

2018

Consumer willingness to pay and economic viability of speciality milk products

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<http://hdl.handle.net/10026.1/11637>

<http://dx.doi.org/10.24382/1260>

University of Plymouth

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**RESEARCH
DEGREES
WITH
PLYMOUTH
UNIVERSITY**

**CONSUMER WILLINGNESS TO PAY AND ECONOMIC
VIABILITY OF SPECIALITY MILK PRODUCTS**

by
ANDREW JONES

A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of

RESEARCH MASTERS IN AGRICULTURE AND FOOD

School of Biological and Marine Sciences

March 2018

Author's acknowledgements.

Firstly I would like to thank my supervisors Dr Stephen Roderick, Dr Peter McGregor and Dr Victor Kuri for their indispensable help and support throughout this project. I would also like to thank the directors of Dairyland Farmworld for allowing me to use the park as my primary survey site and Merlin Entertainment for allowing me to conduct a further survey at Gweek Seal Sanctuary. Thank you to the Gloucester Cattle Society and the Shetland Cattle Society for the contacts provided and to the producers I visited for their time and the information provided. Finally I would like to thank the Seale Hayne Education Trust, for giving me the means to enrol and complete my masters.

Author's declaration.

At no time during the registration for the degree of Research Masters (Agriculture and Food) has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee. Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment. This study was financed with the aid of a bursary from the Seale Hayne Education Trust.

Presentation and Conferences Attended: Newquay Research and Scholarship day
(Presentation May 2016 & May 2017)

Word count of main body of thesis: 18,278

Signed.....

Date.....

Abstract.

Consumer willingness to pay and economic viability of speciality milk products

By Andrew Jones

Industrial change over the past century has driven a decline in UK dairy farming. This study examines potential diversification within the sector through investigating consumer demand and the economic viability of 'speciality' milk products. The data for this study was collected from both consumers and producers in order to produce a model integrating both supply and demand economics. Information from consumers was collected via a questionnaire whereby dairy farming knowledge, opinion and willingness to pay (WTP) for speciality milk products was investigated. As economic or production data for speciality products is not readily available, this information was gathered through multiple case studies. A significant proportion of respondents claimed they would be willing to pay more for milk from all three speciality factors, with locally produced milk defined as the most important factor with the highest proportion of 'yes' responses and the highest WTP value. A regression analysis was used to predict willingness to pay from survey results and a significant regression equation was found using respondent estimates of both farmer milk sales share and average pint cost. An economic model was produced using both survey results and case study data in order to examine the economic viability of speciality products. The model suggests that the cost of reduced milk yield from rare breeds could be mitigated by consumer WTP, and that micro-dairies could be economically viable and substantially less susceptible to external fluctuations in costs than conventional farms. The results from this study support evidence from past studies on demand from local produce, provide insight into how new entrants into dairy farming could be encouraged through the use of micro-dairies and suggests a potential way of using rare breeds as added value milk producers which could improve their commercial viability.

Keywords: rare breeds, conservation, local produce, provenance, dairy marketing, micro-dairy, value added.

| Contents. | Page. |
|---|--------------|
| i. Copyright declaration | 1 |
| ii. Title page | 2 |
| iii. Author’s acknowledgements | 3 |
| iv. Author’s declaration | 4 |
| v. Abstract | 5 |
| vi. Contents | 6 |
| vii. List of Illustrations | 8 |
| a. Tables..... | 8 |
| b. Figures..... | 8 |
| c. Appendices..... | 8 |
| 1. Chapter 1. Introduction | 9 |
| 1.1 The UK Dairy Industry at present..... | 9 |
| 1.1.1 History..... | 9 |
| 1.1.2 Issues faced by the UK dairy industry..... | 12 |
| 1.2 Current milk marketing strategies..... | 17 |
| 1.2.1 Processing methods..... | 18 |
| 1.2.2 Alternative farming methods..... | 20 |
| 1.2.3 Product benefits..... | 22 |
| 1.3 Major costs involved in dairy farming..... | 23 |
| 1.3.1 Concentrates..... | 24 |
| 1.3.2 Veterinary and medicines..... | 24 |
| 1.3.3 Forage..... | 26 |
| 1.4 Willingness to pay..... | 26 |
| 1.5 Scope of this study..... | 28 |
| 1.5.1 Conceptual framework..... | 29 |
| 2. Chapter 2. Materials and methods | 30 |
| 2.1 Consumer questionnaire..... | 30 |
| 2.1.1 Outline..... | 30 |
| 2.1.2 Data collection site..... | 30 |
| 2.1.3 Questionnaire development..... | 31 |
| 2.1.4 Questionnaire data collection..... | 34 |
| 2.1.5 Questionnaire data analysis..... | 34 |
| 2.2 Producer case studies..... | 37 |
| 2.2.1 Outline..... | 37 |
| 2.2.2 Case study data collection..... | 38 |
| 2.2.3 Case study data analysis..... | 39 |
| 2.3 Dairy economic model..... | 40 |
| 3. Chapter 3. Results | 42 |
| 3.1 Consumer questionnaire..... | 42 |
| 3.1.1 Consumer profile..... | 42 |
| 3.1.2 Willingness to pay (WTP)..... | 43 |
| 3.1.3 Effect of respondent characteristics on question responses..... | 46 |

| | |
|--|------------|
| 3.1.4 Seal Sanctuary survey..... | 51 |
| 3.1.5 Regression analysis..... | 53 |
| 3.2 Producer case studies..... | 55 |
| 3.2.1 Case study 1. Milk vending machine..... | 55 |
| 3.2.2 Case study 2. Micro-dairy..... | 56 |
| 3.2.3 Case study 3. Free range cows..... | 57 |
| 3.2.4 Case study 4. Raw milk..... | 58 |
| 3.2.5 Case study 5. Rare breed cattle..... | 59 |
| 3.3 Dairy economic model..... | 61 |
| 3.3.1 Dairy economic model annotation..... | 62 |
| 3.3.2 Premium dairy economic model..... | 63 |
| 4. Chapter 4. Discussion..... | 64 |
| 4.1 Consumer survey..... | 64 |
| 4.1.1 Willingness to pay..... | 64 |
| 4.1.2 Effect of respondent characteristics on question responses | 67 |
| 4.1.3 Comparison with Seal Sanctuary survey..... | 70 |
| 4.1.4 Limitations of survey..... | 72 |
| 4.2 Dairy economic model..... | 76 |
| 4.2.1 Model overview..... | 76 |
| 4.2.2 Sensitivity analysis..... | 77 |
| 4.2.3 Premium economic model..... | 81 |
| 4.3 Consumer survey as a predictive model..... | 81 |
| 4.4 Case studies..... | 83 |
| 4.4.1 Consumer demand for local produce..... | 83 |
| 4.4.2 Entrepreneurship..... | 83 |
| 4.5 Conceptual framework..... | 84 |
| 4.5.1 Consumer survey..... | 85 |
| 4.5.2 Case studies..... | 85 |
| 4.5.3 Comparison to national statistics..... | 85 |
| 5. Chapter 5. Conclusions..... | 86 |
| 5.1 Rare breed cattle..... | 86 |
| 5.2 Small herd sizes..... | 88 |
| 5.3 Local produce..... | 90 |
| 5.4 Recommendations..... | 90 |
| 6. Chapter 6. References..... | 92 |
| 7. Chapter 7. Appendices..... | 101 |

List of illustrations.

| Tables. | Page. |
|--|--------------|
| Table 1. Summary of case studies used and major factors of interest..... | 39 |
| Table 2. Summary of consumer profile responses..... | 43 |
| Table 3. Dairy economic model..... | 61 |
| Table 4. Dairy economic model input annotation..... | 62 |
| Table 5. Premium dairy economic model..... | 63 |
| Table 6. Effect of increase in oil price..... | 78 |
| Table 7. Effect of decrease in milk value..... | 80 |

| Figures. | |
|--|----|
| Figure 1. Average yearly variable costs per cow..... | 23 |
| Figure 2. Conceptual framework for the scope of the study..... | 29 |
| Figure 3a. Cumulative percentage of willingness to pay for rare breed milk..... | 44 |
| Figure 3b. Cumulative percentage of willingness to pay for small herd milk..... | 45 |
| Figure 3c. Cumulative percentage of willingness to pay for locally produced milk.... | 45 |
| Figure 4. The effect of age on WTP _r , WTP _I & WTPs..... | 47 |
| Figure 5. The effect of age on respondent estimate of average pint cost..... | 47 |
| Figure 6. The effect of age on respondent estimates of average & small herd sizes. | 48 |
| Figure 7. The effect of respondent level of education on WTP _r , WTP _I & WTPs..... | 48 |
| Figure 8. The effect of respondent income on WTP _I | 49 |
| Figure 9. Milk vending machine..... | 56 |
| Figure 10. Outdoor milking bail..... | 58 |
| Figure 11. Rare breed Gloucester cattle..... | 60 |
| Figure 12. Consumer average pint cost estimates from questionnaire..... | 73 |

| Appendices. | |
|---|-----|
| Appendix 1. Dairy farming timeline..... | 101 |
| Appendix 2. Consumer questionnaire poster..... | 102 |
| Appendix 3. Pilot questionnaire (open)..... | 103 |
| Appendix 4. Pilot questionnaire (pay card)..... | 106 |
| Appendix 5. Consumer questionnaire (final)..... | 109 |

Chapter 1. Introduction.

The UK Dairy industry has undergone considerable change over the past century brought about by an increasing population (Tilman *et al.*, 2011), changes in government policy (Empson, 1998; Bates and Stephen, 2003), cultural shift (Sayid, 2016; Bates *et al.*, 2017) and ever developing technology (Grant, 1998; Capper, Cady and Bauman, 2009; Woods, 2014) (see Appendix 1). These changes led to substantial growth within the dairy industry in the decades following the Second World War, but have now left the industry with low milk prices being paid to producers (Agriculture and Horticulture Development Board, 2016), ever expanding herd sizes (Baker, 2015) and the deterioration of many functional traits within dairy cattle, caused by prolonged selection for enhanced productivity (Boichard and Brochard, 2012). The aim of this study is therefore to investigate opinion and demand for ‘speciality’ milk products in order to encourage diversification within the industry and better inform producers on how to market their milk products.

1.1 The UK Dairy industry at present

1.1.1 History

During the 19th century the majority of UK agriculture involved small-scale, multi-purpose farms each consisting of multiple farming methods (arable, dairy, eggs and livestock etc.) (Clothier *et al.*, 2008). This format was driven by the demand for food as produce needed to be consumed locally due to the lack of refrigeration and transport technology available at the time. Milk has always been a particularly difficult product to market as it is liquid, heavy and perishes rapidly (Empson, 1998). Because of this, the majority of milk was either delivered locally by the producer, or sold to milk processors who would then bottle and deliver the milk.

During this period most dairy cows were native breeds such as the Ayrshire or Shorthorn (Castle and Watkins, 1979), and were selected for multiple traits including hardiness, fertility and calving ability, in addition to milk yield. Milking was conducted either by hand or as technology developed, through the use of hand-portable milking machines.

Following the First World War, the global recession led to the price of milk and other agricultural products collapsing (Cole and Ohanian, 2002). This in turn led to the formation of the Milk Marketing board in 1934 (Empson, 1998). The Milk Marketing Board (MMB) was a government approved cooperative of producer-elected representatives, created to control the production and distribution of milk products and therefore guaranteeing a minimum price paid to producers. This provided stability for producers and a steady supply of milk availability for consumers.

During the Second World War, much of the land used for pasture was converted into wheat fields to provide food for rationing (Bowers, 1985). Dairy production was protected somewhat by the School Milk Act 1946, which guaranteed that children under 18 received a third of a pint of milk a day. Following the end of the war the government was keen to encourage agricultural growth in order to end rationing and reduce the country's reliance on food imports. This culminated in The 1947 Agriculture Act which aimed to provide 'stability and efficiency' and guaranteed the price paid to farmers for many agricultural products (Burkitt and Baimbridge, 1990). This act inevitably encouraged substantial expansion within the dairy industry and led to many new entrants into dairy farming.

In conjunction with the financial incentives provided, advancing technology allowed farmers to increase their output. Milking parlour technology development meant that a larger number of cows were able to be milked with reduced labour, for example; the introduction of the Herringbone milking parlour meant that over a hundred cows could be milked by a single herdsman (Grant, 1998). Breeding genetics and artificial insemination (driven by the 'Breeding and Product division' of the MMB) meant that farmers were able to select for higher milk yields. From the 1970s onwards large scale imports of high-yielding Holstein Friesians from the USA began. Since then, Holsteins have become the dominant dairy cattle breed in Europe and led to a shift away from traditional native breeds (Oltenu and Broom, 2010). The culmination of these factors led to the UK's overall milk production increasing dramatically.

The United Kingdom joined the European Union in 1973 and shortly after; the Common Agricultural Policy. This identified the over-production of dairy products within Europe, leading to the national media regularly reporting on 'butter-mountains' and 'milk-lakes' during the 1980's (Reinhorn, 2007). Due to this overproduction, the milk quota system was introduced as part of the Dairy Produce Quota Regulations 1984 (Kempen *et al.*, 2011). This system restricted the amount of milk farmers were allowed to produce and was originally intended to run until 1989 in order to stabilise European milk production.

In 1994 the Milk Marketing board was disbanded (save for residual duties) which meant the deregulation of the sector and a competitive market for milk being re-established (Fearne and Ray, 1996). Due to the increased buying power of supermarkets, this led to a strongly consumer-driven market for dairy products which resulted in milk prices dropping gradually.

This has led to a significant decrease in the numbers of dairy herds, with the remaining herds increasing in scale in order to reduce the production cost per unit of milk (Huettel and Jongeneel, 2011).

1.1.2 Issues faced by the UK dairy industry

1.1.2a) Loss of dairy cattle breed diversity

The number of cattle breeds used within the UK dairy industry has steadily declined over the past few decades and at present, of the c.3 million dairy cows within the UK, around 98% belong to one of only 3 breed types; 'Black and white' (Holstein Friesian, British Friesian & cross breeds), Jersey and Ayrshire (DEFRA, 2008). The reason for this decline can largely be attributed to modern dairy systems favouring breeds which are selected for high milk yields. This situation also occurs within other European countries. A study on threatened cattle breeds in Italy suggested that the increase in single-purpose cattle breeds meant they were indeed replacing more multipurpose traditional breeds (Zander *et al.*, 2013).

Genetic selection on dairy cattle has led to multiple improvements over time, including increased milk yield and decreased production costs (VanRaden, 2004). Intensive selection for particular traits has however, resulted in detrimental effects in other areas. Within the Holstein breed in particular, long-term intensive selection for higher productivity has driven the deterioration of many functional traits. This includes female fertility, disease resistance and longevity (Boichard and Brochard, 2012). Intensive selection on phenotype can also drive a genetic bottleneck effect which leaves species inflexible and vulnerable to future threats, such as climate change and disease outbreaks (Rege and Gibson, 2003).

Protecting genetic diversity through conservation of animal genetic resources (AnGR) therefore has value in itself. Maintaining variation within species thus provides us with a critical resource, which can potentially be exploited in future in order to improve both adaptability and production. The loss of this genetic information through extinction of a threatened breed, would be impossible to recreate if it was later required. This value is recognised by the European Council which offers 'payment scheme' incentives to farmers who rear local, traditional breeds which are at risk. This contribution is often inadequate at covering costs incurred from rearing such breeds (Signorello and Pappalardo, 2003) meaning if conservation efforts are to succeed, costs must be met through other means.

Past studies in Europe have suggested that the general public are willing to support the conservation of threatened breeds and are in favour of public funding being used to aid conservation efforts (Zander *et al.*, 2013). As has been previously mentioned, this funding is seldom sufficient at meeting the monetary costs required. It could be suggested that public willingness to pay for conservation could be harnessed in other ways. Although there are currently limited studies surrounding the concept; products derived from threatened breeds could provide added value, provided the consumer was aware of its origin.

1.1.2b) Increasing dairy herd size

The average dairy cattle herd size within the UK has been steadily increasing and currently stands at around 142 cows (Agriculture and Horticulture Development Board, 2016). Rising costs within the UK dairy industry favour a larger herd size as increasing output provides a way of offsetting costs by diluting the costs of production (Huettel and Jongeneel, 2011; WSPA, 2011).

The effect of dairy herd size on animal welfare is a controversial issue and it has been argued that higher cattle densities lead to a lower level of animal welfare. For example it has been suggested that higher densities of cattle results in higher levels of aggression between animals, and that large herds are required to walk further in order to obtain sufficient grazing. Regardless of the actuality, it has been suggested that public opinion on the issue is that larger herds are seen as having a lower level of animal welfare (Broom, 2013).

The scale of conventional dairy farms also means it is becoming increasingly difficult for new entrants into the sector to raise enough funds to begin dairy farming (Stokes, 2006). According to a study conducted in Ireland the average herd size of a dairy start-up is around 70 cows, with a projected set up cost of €190,114 (£144,799) (McDonald *et al.*, 2015).

Large scale dairy herds also have a significant impact on the production of greenhouse gases (GHG). Recent climate change is driven by an increase in GHG, chiefly caused by human industrial activity (Montzka, Dlugokencky and Butler, 2011) with an estimated 35% of emissions originating from agriculture (Monteny, Bannink and Chadwick, 2006). Livestock farming in particular can be identified as a major contributor with methane and nitrous oxide being the gases of main concern (Place and Mitloehner, 2010). Although a reduction in herd size may not necessarily reduce the amount of overall gases produced by animals (a number of small herds would produce no more than one large herd, provided both contained equal head of cattle), small and local herds could mean reduced mechanisation and transportation to consumers, thus reducing overall emissions produced. A reduction in herd size could thus help to reduce both factors and could potentially still prove viable, through the emerging micro-dairy approach.

The basic concept of a micro-dairy is to reduce the overall scale of farming thus reducing overheads and costs. This reduction in scale is inclusive of land, equipment and herd size (Levitt, 2014; O'Connell, 2014). To make up for lost income the product is supplied directly to the consumer (ensuring a higher percentage of milk sale value received by the producer) and value is added through perceived higher welfare, provenance and a focus on higher-quality small batches. As this is an emerging concept that works against modern industry trends, there is minimal literature directly relating to micro-dairies (Wathen-Jones, 2015) however, many parallels may be drawn with other micro-industries.

Micro-breweries are a spreading phenomenon throughout Europe and USA. In the USA, the number of micro-breweries grew rapidly in the late 1980s and 1990s, from 21 breweries in 1985, to 88 breweries in 1991 (Wesson and De Figueiredo, 2001) and numbering several hundred more at the present date. The reason for their success is predominantly due to them being specialists, and offering differing tastes to those offered by national brewers who have committed themselves to more generalist strategies. This strategy allows them to capitalise on a narrow segment of the market, and gain a high market share within that segment, as opposed to marketing to a broader cross-section of consumers and risking having a lower appeal and lower customer loyalty. This tactic is evident in successful micro-dairies who market their milk, not at consumers seeking a generic product at the lowest price, but at those willing to pay more for a product which is deemed to have better ethical values, is of a higher quality and is produced from cattle with a higher standard of perceived animal welfare.

1.1.2c) Centralisation of processing

Modernisation within the food industry has meant an increase in the amount of processed foods we eat. Combined with faster and more efficient transport, this has in turn meant an increase in 'food miles' (Giovannucci, Barham and Pirog, 2010; Kemp *et al.*, 2010). Food miles can be defined as the number of miles a product has to be transported to get from producer, through various stages of processing until it reaches the supermarket and finally the consumer (Saunders and Barber, 2008). This concept has become increasingly relevant in recent years as food products which must be transported a long distance require the burning of more fossil fuels, which in turn increases the amount of GHG released into the atmosphere (Caputo, Nayga and Scarpa, 2013). Encouraging consumers to buy more locally produced food has therefore been one method of attempting to reduce this effect (Schnell, 2013).

Numerous studies have suggested that consumers are willing to pay more for domestic or local food products (Ehmke, 2006; Lusk *et al.*, 2006; Loke, Xu and Leung, 2015). Specific product provenance is suggested to be a more effective marketing strategy as geographical indications (e.g. South West England) are attributed, rather than being owned or trademarked. A study conducted in Italy investigated consumer willingness to pay for milk products specified as being produced in Italy. As 41% of Italy's milk is used in the production of Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) labelled dairy products (cheese, yoghurts etc.), a large proportion of the liquid milk consumed in Italy has to be imported from surrounding countries. As the production cost of imported milk is substantially lower than domestic milk, it is in the interest of Italian producers to add value to their produce in order to remain competitive. Country of origin

labelling (COOL) was found to be a powerful marketing tool, and was effective at adding value to domestic products (Tempesta and Vecchiato, 2013).

This price premium could therefore be of significance to dairy farmers however, there have been limited studies on the added value of milk marketed as being produced locally. A study conducted in Hawaii investigated potential added value of organic and local milk (Loke, Xu and Leung, 2015). The study looked at consumer preference for fluid milk sold in Hawaii through hedonic price modelling, whereby a product is considered as a number of contributing attributes, each having individual value. The findings suggested an estimated 24.6% premium for organic milk, and a 17.4% premium for milk that was labelled as local. This suggests a potential added value for local milk products, provided appropriate marketing strategies are implemented.

There have been multiple international studies conducted regarding COOL (Lusk *et al.*, 2006; Lagerkvist *et al.*, 2014) however, there are limited studies within the literature regarding regional provenance, particularly of milk products. Regional origin labelling is a strategy already used by some milk retailers in the UK. As the majority of liquid milk consumed within the UK is domestically produced, there have been limited studies conducted within the UK regarding milk product provenance, and even fewer regarding added value of regional milk provenance labelling within the UK.

1.2 Current milk marketing strategies

The UK liquid milk market is currently valued at around £2.9 Billion, and while the value of the sector has grown by 0.2% over the last year, the volume produced has continued to

decline (Agriculture and Horticulture Development Board, 2016) and has reduced by a further 1.8% over the past year (Organic Milk Suppliers Cooperative, 2017). Within the liquid milk sector in 2016, 81% of liquid milk sold was defined as 'standard milk', 6% was 'dairy alternatives', 6% was 'filtered', 5% was 'organic' and 2% was defined as 'other' (Organic Milk Suppliers Cooperative, 2017).

In recent years the steady decline in 'standard' milk demand has been partially attributed to an increase in the number of individuals identifying as vegan, particularly among the younger generations. In direct response to this some brands have implemented a strategy of increasing the focus on ethical values surrounding milk production. This has resulted in an increase in organic milk sales, and also farmer organisations launching 'free-range milk' products (Mintel, 2017). In order to appeal to younger consumers, certain brands (such as Cravendale) have focussed their advertising on the quality and health benefits of milk, but also on attempting to promote the product as both fun and versatile (Mintel, 2017).

A market report conducted in May 2017 by Mintel has also suggested that the majority of existing milk buyers would be willing to pay more for milk than supermarkets already charge, suggesting an opportunity for premium milk products. The following section outlines the various ways liquid milk is currently marketed in the UK, in order to provide context for potential niche areas of the industry.

1.2.1 Processing methods

The vast majority of liquid milk sold in the UK will go through a number of processes before it is bottled and sold. Some of these processes are not necessarily essential for preparing the

milk to be safely consumed, and there are some perceived benefits and potential added value in bypassing some of these procedures. The following sections outline the major processes currently used.

1.2.1a) Homogenisation

The majority of milk in the UK is sold as homogenised, a process by which milk is pumped at high pressure through a disruption system, in order to break down the fat globules present (Köhlera and Schuchmann, 2011). This process is used in order to improve product properties such as colour and consistency. Homogenisation became popular in the UK during the late 1970s when supermarkets began selling milk and required a more standardised product. As homogenisation reduces the size of the fat globules present in milk there is evidence that fat from processed milk is more easily absorbed into the gut (Berton *et al.*, 2012). Due to this, there is presently some debate as to the effect of homogenised milk on human health (Michalski and Januel, 2006), meaning there could potentially be a market for milk which remains non-homogenised.

1.2.1b) Pasteurisation

Pasteurisation is the method by which milk is treated in order to destroy any organisms present, so that the potential impact on human health is reduced and shelf life is extended (Holsinger, Rajkowski and Stabel, 1997; Boor, 2001). The current most common method for pasteurising milk is 'High Temperature Short Time' (HTST) pasteurisation whereby milk is heated to 72°C for at least 15 seconds (Food Standards Agency, 2010).

Since 1945 the vast majority of milk in the UK has been sold as pasteurised and indeed pasteurisation of milk is a legal requirement in many countries (including USA and Scotland). In England it is illegal to sell raw drinking milk (RDM) from a shop (Food Standards Agency, 2017). It is however, still legal to sell raw milk from the farm gate or from a milk-round. Raw milk sales make up around 0.01% of liquid cow milk sales in the UK, with around 100 producers in 2016 (Food Standards Agency, 2017). It has widely been suggested that there are various health benefits to drinking milk raw, such as protecting against allergies (MacDonald *et al.*, 2011; Van Neerven *et al.*, 2012). In addition to potential health benefits, selling raw milk at the farm gate can mean a reduced setup cost through not purchasing expensive pasteurisation equipment.

1.2.2 Alternative farming methods

The majority of liquid milk sold in the UK is produced via 'conventional' dairy farming techniques, and therefore marketed without reference to its production method. This section outlines the various ways that milk products are currently marketed with regard to alternative agricultural methods.

1.2.2a) Organic

Organic farming is the most widespread 'alternative' farming method with the global Organic food and drink market being valued at \$82bn in 2017 (Organic Milk Suppliers Cooperative, 2017). According to 'The Soil association' *"Organic is a 'whole system' approach to farming and food production. It recognises the close interrelationships between all parts of the production system from the soil to the consumer"* (Soil Association, 2014). In effect this means in order to qualify as organic, animals must be kept to a high level of

welfare, there must be no routine use of antibiotics, no artificial chemical fertilizers or pesticides and cows must be 'free-range' and have a 'natural, grass-based diet'. Dairy is the biggest organic food and drink sector, with organic milk representing 2.5% of the total UK liquid milk market (Agriculture and Horticulture Development Board, 2016).

1.2.2b) Free-range

Free-range milk labelling was started in the UK by Neil Darwent in 2014 and aims to; *'Promote the value of pasture based milk production on British dairy farms for the benefit of farmers, cows and consumers'* (Darwent, 2017). In order to qualify as 'free range', milk must come from *'traditional pasture-based farms where the cows have at least 180 days and nights outdoor grazing a year'* (ASDA, 2017). In March 2017 ASDA became the first major UK retailer to stock milk with 'Pasture Promise Guarantee' labelling, which is now available in some Morrisons and Co-op stores (Darwent, 2017).

Free range milk is not aimed at being mutually exclusive from Organic (Organic milk is also required to be 'free range') rather it is intended to both provide a specified number of days cows must be grazed outdoors, and show recognition for farmers who graze their cattle outdoors, but are not necessarily eligible for Organic certification.

1.2.2c) Pasture fed

Increasing controversy surrounding zero-grazed dairy systems has led to consumers becoming more aware of the diets being fed to dairy cows (Newsbeat, 2017). This has led to more products being labelled as 'grass-fed' or 'pasture-fed', particularly in the USA where zero-grazed herds are seen as the dairy industry standard, with some calling 'grass-fed' the

new Organic (Dairy Foods, 2006; Siegle, 2016). As above, pasture-fed milk is not unrelated to either Organic or free-range products; it merely highlights the cow's diet as a way of appealing to a specific consumer requirement.

1.2.3 Product benefits

1.2.3a) A² milk

The presence of differing protein structures in milk called β -caseins was first discovered in 1979 (Brantl *et al.*, 1979). In 2009 the European Food Safety Authority (EFSA) recognised that these differing β -caseins (A¹ and A²) are digested by the human intestine in different ways (De Noni *et al.*, 2009). Multiple studies have shown that individuals who experienced intestinal discomfort through drinking conventional milk had significantly reduced effects when consuming milk containing exclusively A² β -caseins (Ho *et al.*, 2014; Jianqin *et al.*, 2016).

A² milk marketing was started by Dr Corran McLachlan in Australia after he founded the 'A² Milk Company' in 2000 and has since spread to New Zealand, USA and the UK (Mellentin, 2003b). A² milk has been available in the UK since 2012, but currently has a low level of popularity potentially due to a lack of product marketing (Hilpern, 2014).

1.2.3b) Night-milk

Melatonin is a hormone produced by mammals which helps to regulate the circadian rhythm (sleep cycle) (Carter and Juurlink, 2012). Bovine milk contains levels of melatonin and some studies have suggested that cows milked at night have a higher level of melatonin in their milk (Milagres *et al.*, 2014). Drinking milk with high melatonin levels has been shown

to improve sleep quality (Valtonen *et al.*, 2005) leading to some companies marketing milk with high-melatonin levels as ‘Night-milk’, ‘Lullaby milk’ or ‘Slumber-milk’. ‘Night-milk’ has been marketed in the UK since 2002 as a sleeping aid for both adults and children, and was initially a success for dairy company ‘Red Kite’ (Mellentin, 2003a), although in recent years popularity has waned.

1.3 Major costs involved in dairy farming

Profitability in dairy farming is heavily reliant on both milk yield and the amount farmers are paid per litre of milk produced, but also involves a large amount of capital and high overheads compared to other agricultural sectors (Castle and Watkins, 1979; South West England Farm Business Survey, 2017). This section aims to outline the most significant variable costs in dairy farming which will therefore highlight the greatest financial constraints for speciality milk producers to overcome.

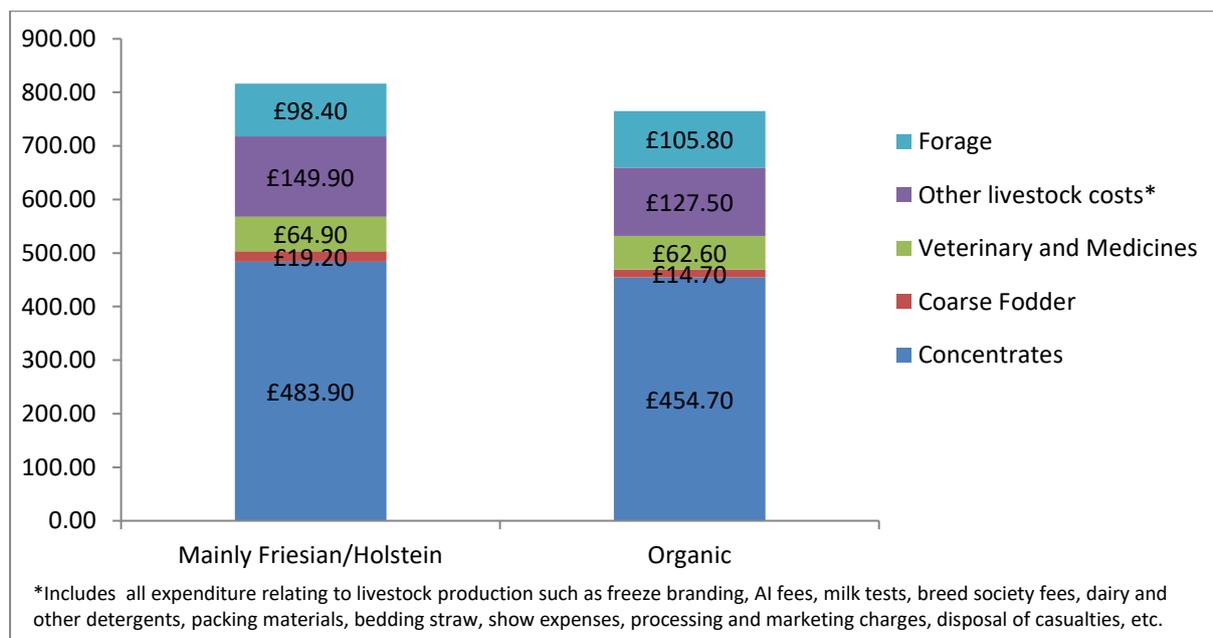


Figure 1. The average yearly variable costs per cow for both Organic and ‘Mainly Friesian/Holstein’ herds (Rural Business School, 2017).

1.3.1 Concentrates

Concentrates are dietary supplements which meet a specific nutritional demand not filled by the basal diet (de Oliveira *et al.*, 2010). According to the 'South West England Farm Business Survey' (Rural Business School, 2017) concentrates account for 59% of the variable costs encountered for 'herds containing mainly Friesians/Holsteins' (Figure 1).

This cost looks set to increase further in future as an increase in global oil prices has led to a hike in world grain prices, which in turn has seen concentrates rise from £150/£160 per tonne to around £250 per tonne (WSPA, 2011).

Organic farming constraints require farmers to grow as much feed as possible on the farm as the majority of dry-matter feed must come from forage (Soil Association, 2014), meaning a lower amount of concentrates are used (DairyCo, 2017). Despite this, concentrate costs remain high due to organic concentrates having a higher production cost than non-organic concentrates. According to 'South West England Farm Business Survey' statistics, the average concentrate cost for organic dairy farms was slightly higher than non-organic at 64% of the total variable cost (Figure 1).

1.3.2 Veterinary and medicines

The second highest variable cost in dairy farming is 'veterinary and medicine' (Rural Business School, 2017). The most costly diseases and health issues affecting dairy cows are mastitis, lameness and fertility problems (Esslemont and Kossaibati, 1996) and selection for higher milk yield has exacerbated all three of these conditions in recent decades (Jones, Hansen and Chester-Jones, 1994; Boichard and Brochard, 2012). Veterinary and medicine costs account for 7.95% of all variable costs in mainly Friesian/Holstein herds, and are only

marginally lower in organic herds at 7.13% (Figure 1). A significant factor regarding these costs in dairy herds is that they often directly affect milk output, and therefore incur an additional indirect cost (Dijkhuizen and Morris, 1997).

Mastitis is considered the most prevalent and costly disease affecting dairy cow herds in developed countries (Seegers, Fourichon and Beadeau, 2003). In addition to the cost of medical treatment, mastitis depresses milk yield and can result in a considerable quantity of milk being discarded and extra culling of animals (Esslemont and Kossaibati, 1996). Intensive selection for increased milk yield has led to the average yield doubling in the last 40 years (Oltenacu and Algers, 2005) and despite advances in veterinary medicine techniques, mastitis prevalence has grown as a result of increased milk yield (Broom, 2001).

Lameness is considered the second most important disease found in dairy herds as it affects milk yield (through stress and reduced appetite) and extends calving intervals (Esslemont and Kossaibati, 1996). Lameness also accounts for a substantial percentage of cows needing to be culled (Esslemont and Kossaibati, 1997). An increased milk yield has also been associated with an increase in lameness (Amory *et al.*, 2008). Increased milk yield is strongly correlated with increased udder dimensions (Gowen, 1920) and in turn, this causes an impediment to perfect gait which has been correlated to an increase in lameness prevalence (Boelling and Pollott, 1998). Higher yielding cows are also at greater risk of metabolic disorders, which in turn has been associated with a reduction in hoof-horn quality and therefore increases the risk of lameness (Amory *et al.*, 2008).

Infertility is defined as the third highest veterinary costs, with the main issue being 'oestrus not observed' (Esslemont and Kossaibati, 1996) and is the most prevalent causative factor for culling (Esslemont and Kossaibati, 1997). The main cost provided by infertility is the extension of calving intervals, which increases the amount of time a cow is non-productive and therefore incurring costs to keep but without providing any economic gain (Dijkhuizen and Morris, 1997). There have been multiple studies suggesting that increased milk yield is strongly associated with an increase in fertility problems (Webster, 2000; Broom, 2001) which has over time led to a steady decline in bovine fertility with the pregnancy rate at first service decreasing from 56% in 1975-1982 to about 40% in 1995-1998; a decrease of about 1% per year (Royal *et al.*, 2000).

1.3.3 Forage

Forage costs constitute any economic cost which provides grown feed, and includes seeds, fertilisers and sprays (Rural Business School, 2017). Broadly speaking, forage refers to grazed pasture, but can also refer to other forage crops such as maize, turnips or kale (Castle and Watkins, 1979).

1.4 Willingness to pay

Willingness to pay (WTP) is defined as a measure of the maximum amount an individual is willing to pay for goods, or services that are of benefit to the individual (Gafni, 1998). WTP is a fast and efficient measure for estimating financial value; but it does have limitations. One of the main limitations of a WTP survey is the assumption that the respondent will answer with the truth. Even in an unbiased survey with no 'real world' ramifications, respondents may answer with either their idealised answer, or with an answer they deem to be the most

socially acceptable (Borger, 2013). This effect can be mitigated through anonymity and by removing direct contact with the interviewer.

A common method of estimating WTP is by using the contingent choice, or contingent valuation methodology. This method is often used to value specific changes from the status quo, and is therefore useful for measuring value associated with concepts not usually associated with financial cost, such as species conservation (Kaffashi *et al.*, 2015). There are four main types of contingent valuation method; firstly open-ended ('how much would you be willing to pay?'), secondly referendum ('the government creating X will cost you Y, would you vote in favour of such a proposal?'), thirdly pay-card ('how much would you be willing to pay; a, b or c' etc.) and finally bidding ('would you be willing to pay £1?, if yes then how about £2?' etc.) (Hanemann, Loomis and Kanninen, 1991).

This method has been widely used within marketing studies for estimating value added to speciality or organic products (Stefani, Romano and Cavicchi, 2006; Giuseppe, Hubbard and Scarpa, 2010; van Doorn and Verhoef, 2011; Tempesta and Vecchiato, 2013) and has been proposed as a way of estimating the value of novel agricultural products (Lusk and Hudson, 2004); however, there are few studies within the literature involving milk and fewer still conducted within the UK. A previously mentioned study in Italy (Tempesta and Vecchiato, 2013) used the contingent valuation method as an effective means for measuring willingness to pay for milk with: a) differing geographic origins; b) differing terrain origins (mountain, plains etc.); and c) rearing method. This suggests a similar method would be suitable for use within this study for investigating willingness to pay for milk originating from either Rare Breed dairy cattle, small herds or local herds.

1.5 Scope of this study

Within this study the 'speciality' milk products that were investigated fell into three categories; milk from small herds, milk from rare breed cattle and milk from local producers. In order to investigate the future potential of these three factors within the dairy industry, the main aims of this study can be broadly divided into two main sections; consumer willingness to pay for speciality milk products, and farmer ability to viably produce speciality milk products.

Consumer data was collected via a questionnaire study conducted at Dairyland Farmworld, and will examine consumer knowledge and opinion on the dairy industry and potential willingness to pay for milk involving certain speciality factors. This questionnaire will be necessary as although there have been extensive studies regarding consumer willingness to pay for organic products (van Doorn and Verhoef, 2011; Loke, Xu and Leung, 2015) and product provenance (Giovannucci, Barham and Pirog, 2010; Loke, Xu and Leung, 2015), there is little to no research into products involving rare breeds or small herd sizes.

Producer data will be collected via a series of case studies as although there is extensive data available regarding large, conventional or organic dairy farms via the Farm business survey (Rural Business School, 2017) there is limited data regarding production costs of the three speciality factors of interest.

1.5.1 Conceptual framework

As shown in Figure 2 the data from both sources will be combined with existing economic data from the Farm Business Survey and an economic model for the three speciality factors will be formulated in order to investigate the economic viability of farmers to produce milk using small herds (micro-dairies), rare breeds or by marketing the milk locally.

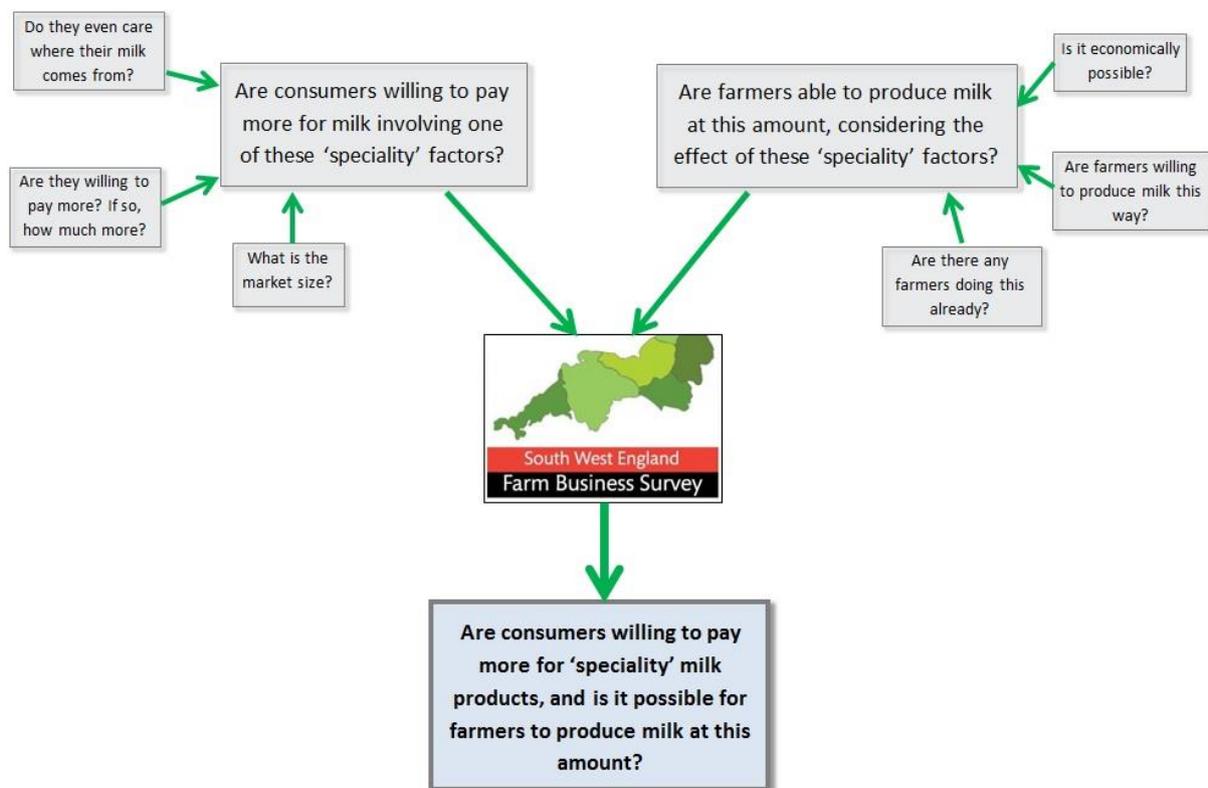


Figure 2. Conceptual framework for the scope of this study.

Chapter 2. Materials and Methods.

2.1 Consumer questionnaire

2.1.1 Outline

A consumer survey was used for the collection of willingness to pay data. Questionnaires (see Appendix 5) were completed by visitors to 'Dairyland Farmworld' from 24th of March to the 1st of October 2016. Participants were recruited through their own choice, but encouraged to do so via a prize-draw incentive. Participants were informed of the survey through posters (Appendix 2) placed around the site. As discussed in section 2.1.3, questions involved both multiple choice and short answers and investigated both willingness to pay for speciality milk products and consumer opinion and knowledge of the dairy industry.

2.1.2 Data collection site

Dairyland Farmworld (hereafter referred to simply as 'Dairyland') is a farm-park in Cornwall; a tourist attraction with a focus on animals and specifically dairy farming (www.dairylandfarmworld.com). The venue was primarily selected due to high footfall of consumer-aged persons. In order to test for any biased visitor opinion linked to the nature of the park (visitors to a dairy-themed attraction have the potential to be positively biased toward dairy farming) a small sample of surveys were conducted at a second site; the Cornish Seal Sanctuary Gweek (www.visitsealife.com/gweek).

2.1.3 Questionnaire development

A pilot survey was initially written to develop three key areas; firstly to develop functionality, secondly to investigate what potentially sensitive information respondents are willing to part with and finally to examine the style of questions which would reduce the amount of unnecessary information provided by the respondent.

The pilot study was circulated among friends and family of the author partially due to practicality, but mainly to ensure honesty of feedback to develop the structure of the survey. To facilitate feedback, space was provided for annotations and comments. The primary information required from the consumer questionnaire was whether consumers were willing to pay more for 'speciality' milk products, and if so how much more. This was implemented using 'willingness to pay' (WTP) methodology (Frew, Wolstenholme and Whynes, 2004; Giuseppe, Hubbard and Scarpa, 2010; Bai, Zhang and Jiang, 2013). As discussed in section 1.4 there are multiple types of WTP methodology and to decide which format would be most appropriate, both pay-card and open-ended techniques were used within the pilot study.

Pilot questionnaire respondents were divided equally into two separate treatments. 50% of respondents (n=11) completed 'Pilot A' (Appendix 3) which included 'pay-card' answers where a range of answers were provided for the respondent to choose from, for example;

Question 8. Would you be willing to pay more for milk from rare breeds of dairy cattle? If so how much? (Current average cost of a supermarket pint – 45p)

- A. No, I would not be willing to pay more*
- B. Yes, **less than 5p** per pint
- C. Yes, **5p** per pint
- D. Yes, **10p** per pint
- E. Yes, **15p** per pint
- F. Yes, **more than 15p** per pint

*If you answered A, please state why -

The remaining respondents completed 'Pilot B' (Appendix 4) which included 'open-ended' questions, where an open space was provided, for example;

Question 8. Would you be willing to pay more for milk from rare breeds of dairy cattle?
If so how much? If not, why not? (Current average cost of a supermarket pint – 45p)

.....
.....

The questionnaires received were then examined for functionality and ambiguity. Answers from 'open' questionnaires were often verbose, unclear (due to handwritten answers) and non-specific. Conversely, answers from 'pay-card' questionnaires were specific; however, the range of answers provided was insufficient, with a significant proportion of answers provided being outside the provided parameters.

A combination of methodologies was eventually used, with some questions being fragmented (would you be willing to pay more? if you answered yes, then how much more?) and a small space provided for answers which would only allow specific information to be entered, for example;

| |
|---|
| <p>Question 8. If you answered 'yes' to question 7, how much more would you be willing to pay per pint? (i.e. on top of what you are already paying)</p> <p>£ __ . __ p</p> |
|---|

The secondary aims of the questionnaire were to gauge consumer knowledge and opinion of the UK dairy industry. This was done with a combination of Likert scales (Likert, 1932) and short answer questions. Regarding consumer knowledge, respondents were asked to rate their knowledge on certain aspects from 1 to 5. Following this they were asked a specific question on the dairy industry in order to provide a proxy for 'actual knowledge' in order to compare 'perceived' and 'actual' knowledge, and therefore validate their rating.

Proxy questions for 'actual' knowledge were reviewed during the pilot study as many of the answers were available throughout the park. These were replaced with more general questions such as 'how much do you think an average pint of milk costs?'

Consumer opinion was measured in a similar manner, initially with a Likert rating followed by a validating question. Within the pilot studies information was initially provided in order to provide context, prior to the question being asked, for example;

'98% of dairy cows in the UK belong to one of three breeds; Friesian, Jersey and Ayrshire. Do you believe it is important to conserve rare breeds of dairy cattle?'

This information was later removed as it had the potential to introduce bias.

Personal details were the most difficult information to gather during the pilot study, as respondents were often unwilling to provide specific, personal information. These questions were then modified to categorical factors as participants were more willing to provide less specific answers. The most sensitive questions (age, education & income) were also moved to the end of the questionnaire, so if the respondent halted completion of the survey upon reading questions they felt uncomfortable to answer, they were still likely to submit the answers given to that point.

Informed consent was confirmed with a tick-box stating the participant was aware of the aims of the study and was happy to have their information used. Ethical approval was applied for through the University of Plymouth Faculty of Science and Environment Research Ethics Committee and was approved.

2.1.4 Questionnaire data collection

The survey was distributed to visitors of Dairyland Farmworld through hard-copy paper questionnaires being placed on a table with pen and return receptacle provided. In order to make respondents aware of the study, posters were placed around the site, with a large banner above the table (Appendix 2) informing the respondent of the reason for the study and encouraging them to complete a questionnaire via a prize draw incentive of three dairy-themed prizes (a block of cheese, toy cow and family pass to Dairyland). Winners were to be chosen following the end of the data collection period, whereby three questionnaires were selected at random and the winners contacted via the email address supplied.

Completed questionnaires were placed into a receptacle provided, which was regularly emptied in order to ensure participant confidentiality as some personal details were provided such as name and email address (for the prize-draw). Dairyland receives around 400 to 500 visitors per day during peak periods, and the survey received a response rate of c.3-6% per day. Information from completed questionnaires was transferred into a spreadsheet, following which questionnaires were kept until the information was fully collated, after which hardcopies were destroyed to keep information confidential. Data was later imported into the R v2.15.1 statistical package for further analysis.

2.1.5 Questionnaire data analysis

Initial data appraisal was conducted in Excel 2010, whereby basic descriptive tests were conducted in order to gain an indication of patterns within the data. This spreadsheet was then imported into the R statistical package. Data was initially analysed for the effect of respondent characteristics on question responses, particularly to investigate any significant

difference in WTP between demographic and economic groups. This was conducted using basic summary statistics and visual appraisal including measuring averages, and checking for normality of data with histograms.

In order to measure 'actual' knowledge of dairy farming, respondent estimations on both average herd size and price of a pint of milk were compared to the actual value. The estimates were subtracted from the actual value in order to provide an accuracy figure, which was used as a proxy for actual knowledge. Each question within the survey was given a 'short-name' in order to provide a quick reference and ease of analysis within statistical software, for example 'How much do you know about dairy farming?' was referred to as 'knowdairy'.

2.1.5a) Effect of respondent characteristics on question responses

In order to test for any effect of respondent characteristics on respondents answers (e.g. does gender have an effect on respondent willingness to pay), the data from Excel was imported into the 'R v2.15.1' statistical package. In order to decide on the statistical tests suitable, the data from each question was initially visually appraised in a histogram to assess normality, and then tested using a Shapiro-Wilk test. As all of the responses were non-normally distributed, non-parametric tests were used.

Wilcoxon signed-ranks tests were used to test for differences between two groups, for example testing for differences in dairy farming knowledge between individuals with a connection to the dairy industry and those without. To test for differences between multiple groups a Kruskal-Wallis test was used, for example to test for differences in average herd

size estimates between highest level of education categories. Where a correlation was investigated a Spearman's-rank correlation was used, for example to test for a relationship between average pint cost estimate and willingness to pay for local milk.

Data from the Seal Sanctuary survey was compared to responses from the Dairyland study in order to test for any significant differences between groups. For comparisons of counts of groupings, a Chi-squared test was used, except in instances where the sample size in one or more categories was lower than five whereby a Fishers exact test was used, for example to test the gender bias between sample sites. To test for differences between all other questions a Wilcoxon signed-ranks test was used.

2.1.5b) Cumulative percentage for willingness to pay

A cumulative percentage (or Pareto) chart was used to display frequency distribution and therefore define the proportion of 'premium' willingness to pay respondents. Charts were created for willingness to pay for rare breed milk (WTP_r), small herd size milk (WTP_s) and local farm milk (WTP_l) using Excel. From the cumulative percentage chart it was possible to define the top one-third of willingness to pay values, and an average of this proportion was defined as the 'premium' value for that factor.

2.1.5c) Linear regression model

In order to analyse the proportion of the variation in willingness to pay responses that can be explained via answers from other questions, and to potentially use the responses given as a tool to predict willingness to pay, a linear regression model was used (Cheng, Yin and Chien, 2015). As the data to be used was either continuous or on an ordered categorical

scale, a linear model was used rather than a generalised linear model. All appropriate data with either continuous or categorical responses were fitted in a maximal model, including responses on household size, average pint cost estimates, average dairy herd size estimates, estimates of farmer milk value share, age, education and income. All non-significant factors were removed using the 'step' function in R which deletes predictors in order to optimize the model. The AIC (Akaike Information Criterion) was then obtained for the model in order to select the most appropriate model (Bozdogan, 1987).

2.2 Producer case studies

2.2.1 Outline

In order to obtain financial and production data for speciality milk production, five case studies were conducted to gain information from existing producers. Obtaining fiscal data from a large sample of consumers meant a survey methodology was appropriate for consumer willingness to pay data, however due to the small number of niche producers currently producing speciality milk products, a survey methodology would not have yielded adequate data from producers. Furthermore, the information required from producers included qualitative data. A mixed method was therefore used within the study, comprising a survey to gather data from consumers, and case studies with informal interviews to gather information from producers. The information from both sources was eventually refined into data which was appropriate for use in the dairy economic model (section 3.3).

These case studies were initially selected via online searches using relevant keywords, contact with breed societies or via existing contacts within the sector. Producers who met the desired criteria were then divided into the three categories of interest (local, rare breed

and small scale) and contacted in turn. Those that were no longer active or unwilling/unable to provide information were discarded from the list. Within each category, the producers most willing to participate and provide information were contacted again, and farm visits arranged. Case studies were selected during the summer and autumn of 2016 and visited between October 2016 and July 2017. Informal interviews were conducted during farm visits which, combined with subsequent email correspondence, yielded information relevant for use within the dairy economic model.

2.2.2 Case study data collection

A substantial amount of financial and production data from commercial dairy farms is available through sources such as the Farm Business Survey. Conversely, information on 'speciality' production systems is either sparse or non-existent. The lack of large scale datasets for speciality milk producers therefore meant individual case studies of speciality producers was the most suitable method of collecting relevant information. Key areas where information was required included; the use of rare-breed cattle in dairy systems, milk products being sold locally, and the use of small-scale dairy systems (micro-dairies).

Case studies were primarily selected through the use of online search engines, where specific keywords such as 'micro dairy', 'rare breed milk' and 'local milk' were used. This often led to relevant news articles, which in turn yielded contact information for the producers involved. Relevant breed societies (e.g. Gloucester Cattle Society & Shetland Cattle Society) were also contacted, who provided contact details of relevant producers. Existing contacts within the dairy sector also provided some links to producers.

Producers, who met the required criteria, i.e. are currently producing milk involving one or more of the factors of interest, were contacted in turn. Those who responded and were willing to participate were visited and informally interviewed about how their business operates, and any relevant production or financial data was requested. The information gathered from these visits was summarised into short write-ups and any relevant information was included within economic models. Table 1 shows the case studies visited and the major factors of interest involved.

Table 1. Factors of interest involved within each case study.

| Speciality Factor | Case Study | | | | |
|--------------------|------------|----|----|----|----|
| | 1. | 2. | 3. | 4. | 5. |
| Local produce | ✓ | ✓ | ✓ | ✓ | ✓ |
| Non-Homogenized | ✓ | | | ✓ | ✓ |
| Rare breeds | | | | | ✓ |
| Micro-dairy | | ✓ | | | ✓ |
| Unpasteurised milk | | | | ✓ | ✓ |
| Organic | | ✓ | | | |
| Pasture fed | | ✓ | ✓ | | ✓ |

2.2.3 Case study data analysis

Data useful for economic models included the use of qualitative information. For example Gloucester cattle are known to have better longevity than Friesians, meaning they would incur a less severe depreciation cost.

Substantial economic data was provided from one case study consisting of all financial records from the previous 6 years. Information from these records was collated and averaged in order to provide an average cost for certain factors (veterinary medicines, concentrates, fuel and other general livestock costs).

2.3. Dairy economic model

In order to ascertain the viability of producing milk involving one of the three speciality factors previously discussed, an economic model was completed using information from three sources; willingness to pay from the consumer questionnaire, specific costs from producer case studies and general dairy farming costs from the Rural Business School farm business survey 2017.

2.3a) Willingness to pay value from consumer questionnaire

Within the consumer questionnaire willingness to pay was defined for three different factors; WTP_r, WTP_s & WTP_I (see 2.1.5b). From this information two values were defined from each factor; a mean willingness to pay to represent the average a positive respondent would spend, and a 'premium' willingness to pay, based on the average amount the top one third of respondents were willing to pay (using the same definition of 'premium' as used in the Farm Business Survey) in order to show the extent of a smaller but higher value customer base. These figures were then combined with the average price of a pint of milk in 2016, and this figure used as the price (pence/pint) within the model.

2.3b) Speciality production costs

During the case studies detailed in sections 3.2.1 to 3.2.5, producers were informally interviewed on various aspects of their particular method of production. These questions were generally tailored towards the specific case study. For example during the rare-breed case study visit, the producer was asked questions regarding aspects such as milk yield and quality and specific demand for produce from that breed, whereas in the local produce case studies the farmer was asked questions on demand and costs of processing and packaging the milk themselves. Case study visits were written in full in order to aid memory and some were published in the Rural Business School newsletter (Jones, 2017), with the remainder to be published in future editions.

Quantitative data regarding finances or production was transferred into the economic model. Any qualitative data regarding breed traits was recorded and used to influence values within the model, for example; Gloucester cattle are known to have lower milk yields than Friesian, so are likely to suffer less from lameness, mastitis and infertility, so veterinary and medicine costs within the model are reduced by 20% to compensate.

2.3c) Dairy production data

Dairy farming as a business has been widely studied and as such there is a substantial amount of data on all financial and production aspects of large scale dairy farming in the UK (South West England Farm Business Survey, 2017). As a result of this, the majority of the data used within the economic model used in this study was taken directly from existing data. This data was provided by the South West England Farm business survey, and specifically the Farm Business Management Digest 2017 (South West England Farm Business

Survey, 2017). Gross margins and variable costs per cow and per hectare for 'Mainly Friesian/Holstein' herds was taken from section 3; page 96, and information on fixed costs from section 2; page 38. Gross margin and variable costs per cow and per hectare for 'Organic milk production' was taken from section 3; page 97, and information on fixed costs from section 2; page 80.

Chapter 3. Results.

3.1 Consumer questionnaire

3.1.1 Consumer profile

Eight hundred and seventy five usable questionnaires were received, with 27 being received as spoiled or otherwise unusable. Economic and demographic data from respondents are displayed in Table 2. There was a heavy gender bias towards female with 75.01% of respondent being female. The vast majority of respondents bought dairy products (98.17%) and most of the respondents had no connection with dairy farming (86.40%).

The majority of respondents were the main grocery buyer (81.49%) and the most popular family size was 4-6 individuals (51.66%) closely followed by a family size of 1-3 (45.03%). Most of the surveys were completed by respondents visiting Cornwall (60.57%) and the most popular age group of respondents was 25-44 years old (65.60%).

The most common highest level of education achieved category was fairly split between A level (31.31%) and GCSE (30.86%) and the most popular income category was also fairly evenly distributed between £16,000 - £30,000 (30.86%) and £30,000 - £45,000 (25.83%).

Table 2. Summary of consumer profile responses

| Question | Response | | | | | |
|-------------------------------|----------------------------|-----------------------------|-----------------------------|-----------------------------|---------------------------|---------------------|
| Gender | Female (n=657) 75.01% | Male (n=217) 24.8% | N/A (n=1) 0.1% | - | - | - |
| Regularly buy dairy products | Yes (n=859) 98.17% | No (n=14) 1.6% | N/A (n=2) 0.23% | - | - | - |
| Connection with dairy farming | Yes (n=119) 13.6% | No (n=756) 86.4% | - | - | - | - |
| Main grocery buyer | Yes (n=713) 81.49% | No (n=162) 18.51% | - | - | - | - |
| Individuals in household | 1-3 (n=394) 45.03% | 4-6 (n=452) 51.66% | 7-9 (n=21) 2.4% | 10+ (n=4) 0.46% | N/A (n=4) 0.46% | - |
| Live in Cornwall or visiting | Cornwall (n=345) 39.43% | Visiting (n=530) 60.57% | - | - | - | - |
| Age | 15-24 (n=148) 16.91% | 25-44 (n=574) 65.6% | 45-64 (n=133) 15.2% | 65+ (n=17) 1.94% | N/A (n=3) 0.34% | - |
| Level of education | <GCSE* (n=72) 8.23% | GCSE* (n=270) 30.86% | A Level* (n=274) 31.31% | Degree* (n=175) 20% | Postgrad* (n=72) 8.23% | N/A (n=12) 1.37% |
| Income | 0-£16k† (n=152) 17.37% | £16k-£30k (n=270) 30.86% | £30k-£45k (n=226) 25.83% | £45k-£60k (n=110) 12.57% | £60k+ (n=72) 8.23% | N/A (n=45) 5.14% |

*or equivalent, † k denoting 1000

3.1.2 Willingness to pay (WTP)

WTP responses were collected for three different questions: Willingness to pay for milk from rare breeds (WTPr); willingness to pay for milk from small herds (WTPs); and willingness to pay for milk from local farms (WTPI). WTPr had 79.7% 'yes' responses (n=697) with a median WTP of an additional 50 pence per litre of milk, on top of existing milk value (IQR = 25-100) and a mean WTP of 69.8 ± 2.1 pence. WTPs had 66.5% 'yes' responses (n=582) with a median WTP of 50 pence (IQR = 20-100) and a mean WTP of 64.1 ± 2.2 pence. WTPI had 93.8% 'yes' responses (n=821) with a median WTP of 50 pence (IQR = 25-100) and a mean WTP of 71.4 ± 2.4 pence.

3.1.2a) Cumulative percentage

Figures 3a, 3b and 3c show a cumulative percentage of consumers' willingness to pay values. In effect this shows that $X\%$ of respondents were willing to pay X pence or less for the product specified. There are obvious 'steps' in the line of all three charts, and these are due to bids tending to cluster around known currency denominations (20 pence, 50 pence, £1 etc.) (Ryan and Spash, 2011).

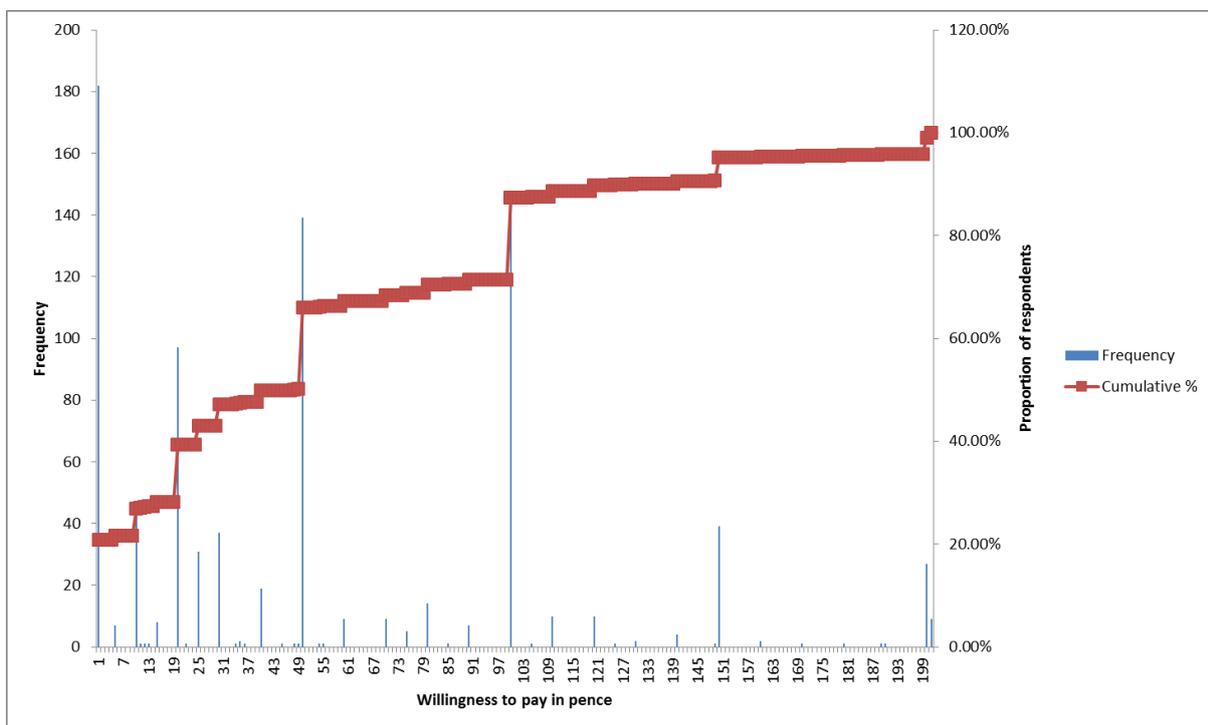


Figure 3a. Cumulative percentage of WTPr.

In Figure 3a, of the positive responses; 71.77% of respondents were willing to pay an additional 20p or more for milk from rare breeds, 49.83% were willing to pay an additional 50p or more, and 28.57% were willing to pay an additional £1 or more. The top one third of respondents were willing to pay an average of 123.03 pence, giving the premium WTPr.

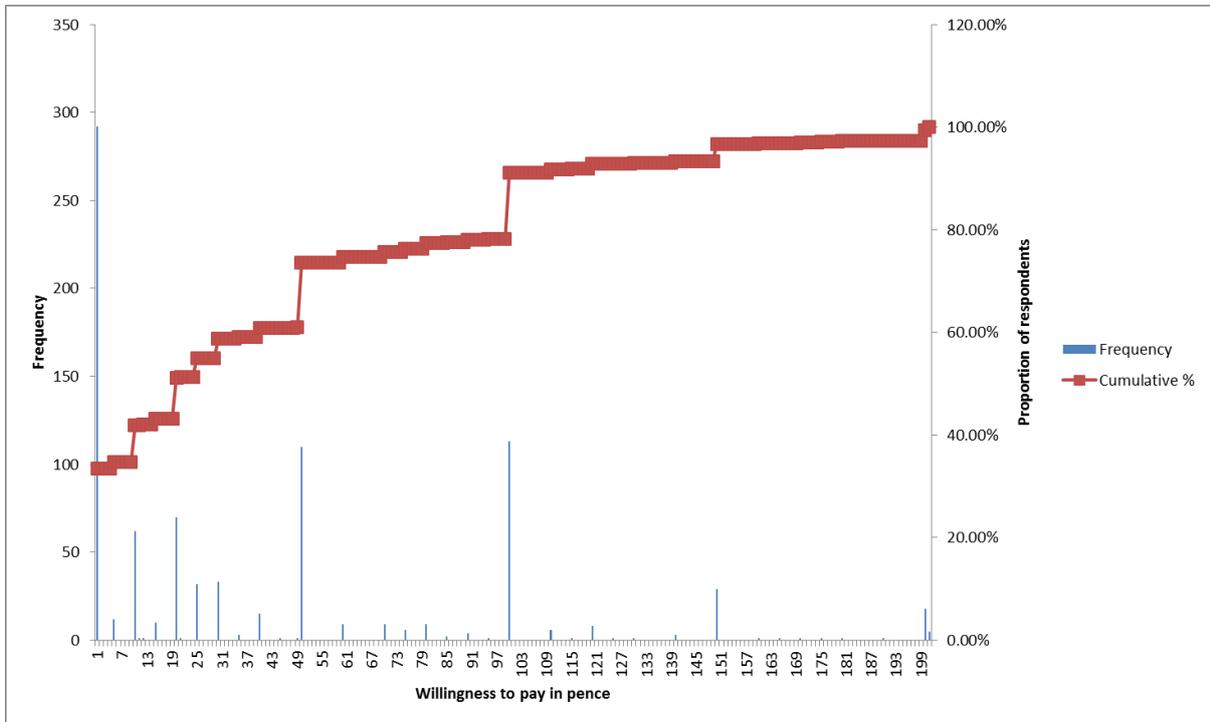


Figure 3b. Cumulative percentage of WTPs.

In Figure 3b, of the positive responses; 56.80% of respondents were willing to pay an additional 20p or more for milk from small herds, 38.97% were willing to pay an additional 50p or more, and 21.83% were willing to pay an additional £1 or more. The top one third of respondents were willing to pay an average of 116.95 pence, giving the premium WTPs.

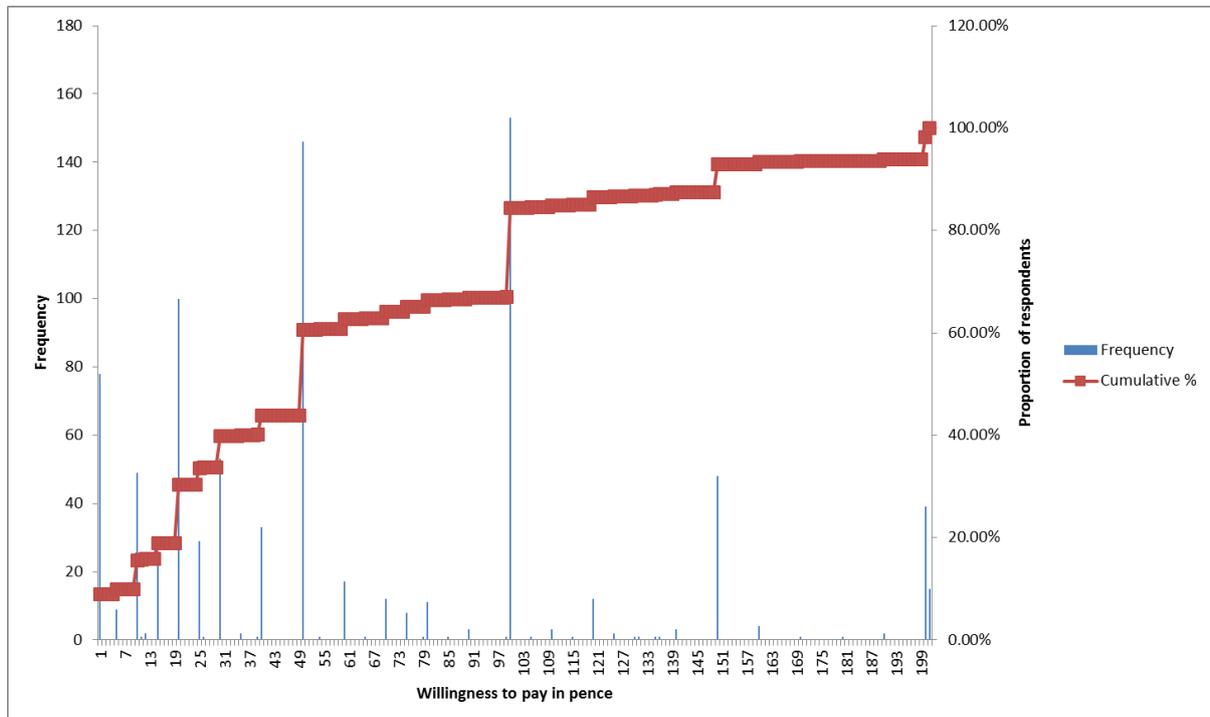


Figure 3c. Cumulative percentage of WTPl.

In Figure 3c, of the positive responses; 81.14% of respondents were willing to pay an additional 20p or more for milk from local farms, 56.11% were willing to pay an additional 50p or more, and 33.03% were willing to pay an additional £1 or more. The top one third of respondents were willing to pay an average of 134.82 pence, giving the premium WTPI.

3.1.3 Effect of respondent characteristics on question responses

Data was tested for normality using a Shapiro-Wilk test, which indicated all data was non-parametric. Differences between two groups were then tested using a Wilcoxon signed-ranks test, and differences between multiple groups were tested with a Kruskal-Wallis rank sum test. Where a relationship between two groups was tested, the data was tested for normality using a Shapiro-Wilk test and analysed with a Spearman's-rank correlation.

3.1.3a) Effect of respondent demographic

There was no significant effect of gender on the majority of responses, but there was a statistically significant difference between male and female answers for perceived knowledge of dairy farming ($W=64777$, $n=875$, $p<0.05$) with men claiming a higher level of perceived knowledge on a Likert scale (mean of 2.80 against 2.62). There was no statistically significant difference between male and female 'actual' knowledge, which was estimated using respondent estimates of herd size and average pint cost subtracted from the actual value, to give an accuracy figure which was used as a proxy for 'actual' knowledge.

Age had a significant effect on WTP for both rare breeds ($\chi^2=15.68$, $d.f.=3$, $p=0.001$) and local produce ($\chi^2=26.27$, $d.f.=3$, $p<0.001$), but not on small herd sizes (Figure 4).

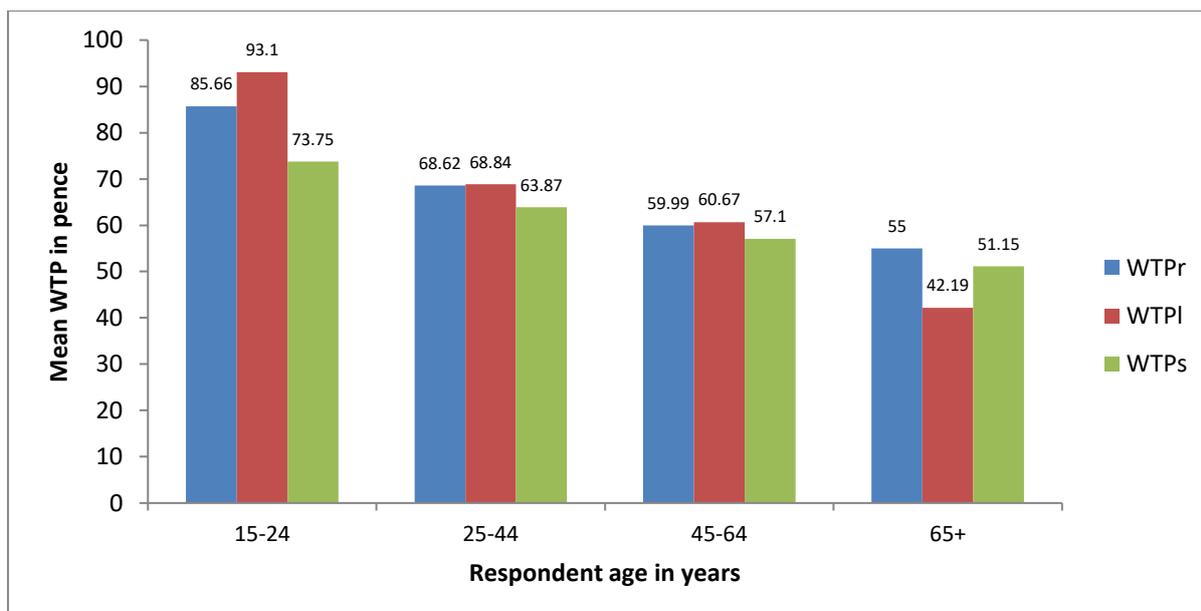


Figure 4. The effect of age on WTPr, WTPI & WTPs.

Age also had an effect on respondent knowledge with a significant difference between respondents estimate of the cost of a pint of milk (Figure 5) ($\chi^2=11.64$, d.f.=3, $p<0.01$), the average size of a dairy herd ($\chi^2=17.73$, d.f.=3, $p<0.001$) and the size of a small herd ($\chi^2=30.64$, d.f.=3, $p<0.001$) (Figure 6).

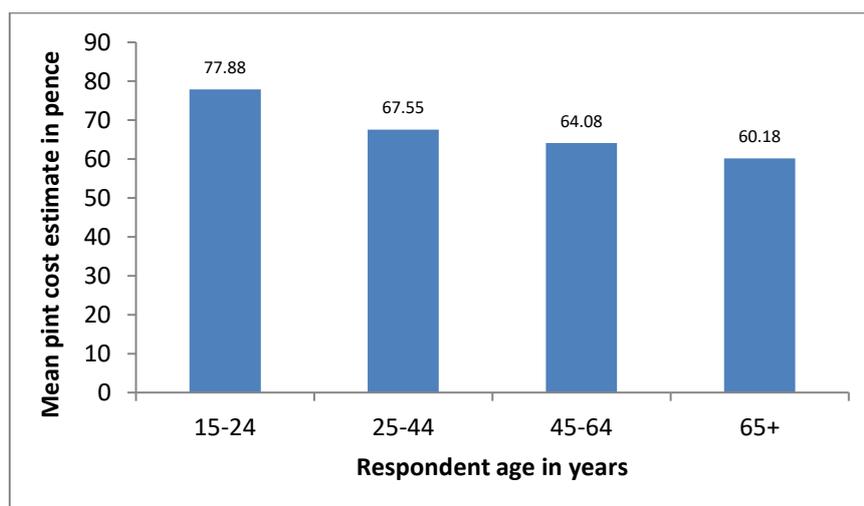


Figure 5. The effect of age on respondent estimate of average pint cost.

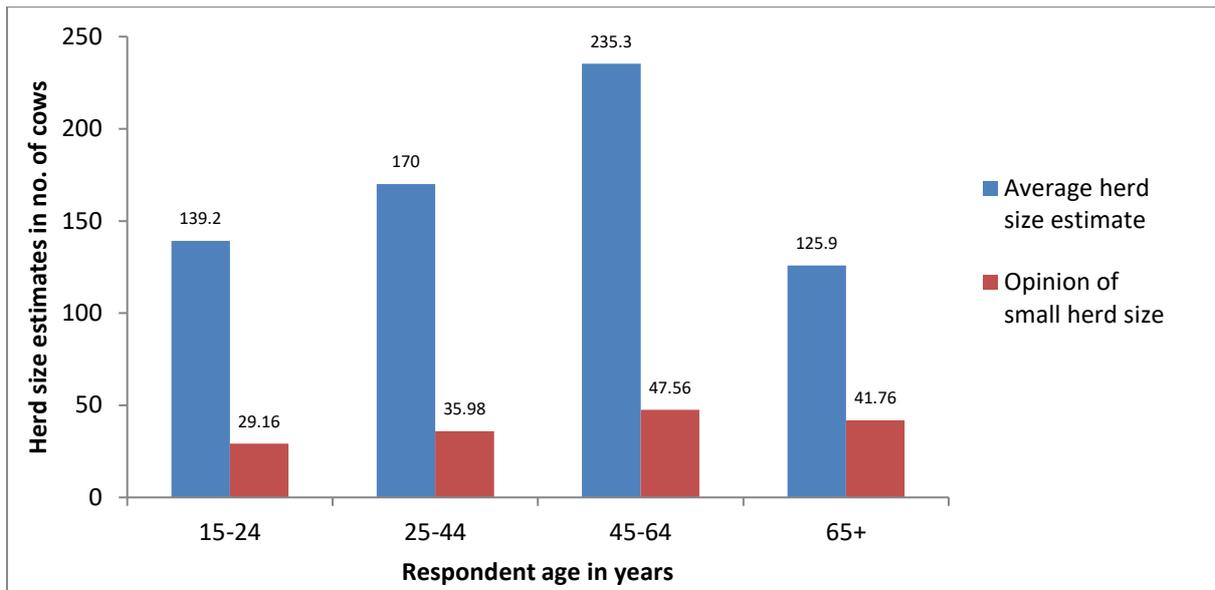


Figure 6. The effect of age on respondents estimates of average & small herd sizes.

3.1.3b) Effect of socioeconomic factors

Education had a significant effect on WTP for rare breeds ($X^2=15.68$, d.f.=3, $p<0.01$), small herd sizes ($X^2=18.90$, d.f.=5, $p=0.002$) and local produce ($X^2=26.78$, d.f.=5, $p<0.001$) (Figure 7).

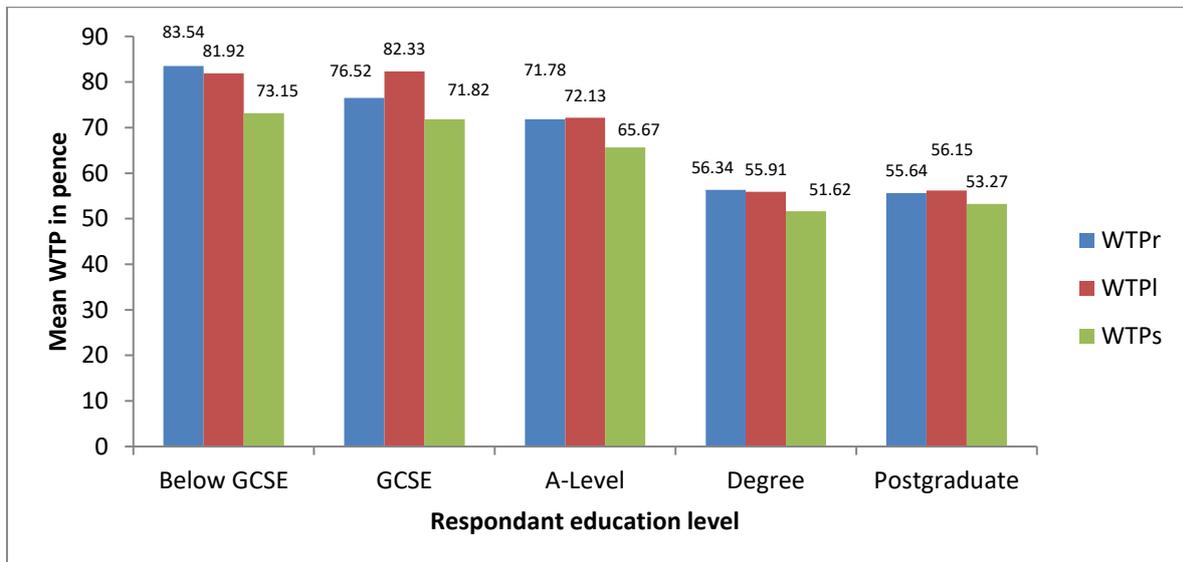


Figure 7. The effect of respondent level of education on WTPr, WTPI & WTPs.

Income had no effect on the majority of answers, but did have a significant effect on WTP for local produce ($X^2=18.43$, d.f.=4, $p=0.001$) (Figure 8).

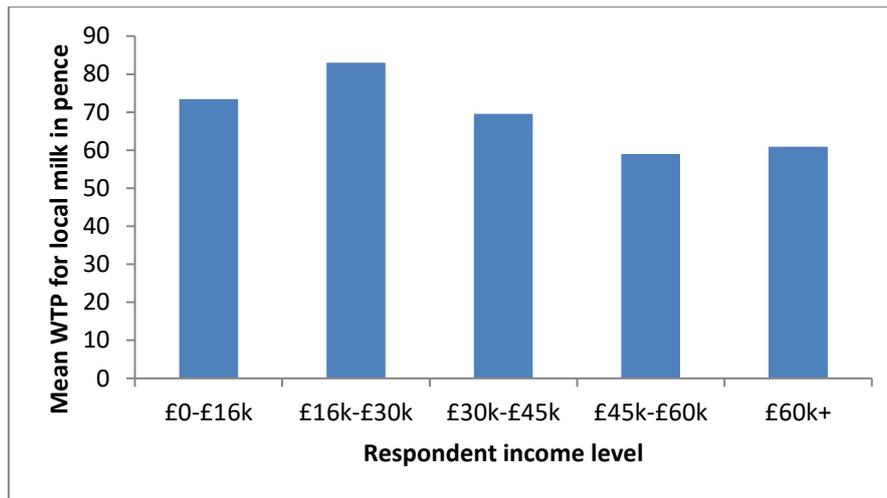


Figure 8. The effect of respondent income on WTP.

There was no statistical significance between answers from dairy product buyers and non-dairy product buyer. The respondent being the main grocery buyer, family size and whether the respondent was from Cornwall or visiting also had no significant effect on any responses.

Respondent connection with the dairy industry had no significant effect on any WTP or most other answers; though it had multiple effects on some knowledge and opinion responses. There was a significant effect on perceived knowledge of dairy farming between connected and non-connected respondents ($W= 18394$, $n=875$, $p<0.001$) with connected respondents claiming a higher level of perceived knowledge on a Likert scale (mean of 3.75 against 2.49). There was a similar effect on perceived knowledge of dairy breeds ($W=18394$, $n=875$, $p<0.001$) with connected individuals again claiming a higher perceived knowledge (mean of 3.22 against 1.99).

Connected individuals estimated a significantly higher average herd size than non-connected individuals ($W=31431$, $n=875$, $p<0.001$) with connected individuals having a mean estimation of 211.6 cows against 170.8 cows for non-connected respondents. Connected individuals also had marginally more accurate average herd-size estimates with connected individuals having a mean error of 145.9 cows against 156.4 cows ($W=0.25$, $n=875$, $p<0.001$). Respondent connection also had a significant effect on opinion. There was a significant difference between respondent opinion on the importance of protecting rare breeds of cattle ($W=48675$, $n=875$, $p=0.05$) with connected individuals having a lower mean score on a Likert scale (4.56 against 4.69) meaning connected individuals put slightly less emphasis on the importance of protecting rare breeds.

There was a significant difference between responses regarding opinion on smaller herds having a higher level of welfare ($W=51093$, $n=875$, $p=0.002$) with connected individuals having a lower score on a Likert scale than non-connected individuals (3.16 against 3.52) meaning individuals with a connection to the dairy industry had a lower perceived correlation between herd size and welfare.

3.1.3c) Effect of respondent knowledge and opinion

Unsurprisingly, perceived knowledge of dairy farming had a significant effect on perceived knowledge of dairy breeds ($\chi^2=451.17$, $d.f.=4$, $p<0.001$) with individuals estimating their knowledge of dairy farming to be high, also estimating their knowledge of dairy breeds to be high. Perceived knowledge of dairy farming also had a significant effect on estimated average herd sizes ($\chi^2=45.53$, $d.f.=4$, $p<0.001$) with individuals with a higher perceived level of knowledge estimating larger herd sizes.

A significant effect was also seen on accuracy of average herd size estimates ($X^2=13.17$, d.f.=4, $p=0.01$) with respondents who estimated their knowledge of dairy farming to be low, surprisingly having more accurate average herd size estimates. Perceived knowledge of dairy farming also had a significant effect on the respondents opinion of what a 'small' herd size would be ($X^2=54.49$, d.f.=4, $p<0.001$) with respondents with a higher level of perceived knowledge having higher 'small' herd size estimates.

A respondents estimate of the average cost of a pint of milk had a significant positive correlation with all three WTP responses; WTPr ($r_s=0.3166$, $p<0.001$), WTPs ($r_s=0.3077$, $p<0.001$) & WTPI ($r_s=0.3255$, $p<0.001$) meaning respondent who estimated a higher average cost for a pint of milk, were on average willing to pay more for milk involving all three factors.

There was also a strong positive correlation between average herd size estimates and 'small' herd size estimates ($r_s=0.7755$, $p<0.001$) meaning respondents who estimated a higher average dairy herd size also estimated a higher 'small' herd size.

3.1.4 Seal Sanctuary survey

In order to test for any respondent bias due to the nature of the study site, an additional smaller ($n=33$) study was conducted at the Seal Sanctuary in Gweek. The results from this study were compared with the results from the Dairyland study to look for any significant difference in trends. For comparisons of the counts of groupings a Chi-squared test was used, except in cases where sample size was lower than five whereby a Fishers exact test was used. Results with continuous data were analysed for normality using a Shapiro-Wilk

test, and all were non-parametric meaning a Wilcoxon signed-ranks test was used to test for difference between groups.

There was no significant difference in results for respondent gender or proportion of respondents who regularly bought dairy products. There was a significant difference in the proportion of individuals with a connection to the dairy industry (Fishers exact test $p=0.03$) with Seal Sanctuary respondents having a higher proportion of connected individuals (15.6% vs 13.6%).

A higher proportion of Dairyland visitors were grocery buyers ($X^2=4.54$, $df=1$, $p= 0.03$) and Dairyland visitors had a larger average household size ($W=6746$, $n=876$, $p<0.001$).

There was no significant difference in the proportion of respondents who were local, respondents perceived knowledge of dairy farming, respondents perceived knowledge of dairy breeds or how much respondents thought a pint of milk costs. There was no significant difference in respondent estimates of the average size of a dairy herd or estimates of how big a 'small' dairy herd would be. There was no difference in the proportion of individuals who thought it was important to protect rare breeds or the proportion of individuals who were willing to pay more for milk from rare breeds. There was a significant difference in the amount respondents were willing to pay for milk from rare breed cattle, with Dairyland respondents reporting a higher willingness to pay ($W=10470$, $n=876$, $p=0.03$).

There was no significant difference in respondent opinion on whether small herds had higher welfare, the proportion of individuals who were willing to pay more for milk from small herds, or the amount respondents were willing to pay for milk from small herds.

There was no significant difference in the amount respondents thought farmers received for their milk, or in respondent opinion on whether farmers should receive more money for the milk they produce. There was no significant difference in respondent willingness to pay for milk from a local farmer or in the amount individuals were willing to pay for milk directly from local farmers.

There was a significant difference in the age of respondents with Seal Sanctuary visitors being older on average ($W=7771$, $n=876$, $p<0.001$).

There was no significant difference in the education or income of respondents.

3.1.5 Regression analysis

As detailed in section 2.1.5c, all continuous or ordered categorical response data was input into a multiple regression model. This was done in order to measure the predictability of willingness to pay with regard to consumer questionnaire responses. All questionnaire responses which were either ordered categorical or continuous data were used in the model, which were then refined to define the factors which accounted for the largest proportion of variance in responses. This was done by using the 'step' function in R which deleted predictor variables in order to produce the model with the lowest AIC, thereby defining the minimal sufficient model. This resulted in two factors being included as predictors for all three willingness to pay responses; respondent estimate of farmer milk sales share and respondent estimate of average pint cost.

3.1.5a) Willingness to pay for milk from rare breeds

A multiple linear regression was used to predict willingness to pay for milk from rare breeds (WTP_r) based on respondents estimates of farmer milk sales share, and average cost of a pint of milk. A significant regression equation was found ($F(2,677) = 37.88, p < 0.001$), with an R^2 of 0.1006, meaning 10.06% of the variation between respondent answers can be explained by the respondents estimates of farmer share and milk cost. Respondents predicted WTP_r is equal to $30.81 + 0.21$ (farmer share estimate) $+ 0.51$ (average pint cost estimate), where farmer share is measured in percentage and average pint cost is measured in pence. WTP_r increased 0.21 pence for each percentage of farmer share estimate and increased by 0.51 pence for each pence increase in average pint cost estimate. Both average pint estimate and farmer share estimates were significant predictors of WTP_r.

3.1.5b) Willingness to pay for milk from small herds

A multiple linear regression was used to predict willingness to pay for milk from small herds (WTP_s) based on respondents estimates of farmer milk sales share, and average cost of a pint of milk. A significant regression equation was found ($F(2,567) = 33.85, p < 0.001$), with an R^2 of 0.1067, meaning 10.67% of the variation between respondent answers can be explained by the respondents estimates of farmer share and milk cost. Respondents predicted WTP_s is equal to $27.89 + 0.35$ (farmer share estimate) $+ 0.43$ (average pint cost estimate), where farmer share is measured in percentage and average pint cost is measured in pence. WTP_s increased 0.35 pence for each percentage of farmer share estimate and increased by 0.43 pence for each pence increase in average pint cost estimate. Both average pint estimate and farmer share estimates were significant predictors of WTP_s.

3.1.5c) Willingness to pay for milk from local farmers

A multiple linear regression was used to predict willingness to pay for milk from local farmers (WTPI) based on respondents estimates of farmer milk sales share, and average cost of a pint of milk. A significant regression equation was found ($F(2,777) = 40.64, p < 0.001$), with an R^2 of 0.0947, meaning 9.47% of the variation between respondent answers can be explained by the respondents estimates of farmer share and milk cost. Respondents predicted WTPI is equal to $33.74 + 0.31$ (farmer share estimate) $+ 0.46$ (average pint cost estimate), where farmer share is measured in percentage and average pint cost is measured in pence. WTPI increased 0.31 pence for each percentage of farmer share estimate and increased by 0.46 pence for each pence increase in average pint cost estimate. Both average pint estimate and farmer share estimates were significant predictors of WTPI.

3.2 Producer case studies

To provide production data for speciality milk products, five case studies were conducted involving visits to producers using farming methods of interest (Table 1). The data collected from these case studies is used in the economic model detailed in section 3.3.

3.2.1 Case study 1. Milk vending machine

Profile: An industry-typical dairy farm consisting of a herd of c.200 Holstein Friesian cattle, which has recently installed a milk vending machine on site (Figure 9).

Relevance of case study: The majority of modern commercial dairy herds are contracted with milk suppliers who package the milk and either market the products independently, or supply supermarkets who then market the milk themselves. Selling milk directly to consumers via a

vending machine allows producers to reduce the supply chain links and therefore obtain a higher proportion of milk sale value. This case study provides insight into consumer willingness to pay for milk directly from the producer and with local product provenance.



Figure 9. Milk vending machine.

Key information: The vending machine cost around £6,500, and in total the setup cost was estimated at £15,000 inclusive of installation, pasteurisation unit and the initial batch of bottles and labelling. Milk is sold at £1 per litre, with bottles sold at £1 each however, they are reusable. At the time of visiting, the daily sales were between 150-180 litres of milk per day, with up to 250 litres during peak times. Using these figures, the producer estimated a projected yearly income of £70,000-£80,000, increasing the farms total income by c.15%.

3.2.2 Case study 2. Micro-dairy

Profile: A micro-dairy setup consisting of 15 Ayrshire cattle, where milk is bottled on site and sold via a local milk-round.

Relevance of case study: The average size of dairy herds in the UK was 142 in 2015 (Agriculture and Horticulture Development Board, 2016) and this number increases every year. The main reason for this increase is as production costs continue to grow; a larger herd size provides a way of diluting overheads. Small scale milk production is therefore often considered old fashioned and economically unviable. This case study provides insight into the viability of small scale milk production, and consumer willingness to pay for local produce.

Key information: The herd consists of 15 dairy cows which graze on 36 acres of rented pasture. 12 cows are milked at a time (with 2 or 3 dried off) which provide enough milk to supply a c.300 customer milk-round. Milk is sold at £1.20 a litre delivered, and yoghurt and ice-cream are sold seasonally. When cull cattle are slaughtered existing customers are emailed directly meaning beef can also be sold directly to consumers. Extensive financial data regarding the costs associated with small scale production was gained via this case study.

3.2.3 Case study 3. Free-range cows

Profile: A large New-Zealand style dairy herd of c.950 cows, which are kept permanently outside on pasture and milked outdoors in portable milking-bails (Figure 10).

Relevance of case study: The vast majority of modern dairy herds are milked indoors, with a large proportion kept indoors all year using a 'zero-grazed' system. This is contrasting to the idealistic view of many consumers who assume all dairy cows are kept outdoors on grass. This case study provides insight into an alternative dairying method, along with an indication of consumer willingness to pay for products with local provenance.



Figure 10. *Outdoor milking bail.*

Key information: The herd consists of c.950 head of Jersey cross cattle, grazed on 700 acres of rented pasture and is run using a New Zealand style system, meaning low input and pasture grazed. The cows are moved to fresh pasture on a daily basis and as the cows are moved, the parlour is moved also. Operating in this nomadic style means that there is a low initial setup cost, reduced cost of housing, no requirement for slurry storage, and indirect savings in lameness treatment as the cattle don't walk far to be milked. The milk produced is used for cheese as it has high milk solids content, and is to be marketed using the USP of being from 'truly free range cows'.

3.2.4 Case study 4. Raw milk

Profile: A zero-grazed Holstein Friesian dairy farm, which has recently begun selling small quantities of raw milk at the farm gate.

Relevance of case study: Since around the 1930s the vast majority of milk in the UK has been sold as pasteurised in order to reduce the risk of disease transmission (e.g. Tuberculosis).

However, the sale of raw milk is not illegal and there is some evidence to suggest that there are certain health benefits from drinking milk unpasteurised. This case study provides an indication of consumer opinion and demand on this speciality product, and provides an insight into consumer willingness to pay for local milk.

Key information: The farm is a modern setup with a herd of 180 Holstein Friesians kept indoors on a zero-grazed system and milked by three robotic milking machines. The majority of the milk produced is contracted with a local dairy company, but c.35 litres of milk per day are sold on the farm gate as unpasteurised and non-homogenized. The milk is sold for £1 per litre and costs 50p to package with 10p per carton, 9p per label and the remainder in labour costs, meaning a profit of 50p per litre (the producer currently receives 26.5p per litre through his dairy contract). To control for disease transmission the milk is tested daily by an independent lab, and quarterly by the Food Standards Agency.

3.2.5 Case study 5. Rare breed cattle

Profile: A herd of rare-breed Gloucester cattle (Figure 11) in Gloucestershire, which are milked for the production of Single and Double Gloucester cheese.

Relevance of case study: Over 98% of dairy cattle in the UK are Friesian or Friesian cross as this breed has the highest milk yield. Dairying is therefore not generally seen as a sector associated with rare breeds, with beef and conservation grazing being the main areas where rare cattle breeds are used. This case study provides insight into the viability of using rare breeds as milk producers. Gloucester cattle are currently designated as 'at risk' by the Rare

Breed Survival Trust, meaning there are between 450 and 750 registered breeding females in the UK, a substantial increase from the 1970s when this number was below 70.



Figure 11. *Rare breed Gloucester cattle.*

Key information: The herd in this case study consists of 80 Gloucester cattle which are reared mainly for beef, but 18 at a time are milked to provide milk for cheese. Cheese is sold for £18.50 per kilo and each kilo of cheese requires eight litres of milk, meaning an income of £2.30 per litre of milk (exclusive of cheese production costs). Gloucester cattle milk is high in protein and milk yields range from 3,700 to 4,500 litres of milk per lactation. Single Gloucester cheese is a Protected Designation of Origin (PDO) product, meaning it must be produced within Gloucestershire and using milk from a registered herd of Gloucester cattle, a factor which has likely had an impact on Gloucester cattle numbers.

3.3 Dairy economic model

To investigate the economic viability of speciality milk production, production data from case studies is combined with economic data from the consumer survey into Table 3 below.

Table 3. Dairy economic model showing yearly financial status of conventional and organic dairy farms compared with derived data from 'specialist' dairy farms.

| | Mainly Friesian ¹ | Organic ¹ | Local farmer (WTPI) ² | Small herd (WTPs) ³ | Rare breed (WTPr) ⁴ |
|---|------------------------------|----------------------|----------------------------------|--------------------------------|--------------------------------|
| Enterprise output | | | | | |
| Yield (pints/cow) ⁵ | 12580.45 | 10609.53 | 12580.45 | 7390.95 ⁶ | 6511.08 ⁷ |
| Price (pence/pint) | 14.49 ⁸ | 19.72 ⁸ | 108.13 ⁹ | 85.72 ⁹ | 98.24 ⁹ |
| Stocking rate Cows/Hectare | 1.85 | 1.31 | 1.85 | 1.85 | 1.85 |
| Stocking rate Hectare/cow | 0.54 | 0.76 | 0.54 | 0.54 | 0.54 |
| Milk output (£) ¹⁰ | 1822.99 | 2091.30 | 13602.70 | 6334.98 | 6395.94 |
| Miscellaneous revenue (£) | 11.70 | 9.80 | 11.70 | 11.70 | 11.70 |
| Calves sold (£) | 116.50 | 102.90 | 116.50 | 116.50 | 116.50 |
| Depreciation (£) | -171.00 | -134.90 | -171.00 | -171.00 | -136.80 ¹¹ |
| Total output (£) | 1780.19 | 2069.10 | 13559.90 | 6292.18 | 6387.34 |
| Variable costs | | | | | |
| Concentrates | 483.90 | 454.70 | 483.90 | 367.14 ¹² | 181.20 ¹³ |
| Coarse Fodder | 19.20 | 14.70 | 19.20 | 14.70 | 19.20 |
| Veterinary and medicines | 64.90 | 62.60 | 64.90 | 40.58 ¹² | 64.90 |
| Other livestock costs ¹⁴ | 149.90 | 127.50 | 342.89 ¹⁵ | 342.89 | 149.90 |
| Forage | 98.40 | 105.80 | 105.80 | 105.80 | 98.40 |
| Total variable costs | 816.30 | 765.30 | 1016.69 | 871.11 | 816.30 |
| Gross margin (per cow) | 963.89 | 1303.80 | 12543.21 | 5421.07 | 5571.04 |
| Gross margin (per hectare) | 1783.20 | 1707.97 | 23204.95 | 10028.98 | 10306.42 |
| Fixed costs | | | | | |
| Fixed costs (per hectare) ¹⁶ | 1059 | 861 | 1059 | 1059 | 1059 |
| Other general costs | 46 | 32 | 196.17 ¹² | 196.17 ¹² | 46 |
| Total fixed costs excl. rent & interest | 1105 | 893 | 1255.17 | 1255.17 | 1105 |
| Profit before rent & interest | 678.20 | 814.97 | 21949.78 | 8773.81 | 9201.42 |
| Rent & interest (per hectare) | 179 | 171 | 179 | 179 | 179 |
| Net profit (per hectare) | 499.20 | 643.97 | 21770.78 | 8594.81 | 9022.42 |

3.3.1 Dairy economic model annotation

The data used in the model (Table 3) was collected from multiple sources detailed below (Table 4). The framework data for the model was sourced from both conventional dairy and organic dairy data from the 2017 Farm Business Survey (as detailed in section 2.3c), and specific data for speciality products was attained via producer case studies, hereby referred to as CS 'X' (as detailed in section 3.2).

Table 4. Dairy economic model input annotation

| Notation | Data source |
|----------|---|
| 1. | Entirety of data retrieved from Farm business survey 2017 (FBS). |
| 2. | Data gathered largely from FBS with some input from CS 2. |
| 3. | Data consisting of largely 'Mainly Friesian' FBS data, with input from CS 2 |
| 4. | Data consisting of largely 'Mainly Friesian' FBS data, with input from CS 5. |
| 5. | Milk yields converted from litres to pints in order to match WTP from survey |
| 6. | Estimated milk yield from micro-dairy herd, gained from CS.2. |
| 7. | Estimated milk yield from Rare breed Gloucester cattle, gained from CS 5. |
| 8. | These figures taken from FBS, but converted from litres into value per pint. |
| 9. | These values consisting of actual average price of a pint of milk in 2016 added to WTP from consumer survey. |
| 10. | Equal to yield multiplied by price |
| 11. | Gloucester Cattle Society claim increased longevity (confirmed by CS 5. producer) so depreciation decreased by 20%. |
| 12. | Figure calculated using average expenditure over six years from CS 2. |
| 13. | Figure extrapolated from estimated daily concentrate usage from CS 5. |
| 14. | This figure consisting of all other costs relating directly to livestock, including; freeze branding, AI, milk tests, breed society fees, dairy detergents, packing materials, bedding straw, show expenses and processing. |
| 15. | Figure calculated using average expenditure over six years from CS 2, adjusted to include additional fuel and packaging costs involved with marketing the milk locally. |
| 16. | Fixed costs consist of paid labour, unpaid family labour, casual labour, contract, machinery repair, machinery fuel, machinery depreciation, other depreciation, property maintenance, electricity, other fuel, water, insurance and professional fees. |

3.3.2 Premium dairy economic model

In order to define the value of 'premium' value consumers, derived data from speciality farms was taken from Table 3, and combined with the average WTP of the top one third of responses, and entered into Table 5 below.

Table 5. Premium dairy economic model showing the financial processes of dairy farms using speciality milk factors, adjusted to include the average WTP of the top third of respondents.

| | Local farmer (WTPI) | Small herd (WTPs) | Rare breed (WTPr) |
|---|---------------------|-------------------|-------------------|
| <u>Enterprise output</u> | | | |
| Yield (litres/cow) | 12580.45 | 7390.95 | 6511.08 |
| Price (pence/litre) | 177.82 | 159.95 | 166.03 |
| Stocking rate Cows/Hectare | 1.85 | 1.85 | 1.85 |
| Stocking rate Hectare/cow | 0.54 | 0.54 | 0.54 |
| Milk output (£) | 22370.02 | 11821.28 | 10809.80 |
| Miscellaneous revenue (£) | 11.70 | 11.70 | 11.70 |
| Calves sold | 116.50 | 116.50 | 116.50 |
| Depreciation | -171.00 | -171.00 | -136.80 |
| Total output | 22327.22 | 11778.48 | 10801.20 |
| <u>Variable costs</u> | | | |
| Concentrates | 483.90 | 367.14 | 181.20 |
| Coarse Fodder | 19.20 | 14.70 | 19.20 |
| Veterinary and medicines | 64.90 | 40.58 | 64.90 |
| Other livestock costs | 342.89 | 342.89 | 149.90 |
| Forage | 105.80 | 105.80 | 98.40 |
| Total variable costs | 1016.69 | 871.11 | 816.30 |
| Gross margin (per cow) | 21310.53 | 10907.37 | 9984.90 |
| Gross margin (per hectare) | 39424.48 | 20178.64 | 18472.06 |
| <u>Fixed costs (per hectare)</u> | | | |
| Other general costs | 196.17 | 196.17 | 46 |
| Total fixed costs excl. rent & interest | 1255.17 | 1255.17 | 1105 |
| Profit before rent & interest | 38169.31 | 18923.47 | 17367.06 |
| Rent & Interest (per hectare) | 179 | 179 | 179 |
| Net profit (per hectare) | 37990.31 | 18744.47 | 17188.06 |

Chapter 4. Discussion.

4.1 Consumer survey

4.1.1 Willingness to pay

The consumer survey suggests that there is a demand for milk products produced locally, from small herds and from rare breeds, with willingness to pay responses for all three factors showing a significant proportion of positive 'yes' responses. Milk from local farmers was considered the most important factor as it had both the highest proportion of positive responses and highest WTP value, followed by milk from rare breeds and then milk from small herds.

4.1.1a) Willingness to pay for milk from local farmers

Local milk was the factor most likely to elicit a higher willingness to pay, with 93.83% of respondents answering that they would pay more for milk purchased directly from a local farmer. This finding correlates with multiple studies on consumer willingness to pay for local foods (Loureiro and Hine, 2002; Meas *et al.*, 2015) and in particular a study conducted in the USA which suggested that food produced locally is becoming a more important factor than food produced organically (Adams and Salois, 2010).

A study conducted in South Carolina investigating willingness to pay for locally grown produce also found that consumers were willing to pay a premium for local produce (Carpio and Isengildina-Massa, 2009). The study found that consumers were willing to pay a premium of 27% for local produce and 23% for local animal products, with 71% of respondents stating that their main motivation for buying products locally was to support either local farmers or the local economy.

A factor influencing willingness to pay for British milk in particular, could be high consumer awareness of low milk prices being paid to farmers through extensive media coverage (Anderson, 2016 and BBC News, 2016). This effect could be compounded by perceived unfairness of the treatment of farmers within the dairy industry being likely to drive an emotive response, and therefore influence willingness to pay (Lau, White and Schnall, 2013).

An additional reason could be linked to local produce being associated with product quality. Rare breed and small herd size milk are both factors which involve moral issues (rare breed conservation and animal welfare) whereas local produce also involves product quality, through perceived freshness and a reduction in processing (Carpio and Isengildina-Massa, 2009; Pearson *et al.*, 2011).

4.1.1b) Willingness to pay for milk from rare breed cattle

Milk from rare breeds was the second most important factor with 79.66% of respondents answering that they would be willing to pay more for milk from rare breeds of cattle. As this question is asked without mention of the physical attributes of the product (creaminess, taste etc.) it must be assumed that this level of willingness to pay is derived from factors involving the product's origin.

Consumer desire to aid in rare breed conservation is the most likely explanation for the willingness to pay response received. Comparable studies investigating consumer willingness to contribute to domestic breed conservation have yielded similarly positive responses (Cicia, D'Ercole and Marino, 2001; Zander *et al.*, 2013).

There has been limited research into using value added products as a means for breed conservation, although one Finnish study investigated consumer willingness to pay for beef from threatened indigenous 'Finncattle' (Tienhaara, Ahtiainen and Pouta, 2013). Within the study 86% of respondents stated they would be willing to purchase Finncattle meat, and a quarter of respondents stated that they would be willing to pay more for Finncattle beef over beef from conventional breeds.

A factor which could have partial influence over respondent willingness to pay for rare breed milk is an effect known by economists as 'the Snob effect' (Leibenstein, 1950). The Snob effect essentially means that products which are rarer have a higher value. This is because a product that is seen as niche or novel is considered by consumers to be of higher value. This effect is likely to be minimal with regard to milk purchase however, as conspicuousness has a high influence on whether or not a product will elicit a Snob effect (Kuwashima, 2015).

4.1.1c) Willingness to pay for milk from small herds

Milk from small herds was the factor with the lowest willingness to pay value, and the lowest proportion of positive responses with 66.51% of respondents stating that they would be willing to pay more for milk from small herds. This figure is likely to be linked to a perceived correlation between herd size and animal welfare, with 18% of respondents answering they 'strongly agree' small dairy herds have a higher level of animal welfare, as opposed to just 4% who strongly disagreed with this statement.

As this correlation is only perceived by a relative minority (78% of respondents did not feel strongly either way) there must be other factors influencing respondent willingness to pay. One such reason could be linked to consumer perceptions of small, family run farms being linked to local produce, with some studies suggesting that the two terms are considered by some to be almost synonymous (Hughes *et al.*, 2007; Meas *et al.*, 2015).

4.1.2 Effect of respondent characteristics on question responses

4.1.2a) *Effect of respondent gender*

Men claimed a significantly higher knowledge of dairy farming than women, which could potentially be due to two reasons. Firstly, many studies have suggested that in self-assessment tests male respondents estimate their knowledge and intelligence to be consistently higher on average than female respondents (Beyer, 1998; Furnham, 2001). It could therefore be implied that men simply overestimate their knowledge of dairy. Conversely, there are currently almost three times as many men than women in livestock-based UK agriculture (Office for National Statistics, 2015) meaning it is possible that a higher proportion of male respondents had experience of dairy farming than female respondents.

Respondent 'actual' knowledge was estimated by asking the respondent to estimate both the average UK dairy herd size and the average cost of a pint of milk. Their answer was then subtracted from the correct figure in order to give an 'accuracy' figure which was used as a proxy for respondent 'actual knowledge'. As there was no significant difference between male and female 'actual knowledge' responses, this suggests that over-estimation is the most likely reason for the difference in perceived knowledge of dairy farming between genders.

4.1.2b) Effect of respondent age

Age had a significant effect on respondent's willingness to pay for milk from rare breeds and milk from local farmers, with the youngest age group willing to pay the highest amount and the oldest age group the least. This effect is likely linked to the significant difference in average pint cost estimates between age groups (Figure 5). This difference in average pint cost estimates could be attributed to consumer uncertainty on milk pricing being combined with the retail value of milk increasing periodically (Office for National Statistics, 2017b) which could lead to older respondents basing their estimation on the price of milk earlier in their life.

4.1.2c) Effect of socioeconomic factors

Education had a significant effect on WTP_r, WTP_I & WTP_s with lower educated respondents having a higher willingness to pay for all three factors. Previous studies have investigated the impact of education level on consumer willingness to pay for organic food products, although the results do not provide an established consensus on its effect (Loureiro and Hine, 2002; Naukowy and Ekonomicznego, 2017).

Income had a significant effect on WTP_I although not in the initially anticipated direction, as the second to lowest income level had the highest willingness to pay. Although this does not initially seem like an intuitive result, income often has little to no effect on willingness to pay (Horowitz and McConnell, 2003). A study investigating willingness to pay for organic and rBST-free (recombinant bovine somatotropin) labelled milk in America also investigated any correlation between willingness to pay and income, and found no significant relationship (Dhar and Foltz, 2005).

Respondent connectedness to the dairy industry had a significant effect on the perceived knowledge of both dairy farming and dairy breeds with connected individuals claiming a higher knowledge of both. This result is logical as connected individuals are more likely to spend time around dairy farms or individuals involved with dairy farms, and therefore gain more knowledge of both breeds and the industry.

Connected individuals also had higher average herd size estimates which were closer to the published data on herd size, which is again unsurprising due to the reason discussed above. There was however, no statistically significant difference in accuracy of average pint estimates between connected and unconnected individuals, which suggests that individuals with a connection to the dairy industry may well spend more time around farms and farmers, but they do not necessarily have a higher interest or awareness of the end product.

Connected individuals were less likely to associate small herd size with a higher level of welfare, possibly due to individuals who are involved in dairy farming being more likely to have experience of relatively large herds (average herd size being 146) and would therefore be biased to consider the dairy farming method they are associated with to have a high level of welfare.

4.1.2d) Effect of respondent knowledge and opinion

Perceived knowledge of dairy farming had a significant effect on perceived knowledge of dairy breeds, with (unsurprisingly) individuals who claimed a higher knowledge of dairy farming to also claim a higher knowledge of dairy cattle breeds. Respondents who claimed to know a lot about dairy farming had the highest average herd size estimate, and were also

the most accurate. Opinion on the size of a 'small herd' was also strongly correlated to perceived knowledge of dairy farming, with individuals claiming a higher knowledge to estimate a higher number.

Estimate of an average pint of milk had a strong positive correlation with all 3 WTP responses, i.e. those who thought milk cost more per pint were willing to pay more for milk with speciality factors involved. This result was the inverse to what was predicted initially, as it could be assumed that the more an individual thinks they are paying for milk at present, the less they will be willing to pay in addition. However, this affect could be attributed to respondents who are presently paying a higher amount for milk products (via organic products for example) will also be willing to pay more on top of that amount for products with further desirable factors.

4.1.3 Comparison with Seal Sanctuary survey

As detailed in section 2.1.2 an additional smaller survey was conducted at Gweek Seal Sanctuary in an attempt to mitigate any potential bias, intrinsically linked to the main survey site, i.e. positive bias towards dairy products through visiting an agriculture based tourist destination. This survey was designed to mitigate any specific bias based on dairy farming, meaning bias towards destination type would not be controlled for. Both sites are tourist attractions in Cornwall based around animals, so there may well be common bias between sites involving certain demographic information. It should also be noted at this point that there was a substantial difference in the number of respondents from each site with a sample size of 31 from the Seal Sanctuary and 875 from Dairyland.

The majority of questions showed no significant difference in responses between the two sites; but there were five questions which did. The proportion of respondents with a connection to the dairy industry was higher for visitors to the Seal Sanctuary with 16.13% of respondents from the Seal Sanctuary claiming a connection, compared to 13.6% of Dairyland respondents. This could be interpreted as; individuals with a connection to dairy farming are more likely to be able to experience the activities that are offered at Dairyland in their home lives either through being farmers themselves, or through friends and relatives, and will therefore less likely to want to visit such an attraction as there is less unique appeal due it being a 'Busman's holiday'.

The proportion of respondents who were grocery buyers was higher for Dairyland, with 81.49% of Dairyland respondents being grocery buyers and 64.51% of Seal Sanctuary respondents being grocery buyers. This could be attributed to the fact that Dairyland is aimed more towards younger children, meaning family groups often consist of a single parent with multiple children, and rarely attracts adult couples of family groups with adult children. This is opposed to the Seal Sanctuary which experiences a higher proportion of older and retired couples.

The household size was larger for Dairyland respondents with an average size of 3.73 compared to 2.74 for the Seal Sanctuary. This is likely linked to the factors discussed above, that Dairyland tends to attract more families with young children and less childless couples and retired individuals. Unsurprisingly this also meant Seal Sanctuary respondents were significantly older on average.

Willingness to pay for milk from rare breeds of cattle was the only WTP response which was significantly different between the two sites. Dairyland visitors claimed an average WTP of 69.75 pence, compared to a WTP of 49.17 pence for Seal Sanctuary responses. This response could indicate a potential bias introduced due to the nature of Dairyland as an attraction. Around the Dairyland park is posted information on dairy farming and in particular the various breeds involved, this could therefore suggest that visitors to Dairyland were more aware of the issues surrounding rare cattle breeds and therefore willing to pay more for rare breed products.

4.1.4 Limitations of survey

4.1.4a) *Honesty*

The main limitation involved in consumer surveys is that it is assumed the respondent is answering honestly. This is not to suggest that respondents would intentionally give misleading responses, but there are many studies suggesting that consumers often overstate their willingness to pay in hypothetical settings (Murphy *et al.*, 2005). In a 2013 study by Börger, it was found that respondents would give willingness to pay answers which were biased towards what was perceived as socially desirable, regardless of level of anonymity (Borger, 2013). This could indeed be perceived as an influencing factor within this study as it could be suggested that paying a higher amount for these speciality factors would be perceived as socially desirable as it suggests a higher amount of expendable income.

4.1.4b) Existing consumer knowledge

Variation in consumer average milk price estimates suggests that consumers often cannot accurately estimate how much milk costs at present (Figure 12). This in turn suggests that if consumers do not know how much a product costs already, then any claimed willingness to pay on top of this price could therefore be reduced in accuracy also.

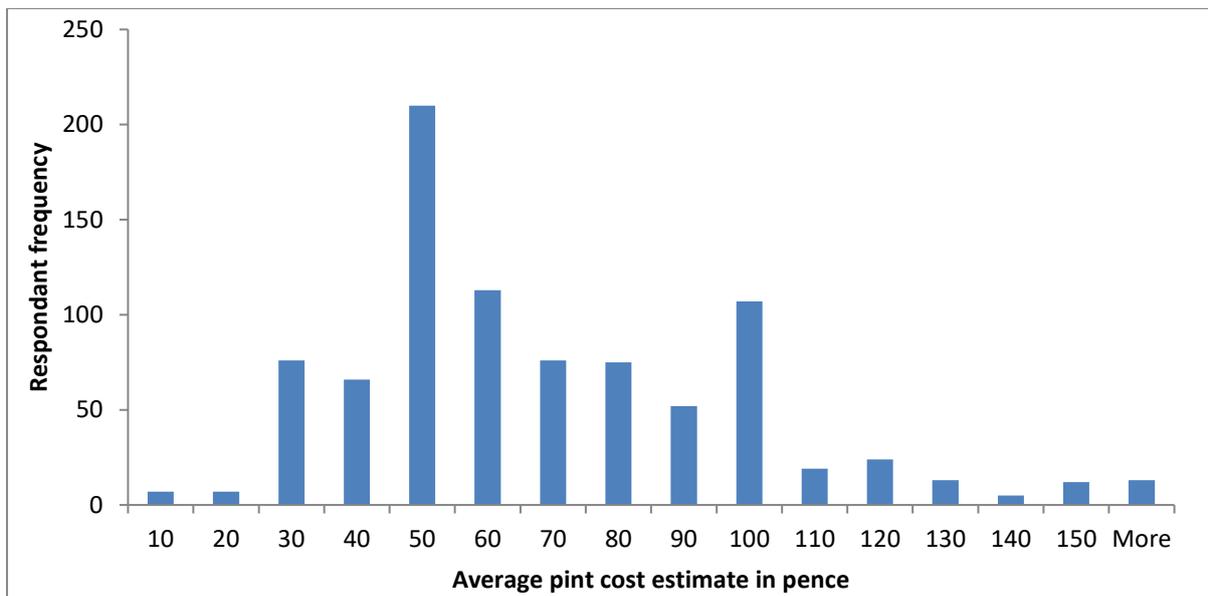


Figure 12. Consumer average pint cost estimates from questionnaire.

4.1.4c) Currency denomination cognitive bias

As can be seen in the cumulative percentage graphs in section 3.1.2, bids tend to cluster around known currency denominations. Although this effect does not necessarily bias any of the responses, it could have an impact on accuracy as respondents lump their responses toward known currency values (50p, £1 etc.) which may cause them to either increase or decrease their willingness to pay subconsciously in order to meet these figures (Raghubir and Srivastava, 2009; Ryan and Spash, 2011).

4.1.4d) Abstract concept

Consumer knowledge and opinion responses suggest that many consumers are unaware of how the UK dairy industry operates at present, either through having an archaic view of dairy farming, or simply because it is an area they have never given much thought. The concept of paying more for products with factors that have previously not been considered may be too abstract a concept for many consumers to provide accurate answers to. For example, if a respondent has always assumed that all cows in the UK are more or less the same, introducing the concept of dairy cattle being separate to beef cattle, and then going further to suggest some of the many dairy cattle breeds are rare, may be too much information for a respondent to fully appreciate and provide an accurate willingness to pay figure as a result.

4.1.4e) Speciality factor interlinking

A factor which may complicate estimations further is the fact that the three WTP categories are intrinsically linked together. Using any viable business model for rare or small herds to work the product must be marketed locally in order to drive a higher value and therefore be profitable. Willingness to pay for either milk from small herds or rare breeds as independent factors may be difficult to accurately estimate as rare breed or small herd milk cannot be viably produced in any way other than locally.

4.1.4f) Survey site sampling effect

Although efforts were made in an attempt to mitigate any sampling bias linked to the survey site, there is potential that the nature of the site provided a biased sample of consumers who were surveyed. It could be argued that individuals who adopt a vegan lifestyle would

be unlikely to visit a tourist attraction based around the use of animals for food produce, however as the survey was aimed at existing dairy consumers this would unlikely have a significant effect on the overall responses. Conversely, producers who are more directly involved with milk products (i.e. dairy farmers) would be unlikely to visit an attraction such as Dairyland, and are therefore likely to be underrepresented in the sample. Alternatively, due to the site being predominantly visited by tourists and holidaymakers, responses could be positively biased due to the 'feel good effect', i.e. individuals who are on holiday and feeling relaxed may claim a higher hypothetical willingness to pay than consumers who are in a supermarket and actually in the process of buying a product.

4.1.4g) General limitations

With regard to the outcome of the overall study, the most significant limiting factor (as mentioned in section 4.1.4a) relates to how realistic respondents willingness to pay figures were, and how transferable the results are to a 'real world' scenario. If the survey were to be conducted again, a similar questionnaire examining consumers buying behaviour in supermarkets, perhaps similar to a 2015 study in Hawaii (Loke, Xu, & Leung, 2015), could have provided a means of qualifying the responses.

4.2 Dairy economic model

4.2.1 Model overview

Data for the model used (Table 3) was supplied by multiple sources with the core data being actual farm data provided by the South West England Farm Business Survey (FBS) (South West England Farm Business Survey, 2017). Speciality farms within the model used FBS data as a framework, with financial inputs from case studies used to adjust certain variables (Table 4). The price of milk used for speciality farms was derived from willingness to pay figures gathered from the consumer survey (section 4.1.1). Due to the nature of the sampling site (section 4.1.4f), there is a possibility that the WTP data received from consumer questionnaires, and hence the outputs from the model, may be exaggerated.

The function of the model is similar in application to the 'Moorepark Dairy System Model' (MDSM), as the MDSM; 'investigates the effects of varying biological, technical, and physical processes on farm profitability' (Shalloo *et al.*, 2004). The model used within this study predominantly focuses on varying financial and physical inputs, although farm profitability remains the focus. Previous studies have developed models to demonstrate the impact of milk price volatility (Nicholson and Fiddaman, 2003) and the model generated within this study shows that the price of milk per pint is indeed a crucial variable as combined with milk yield, milk price is responsible for the bulk of enterprise output.

Local milk production has the potential to be the most profitable of the products simulated as it has the highest net profit, even with an adjusted 'Other general costs' figure to take into account milk packaging and delivery. As this section of the model is based on a conventional size dairy herd however, the model assumes that all of the milk produced via this method can be supplied locally. In reality this is unrealistic as it would be improbable for

a suitable scale customer base to exist within the bounds of 'locality', for the milk quantity produced.

Net profit per hectare for small herds is substantially lower than that of local farms, although as milk produced using this method would have to be supplied locally to be viable, in reality the net profit for small herds would likely be closer to that of local farms through a higher willingness to pay (section 4.1.5e). The intention for this section of the model was to provide a net profit per hectare, which can then be multiplied by the area required for a small herd, and therefore simulate the whole-farm net profit of a micro-dairy herd (Table 6).

As rare breed milk yield is the lowest used within the model, this has an anticipated impact on the enterprise output. Consumer willingness to pay for rare breed milk reduces the impact of this reduction in yield, and combined with a reduction in other costs (depreciation, veterinary costs, etc.) this suggests rare breed milk could potentially prove economically viable.

4.2.2 Sensitivity analysis

Economic modelling provides a way to test the robustness of businesses models through simulated fluctuations in input factors (Pannell, 1997; Nicholson and Fiddaman, 2003). The impact of an increase in crude oil price and a drop in milk value are discussed below.

4.2.2a) Oil price

The price of crude oil can be extremely volatile (Hamilton, 2009) which has a significant impact of many areas of industry (most notably through increasing the cost of fuel).

Between 2009 and 2011 oil prices rose 57% causing an increase in the production costs of grain (WSPA, 2011), this in turn caused the cost of dairy concentrates to increase from £150/tonne to £250/tonne, an increase of around 66%. In addition, this caused an average increase of 33% for diesel fuel, from 105 pence per litre to 140 pence per litre (Office for National Statistics, 2017a). In Table 6 the figures for concentrates and fuel (other general costs) are adjusted for both a conventional farm and a micro-dairy herd.

Table 6. The effect of a 33% an increase in fuel and a 66% increase in concentrate cost on both conventional and micro-dairy herds.

| | Before hypothetical increase in oil price | | After hypothetical increase in oil price | |
|---|---|-------------------|--|-------------------|
| | Conventional dairy herd | Micro-dairy herd | Conventional dairy herd | Micro-dairy herd |
| Enterprise output | 1780.11 | 6292.18 | 1780.11 | 6292.18 |
| <u>Variable costs</u> | | | | |
| Concentrates | 483.90 | 367.14 | 803.27 | 609.45 |
| Coarse fodder | 19.20 | 19.20 | 19.20 | 19.20 |
| Veterinary and medicines | 64.90 | 40.58 | 64.90 | 40.58 |
| Other livestock costs | 149.90 | 342.89 | 149.90 | 342.89 |
| Forage | 98.40 | 105.80 | 98.40 | 105.80 |
| Total variable costs | 816.30 | 875.61 | 1135.67 | 1117.92 |
| Gross margin (per cow) | 963.81 | 5416.57 | 644.44 | 5174.26 |
| Gross margin (per hectare) | 1783.04 | 10020.66 | 1192.21 | 9572.39 |
| <u>Fixed costs (per hectare)</u> | | | | |
| Other general costs | 46 | 196.17 | 61.18 | 260.91 |
| Total fixed costs excl. rent & interest | 1105 | 1255.17 | 1120.18 | 1319.91 |
| Profit before rent and interest | 678.04 | 8765.49 | 72.03 | 8252.48 |
| Rent & interest (per hectare) | 179 | 179 | 179 | 179 |
| Net profit (per hectare) | 499.04 | 8586.49 | -106.97 | 8073.48 |
| Average farmed area | 156 | 8.1 | 156 | 8.1 |
| Average net profit per farm | £77,850.76 | £69,550.56 | -£16,687.50 | £65,395.15 |

Before a hypothetical increase in oil price, the average net profit per farm for a micro-dairy herd is comparable to that of a conventional herd. This is because while the average farmed area is significantly larger for a conventional herd, the gross margin per cow is substantially higher in a micro-dairy, through a higher milk price driving an increased output.

Concentrate use within a conventional herd is higher than within a micro-dairy herd, using the figures supplied by case study 2 (3.2.2), meaning that a percentage increase in concentrate costs is more substantial for conventional herd. However, due to the cost of delivering milk through a micro-dairy business a percentage increase in fuel costs per cow has a greater impact on micro-dairy herds. As the number of cows within a micro-dairy herd is considerably reduced in comparison to a conventional herd, an increase in concentrate cost and general cost per cow has a reduced impact on overall net profit.

4.2.2b) Milk price

The price of milk is one of the most important economic factors affecting dairy farming (Nicholson and Fiddaman, 2003). This price is often subject to volatility, which can be driven by the consumer and through supermarkets using milk as a 'loss leader' (Widenhorn and Salhofer, 2014). Between 2014 and 2016 milk value dropped from 47 pence per pint to 42 pence per pint, a decrease of around 10.6% (Office for National Statistics, 2017b). To simulate the impact of a 10.6 % decrease in milk value on both conventional and micro-dairy farms, these figures have been adjusted in Table 7 below.

Table 7. The effect of a 10.6% decrease in milk value on both conventional and micro-dairy herds.

| | Before hypothetical decrease in milk value | | After hypothetical decrease in milk value | |
|------------------------------------|--|-------------------|---|-------------------|
| | Conventional dairy herd | Micro-dairy herd | Conventional dairy herd | Micro-dairy herd |
| Enterprise Output | | | | |
| Yield (litres/cow) | 12580.45 | 7390.95 | 12580.45 | 7390.95 |
| Price (pence/litre) | 14.49 | 85.72 | 12.95 | 76.63 |
| Stocking rate Cows/Hectare | 1.85 | 1.85 | 1.85 | 1.85 |
| Stocking rate Hectare/cow | 0.54 | 0.54 | 0.54 | 0.54 |
| Milk output (£) | 1822.99 | 6334.98 | 1629.17 | 5663.14 |
| Miscellaneous revenue | 11.70 | 11.70 | 11.70 | 11.70 |
| Calves sold | 116.50 | 116.50 | 116.50 | 116.50 |
| Depreciation | -171.00 | -171.00 | -171.00 | -171.00 |
| Total output | 1780.19 | 6292.18 | 1586.37 | 5620.34 |
| | | | | |
| Total variable costs | 816.30 | 875.61 | 816.30 | 875.61 |
| | | | | |
| Gross margin (per cow) | 963.89 | 5416.57 | 770.07 | 4744.73 |
| Gross margin (per hectare) | 1783.20 | 10020.66 | 1424.63 | 8777.76 |
| | | | | |
| Total fixed costs | 1284.00 | 1434.17 | 1284.00 | 1434.17 |
| Net profit | 499.20 | 8586.49 | 140.63 | 7343.59 |
| | | | | |
| Average farmed area | 156 | 8.1 | 156 | 8.1 |
| Average net profit per farm | £77,874.67 | £69,550.56 | £21,937.81 | £59,483.08 |

In the proposed micro-dairy business model the producer has substantially more influence over the price paid for their milk than in a conventional dairy farm scenario, where milk is generally contracted to a milk processor who will set the price paid to the producer (Fearne and Ray, 1996). Because of this, milk price fluctuations in a micro-dairy scenario are unlikely to be as pronounced as suggested in Table 7, although it does demonstrate the impact of a fairly minor reduction of 10.6%.

As the milk price for conventional dairy farms is low, a reduction in milk value of only 1.54 pence means the overall farm net profit is reduced by 71.83%. Conversely, due to the high profit margin per cow in the micro-dairy scenario, even though milk price drops by 9.09 pence overall farm profit is less affected and drops by only 14.48%.

These models suggest that smaller scale dairy herds could be significantly less susceptible to fluctuations in external inputs, a result supported by the findings of a study on dairy farms in the USA (WSPA, 2011).

4.2.3 Premium economic model

The aim of defining the average willingness to pay of the top one third of respondents was to define a 'premium' added value for the product specified. As can be seen from the model, the premium figure for all three factors was substantially higher than the willingness to pay values in the standard model, which contributed to a substantial net profit per hectare. As product value is generally negatively correlated to product demand, defining optimal pricing for food products is an area which has been studied extensively (Gardner, 1975; Andreyeva, Long and Brownell, 2010)

4.3 Consumer survey as a predictive model

The multiple linear regression model detailed in section 3.1.5 had a similar result for all three WTP factors, in that it showed that around 10% of the variation in willingness to pay can be explained by respondent's estimate of the average pint cost and a respondent estimate of the percentage of milk sales value received by the farmer. Both of these factors had a positive correlation on willingness to pay for speciality milk.

In effect the model suggests that the more consumers think milk costs currently, the more they are willing to pay for milk involving one of the speciality factors specified.

This result contradicts initial predictions as it was assumed that consumers who estimated they were already paying a higher amount for milk would be less willing to pay extra for speciality milk, compared to those who estimated that they currently paid less. The reason for this is unclear, although it could be suggested that respondents who gave lower and more reserved answers for WTP were also more likely to give lower, more pessimistic answers for farmer percentage share as individuals are likely to be consistent with answers in order to avoid cognitive dissonance (Alfnes, Yue and Jensen, 2010).

The model also suggests that the more consumers estimate farmers get paid for their milk, the more they are willing to pay. This contradicts initial predictions as was assumed that consumers who estimated farmers received a lower amount, would be willing to pay more to compensate for this. The model however, suggests that there is no such emotional response and that consumers who think farmers receive a low amount are unwilling to pay more money for milk because of this. Equally, this suggests that consumers who believe farmers receive a higher proportion of milk sales value are willing to pay a higher amount for speciality milk products. This suggests that the level of willingness to pay for milk directly from local farmers (section 3.2.1) is not linked to consumer sympathy for farmers, but due to valuing other attributes of local products. The model also highlights the complexities of the factors influencing consumer choice, as c.90% of the variation in responses for willingness to pay cannot be explained by the information collected.

4.4 Case studies

The case studies detailed in section 3.2 were conducted primarily in order to gather data for the economic model detailed in section 2.3, but producer interviews also provided insight into other areas worthy of mention.

4.4.1 Consumer demand for local produce

A common theme throughout many of the case studies was the prevalence of consumer demand for local produce. In case study one involving the milk vending machine (3.2.1) the producer interviewed said he was surprised by the success that his venture had enjoyed and when asked, many of his customers mentioned that a major appeal of purchasing milk via the vending machine was that they knew the money from milk sales was going directly to the farmer. This anecdotal evidence is supported by studies in America which have shown that there is a demand for local products which aid the local economy and local producers (Carpio and Isengildina-Massa, 2009). In addition to supporting local farmers, the producer involved in case study two (the micro-dairy), stated that his customers preferred his product as they considered it to be a higher quality than milk supplied in shops, another finding which is supported by multiple studies (Herche, 1994; Wolf, Spittler and Ahern, 2005)

4.4.2 Entrepreneurship

Many of the producers interviewed seemed to be attempting a diverse range of alternative methods to improve the viability of dairying. This level of entrepreneurship is likely driven by the low profit margins evident in conventional dairy farming (Pyysiäinen *et al.*, 2006).

The producer from case study one installed a vending machine to supply milk to public directly, while the producer in case study two reduced the scale of production and focussed on processing and delivering the product directly. The producers involved in case study three employed the use of outdoor milking bails in order to reduce the initial setup costs involved, while the producer in case study four employed the use of modern robotic milking parlours. These studies all show evidence of the producer diversifying their methods in order to improve the profitability of their business.

The scale of dairy farming could have an impact on the prevalence of entrepreneurship. A study conducted in Holland investigated the occurrence of entrepreneurial behaviour in dairy farmers, and how this behaviour was related to farm size. The results suggested that producers with smaller farms were more likely to pursue an extra source of income (Bergeroet *et al.*, 2004), meaning entrepreneurial behaviour could be more common in farmers employing a micro-dairy approach. A case study in Finland suggested that due to the changing nature of the agricultural industry in Europe, there has been an increase in farmers pursuing additional enterprises in conjunction with their primary agricultural production. This has led to an emergence in farmers identifying themselves both as entrepreneurs and as producers (Vesala and Vesala, 2010).

4.5 Conceptual framework

The conceptual framework detailed in section 1.5.1 was intended to provide an illustration of how the research question was to be investigated. Broadly the framework yielded

appropriate data to investigate the intended questions, though there were certain elements missing from the scope of the study.

4.5.1 Consumer survey

The scope of the consumer survey did not investigate the respondent's current buying behaviour in any depth. As a result, comparisons to current consumer behaviour were unviable. Additionally, the survey did not investigate consumer opinion on current milk marketing practises such as organic, free range or pasture fed, meaning it was not possible to investigate any interaction between these factors and the speciality factors investigated.

4.5.2 Case studies

The case studies investigated the prevalence of farmers producing milk involving the speciality factors investigating, and attained information on the financial cost of this production. What the scope of the case studies did not include was the reason behind the producers diversifying into these areas. The scope of a future study could therefore investigate farmer incentives for diversification in order to investigate their appeal with regard to non-fiscal motivations.

4.5.3 Comparison to national statistics

The scope of this study investigated the viability of producing speciality products by surveying a sample of consumers. In a future study comparisons to national demographic data could provide insight into the market size for the products investigated.

Chapter 5. Conclusions.

5.1 Rare breed cattle

The results from the survey suggest that consumers are willing to pay more for milk from rare breeds, and that this willingness to pay is linked to a desire to aid the conservation of the breed. Previous studies have suggested a similar willingness to pay for livestock products in order to aid conservation (Tienhaara, Ahtiainen and Pouta, 2013), however willingness to pay for milk has not been previously investigated.

The economic model (Table 3) suggests that consumer willingness to pay could add enough value to rare breed milk to counteract the effect of a lower milk yield. Milk from rare breeds could therefore prove economically viable purely through consumer willingness to conserve the breed, but the use of rare breeds as milk producers could provide further added value through other aspects.

Milk from different breeds of cattle often has differing qualities which can have a range of applications. As discussed in case study five (section 3.2.5) the milk from Gloucester cattle contains fat and protein percentages which are appropriate for use in the production of traditional single and double Gloucester cheeses. These qualities within the milk of certain rare breeds could be applied to the increasing niche market for speciality cheese production, which is seeing more cheese being sold directly to the public via farmers markets (Rare Breed Survival Trust, 2015). Using the milk in this way not only adds value to the milk, but also helps to conserve local traditions (Mathias, Mundy and Köhler-Rollefson, 2010).

Another example of added value through differing milk quality is demonstrated by Shetland cattle. Shetland cattle are a rare breed currently classified as at-risk by the Rare Breed Survival Trust, their milk yield is low (c.2500 litres) but is high in butterfat (Rare Breed Survival Trust, 2015) and predominantly carries the A² beta-casein as discussed in section 1.1.3a (Yarker, 2015). This could encourage their use as milk producers, through the increasing demand for A² milk.

Although rare breeds have a significantly reduced milk yield in comparison to Friesians & Holsteins, this could also provide added value. Increased milk yield is associated with an increase in both mastitis (Jones, Hansen and Chester-Jones, 1994) and lameness (Amory *et al.*, 2008). This suggests that some rare breeds are likely to incur reduced veterinary costs which would make them suitable for use within low-input 'New-Zealand style' dairy systems, where the focus is on reducing the cost per cow.

Many rare-breed cattle are often described as less 'fussy' grazers making them suitable for use as conservation grazers. Conservation grazing involves using animals as 'ecosystem engineers' to graze a site in order to improve biodiversity (Byington, 2011). The use of dairy cattle within conservation grazing systems could feasibly be used alongside a 'nomadic' style of outdoor dairying as used in case study 3 (section 3.2.3) in order to provide a way of both managing the environment and creating a product which could be used to create additional funds for the conservation of both the breed and the environment.

5.2 Small herd sizes

Consumer willingness to pay for milk from small herds was the lowest of the three factors investigated, although as there is a strong perceived link between small farms and local produce (Hughes *et al.*, 2007; Meas *et al.*, 2015) this willingness to pay is likely to be higher in reality. In addition milk produced from small herds would need to be marketed locally to be viable, so it is unlikely small herd milk could ever be sold independently of being local.

Overall profits from a small herd could prove comparable to that of a conventional herd, considering the added value suggested by the consumer survey (Table 6). As suggested by the sensitivity analyses carried out in section 4.2.2 the higher value provided per cow could also mean that a micro-dairy is less susceptible to fluctuations in the cost of inputs, a finding supported by a study on dairy farms in America (WSPA, 2011).

Conventional dairy farming generally takes place as an independent system with a focus on producing forage and crops for feeding the herd. A smaller herd could provide a way for farmers to diversify their farm (Bergevoet *et al.*, 2004) and allow a dairy herd to fit within a larger agricultural system. The use of livestock grazing within arable rotations is not a new concept and has been linked to an increase in environmental sustainability and soil diversity (Lemaire *et al.*, 2015). This method is generally linked to farming livestock for meat and typically involves either beef cattle or sheep, but a small scale dairy herd could potentially fit within an arable rotation, particularly if combined with an outdoor milking bail, as used in case study 3 (section 3.2.3).

The high initial cost involved in dairy farming means the number of new entrants into the sector is low; but the comparably low setup costs involved in micro-dairying could provide a way of encouraging new entrants. Initial start-up cost estimations vary substantially but can be between £30,000 and £50,000 according to Nick Snelgar of Maple Field Milk (Mr N Snelgar 2016, pers.comm., 3rd December). This cost is inclusive of cattle, equipment and land hire, although this initial outlay can be substantially reduced through the use of crowdfunding.

Crowdfunding is a relatively recent concept, whereby the initial financial outlay for a project is collected from a large number of people (Njegomir and Tepavac, 2017), who in turn receive their investment back either with interest or as equity (UK Crowdfunding, 2017). In 2014 Nick Snelgar attempted to use crowdfunding as a means of starting a micro-dairying business, whereby £80 worth of milk was promised to an investor of £1000 (Tappenden, 2014). The producer discussed in case study 2 (section 3.2.2) took this concept a step further and coined the term 'Cow-bonds' which acted as private loans between local patrons and aided in the initial purchase of cattle.

A combination of crowdfunding, agricultural development grants and business loans suggest that micro-dairies could provide a way new for entrants to access the dairy sector, particularly when compared to the substantially larger investment involved in conventional dairy farming.

5.3 Local produce

The questionnaire suggests that milk produced locally is the speciality factor considered most important by consumers, a finding which is well supported by numerous other studies on local produce (Hughes *et al.*, 2007; Adams and Salois, 2010; Pearson *et al.*, 2011; Meas *et al.*, 2015). Marketing milk locally would be suitable for both rare-breeds and micro-dairies, as viability of using either system would be improved by marketing produce directly to consumers, as this provides a way of directly dictating milk price.

Farmers using conventional dairy systems would unlikely be able to supply all of their milk locally due to a lack of a suitable scale customer base (as discussed in section 4.2.1) although a selling a portion of their milk locally could provide an extra source of income.

Many dairy contracts allow for a percentage of milk volume produced by suppliers to be sold through alternative means. Arla, for example allow their suppliers to sell 10% of their milk independently (Mr J Hares 2016, pers.comm., 13th November) and as demonstrated in case studies one (section 3.2.1) and four (section 3.2.4) there is substantial consumer demand for milk products purchased directly from the farm gate.

5.4 Recommendations

The outcomes of this study could provide an incentive for dairy producers to investigate the possibility of selling more produce locally, and therefore adding further value to their milk. If more farmers were able to sell their products to local consumers, this could result in an increase in financial independence for producers and therefore a reduced reliance on the price offered by supermarkets.

As outlined in section 5.2 short term grass leys which are then grazed by livestock are often used within arable systems as a means of re-introducing soil fertility during a crop rotation. The results of this study would suggest that there may be economic opportunities for the introduction of small scale dairying as a grazing enterprise within these arable rotational systems.

The use of rare or endangered breeds could provide a further way to diversify both the functionality and produce of a dairy herd. As mentioned in section 5.1, some rare breeds have the ability to utilise some grazing more effectively than conventional dairy cattle and the introduction of rare breed genetics into a herd could also provide a means of improving milk quality (e.g. butterfat, protein A2 β -caseins content).

There are also opportunities for farmers to use rare breed animals as a means of meeting some of the subsidised requirements envisaged in future Government environment policy, as outlined in the '25 year environment plan' (DEFRA, 2018). Although there has been evidence in the past that some rare breeds have remained unprofitable despite financial assistance (Signorello and Pappalardo, 2003), profitability could be substantially improved if products were appropriately marketed by utilising the apparent willingness to pay for products from rare breeds.

Chapter 6. References

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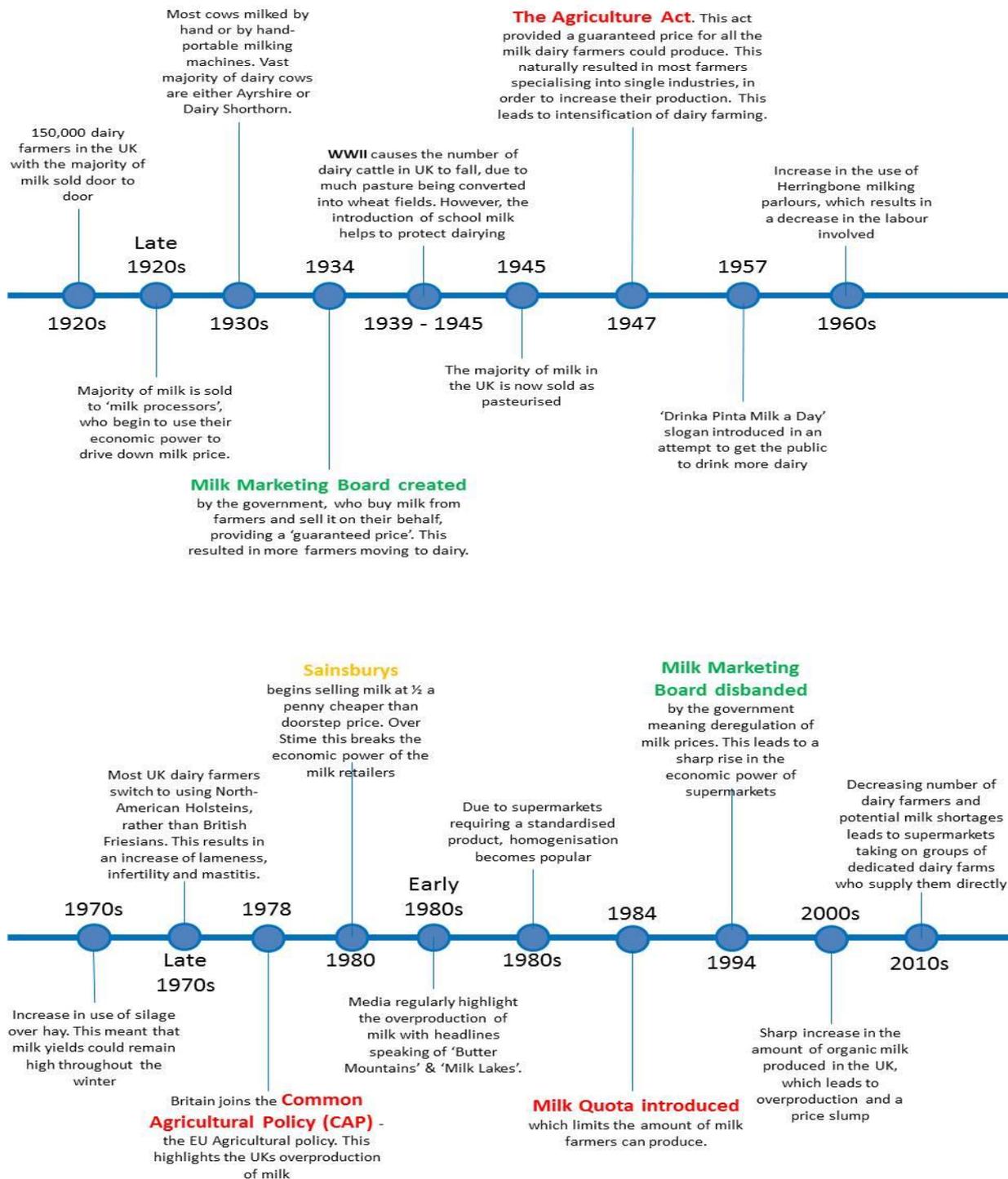
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Chapter 7. Appendices.

Appendix 1. Dairy farming timeline



Source - *Mud, Sweat and Tractors: The Story of Agriculture.* (2009). [Online] UK : BBC



Free Prize Draw!

For your chance to win one of the prizes below, please complete a short questionnaire which should take around 5 minutes.

The information you give will contribute to research being conducted regarding the UK Dairy industry, in conjunction with Plymouth University & Duchy College



Cuddly Dazy the Cow!



'Cornish Yarg' cheese



Family Pass to Dairyland

Please note: The prizes offered are provided by Dairyland Farmworld and not by Plymouth University or Duchy College; prize-winners will be selected at random on the 1st of September 2016 and the winners will be contacted via email and their names posted to Dairyland social media

Pilot questionnaire

Thank you for taking the time to fill in this short questionnaire. The aim of this pilot study is to iron out any kinks in the methodology before the full study is launched in the summer (2016) Please therefore feel free to annotate with any **comments** or **criticism**, regardless of how harsh they are (don't worry, I'll forgive you!) If you do not know the answer to a question or would rather not say, please leave the answer blank. Please also be aware that the information given will be used solely for the purposes of research and your information will not be used for marketing or passed on to a third party. Thanks again!

Personal details

Full name.....

Email address

What is your gender? Male Female

Do you buy dairy products? Yes No

Question 1. How much do you know about dairy farming? (Please circle)

Very little a lot
1 2 3 4 5

Question 2. How much do you know about rare breeds of dairy cattle?

Very little a lot
1 2 3 4 5

Question 3. How many breeds of dairy cattle can you name? (Please list)

.....
.....

Question 4. How much do you think a pint of milk currently costs, on average?

.....

Question 5. What do you think the average size of a dairy herd is in the UK?

.....

Question 6. In your opinion, how many cows would be in a ‘Small Herd’?

.....

At present there are around 3 million dairy cows in the UK, however over 98% of these Cows belong to one of three breeds; Friesian, Jersey and Ayrshire (Defra 2008).

Question 7. Do you believe it is important to conserve rare breeds of dairy cattle?

Strongly disagree

strongly agree

1

2

3

4

5

Question 8. Would you be willing to pay more for milk from rare breeds of dairy cattle? If so how much? If not, why not? (Current average cost of a supermarket pint – 45p)

.....

.....

The average size of dairy herds in the UK is gradually increasing, and currently stands at an average of 133 cows per herd (AHDB 2015)

Question 9. Do you consider smaller dairy herds to have a higher level of animal welfare?

Strongly disagree

strongly agree

1

2

3

4

5

Question 10. Would you be willing to pay more for milk from a ‘small’ herd? If so, how much? If not why not? (Current average cost of a pint – 45p)

.....

.....

Question 11. What is your occupation?

.....

Question 12. What is your age? (If unwilling to disclose please leave blank)

- A- 15 – 24
- B- 25 – 44
- C- 45 – 64
- D- 65+

Question 13. What is your highest level of education? (If unwilling to disclose please leave blank)

- A- Below GCSE level
- B- GCSE (or equivalent)
- C- A-Level (or equivalent)
- D- Bachelors Degree (or equivalent)
- E- Masters degree and above (or equivalent)

Question 14. What is your approximate household income per annum? (If unwilling to disclose please leave blank)

- A- 0 - £15,000
- B- £16,000 - £30,000
- C- £31, 000 - £45,000
- D- £46,000 - £60,000
- E- £61,000+

.....

At present there are around 3 million dairy cows in the UK, however over 98% of these Cows belong to one of three breeds; Friesian, Jersey and Ayrshire (Defra 2008).

Question 7. Do you believe it is important to conserve rare breeds of dairy cattle?

Strongly disagree strongly agree

1 2 3 4 5

Question 8. Would you be willing to pay more for milk from rare breeds of dairy cattle? If so how much? (Current average cost of a supermarket pint – 45p)

- A. No, I would not be willing to pay more*
- B. Yes, **less than 5p** per pint
- C. Yes, **5p** per pint
- D. Yes, **10p** per pint
- E. Yes, **15p** per pint
- F. Yes, **more than 15p** per pint

*If you answered A, please state why -

The average size of dairy herds in the UK is gradually increasing, and currently stands at an average of 133 cows per herd (AHDB 2015)

Question 9. Do you consider smaller dairy herds to have a higher level of animal welfare?

Strongly disagree strongly agree

1 2 3 4 5

Question 10. Would you be willing to pay more for milk from a 'small' herd? If so, how much? (Current average cost of a pint – 45p)

- A. No, I would not be willing to pay more*

- B. Yes, **less than 5p** per pint
- C. Yes, **5p** per pint
- D. Yes, **10p** per pint
- E. Yes, **15p** per pint
- F. Yes, **more than 15p** per pint

*If you answered **A**, please state why -

Question 11. What is your occupation?

.....

Question 12. What is your age? (If unwilling to disclose please leave blank)

- A- 15 – 24
- B- 25 – 44
- C- 45 – 64
- D- 65+

Question 13. What is your highest level of education? (If unwilling to disclose please leave blank)

- A- Below GCSE level
- B- GCSE (or equivalent)
- C- A-Level (or equivalent)
- D- Bachelors Degree (or equivalent)
- E- Masters degree and above (or equivalent)

Question 14. What is your approximate household income per annum? (If unwilling to disclose please leave blank)

- A- 0 - £15,000
- B- £16,000 - £30,000
- C- £31, 000 - £45,000
- D- £46,000 - £60,000
- E- £61,000+

Question 3. What do you think is the current average price of a pint of milk?

£ __ . __ p

Question 4. What do you think is the average size dairy herd in the UK?

(Number of cows)

_____ cows

Question 5. In your opinion how many cows would be in a 'small herd'?

(Number of cows)

_____ cows

Question 6. Do you believe it is important to protect rare breeds of dairy cattle?

(Please circle)

Strongly disagree

Strongly agree

1

2

3

4

5

Question 7. Would you be willing to pay more for milk from rare breeds of cattle?

(Please tick)

Yes

No

Question 8. If you answered 'yes' to question 7, how much **more** would you be willing to pay per pint? (i.e. on top of what you are already paying)

£ __ . __ p

Question 9. Do you think cows within 'small' dairy herds have a higher level of animal welfare? (Please circle)

Strongly disagree

Strongly agree

1

2

3

4

5

Question 10. Would you be willing to pay more for milk from a 'small' herd?

(Please tick)

Yes

No

Question 11. If you answered 'yes' to question 10, how much **more** would you be willing to pay per pint? (i.e. on top of what you are already paying)

£ __ . __ p

Question 12. What proportion of the money made from milk sales do you think goes to the farmer?

_____ %

Question 13. Do you think dairy farmers should receive a higher proportion of the money made from milk sales? (Please circle)

Strongly disagree

Strongly agree

1

2

3

4

5

Question 14. Would you be willing to pay more for milk purchased directly from a local farmer? (Please tick)

Yes

No

Question 15. If you answered 'yes' to question 14, how much **more** would you be willing to pay per pint? (i.e. on top of what you are already paying)

£ __ . __ p

Question 16. What is your current age? (Please tick)

15 – 24

25 – 44

45 – 64

65+

Question 17. What is your highest level of education? (Please tick)

Below GCSE level

GCSE (or equivalent)

A-Level (or equivalent)

Bachelors degree (or equivalent)

Masters degree or above

Question 18. What is your approximate household income per year? (Please tick)

0 - £16,000

£16,000 - £30,000

£30,000 - £45,000

£45,000 - £60,000

£60,000+

Question 19. Where do you usually buy your milk from? (Please tick **one**)

Supermarket

Convenience store

Local shop

Milk-round

Farm shop

Direct from farm

I don't buy milk

Question 20. When deciding what milk to buy, what is the main thing you look at? (Please tick **one**)

Price

Organic

Locally produced

Specific brand

British produce

I don't buy milk