5.5277227) | (5.382745) | | | |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

## 6.6 Discussion

This chapter presented the findings of the study conducted on English and Scottish farmers where preferences towards farm animal health and welfare were analysed in the context of expected income, income uncertainty and disease risk. The approach used in this study allowed me to observe the trade-offs between different attributes in the farmers' decision-making process. Farmers with cattle and sheep were asked to make choices regarding the takeover of the management of a farm, thereby, enabling the capture of possible substitution effects. This is central to my study as it gives me insight into how farmers perceive and value farm animal health and welfare through the understanding of their decision process when managing a farm in the presence of disease risk and income.

The results of this study suggest that farmers have a significant and positive preference for lower infection levels of lameness in sheep and BVD in cattle in the farms they would opt to manage, when controlling for the effects of mean income and income volatility. That is, for a given expected income from farming and a specific degree of income volatility, farmers value (are willing to pay for) improvements in animal health. On average, farmers preferred higher expected gross margins, fewer fluctuations in possible future income, and a smaller level of infection rates in their livestock. Farmers were willing to accept moderate future income volatility of 30% as it seems the potential rewards outweighed the potential loses. Farmers although did not prefer but rather were willing to accept the management of a farm with higher infection level provided that it had higher gross margins than the 0 infection level farms. Critically, I find that a positive, separable benefit exists for lower levels of disease prevalence both in English and Scottish farmers.

Nevertheless, when I look at all the farmers, I observe that they were willing to accept a reduction in farm income for an increase in animal health. This result holds whether I investigate farmers in England or Scotland and also extends to both cattle and sheep farmers. I also observe significant taste heterogeneity in all attributes apart from income fluctuations of 30% in most cases.

A direct comparison of the results between cattle farmers from England and those from Scotland showed that the behaviour of the farmers did not appear to be significantly different in the choices they made. This result did not hold for sheep farmers. Scottish sheep farmers appear to be more risk averse than their English counterparts. When comparing farmers within each country, English cattle farmers and sheep farmers had significantly differing preferences in the handling of lower levels of disease risk (at 0% and 10% infection level). Whereas Scottish cattle farmers and sheep farmers diverged at 0% infection level. This is not surprising given the differing disease types. Despite being endemic, these diseases are distinct in that they have no negative effects on human health. The handling and management approaches also differ, since, BVD is an infectious disease whereas lameness is primarily a management issue. Lameness is more readily observable in sheep whilst cattle infected with BVD are harder to detect visually unless tested. Additionally, the fact that the legislation in Scotland and England differ regarding the treatment and management of BVD could be a contributing factor. The implications are much more costly for Scottish cattle farmers for keeping BVD positive cattle on their farms. Moving BVD “not negative” cattle is also unlawful within Scotland. However, Scottish farmers are able to buy cattle from England that may not have been tested for BVD. In such cases, Scottish farmers are required to have the cattle tested and kept in quarantine until their BVD status is known. It is also important to note the difference in sample sizes between the groups as a bigger sample size may have led to a more robust analysis.

Furthermore, it is evident from the demographic statistics that there are two dimensions that we need to consider when interpreting the results (see appendix). Firstly, the mean income of sheep farmers in England is lower compared to the mean income of cattle farmers in England. The opposite holds true for Scottish farmers. Secondly the majority of the respondents were classified as small to medium income farmers. Thus, the difference in the average farming income between farmer type could explain (at least partially) the difference in the attitude towards risk. Farmers showing income risk aversion is understandable given the need for financial stability. Farming is seasonal and certain periods have higher expenses than others with returns realised at the end of the season. Having stable, non-negative income stream is crucial to farmers in order to run their business.

Bock and Van Huik (2007) state that some farmers may view animal welfare enhancements as a moral/ethical obligation. However, the authors also argue that these considerations are not the only factors contributing to increased FAW but that the farms' financial objectives also play a role. This conclusion has been echoed by several studies over time (McInerney, 2004, Lagerkvist et al., 2011). As such, I can conclude that despite the presence of compassion or ethical considerations reflected in the preference for low disease level in the flock/herd, farmers' choices reveal to be (at least partially) the outcome of economic optimisations. However, one should not dismiss the evidence of substantial preference heterogeneity in my sample. Although the respondents did not seem willing to engage in highly risky practices as reflected in their preferences for lower infection levels in the herd/flock and lower financial uncertainty, as in Vanhonacker et al. (2008), I too find evidence of "a heterogeneous set of farmers' perceptions about FAHW".

*The survey can be found in the appendix at the end of chapter 8.

## 6.7 Appendix

Table 6.19: (A1) Mean income value for farmers

| | Mean | Minimum(£) | Maximum (£) |
|---|---|---|---|
| Scottish sheep farmers | 241603.8 | 30000 | 1500000 |
| Scottish cattle farmers | 212843.1 | 30000 | 925000 |
| English sheep farmers | 126436.8 | 30000 | 925000 |
| English cattle farmers | 229329.3 | 30000 | 1500000 |

Table 6.20: (A2) England- cattle farmers with ASCs

|  | (1) | (2) |  |
|---|---|---|---|
| Variables | Model 1 | Model 2 |  |
|  | MNL | Random parameter logit (RPL) |  |
|  | $\beta_1$ (SE) | $\beta_2$ (SE) | Standard deviation |
| *Expected gross margins* | 0.0180*** | 0.0310 | 0.151*** |
|  | (0.00529) | (0.0258) | (0.0383) |
| *Possible future income fluctuation (Base level = ± 10%)* |  |  |  |
| ± 30% | -0.515*** | -0.766** | 0.542 |
|  | (0.185) | (0.300) | (0.564) |
| ± 50% | -0.157 | -0.238 | 1.189*** |
|  | (0.125) | (0.241) | (0.288) |
| *Infection level (Base level = 0%)* |  |  |  |
| 10% infection in the herd/flock | -1.659*** | -2.302*** | -1.191** |
|  | (0.187) | (0.404) | (0.565) |
| 20% infection in the herd/flock | -2.136*** | -3.217*** | -0.0726 |
|  | (0.215) | (0.427) | (0.640) |
| 30% infection in the herd/flock | -3.276*** | -4.803*** | 1.306*** |
|  | (0.272) | (0.630) | (0.496) |
| *ASC3* | 0.0722 | 0.194 | -0.153 |
|  | (0.147) | (0.209) | (0.324) |
| *ASC2* | 0.169 | 0.325* | -0.0415 |
|  | (0.137) | (0.194) | (0.267) |
| **Information criteria** |  |  |  |
| Number of observations | 1,476 | 1,476 |  |
| Log-likelihood | -377.9 | -329.8 |  |
| AIC | 771.7151 | 691.6833 |  |
| BIC | 814.0918 | 776.4367 |  |

+Standard errors in parentheses*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6.21: (A3) England- sheep farmers with ASCs

| | (1) | (2) | |
|---|---|---|---|
| Variables | Model 1 | Model 2 | |
| | MNL | Random parameter logit (RPL) | |
| | $\beta_1$ (SE) | $\beta_2$ (SE) | Standard deviation |
| *Expected gross margins* | 0.0506*** | 0.391*** | 0.523*** |
| | (0.00601) | (0.0627) | (0.0865) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.534*** | -0.663** | 0.154 |
| | (0.154) | (0.308) | (0.552) |
| ± 50% | -0.128 | -0.498* | 1.841*** |
| | (0.108) | (0.284) | (0.421) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -0.296* | -1.130*** | -0.901* |
| | (0.153) | (0.383) | (0.471) |
| 20% infection in the herd/flock | -0.671*** | -2.571*** | 1.269*** |
| | (0.154) | (0.473) | (0.435) |
| 30% infection in the herd/flock | -1.652*** | -5.762*** | 2.725*** |
| | (0.189) | (0.982) | (0.617) |
| *ASC3* | -0.157 | -0.0240 | -0.276 |
| | (0.122) | (0.220) | (0.435) |
| *ASC2* | 0.0729 | 0.225 | -0.793*** |
| | (0.115) | (0.226) | (0.297) |
| **Information criteria** | | | |
| Number of observations | 1,566 | 1,566 | |
| Log-likelihood | -490.8 | -383.5 | |
| AIC | 997.6167 | 799.0276 | |
| BIC | 1040.467 | 884.7281 | |

+Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 6.22: (A4) Scotland cattle farmers with ASCs

| | (1) | (2) | |
|---|---|---|---|
| **Variables** | **Model 1** | **Model 2** | |
| | **MNL** | **Random Parameter Logit** | |
| | **β(SE)** | **β(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0381*** | 0.218** | 1.093*** |
| | (0.00668) | (0.0858) | (0.402) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.615** | -4.698** | -8.528*** |
| | (0.242) | (1.827) | (3.258) |
| ± 50% | -0.493*** | -1.285 | 7.865*** |
| | (0.164) | (0.837) | (2.778) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -1.693*** | -7.702*** | -0.292 |
| | (0.228) | (2.707) | (1.081) |
| 20% infection in the herd/flock | -2.367*** | -17.99*** | 5.631** |
| | (0.279) | (6.554) | (2.264) |
| 30% infection in the herd/flock | -3.552*** | -26.02*** | 9.050*** |
| | (0.348) | (9.241) | (3.416) |
| *ASC3* | -0.0928 | 1.165 | 0.825 |
| | (0.190) | (1.002) | (0.738) |
| *ASC2* | 0.159 | 4.852** | 3.392** |
| | (0.172) | (1.932) | (1.328) |
| **Information criteria** | | | |
| Number of observations | 918 | 918 | |
| Log-likelihood | -224.7 | -178.2 | |
| AIC | 465.3283 | 388.4959 | |
| BIC | 503.9059 | 465.651 | |

+Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 6.23: (A5) Scotland sheep farmers

| | **(1)** | **(2)** | |
|---|---|---|---|
| **Variables** | **Model 1** | **Model 2** | |
| | **MNL** | **Random parameter logit (RPL)** | |
| | **$\beta_1$(SE)** | **$\beta_2$(SE)** | **Standard deviation** |
| *Expected gross margins* | 0.0424*** | 0.104*** | 0.292*** |
| | (0.00619) | (0.0305) | (0.0811) |
| *Possible future income fluctuation (Base level = ± 10%)* | | | |
| ± 30% | -0.478** | -0.845** | 0.135 |
| | (0.204) | (0.362) | (0.601) |
| ± 50% | -0.471*** | -0.972*** | 0.927** |
| | (0.143) | (0.306) | (0.461) |
| *Infection level (Base level = 0%)* | | | |
| 10% infection in the herd/flock | -0.652*** | -0.678* | -0.328 |
| | (0.205) | (0.397) | (0.575) |
| 20% infection in the herd/flock | -1.117*** | -2.400*** | 2.128* |
| | (0.220) | (0.713) | (1.130) |
| 30% infection in the herd/flock | -2.648*** | -8.070*** | 4.153*** |
| | (0.295) | (2.130) | (1.082) |
| *ASC3* | -0.0324 | 0.137 | -0.177 |
| | (0.162) | (0.275) | (0.734) |
| *ASC2* | 0.0158 | 0.235 | 0.383 |
| | (0.155) | (0.260) | (0.430) |
| **Information criteria** | | | |
| Number of observations | 954 | 954 | |
| Log-likelihood | -281.5 | -222.8 | |
| AIC | 579.0382 | 477.5678 | |
| BIC | 617.9236 | 555.3384 | |

+Standard errors in parentheses: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

# Chapter 7

# Farmers' Purchasing behaviour at cattle auctions

## 7.1 Abstract

This chapter investigates the purchasing behaviour of farmers in England (n = 174) and in Scotland (n = 106). The proposed discrete choice experiment (DCE) models buyer preferences towards cattle purchases at auction markets in the context of BVD in cattle. Given the differing approaches undertaken by the respective countries, the choice experiments are adapted to each country's requirements. While English farmers' preferences are modelled with respect to BVD disease status, Scottish farmers preferences are examined instead through the different testing measures available.

The results show that farmers in England showed a strong preference for purchasing BVD free cattle. Similarly, Scottish farmers preferred BVD tests that were administered to the whole herd minimising disease risk. Although farmers in both countries seem aware of the consequences of BVD, they were still willing to partake in partially risky behaviour through the purchase of cattle with either unknown BVD status in England or with purchasing cattle that came from a herd where a sub-sample of calves only were tested. The study finds that farmers purchasing behaviour is also influenced by seller characteristics.

The chapter is structured as follows. In section 7.2 I provide a brief introduction to the chapter and review the related literature. In 7.3, I lay out the survey design and farmer demographic data, followed by the empirical findings in section 7.4. In section 7.5, I conclude and discuss implications.

## 7.2 Introduction

As discussed in the previous chapters, the existing literature highlights the difference between perceptions of consumers and producers towards farm animal health and welfare (FAHW). This chapter seeks to investigate producer preferences to FAHW in context of farmer purchasing behaviour at cattle auctions.

The motivation behind this study comes from the seminal work of Enright and Kao (2015) who look at how disease spread in livestock is affected by human behaviour and how strategic choices influence the transmission of the livestock disease through a contact network. As such, this study uses a discrete choice experiment (DCE) to model farmers' purchasing behaviour at cattle auctions to identify the key attributes that shape farmers' decisions and how they connect to FAHW in the context of BVD. However, given the different legislation present between England and Scotland, when it comes to managing this disease, the attributes in regard to BVD considered in the England and Scotland case study are different. For England, I look at the farmers' willingness to purchase a bull at an auction given differing BVD status. On the other hand, in the Scottish case study, due to the difference in the BVD management I examine how different testing methods for BVD may affect the buyer's behaviour. As noted by Brennan and Christley (2012), although most farmers in the UK rely on private veterinarians and DEFRA for information/instructions in the handling of livestock diseases, there is little consensus regarding the testing method.

With frequent transfers between cattle farms and markets in the UK, farmer's choices regarding their own herd can impact the nationwide effort to manage endemic diseases (Vernon, 2011) as well as the potential risk of contagious diseases spreading between nearby herds (Graham et al., 2016). For farms with low BVD infection rates, keeping a herd healthy and free of disease becomes more costly (Gunn et al., 2005). As a result, this chapter also tries to gauge whether farmers are aware of the biosecurity[1] risks associated with risky purchasing behaviour (i.e. buying cattle with unknown BVD status) and whether they rely on informal channels (i.e. seller's reputation) to mitigate this risk. Hidano et al. (2019) provide a rigorous discussion on farmers' decision-making regarding farm animal trading practices, the biosecurity implications as well as on behavioural influences that shape their behaviour.

Vanhonacker et al. (2008) noted that the viewpoint of the farmer in regard to animal welfare may be judged by the two issues farmers relate to "good" animal welfare with 1. fast growth and 2. satisfactory food conversion. The authors found that farmers relate animal welfare primarily to animal health. The farmer was of the opinion that, "if an animal eats well, it will grow fast, which means that it is healthy, and that the welfare level is good ". As in Webster (2001), one would expect that the costs associated with high FAH and FAW levels are disproportionately placed on farmers compared to consumers. This paper focuses solely on farmer preferences towards farm animal health and welfare. I study the purchasing behaviour of cattle farmers in England and Scotland, via auction markets. I focus on the effects of the endemic condition, Bovine Viral Diarrhoea (BVD) in cattle and how they might influence buyer behaviour. The central idea is to investigate trade-offs between disease risk, familiarity to the sellers and the price farmers would be willing to pay (WTP) as part of the farmer's decision- making process when purchasing cattle. These deci-

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[1] The term "biosecurity" refers to a collection of procedures used to prevent disease from entering or exiting an area where livestock is present (DEFRA, 2003).

sions affect biosecurity, disease management/control and spread of endemic diseases both within and across different farms.

This chapter focuses solely on farmer preferences towards farm animal health and welfare. I study the purchasing behaviour of cattle farmers in England and Scotland, via auction markets, concentrating solely on the consequences of the endemic disease Bovine Viral Diarrhoea (BVD) in cattle and how it may affect buyer behaviour. The central idea is to investigate trade-offs between disease risk, familiarity to the sellers and the price farmers would be willing to pay (WTP) as part of the farmer's decision- making process when purchasing cattle. These decisions affect biosecurity, disease management/control and spread of endemic diseases both within and across different farms.

## 7.3 Related Literature

I present a short exposition on recent literature on farmer preferences towards FAHW. There is a paucity of research on farmer preferences, in various contexts, using diverse approaches to model these farmer preferences for farm animal health (FAH) and farm animal welfare (FAW), from a socio-economic science viewpoint. In this subsection, I briefly discuss some of the key papers in order to provide an overview of the seminal research in this area.

Although the UK government has commissioned socioeconomic studies on biosecurity issues (DEFRA, 2020), which explicit call for research on this subject implies that there is considerable way to go in integrating social and natural sciences to tackle the management of endemic diseases. A notable exception is the interdisciplinary project known as FIELD (2018- 2022), which attempts to provide answers to these questions from different perspectives (including food science, economics, history and epidemiology.). In many countries participation in livestock disease eradication schemes take place on a voluntary basis despite the threat to biosecurity. As noted by Jones and Whitehead (2018) since the introduction of modern disease control for livestock, financial incentives have been used to induce participation in disease surveillance programmes and subsidies were offered to farmers whose animals are culled to control/eradicate the disease. Many have noted that the safety net[2] provided in most advanced economies could incentivise producers (i.e. cattle farmers in my case) to participate in risky "trading/purchasing" behaviour. Recently policy makers have started relying on "behavioural tools" such as holding back or decreasing subsidies alongside other behavioural nudges as a way of 'nudging' farmers towards better biosecurity.

As documented by Higgins et al. (2016), the responsibility for biosecurity has been transferred to the private sector, particularly to the farming industries as a whole as well the individual farmer, due to the rising cost of biosecurity to the government. The authors assert that governments are showing a growing reluctance to introduce new regulation, and instead search for more effective ways to engage farmers and the general public in biosecurity practices. However, some farmers are shown to have little faith in authorities/testing, and they do not acknowledge biosecurity as their responsibility (Enticott et al., 2014). As a result, the suggested biosecurity policies are being poorly implemented (Gunn et al., 2008; Higgins et al., 2016).

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[2] I refer to the compensation offered to farmers by the government to incentivise them to cull diseased animals.

As highlighted by Brennan and Christley (2012; 2013), in their study on biosecurity on UK cattle farms, they find that even though certain biosecurity measures are implemented, many of them are done so irregularly or not at all. For example, most cattle farmers in their study admit not to isolate new cattle brought to their farms nor did they report performing any health screenings after moving animals. This might be due to a number of reasons, including cost (both financial and in terms of time), the lack of practises with proven effectiveness, and the lack of necessary knowledge among veterinarians, farmers, and other specialists in herd health. Still, they list veterinarians as their principal source of information regarding biosecurity. The authors also report that cattle farmers place little weight on their behaviour and attribute most risk to indirect contact with the disease (for example, through dead-stock collection).

In their review article, Dessart et al. (2019) draw the conclusion that behavioural factors can enhance economic assessments of farmer decision-making, resulting in more practical policies. Similarly, Owusu-Sekyere et al. (2021), find that actions to promote increased adoption of techniques that improve animal welfare can be more effectively targeted by employing insights into motivational attributes for farmers. These can be further enhanced by improving policy communication that considers both use and non- use motivational constructs of farmers.

Sok et al., (2018) used a discrete choice experiment (DCE) to estimate farmer preferences towards vaccination programmes to control bluetongue disease, by applying hybrid models like the integrated choice and latent variable (ICLV) approach. The authors concluded that the farmers' participation in such schemes could be increased through the provision of information and subsidies. Toma et al. (2013) in their study found that information and advice on biosecurity measures influenced farmer behaviour and suggested a way to achieving behavioural change was through increased access to biosecurity information and advice sources.

A similar study was conducted by the Latacz-Lohman and Schreiner (2018), who also relied on DCE to investigate producer WTP for higher standards of FAHW for pork. The authors looked at the supply curve for high welfare pork in Germany and found that pig farmers were willing to pay only for 'surface area per pig' and 'the amount of bedding material on offer'. Bock and Van Huik (2007) argue that farmers perceive farm animal welfare (FAW) enhancements as a moral/ethical duty up to a certain degree. However, these concerns are not the only influences contributing to increased FAW levels but also the farms' financial objectives are a key contributor.

This chapter compares farmers in England and Scotland and their preferences to FAHW in the context of cattle auctions. I employ a hypothetical choice experiment and try to gauge the costs and incentives (both financial and behavioural) that motivate farmers purchasing behaviour (via auction markets). Given the differences in approach to handling BVD between the two countries (as has been extensively examined in chapter 1) I adapt the choice experiment taking these differences into account. For the farmers in England, trade-offs they make between disease risk specifically the BVD status of the cattle, familiarity to the sellers and the prices of the cattle are measured. On the other hand, Scottish farmers trade-offs are calculated between the similar attributes however this time, disease risk is modelled as the type of BVD test conducted on the cattle being sold at the auction. The rest of the chapter is organised as follows. First, I present the methodology and the experimental design. Following that, section 7.4 presents the main results along with the marginal willingness to pay. And finally, section 7.5 presents the discussion for this chapter.

## 7.4 Methodology

### 7.4.1 Experiment design and data

I describe the two choice experiments' designs in this section and describe the main data. The aim of this chapter was to evaluate farm animal health and welfare preferences of cattle farmers in England and Scotland in the absence of farm income considerations. Using an auction scenario to gauge farmers purchasing behaviour in relation to disease risk and how such purchasing preferences may be connected to and have an impact on disease management.

The choice experiment itself was inspired by an auction I attended at the York auction centre. I relied on relevant literature on the subject of farm preference towards FAHW as well as on farmers attitudes regarding trading behaviour and disease risk management for the choice of the attributes and their relevant levels. The selection of attributes and their levels was concluded after consulting farmers and auctioneers at the York auction centre.

The survey was delivered to cattle and sheep farmers across England and Scotland online. The experimental design was created in NGene, and the survey was implemented with the Sawtooth programme. A D-efficient experimental design was generated via a two-step procedure for the survey in England. First, a pilot experimental design was used assuming MNL to be the best model to describe preferences. The design was then revised to fit a RPL model using data from the pilot study of n = 10 respondents. Using a D-error criterion [3], the best design was chosen by minimising the standard errors of the model parameter estimations. A sufficiently low D-error design is called a D-efficient design. The experimental design method is specifically structured to increase the statistical performance of the models when applied to small samples and thus allowing for more robust results compared to other less efficient (statistically) designs such as orthogonal designs (Rose et al., 2008). A D-efficient design was also generated for Scotland with zero priors[4]. The experimental designs for the main study were made up of three blocks, each with six choice scenarios. Respondents were asked to answer a sequence of six hypothetical choice scenarios and their responses were recorded in the attribute variables. The answers to these questions provide us with useful conditioning variables in our effort to estimate the WTP.

The dataset for this chapter consists of n = 174 farmers from England and n = 106 farmers from Scotland. Once again, farmer emails were identified from various farming websites that had them listed in their directories. The contact information was publicly available in the directories. I also distributed the survey to farmer networks on twitter and two farming charity websites circulated the survey to their subscribers in England and Scotland. As an incentive for participating in this choice experiment, a donation of £5 was made to these two farming charities for every completed survey. The charities involved were the Farming Community Network in England and the Royal Scottish Agricultural Benevolent Institution in Scotland.

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[3] D-error is equal to the determinant of the estimated model's asymptotic variance-covariance matrix.

[4] The pilot study in Scotland was on n = 3 farmers. Further in-person scheduled appointments were cancelled due to the COVID19 pandemic.

The survey was structured as follows: Section A started with some demographic questions on the farmer and their individual farming characteristics. Section B presented the auction choice experiment. This section introduced the hypothetical scenarios and defined the key attributes. Firstly, respondents were presented with an information page on BVD in cattle. Next, they were exposed to an example choice card to familiarise themselves with the different scenarios and the type of purchasing decision they will make. Following this brief introduction, six choice scenarios were presented consecutively. Each scenario involved the purchase of a stock bull for a suckler herd. The following sections of the survey were related to the farm management choice experiment as was presented in the previous chapter.

Many farmers buy and sell cattle at auction marts. Farmers are asked to make a hypothetical purchasing decision at an auction between two stock bulls. The choice scenarios attempt to reflect choices farmers might face on a visit to an auction. In each scenario, the farmer chooses the option that they would most likely choose in a real buying situation. If the farmer prefers to buy neither of the cattle, they can opt out of buying. The attributes serve the purpose of describing possible scenarios at an auction market based on which they may need to make their purchasing decisions.

The attributes associated with both choice scenarios along with their levels have been summarised in table 7.1 with table 7.2 providing key terminology definitions as provided by the Scottish government on the BVD eradication scheme. When farmers go to auctions. they may think about more options than included in the choice experiment design. Previous iterations of the survey design included a number of different attributes such as the weight, age and breed certification of cattle. However, since I cannot include all attributes and in order to keep the choice experiment simple, after consultation with farmers and auctioneers, I reduced the number of attributes included in the survey to those deemed most important for the study.

1. Seller – this attribute states the familiarity of the buyer to the seller of the cattle. I hypothesise that prior experience dealing with the seller or the seller's reputation act as an informal channel that reduces the perceived disease risk from the transaction. The farming communities frequenting local auction markets are finite. As such, the seller's reputation is a strong signal regarding the disease risk. Shortall et al. (2017) found that vets believed "farmer's trust in and kinship connection with the seller farm is used as a proxy for knowledge of the animals' disease status".
   Levels:

   - Well-known and traded with extensively - The buyer is asked to assume that the seller and the buyer have had previous transactions of livestock.

   - Well-known but never traded with previously – Here the seller is known to the buyer but has no previous history of livestock transactions with each other.

   - Unknown seller - refers to a seller that the buyer has never heard of and have never traded with previously.

Table 7.1: Attributes and their levels

| | |
|---|---|
| Seller | Well-known and traded with extensively |
| | Well-known but never traded with previously |
| | Unknown |
| BVD status - England | BVD Free! - BVD virus negative |
| | Buyers take care! - the animal has not been tested (unknown) |
| | Buyer Beware! - BVD virus positive |
| BVD tests - Scotland | Test whole herd |
| | Test all calves |
| | Check test on a subset of calves |
| Price = | £4,000 |
| | £5,500 |
| | £9,000 |
| | £14,000 |

*Note, price was modelled as a continuous variable while seller status, BVD status and BVD tests were categorical variables.

2. BVD status – This is an animal welfare certification and informs potential buyers of the status of the cattle according to tests currently available. This attribute was used in the choice experiment for English farmers only as BVD testing is optional and there is no legislation preventing trade of cattle without BVD virus testing. The following attribute levels are as described by the BVD Free England voluntary industry-led scheme (AHDB, 2017).

   Levels:

   - BVD beware - the animal tested BVD virus positive
   - BVD free – the animal tested BVD virus negative
   - BVD unknown - the animal has not been tested

3. BVD tests - This is a farm-level certification. It tells you the status of the cattle according to the BVD tests conducted at the respective farms. This characteristic is intended specifically for Scottish farmers who are limited to trading BVD-negative livestock. When importing animals from England, the farmers are required to isolate these animals imported from outside of Scotland and test them individually for the virus using either a blood or a tissue test as soon as they arrive at their holding or the farm loses their BVD negative status according to Scotland's legislated BVD eradication scheme of 2019.

   The following attribute levels are as described by the Scottish eradication scheme.
   Levels:

   - Test whole herd – this is a whole herd screen where all animals in the herd are tested for BVD virus. Individually blood or tissue samples are taken of all the animals on the holding at the same time. This is a test for virus and has the advantage that all the persistently infected (PI) animals in the herd can be identified and removed. The farmer may choose to tissue tag everything, in which case a vet does not need to be consulted.

   - Test all calves – This is a calf screen only. Individually, all calves born in the herd within the year are tested for virus by blood or tissue sample. You can test the calves as they are born or all at once. Ear tissue tag testing is a useful way to do this.

   - Check test on a subset of calves – This is a sampling calves method where five calves aged 9- 18 months or 10 calves ages 6 – 18 months are tested.

4. Price – this is the monetary value of the bull sold at an auction. AHDB auction market reports were used initially. These were updated with the finalised proposed prices after consultation with farmers, industry experts as well as auctioneers during my visit at the York auction market.

Table 7.2: BVD eradication scheme phase 5: December 2019 guidance (Source: Scottish Government)

| **BVD herd status** | **Description** | **Impact on movements to other herds or livestock markets** |
|---|---|---|
| Not negative | The herd shows evidence of exposure to BVD;<br>status has expired;<br>status was never established;<br>has been downgraded. | Cattle that don't have an individual BVD Negative or Assumed Negative status must be tested prior to move. |
| Positive | Herd includes one or more persistently infected (PI) animals. | Cattle that don't have an individual BVD Negative or Assumed Negative status must be tested prior to move. |
| **BVD individual status** | | |
| Negative | | No restrictions |
| Not negative | | Must not move to another herd or market if from a Scottish holding. If from a non-Scottish holding it may require BVD testing within 40 days. Isolate from breeding stock and individually test |
| Positive | | Cannot move to another herd or market. Can only go directly to an abattoir, or under an APHA licence in special circumstances. |

Figure 7.1: Example choice scenario for English farmers.

Figure 7.1 and figure 7.2 are example choice scenarios presented to farmers in the survey. The survey included a choice set with six choice scenarios as presented in the examples. Each choice scenario had three alternatives, first of the two were a choice to purchase a bull with specified characteristics and the third alternative allowed farmers to opt out of buying. In the survey farmers were given a short summary of BVD before they completed the choice cards.

Tables 7.3 - 7.5 summarise some of the key farmer characteristics. My sample features $n_1 = 174$ farmers from England and $n_2 = 106$ farmers from Scotland. English farmers have a mode of 40 years in farming with the sample average being approximately 30 years of farming, thus placing the age of a representative farmer from my sample in their mid-fifties and sixties in line with the Agricultural evidence for England, DEFRA (2022). Similarly, the Scottish respondents have a mode of 35 years of farming with sample mean being at approximately 33 years placing a representative respondent in their early and mid-fifties. According to the Scottish Agricultural Census (2021), the majority of Scottish farmers are over fifty-five years old, approximately in line with our sample.

Additionally, from the demographic information collected from the survey, I have witnessed that 31% of the English farmers are first generation farmers whilst only 15% of the farmers in Scotland were first generation farmers. In the sample, 63% of the Scottish farmers had a family history of farming at the current farm compared to 44% of English farmers who followed such a family tradition. Farmers from both countries predominantly had farming as their primary job. There was also consensus among farmers about their perceptions of the public image of agriculture in the UK with farmers believing that the public predominantly have a poor image of the agricultural sector in the UK. 60% of the respondents from England and 75% of the respondents from Scotland are clas-

Figure 7.2: Example choice scenario for Scottish farmers.

Table 7.3: Farmer characteristics

| No. | Variable | | England<br>n = 174 | Scotland<br>n = 106 |
|---|---|---|---|---|
| 1 | Farming primary job | Yes | 122 (70.11 %) | 77 (72.64 %) |
| | | No | 52 (29.89 %) | 29 (27.36 %) |
| 2 | Family farming history | Family farmed before current farmer | 76 (43.68 %) | 67 (63.21 %) |
| | | Family farmed elsewhere | 44 (25.29 %) | 23 (21.70 %) |
| | | First generation farmer | 54 (31.03 %) | 16 (15.09 %) |
| 3 | Perception of public image of agriculture | Very negative | 8 (4.60 %) | 8 (7.55 %) |
| | | Negative | 56 (32.18 %) | 37 (34.91 %) |
| | | Neutral | 65 (37.36 %) | 39 (36.79 %) |
| | | Positive | 41 (23.56 %) | 18 (16.98 %) |
| | | Very positive | 4 (2.30 %) | 4 (3.77 %) |
| 4 | Number of years farming | | Mean = 29.60<br>Mode = 40 | Mean = 33.25<br>Mode = 35 |

sified as cattle farmers since at least 50% of their agricultural income comes from cattle farming[5]. The remainder of the respondents are farmers whose primary source of agricultural revenue does not come from cattle farming. In table 7.4, I compare the average size in hectares grouped by farm size and number of farms for both England and Scotland. The benchmark statistics are provided by DEFRA (2020). The data-set traces out the UK averages, with the data for England being particularly close to the reported statistics. The reason that the English data-set is marginally closer to the data compared to the Scottish is twofold. Firstly, the sample size for English farmers is almost twice that for Scottish farmers. As the sample size increases the data becomes more representative. And secondly, the majority of the respondents in Scotland operated mid-sized (hectares per farm) farming businesses, skewing my sample slightly to the right. Overall, the data-set employed is fairly representative of the UK cattle-farming sector, thus allowing the generalisation of the models' predictions.

According to the code of recommendations for the welfare of livestock sheep in England (2013) and Welfare of sheep: Code of Practice (2012) in Scotland, lame sheep must not be consigned to markets or transported anywhere else where movement is likely to worsen the condition. Consequently, a choice experiment with lame sheep at an auction was abandoned. Instead, all farmers were asked to "imagine you want to purchase cattle at an auction mart even if you are not a cattle farmer". Respondents of this survey were classified as either Sheep farmers or Cattle farmers depending on their primary source of agricultural income. Hence, it can be inferred that a percentage of Sheep farmers also own a cattle herd and vice versa. As such, it can be assumed that most participants had intimate knowledge of the disease risk involved in purchasing cattle from auctions, depending on the purchased animal(s) characteristics. Before the choice experiment began, a BVD information template was provided to every respondent.

In table 7.5, I provide a summary statistics of farmer choices to opting out of the auction choice scenarios. For England, notice almost 26% of the farmers always opted out of purchasing, 72% sometimes opted out and 2% never opted out of purchasing a bull as presented in the choice experiment. In contrast, 12% of Scottish farmers always opted out, 57% opted out sometimes and 31% never opted out. The main reasons stated by respondents for always opting out boiled down to mistrust of auctions and limited information on the pedigree. A number of respondents who always opted out stated that it would be safer for them to acquire a bull through private sellers that they were already familiar with. As expected the percentage of Scottish farmers who always opted out was much lower compared to their English counterparts. This could be attributed to the difference in legislation regarding BVD management as discussed above. As in the case of the consumer survey the respondents who consistently opted out were included in the final sample.

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[5] In this study, I classify strictly as cattle farmer, a farmer who receives the majority of their agricultural income from cattle farming. However, a number of respondents received 50% of their income from cattle and 50% from sheep and therefore, I classify them as cattle farmers too.

Table 7.4: Size of farms grouped by farm area and by number of farms

| **Size of farms in hectares (percentages)** | | | | |
|---|---|---|---|---|
| **Grouped by farm area** | | | | |
| **Hectare per farm** | **England DEFRA (%)** | **England Sample (n=174) (%)** | **Scotland DEFRA (%)** | **Scotland Sample (n=106) (%)** |
| **< 20** | **3.454268995** | **1.6495** | **2.844522968** | **0.4945** |
| **20 to 50** | **7.723223984** | **5.0929** | **3.32155477** | **1.274** |
| **50 to 100** | **13.94742559** | **9.229** | **5.93639576** | **2.3874** |
| **100 & over** | **74.87508147** | **84.0286** | **87.87985866** | **95.8441** |

| **Size of farms in hectares (percentages)** | | | | |
|---|---|---|---|---|
| **Grouped by number of farms** | | | | |
| **Hectare per farm** | **England DEFRA (%)** | **England Sample (n=174) (%)** | **Scotland DEFRA (%)** | **Scotland Sample (n=106) (%)** |
| **< 20** | **38.68** | **34.4828** | **62.74509804** | **36.7925** |
| **20 to 50** | **19.81** | **18.3908** | **11.76470558** | **11.3208** |
| **50 to 100** | **16.98** | **16.6667** | **9.803921569** | **9.434** |
| **100 & over** | **23.58** | **30.4598** | **17.64705882** | **42.4528** |

Table 7.5: Farmer distribution of choices

| **Variable** | **Country** | Farmer chose out of 6 choice cards with 3 alternatives | | | Total sample |
|---|---|---|---|---|---|
| | Farmer choices | Always opted out | Sometimes opted out | Never opted out | |
| | | Number (Percentage) | Number (Percentage) | Number (Percentage) | |
| | England | 45 (25.86%) | 126 (72.42%) | 3 (1.722%) | 174 |
| | Scotland | 13 (12.26%) | 60 (56.7%) | 33 (31.13%) | 106 |

## 7.5 Results

Following the majority of relevant literature on choice experiments, I will be discussing the Multinomial logit model (MNL) and Random Parameter Logit (RPL) model in this chapter. Note throughout the chapter, the sign of the estimated standard deviations for the RPL models is irrelevant.

### 7.5.1 England

I start by analysing data for English farmers with and without interactions with some of the farmer characteristics listed in the table 7.3 using the MNL and RPL model. Next, I report the willingness to pay (WTP).

### Multinomial Logit and Random Parameter Logit models

The multinomial logit model results are reported in table 7.6. The opt-out variable, an alternative specific constant, informs us that farmers decide not to buy either of the bulls that are offered to them. This parameter was found to be positive and statistically significant indicating that English producers on average preferred to opt out of the purchase as presented to them in the choice scenarios. The *price* attribute had a negative and statistically significant coefficient indicating a negative relationship between utility and price. Particularly, for English farmers the higher the price of buying, the lower the likelihood of purchasing. This result holds true for both model (1) and model (2) where farmer characteristics were introduced. In other words, the interaction of the opt out variable with farmer characteristics had no impact on how buyers felt about costs.

The attribute *seller familiarity* showed that English farmers strongly preferred bulls sold by sellers they know and have traded within the past. As expected, respondents seem to rather purchase cattle from a known seller with whom they have had a trading history compared to a known seller that they have not engaged in trading before, highlighting the importance of reputation and personal experiences in the farming community. One could argue, sellers' reputation acts as an informal channel of biosecurity. Furthermore, notice that respondents seem to be indifferent between buying cattle from a known seller that they have no prior experience trading with and an unknown seller. However, at the 90% significance level, this attribute becomes negative and significant, illustrating a preference towards the known seller with no trading history between the respondent and seller. Thus, indicating that preference gets stronger as familiarity with sellers increases.

English farmers also showed a strong preference for purchasing bulls that were certified *BVD free* compared to the base level of bulls sold with BVD positive status. As expected, both certified BVD negative bulls and those bulls being sold with status unknown are shown to be strongly preferred to the baseline case of BVD positive status i.e. farmers would rather buy a bull with unknown BVD status or BVD negative status than buying a bull that is BVD positive. As the probability of a bull being infected with BVD decreases the farmers show that they are willing to pay progressively more.

Finally, model (2) shows that as producer income from farming increases it becomes more likely that farmers will choose buying a bull instead of opting out. Additionally, producers whose primary source of income came from farming activities were more likely to choose to purchase a bull under the conditions specified in the choice experiment. However, an interesting result stemming from model (2), is that the farmers' experience does not seem to affect their purchasing behaviour since the number of years farming is not (statistically) significant and thus, not affecting the probability of a farmer opting out from purchasing a bull.

Next, I analyse the results from the random parameter logit model as it has been presented in table 7.7. I employ this technique since it allows us to model preference heterogeneity within the sample and thus permits us a better understanding of the data. The RPL model was estimated using Gauss quadrature with 3 draws instead of pseudo-random draws as it requires fewer simulations and as a result is able to evaluate a higher number of designs without a high computational cost. Attribute parameters are allowed to vary randomly over individuals on the assumption that there exists some continuous distribution (Hensher and Greene, 2003). Estimated coefficients were assumed to follow a normal distribution (Louviere et al., 2010) except price attribute which was assumed fixed. Once again, I present two alternative specifications, model (1) and model (2). Model (2) captures the individual farmer characteristics and how they might affect the purchasing choices of the respondents. Model (2) is presented as a contrast to the main-effects base model model (1).

The opt- out result was found to be positive and statistically significant in both models. In other words, respondents preferred opting out from the purchasing bulls as presented in the choice scenarios shown to them. The RPL model estimates are presented under the assumption that the base level for BVD status and Seller status are "BVD positive" and "well known seller but never traded before", respectively. Seller familiarity, as with the MNL model, was preferred and having traded with the seller previously increased the likelihood of purchase significantly. The estimate for the attribute "Well known seller and have traded extensively" was not found to be statistically significant, illustrating once again, the weight farmers place on reputation and interpersonal relationships. The results demonstrate that farmers have increasing preferences when it comes to familiarity with sellers. Known seller is preferred to an unknown seller when it comes to the purchasing of cattle. This fact is captured by the magnitude of the attributes' coefficient compared to their base level.

Both model specifications deliver coefficients for BVD status negative and BVD status unknown that are positive and statistically significant. The magnitude of these estimates show that farmers strongly prefer negative BVD status over status unknown and also, they have a clear preference for unknown status over BVD positive status. However, there is substantial preference heterogeneity

Table 7.6: Estimation results from multinomial logit model - England

| England<br>Variables | (1)<br>$\beta_1(SE)$ | (2)<br>$\beta_2\ (SE)$ |
|---|---|---|
| Price | -7.72e-05*** | -7.85e-05*** |
| | (2.27e-05) | (2.29e-05) |
| *Status (Base level = BVD status unknown)* | | |
| BVD free (-ve) | 4.572*** | 4.598*** |
| | (0.309) | (0.310) |
| BVD beware (+ve) | 1.178*** | 1.186*** |
| | (0.341) | (0.342) |
| *Seller (base level = unknown)* | | |
| Well-known Seller and traded with extensively | 0.735** | 0.728** |
| | (0.361) | (0.362) |
| Well-known but never traded with previously | -0.315* | -0.313* |
| | (0.173) | (0.173) |
| Opt-out | 3.464*** | 6.286*** |
| | (0.363) | (1.161) |
| **Interactions with Opt-Out alternative** | | |
| Gross revenue | | -0.191** |
| | | (0.0882) |
| | | 0.00220 |
| Number of years farming | | (0.00393) |
| | | -0.533*** |
| Farming primary job | | (0.190) |
| **Information criteria** | | |
| Number of observations | 3,132 | 3,132 |
| Number of respondents n | 174 | 174 |
| Log likelihood | -586.3 | -581.6 |
| AIC | 1184.56 | 1181.11 |
| BIC | 1220.86 | 1235.55 |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicate significance.

Table 7.7: Estimation results from random parameter logit model - England

| England<br>Variables | (1)<br>$\beta_1$ (SE) | <br>Standard deviation | (2)<br>$\beta_2$ (SE) | <br>Standard deviation |
|---|---|---|---|---|
| Price | -0.000164*** | | -0.000166*** | |
| | (4.01e-05) | | (4.05e-05) | |
| **Random parameters** | | | | |
| Opt-out | 5.115*** | 2.966*** | 13.36*** | 2.770*** |
| | (0.662) | (0.411) | (4.715) | (0.412) |
| *Status (Base level = BVD beware (+ve))* | | | | |
| BVD free (-ve) | 8.139*** | 3.997*** | 8.090*** | 4.574*** |
| | (0.864) | (0.675) | (0.839) | (0.849) |
| BVD status unknown | 1.551*** | -0.799 | 1.593*** | -0.801 |
| | (0.463) | (0.507) | (0.477) | (0.737) |
| *Seller (base level = Well-known but never traded with previously)* | | | | |
| Well-known Seller and traded with extensively | 0.703 | -0.0507 | 0.680 | 0.491 |
| | (0.470) | (0.705) | (0.498) | (0.381) |
| | -0.978*** | 1.537*** | -1.015*** | -1.637*** |
| unknown | (0.367) | (0.557) | (0.379) | (0.504) |
| **Interactions with opt-out** | | | | |
| Gross revenue | | | -0.532 | |
| | | | (0.361) | |
| Number of years farming | | | -0.00547 | |
| | | | (0.0145) | |
| Farming primary job | | | -1.457** | |
| | | | (0.720) | |
| **Information criteria** | | | | |
| Number of observations | 3,132 | | 3,132 | |
| Number of respondents n | 174 | | 174 | |
| Log likelihood | -461.2 | | -459.5 | |
| AIC | 944.53 | | 947.03 | |
| BIC | 1011.07 | | 1031.072 | |

Note: Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicates significance.

in the data for the BVD negative status but none when considering unknown BVD status over BVD positive status of the bull.

The presence of statistically significant standard deviation in the estimates indicates the presence of heterogeneity amongst respondents regarding this attribute. The estimated standard deviations for sellers with whom there was no transactional history were found to be significant. This suggests that there is significant individual heterogeneity in attitudes towards purchasing a bull. Partially, this result can be explained due to the existence of a free riders problem. England and Scotland have different legislation regarding disease management. This implies that an English farmer could be indifferent between purchasing a bull from an unknown seller if the seller has certain characteristics that ensure or at least signal biosecurity. This result also holds for model (2), suggesting that despite accounting for farmer characteristics the random taste variation remains. Therefore, since the standard deviations are significant, one can conclude that there exists significant unobserved heterogeneity in the preferences displayed by farmers.

Lastly, I compared the model fit by looking at the Akaike Information Criteria (AIC), Bayesian Information Criterion (BIC) and the log-likelihood for model (1) in each of the MNL and RPL tables. The AIC and BIC for RPL models (944.53, 1011.07 respectively) are lower than for the multinomial logit model (1184.56, 1220.86 respectively). The log likelihood for the RPL model (-461.2) is higher than the log likelihood for the multinomial logit model (-586.3). All three of the information criteria indicate the RPL model is preferred over the MNL model.

### 7.5.2 Willingness to pay- England

In this section, I describe the willingness to pay (WTP) estimates for respondents in England in table 7.8. I compute these ratios using the Delta method, much like for the WTP calculations included in the consumer chapters (Hole, 2007) and the calculations are based on the main effects RPL model (model 1).

As expected from the econometric output discussed above, English cattle farmers exhibit positive and significant WTP estimates when it comes to the BVD status of cattle. The WTP for both alternatives is found to be positive and significant. This illustrates that farmers are willing to pay more for a bull with either BVD negative status or with status unknown, compared to the baseline of BVD positive status. Looking at the magnitude for the WTP estimates, it becomes evident yet again, that respondents strongly prefer cattle with BVD negative status compared to status unknown. And status unknown is also preferred to BVD positive status. The fact that farmers are willing to pay many times the average price of a bull to ensure that the cattle purchased does not have a BVD positive status, it is evident that farmers would not opt to buy the base option (i.e. BVD positive). The magnitude of the coefficient could also be affected by the preference heterogeneity observed in the estimated model in table 7.7.

Now, let us look at the farmers' WTP with respect to the sellers' characteristics and reputation. It is clear that when respondents are presented with the opportunity to buy a bull from a known seller they do not seem to place much weight on their trading history with them but they rather seem to focus on the sellers' reputation. This fact is reflected in the WTP estimate not being found

Table 7.8: Marginal willingness to pay estimates - England

| **WTP** | **RPL (£ per unit change)** [95% CI] |
|---|---|
| BVD free (-ve) | 49579.72 ***<br>[27197.42; 71962.02] |
| unknown status (not tested) | 9449.04 ***<br>[2937.26; 15960.82] |
| ***Base:* BVD beware(+ve)** | |
| Well-known seller and traded with extensively | 4281.51<br>[ -1976.27; 10539.30] |
| Unknown seller | -5955.91 ***<br>[-9668.11; -2243.70] |
| **Base: Well-known but never traded with** | |

+Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicates significance.

statistically significant. Lastly, respondents show a clear preference to trading with sellers' they know. The WTP estimate for unknown sellers is found to be negative and significant. Once again, looking at the magnitudes of the WTP coefficients for these attributes, it is evident that buyers are willing to pay more as the familiarity with sellers increases.

### 7.5.3 Scotland

Next, let us analyse the data for Scottish farmers. I start with a multinomial logit model, moving on to random parameter logit model.

### Multinomial Logit and Random Parameter Logit models

Table 7.9 shows the results of the MNL model, with and without interacting key respondent characteristics with the opt out variable (model(2) and model(1), respectively).

Immediately, it becomes evident that Scottish farmers have a positive preference for price. However, this coefficient is only significant at 90% significance level. As such, it can be concluded that the coefficient is zero and thus, indicates that price does not appear to shape Scottish cattle farmers' behaviour. Prices here are modelled as a continuous variable bounded from both below and above, hence this result is better interpreted as, given the range for prices considered in this study, Scottish farmers value other product/animal characteristics more when making their purchasing decisions. The fact that price is found to be positive and significant at the 90% significance level signals that to a certain degree Scottish farmers associate price with quality. In this context, they associate price with high livestock welfare since Scottish legislation ensures cattle brought to an auction in Scotland are not BVD positive.

Due to the differing approaches regarding BVD management between the two countries considered in this study, I examine the effects of different types of BVD testing on the purchasing decisions of Scottish farmers at cattle auctions. The base level of this attribute is “testing only a sub-sample of calves”. Just by glancing at table 7.9, it is evident that Scottish farmers have a clear preference for more rigorous testing procedures. These coefficients were found to be significant for all levels. The magnitude of these coefficients indicate that testing the whole herd is preferred to testing only calves and in turn, testing only/all calves is preferred to testing only a sub-sample of them.

When it comes to the seller, the base level is that the seller is well-known but never traded with previously. Scottish farmers prefer trading with a known seller that they had traded extensively in the past rather an seller that is well known but they do not have any personal experience buying from them. However, cattle farmers seem to prefer trading with an unknown seller compared to a well known seller with whom they have not traded before. This result, although not intuitive at a first glance, reflects the implication of the disease management legislation (for livestock) in Scotland. Typically, buying from an unknown seller increases the risk to biosecurity and disease transmission as well as potential financial risk to the farmer. Scotland however, has in place legislation that prohibits the transport and selling of BVD non-negative cattle. As a result Scottish farmers seem keen on expanding their network and cooperating with sellers that they had not encountered before. Once again the opt-out attribute was found to be positive and significant, meaning that farmers were more likely to opt-out from buying a bull given the choice scenarios they were presented with.

Finally, in model (2), I interact key farmer characteristics variables with the opt-out alternative only. Although gross revenue, number of years farming and farming as primary occupation were all found to be positive, they were not found to be significant at any significance level and thus, I can conclude that they do not affect the respondents' purchasing behaviour.

Next in table 7.10 I report the results from the RPL model. Price is assumed fixed while all other attributes are randomised assuming normal distribution. In both model (1) and model (2) the price attribute is found to be positive and significant. Indicating that Scottish farmers mildly correlate price with quality. As discussed above, due to Scotland's stance on BVD, quality in this context could refer not only to a BVD non-positive status but also to higher farm animal welfare.

For model (1) the opt-out coefficient is positive and significant. The positive sign indicates that respondents are likely to opt- out instead of buying a bull from any of the choice cards presented to them. The standard deviation of the attribute is also found to be significant, thus showing the lack of homogeneous responses in the data. However, in model (2) the opt- out attribute is not significant at any level, illustrating that when opt- out is interacted with individual buyer characteristics, farmers become indifferent between buying the proposed bulls or opting out. Yet, there is still significant heterogeneity amongst respondents in regards to this attribute.

Now, let us examine how the type/ level of testing affects cattle purchasing decisions. The base level for the test here is that farmers only test a subset of calves. As in the MNL case, discussed above, more testing is preferred. However, we observe that buyers' preferred testing method is to test the whole herd instead of testing all calve or a sample of the calves. Testing the whole herd is found to be significant and also respondents seem unified on this front as no heterogeneity was detected in this attribute. Farmers seem to be indifferent between testing all calves or only a sample of them, since the attribute coefficient is not found to be significant. Nevertheless, preference heterogeneity is present for this attribute in both models.

Similar to the MNL model's predictions, buyers prefer buying from an unknown seller rather than a well known seller that they have not traded before. This result stems first and foremost from the safety net provided by the Scottish government, guaranteeing that BVD positive animals cannot be brought to auctions. Although, there could be another dimension shaping this result, Scotland is a fairly small market and thus, if a farmer chooses not to trust well known sellers, it could be argued that the rationale behind this decision is the seller's own reputation. For this attribute, no heterogeneity is detected in the sample. Interestingly enough, we observe that buyers are indifferent between buying from well known sellers in spite of their past relation with them. This conclusion is drawn since the coefficient for the Well-known Seller and traded with extensively attribute is not found to be significant in either model. However, one must note that there exists heterogeneity amongst respondents with regards to this attribute.

Finally, as in the MNL model, it is evident that interacting the opt out attribute with individual respondent's characteristics such gross revenue, years of farming or primary occupation are not found to be significant and thus, do not affect the buyer's purchasing decisions. The responses in regards to this attribute seem to be homogeneous. All in all, as it was the case with England, here too we observe that the RPL model outperforms the MNL as shown by the AIC, BIC and log- likelihood criteria. Since price was found to be positive, WTP for Scottish farmers was not reported.

Table 7.9: Estimation result for multinomial logit model - Scotland

| Scotland<br>Variables | (1)<br>$\beta_1(SE)$ | (2)<br>$\beta_2\ (SE)$ |
|---|---|---|
| Price | 3.84e-05* | 3.85e-05* |
| | (2.08e-05) | (2.08e-05) |
| *Status (Base level = BVD status unknown)* | | |
| BVD free (-ve) | 0.501*** | 0.501*** |
| | (0.159) | (0.159) |
| BVD beware (+ve) | 0.497*** | 0.496*** |
| | (0.178) | (0.178) |
| *Seller (base level = unknown)* | | |
| Well-known Seller and traded with extensively | 0.559*** | 0.559*** |
| | (0.181) | (0.181) |
| Well-known but never traded with previously | 0.618*** | 0.619*** |
| | (0.150) | (0.151) |
| Opt-out | 1.171*** | -0.0470 |
| | (0.277) | (1.228) |
| **Interactions with Opt-Out alternative** | | |
| Gross revenue | | 0.0745 |
| | | (0.0871) |
| | | 0.00128 |
| Number of years farming | | (0.00355) |
| | | 0.242 |
| Farming primary job | | (0.231) |
| **Information criteria** | | |
| Number of observations | 1908 | 1908 |
| Number of respondents n | 106 | 106 |
| Log likelihood | -686.6 | -686.00 |
| AIC | 1385.28 | 1390 |
| BIC | 1418.60 | 1439.98 |

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicates significance.

Table 7.10: Estimation results from random parameter logit model - Scotland

| Scotland<br>Variables | (1)<br>β (SE) | Standard deviation | (2)<br>β (SE) | Standard deviation |
|---|---|---|---|---|
| Price | 0.000102*** | | 0.000102*** | |
| | (2.91e-05) | | (2.90e-05) | |
| **Random parameters** | | | | |
| Opt-out | 1.489*** | 2.249*** | -1.340 | 2.263*** |
| | (0.441)) | (0.319) | (3.577) | (0.329) |
| *Status (Base level = check test on subset of calves)* | | | | |
| Test whole herd | 0.766*** | 0.489 | 0.741*** | -0.585* |
| | (0.222) | (0.732) | (0.217) | (0.353) |
| Test all calves | 0.145 | 2.221*** | 0.150 | 2.239*** |
| | (0.145) | (0.436) | (0.346) | (0.439) |
| *Seller (base level = Well-known but never traded with previously)* | | | | |
| Well-known Seller and traded with extensively | 0.426 | 1.419*** | 0.429 | 1.480*** |
| | (0.287) | (0.393) | (0.284) | (0.389) |
| | 0.810*** | 0.0295 | 0.816*** | -0.00768 |
| unknown | (0.204) | (0.253) | (0.202) | (0.255) |
| **Interactions with opt-out** | | | | |
| Gross revenue | | | 0.179 | |
| | | | (0.264) | |
| Number of years farming | | | 0.00465 | |
| | | | (0.0108) | |
| Farming primary job | | | 0.461 | |
| | | | (0.685) | |
| **Information criteria** | | | | |
| Number of observations | 1908 | | 1908 | |
| Number of respondents n | 106 | | 106 | |
| Log likelihood | -594.6 | | -593.4 | |
| AIC | 1211.196 | | 1214.835 | |
| BIC | 1272.288 | | 1292.589 | |

+Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1 indicates significance.

## 7.6 Discussion

This chapter aims to explore farmers' purchasing behaviour at cattle auctions. The study was conducted on farmers in England and Scotland in the context of BVD. Given the two countries differing approaches to BVD management, the results highlight farmer behaviour in the presence of disease risk and uncertainty. For England, I examine farmers' purchasing behaviour for a bull under different BVD status (BVD positive, BVD negative and BVD unknown status). For Scotland, on the other hand, due to the presence of the legislated BVD eradication scheme, I look at how different BVD testing methods affect the purchasing behaviour of the respondents.

The results for cattle farmers in England show a strong preference for trading with a seller they know compared to an unknown seller. However, they are indifferent between sellers when the only difference between them is the respondent's personal trading history with the sellers. Thus, English cattle farmers place a high weight on the seller's reputation. The cattle farming industry appears to operate based on trust and the seller's reputation acts as an informal channel that reduces risk to biosecurity and disease spread. As for Scottish farmers, the results of my econometric analysis indicate a similar indifference between well-known sellers when the only point of deviation is their personal experience trading with them. On the other hand, Scottish cattle farmers are willing to purchase from an unknown seller compared to a well-known seller. Although to a certain degree this could constitute a risky behaviour with respect to biosecurity and disease spread, Scottish legislation ensures that BVD positive animals can not be transported to a market, thus mitigating the buyer's exposure to this risk. However, to do so Scottish farmers want to be compensated as shown by the negative value of price.

English farmers seem to be aware of the severity of BVD and its implication despite the fact that BVD is not treated as a high priority disease by policy makers in England. Yet, English farmers participate in the BVD Free initiative. According to BVDFree England, in 2021 there were just under 50% of breeding cattle registered with the voluntary scheme. My results show that English buyers have a strong preference when it comes to the BVD status of the bull they consider buying and introduce to their herd. This is evident by both the estimation output and WTP coefficients associated with this attribute. Cattle farmers in England, prefer purchasing a BVD negative bull compared to BVD status unknown bull whilst status unknown is preferred to BVD positive status. One could claim that this result is partially affected by the presence of a positive externality. This externality comes into play when cattle farmers in England are presented with the opportunity to buy stock from Scottish farms. Even if the seller is unknown, the difference in legislation ensures that cattle brought to auction from Scottish farms pose a lower threat to biosecurity due to the different legislation and behavioural 'nudges' to farmers in Scotland.

A similar conclusion can be drawn for Scottish farmers regarding the BVD "test type" of the bull they consider buying. Scottish farmers showed a clear preference for more testing (i.e. testing the whole herd) rather than only testing all calves or even a sub-sample of calves. This is evident from both the estimation results and the WTP coefficient for this attribute. If Scottish buyers are forced to rely on riskier tests (or at least what they perceive as riskier tests) they demand to be compensated, as shown by the negative and significant WTP estimates.

However, as highlighted by Brennan and Christley (2012), in their study on biosecurity with regards to UK's cattle farms, the authors find that even though most cattle farmers in their study admit not to isolate new cattle brought to their farms, they still do not acknowledge that infection risk could stem from their "potentially" risky behaviour but rather place the blame on indirect contact (for instance, deadstock collectors).

Nevertheless, the fact that farmers are willing to purchase cattle with BVD status unknown or cattle tested with what they perceive to be inferior testing measures, is signalling that buyers do not fully realise that the biggest threat to biosecurity and disease spread comes from their purchasing behaviour (Enticott and Little (2022)). As highlighted in Shortall et al. (2017), it is critical that we understand the many types of risks associated with the biosecurity discussion. Overall, the results indicate that farmers are aware of the consequences of BVD when making their purchasing decisions at auctions and care about the effects of their purchasing behaviour on FAHW.
*The survey can be found in the appendix at the end of chapter 8.

# Chapter 8

# Discussion

## 8.1 Introduction

The objective of the following chapter is to discuss the key results of my thesis and their implications. We will start with a brief review of each of the data chapters and summarise some of the key findings in each chapter in relation to the research questions of the thesis in section 8.2. Section 8.3 will then evaluate the findings against current policy considerations, specifically the new Agricultural Transition Plan and Animal Health and Welfare Pathway and how FAHW fit into considerations of public goods. In section 8.4, I assess the main limitations of my thesis and finally consider what could have been done differently and the direction it could take given the absence of resource constraints.

### 8.1.1 Research Aims

The aim of this thesis was to gain an understanding of the decision-making process of both consumers and farmers in terms of farm animals and their products and what role FAHW plays if at all in shaping purchasing and management decisions. Throughout this thesis, I study FAH and FAW of two endemic diseases. These two diseases- lameness in sheep and BVD in cattle - are known to have significant adverse effects on FAHW but they are not known to have any impact on human health. Of course, several factors can influence both consumer and producer decisions towards FAH and FAW. A range of factors were considered to ascertain the best attributes that could potentially contribute to the understanding of the perceptions and preferences towards FAHW.

One of the key questions that my thesis tries to answer is whether higher farm animal health and animal welfare is desirable and if so, who is willing to pay for it. I provide answers by looking at this problem from both the farmer and the consumer perspective.

Before we delve into the findings, I shall re-state the research objectives.

- Part 1- Assessing consumer preferences

RO1 Are animal health and animal welfare separate components of utilities? What is the consumer Willingness to pay (WTP) for animal products when considering animal health and welfare?

RO2 Does information asymmetry on the safety of the product change consumers preferences towards FAH and FAW?

- Part 2 – Assessing producer preferences

RO3 What are farmer preferences to FAH and FAW when monetary returns, income uncertainty and sickness levels are part of the operational decision-making process?

RO4 What is the farmers' willingness to trade-off changes in bio-security risk against other attributes of animals bought at auction?

## 8.2 Summary of key results

### 8.2.1 Consumer preferences for farm animal health and welfare

The first part of the research agenda focused on assessing UK consumers preferences towards FAHW (Chapter 4). This study was conducted using DCE's with beef, milk, lamb chops and wool as products to evaluate trade-offs between four product attributes. The attributes deemed important for this analysis were the price of the product in order to calculate the WTP, infection levels in the herd/flock, animal welfare grading and the origin of the product which represented the proximity of the consumer (at the point of purchase) to the production location. This latter attribute acted as a proxy for food mileage and traceability. Animal health was represented by sickness levels in animals in the context of BVD [1] in cattle and lameness in sheep and animal welfare by an overall welfare grading system signifying the welfare level at the individual farm level. Data was collected on a representative sample of UK consumers (n = 515) between May and July 2020.

Addressing RO1, my thesis reported the findings of the attribute's animal health and animal welfare as separate attributes using DCE's. The results showed that consumers had a strong preference for high animal welfare separately to high animal health, with infection levels being the most important attribute, even when there was no link between livestock health and human health. Consumers also preferred locally produced products over those that were produced over 50 miles away or outside the UK, indicating the presence of a strong home bias amongst UK consumers. This was true across all four products: beef steak, lamb chops, milk and wool. For every product consumers were willing to pay a price premium to ensure low sickness prevalence and high welfare standards.

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[1] Bovine Viral Diarrhoea (BVD) is a contagious disease of cattle occurring worldwide and many livestock farmers rate it among their highest economic and welfare concerns (See Scottish government BVD eradication guidelines, 2018).

### 8.2.2 Information asymmetry on product safety and its influence on consumer preferences

In order to then test whether information on product safety for consumption could have influenced decisions, I retested the survey a year later in chapter 5 addressing RO2. This time two surveys were administered between May and June 2021. One treatment group had information (n = 258) on the safety of the product for consumption highlighted with strong reassurances that there was no risk to human health whilst the second treatment group had no information on the safety (n = 269) of the products with regards to human health.

First, despite the uncertainty caused by the ongoing COVID19 pandemic, the UK public's preferences towards FAH and FAW could still be modelled using a separable utility function. Secondly, I find the WTP coefficients for both FAH and FAW to be positive across both groups of respondents. Consumers consistently favoured higher animal health and welfare products, regardless of the safety information (or lack thereof) that was made available to them. The magnitude of the WTP estimates, on the other hand, marginally differed across treatment groups depending on the amount of information that each group had received (i.e. Full information vs No- information). However, upon testing, I found these coefficients were not significantly different between the information and no-information treatment group.

All in all, the results from the consumer surveys echo the British public's willingness to pay to ensure high farm animal health and farm animal welfare. In fact, the evidence suggests that British consumers are willing to pay for high FAH independent of FAW even after receiving explicit information that the endemic diseases considered would not affect human health. These results are in line with those from Bennett et al. (2019) and Clark (2022).

### 8.2.3 Producer preferences in the presence of monetary uncertainty and disease risk

Now let us move on to the next part of the research agenda where I focus on producer preferences. With the aim of teasing out farmer preferences to FAH and FAW, I explored two choice experiments. One where expected income plays an explicit role in the decision process through choices over the management of a farm with livestock sickness (RO3); and the other where farmers make purchasing decisions at an auction and do not directly account for income in the scenario (RO4).

In the farm management study (chapter 6), the attributes comprised of expected gross returns dependent on farmer income categories, income variability to indicate uncertainty (income risks) and livestock infection risks identical to the consumer survey attribute. The survey was conducted between February and October 2020 with some pauses in between due to disruptions. With a sample size of n = 169 farmers in England and n = 104 farmers from Scotland, I found that cattle farmers in England do not have statistically different preferences for potential income volatility and livestock disease risk to cattle farmers in Scotland. However, this result does not hold when comparing the preferences of sheep farmers in Scotland and in England. Scottish sheep farmers appeared to be more risk averse compared to their English counterparts. Lastly, there was a clear preference for lower disease risk in farmers. However, the magnitude of preference coefficient depended on the underlying livestock disease.

### 8.2.4 Farmers willingness to trade-off changes in disease risk against other attributes at an auction

In the second producer study in chapter 7, I investigated farmers' purchasing decisions at cattle auctions. The attributes included were price, buyers' familiarity to the seller and finally due to differing legislative laws in Scotland and England, the third attribute for England was the BVD status of the animal while for Scotland was the type of BVD test and thus, addressing RO4. The sample consisted of n = 174 English farmers and 106 Scottish farmers. Farmers in England showed a strong preference for purchasing BVD free cattle. Similarly, Scottish farmers preferred BVD tests that were administered to the whole herd hence, minimising disease risk. The study finds that farmers purchasing behaviour was also influenced by seller characteristics. English farmers willingness to purchase cattle increased proportionally to the familiarity with the seller. In contrast, farmers in Scotland preferred buying cattle from sellers that they had not engaged in trading before. This could be as a result of the Scottish BVD legislation which acts as a safety net, allowing Scottish farmers to explore new trading partners. Although both English and Scottish farmers seem to understand the consequences of introducing BVD into their herd, they were still displaying (partially) risky purchasing behaviour. This result can mainly be inferred from the fact that farmers are not buying only BVD free certified cattle (in England) or cattle coming from herds that were tested as a whole (in Scotland).

Therefore, the results from both the producer studies illustrate that farmers decisions over disease management and/or cattle purchasing behaviour are not only motivated by financial objectives but also their decisions reflect their concern for FAWH. Although farmers prefer high expected gross margins when it comes to the management of a farm, their responses are affected by the infection levels in the herd. Similar result comes out of the cattle auction study. Farmers want to minimise the biosecurity[2] and disease spread risk, however there are not willing to purchase only BVD free animals (in England) or bulls coming from a herd where whole herd testing was administered. As a result we observe that farmers, although risk averse, are willing to engage in partially risky behaviour if the expected reward is high enough.

## 8.3 Policy relevance

In this section, I review why government intervention maybe necessary in light of my findings (8.3.1). Following this, I define the meaning of public goods and discuss farm animal health and welfare as a public good in sub-section 8.3.2. Finally in 8.3.3, I discuss the free riders problem from the consumers' and producers' perspective.

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[2] The term "biosecurity" refers to a collection of practises used to prevent disease from entering or living an area where livestock is present (DEFRA, 2003).

### 8.3.1 Is government intervention necessary?

In this sub-section, I discuss the arguments on whether FAH and FAW should be considered a public good. First, I present the importance of FAHW from both the consumer and producer side. As part of this thesis, I designed and distributed consumer and farmer surveys, at the beginning and during the COVID-19 pandemic to help me model both consumer and producer preferences towards FAHW. My results indicate that consumers despite the period of increased uncertainty, care about FAH independently of FAW. I also find consumers to be home biased and tend to view locally produced animal products as both high quality and also to be the product of good farming practises which guarantee high FAHW standards (Chapters 4 and 5). In tables 8.1 and 8.2, I explore consumer attitudes towards animal products - wool, dairy and meat. I examine the degree to which prices shape consumer purchasing decisions and the impact of FAHW on them. Interestingly enough, there was no major discrepancy when comparing consumer attitudes at the beginning and during COVID19- a period characterised by high uncertainty. Generally, the majority of the British public value higher FAHW as was confirmed in chapters 4 and 5. This seems to indicate that even if prices go up, a representative UK consumer would continue purchasing high FAHW products. These results are more robust for edible animal products but this is not to say that wool consumers do not care about the welfare of the animals.

The question is therefore: Who is responsible for ensuring high FAHW? In tables 8.3 and 8.4, nearly 85% of the respondents in both my consumer surveys (beginning of COVID19 and during COVID19) believe that it is the farmers' responsibility to ensure high FAHW. Next, at least 50% of all respondents rely on government legislation and signals from independent bodies (for instance, the presence of the Red Tractor logo on the product that in fact the animal product that they are purchasing is the result of good farming practices that ensure high FAHW. So, despite the consumers WTP to ensure this outcome, consumers still do not seem to view it as their sole responsibility (at least the majority) rather a collective one. This is an interesting result as studies have found that consumers assign FAW a high ranking in contrast to when asked to identify factors they consider the most important unprompted (Clark et al., 2016, European Commission, 2019). Similarly, Uehleke and Huttel, (2019) find that when consumers are asked to vote collectively rather than asking the individual consumer their WTP to a welfare label, consumers seem to have a bigger WTP on collective provision of animal welfare.

In my producer chapters, I find that producers prefer managing farms with low infection levels in the herd/flock. They are willing to trade-off higher expected gross margins to ensure low disease risk as well as higher financial stability. On the other hand, when it comes to their purchasing behaviour at auctions, once again, I observe that farmers are aware of the biosecurity risks of BVD and disease spread. And thus, try to mitigate the spread of BVD by limiting risky trading behaviour. As documented by Higgins et al. (2016), the responsibility for biosecurity has been transferred to the private sector by governments, particularly to the farming industries as a whole as well the individual farmer, due to the rising cost of biosecurity to the government. The authors claim that governments are becoming less willing to enact new regulations and are instead looking for better ways to educate farmers and the public at large about biosecurity precautions. On the other hand, farmers are shown to be unwilling to ensure biosecurity as their sole responsibility (Enticott et al., 2014). Garforth et al. (2013), argue that the industry and the government should share responsibility for biosecurity and cost of endemic disease control. Looking at the WTP results from both consumer and farmer chapters, it is evident that the British public is willing to pay

Table 8.1: Consumer purchasing decisions at the beginning of COVID19

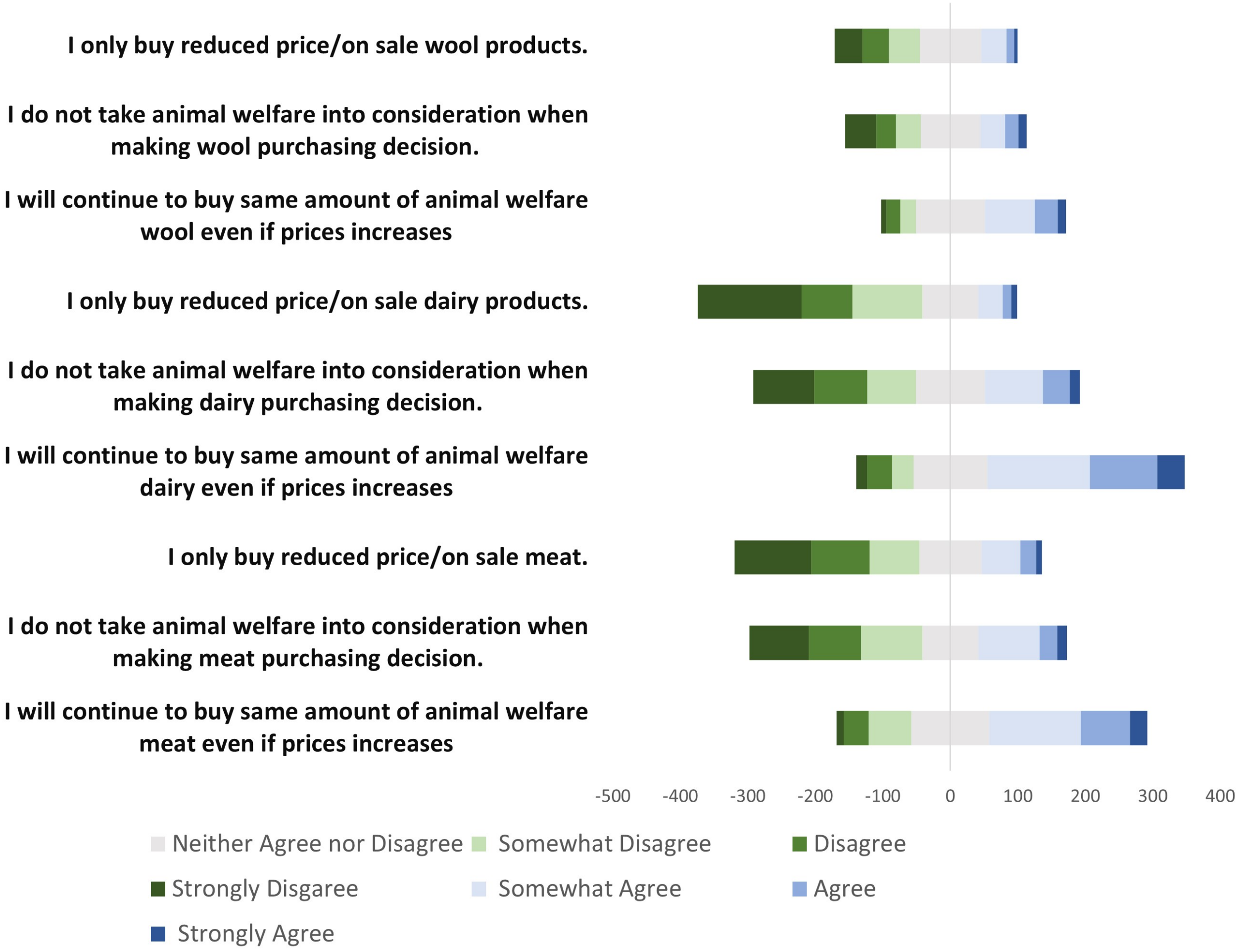


Table 8.2: Consumer purchasing decisions during-COVID19

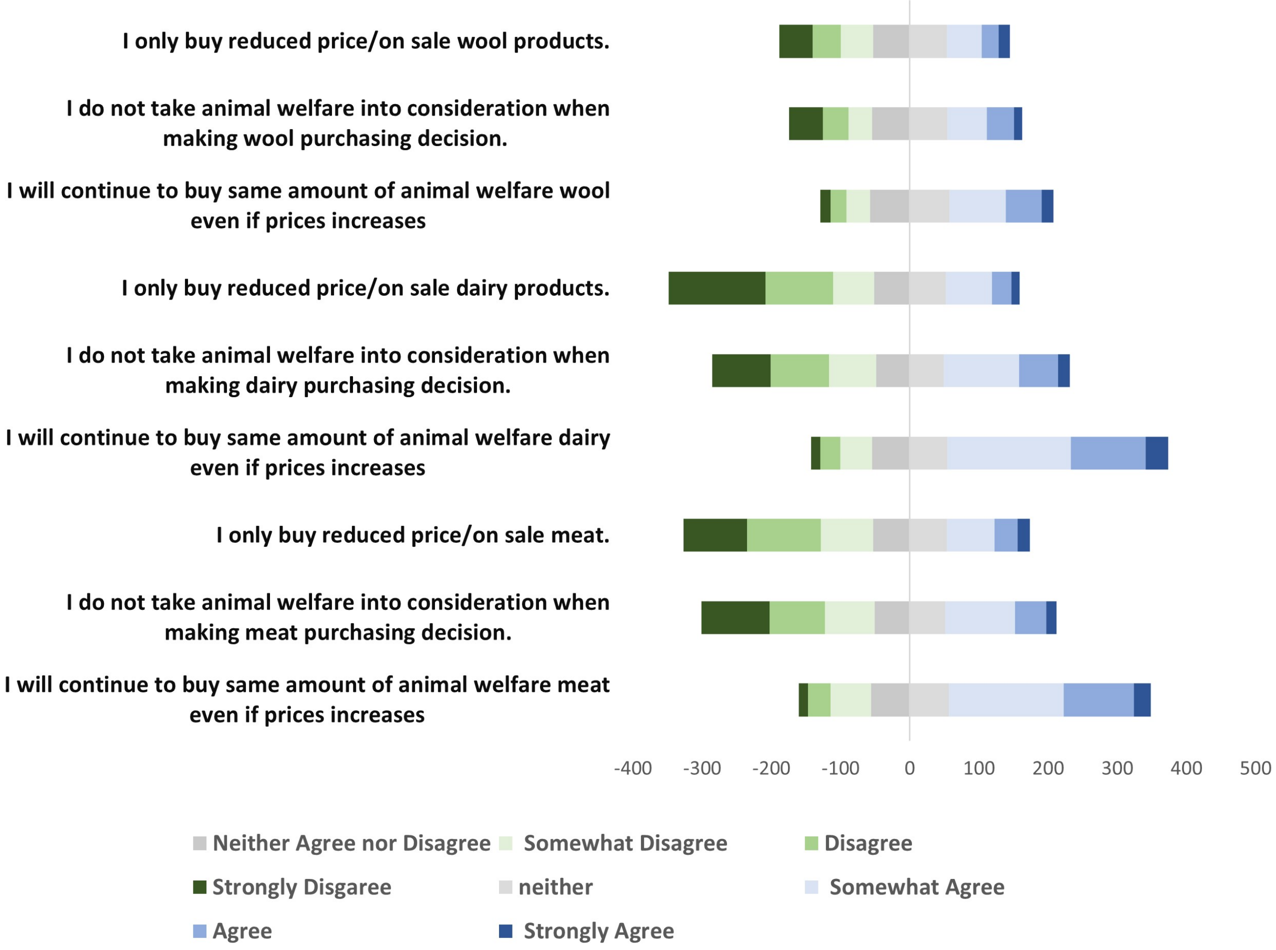
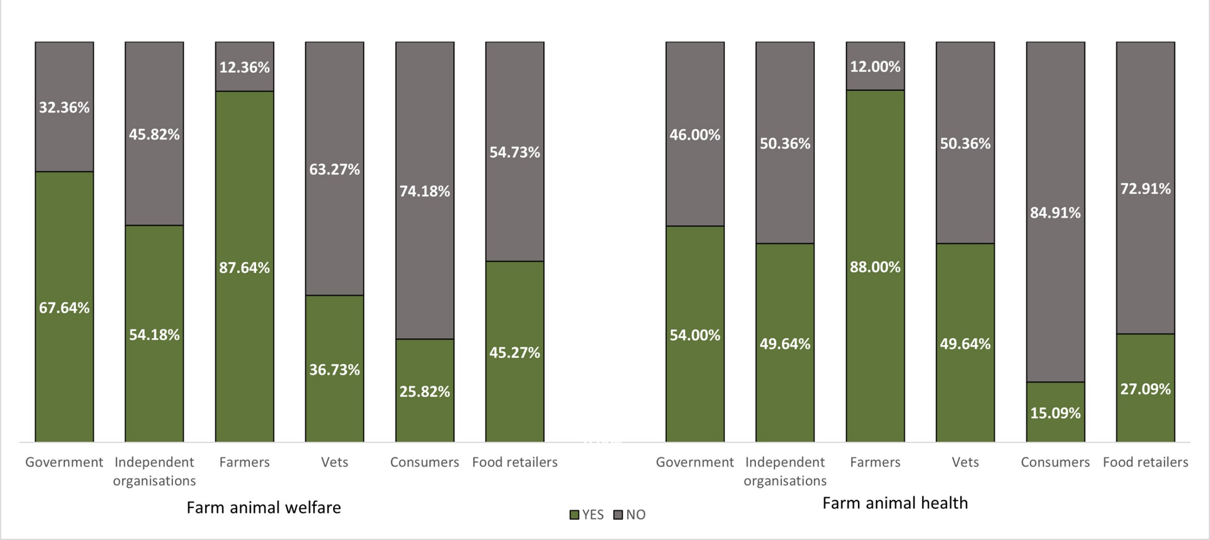


Table 8.3: Responsibility to ensure farm animal health and welfare from a consumer perspective at the beginning of COVID19



to ensure high FAH and FAW. Clark (2022) provides further evidence of the UK public's willingness to "subsidise" FAHW costs and further recommends that the new legislation should ensure the provision of public funds to ensure high FAHW. Therefore, defining FAHW as a public good could help farmers deliver the standards expected as the responsibility is shared between multiple stakeholders.

Furthermore, my results also indicate that consumers are home biased and tend to view locally produced animal products as both high quality and also to be the product of good farming practises which guarantee high FAHW standards. This is also illustrated table 8.5, where I present consumer and producer perspective on the image of the UK's farming sector. The key result is that the consumers seem to have a more positive view of the British farming sector than the producers themselves with Scottish farmers being more optimistic than their English counterparts.

In light of all the results highlighted above, it becomes apparent that government interventions are necessary to deliver high FAHW. The UK government wants to ensure high FAHW, and as we saw in my findings the British public is willing to pay for low disease levels in the livestock. However, this market demand might not be enough to ensure the socially optimal level of disease control and hence government intervention may be necessary. Traditionally, delivering high FAHW has been associated with increasing production costs on farmers that the government need to subsidise through targeted transfers, or it would lead to price hikes (Sørensen et al., 2007; Lusk and Norwood, 2011). So the question naturally arises of how the public wants to subsidise the production of a public good and via which fiscal instruments.

Next, I offer a discussion of how my results fit in with the new Agricultural Act (DEFRA, 2020)[3], including the consideration of whether FAHW should be a public good. In other words, given that

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[3] DEFRA stands for the Department for Environment Food Rural Affairs

Table 8.4: Responsibility to ensure farm animal health and welfare from a consumer perspective during COVID19

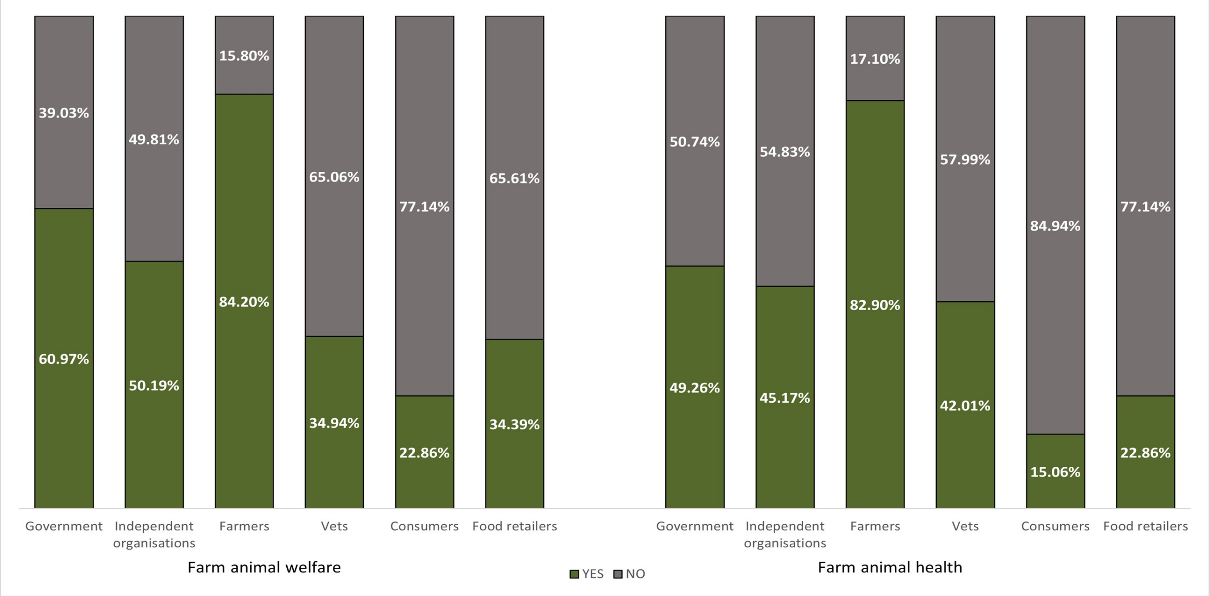
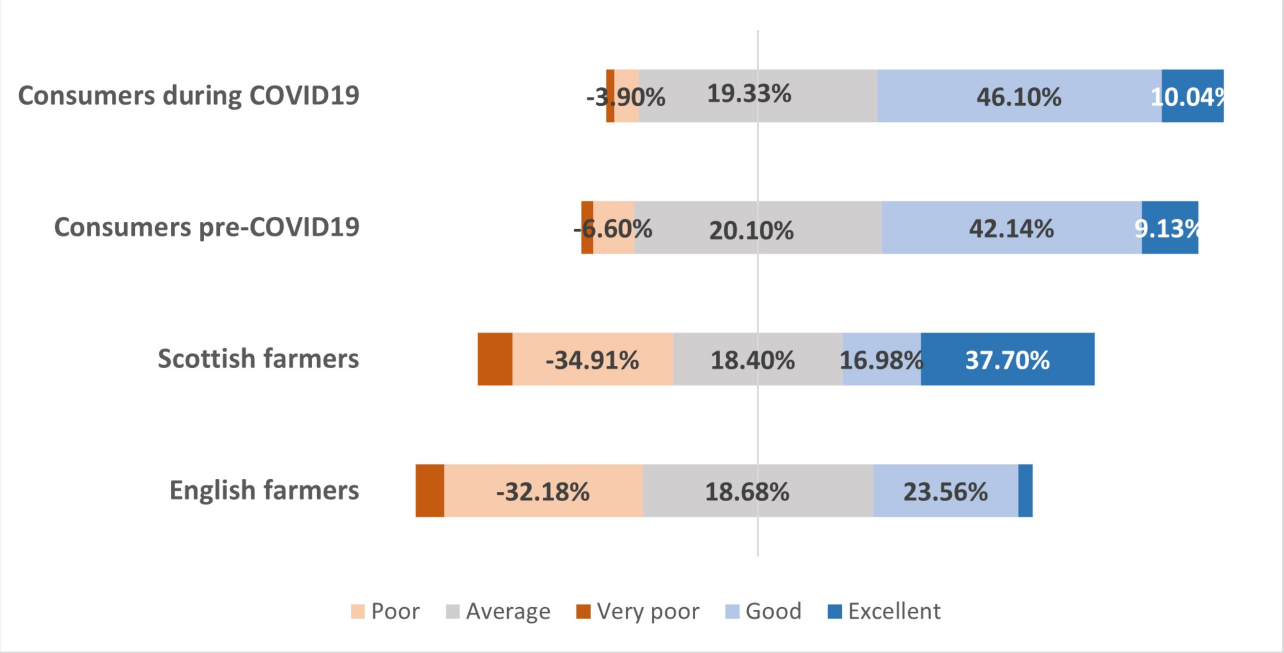


Table 8.5: Consumer and producer perspective of the image of the UK agricultural sector



respondents are willing to pay for high FAH and FAW, what would be the optimal way of ensuring this outcome. Three possible approaches are considered in this discussion. However, before we delve into them, I provide a brief overview of current policy framework.

The UK's separation from the European Union (EU), commonly referred to as BREXIT, has brought many changes in the economy. The farming industry is one of the economic sectors where the effects were immediately visible. For example, from the end of 2020, the UK left EU's Common Agricultural Policy (CAP) system and begun putting in place new legislation to replace it (Siettou, 2022). This new initiative has adopted a public money for public goods approach, initially focusing on farmers delivering environmental public goods (in line with pillar 2 of CAP).

The aim of the new agricultural policy is to support farmers and improve agricultural productivity whilst focusing on "environmental goods" delivery. In fact, the new system seems to place more weight on the environmental goals, providing subsidies to farmers who achieve certain objectives (for example, subsidising farming practices that enhance biodiversity), and focus less on productivity[4] (The UK Agricultural Bill, 2020). As stated in Clark (2022), in the same year, DEFRA stated in their "Agriculture Transition Plan", "that public funds could be used to deliver health and welfare enhancements that are currently not sufficiently delivered by the free-market". The Animal Health and Welfare Pathway (2022) more recently confirmed that public money will be used in this way. This is particularly pertinent for the research carried out in this thesis as the two named conditions for sheep and cattle are lameness and BVD respectively as in my thesis. As money is being used to support the reduction in these conditions, my findings provide invaluable insights into how this could work. In particular, my findings help to answer a broader question of whether FAH and FAW should be considered as a (Quasi-) public good.

### 8.3.2 What do we mean by "public" good?

Although the notion of public good goes all the way back John Stuart Mill, the Nobel laureate Paul Samuelson can lay claim to the term, he named it "collective consumption good" and defined it as:

" a good which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtractions from any other individual's consumption of that good...." (Samuelson 1954, p.387).

According to Samuelson, the key attribute of these commodities is "non-rivalry". A good is "rivalrous" if and only if its utilisation/consumption by any agent hinders the ability of other agents to consume it. Later on, an additional criterion was introduced, that of (non-) excludability (Musgrave, 1959). As the name suggests, a good is "excludable" if and only if it is possible to prevent individuals from consuming it, to "draw a fence around it" as it were (Reiss, 2021)).

In modern economics, goods are usually defined as public goods if and only if they are both "nonrivalrous" and "non-excludable" (Varian 2014, p.414). An example of a public good is national security. If the good fails to satisfy any of these conditions, they are classified as "quasi-public

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[4] There are no more direct payments for production of market goods or income support.

goods" in the case of meeting only one condition or "private good" if both conditions are not met.

Let us now look at different strategies for ensuring FAHW optimally from the perspective of a public good. The first approach is as follows. Households are known not to have non-satiated preferences. Higher levels of consumption are always preferred (more is better). So the question is, as consumers, how do we make choices that maximise our welfare and are consistent with high FAHW given our respective budget constraints? One way would be to impose some kind of tax similar to Pigouvian taxes [5] to offset the externality (FAWC, 2012). It is typical for the government to apply high consumption taxes to products that are deemed harmful to either our health or the environment. Examples of such taxes are high consumption tax on alcohol, sugar and tobacco products (Krugman and Wells, 2012). These kinds of taxes are not only associated with direct adverse effect to human health but we also find them in products that are harmful for the environment. For example, road tax in the UK is linked to CO2 emissions (how much you pollute). So, imposing Pigouvian-esque taxes on high consumption animal products associated with low FAHW would drive these products out of the market. This would ensure that consumers would opt to buy animal products with higher welfare grading since the price differential disappears. On the other hand, low income consumers may be forced to consume less or even be priced out completely. This implies that although high FAHW is financed through product specific taxes, it could potentially exclude certain consumers from having access to it and as such it can no longer be thought as a public good. And therefore, the mitigation of endemic diseases or of any other factor that diminishes FAHW will become the optimal (economic) choice for the producer. Nevertheless, since the government believes that the financial burden should be distributed across the society (taxpayers), other solutions need to be considered.

Now, a second approach to optimally ensure FAHW, is to consider it a public good. And, characteristics of FAH and FAW suggest that it could be viewed as such. Using the strict definition, however, one could argue that FAHW is not a public good but rather a "Quasi"- public good [6]. This is because higher levels of either " farm animal health" or " farm animal welfare" may be both "non-rivalrous" and "non-excludable". However, how we attain these higher levels of FAHW plays a central role. If they are financed through an increase in taxation, for example through an increase in consumption tax (VAT), then that could cause low-income households to reduce their consumption of animal products thus, violating the "non-excludability" assumption. In this case, we would classify FAHW as a Quasi-public good.

On the other hand, if the government either delivers an equal subsidy to hand-to-mouth[7] households so that their consumption would remain unchanged should there be a tax levy then of course the "non-excludable" assumption would hold. It could also be argued that goods like bread, eggs, milk and meat are classified as "basic" goods. In other words, an increase in their price, in this instance due to an increase in FAHW could leave their demand unchanged whilst consumers adjust

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[5] A Pigouvian tax, is a tax that generates a negative externality meaning an activity that not only affects adversely the individual but the society as a whole.

[6] Quasi-public goods are goods that combine elements of both private and public goods. A private good is a good that is excludable and rival.

[7] Hand- to- mouth consumers are consumers who have little to no wealth and consume their entire labour income, plus any government benefits that they might receive. So, essentially the term describes consumers who live paycheck-to- paycheck.

their demand towards luxury goods.

And this leads us on to the third approach where FAHW is strictly considered a public good i.e. FAHW is funded not through consumption tax that excludes parts of society but through the re-allocation of existing public funds. This would ensure high FAHW is realised without forcing any consumers to alter their consumption habits.

In conclusion, for FAHW to be considered a “public/quasi-public” good, how FAHW is subsidised is crucial. The way the government choose to finance FAHW will ultimately decide its status. My research finds strong evidence that both farmers and consumers are willing to pay to ensure high FAHW, thus, since the society as a whole value this objective it should be considered a public good. According to Houston (2021), the Animal Health and Welfare Pathway and Transition Plan as part of the new agricultural legislation stipulates that there is a provision of public funds available for the enhancement of farm animal health and welfare when this result is not attainable through market clearing alone. This acknowledgement of animal health and animal welfare in the new agricultural legislation, besides the environmental goals is further proof that it should be considered a public good.

### 8.3.3 A free riders’ problem

### Consumers’ perspective of the free riders’ problem

As discussed above, my result indicates that both producers and consumers want to ensure high standards for FAHW in the UK, including in relation to endemic disease management. In this subsection, I will focus on the consumer perspective of the free rider problem and the implications for the optimal market outcome.

The market is far from perfect. Market participants can be subject to both power and information asymmetries. For example, animal products are mostly perishable goods that can spoil in a matter of days. Most farms rely on contracts with handful of retailers (Oligopolistic market). As such, the retailers have more bargaining power. This means if the public demands higher FAHW, the retailer could place the cost dis-proportionally on the shoulders of the producer cutting their (already) thin profit margins so that the retail prices remain competitive. In other words, the wholesales sector would not absorb part of the cost and leave to the primary producers and consumers to bare the cost.

Thus, government intervention is necessary to ensure both “social justice”/fairness for producers and consumers and high FAHW. It is something that benefits and affects the society as a whole. Subsets of consumers who do not use nor consume animal products due to moral, ideological, religious or other objections they still benefit from enhancement in FAHW. It can be argued that these subgroups of consumers benefit from enhancements in FAHW indirectly. Thus, creating a free rider problem[8].

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[8] By definition the “free riders’” problem refers to a situation where all individual members of a group benefit from collective efforts, but a subgroup does not contribute towards the cost of that result and still receives their benefits.

One might ask why free riding is such a problem in this case? Why, when only households who consume these products pay to ensure high FAHW creates a free rider problem? If as a consumer I choose not to use animal products because of my objections, it can be easily inferred that I am abstaining from consuming these goods because I perceive them to be the product of animal exploitation. Thus, we come to the same conclusion that enhancements in FAHW still provides me with indirect utility. Thus, I should bear part of the cost.

Asymmetric information acts in a similar manner. Producers have the most information regarding their farming practises. If the retailers, independent bodies, or the consumers want to have the same amount of information that could entail a very costly process. Given the presence of market failure it guarantees disproportional costs for the market participants with the least power.

So, in order for the government to achieve the goal of maximising the aggregate (Social) welfare [9] and ensure that low-income households are not priced out of consumption of basic goods (like animal products), everyone needs to pay their share for ensuring this desired improvement in FAHW.

## Producer perspective of the free riders' problem

Now, we are going to look at the problem from the farmers' perspective. In this thesis, I have studied FAHW in the UK in the context of two endemic diseases "Lameness" in Sheep and "BVD" in cattle both discussed in chapter 1. In this section, I will focus only the effects of BVD. This disease results in higher production costs for producers through decrease in the life expectancy, reduction in production and damage to the farm's reputation. Additionally, BVD can have severe adverse affects on livestock health and welfare. However, they do not have any adverse health impact on people who consume animal products coming from infected herds[10].

In the working paper on public goods by FIELD et al. (2022), the authors argue the following "We observe that when mitigation of such diseases are left to the free market, farmers are only likely to invest in disease risk mitigation up to the point where the marginal (incremental) benefits of them taking action are equal to the expected marginal costs of the disease burden. Given that the perceived marginal benefits of control are greater than the perceived marginal costs, then farmers are predicted to wish to increase their control efforts. However, as stated by McInerney et al. (1992) this also means that few farmers would want to incur a high enough cost to eliminate the disease, especially if the marginal benefits of controls are declining and the marginal costs of treatment are increasing. From an economics perspective, the persistence of endemic disease is economically optimal for the farmer and thus government intervention is imperative". The fact that actions consistent with the eradication or at least mitigation's of such (endemic) diseases are not the outcome prescribed by the open market but only a subset of farmers choose it[11], points to a market failure which gives rise to the free riders' problem.

My "farmer" studies (Chapters 6 and 7) examine producers' attitudes towards FAHW both in Scotland and in England and respondents are geographically dispersed across the countries. Scotland

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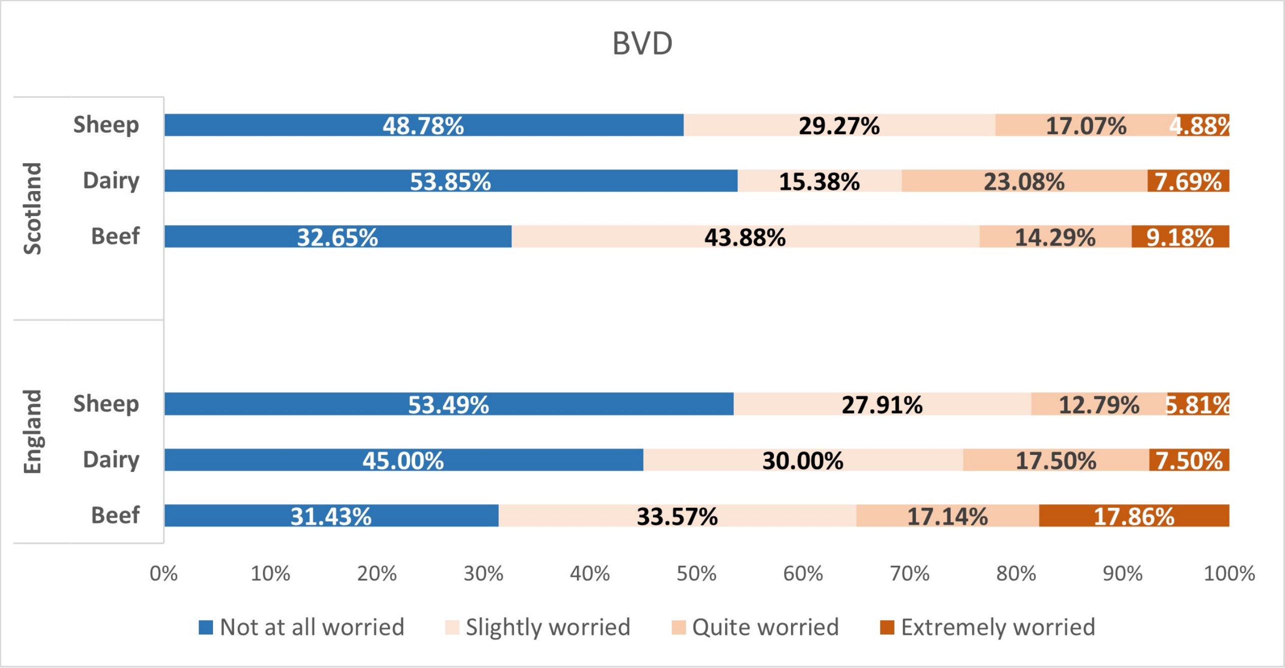
[9] The term "Social" or "Aggregate" Welfare refers to society's utility function.

[10] This point has been discussed in detail in previous chapters.

[11] Their decision is driven by non- monetary objectives like ethics, views or social norms.

Table 8.6: Farmer attitude towards BVD



has in place a compulsory BVD eradication scheme forcing farms to cull infected livestock and restricts the trade across farms to only farms with unknown (with the requirement of testing within 40 days) or BVD negative status (BVD eradication scheme Scotland, 2018). However, in England participation in this scheme which has been running since July 2016 with industry led support is voluntary (BVD Free England).

One can see a quick comparison between the two nations' attitudes towards BVD in table 8.6. Although there are very small differences between the two farming groups regarding attitudes towards BVD, I observe that English farmers are more worried than Scottish farmers when to comes to dairy cattle. This result is not surprising given England's' lack of legislation to manage BVD and the fact that BVD has the largest economic impact on dairy Production. Ruminant Health and Welfare survey, 2021 lists BVD as one of the main concerns.

In chapter 7, my results indicate that English farmers have a clear preference for purchasing BVD free cattle. Similarly, Scottish farmers preferred BVD tests that were administered to the whole herd minimising disease risk. Although farmers were aware of the BVD threat to biosecurity and disease spread, English farmers were still willing to engage in risky behaviour through the purchase of bulls with either BVD unknown status and Scottish farmers with purchasing bulls that came from a herd where only a sub-sample of calves were tested. The study finds that farmers purchasing behaviour is also influenced by seller characteristics. These results demonstrate the extent of the free riders' problem coming from these transactions as explained below.

Farmers' from England trade/buy cattle from Scottish farms. However, Scottish producers can only move cattle if they have been tested for BVD prior to the transaction (BVD eradication scheme Scotland, 2019). As a result, a Scottish farm has to incur the costs of frequent testing and culling to ensure their negative BVD status. Thus, English farmers can enjoy the same biosecurity without having to bare the cost.

English farmers also displayed WTP for increased information on BVD status. This translates into them being willing to pay more for cattle sold by Scottish farmers, given this additional assurance on the BVD status. Essentially, the Scottish legislation eradicated the market failure associated with information asymmetry but increased inequality between English and Scottish farmers since only the Scottish farmers are obliged to undertake the costly measure whilst English farmers participate on a voluntary basis.

Hence, English primary producers who do not participate in the voluntary scheme benefit from these transactions more as the Scottish producers essentially provide them with a guarantee that the procured animals are BVD free or at the very least have an "unknown" status, without having to incur any direct cost. Treating high FAHW as a public good means that the cost is distributed proportionally across all individuals (both consumers and producers) who directly or indirectly benefit from its presence thus, solving the "free riders'" problem.

## 8.4 Limitations and future research

In this section I will discuss the research limitations and what I could have done differently in the absence of time and monetary constraints and provide recommendations for future research.

Given the transition from EU's CAP system to the Agricultural act of 2020, there has been continued instability and uncertainty especially in relation to farming subsidies but also the possibility of a more promising future to improve our farming systems. The fact that we are designing a new system gives rise to the need for more research in this area with immediate policy implications.

In relation to this, steps that would be beneficial to future research could include a more pro-active approach in data collection from farmers which could have helped increase the sample size and provide me with even more robust results. Although arrangements such as farm visits to collect data had been made, COVID-19 restrictions impeded these plans. Nevertheless, my sample size for farmers proved sufficient for the analysis I wanted to undertake.

Several of the survey questions could have been incorporated in both consumer and farmer surveys for e.g. the question on whose responsibility it is to ensure FAH and FAW in order to facilitate comparison between perspectives. This could have been particularly useful for making comparisons of perspectives. Additionally, the length of the survey was controlled in order to ensure that it was reasonable for respondents to complete. I would have liked to have had more questions on the socio-demographic characteristics of the respondent to help me better understand the preference heterogeneity which is present in almost all the attributes considered.

Furthermore, if I was not limited by the end date of my PhD, I would have explored further farmer decision making in the context of altruism and whether farmers are bound by social norms. Why is there a hesitancy to achieve zero sickness levels for instance? My study indicates that farmers are willing to pay to ensure high FAHW. Does this mean that the existing level of these endemic diseases is the outcome of a complex profit/utility optimisation problem or is it the result of market failure? As discussed above in this chapter, without proper legislation for BVD (See the case of England), when it comes to culling a diseased animal to mitigate the spread of the disease, many farmers will not choose to cooperate voluntarily as it is not justifiable as the optimal economic outcome. The underlying causes could be explored from an institutional (farming as a whole) viewpoint focusing on the environment, how animals are kept and managed and how these perspectives could have changed over the years.

Again, in the context of BVD, I have brought attention to the free rider's problem. Given that Scottish farmers have been pursuing BVD eradication at a national scale and English farmers operate under a voluntary scheme despite their proximity and the close trading links with each other, it appears to be in the best interest of England to also follow a government mandated BVD eradication scheme to allow free trade and reduce the incidence of disease risk. Future research could run a follow-up survey focusing on farmers' views of this problem and study the spill-over effects of interventions such as subsidies and movement restrictions resulting in policy suggestion to solve it.

My consumer surveys were conducted at the beginning (between May and July 2020) and during the COVID-19 pandemic (between May and June 2021) and the farmer surveys between the period of February 2020 and October 2020. In both instances, I observed a level of inflation that was very low compared to the historic average. Additionally, due to the large fiscal transfers paid by the government during the pandemic, my consumer respondents seemed to be optimistic about their future income. These results coupled together indicate that my surveys were conducted during a period of economic prosperity. Currently (autumn 2022), we are all faced with the aftermath of this large expansionary fiscal policy. The social safety net provided during harsh times, although helped many households and businesses, has doubled the amount of outstanding fiscal debt, creating high inflationary pressures [12] and a subsequent need for the government to both increase taxes and reduce public spending.

However, the government still has some alternatives to mitigate (the politically undesirable) measure of tax increases. That is to say that the government could reduce the size of the public sector through privatisation and use the funds to decrease the debt burden. Alternatively, and most likely, the government has to reduce public spending to areas that are deemed of secondary importance. Recent literature (Clark, 2022), has found that consumers want to be included in the dialog regarding public spending and the general decision-making process when it comes to food policy. So, perhaps if I had conducted the same survey during the cost of living crisis, I might have received significantly different answers.

Assuming that a representative participant is a Ricardian consumer[13], there are two considerations.

1. A Ricardian consumer may want to smooth his/her lifetime consumption. If the government

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[12] An excellent exposition of the problem is presented in "A fiscal theory of the price level", by J. Cochrane (2022), Princeton publishing.

[13] Consumers are forward-looking and they internalise the government's budget constraint when making their consumption decisions. So, agents believe that higher fiscal transfers or government debt today means higher taxes tomorrow.

is borrowing today to fund FAHW, the decision will impact the consumption behaviour since consumers expect higher taxes in the future. And agents do not only care about present consumption, but they are rather concerned with their life-time consumption.

2. Generational effect- Government borrowing today may mean the consumer of the future bears the current costs.

Therefore, the way FAHW is funded as a public good will play a key role in determining the effects of such an intervention.

Chapters and 4 and 5 highlighted consumers stated WTP. Future research could look to corroborate these findings through actual purchase data. One means of doing so would be through the use of supermarkets/retailers' customer data enabling me to calculate the observed WTP. That would provide me with the opportunity to compare the results attained using Stated and Revealed preferences. In addition, if longitudinal data could be obtained (i.e., retailer loyalty schemes such as Tesco Clubcard), then changes in purchasing habits over the COVID19 pandemic, and in the changing financial context could be explored in relation to animal products, in particular higher welfare items and brands.

And lastly, some comments on the choice of methodology. Stated choice experiments have become increasingly popular in disciplines like environmental, health and agricultural economics. Continuous strides are being made to improve the robustness of such data. Campbell et al.(2008) in their paper incorporate discontinuous preferences into their analysis to check behavioural relevance. There are two ways of addressing such questions. One would be to analyse follow up questions post- choice experiment and the other would be looking at the choices made.

Sampling and recruitment used within the study should also be considered. Another common criticism of the methodology used in my thesis is on the usage of internet panels. The concern lies in the fact that there might exist some selection bias and as such condition respondents' preferences to adjust based on the panel. In my consumer studies, a UK representative selection of participants were chosen in order to reflect the general UK public's perceptions. With models like the latent class model, it was possible to ensure quantifiable trade-offs are measured even in the presence of latent preference classes. Despite the presence of such concerns, the benefits of reaching a large sample through internet panels and ensuring it is a representative panel is possible and vital in identifying heterogeneity (Dennis, 2001).

Farmer surveys were administered through emails and advertised on various farming websites with incentives provided for completion. Although, I did not collect information on the age of the farmers in my sample, it is estimated that the average age of farmers is 60 years old (DEFRA, 2020). Given the survey was mainly completed online, it could be argued that it may have appealed a younger demographic more however this means the respondents are more likely to be working directly with animals rather than being farm holders only. Regardless, Best et al. (2020) found no association between farmer age and adoption of 5 PP (Five point plan- a national strategy launched in 2014 to tackle lameness in UK sheep farms) in managing lameness in sheep implying farmer age would have no implication on the observed preferences.

Farming, an essential part of the UK produces a range of private and public goods and services to citizens. Mainly dominated by male (84%) farmers with an average age of 60 years, agriculture is estimated to contribute 0.49% to the national economy employing 1.44% of the workforce with the wider food sector that often relies on raw agricultural materials contributing to an even bigger percentage (DEFRA, 2020). Concerns about FAHW have been particularly at the fore front in the last 10 years across the globe varying widely across societies and individuals. We have seen its evolution over time with continuous improvement with calls for legislation in order to safeguard the health and welfare of farm animals. My thesis contributes to the ongoing dialogue and the suggestions that come out of my research help the design of relevant policies in the coming years.

## 8.5 Appendix

### Consumer Survey (Chapter 5)

## Introduction

**Title of Project:** Farm-level Interdisciplinary approaches to Endemic Livestock Disease (FIELD)
**Name of Researcher(s):** Maria Rodrigues, Professor Nicholas Hanley

Dear Sir/ Madam,

We invite you to take part in a survey as part of the FIELD project (click the link for more information on our project). In the survey, we will ask for your views on what influences the choices that we as consumers make, particularly thinking about farm animal health and welfare. **There are no right or wrong answers, we are interested in your views whatever they are.**

Participation in the study is voluntary and you have the right to decline the invitation or to withdraw from the study at any time. All personal information collected about you, or responses that you provide during the course of the study will be completely anonymous. The results will be used for research purposes only. All data will be secured in line with the new General Data Protection Regulation (GDPR) law requirements as it applies in the UK.

The survey will take approximately 10-15 minutes to complete.

**We would like to thank you in advance for your time and contribution to this research which aims to understand what people think of farm animal health and welfare**.

Yours faithfully,

Maria Rodrigues and Professor Nick Hanley

University of Glasgow

## PIS and Consent

Before you start the survey , if you'd like further information please, Click here .

I confirm that I had the chance to read and understand the Participant Information Sheet for the above study.
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

○ **I hereby agree to take part in the study.**
○ I do not agree to take part in this study

## Section A- Quota

1. In which country do you currently reside?

2. What is your current country of residence?

○ Scotland
○ England
○ Wales
○ Northern Ireland

## Section A

3. How old are you?

○ 18-24
○ 25-34
○ 35-44
○ 45-54
○ 55-64
○ 65 and above
○ Under 18

4. What is your gender?

○ Male
○ Female
○ Other

5. What is your **total household income** range before tax **per month**?

○ 1000 or less
○ £1001 – £1500
○ £1501 – £2000
○ £2001 – £2500
○ £2501 – £3000
○ £3001 – £3500
○ £3501 – £4000
○ £4001 – £4500
○ £4501 – £5000
○ £5001 or more

6. What is the **highest education level** you have **completed**?

○ GCSE or GNVQ or equivalent
○ A-levels or advanced GNVQ or equivalent
○ University undergraduate degree
○ Postgraduate degree or higher

## Section B

### Section B

1. How would you describe your dietary choices? (Tick ALL that apply)

☐ I eat beef
☐ I eat lamb
☐ I eat pork
☐ I eat chicken
☐ I eat dairy products (milk, cheese, etc.)
☐ I am vegetarian
☐ I am vegan
☐ Other, please specify

**2**. What are your dietary choices based on? Tick all that apply.

☐ Personal taste
☐ Religious beliefs
☐ Cultural
☐ Prices, costs, income
☐ Health
☐ Environment
☐ Animal health and welfare

☐ Other, please specify

## Choiceexperiment

Here is your unique participant ID ${e://Field/RandomID}

Please take **NOTE/COPY of this number** and enter it in the next part of the survey i.e. Section C.

1. For section C, please click on the following link which will take no more than 5 minutes to complete: Choice experiment
2. **After completing section C, you will be provided with a password in order to have access to section D below.**

Please enter the password to access section D here:

## Section C

### Section D- Food and shopping

*All questions in this section will focus on red meat (beef), dairy and wool products.*

*Purchasing habits*

**1. Are you the person who does the main food shopping in your household?**

○ Yes
○ No
○ Shared responsibility

2. On average, how frequently does your **household** **purchase** the following type of items? (For yourself or other members of your household)

| | I never purchase this product | I don't know | Rarely | Once a month | 1 - 3 per month | Once a week | 2 - 4 per week | 5 - 6 per week |
|---|---|---|---|---|---|---|---|---|
| Organic dairy milk | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Non-organic dairy milk | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Non-dairy milk (soya, almond, oat milk etc.) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Fresh beef | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Frozen beef | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Organic beef | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Non-organic beef | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wool | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**3. Where does your household most frequently make the following purchases? Tick all that apply.**

| | I do not buy this product | Supermarkets | Specialised stores( i.e. Butchers, yarn shops etc.) | Online shopping | I do not buy this product from the sources listed above |
|---|---|---|---|---|---|
| Beef | ☐ | ☐ | ☐ | ☐ | ☐ |
| Dairy Milk | ☐ | ☐ | ☐ | ☐ | ☐ |
| Wool | ☐ | ☐ | ☐ | ☐ | ☐ |

3a.(Optional) If there are other sources, please feel free to specify below.

| | Beef | Dairy Milk | Wool |
|---|---|---|---|
| Other, please specify | ☐ | ☐ | ☐ |

## Section D2

4a. To what extent do you agree or disagree with the following statements on meat?

**Meat**

**Meat**

| | Not applicable | Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|---|
| | Not applicable | Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree |
| I will continue to **buy** the same amount of high animal welfare **meat** even **if the price increases.** | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I do not take animal welfare into consideration when making **meat** purchasing decision. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I only buy **reduced price/on** sale meat. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**4b. To what extent do you agree or disagree with the following statements on Dairy?**

**Dairy**

| | Not applicable | Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|---|
| I will continue to **buy** the same amount of high animal welfare **dairy** even **if the price increases.** | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**Dairy**

| | Not applicable | Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongl Agree |
|---|---|---|---|---|---|---|---|---|
| I do not take animal welfare into consideration when making **dairy** purchasing decision. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I only buy **reduced price/on sale** dairy products. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**4c. To what extent do you agree or disagree with the following statements on wool?**

**Wool**

| | Not applicable | Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongl Agree |
|---|---|---|---|---|---|---|---|---|
| I will continue to **buy** the same amount of **wool** coming from high animal welfare even **if the price increases.** | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I do not take animal welfare into consideration when making **wool** purchasing decision. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| I only buy **reduced price/on sale** wool products. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

5. Please rank by **importance** at least the **TOP 4 (1,2,3,4)** of the characteristics when purchasing **Meat.**
1 = Most important, 2= second most important and so on.

☐ Low prices

☐ Freshness

☐ Carbon footprint

☐ Good for health

☐ Taste

☐ Brand

☐ Convenience

☐ Animal health

☐ Animal welfare

☐ Free-range

☐ Organically produced

☐ Other, please specify and rank

☐

5b. Please rank by **importance** at least the **TOP 4 (1,2,3,4)** of the characteristics when purchasing **Dairy Milk.**
1 = Most important
* If you and your household do not consume milk, you may hypothetically rank these characteristics.

☐ Low prices

☐ Freshness

☐ Carbon footprint

☐ Good for health

☐ Taste

☐ Brand

☐ Convenience

☐ Animal health

☐ Animal welfare

☐ Free-range

☐ Organically produced

☐ Other, please specify and rank

☐

5c. Please rank by **importance** at least the **TOP 4 (1,2,3,4)** of the characteristics when purchasing **Wool.**
1 = Most important
* If you and your household do not use wool, you may hypothetically rank these characteristics.

☐ Low prices

☐ Carbon footprint

☐ Brand

☐ Convenience

☐ Animal health

☐ Animal welfare

☐ Other, please specify and rank

☐

## Section D3

Consumption Habits

**6. Have you reduced consumption of red meat in your household in the last year?**

○ Yes
○ No
○ I don't eat meat (at all)

6b. If yes, what was the primary reason that affected your decision? (Tick **all** that apply)

☐ Prices
☐ Information regarding how animals are kept
☐ Environmental reasons
☐ Health reasons
☐ Availability of meat alternatives
☐ Other, please specify

☐

7. Do you currently have or have had any connections to farming?

○ Yes, I currently live or have lived on a farm raising animals
○ Yes, I currently work or have worked on a farm raising animals
○ Yes, my family and/or friends live or have lived/worked on a farm
○ No connections at all with farming

7b. If not, have you ever **visited** a sheep/cattle farm?

○ Yes
○ No

## SectionD4

8. Whose **responsibility** do you think it is to ensure **farm animal welfare (***as opposed to animal health)? Tick all that apply.

☐ Government
☐ Independent organisations (e.g. RSPCA, Red tractor etc.)
☐ Farmers
☐ Vets
☐ Consumers
☐ Food retailers
☐ Other (Please specify)

9. Whose **responsibility** do you think it is to ensure **farm animal health**? Select all that apply.

☐ Government
☐ Independent organisations (e.g. RSPCA, Red tractor etc.)
☐ Farmers
☐ Vets
☐ Consumers
☐ Food retailers
☐ Other (Please specify)

10. How would you rate your **image** of the **UK livestock agricultural** sector? *Livestock are domesticated animals raised in an agricultural setting to produce labour and commodities like meat, milk, wool etc.

| | Very poor | Poor | Average | Good | Excellent |
|---|---|---|---|---|---|
| Image of UK livestock industry | ○ | ○ | ○ | ○ | ○ |

## section D5

Thank you for getting this far. You are almost there!

**11.** Please rank how **<u>trustworthy</u> you think the following are in providing consumers like you with <u>information</u> about <u>diseases</u> in cattle and sheep production?**

**(1= most trustworthy to 5 = least trust worthy)**

***Use each number only once**

☐ I trust farmers

☐ I trust food retailers

☐ I trust food manufacturers

☐ I trust the government

☐ I trust independent bodies (RSPCA, Red tractor etc.)

☐ Other, please specify and rank

12. Do you **belong to or follow** any group associated with environment or farm animal health and welfare? (Facebook, Instagram, Blogs etc.)

○ Yes

○ No

13. Do you follow any **current debates/news** on farm animal health and welfare?

○ Yes

○ No

14. In your opinion, which of the following groups listed below **SHARE SIMILAR** food consumption habits as you? (**Tick all that apply**).

☐ Family/relatives

☐ Colleagues

☐ People I admire

☐ Friends

☐ Other, please specify

15. In your opinion, which of the following groups listed below **APPROVE** of your food consumption habits? **(Tick all that apply).**

☐ Family/relatives

☐ Colleagues

☐ Friends

☐ Other, please specify

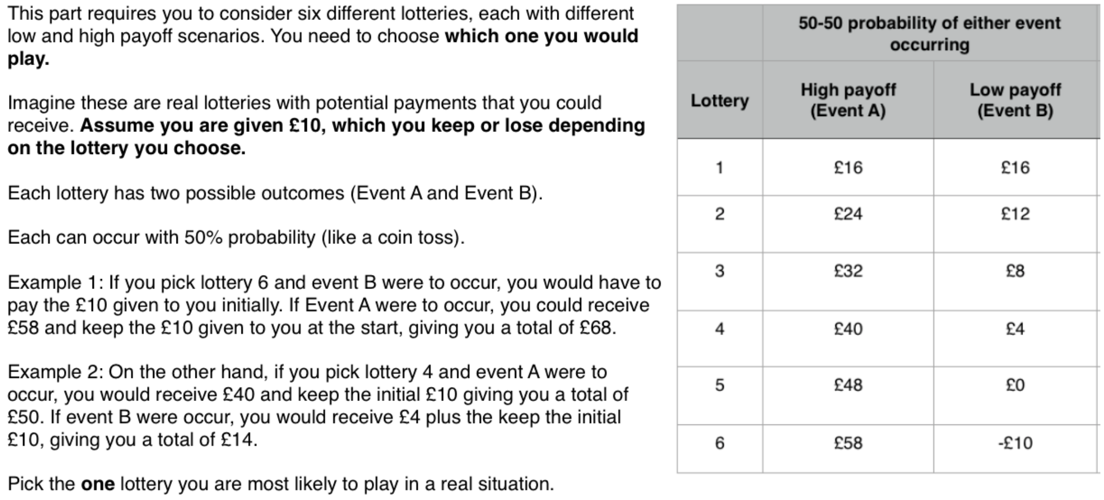
## Block 10

## Section E - Risk attitude

### Part 1

In this part of the survey, you will be asked to make decisions that will tell us something about your risk preferences.

**A**



This part requires you to consider six different lotteries, each with different low and high payoff scenarios. You need to choose **which one you would play.**

Imagine these are real lotteries with potential payments that you could receive. **Assume you are given £10, which you keep or lose depending on the lottery you choose.**

Each lottery has two possible outcomes (Event A and Event B).

Each can occur with 50% probability (like a coin toss).

Example 1: If you pick lottery 6 and event B were to occur, you would have to pay the £10 given to you initially. If Event A were to occur, you could receive £58 and keep the £10 given to you at the start, giving you a total of £68.

Example 2: On the other hand, if you pick lottery 4 and event A were to occur, you would receive £40 and keep the initial £10 giving you a total of £50. If event B were occur, you would receive £4 plus the keep the initial £10, giving you a total of £14.

Pick the **one** lottery you are most likely to play in a real situation.

| | **50-50 probability of either event occurring** | |
|---|---|---|
| **Lottery** | **High payoff (Event A)** | **Low payoff (Event B)** |
| 1 | £16 | £16 |
| 2 | £24 | £12 |
| 3 | £32 | £8 |
| 4 | £40 | £4 |
| 5 | £48 | £0 |
| 6 | £58 | -£10 |

○ Lottery 1
○ Lottery 2
○ Lottery 3
○ Lottery 4
○ Lottery 5
○ Lottery 6

B. This time using the same six lotteries, **which lottery do you think people around/close to you would pick?**

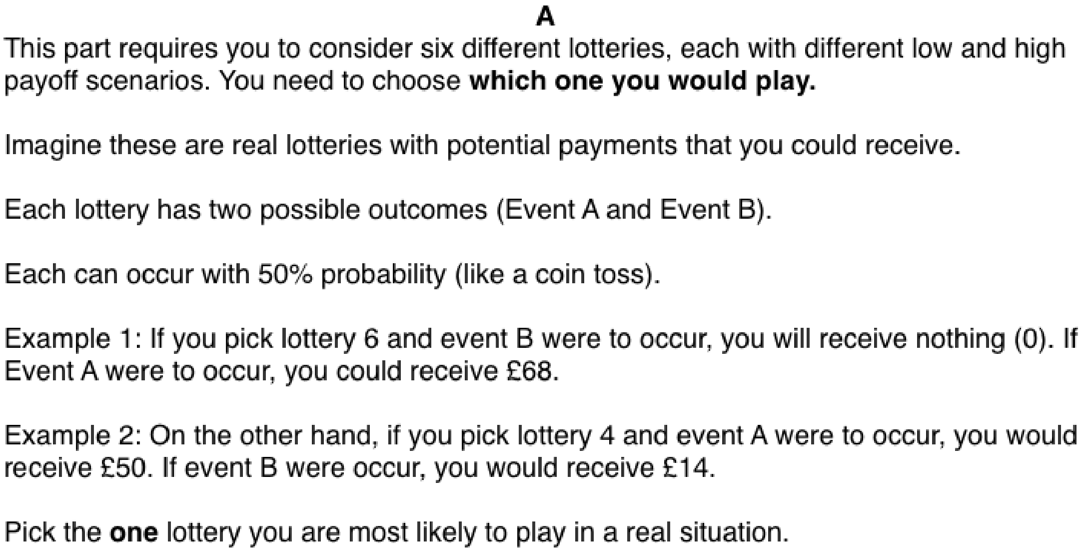
○ Lottery 1
○ Lottery 2
○ Lottery 3
○ Lottery 4
○ Lottery 5
○ Lottery 6

### Block 11

## Section E - Risk attitude

### Part 1

In this part of the survey, you will be asked to make decisions that will tell us something about your risk preferences.



**A**

This part requires you to consider six different lotteries, each with different low and high payoff scenarios. You need to choose **which one you would play.**

Imagine these are real lotteries with potential payments that you could receive.

Each lottery has two possible outcomes (Event A and Event B).

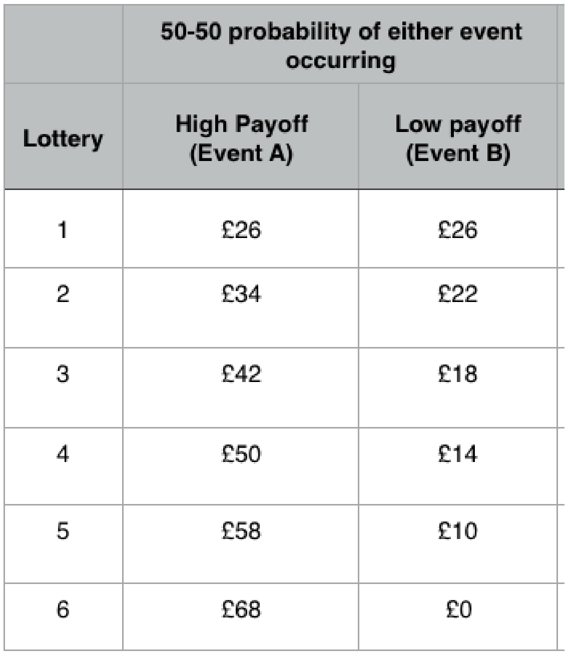
Each can occur with 50% probability (like a coin toss).

Example 1: If you pick lottery 6 and event B were to occur, you will receive nothing (0). If Event A were to occur, you could receive £68.

Example 2: On the other hand, if you pick lottery 4 and event A were to occur, you would receive £50. If event B were occur, you would receive £14.

Pick the **one** lottery you are most likely to play in a real situation.

○ Lottery 1
○ Lottery 2
○ Lottery 3
○ Lottery 4
○ Lottery 5
○ Lottery 6



| | 50-50 probability of either event occurring | |
|---|---|---|
| Lottery | High Payoff (Event A) | Low payoff (Event B) |
| 1 | £26 | £26 |
| 2 | £34 | £22 |
| 3 | £42 | £18 |
| 4 | £50 | £14 |
| 5 | £58 | £10 |
| 6 | £68 | £0 |

B. This time using the same six lotteries, **which lottery do you think people around/close to you would pick?**

○ Lottery 1
○ Lottery 2
○ Lottery 3
○ Lottery 4
○ Lottery 5
○ Lottery 6

## Block 12

## Part 2

Are you in general a person who takes risk or do you avoid risks? Please **self-grade** your choices.

Finance

| | **Not at all** prepared to take a **risk** 1 | 2 | 3 | **Indifferent** to **risk** 4 | 5 | 6 | **Very willing** to take **risk** 7 |
|---|---|---|---|---|---|---|---|
| **Your attitude** towards your **own finance** | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Career

| | **Not at all** prepared to take a **risk** 1 | 2 | 3 | **Indifferent** to **risk** 4 | 5 | 6 | **Very willing** to take **risk** **7** |
|---|---|---|---|---|---|---|---|
| Your attitude towards **your career** | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Health

| | **Not at all** prepared to take a **risk** 1 | 2 | 3 | **Indifferent** to **risk** 4 | 5 | 6 | **Very willing** to take **risk** **7** |
|---|---|---|---|---|---|---|---|
| **Your attitude** towards your **own health** | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Education

| | **Not at all** prepared to take a **risk** 1 | 2 | 3 | **Indifferent** to **risk** 4 | 5 | 6 | **Very willing** to take **risk** **7** |
|---|---|---|---|---|---|---|---|
| **Your attitude** towards your **education** | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## Section E

**That's it! A few questions about your household and you are done!**

1. What is the size of your household (including children)?

2. How many children under-18 currently reside in your household?

3. What is your current employment status? Pick all that apply.

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ Unemployed
- ☐ Student
- ☐ Home-maker
- ☐ Self-employed
- ☐ I do not wish to say
- ☐ Other, please specify

4. How would you describe your current place of residence?

- ○ Predominantly rural
- ○ Predominantly urban
- ○ Urban with significant rural

5. Has your **expected future household income** been affected due to the current restrictions caused by the Covid-19 **pandemic**?

- ○ Yes
- ○ No

**Thank you for your valuable contribution to the research study!**

Should you require further information on the experiment, please contact the investigator Maria Rodrigues (*maria.rodrigues@glasgow.ac.uk*). Should you wish to pursue any complaints concerning this experiment, please contact the College of MVLS Ethics Committee, University of Glasgow.

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BVDinfo

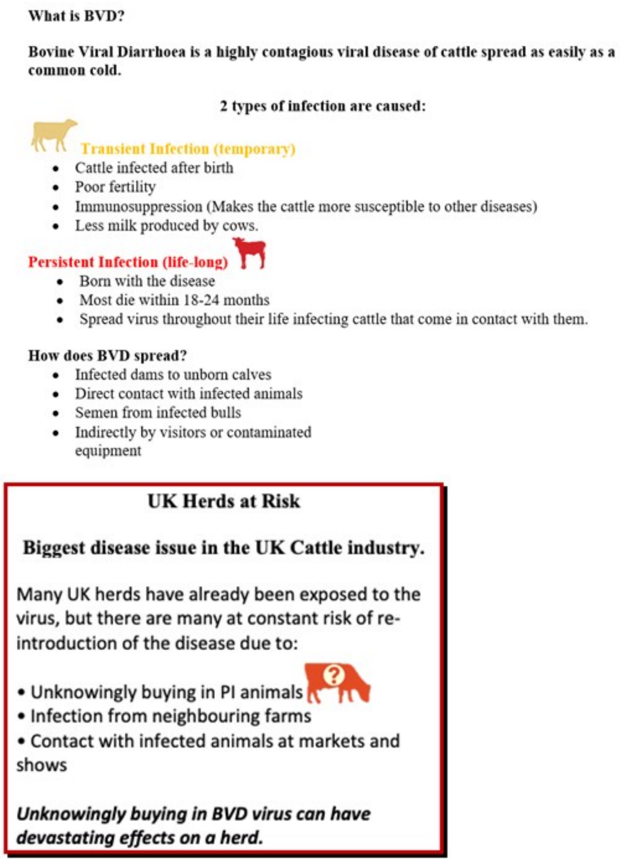
**Section C**

In this section you will be asked to make buying decisions. You will be shown two products. 1 from cattle and 1 from sheep.

•The cattle product may or may not come from a herd that has BVD (Bovine Viral Disease)- a viral disease (description below).
•Similarly, the sheep product may or maynot come from a flock infected by lameness.

Before we start with the choice experiments, I would like to briefly describe BVD in Cattle- a viral disease.

This disease undermines farm animal health and welfare.



**What is BVD?**

**Bovine Viral Diarrhoea is a highly contagious viral disease of cattle spread as easily as a common cold.**

**2 types of infection are caused:**

**Transient Infection (temporary)**
- Cattle infected after birth
- Poor fertility
- Immunosuppression (Makes the cattle more susceptible to other diseases)
- Less milk produced by cows.

**Persistent Infection (life-long)**
- Born with the disease
- Most die within 18-24 months
- Spread virus throughout their life infecting cattle that come in contact with them.

**How does BVD spread?**
- Infected dams to unborn calves
- Direct contact with infected animals
- Semen from infected bulls
- Indirectly by visitors or contaminated equipment

**UK Herds at Risk**

**Biggest disease issue in the UK Cattle industry.**

Many UK herds have already been exposed to the virus, but there are many at constant risk of re-introduction of the disease due to:

- Unknowingly buying in PI animals
- Infection from neighbouring farms
- Contact with infected animals at markets and shows

***Unknowingly buying in BVD virus can have devastating effects on a herd.***

https://bvdfree.org.uk/the-disease/

Back Next

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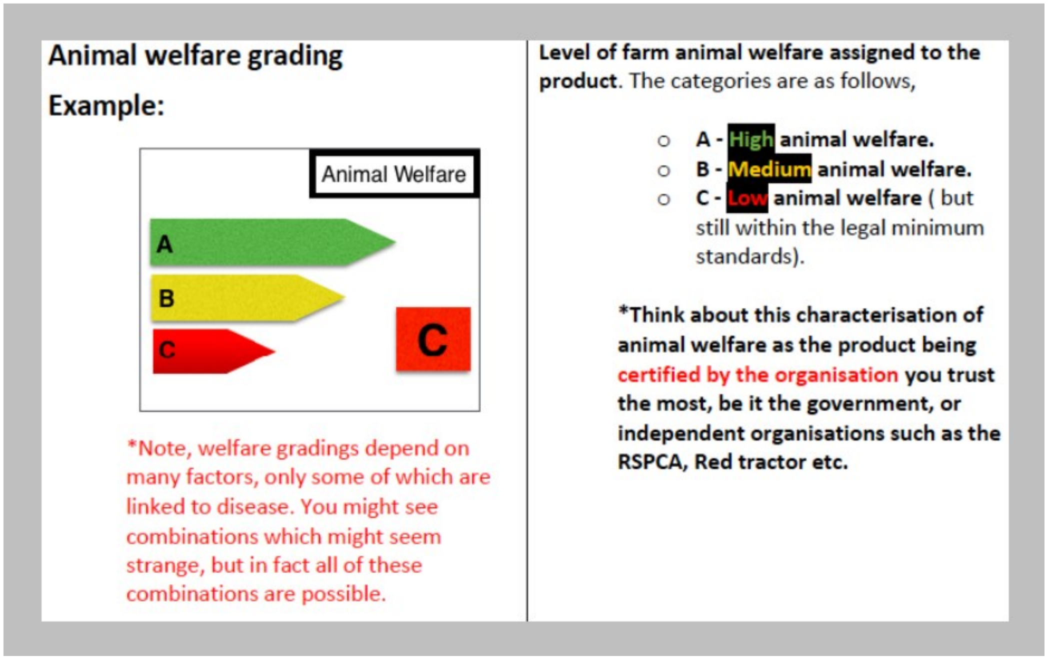
IntroATT

**Please read the following before starting:**
As consumers we purchase animal products at supermarkets, butcher shops or at independent stores. **In this part of the survey, <u>you will see with 6 choice scenarios with 3 options each.</u>** Every choice scenario looks at a real life situation where you are asked to make purchasing decisions. Consider only the information provided in the choice scenario and treat each scenario separately.

If you think the alternatives are too expensive or if you do not normally buy these items, you should choose the **'I will buy neither'** option.

Each of the options feature *<u>some combination of the following 4 characteristics</u>* :

1.



**Animal welfare grading**

**Example:**

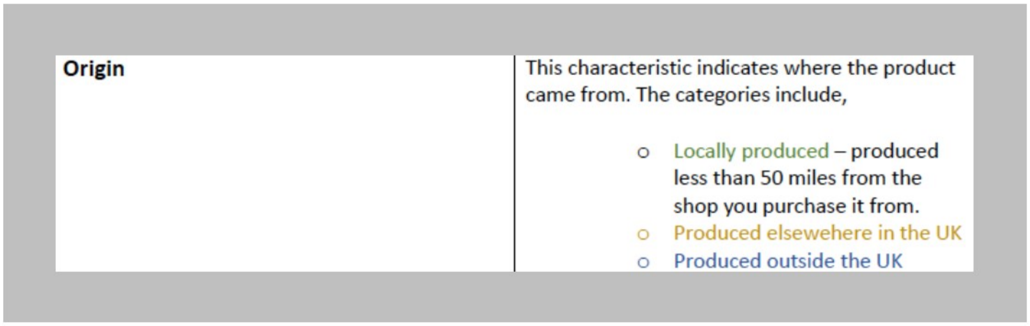
*Note, welfare gradings depend on many factors, only some of which are linked to disease. You might see combinations which might seem strange, but in fact all of these combinations are possible.

**Level of farm animal welfare assigned to the product**. The categories are as follows,

- **A - High animal welfare.**
- **B - Medium animal welfare.**
- **C - Low animal welfare** ( but still within the legal minimum standards).

***Think about this characterisation of animal welfare as the product being certified by the organisation you trust the most, be it the government, or independent organisations such as the RSPCA, Red tractor etc.**

2.

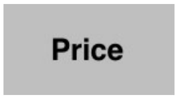


**Origin**

This characteristic indicates where the product came from. The categories include,

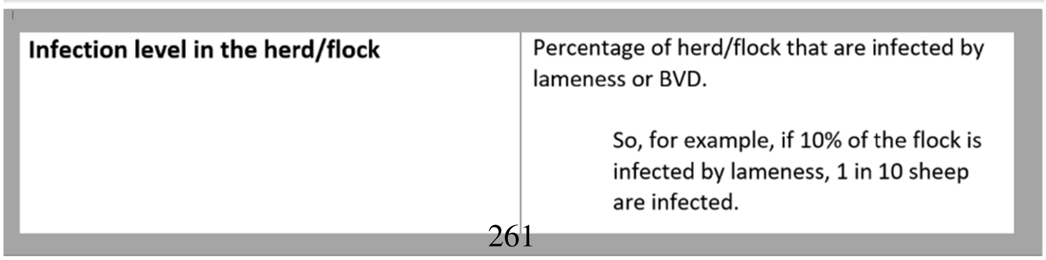
- Locally produced – produced less than 50 miles from the shop you purchase it from.
- Produced elsewhere in the UK
- Produced outside the UK

3.



**Price**

4.



**Infection level in the herd/flock**

Percentage of herd/flock that are infected by lameness or BVD.

So, for example, if 10% of the flock is infected by lameness, 1 in 10 sheep are infected.

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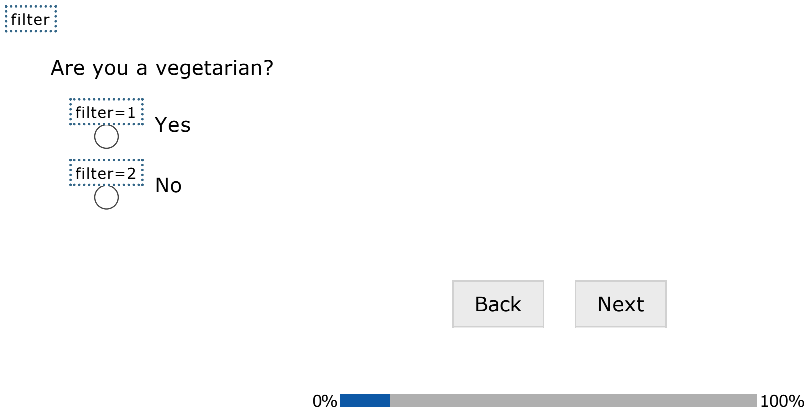
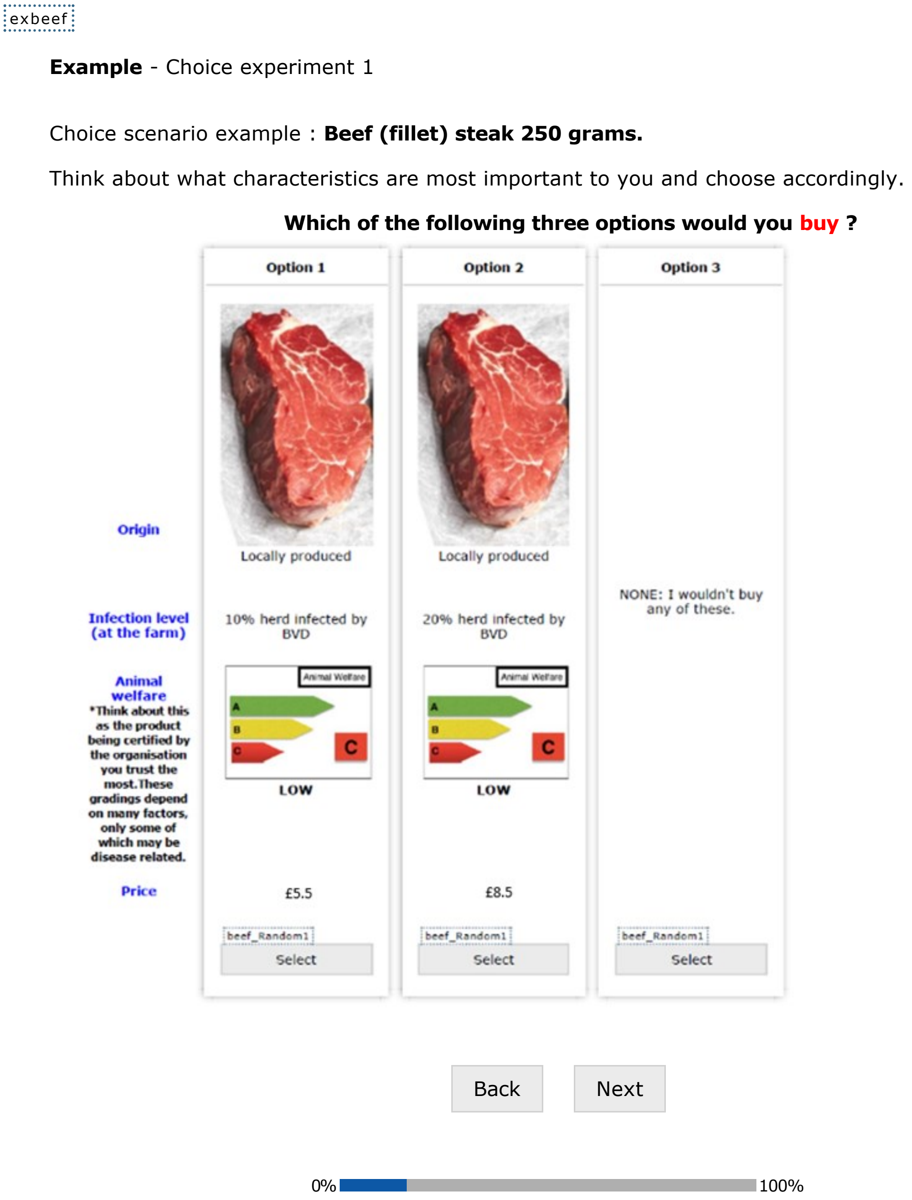


filter

Are you a vegetarian?

filter=1 ○ Yes

filter=2 ○ No



exbeef

**Example** - Choice experiment 1

Choice scenario example : **Beef (fillet) steak 250 grams.**

Think about what characteristics are most important to you and choose accordingly.

**Which of the following three options would you buy ?**

| | **Option 1** | **Option 2** | **Option 3** |
|---|---|---|---|
| **Origin** | Locally produced | Locally produced | NONE: I wouldn't buy any of these. |
| **Infection level (at the farm)** | 10% herd infected by BVD | 20% herd infected by BVD | |
| **Animal welfare** *Think about this as the product being certified by the organisation you trust the most. These gradings depend on many factors, only some of which may be disease related. | C<br>LOW | C<br>LOW | |
| **Price** | £5.5 | £8.5 | |

beef_Random1

Which of the following three options of **Beef (fillet) steak (250 grams approx. 1 steak)** would you buy ?

(1 of 6)

| | **Option 1** | **Option 2** | **Option 3** |
|---|---|---|---|
| **Origin** | Locally produced | Locally produced | NONE: I wouldn't buy any of these. |
| **Infection level (at the farm)** | 10% of the herd infected by BVD | 20% of the herd infected by BVD | |
| **Animal welfare**<br>***Think about this as the product being certified by the organisation you trust the most.These gradings depend on many factors, only some of which may be disease related.** | **LOW** | **LOW** | |
| **Price** | £8.5 | £5.5 | |
| | beef_Random1<br>Select | beef_Random1<br>Select | beef_Random1<br>Select |

thankyoubeef

Thank you. Next, You will see a few follow-up questions.

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Intromilk

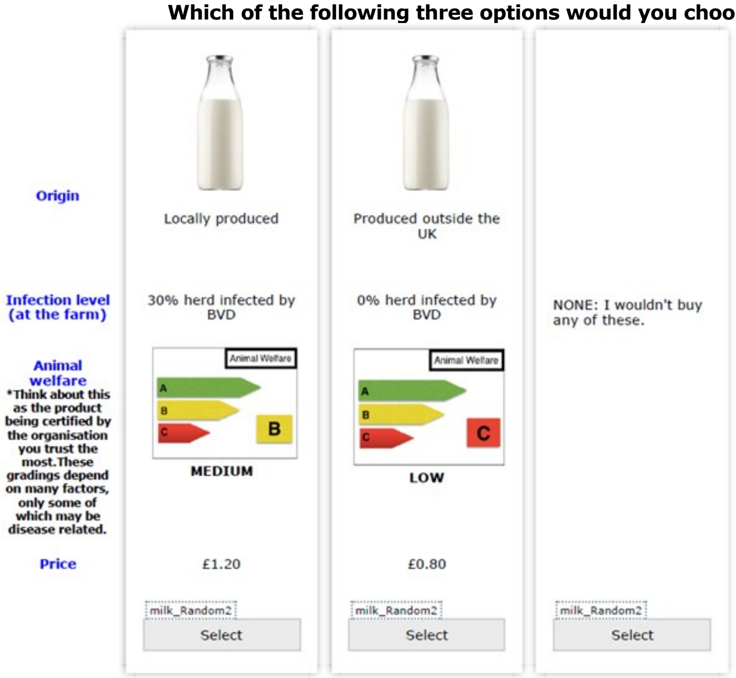
Click NEXT to start the choice experiment.

vegexample1

Example - Choice experiment 1

Choice scenario example : **MILK 1 litre.**

Think about what characteristics are most important to you and choose accordingly.



**Which of the following three options would you choose ?**

| | | | |
|---|---|---|---|
| **Origin** | Locally produced | Produced outside the UK | |
| **Infection level (at the farm)** | 30% herd infected by BVD | 0% herd infected by BVD | NONE: I wouldn't buy any of these. |
| **Animal welfare**<br>*Think about this as the product being certified by the organisation you trust the most. These gradings depend on many factors, only some of which may be disease related. | Animal Welfare<br>A<br>B<br>C<br>B<br>**MEDIUM** | Animal Welfare<br>A<br>B<br>C<br>C<br>**LOW** | |
| **Price** | £1.20 | £0.80 | |
| | milk_Random2<br>Select | milk_Random2<br>Select | milk_Random2<br>Select |

Back Next

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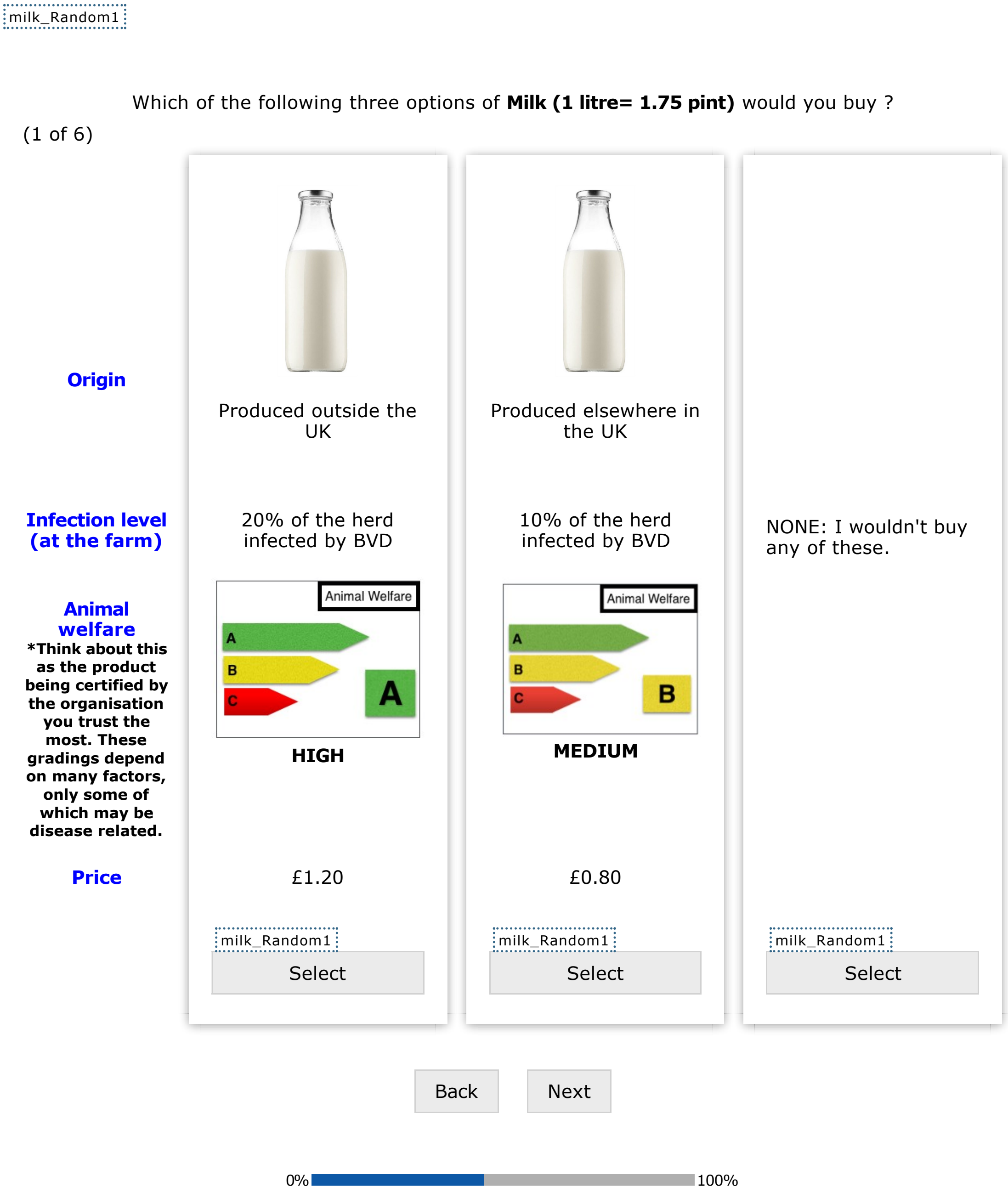

milk_Random1

Which of the following three options of **Milk (1 litre= 1.75 pint)** would you buy ?

(1 of 6)

| | | | |
|---|---|---|---|
| **Origin** | Produced outside the UK | Produced elsewhere in the UK | |
| **Infection level (at the farm)** | 20% of the herd infected by BVD | 10% of the herd infected by BVD | NONE: I wouldn't buy any of these. |
| **Animal welfare**<br>***Think about this as the product being certified by the organisation you trust the most. These gradings depend on many factors, only some of which may be disease related.** | **HIGH** | **MEDIUM** | |
| **Price** | £1.20 | £0.80 | |

followupcattle

Now, I would like to ask you a few questions about your decisions in the choice scenarios you have just answered.

1. How certain were you of your choices in these scenarios?

| Completely Uncertain 1 | 2 | 3 | Neither Certain nor Uncertain | 5 | 6 | Co |
|---|---|---|---|---|---|---|
| followupcattle_r1=1<br>○ | followupcattle_r1=2<br>○ | followupcattle_r1=3<br>○ | followupcattle_r1=4<br>○ | followupcattle_r1=5<br>○ | followupcattle_r1=6<br>○ | follow |

debrief

2. On a scale from 1 (strongly disagree) to 7 (strongly agree ), how much do you agree or disagree with the following statements?

| | Strongly Disagree | Disagree | Somewhat Disagree | Neither agree nor Disagree | Somewhat Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|
| Even if a herd of cattle has high levels of BVD, this has no effect on the safety or quality of the products produced from that herd | debrief_r1=1<br>○ | debrief_r1=2<br>○ | debrief_r1=3<br>○ | debrief_r1=4<br>○ | debrief_r1=5<br>○ | debrief_r1=6<br>○ | debrief_r1=7<br>○ |

buyneither1

3. If you have chosen ‵‵ I will buy neither'' in **all** the choice scenarios presented to you, please explain why you did so?

buyneither1=1 ○ I do not consume these products

buyneither1=2 ○ None of the most important features I care about were included in these scenarios.

buyneither1=3 ○ buyneither1_3_other Other, please specify ☐

rank1

4. Please rank the characteristics according to their importance to you. (1= most important, 4= least important)

rank1_1 ☐ Price

rank1_2 ☐ Animal welfare grading

rank1_3 ☐ Infection level

rank1_4 ☐ Origin

anyother1

5. Were there any product features that you care about the most that were not included in the choice experiment?

☐

Back Next

0% 100%

introlameness

Before we start with the choice experiment, I would like to briefly describe lameness in sheep.

This is a condition that undermines farm animal health and welfare.

# Lameness in sheep

Lameness is one of the most wide spread and persistent welfare problem in the UK sheep flock.

**It is a significant cause of discomfort and pain, as well as a major source of economic loss to the farmer and the sheep industry.**

There are many different causes of lameness in sheep ranging from infections to environmental conditions.

Footrot alone has been estimated to cost the UK sheep industry **£24 million a year.**

Source: https://beefandlamb.ahdb.org.uk/wp-content/uploads/2016/03/BRP-Reducing-lameness-manual-7-080316.pdf , farmhealthonline.com

Source:

https://www.nadis.org.uk/disease-a-z/sheep/lameness-control-in-sheep/

Back Next

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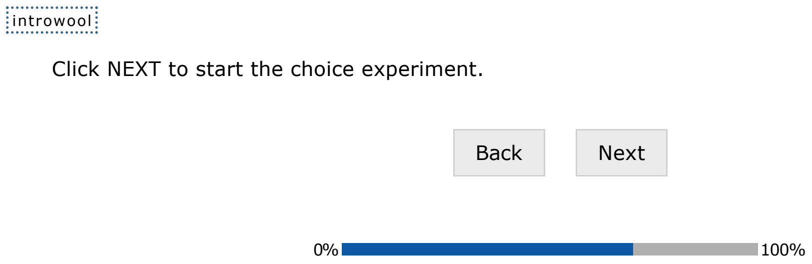
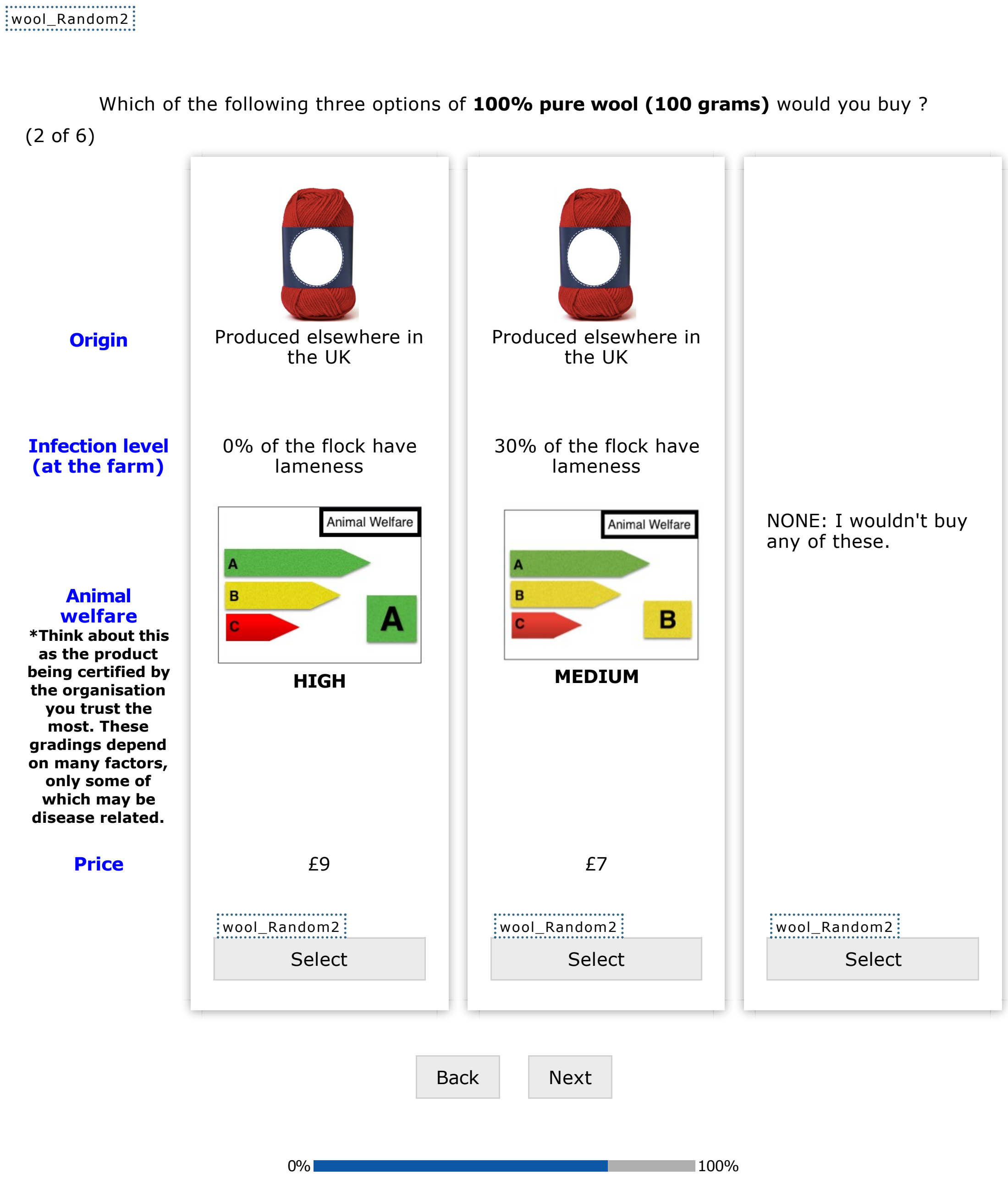


Click NEXT to start the choice experiment.

Which of the following three options of **100% pure wool (100 grams)** would you buy ?
(1 of 6)

| | | | |
|---|---|---|---|
| **Origin** | Locally produced | Produced elsewhere in the UK | NONE: I wouldn't buy any of these. |
| **Infection level (at the farm)** | 0% of the flock have lameness | 30% of the flock have lameness | |
| **Animal welfare**<br>***Think about this as the product being certified by the organisation you trust the most. These gradings depend on many factors, only some of which may be disease related.** | **LOW** | **LOW** | |
| **Price** | £11 | £7 | |



Which of the following three options of **100% pure wool (100 grams)** would you buy ?
(2 of 6)

| | | | |
|---|---|---|---|
| **Origin** | Produced elsewhere in the UK | Produced elsewhere in the UK | |
| **Infection level (at the farm)** | 0% of the flock have lameness | 30% of the flock have lameness | |
| **Animal welfare** ***Think about this as the product being certified by the organisation you trust the most. These gradings depend on many factors, only some of which may be disease related.** | **HIGH** | **MEDIUM** | NONE: I wouldn't buy any of these. |
| **Price** | £9 | £7 | |

followupSHEEP

Now, I would like to ask you a few questions about your decisions in the choice scenarios you have just answered.

1. How certain were you of your choices in these scenarios?

| Completely Uncertain 1 | 2 | 3 | Neither Certain nor Uncertain | 5 | 6 | Com |
|---|---|---|---|---|---|---|
| followupSHEEP_r1=1<br>○ | followupSHEEP_r1=2<br>○ | followupSHEEP_r1=3<br>○ | followupSHEEP_r1=4<br>○ | followupSHEEP_r1=5<br>○ | followupSHEEP_r1=6<br>○ | follo |

debrief1

2. On a scale from 1 (strongly disagree) to 7 (strongly agree ), how much do you agree or disagree with the following statements?

| | Strongly Disagree | Disagree | Somewhat Disagree | Neither agree nor Disagree | Somewhat Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|
| Even if a flock of sheep has high levels of lameness, this has no effect on the safety or quality of the products produced from these sheep | debrief1_r1=1<br>○ | debrief1_r1=2<br>○ | debrief1_r1=3<br>○ | debrief1_r1=4<br>○ | debrief1_r1=5<br>○ | debrief1_r1=6<br>○ | debrief1_r1=7<br>○ |

buyneither3

3. If you have chosen '' I will buy neither'' in **all** the choice scenarios presented to you, please explain why you did so?

buyneither3=1 ○ I do not consume these products

buyneither3=2 ○ None of the most important features I care about were included in these scenarios.

buyneither3=3 ○ buyneither3_3_other Other, please specify ☐

rank3

4. Please rank the characteristics according to their importance to you. (1= most important, 4= least important)

rank3_1 ☐ Price

rank3_2 ☐ Animal welfare grading

rank3_3 ☐ Infection level

rank3_4 ☐ Origin

anyother3

5. Were there any product features that you care about the most that were not included in the choice experiment?

☐

Back Next

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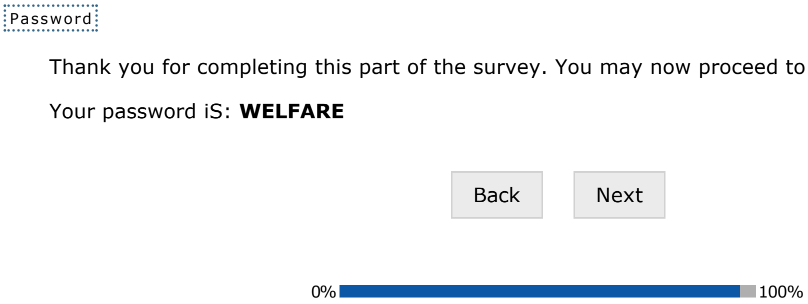

Password

Thank you for completing this part of the survey. You may now proceed to Section D.

Your password iS: **WELFARE**

thankyou

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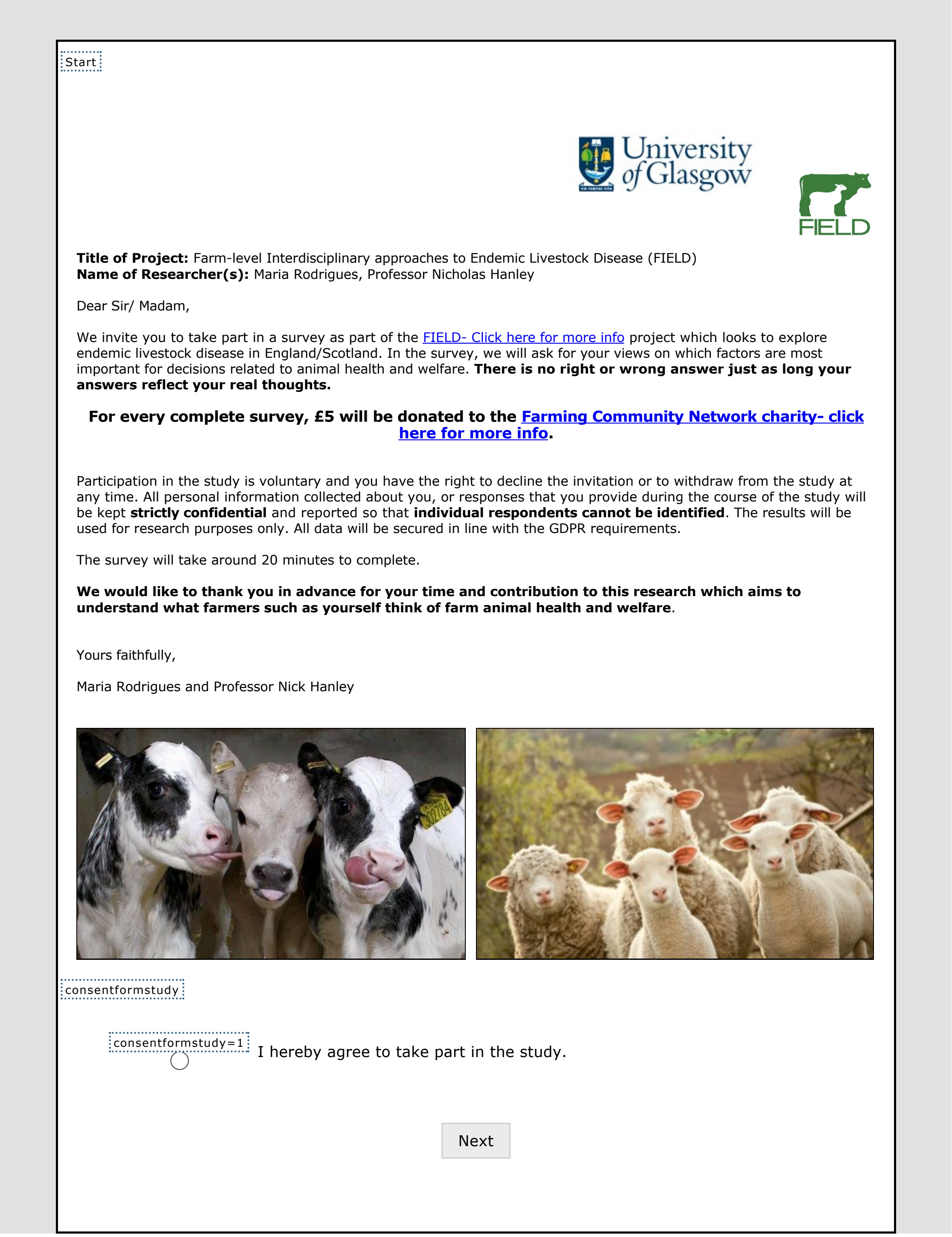
## Farmer Survey (Chapters 6 & 7)



Start

**Title of Project:** Farm-level Interdisciplinary approaches to Endemic Livestock Disease (FIELD)
**Name of Researcher(s):** Maria Rodrigues, Professor Nicholas Hanley

Dear Sir/ Madam,

We invite you to take part in a survey as part of the FIELD- Click here for more info project which looks to explore endemic livestock disease in England/Scotland. In the survey, we will ask for your views on which factors are most important for decisions related to animal health and welfare. **There is no right or wrong answer just as long your answers reflect your real thoughts.**

**For every complete survey, £5 will be donated to the Farming Community Network charity- click here for more info.**

Participation in the study is voluntary and you have the right to decline the invitation or to withdraw from the study at any time. All personal information collected about you, or responses that you provide during the course of the study will be kept **strictly confidential** and reported so that **individual respondents cannot be identified**. The results will be used for research purposes only. All data will be secured in line with the GDPR requirements.

The survey will take around 20 minutes to complete.

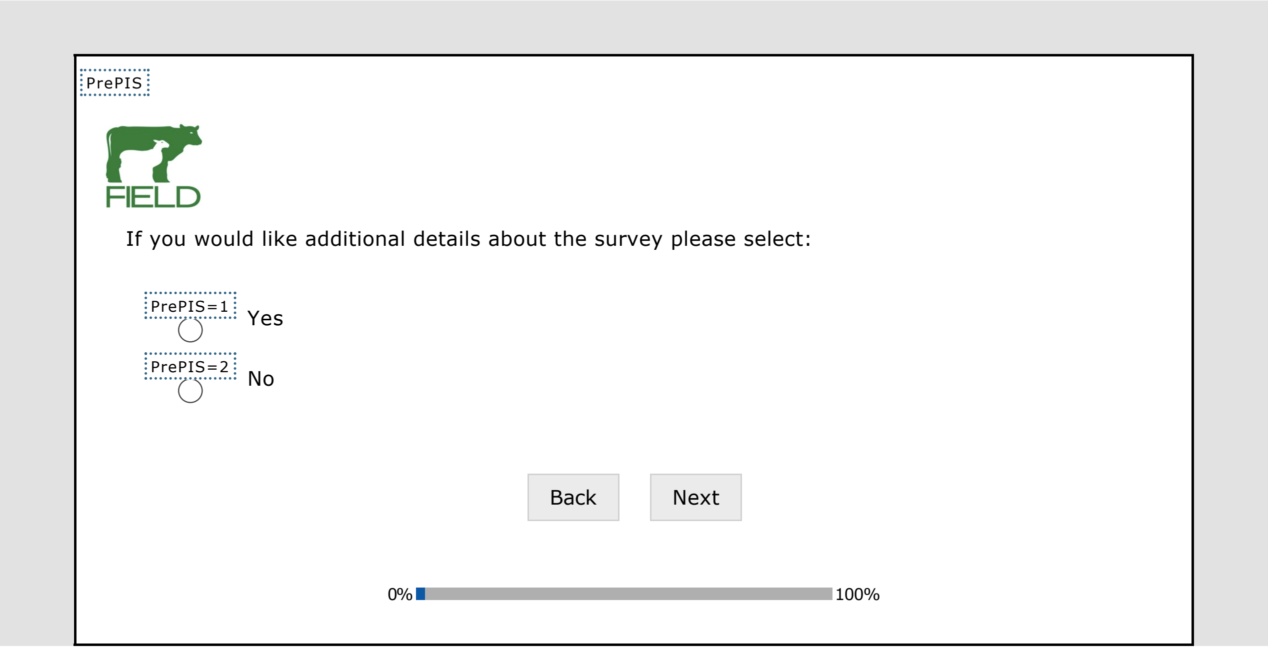
**We would like to thank you in advance for your time and contribution to this research which aims to understand what farmers such as yourself think of farm animal health and welfare**.

Yours faithfully,

Maria Rodrigues and Professor Nick Hanley

consentformstudy

consentformstudy=1
○ I hereby agree to take part in the study.

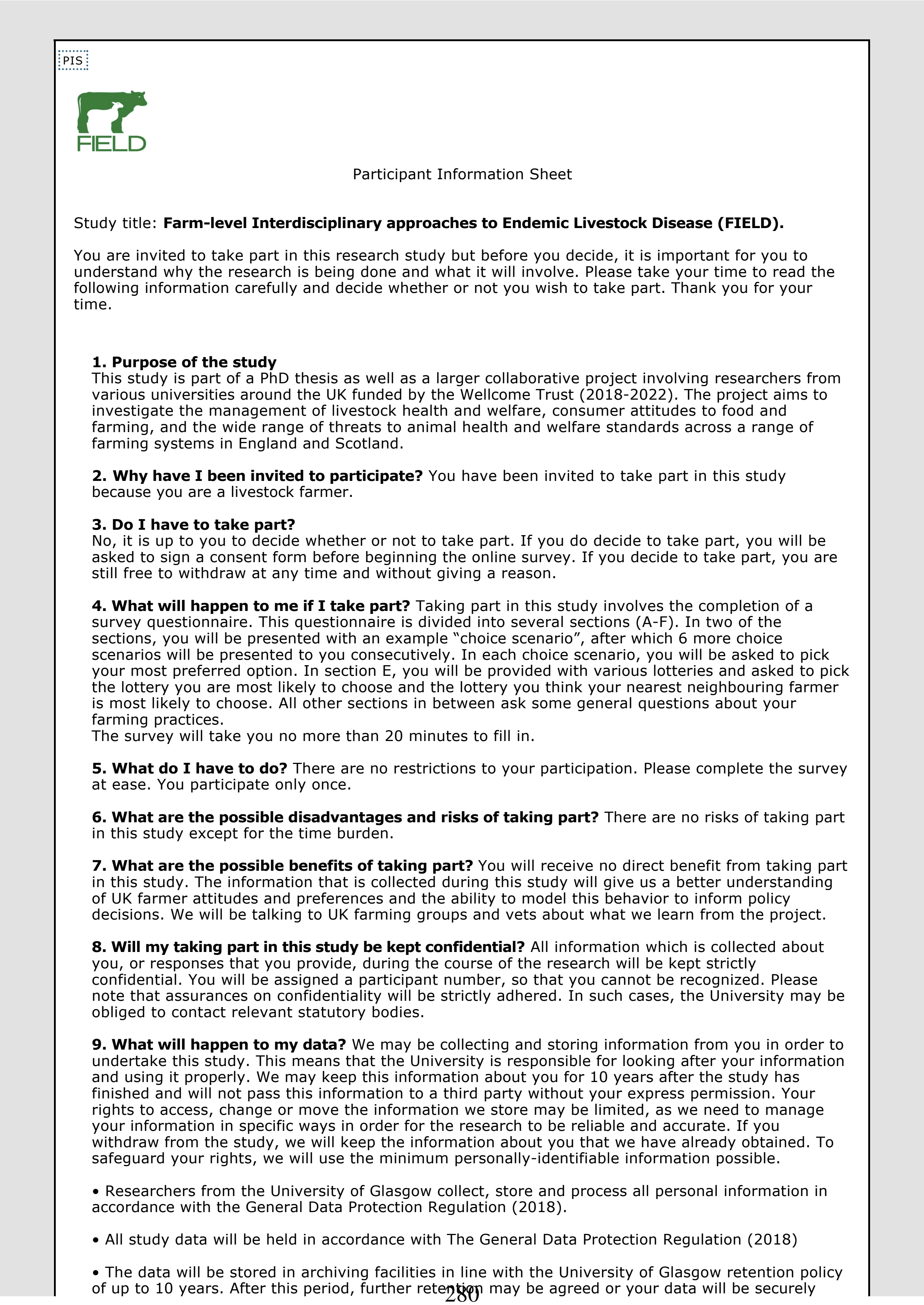


PrePIS

If you would like additional details about the survey please select:

PrePIS=1 ○ Yes

PrePIS=2 ○ No



PIS

FIELD

Participant Information Sheet

Study title: **Farm-level Interdisciplinary approaches to Endemic Livestock Disease (FIELD).**

You are invited to take part in this research study but before you decide, it is important for you to understand why the research is being done and what it will involve. Please take your time to read the following information carefully and decide whether or not you wish to take part. Thank you for your time.

**1. Purpose of the study**
This study is part of a PhD thesis as well as a larger collaborative project involving researchers from various universities around the UK funded by the Wellcome Trust (2018-2022). The project aims to investigate the management of livestock health and welfare, consumer attitudes to food and farming, and the wide range of threats to animal health and welfare standards across a range of farming systems in England and Scotland.

**2. Why have I been invited to participate?** You have been invited to take part in this study because you are a livestock farmer.

**3. Do I have to take part?**
No, it is up to you to decide whether or not to take part. If you do decide to take part, you will be asked to sign a consent form before beginning the online survey. If you decide to take part, you are still free to withdraw at any time and without giving a reason.

**4. What will happen to me if I take part?** Taking part in this study involves the completion of a survey questionnaire. This questionnaire is divided into several sections (A-F). In two of the sections, you will be presented with an example "choice scenario", after which 6 more choice scenarios will be presented to you consecutively. In each choice scenario, you will be asked to pick your most preferred option. In section E, you will be provided with various lotteries and asked to pick the lottery you are most likely to choose and the lottery you think your nearest neighbouring farmer is most likely to choose. All other sections in between ask some general questions about your farming practices.
The survey will take you no more than 20 minutes to fill in.

**5. What do I have to do?** There are no restrictions to your participation. Please complete the survey at ease. You participate only once.

**6. What are the possible disadvantages and risks of taking part?** There are no risks of taking part in this study except for the time burden.

**7. What are the possible benefits of taking part?** You will receive no direct benefit from taking part in this study. The information that is collected during this study will give us a better understanding of UK farmer attitudes and preferences and the ability to model this behavior to inform policy decisions. We will be talking to UK farming groups and vets about what we learn from the project.

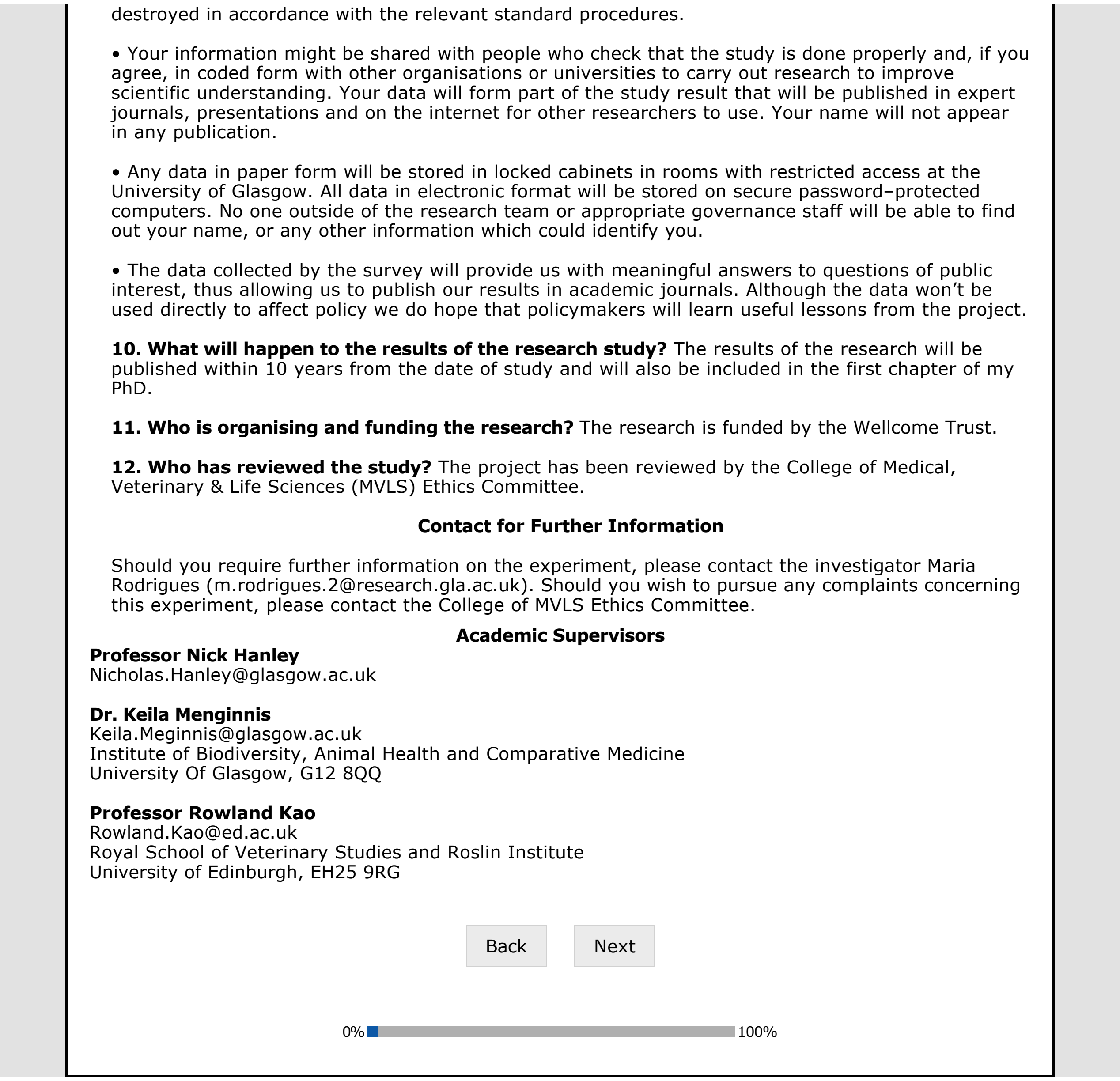
**8. Will my taking part in this study be kept confidential?** All information which is collected about you, or responses that you provide, during the course of the research will be kept strictly confidential. You will be assigned a participant number, so that you cannot be recognized. Please note that assurances on confidentiality will be strictly adhered. In such cases, the University may be obliged to contact relevant statutory bodies.

**9. What will happen to my data?** We may be collecting and storing information from you in order to undertake this study. This means that the University is responsible for looking after your information and using it properly. We may keep this information about you for 10 years after the study has finished and will not pass this information to a third party without your express permission. Your rights to access, change or move the information we store may be limited, as we need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally-identifiable information possible.

- Researchers from the University of Glasgow collect, store and process all personal information in accordance with the General Data Protection Regulation (2018).

- All study data will be held in accordance with The General Data Protection Regulation (2018)

- The data will be stored in archiving facilities in line with the University of Glasgow retention policy of up to 10 years. After this period, further retention may be agreed or your data will be securely



destroyed in accordance with the relevant standard procedures.

• Your information might be shared with people who check that the study is done properly and, if you agree, in coded form with other organisations or universities to carry out research to improve scientific understanding. Your data will form part of the study result that will be published in expert journals, presentations and on the internet for other researchers to use. Your name will not appear in any publication.

• Any data in paper form will be stored in locked cabinets in rooms with restricted access at the University of Glasgow. All data in electronic format will be stored on secure password–protected computers. No one outside of the research team or appropriate governance staff will be able to find out your name, or any other information which could identify you.

• The data collected by the survey will provide us with meaningful answers to questions of public interest, thus allowing us to publish our results in academic journals. Although the data won't be used directly to affect policy we do hope that policymakers will learn useful lessons from the project.

**10. What will happen to the results of the research study?** The results of the research will be published within 10 years from the date of study and will also be included in the first chapter of my PhD.

**11. Who is organising and funding the research?** The research is funded by the Wellcome Trust.

**12. Who has reviewed the study?** The project has been reviewed by the College of Medical, Veterinary & Life Sciences (MVLS) Ethics Committee.

**Contact for Further Information**

Should you require further information on the experiment, please contact the investigator Maria Rodrigues (m.rodrigues.2@research.gla.ac.uk). Should you wish to pursue any complaints concerning this experiment, please contact the College of MVLS Ethics Committee.

**Academic Supervisors**

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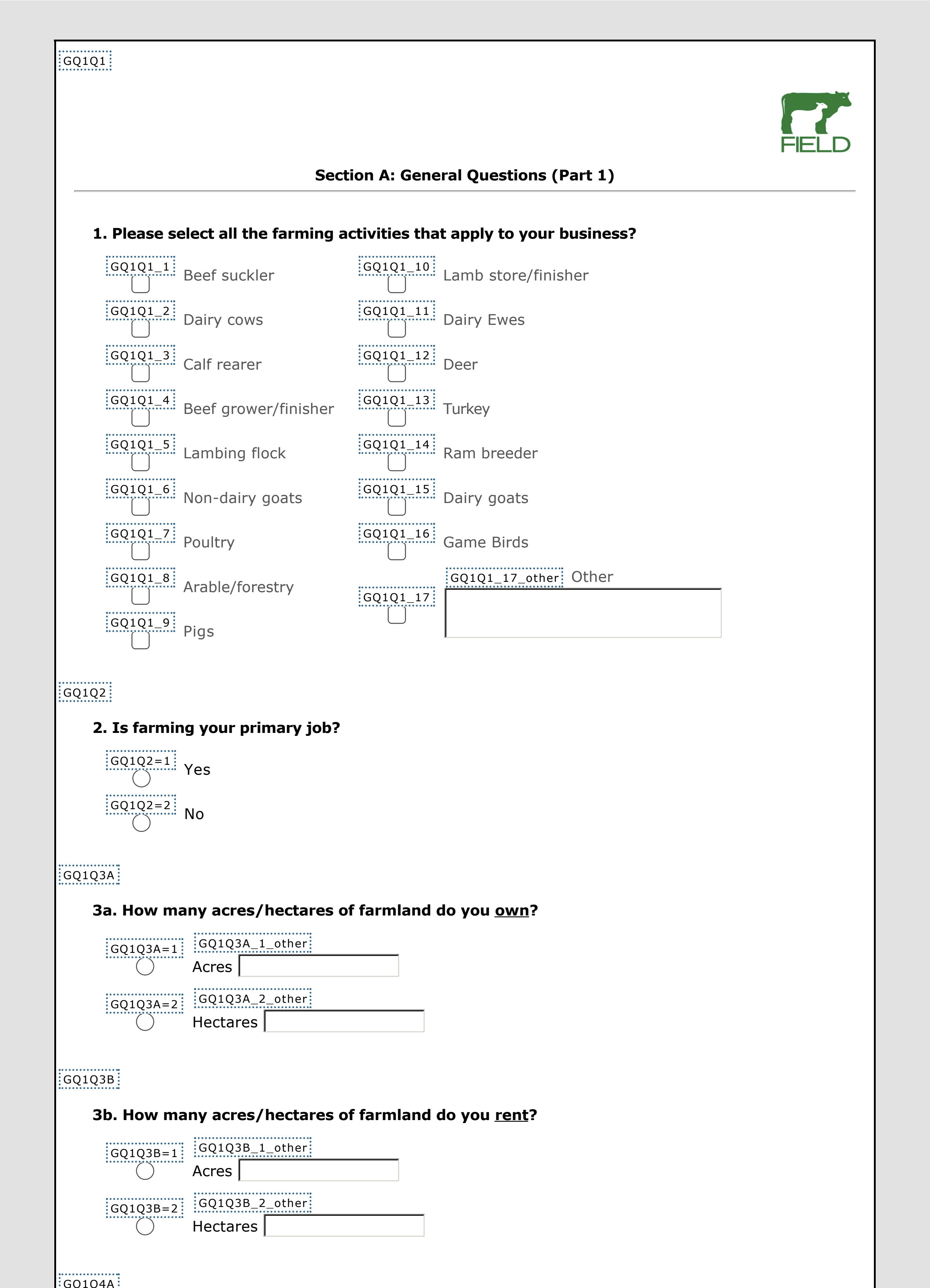
Royal School of Veterinary Studies and Roslin Institute
University of Edinburgh, EH25 9RG



GQ1Q1

### Section A: General Questions (Part 1)

**1. Please select all the farming activities that apply to your business?**

GQ1Q1_1 ☐ Beef suckler
GQ1Q1_2 ☐ Dairy cows
GQ1Q1_3 ☐ Calf rearer
GQ1Q1_4 ☐ Beef grower/finisher
GQ1Q1_5 ☐ Lambing flock
GQ1Q1_6 ☐ Non-dairy goats
GQ1Q1_7 ☐ Poultry
GQ1Q1_8 ☐ Arable/forestry
GQ1Q1_9 ☐ Pigs
GQ1Q1_10 ☐ Lamb store/finisher
GQ1Q1_11 ☐ Dairy Ewes
GQ1Q1_12 ☐ Deer
GQ1Q1_13 ☐ Turkey
GQ1Q1_14 ☐ Ram breeder
GQ1Q1_15 ☐ Dairy goats
GQ1Q1_16 ☐ Game Birds
GQ1Q1_17 ☐ GQ1Q1_17_other Other

GQ1Q2

**2. Is farming your primary job?**

GQ1Q2=1 ○ Yes
GQ1Q2=2 ○ No

GQ1Q3A

**3a. How many acres/hectares of farmland do you <u>own</u>?**

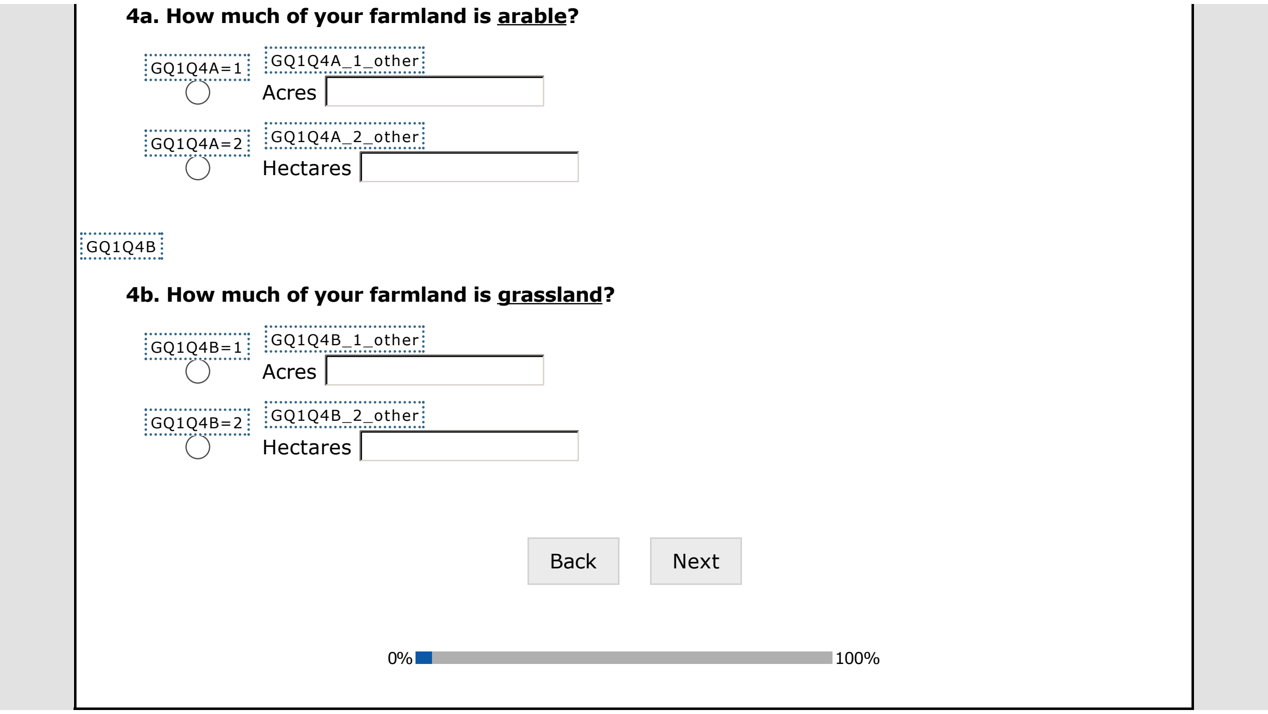
GQ1Q3A=1 ○ GQ1Q3A_1_other Acres
GQ1Q3A=2 ○ GQ1Q3A_2_other Hectares

GQ1Q3B

**3b. How many acres/hectares of farmland do you <u>rent</u>?**

GQ1Q3B=1 ○ GQ1Q3B_1_other Acres
GQ1Q3B=2 ○ GQ1Q3B_2_other Hectares

GQ1Q4A



**4a. How much of your farmland is arable?**

GQ1Q4A=1 ○ GQ1Q4A_1_other Acres ☐

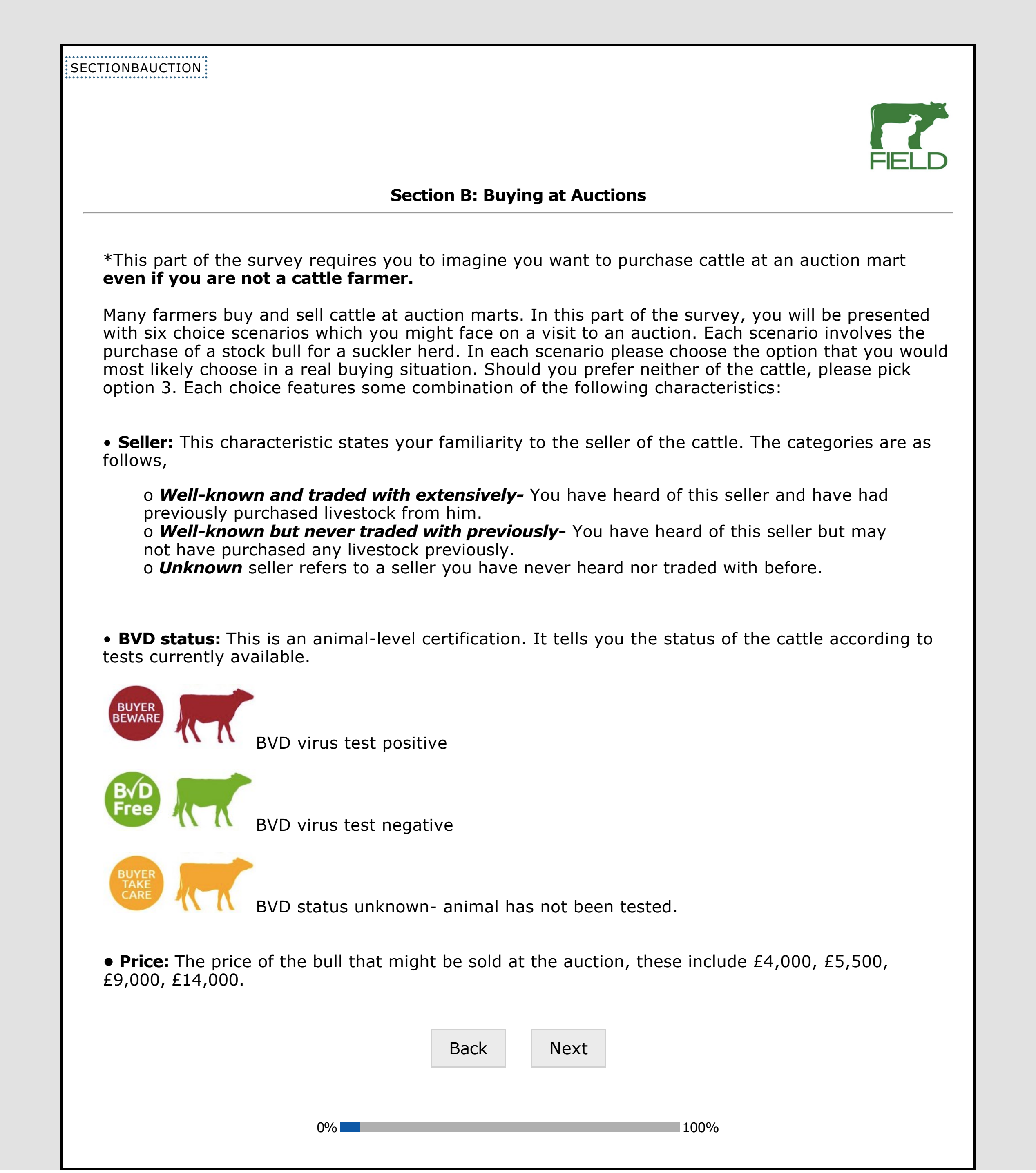
GQ1Q4A=2 ○ GQ1Q4A_2_other Hectares ☐

GQ1Q4B

**4b. How much of your farmland is grassland?**

GQ1Q4B=1 ○ GQ1Q4B_1_other Acres ☐

GQ1Q4B=2 ○ GQ1Q4B_2_other Hectares ☐



### Section B: Buying at Auctions

*This part of the survey requires you to imagine you want to purchase cattle at an auction mart **even if you are not a cattle farmer.**

Many farmers buy and sell cattle at auction marts. In this part of the survey, you will be presented with six choice scenarios which you might face on a visit to an auction. Each scenario involves the purchase of a stock bull for a suckler herd. In each scenario please choose the option that you would most likely choose in a real buying situation. Should you prefer neither of the cattle, please pick option 3. Each choice features some combination of the following characteristics:

- **Seller:** This characteristic states your familiarity to the seller of the cattle. The categories are as follows,
    - o ***Well-known and traded with extensively-*** You have heard of this seller and have had previously purchased livestock from him.
    - o ***Well-known but never traded with previously-*** You have heard of this seller but may not have purchased any livestock previously.
    - o ***Unknown*** seller refers to a seller you have never heard nor traded with before.

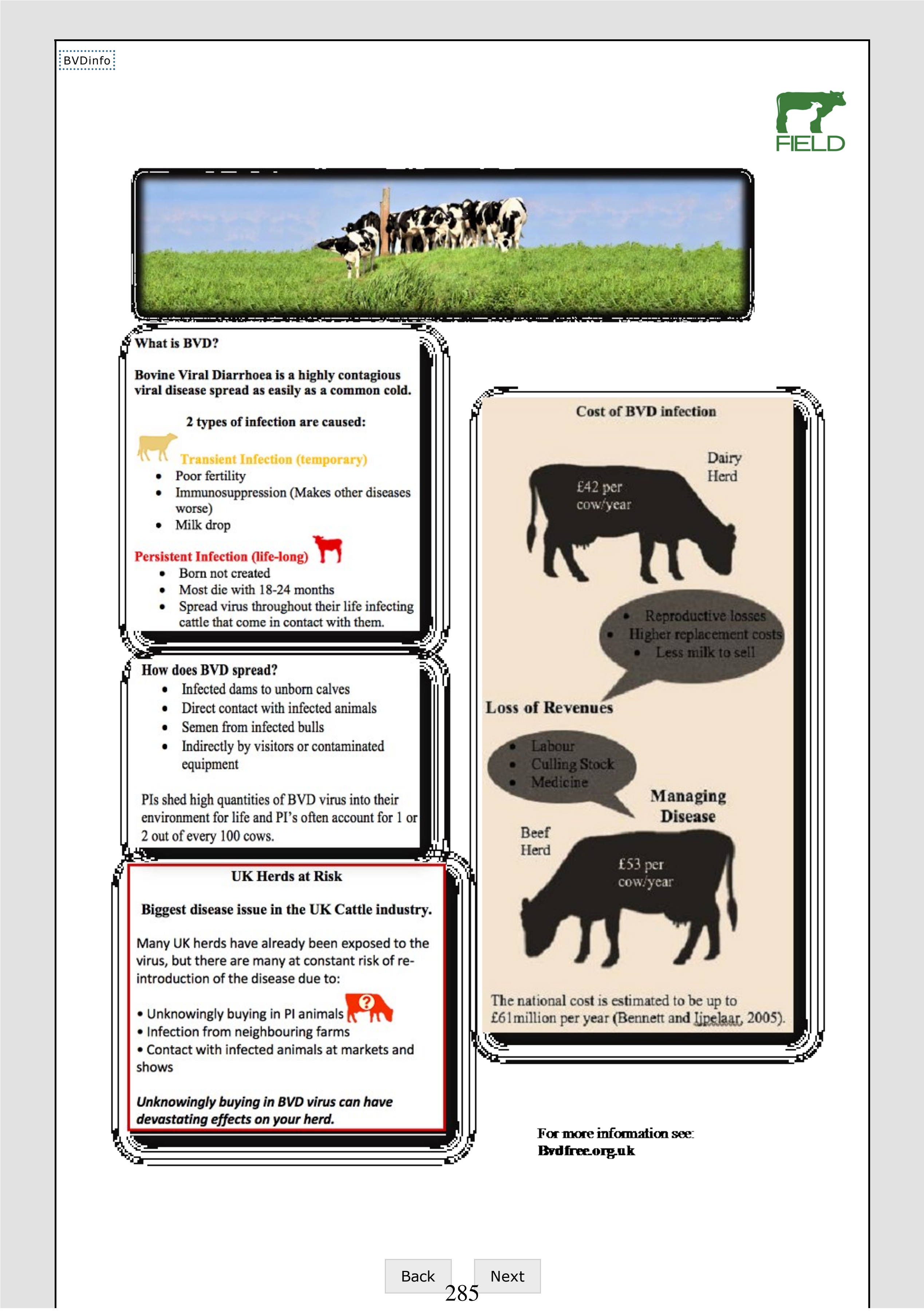
- **BVD status:** This is an animal-level certification. It tells you the status of the cattle according to tests currently available.

BVD virus test positive

BVD virus test negative

BVD status unknown- animal has not been tested.

- **Price:** The price of the bull that might be sold at the auction, these include £4,000, £5,500, £9,000, £14,000.



**What is BVD?**

**Bovine Viral Diarrhoea is a highly contagious viral disease spread as easily as a common cold.**

**2 types of infection are caused:**

**Transient Infection (temporary)**
- Poor fertility
- Immunosuppression (Makes other diseases worse)
- Milk drop

**Persistent Infection (life-long)**
- Born not created
- Most die with 18-24 months
- Spread virus throughout their life infecting cattle that come in contact with them.

**How does BVD spread?**
- Infected dams to unborn calves
- Direct contact with infected animals
- Semen from infected bulls
- Indirectly by visitors or contaminated equipment

PIs shed high quantities of BVD virus into their environment for life and PI's often account for 1 or 2 out of every 100 cows.

**UK Herds at Risk**

**Biggest disease issue in the UK Cattle industry.**

Many UK herds have already been exposed to the virus, but there are many at constant risk of re-introduction of the disease due to:

- Unknowingly buying in PI animals
- Infection from neighbouring farms
- Contact with infected animals at markets and shows

***Unknowingly buying in BVD virus can have devastating effects on your herd.***

**Cost of BVD infection**

Dairy Herd

£42 per cow/year

- Reproductive losses
- Higher replacement costs
- Less milk to sell

**Loss of Revenues**

- Labour
- Culling Stock
- Medicine

**Managing Disease**

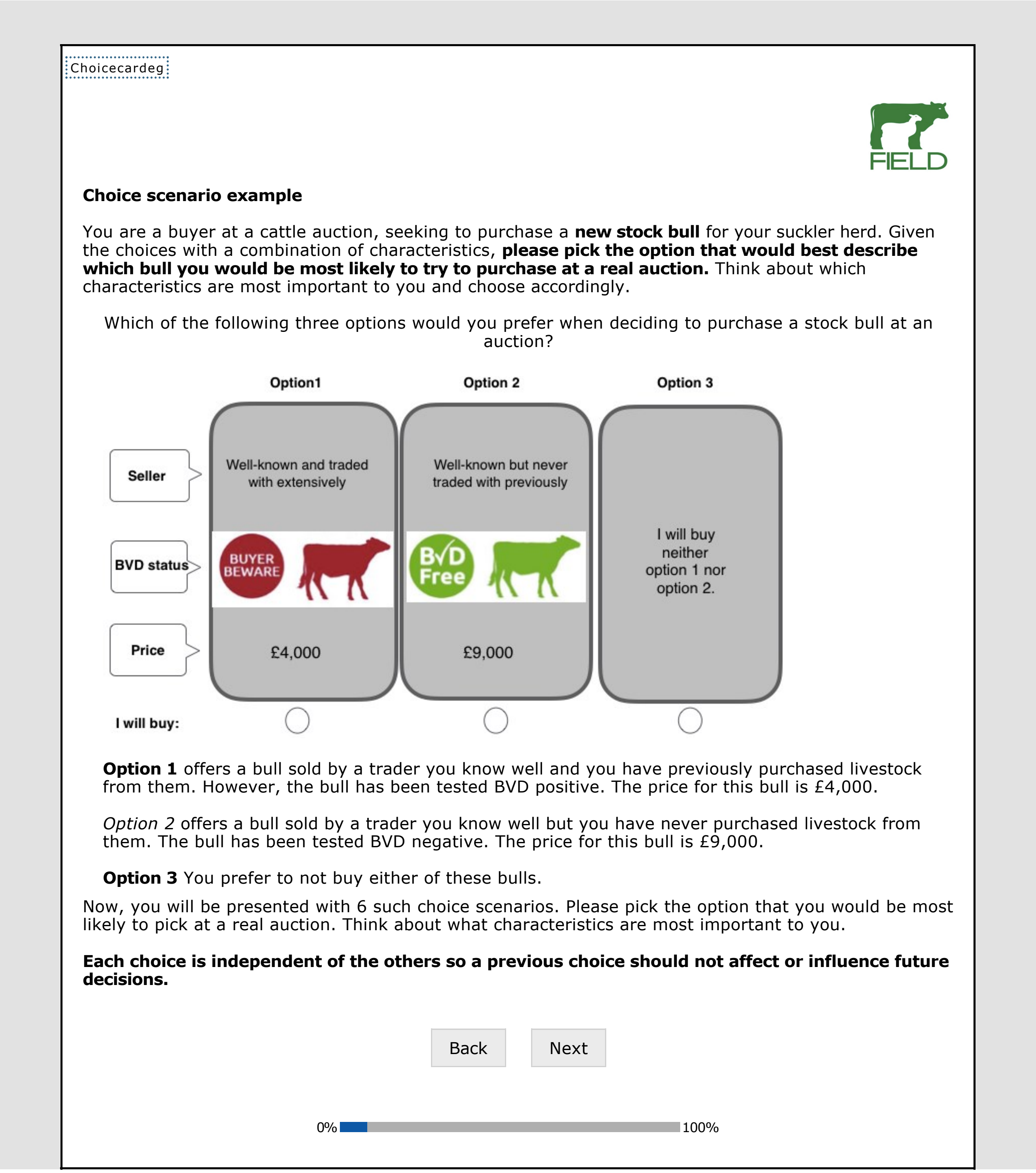
Beef Herd

£53 per cow/year

The national cost is estimated to be up to £61million per year (Bennett and Ijpelaar, 2005).

**For more information see:**
**Bvdfree.org.uk**

0% 100%



**Choice scenario example**

You are a buyer at a cattle auction, seeking to purchase a **new stock bull** for your suckler herd. Given the choices with a combination of characteristics, **please pick the option that would best describe which bull you would be most likely to try to purchase at a real auction.** Think about which characteristics are most important to you and choose accordingly.

Which of the following three options would you prefer when deciding to purchase a stock bull at an auction?

| | **Option1** | **Option 2** | **Option 3** |
|---|---|---|---|
| **Seller** | Well-known and traded with extensively | Well-known but never traded with previously | I will buy neither option 1 nor option 2. |
| **BVD status** | BUYER BEWARE | BVD Free | |
| **Price** | £4,000 | £9,000 | |
| **I will buy:** | ○ | ○ | ○ |

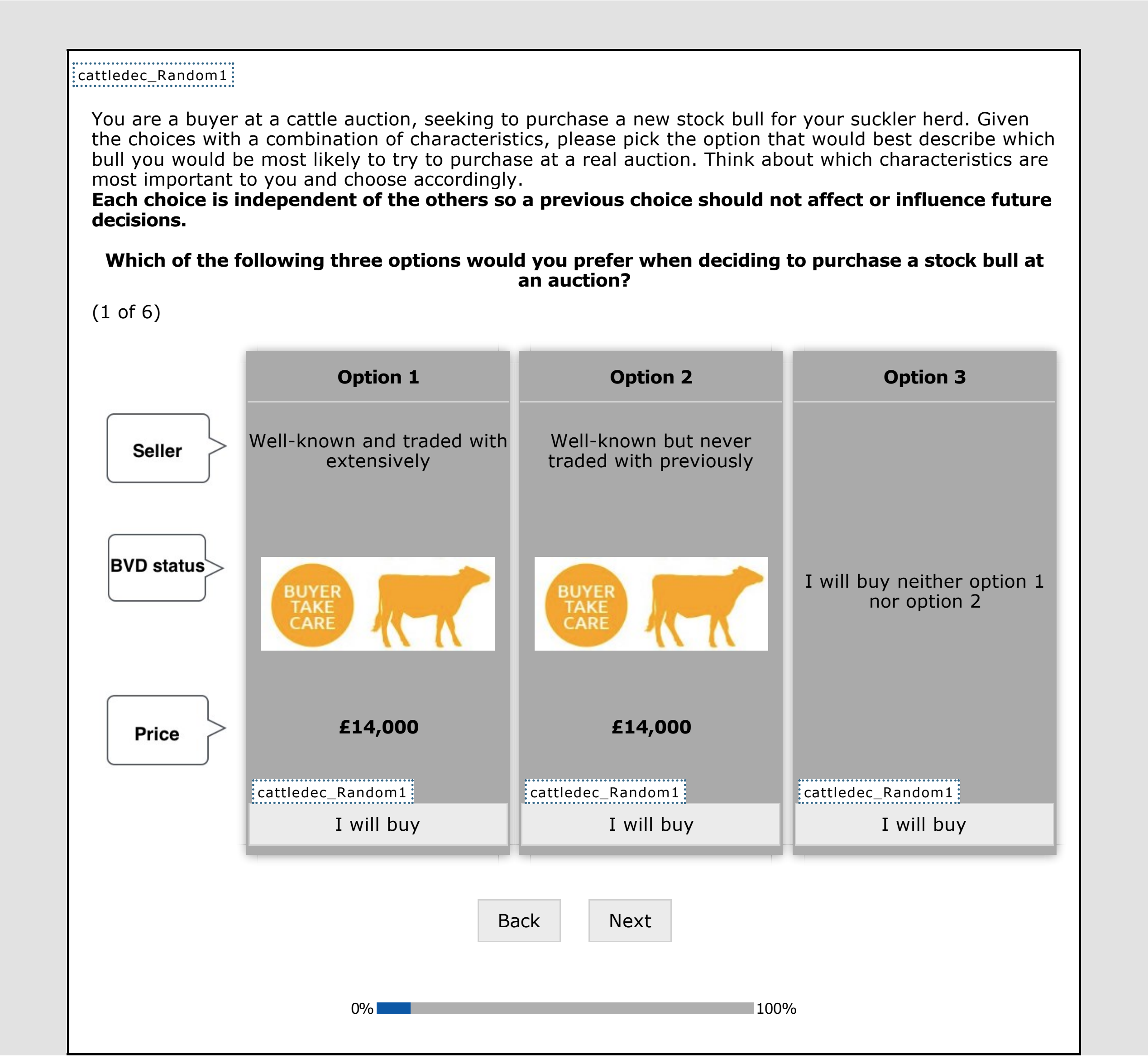
**Option 1** offers a bull sold by a trader you know well and you have previously purchased livestock from them. However, the bull has been tested BVD positive. The price for this bull is £4,000.

*Option 2* offers a bull sold by a trader you know well but you have never purchased livestock from them. The bull has been tested BVD negative. The price for this bull is £9,000.

**Option 3** You prefer to not buy either of these bulls.

Now, you will be presented with 6 such choice scenarios. Please pick the option that you would be most likely to pick at a real auction. Think about what characteristics are most important to you.

**Each choice is independent of the others so a previous choice should not affect or influence future decisions.**

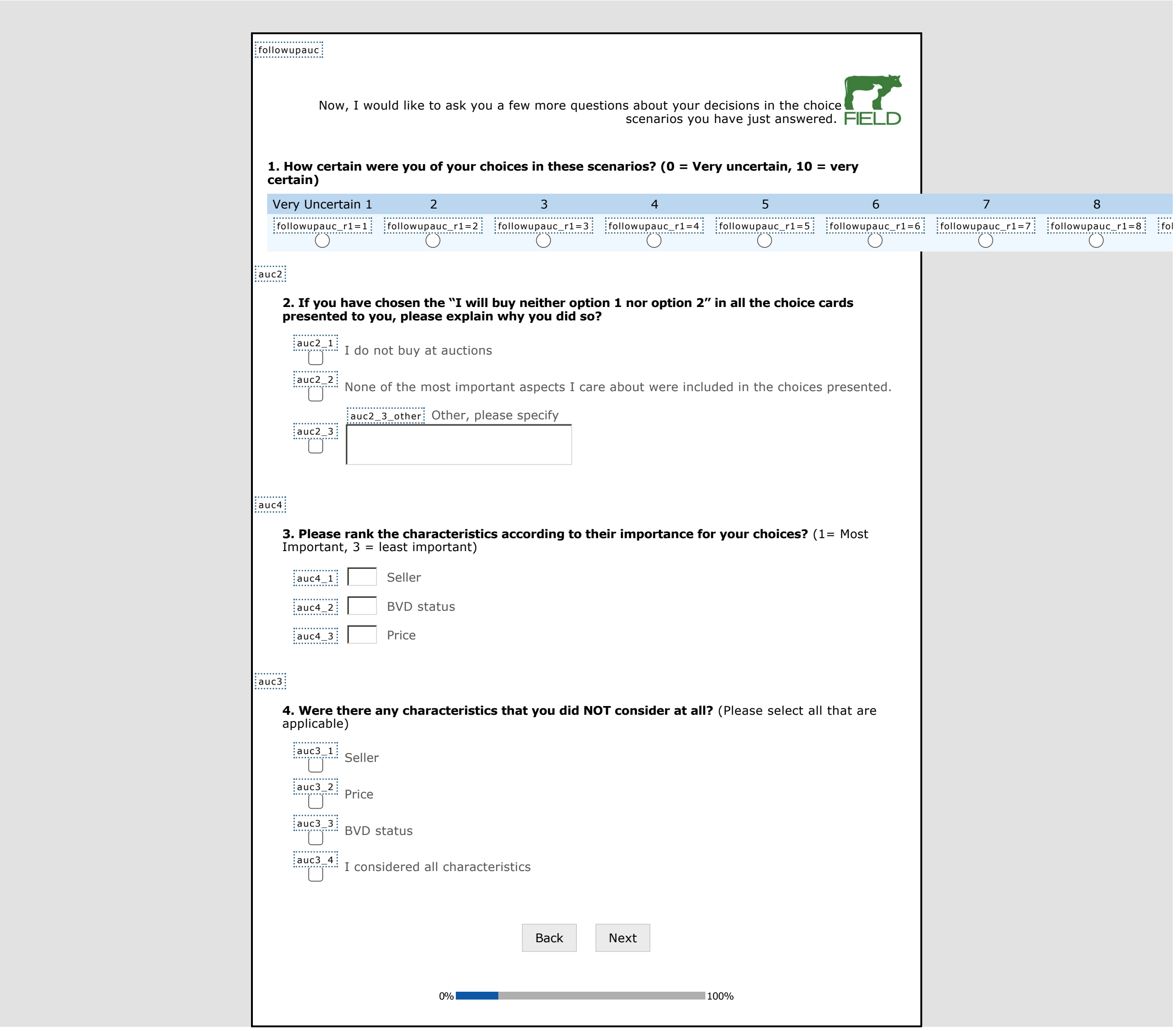


You are a buyer at a cattle auction, seeking to purchase a new stock bull for your suckler herd. Given the choices with a combination of characteristics, please pick the option that would best describe which bull you would be most likely to try to purchase at a real auction. Think about which characteristics are most important to you and choose accordingly.
**Each choice is independent of the others so a previous choice should not affect or influence future decisions.**

**Which of the following three options would you prefer when deciding to purchase a stock bull at an auction?**

(1 of 6)

|  | **Option 1** | **Option 2** | **Option 3** |
|---|---|---|---|
| **Seller** | Well-known and traded with extensively | Well-known but never traded with previously | I will buy neither option 1 nor option 2 |
| **BVD status** | BUYER TAKE CARE | BUYER TAKE CARE |  |
| **Price** | **£14,000** | **£14,000** |  |



Now, I would like to ask you a few more questions about your decisions in the choice scenarios you have just answered.

**1. How certain were you of your choices in these scenarios? (0 = Very uncertain, 10 = very certain)**

| Very Uncertain 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| followupauc_r1=1 ○ | followupauc_r1=2 ○ | followupauc_r1=3 ○ | followupauc_r1=4 ○ | followupauc_r1=5 ○ | followupauc_r1=6 ○ | followupauc_r1=7 ○ | followupauc_r1=8 ○ |

**2. If you have chosen the "I will buy neither option 1 nor option 2" in all the choice cards presented to you, please explain why you did so?**

auc2_1 ☐ I do not buy at auctions

auc2_2 ☐ None of the most important aspects I care about were included in the choices presented.

auc2_3 ☐ auc2_3_other Other, please specify

**3. Please rank the characteristics according to their importance for your choices?** (1= Most Important, 3 = least important)

auc4_1 ☐ Seller

auc4_2 ☐ BVD status

auc4_3 ☐ Price

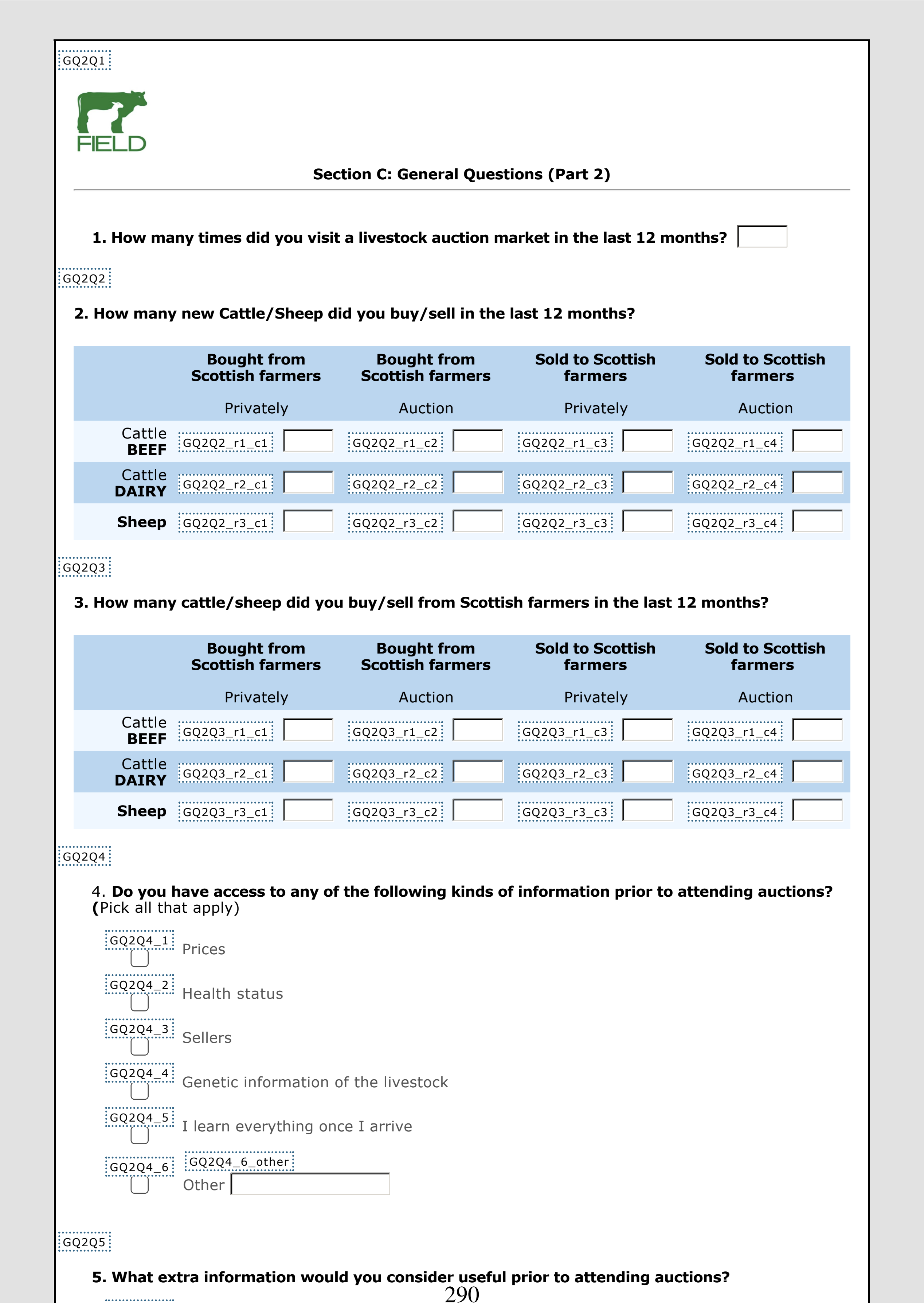
**4. Were there any characteristics that you did NOT consider at all?** (Please select all that are applicable)

auc3_1 ☐ Seller

auc3_2 ☐ Price

auc3_3 ☐ BVD status

auc3_4 ☐ I considered all characteristics



GQ2Q1

FIELD

## Section C: General Questions (Part 2)

**1. How many times did you visit a livestock auction market in the last 12 months?**

GQ2Q2

**2. How many new Cattle/Sheep did you buy/sell in the last 12 months?**

| | **Bought from Scottish farmers**<br>Privately | **Bought from Scottish farmers**<br>Auction | **Sold to Scottish farmers**<br>Privately | **Sold to Scottish farmers**<br>Auction |
|---|---|---|---|---|
| Cattle **BEEF** | GQ2Q2_r1_c1 | GQ2Q2_r1_c2 | GQ2Q2_r1_c3 | GQ2Q2_r1_c4 |
| Cattle **DAIRY** | GQ2Q2_r2_c1 | GQ2Q2_r2_c2 | GQ2Q2_r2_c3 | GQ2Q2_r2_c4 |
| **Sheep** | GQ2Q2_r3_c1 | GQ2Q2_r3_c2 | GQ2Q2_r3_c3 | GQ2Q2_r3_c4 |

GQ2Q3

**3. How many cattle/sheep did you buy/sell from Scottish farmers in the last 12 months?**

| | **Bought from Scottish farmers**<br>Privately | **Bought from Scottish farmers**<br>Auction | **Sold to Scottish farmers**<br>Privately | **Sold to Scottish farmers**<br>Auction |
|---|---|---|---|---|
| Cattle **BEEF** | GQ2Q3_r1_c1 | GQ2Q3_r1_c2 | GQ2Q3_r1_c3 | GQ2Q3_r1_c4 |
| Cattle **DAIRY** | GQ2Q3_r2_c1 | GQ2Q3_r2_c2 | GQ2Q3_r2_c3 | GQ2Q3_r2_c4 |
| **Sheep** | GQ2Q3_r3_c1 | GQ2Q3_r3_c2 | GQ2Q3_r3_c3 | GQ2Q3_r3_c4 |

GQ2Q4

4. **Do you have access to any of the following kinds of information prior to attending auctions? (**Pick all that apply)

GQ2Q4_1 ☐ Prices

GQ2Q4_2 ☐ Health status

GQ2Q4_3 ☐ Sellers

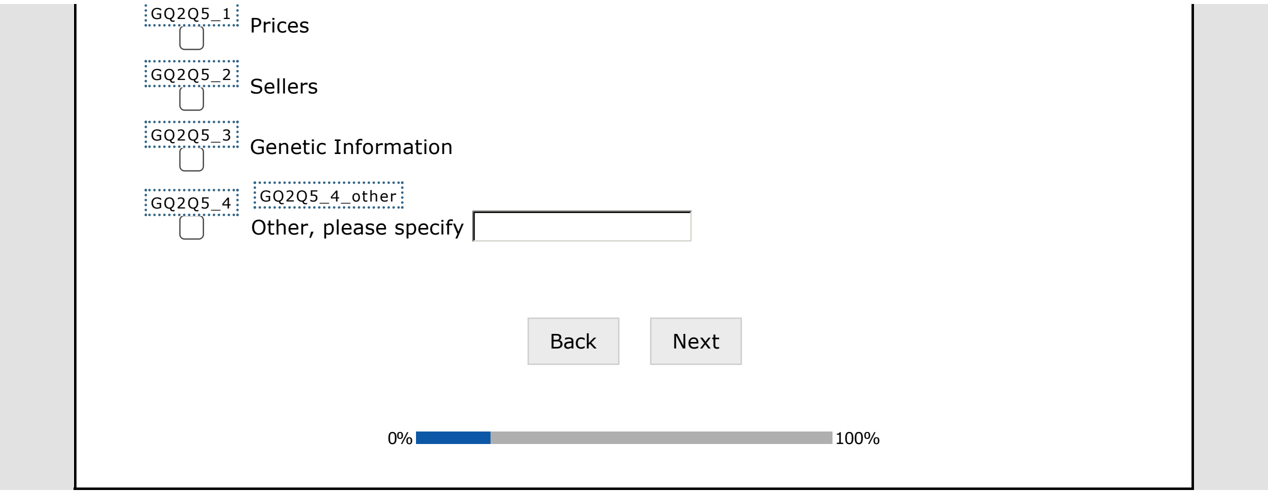
GQ2Q4_4 ☐ Genetic information of the livestock

GQ2Q4_5 ☐ I learn everything once I arrive

GQ2Q4_6 ☐ Other GQ2Q4_6_other

GQ2Q5

**5. What extra information would you consider useful prior to attending auctions?**

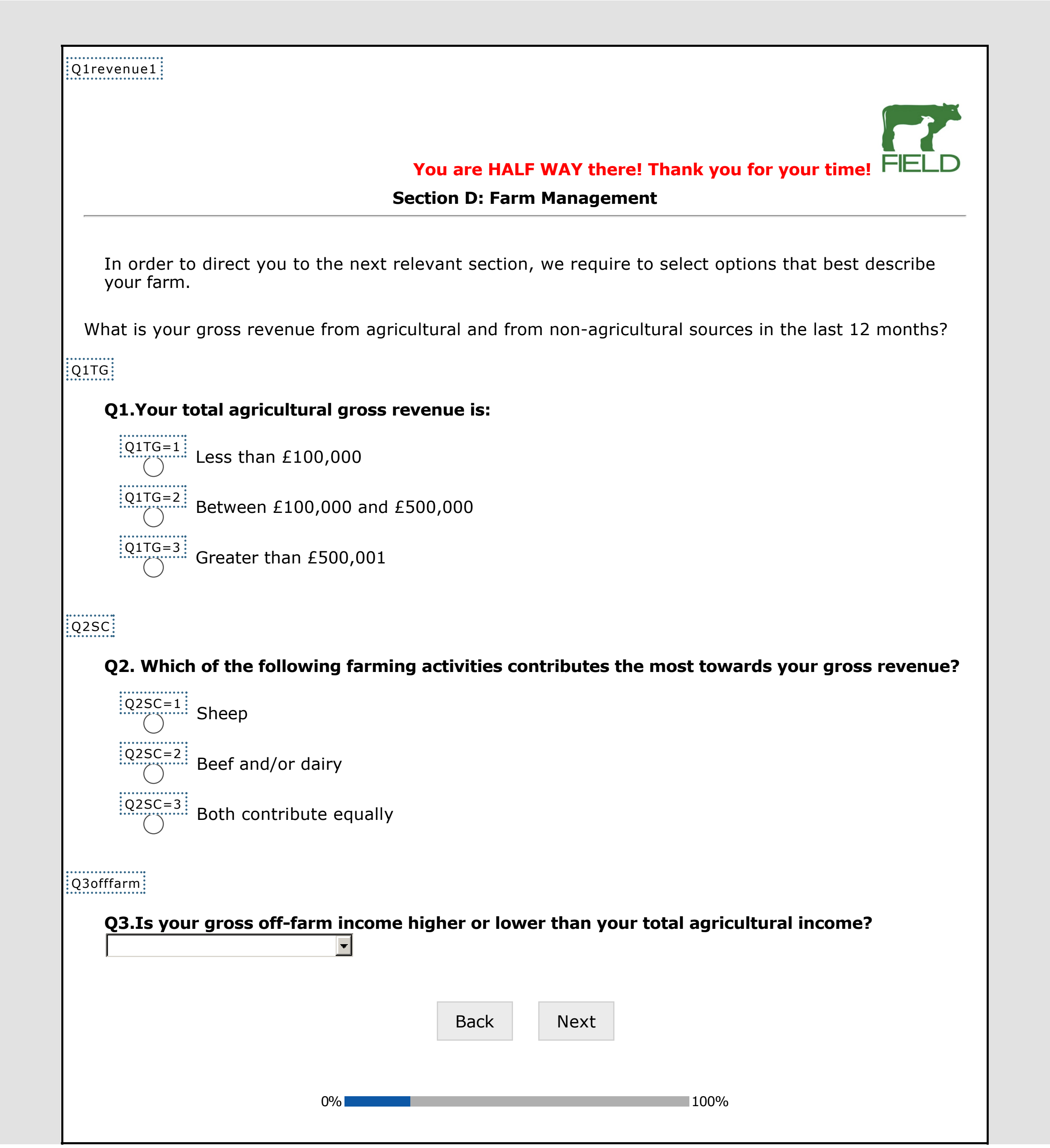


GQ2Q5_1 ☐ Prices

GQ2Q5_2 ☐ Sellers

GQ2Q5_3 ☐ Genetic Information

GQ2Q5_4 ☐ GQ2Q5_4_other Other, please specify ☐



**You are HALF WAY there! Thank you for your time!**

**Section D: Farm Management**

In order to direct you to the next relevant section, we require to select options that best describe your farm.

What is your gross revenue from agricultural and from non-agricultural sources in the last 12 months?

Q1TG

**Q1.Your total agricultural gross revenue is:**

- Q1TG=1 ○ Less than £100,000
- Q1TG=2 ○ Between £100,000 and £500,000
- Q1TG=3 ○ Greater than £500,001

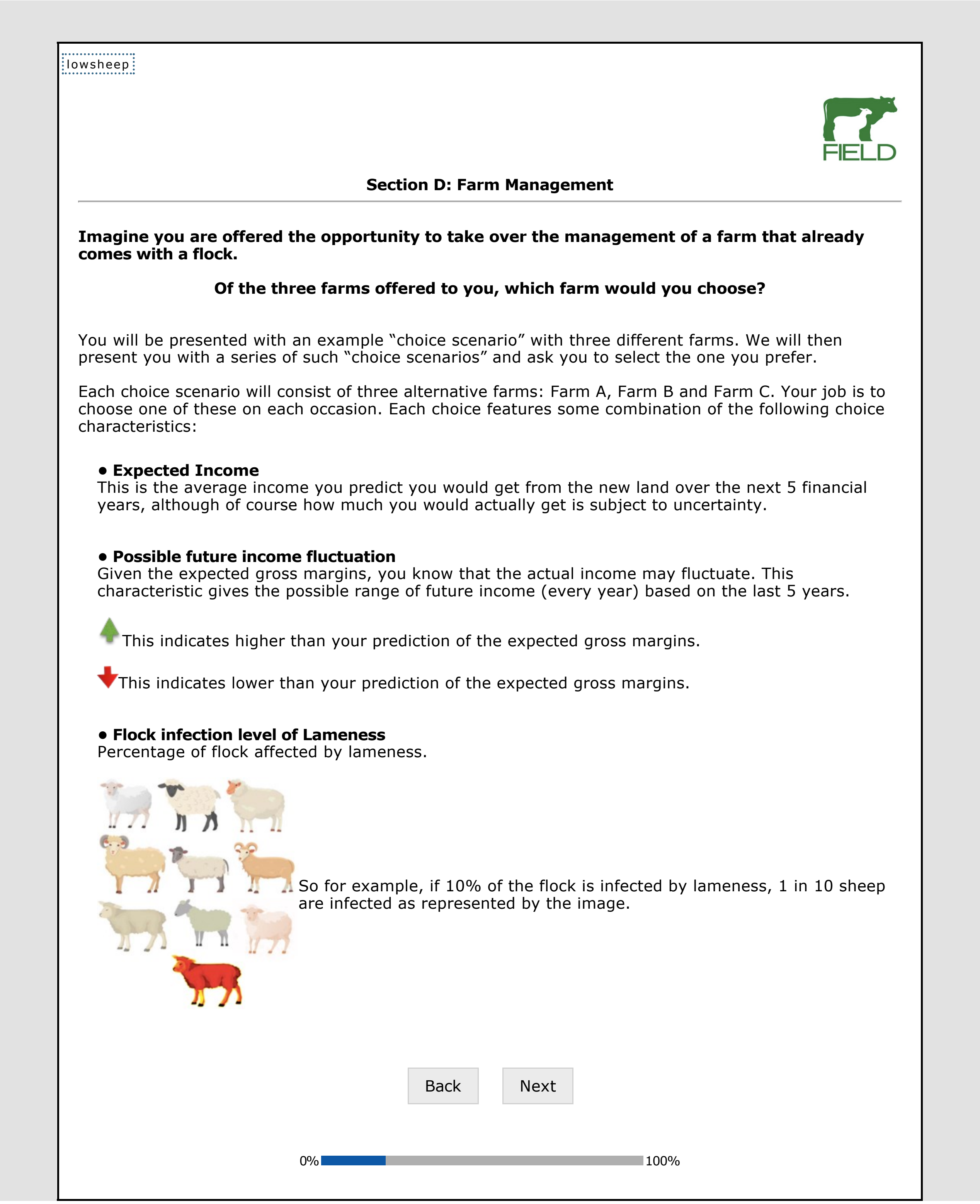
Q2SC

**Q2. Which of the following farming activities contributes the most towards your gross revenue?**

- Q2SC=1 ○ Sheep
- Q2SC=2 ○ Beef and/or dairy
- Q2SC=3 ○ Both contribute equally

Q3offfarm

**Q3.Is your gross off-farm income higher or lower than your total agricultural income?**



**Section D: Farm Management**

**Imagine you are offered the opportunity to take over the management of a farm that already comes with a flock.**

**Of the three farms offered to you, which farm would you choose?**

You will be presented with an example “choice scenario” with three different farms. We will then present you with a series of such “choice scenarios” and ask you to select the one you prefer.

Each choice scenario will consist of three alternative farms: Farm A, Farm B and Farm C. Your job is to choose one of these on each occasion. Each choice features some combination of the following choice characteristics:

- **Expected Income**
  This is the average income you predict you would get from the new land over the next 5 financial years, although of course how much you would actually get is subject to uncertainty.

- **Possible future income fluctuation**
  Given the expected gross margins, you know that the actual income may fluctuate. This characteristic gives the possible range of future income (every year) based on the last 5 years.

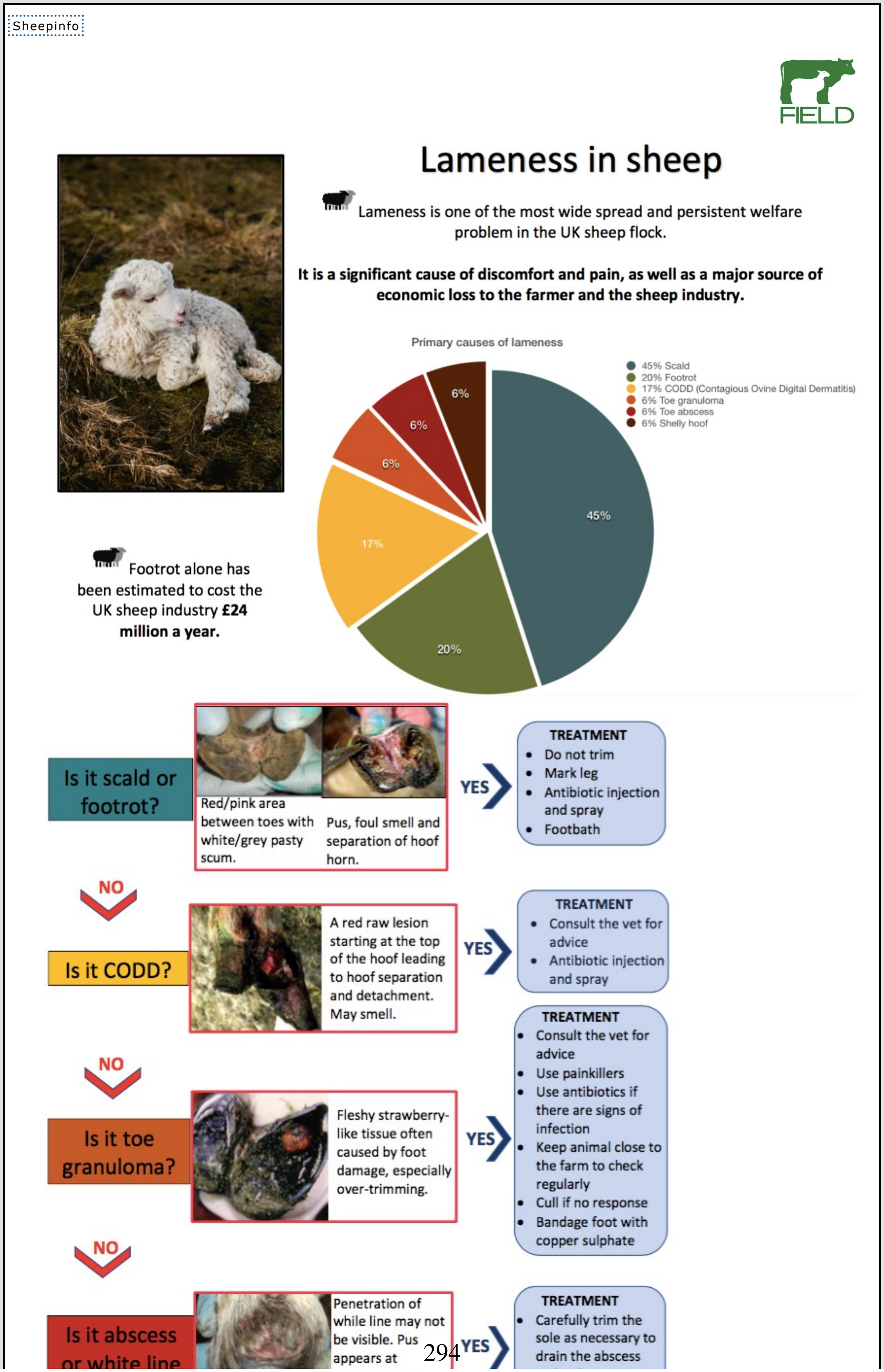
▲ This indicates higher than your prediction of the expected gross margins.

▼ This indicates lower than your prediction of the expected gross margins.

- **Flock infection level of Lameness**
  Percentage of flock affected by lameness.

So for example, if 10% of the flock is infected by lameness, 1 in 10 sheep are infected as represented by the image.

Sheepinfo



FIELD

# Lameness in sheep

Lameness is one of the most wide spread and persistent welfare problem in the UK sheep flock.

**It is a significant cause of discomfort and pain, as well as a major source of economic loss to the farmer and the sheep industry.**

Footrot alone has been estimated to cost the UK sheep industry **£24 million a year.**

Primary causes of lameness

- ● 45% Scald
- ● 20% Footrot
- ● 17% CODD (Contagious Ovine Digital Dermatitis)
- ● 6% Toe granuloma
- ● 6% Toe abscess
- ● 6% Shelly hoof

**Is it scald or footrot?**

Red/pink area between toes with white/grey pasty scum.

Pus, foul smell and separation of hoof horn.

YES

**TREATMENT**

- Do not trim
- Mark leg
- Antibiotic injection and spray
- Footbath

NO

**Is it CODD?**

A red raw lesion starting at the top of the hoof leading to hoof separation and detachment. May smell.

YES

**TREATMENT**

- Consult the vet for advice
- Antibiotic injection and spray

NO

**Is it toe granuloma?**

Fleshy strawberry-like tissue often caused by foot damage, especially over-trimming.

YES

**TREATMENT**

- Consult the vet for advice
- Use painkillers
- Use antibiotics if there are signs of infection
- Keep animal close to the farm to check regularly
- Cull if no response
- Bandage foot with copper sulphate

NO

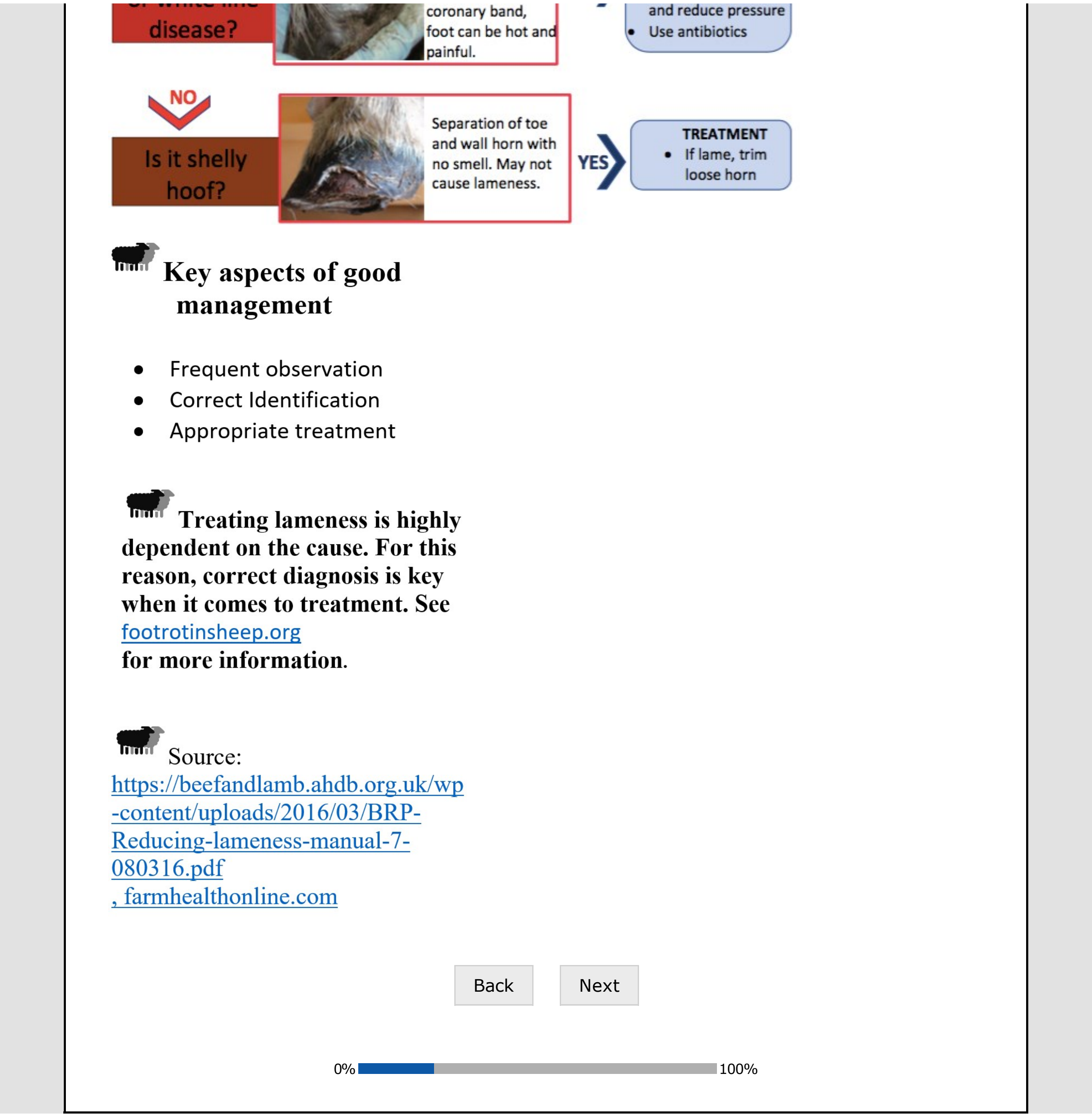
**Is it abscess or white line**

Penetration of while line may not be visible. Pus appears at

YES

**TREATMENT**

- Carefully trim the sole as necessary to drain the abscess

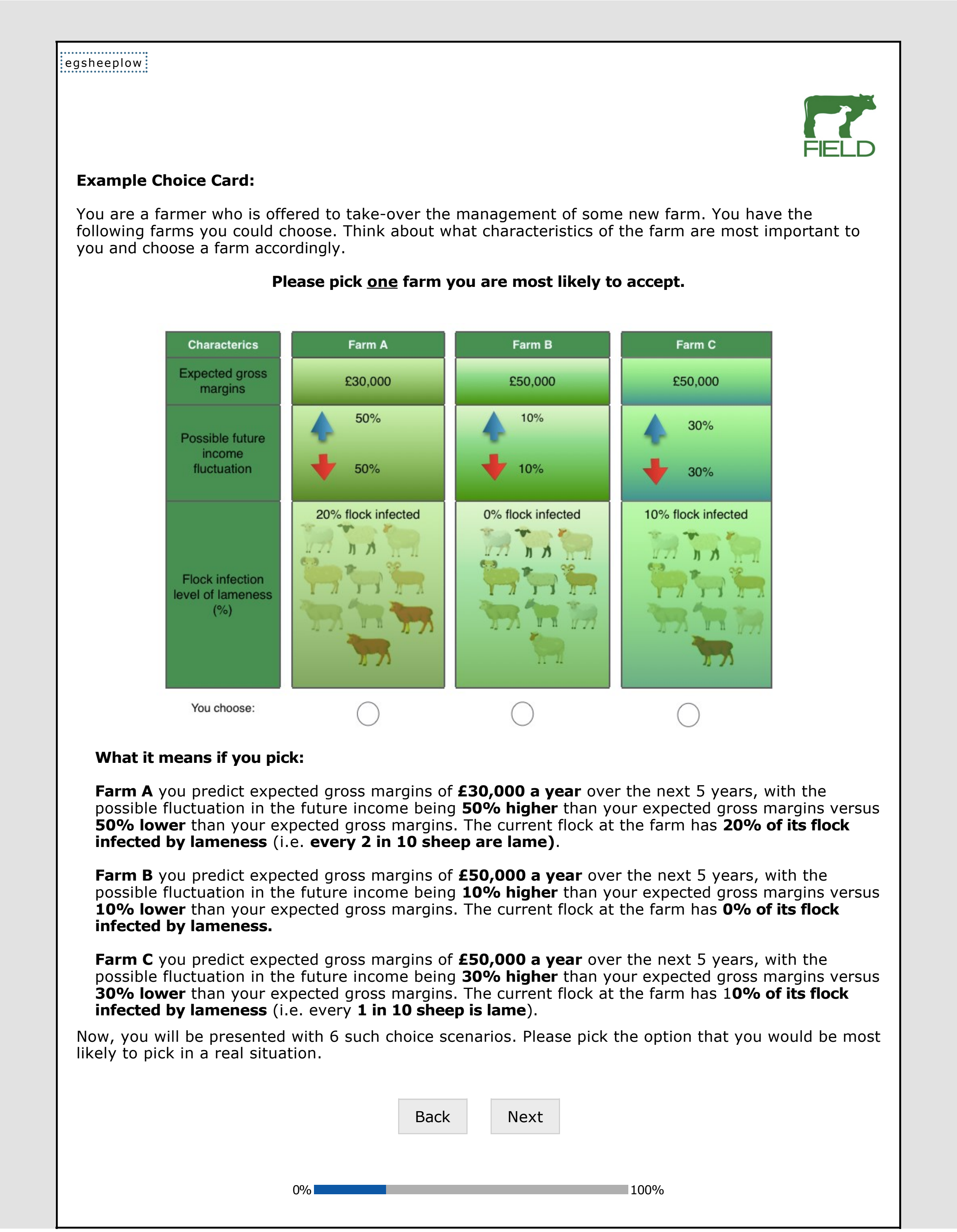


## Key aspects of good management

- Frequent observation
- Correct Identification
- Appropriate treatment

**Treating lameness is highly dependent on the cause. For this reason, correct diagnosis is key when it comes to treatment. See** footrotinsheep.org **for more information.**

Source:
https://beefandlamb.ahdb.org.uk/wp-content/uploads/2016/03/BRP-Reducing-lameness-manual-7-080316.pdf
, farmhealthonline.com



**Example Choice Card:**

You are a farmer who is offered to take-over the management of some new farm. You have the following farms you could choose. Think about what characteristics of the farm are most important to you and choose a farm accordingly.

**Please pick <u>one</u> farm you are most likely to accept.**

| Characterics | Farm A | Farm B | Farm C |
|---|---|---|---|
| Expected gross margins | £30,000 | £50,000 | £50,000 |
| Possible future income fluctuation | ↑ 50%<br>↓ 50% | ↑ 10%<br>↓ 10% | ↑ 30%<br>↓ 30% |
| Flock infection level of lameness (%) | 20% flock infected | 0% flock infected | 10% flock infected |
| You choose: | ○ | ○ | ○ |

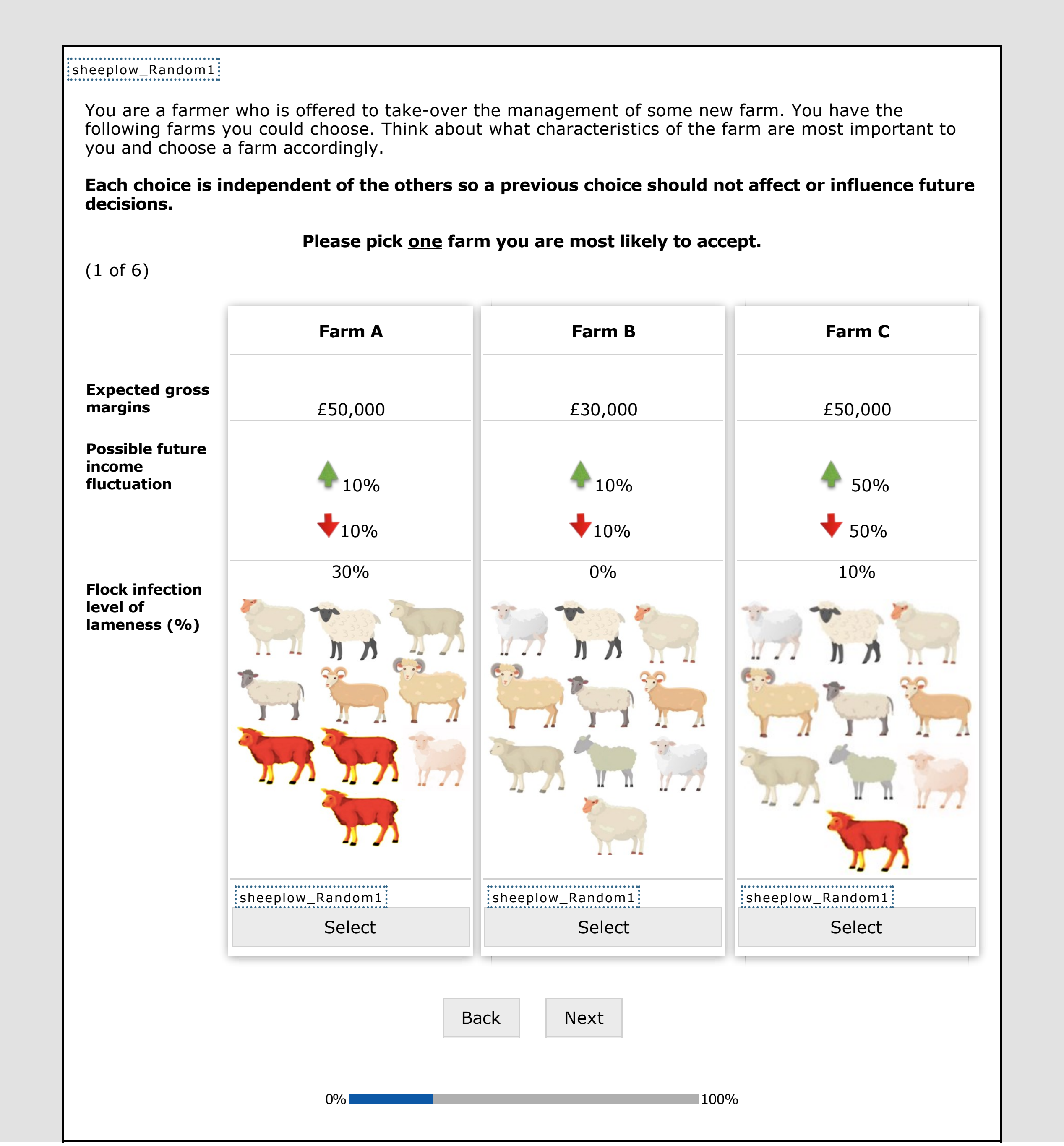
**What it means if you pick:**

**Farm A** you predict expected gross margins of **£30,000 a year** over the next 5 years, with the possible fluctuation in the future income being **50% higher** than your expected gross margins versus **50% lower** than your expected gross margins. The current flock at the farm has **20% of its flock infected by lameness** (i.e. **every 2 in 10 sheep are lame)**.

**Farm B** you predict expected gross margins of **£50,000 a year** over the next 5 years, with the possible fluctuation in the future income being **10% higher** than your expected gross margins versus **10% lower** than your expected gross margins. The current flock at the farm has **0% of its flock infected by lameness.**

**Farm C** you predict expected gross margins of **£50,000 a year** over the next 5 years, with the possible fluctuation in the future income being **30% higher** than your expected gross margins versus **30% lower** than your expected gross margins. The current flock at the farm has 1**0% of its flock infected by lameness** (i.e. every **1 in 10 sheep is lame**).

Now, you will be presented with 6 such choice scenarios. Please pick the option that you would be most likely to pick in a real situation.



sheeplow_Random1

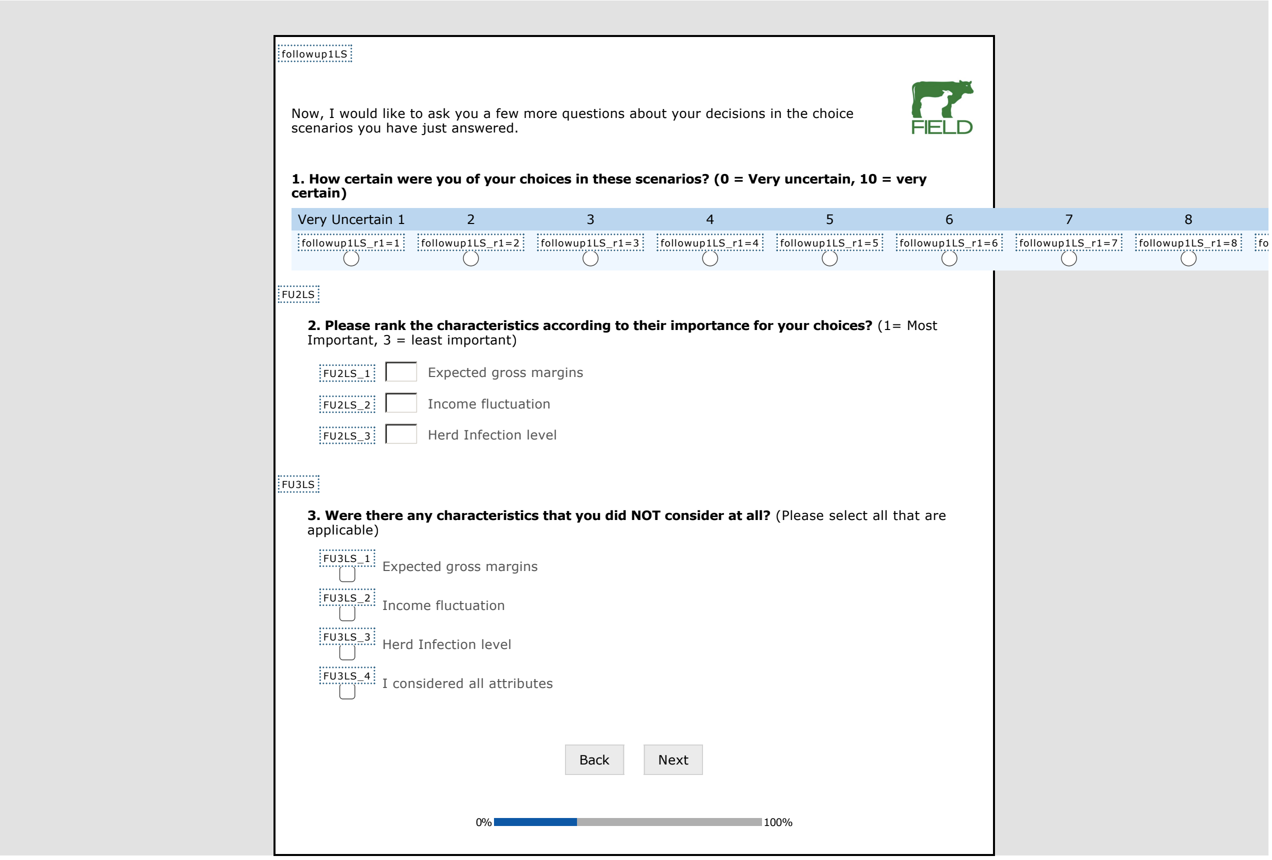
You are a farmer who is offered to take-over the management of some new farm. You have the following farms you could choose. Think about what characteristics of the farm are most important to you and choose a farm accordingly.

**Each choice is independent of the others so a previous choice should not affect or influence future decisions.**

**Please pick one farm you are most likely to accept.**

(1 of 6)

| | **Farm A** | **Farm B** | **Farm C** |
|---|---|---|---|
| **Expected gross margins** | £50,000 | £30,000 | £50,000 |
| **Possible future income fluctuation** | ▲ 10%<br>▼ 10% | ▲ 10%<br>▼ 10% | ▲ 50%<br>▼ 50% |
| **Flock infection level of lameness (%)** | 30% | 0% | 10% |
| | sheeplow_Random1 | sheeplow_Random1 | sheeplow_Random1 |
| | Select | Select | Select |



followup1LS

Now, I would like to ask you a few more questions about your decisions in the choice scenarios you have just answered.

**1. How certain were you of your choices in these scenarios? (0 = Very uncertain, 10 = very certain)**

| Very Uncertain 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
|---|---|---|---|---|---|---|---|---|
| followup1LS_r1=1<br>○ | followup1LS_r1=2<br>○ | followup1LS_r1=3<br>○ | followup1LS_r1=4<br>○ | followup1LS_r1=5<br>○ | followup1LS_r1=6<br>○ | followup1LS_r1=7<br>○ | followup1LS_r1=8<br>○ | fo |

FU2LS

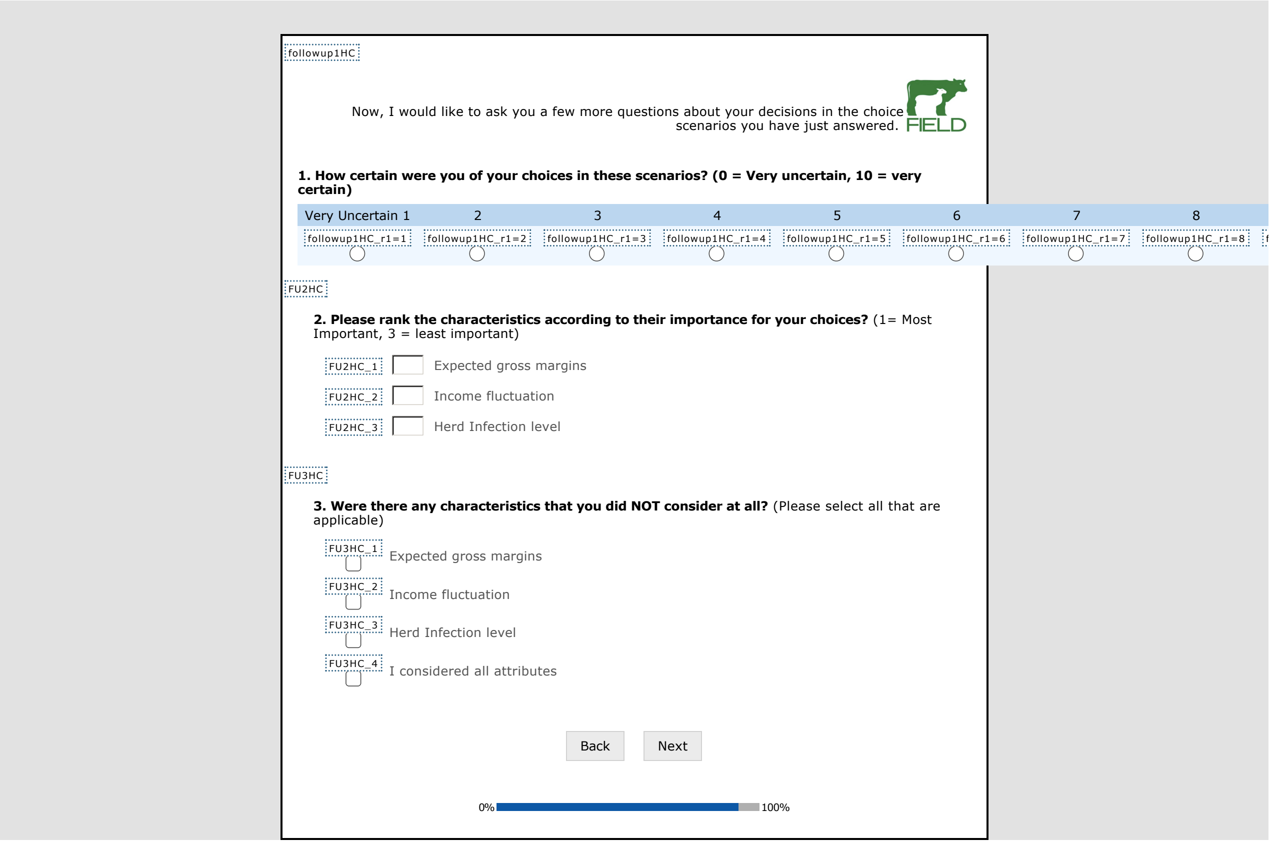
**2. Please rank the characteristics according to their importance for your choices?** (1= Most Important, 3 = least important)

FU2LS_1 ☐ Expected gross margins
FU2LS_2 ☐ Income fluctuation
FU2LS_3 ☐ Herd Infection level

FU3LS

**3. Were there any characteristics that you did NOT consider at all?** (Please select all that are applicable)

FU3LS_1 ☐ Expected gross margins
FU3LS_2 ☐ Income fluctuation
FU3LS_3 ☐ Herd Infection level
FU3LS_4 ☐ I considered all attributes



followup1HC

Now, I would like to ask you a few more questions about your decisions in the choice scenarios you have just answered.

**1. How certain were you of your choices in these scenarios? (0 = Very uncertain, 10 = very certain)**

| Very Uncertain 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| followup1HC_r1=1<br>○ | followup1HC_r1=2<br>○ | followup1HC_r1=3<br>○ | followup1HC_r1=4<br>○ | followup1HC_r1=5<br>○ | followup1HC_r1=6<br>○ | followup1HC_r1=7<br>○ | followup1HC_r1=8<br>○ |

FU2HC

**2. Please rank the characteristics according to their importance for your choices?** (1= Most Important, 3 = least important)

FU2HC_1 ☐ Expected gross margins

FU2HC_2 ☐ Income fluctuation

FU2HC_3 ☐ Herd Infection level

FU3HC

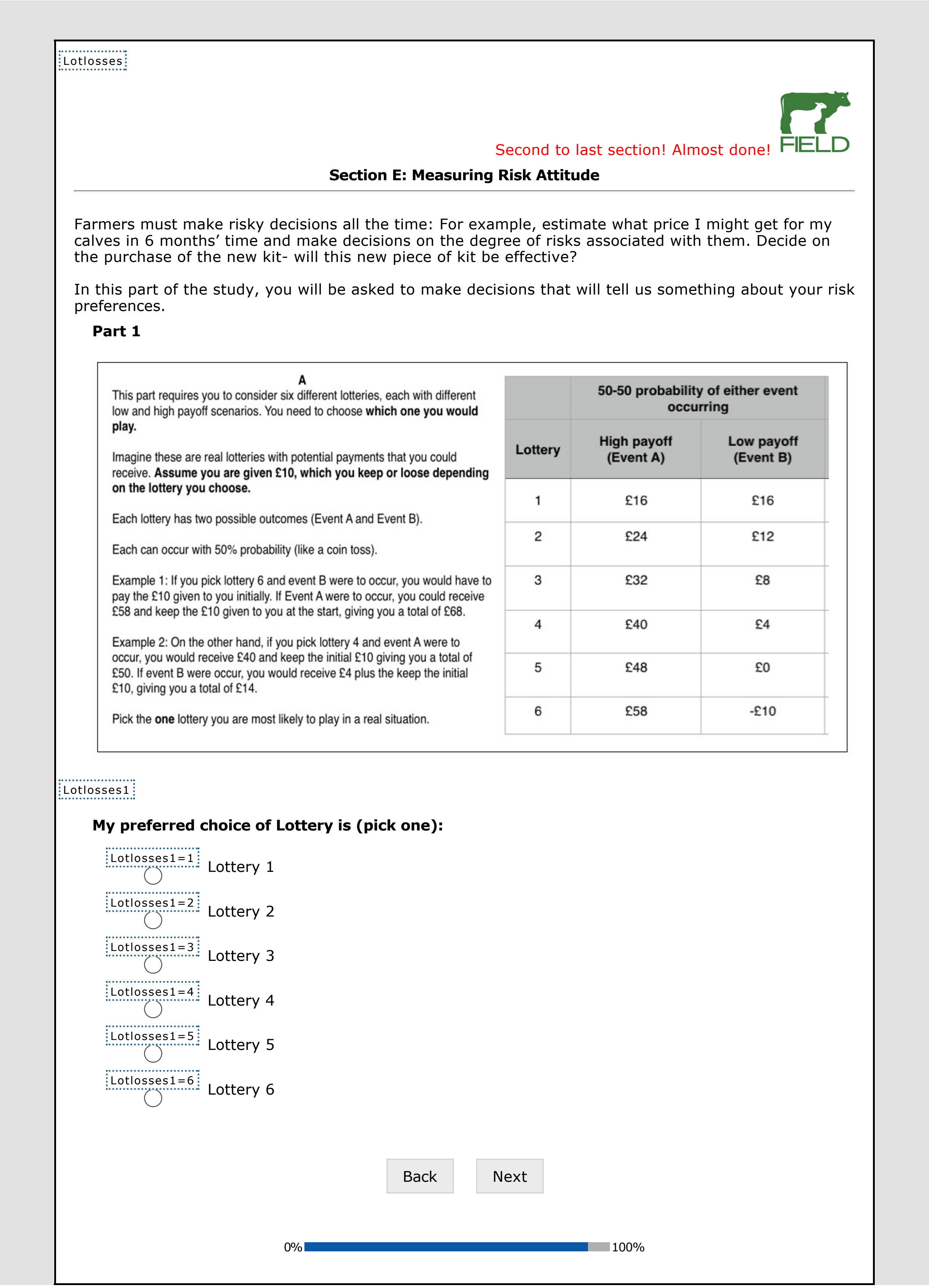
**3. Were there any characteristics that you did NOT consider at all?** (Please select all that are applicable)

FU3HC_1 ☐ Expected gross margins

FU3HC_2 ☐ Income fluctuation

FU3HC_3 ☐ Herd Infection level

FU3HC_4 ☐ I considered all attributes



Second to last section! Almost done!

## Section E: Measuring Risk Attitude

Farmers must make risky decisions all the time: For example, estimate what price I might get for my calves in 6 months' time and make decisions on the degree of risks associated with them. Decide on the purchase of the new kit- will this new piece of kit be effective?

In this part of the study, you will be asked to make decisions that will tell us something about your risk preferences.

**Part 1**

**A**

This part requires you to consider six different lotteries, each with different low and high payoff scenarios. You need to choose **which one you would play.**

Imagine these are real lotteries with potential payments that you could receive. **Assume you are given £10, which you keep or loose depending on the lottery you choose.**

Each lottery has two possible outcomes (Event A and Event B).

Each can occur with 50% probability (like a coin toss).

Example 1: If you pick lottery 6 and event B were to occur, you would have to pay the £10 given to you initially. If Event A were to occur, you could receive £58 and keep the £10 given to you at the start, giving you a total of £68.

Example 2: On the other hand, if you pick lottery 4 and event A were to occur, you would receive £40 and keep the initial £10 giving you a total of £50. If event B were occur, you would receive £4 plus the keep the initial £10, giving you a total of £14.

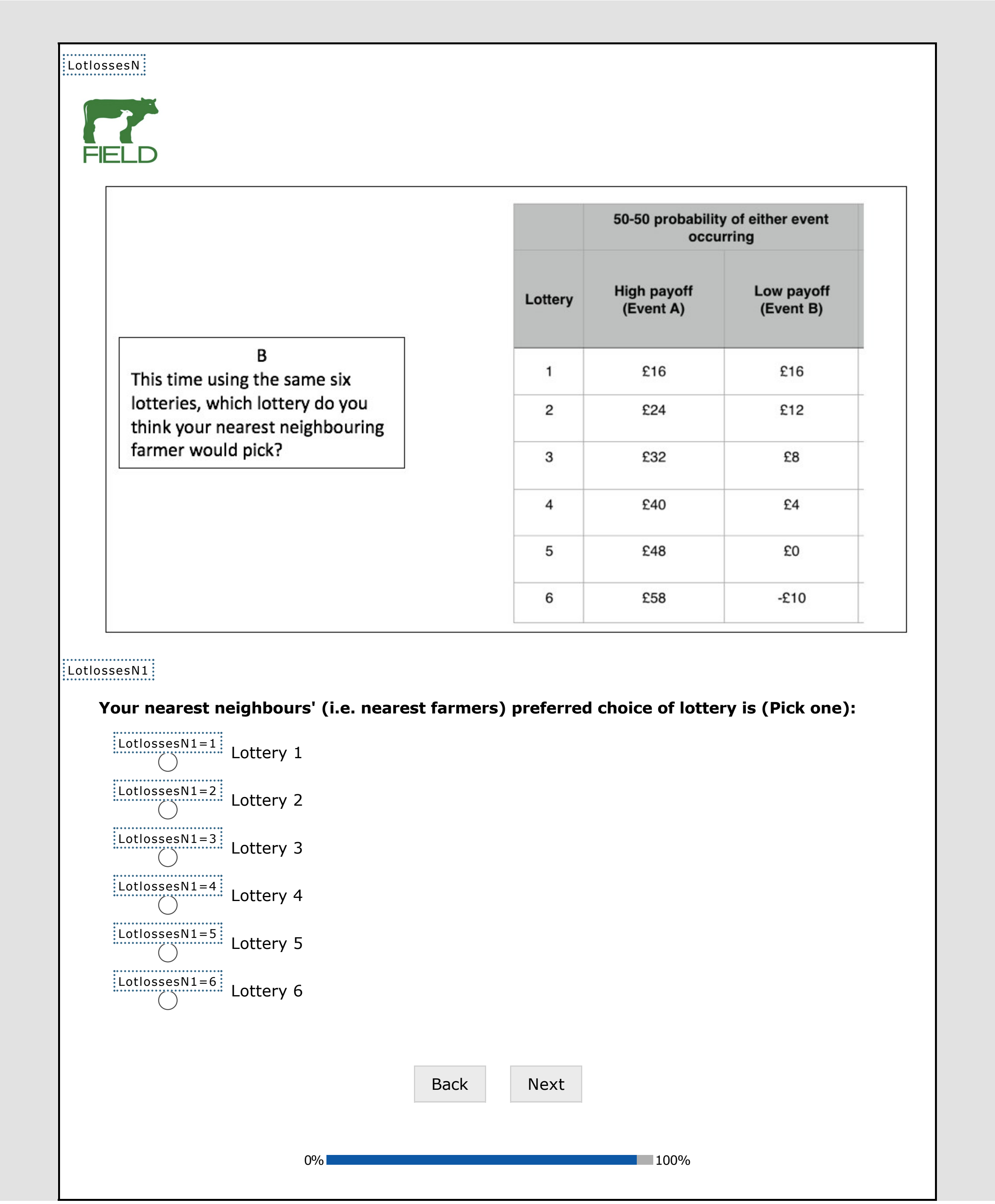
Pick the **one** lottery you are most likely to play in a real situation.

| | **50-50 probability of either event occurring** | |
|---|---|---|
| **Lottery** | **High payoff (Event A)** | **Low payoff (Event B)** |
| 1 | £16 | £16 |
| 2 | £24 | £12 |
| 3 | £32 | £8 |
| 4 | £40 | £4 |
| 5 | £48 | £0 |
| 6 | £58 | -£10 |

Lotlosses1

**My preferred choice of Lottery is (pick one):**

Lotlosses1=1 ○ Lottery 1
Lotlosses1=2 ○ Lottery 2
Lotlosses1=3 ○ Lottery 3
Lotlosses1=4 ○ Lottery 4
Lotlosses1=5 ○ Lottery 5
Lotlosses1=6 ○ Lottery 6



LotlossesN

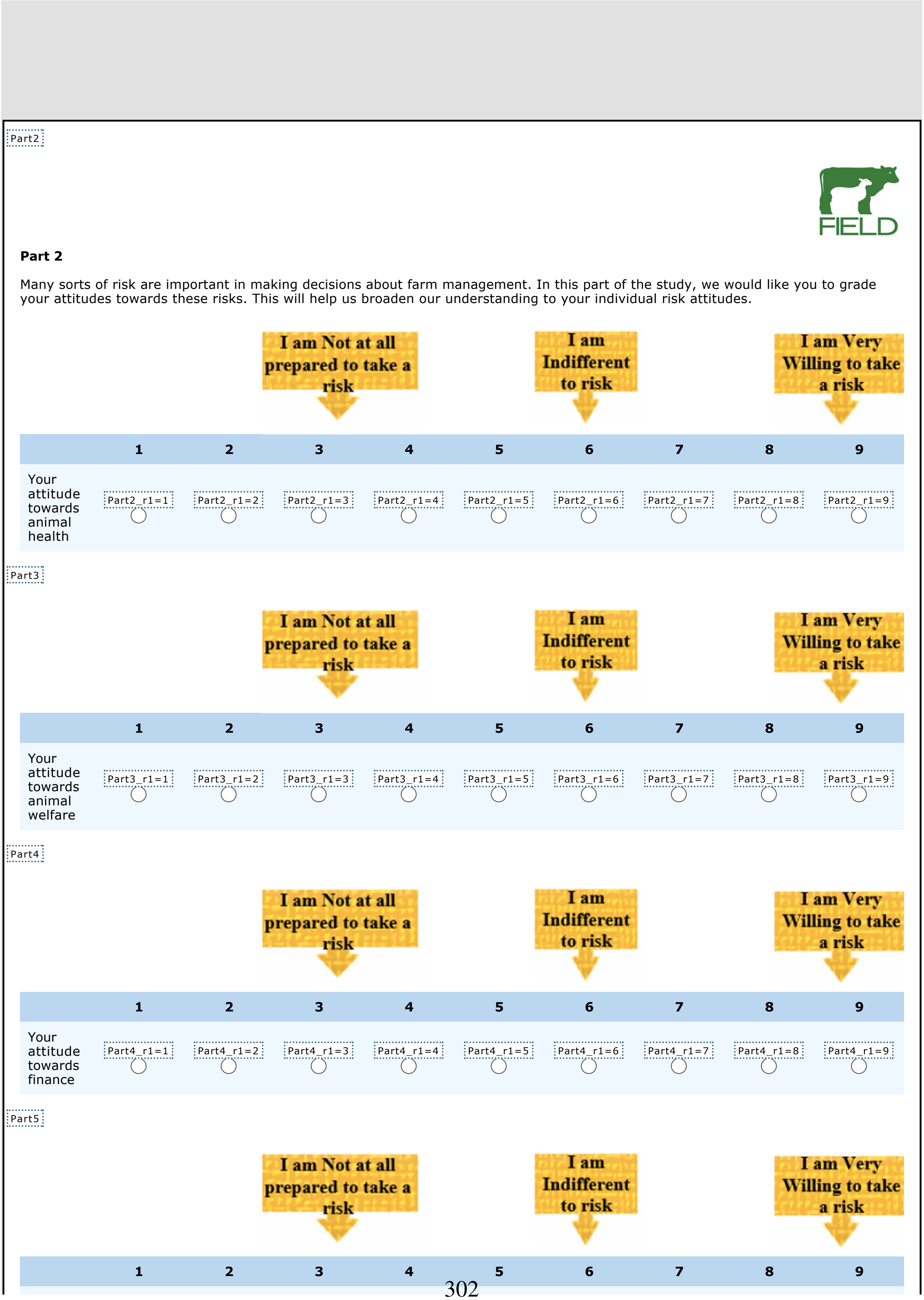
B
This time using the same six lotteries, which lottery do you think your nearest neighbouring farmer would pick?

| | 50-50 probability of either event occurring | |
|---|---|---|
| Lottery | High payoff (Event A) | Low payoff (Event B) |
| 1 | £16 | £16 |
| 2 | £24 | £12 |
| 3 | £32 | £8 |
| 4 | £40 | £4 |
| 5 | £48 | £0 |
| 6 | £58 | -£10 |

LotlossesN1

**Your nearest neighbours' (i.e. nearest farmers) preferred choice of lottery is (Pick one):**

LotlossesN1=1 ○ Lottery 1
LotlossesN1=2 ○ Lottery 2
LotlossesN1=3 ○ Lottery 3
LotlossesN1=4 ○ Lottery 4
LotlossesN1=5 ○ Lottery 5
LotlossesN1=6 ○ Lottery 6



Part2

**Part 2**

Many sorts of risk are important in making decisions about farm management. In this part of the study, we would like you to grade your attitudes towards these risks. This will help us broaden our understanding to your individual risk attitudes.

I am Not at all prepared to take a risk

I am Indifferent to risk

I am Very Willing to take a risk

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Your attitude towards animal health | Part2_r1=1<br>○ | Part2_r1=2<br>○ | Part2_r1=3<br>○ | Part2_r1=4<br>○ | Part2_r1=5<br>○ | Part2_r1=6<br>○ | Part2_r1=7<br>○ | Part2_r1=8<br>○ | Part2_r1=9<br>○ |

Part3

I am Not at all prepared to take a risk

I am Indifferent to risk

I am Very Willing to take a risk

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Your attitude towards animal welfare | Part3_r1=1<br>○ | Part3_r1=2<br>○ | Part3_r1=3<br>○ | Part3_r1=4<br>○ | Part3_r1=5<br>○ | Part3_r1=6<br>○ | Part3_r1=7<br>○ | Part3_r1=8<br>○ | Part3_r1=9<br>○ |

Part4

I am Not at all prepared to take a risk

I am Indifferent to risk

I am Very Willing to take a risk

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Your attitude towards finance | Part4_r1=1<br>○ | Part4_r1=2<br>○ | Part4_r1=3<br>○ | Part4_r1=4<br>○ | Part4_r1=5<br>○ | Part4_r1=6<br>○ | Part4_r1=7<br>○ | Part4_r1=8<br>○ | Part4_r1=9<br>○ |

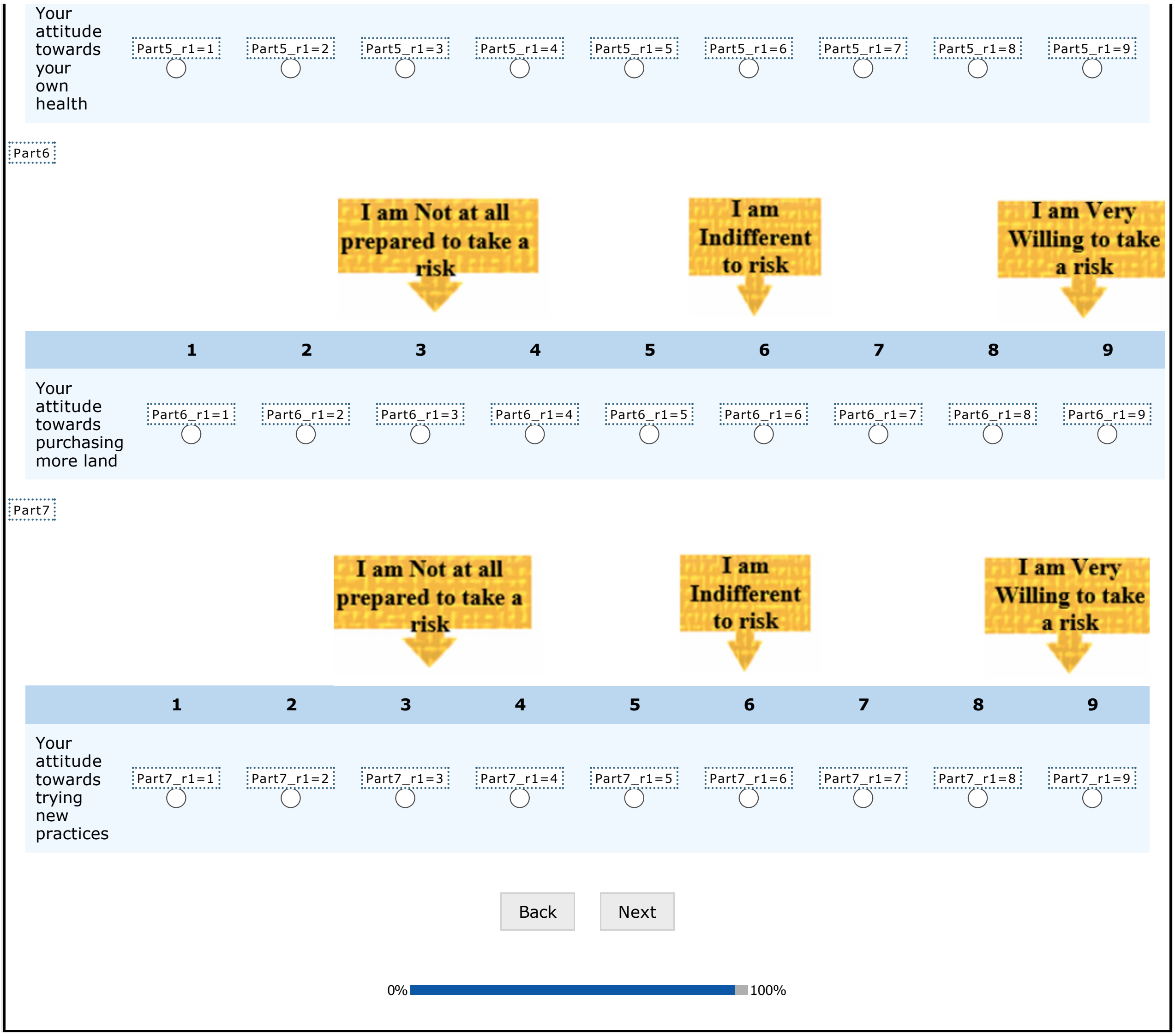
Part5

I am Not at all prepared to take a risk

I am Indifferent to risk

I am Very Willing to take a risk

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Your attitude towards your own health | Part5_r1=1<br>○ | Part5_r1=2<br>○ | Part5_r1=3<br>○ | Part5_r1=4<br>○ | Part5_r1=5<br>○ | Part5_r1=6<br>○ | Part5_r1=7<br>○ | Part5_r1=8<br>○ | Part5_r1=9<br>○ |

Part6

I am Not at all prepared to take a risk

I am Indifferent to risk

I am Very Willing to take a risk

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Your attitude towards purchasing more land | Part6_r1=1<br>○ | Part6_r1=2<br>○ | Part6_r1=3<br>○ | Part6_r1=4<br>○ | Part6_r1=5<br>○ | Part6_r1=6<br>○ | Part6_r1=7<br>○ | Part6_r1=8<br>○ | Part6_r1=9<br>○ |

Part7

I am Not at all prepared to take a risk

I am Indifferent to risk

I am Very Willing to take a risk

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Your attitude towards trying new practices | Part7_r1=1<br>○ | Part7_r1=2<br>○ | Part7_r1=3<br>○ | Part7_r1=4<br>○ | Part7_r1=5<br>○ | Part7_r1=6<br>○ | Part7_r1=7<br>○ | Part7_r1=8<br>○ | Part7_r1=9<br>○ |

GQ3Q1

Last section FIELD

## Section F: General Questions (Part 3)

**1. Did your family farm here before you?**

GQ3Q1=1 ○ Yes

GQ3Q1=2 ○ No, my family farmed elsewhere

GQ3Q1=3 ○ No, I'm a first generation farmer

GQ3Q2

**2. For how many years have you farmed this farm?** ☐

GQ3Q3

**3. To which of the following buyers do you primarily market your livestock?**

| | **Beef** | **Dairy** | **Sheep** |
|---|---|---|---|
| **Sold directly to consumers** | GQ3Q3_r1_c1 ☐ | GQ3Q3_r1_c2 ☐ | GQ3Q3_r1_c3 ☐ |
| **Sold to livestock traders** | GQ3Q3_r2_c1 ☐ | GQ3Q3_r2_c2 ☐ | GQ3Q3_r2_c3 ☐ |
| **Sold to auction marts** | GQ3Q3_r3_c1 ☐ | GQ3Q3_r3_c2 ☐ | GQ3Q3_r3_c3 ☐ |
| **Sold to agricultural cooperatives** | GQ3Q3_r4_c1 ☐ | GQ3Q3_r4_c2 ☐ | GQ3Q3_r4_c3 ☐ |
| **Short term delivery contracts** | GQ3Q3_r5_c1 ☐ | GQ3Q3_r5_c2 ☐ | GQ3Q3_r5_c3 ☐ |
| **Lond term delivery contracts** | GQ3Q3_r6_c1 ☐ | GQ3Q3_r6_c2 ☐ | GQ3Q3_r6_c3 ☐ |
| **Sold to other farmers** | GQ3Q3_r7_c1 ☐ | GQ3Q3_r7_c2 ☐ | GQ3Q3_r7_c3 ☐ |
| **Other (please specify)**<br>**GQ3Q3_r8_other** ☐ | GQ3Q3_r8_c1 ☐ | GQ3Q3_r8_c2 ☐ | GQ3Q3_r8_c3 ☐ |

GQ3Q4

**4. Have you ever had BVD on your farm? (Cattle)**

| | Beef | Dairy | Sheep |
|---|---|---|---|
| Yes, currently | GQ3Q4_c1=1 ○ | GQ3Q4_c2=1 ○ | GQ3Q4_c3=1 ○ |
| Yes, in the past | GQ3Q4_c1=2 ○ | GQ3Q4_c2=2 ○ | GQ3Q4_c3=2 ○ |
| No, never | GQ3Q4_c1=3 ○ | GQ3Q4_c2=3 ○ | GQ3Q4_c3=3 ○ |
| I don't know | GQ3Q4_c1=4 ○ | GQ3Q4_c2=4 ○ | GQ3Q4_c3=4 ○ |

GQ3Q5

**5. In general, how worried are you about BVD on your farm?**

| | Beef | Dairy | Sheep |
|---|---|---|---|
| Not at all worried | GQ3Q5_c1=1<br>○ | GQ3Q5_c2=1<br>○ | GQ3Q5_c3=1<br>○ |
| Slightly worried | GQ3Q5_c1=2<br>○ | GQ3Q5_c2=2<br>○ | GQ3Q5_c3=2<br>○ |
| Quite worried | GQ3Q5_c1=3<br>○ | GQ3Q5_c2=3<br>○ | GQ3Q5_c3=3<br>○ |
| Extremely worried | GQ3Q5_c1=4<br>○ | GQ3Q5_c2=4<br>○ | GQ3Q5_c3=4<br>○ |

GQ3Q6

**6. What would you estimate the approximate prevalence of lameness on your farm to be (percentage)?**

| | **Beef** | **Dairy** | **Sheep** |
|---|---|---|---|
| **When animals are housed indoors** | **GQ3Q6_r1_c1** ☐ | **GQ3Q6_r1_c2** ☐ | **GQ3Q6_r1_c3** ☐ |
| **When animals are out grazing** | **GQ3Q6_r2_c1** ☐ | **GQ3Q6_r2_c2** ☐ | **GQ3Q6_r2_c3** ☐ |

**GQ3Q7**

**7. In general, how worried are you about lameness on your farm? (Sheep)**

| | **Beef** | **Dairy** | **Sheep** |
|---|---|---|---|
| **Not at all worried** | **GQ3Q7_c1=1**<br>○ | **GQ3Q7_c2=1**<br>○ | **GQ3Q7_c3=1**<br>○ |
| **Slightly worried** | **GQ3Q7_c1=2**<br>○ | **GQ3Q7_c2=2**<br>○ | **GQ3Q7_c3=2**<br>○ |
| **Quite worried** | **GQ3Q7_c1=3**<br>○ | **GQ3Q7_c2=3**<br>○ | **GQ3Q7_c3=3**<br>○ |
| **Extremely worried** | **GQ3Q7_c1=4**<br>○ | **GQ3Q7_c2=4**<br>○ | **GQ3Q7_c3=4**<br>○ |

**GQ3Q8**

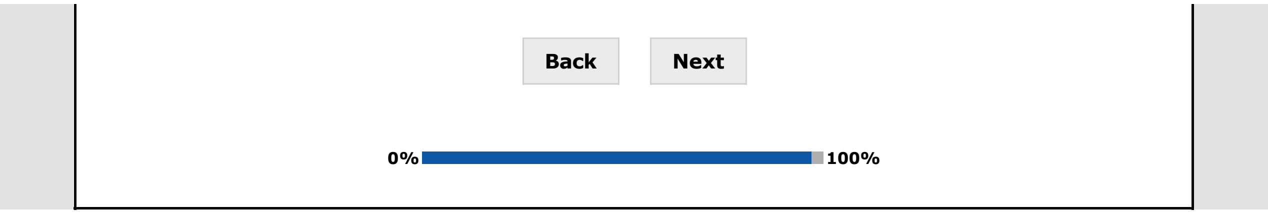
**8. How would you rank the public image of agriculture?**
**(1-Very negative, 2-negative, 3-neutral, 4-positive, 5-very positive)**

| | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| | **GQ3Q8_r1=1**<br>○ | **GQ3Q8_r1=2**<br>○ | **GQ3Q8_r1=3**<br>○ | **GQ3Q8_r1=4**<br>○ | **GQ3Q8_r1=5**<br>○ |

**livestock**

**What type of livestock do you keep? Pick all that apply.**

| | **Beef** | **Dairy** | **Sheep** |
|---|---|---|---|
| **Pedigree** | **livestock_r1_c1**<br>☐ | **livestock_r1_c2**<br>☐ | **livestock_r1_c3**<br>☐ |
| **Commercial** | **livestock_r2_c1**<br>☐ | **livestock_r2_c2**<br>☐ | **livestock_r2_c3**<br>☐ |
| **Purebred** | **livestock_r3_c1**<br>☐ | **livestock_r3_c2**<br>☐ | **livestock_r3_c3**<br>☐ |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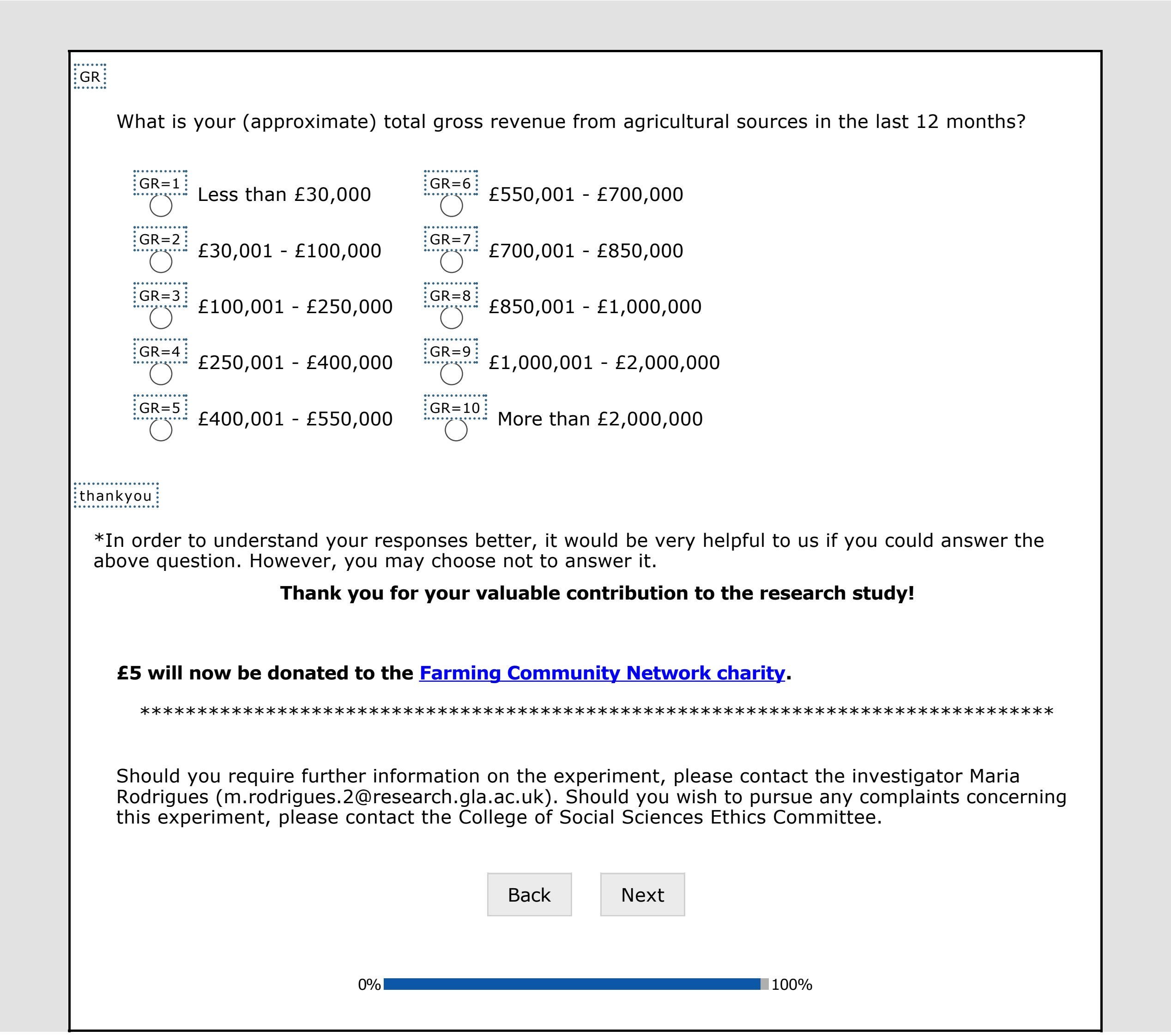


GR

What is your (approximate) total gross revenue from agricultural sources in the last 12 months?

| | |
|---|---|
| GR=1 ○ Less than £30,000 | GR=6 ○ £550,001 - £700,000 |
| GR=2 ○ £30,001 - £100,000 | GR=7 ○ £700,001 - £850,000 |
| GR=3 ○ £100,001 - £250,000 | GR=8 ○ £850,001 - £1,000,000 |
| GR=4 ○ £250,001 - £400,000 | GR=9 ○ £1,000,001 - £2,000,000 |
| GR=5 ○ £400,001 - £550,000 | GR=10 ○ More than £2,000,000 |

thankyou

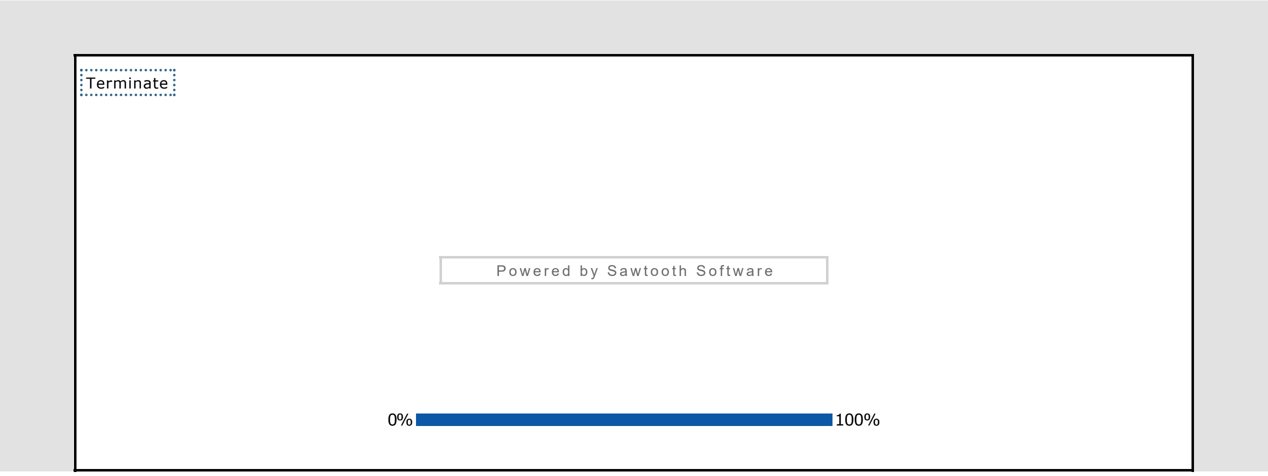
*In order to understand your responses better, it would be very helpful to us if you could answer the above question. However, you may choose not to answer it.

**Thank you for your valuable contribution to the research study!**

**£5 will now be donated to the Farming Community Network charity.**

**********************************************************************************

Should you require further information on the experiment, please contact the investigator Maria Rodrigues (m.rodrigues.2@research.gla.ac.uk). Should you wish to pursue any complaints concerning this experiment, please contact the College of Social Sciences Ethics Committee.



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