

Evolution of Agri-Food Supply Chains to Enhance Competitiveness:

Literature Review

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Executive Summary

The agri-food sector in Northern Ireland is faced with a diverse set of challenges and opportunities that have implications for the whole supply chain. These include increasingly sophisticated consumer preferences; changing attitudes of society to food safety & integrity; health & nutrition concerns; along with biotechnology and information technology developments. In addition, the sector has experienced significant changes in terms of policy reforms, such as decoupling of direct payments, which have increased the influence of the market on production and reduced global trade barriers. It is increasingly recognised that agri-food supply chains need to evolve to meet these challenges and opportunities. This review examines the manner in which the supply chain has evolved to meet competitiveness challenges in other parts of the world.

The review highlights that in general there has been a trend towards tighter forms of coordination globally between actors within the supply chain, such as contracts between farmers and abattoirs/retailers. Tighter forms of coordination provide components of the supply chain closer to the consumer, e.g. retailers and processors, a means to enforce a greater level of control compared to spot markets. However, the trend towards tighter forms of coordination differs across sectors and tends to be more prevalent in the pig and poultry sectors. This trend partly reflects the high level of investment in specialised assets in the pig and poultry sectors, such as production facilities, which needed to be safeguarded. In addition, the narrower genetic base in the pig and poultry sectors favoured closer coordination strategies since it reduced processing costs and enhanced the ability to produce consistent products. Moreover, branding has been a more notable feature of the pig and poultry sectors, which has been facilitated through the use of contracts. Branding has been slower to develop in the beef sector, partly due to the broader genetic base and lack of control over quality across the supply chain. Contracts also play an important role in the fruits and vegetable sector as it provides a means to control quality as these commodities tend to be observed by consumers in their primary form.

Many producers within the UK value their independence and tend to be resistant to stricter forms of vertical coordination. Non-contractual long-term relationships have emerged to provide a middle ground between spot markets and tighter forms of vertical coordination. The literature suggests that the sustainability of long-term relationships is dependent on the development of trust-building measures that encourage collaboration such as good communication, alignment of business objectives and the perception of equitable power distribution. The latter may be enhanced by organising farmers into groupings, such as producer groups or co-operatives, in order to engender a perception of enhanced market power and facilitate communications.

Despite the emergence of these alternative strategies, spot markets will continue to play an important role within the agri-food supply chain, particularly in the beef and sheep sectors. In many circumstances, price signals within spot markets provide an effective means of coordinating production decisions to fulfil consumer demands for product attributes. The extent of spot markets in the future will depend, in part, on the degree to which spot market pricing systems can keep up with changes in product attributes and



consumer demand (MacDonald, 2004). Within the red meat sector, price differentials have been added to the grid pricing system to reflect retail specifications. This encompasses factors such as weight and level of fat but does not take into account key consumer quality attributes such as tenderness. In addition, a significant proportion of carcases do not meet retail specification requirements, partly reflecting continued allegiance to the 'production concept' where animals are pushed onto the market based on what farmers have traditionally produced on their farm or what they believe to grow best there, rather than a more consumer oriented approach

The efficiency of the spot market may be facilitated through the development and effective application of more sophisticated grading systems, which better reflect consumer preferences. Enhanced pricing systems provide producers with incentives to produce desired product attributes. A leading example of a supply chain system that has been developed to identify and control processing factors that affect meat eating quality is the 'Meat Standards Australia' (MSA) grading system. Factors related to meat eating quality taken into account within the Australian system include: muscle, position within muscle, hanging method, % Bos Indicus breed, use of growth promoters, marbling, maturity, carcase weight, rib fat cover, meat colour, ultimate pH, ageing and cooking method. Other processes such as pre-slaughter handling and post mortem processing have absolute requirements to ensure optimum conditions for maximising palatability. The 'Meat Standards Australia' program has acted as a catalyst for substantial change in all sectors of the Australian beef industry encouraging and facilitating research and commercial industry cooperation. This has led to better industrial practices and a general improvement in beef eating quality even where some participants have not formally adopted the 'Meat Standards' Australia' procedure. The relative importance of pre and post slaughter factors in delivering predictable eating quality has highlighted the importance of viewing industry segments as inter-related elements of a single production chain and the value of cooperation and clear communication between all segments of the chain. Consumer trials comparing Australian and Northern Irish consumers showed essentially similar results for consumer preferences for beef eating quality from both countries. Moreover, an adapted MSA grading model reflecting cattle types, production systems and consumers in Northern Ireland was found to predict the eating quality of NI beef with good accuracy and precision.

The feasibility of implementing such enhanced pricing systems is partially dependent upon technologies to measure attributes within a commercial environment. Moreover, in order to make investments in new technologies processors require reassurances that consumers are willing to pay for specific quality attributes. There has been a reluctance to introduce new pricing system technologies for fear of losing throughput due to concerns that suppliers would move to less stringent competitors. Consumers also increasingly require assurances about credence attributes, which reflect both individual consumer concerns, e.g. health/nutrition, and collective concerns, e.g. the environment (Henchion *et al.*, 2014). Products that can deliver these credence attributes can potentially reduce the quality uncertainty of buyers. These credence aspects can potentially be met within the spot market through industry-wide certification schemes.

Within the dairy sector, component pricing, whereby the price of milk depends on the content of different components, is increasingly popular within Europe, US and Oceania. This pricing system provides a means to send market signals to the farm gate by linking the



relative values of component contents to breeding and on-farm management practices. Component pricing is more relevant to milk for manufacture compared to milk for fluid use. As a result, milk for manufacture contracts tend to show some price variation according to underlying components, e.g. protein content, but this is less evident for fluid contracts. In terms of fluid contracts, there is a notable price differential between supermarket aligned and non- aligned contracts in the UK, with the former receiving a premium, particularly when milk prices are generally low. However, the aligned contracts are only available for a small proportion of dedicated producers. This contrasts with the system in the US, where the Federal Milk Marketing Order ensures that premiums do not accrue to a limited number of producers.

Price volatility is a major issue for the dairy sector. Futures and options are widely used to hedge against price volatility in the US, but these markets have struggled to develop in the EU. Within the EU there has been some limited development of forward contracts, wherein producers can lock-in the output price with a cooperative and benefit from price certainty. This enhances the ability of farmers to plan and to obtain continued or new financing. Forward contracts have existed for a longer time period in the US. The empirical evidence in the US indicates that lack of knowledge regarding forward pricing is an important barrier to the uptake of these contracts. This suggests that education, training and the extension service are crucial in the development of these new programmes.

The extent to which cooperatives can offer its members risk management tools depends on their ability to manage risks on their output side. Ultimately, cooperatives require strategies that reduce their reliance on the commodity market and hence output price volatility, for example, contracting with restaurant chains, developing branded cheese *etc.* The risk management tool set could be broadened if the futures market in the UK/EU develops from its current infant state. However, given the typical futures contract size in the US, it will not be easy for milk producers, particularly small ones, to directly participate and cooperatives will be an important intermediate.

A range of business improvement measures applicable to agri-business supply chains were reviewed based on the experience of the Red Meat Industry Forum in GB. These include: farm business improvement clubs using web-based benchmarking; international benchmarking; benchmarking of processor performance on a country basis against international competitor counties; evaluation of processes, practices and outcomes within individuals companies, which are then compared with other comparable companies (Promoting Business Excellence: PROBE); and identification of activities that add value across the entire supply chain (Value Chain Analysis). The experience of the Red Meat Industry Forum demonstrated that these techniques can be applied to smaller businesses but require the full commitment of top management.

The review of the literature concludes with some of the key themes covered in the 2016 World Meat Congress and their implications for the UK meat supply chains. In particular, it was highlighted that demand from emerging and developing economies will become increasingly important, with strong income growth in Asia, Africa and Central America resulting in domestic consumption outstripping domestic production. This growth presents export opportunities for UK suppliers, which have traditionally been geared to servicing British retailers. Of particular importance will be 'fifth quarter' offal products,



which are of minor value in UK markets but high value in Asian markets. A truly effective supply chain needs to secure the best value for each part of the animal regardless of whether that is in the home or an overseas market. More opportunities may emerge for securing advantages in some of these rapidly growing markets if the UK is successful in negotiating Free Trade Agreements following Brexit.

Within the World Congress meeting, it was also emphasised by Rabobank that meat is increasingly being seen through consumer eyes as part of a larger market for protein food products, with greater competition from aquaculture and alternative protein sources. The aquaculture sector in particular has increased global production at a rate of over 5% per annum in the last decade compared with 1.5% for meat. With the growing competition from cheaper sources of protein the red meat sector needs to respond strategically, *e.g.* seek additional attributes and add value in ways that are in line with consumer preferences.



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Chapter1: Background

The agri-food sector in Northern Ireland is faced with a diverse set of challenges and opportunities that have implications for the whole supply chain. These include increasingly sophisticated consumer preferences; changing attitudes of society to food safety & integrity; health & nutrition concerns; along with biotechnology and information technology developments. In addition, the sector has experienced significant changes in terms of policy reforms, which have increased the influence of the market on production and reduced global trade barriers.

It is increasingly recognised that agri-food supply chains need to evolve to meet these challenges and opportunities (Duffy and Fearne, 2006; Bansback, 2014). However, the sector suffers from fragmentation with a large number of small producers with diverse business objectives, a commodity culture and adversarial trading relationships throughout the supply chain. The need to remodel the supply chain is particularly evident in the red meat sector in the UK, which has experienced long-term decline in consumer demand. As shown in Figure 1, per capita UK consumption for beef and sheepmeat fell by 19% and 38% respectively between 1985 and 2014, while that for poultry increased by 80%¹.





Source: Agriculture in the UK

The traditional supply chain is characterised by firms operating independently, both upstream and downstream across different components of the supply chain², i.e. vertically, and within the same stage of the supply chain, i.e. horizontally. Vertically, firms compete

¹ These figures are based on Agriculture in the UK meat supply data. While this measure incorporates stocks it provides a measure of trends in meat consumption and is used as a measure of per capita consumption within the literature, e.g. Kanerva (2013).

^{(2013). &}lt;sup>2</sup> "Upstream" refers to stages of the supply chain closest to the beginning of the production process, while "downstream" refers to those stages closest to the consumer.



with each other, seeking to purchase inputs at the lowest cost and to sell output at the highest price. Horizontally, firms compete with each other by varying buying price or terms in order to secure supply and by varying selling price and services, which ultimately are built into the price, to secure sales (Hayes et al., 1997). Individual firms seeking to make gains at the expense of their buyers and/or suppliers, ultimately transfer the costs up/down the supply chain and do not improve their competitive position as the costs make their way to the final marketplace (Duffy and Fearne, 2006). Adversarial relationships between different components of the supply chain make it difficult to fully co-ordinate strategies to meet consumer needs. In addition, traditional supply chains are inefficient at signalling changes in consumer preferences. This problem is exacerbated as consumer preferences become more sophisticated, specific and varied. Moreover, Lawrence and Hayenga (2002) argue that the incentive structures within these traditional supply chains are too blunt. They contend that there is a need to shift from systems which focus on standard productivity measures such as feed efficiency, growth rates, piglets per sow *etc.* as these often conflict with more customer-oriented genetic and production management choices.

Many agricultural economists have called for greater coordination within agri-food supply chains [e.g. Fearne (1998), Hornibrook and Fearne (2002) and Palmer (1996)]. It is argued that a more compact market structure will improve the performance and competitiveness of the sector by driving down transaction costs throughout the supply chain, e.g. reductions in production and measurement costs (Martinez, 2002). In addition, enhanced co-ordination will facilitate information flows through the supply chain, enabling producers to make necessary changes to respond to consumer needs more effectively (Chambers and King, 2002). Greater co-ordination would also enhance the integrity of food in terms of quality and food safety issues. Within its strategic action plan to stimulate growth within the agri-food industry in Northern Ireland, the Agri-Food Strategy Board highlighted the need for collaboration and consolidation within the local agri-food supply chain. The Board recommended a change in mindset which ensures that:

"each partner is working towards the same goal delivering a product that meets the needs of the marketplace rather than producing a product for which a market is subsequently sought" (Agri-Food Strategy Board, 2013).

A variety of strategies have been developed to improve the level of coordination within the agri-food supply chain. Horizontally, alliances provide a means for firms within the same stage of the supply chain to collaborate. For example, alliances between producers enable participants to expand their marketable output, increasing the volumes offered to processors and thereby improve market power (Hayes *et al.*, 1997). In addition, organisational changes are evident across different stages of the supply chain with evolving forms of vertical coordination. Vertical coordination refers to the process of organizing the flow of products from producers to consumers and the reverse flow of information from consumers to producers (Oklahoma Cooperative Extension Service, 2005). Methods of vertical coordination include the spot market, long-term relationships, marketing contracts, production contracts and vertical integration (Figure 2). Along this continuum of vertical coordination at the



other, the level of control of production shifts from the producer to the contractor/integrator (Martinez, 2002).

The least controlling system is the spot market, wherein coordination across the stages of the supply chain is governed by market prices. At the other extreme, is vertical integration, wherein a single firm owns two or more adjacent stages in the vertical supply chain and controls production decisions to meet consumers' demands. This is the closest form of coordination, which essentially internalises the transaction between the seller and buyer. Between the two poles on the continuum lie contracts. Essentially, contracts are agreements between contractors and producers, which specify conditions of producing and/or marketing of an agricultural product. Under a marketing contract, the contractor and producer may negotiate a price or pricing formula, delivery schedule and product characteristics. While the contractor may provide an outlet for the good, most management decisions remain with the producer, who retains the production risk. Under a production contract, the contractor typically provides a market for the good, engages in many of the production decisions and retains ownership of important production inputs (Martinez, 2002).



Figure 2: Vertical Coordination of Supply Chains

Source: Martinez (2002)

This review will examine the manner in which the supply chain has evolved to meet competitiveness challenges in other parts of the world. Chapter 2 sets the scene, drawing on the economics literature to explain the emergence of different coordination strategies within the agri-food supply chain. The development of supply chains within specific subsectors across the globe is explored in Chapter 3. The Meat, Dairy and Horticulture sectors are considered separately to enable sector specific characteristics to be taken into



consideration. This is followed by a discussion of the application of business improvement techniques in the red meat sector in GB in Chapter 4 and an overview of the key themes covered in the 2016 World Meat Congress in Chapter 5. Finally, conclusions are drawn in Chapter 6.



Chapter 2: Factors Explaining Different Coordination Strategies within the Agri-Food Supply Chain

2.1 Introduction

In general, the agricultural sector has experienced a trend towards tighter forms of vertical coordination. This has coincided with the rise of increasingly differentiated, branded, more value-added food products. Regulations concerning safety, quality and the environment have also strengthened, partly due to concerns from consumers. Together, these factors have contributed to the trend of closer vertical coordination. As discussed below, there are various advantages and disadvantages associated with the different supply chain coordination strategies, *i.e.* from the spot market to vertical integration, and the extent of "closeness" varies across subsectors.

Within the economics literature the concept of transaction costs is widely used to explain alternative forms of vertical coordination within supply chains. Transaction costs within supply chains include costs associated with planning, adapting, and monitoring economic activities, which are required to coordinate the activities of buyers and sellers (Martinez, 2002). Within the spot market, buyers incur costs searching for suppliers offering preferred quality features at favourable prices, while sellers incur costs in determining prices and buyer preferences. These costs can potentially be reduced through tighter forms of vertical integration such as contracts and vertical integration. However, these alternative systems introduce other types of costs, e.g. negotiating contracts and enforcing agreements. The transaction costs theory is used as a basis of discussion below.

2.2 Price Signals

Prices provide a mechanism to pass market signals along the supply chain. Within the spot market, prices can provide an effective means to coordinate production. Prices of similar transactions should converge to a common "market price" as buyers avoid paying excessively high prices and sellers do not accept excessively low ones. This is supported through the provision of accurate pricing and market information, which informs these decisions. For consumers, market prices signal the degree of product scarcity and stimulate production of product attributes that consumers prefer. For sellers, market prices provide signals of buyer preferences and elicit flows of inputs and services (MacDoanld *et al.*, 2004). Thus, market prices within the traditional spot market system directly signal consumer preferences to producers and guides production decisions to fulfil consumer demand.

However, the spot market will fail to provide appropriate market signals to producers and consumers if prices do not reflect the attributes of products that consumers prefer



(MacDoanld *et al.*, 2004). In this case, alternative coordination systems are required in order for production to reflect desired consumer attributes.

The price signal becomes more blurred moving along the continuum from the spot market to vertical integration. There is no price signal along the supply chain in the case of the latter. Ultimately, however, consumers are faced with a price, which is used to allocate their purchases given a certain level of income.

Following Schroeder *et al.* (1997), a distinction is made between the concepts of *price discovery* and *price determination*:

- *"Price discovery* is the process of buyers and sellers arriving at a transaction price for a given quality and quantity at a given time and place."
- *"Price determination* is the interaction of the broad forces of supply and demand which determine the market price level...Transaction prices fluctuate around that market price level. This fluctuation is attributable to the quantity and quality of the commodity brought to market, the time and place of the transaction and the number of potential buyers and sellers present."

In view of these definitions, the structure and behaviour of retailers and their impacts on prices fall in the realm of *price discovery*. In contrast, the issue of volatility falls in the realm of *price determination*; fundamentally, inelastic demand leads to volatile prices. Making a distinction between the two definitions is helpful in analysing the supply chain problem, although this is not always straightforward. Consider the following example:

Suppose a producer complains about producing products of high quality but not receiving sufficient reward, what are the possible reasons and hence solutions?

- *Possible reason 1*: The premium for better quality is inherently low, indicating that this can be classified as a price determination issue. In this case, the producer needs to improve their level of or will be priced out of the premium market.
- *Possible reason* 2: The price is depressed by a powerful buyer or the producer has limited negotiation skills. In this case, some form of external intervention may help the producer continue to produce the high quality product.

In addition, note the phrase "given quality and quantity" within the price discovery definition. In the meat sector, particularly the beef sub-sector, there are difficulties in defining and measuring *quality* and hence, the process of price discovery is difficult. The issue of quality is discussed in detail below.



2.3 Quality

Within the literature product attributes are categorised into three categories: search, experience and credence attributes (Darby and Karni, 1973; Raynaud *et al.*, 2005):

- Search attributes are those that can be evaluated before purchasing.
- *Experience* attributes cannot be evaluated before purchasing, but can be evaluated after consuming the product.
- *Credence* attributes cannot be evaluated before purchasing and even the consumption of the product does not provide information on the quality (Raynaud *et al.*, 2005).

Using beef as an example, the weight of a piece of beef is a *search* attribute, while taste is an *experience* attribute and the antibiotics used in raising the cattle are a *credence* attribute. Search attributes can be defined and measured before purchasing and hence, can be easily communicated through prices. However, asymmetric information between the seller and buyer is an issue for the experience and credence attributes. Consumers incur costs in measuring characteristics for the purposes of verification. A further complication is that the evaluation of experience attributes is often subjective, particularly for agricultural/food products.

Another factor that clouds the relationship between quality and price is variability of the quality of the product. Given the price, consumers will form expectations concerning quality and spend resources to measure the quality of a product, mainly to avoid products below their expectation. Within the transactions cost literature this is termed a "measurement cost" (Barzel, 1982). For example, some product characteristics that influence consumers eating experience depend on the characteristics of the animals. These characteristics may be difficult to measure when the animals are sold, but production inputs, such as genetics, feed and nutrition, and management practices, may affect certain product attributes and hence, the eating experience (Martinez, 2002). Rather than consumers incurring costs of measuring attributes at the time of purchase, the measurement costs can be shifted upstream by controlling farm inputs/management practices through contracts or vertical integration. Thus, tighter forms of vertical coordination can reduce transaction costs and leave more gains to be distributed among the supply chain.

In addition, branding of retail products can reduce measurement costs within the supply chain (Martinez, 2002). If producers can narrow the quality distribution of its product and label it, thereby reducing the measurement costs incurred by consumers, they can obtain a price premium. This gives rise to the premium associated with brands (Barzel, 1982) and explains the frequent association of consistency with branding. Branding requires substantial investment in research and development and marketing, the value of which is capitalised into the value of the brand. This gives rise to the concept of reputational capital in which "It is the threat of termination of the relationship by the consumer, and the corresponding loss of reputation, that makes the implicit 'trademark' contract' self-enforcing." (Raynaud *et al.*, 2005). This in turn leads to more stringent requirements on product consistency for protection of the brand value (Henderson (1998) and Raynaud *et al.* 2005).



Differentiation and branding often happen at stages within the supply chain close to consumers and therefore these investments are often made by, and the requirements come from, downstream players such as processed food producers. Henderson (1998) showed that there is a positive correlation between intensity of investment in research and development and branding and competitiveness of processed food producers. Product differentiation, branding and compliance with regulations imply that attributes beyond price need to be available to (or even controlled by) downstream players in the supply chain. In these situations, the spot market may not be the preferred mechanism to use as it entails substantial transaction costs. These may be reduced by alternative forms of coordination. Henderson (1998) lists a series of causes of failure in market transaction including moral hazard, risk-sharing, unequal information, opportunism and double margin.

2.4 Asset Specificity

The continuum encompassing spot markets, contracts and vertical integration is considered by the transaction cost economics literature as different nodes of governance structure, which have to be and will be matched with the features of the transactions. Based on the assumption that transactions are not frictionless (e.g. using the court to settle disputes is costly and sometimes not feasible), governance costs are introduced in addition to the classical production cost. The sum of these two costs determines the mode of the governance structure (Williamson, 1985, 2001).

The most important condition giving rise to governance costs is asset specificity. Asset specificity refers to investments made specifically for certain transactions. The costs associated with these investments have two features:

- they are incurred in advance of the contemplated exchange;
- and their value in alternative uses, or by alternative users, is greatly reduced (Williamsom, 1983).

In examining how asset specificity gives rise to vertical integration consider the following example of up-stream producers selling intermediate goods to a down-stream processor. Investment in specific assets by the upstream producers results in lower production costs of the intermediate good and thus benefits both parties; however, it creates bilateral dependence between the two parties and requires continuity of the relationship (Williamson, 2001). This case diverts from the classical example of numerous faceless buyers and sellers within the market. Whether such investments are made depends on the relationship between the two parties. An example in the agricultural sector is dairy farmers forming cooperatives to protect the marketing of their milk. In addition, the investments do not have to be made by the upstream producers but can be made by downstream parties such as processors. For example, within the poultry sector, processors may choose to make costly investments to benefit from scale economies (e.g. in genetics or broiler houses) and as a result, implement tighter forms of coordination to protect their investments.



In agriculture, there are five types of asset specificity:

- Site specificity occurs when buyers and seller locate facilities close to each other, which locks parties into an exchange relationship.
- Physical-asset specificity occurs where the physical features of an asset are designed for a specific purpose and have little value for other purposes, e.g. special-purpose equipment or specialised investments required for scale economies.
- Human specificity refers to highly specialised human skills that cannot readily be put to work for other purposes.
- Dedicated specificity refers to a general purpose asset that has been purchased to meet the demand if a specific buyer. Should the buyer cease the relationship, excess capacity will result.
- Temporal specificity refers to assets where timing and coordination of activities is critical and has important implication on product value. Temporal specificity is sometimes crucial within the agriculture sector where products are perishable. Producers of perishable products are vulnerable to buyers threatening delayed acceptance of the product since it is difficult to find alternative processors at short notice.

The transaction costs literature indicates that when investments in asset specificity are high parties within the supply chain will choose alternatives to the spot market in order to protect the investment from opportunistic behaviour and reduce expenditures on bargaining over price (Martinez, 2002). On the other hand, when investments in asset specificity are low the spot market may offer the most efficient form of coordination.

The literature on price signals, quality and asset specificity is used as a basis to inform the discussion of the evolvement of sub-sectors in the next chapter.



Chapter 3: Global Evolvement of Supply Chains Across Different Sectors

3.1: Meat

3.1 (a) Introduction

A major factor affecting meat consumption is the match or mismatch between consumers' expectations and experience (Griffith *et al.* (2001) and Henchion *et al.* (2014)). In particular, variable meat eating quality is regarded as an important reason for consumer dissatisfaction, with inadequate supply chain systems failing to meet the needs of the marketplace. In order to set the context for the evolvement of systems to meet consumers' demands, we begin by providing an overview of research on consumers' expectations concerning meat eating quality. This is followed by an examination of how spot markets, followed by more formal vertical coordination mechanisms, have changed over time to address this issue.

3.1 (b) Meat Eating Quality

Consumer focussed research into meat eating quality has shown that the sensory traits of tenderness, juiciness, flavour and overall palatability remain the most sought after attributes (Miller *et al.*, 2002). Tenderness is often considered to be the single most important component of beef quality identified by consumers in the USA, Australia and the UK with the most tender cuts of meat also being the most expensive. An American study (National Cattlemen's Beef Association) found that 61% of consumers in the US would buy more beef if it was guaranteed tender. There is however increasing evidence to suggest that where tenderness is less variable it is likely that beef flavour increases in relative importance. Consumers of sheep meat usually place the highest weighting on flavour followed by tenderness and lastly, juiciness (Pethick *et al.*, 2006).

The nutritional quality of meat is also important. Beef is a highly nutritious food, an important source of high quality protein, vitamins, minerals, bio-available iron and omega 3 fatty acids and has traditionally been the mainstay of the main family meal. Quantitative research conducted on behalf of Safefood Ireland (2008) indicates that beef dishes remain popular with Irish consumers with more than three in four adults responding that they consume beef, claiming taste and enjoyment as the main reason. In a number of consumer trials investigating attitudes to beef quality in Northern Ireland (Farmer et al. 2005), a majority of N.I. consumers reported being satisfied with the quality of beef with younger age groups more demanding of quality and eating beef less frequently than older consumers.

One reason for the worldwide decline in the consumption of beef is believed to be an inconsistency of eating quality and the fact that purchasers have no reliable basis for the selection of good eating quality beef. Because consumers have substantial difficulties in forming quality expectations for a product of which little information is attached, they



usually resort to visual appearance characteristics (e.g. colour, fat content, marbling, drip loss) in their decision to predict experienced sensory quality and to purchase meat (Verbeke *et al.*, 2005). These intrinsic cues can be considered as poor indicators of overall eating quality. Colour has been reported to be one of the most important fresh meat characteristics at the point of purchase (Gracia *et al.*, 2013), usually because consumers use inadequate colour as an indicator of spoilage and wholesomeness. Irish consumers surveyed by Safefood Ireland declared confidence in assessing the look and smell of beef, perceiving the taste of beef as being closely associated with freshness. Preference for colour is known to vary between and within countries and is culturally determined (Prescott *et al.*, 2004).

To enhance consumer perception (both expected and experienced) of meat and meat products, additional information provided at the point of purchase (Grunert et al. 2004) helps play an important role in reducing uncertainty in the formation of quality expectations. Commonly cited extrinsic cues in determining meat quality expectations include: use by dates, quality labels (including brands and quality assured symbols), place of-purchase, packaging, price, and information related to origin, animal feed, production and processing. Farmer et al. (2002) found that almost half of Northern Irish consumers surveyed felt that price rarely or never was a good indicator of eating quality. Origin and place of purchase have been noted as the two most significant extrinsic cues for meat with an increasing consumer emphasis on health and the environment. Typically in European markets, home produced (domestic) meat is considered fresher, tastier and with higher quality than imports, with independent butchers believed by consumers to offer better quality meat than supermarkets (Becker et al. 2000). Irish consumers surveyed by Safefood (2008) considered Irish beef to be world class with local beef in particular having great appeal as it was perceived to be healthy and fresh. Irish consumers had few concerns with respect to food safety issues with quality assurance marks and place of purchase considered important indicators of food safety. Irish consumers also reported moving towards better, more expensive cuts of beef since the BSE crisis and were confident in how beef was categorised, considering themselves well informed with respect to the varying quality of different cuts of meat. Although a consumer's nutrition knowledge is not directly related to intentions, behaviour or attitudes, it can significantly influence beef-eating behaviour because consumers will make tradeoffs between health benefits and eating pleasure when consuming food (Sapp et al., 1991). In Europe most existing labelling schemes provide assurance that set quality production standards for products that can be traced from farmers to retailers but do not effectively guarantee muscle eating quality at the consumer level. Providing consumers with cuts of meat that have a consistent eating quality and guaranteed tenderness is a major challenge for the European beef industry (Allen et al., 2001). Recent trends in meat consumption suggest that that as the influence of factors such as income and price decline over time, factors such as quality become more significant in influencing consumer choice.



Eating Quality Factors

The most important factors known to influence the eating quality of beef and lamb are well established and include both pre and post slaughter events with many of the determinants interacting with each other. Animal breed, sex, diet, age and pre-slaughter handling are amongst the main production factors that affect quality whereas carcase pHtemperature decline, carcase hanging method, maturation, cooking method and cooked degree of doneness would be considered post slaughter effects. There is a general consensus amongst meat scientists that post-slaughter factors have a greater influence on eating quality than production factors (Ferguson *et al.*, 2001)

It should be noted that a substantial programme of work has been conducted by AFBI in Northern Ireland aimed at quantifying those factors of most importance to the Northern Irish beef industry. This was work based on a large number of consumer assessments of beef from many muscles designed to evaluate performance of the Meat Standard Australia (MSA) grading system in managing beef eating quality in Northern Ireland. Post slaughter effects such as carcase chilling and electrical stimulation , ageing, carcase hanging and cooking method were shown to have a significant impact on eating quality when compared to pre-slaughter activities such as animal handling and lairage time in the Northern Ireland studies. However, the effect of animal breed, particularly the use of dairy breed animals was shown to significantly improve eating quality.

Details on key pre-slaughter and post-slaughter factors affecting eating quality are provided in Appendix A.

3.1 (c) Grid Pricing systems

EUROP Grading

Beef and sheep carcase classification is mandatory in the EU in any plant killing more than 75 animals per week. The EU classification scale (EUROP) for beef and sheep carcases centres on fatness and conformation (or carcase shape) and provides a uniform classification system throughout Europe. Beef and lamb carcasses are classified by a certified grader according to the official EUROP scheme (EC 1208/1981) for conformation (E, U, R, O, P) and fat cover (1, 2, 3, 4, 5). E equals most shape, P, least shape, one equals least fat, five equals most fat. In Ireland, fat class 4 is subdivided into Low (L) and High (H) and conformation class P is subdivided into 3 subclasses. Some countries subdivide each class into 3 to give 15 subclasses each for conformation and fat class. In addition to being used as the basis of a payment schedule to producers, the EUROP scheme is also used for price-reporting purposes and to determine eligibility for intervention. Increments are paid and deductions made for each movement along the grid away from the base grade (U-3). Under this pricing scheme, deductions become steeper for cattle killing closer to the extreme ends of the scale.

Because the scheme depends on human judgement, it has been criticised by some as being subjective and inconsistent. This lack of confidence makes it difficult to agree qualitybased payment schedules that reflect the true value of carcasses to the industry. In Ireland a lack of effective incentives to produce quality carcasses has undoubtedly contributed to



a decline in carcase quality, particularly the high percentage of over fat carcasses (Keane, 1999).

To remove the subjective element of carcase grading, machines have been developed to classify carcases using technology known as Video Image Analysis (VIA) (Craigie et al. 2012) and are now in use in all major abattoirs in Ireland, both North and South (Allen et al. 2001). VIA takes images of a carcase with one or more cameras, extracts data such as lengths, areas, volumes, angles and colours, then processes this data to estimate the conformation class and fat class. VIA machines are configured to grade cattle to a 15-point scale. An advantage of the VIA system is that they can predict the saleable meat content of a carcase. This is of interest to the processor because yield is closely related to the realisable value of a carcase. Visual classification also gives an indication of saleable meat yield but previous tests have shown that the VIA systems are able to predict yield with a greater accuracy than classifiers (Borgaard *et al.*, 1996).

The EUROP grading system is primarily aimed at valuing a carcase in terms of its relative yield of saleable meat. It was not intended to guarantee eating quality but rather to assure conformation and yield. The grid pricing system has been adapted to provide incentives related to market requirements, with animals receiving bonuses/penalties according to whether they meet certain specifications. However, the effectiveness of market signals within the grid pricing system in Northern Ireland is questionable, as demonstrated by the significant proportion of animals not meeting retail specification requirements. Ultimately failure to meet market specifications causes problems along the supply chain with inconsistent raw material and under/over sized products. Based on the market specifications of the major retailers, processors apply an incentive system with bonuses for animals within grade, weight, age, Farm Quality Assurance and Country of Origin specification requirements and penalties for those that do not meet these requirements. With regards to cattle, the bonuses for not meeting the specification requirements (in-spec) are shown in Table 1, while the penalties for not meeting these (out-of-spec) are shown in Table 2.

Bonus Specification	Criteria		
Grades attracting bonus	E, U, R, 3, 4-, 4= and O+3		
Weight	280 to 380kg		
Age	Under 30 months		
Farm Quality Assured	Yes		
Country of origin	UK only		

Table 1: Specification for 8p/kg bonus on steers and heifers



Category	Criteria	Penalty
Steers & Heifers	Over 30 months	10p/kg
Young bulls	Over 16 months	10p/kg
Young bulls	Over 24 months	20p/kg
Steers, Heifers & Young bulls	Under 260kg	£12.50/head
Steers, Heifers & Young bulls	Under 240kg	£24/head
Steers, Heifers & Young bulls	Over 420kg	10p/kg

Table 2: Specification for penalties

Despite the bonus/penalty incentive system, recent figures from the Livestock and Meat Commission for March 2016 indicate that only 34% of steers and heifers fulfilled all the retail specification requirements in Northern Ireland. It should be noted that this proportion varies during the year. Using data for 2012, Oxford Economics (2013) found that a smaller proportion of cattle in Northern Ireland meet retail specifications compared to GB. The authors demonstrated that the primary reasons for animals failing to meet specification requirements in Northern Ireland were due to undesirable grades, weight and to a lesser extent age (Figure 3). To some extent this may reflect the failure of all plants to strictly impose penalties (LMC, 2012). However, as reported by Simmons et al. (2003) problems with out-of-spec animals has been a persistent issue for the red meat sector in the UK. The authors partly attributed the slowness of many producers to respond to price signals due to continued allegiance to the 'production concept', where animals are pushed onto the market based on what farmers have traditionally produced on that farm or what they believe to grow best there, rather than a more consumer oriented approach. In addition, opportunistic trading by both buyers and sellers within the spot market also contributes to the out-of-spec problem, with stock being held back or pushed forward stock based on short term market fluctuations.



Figure 3: Reasons for being 'out-of-spec', 2012

Source: Oxford Economics (2013)



In order to address the out-of-spec issue, Oxford Economics in conjunction with stakeholders of the red meat industry in Northern Ireland recommended that the pricing grid system should be repeatedly reviewed to ensure that appropriate incentives are in place. In addition, it was recommended that data and software systems should be shared up and down the supply chain to facilitate a more integrated approach. This includes the use of the BOVIS database, which provides a means to determine the genetic merit of individual animals and thereby assess breeding systems to meet market requirements (Carson *et al.*, 2009).

The development of supply chain systems to identify and control production and processing factors that affect meat eating quality internationally is discussed below.

Grid Pricing in the US

Prior to the 1990s average pricing was the dominant pricing mechanism for beef producers in the US. Under this mechanism all animals in the sale pen receive the same price. However, it is widely accepted that this average pricing system distorts the transmission of market information since above-average quality cattle sell less than their true value and below-average cattle sell for more than their true value (Feuz, Fausti and Wagner, 1995). This led to problems of inconsistent product quality and failure to provide consumers with beef products that met their needs (Fausti, Qasmi and Diersen, 2008).

Following a review in 1990, there was a concerted shift to grid pricing mechanism in the US, wherein each individual animal is graded using actual carcass characteristics, in a bid to limit the decline in the demand for beef and improve the sector's competitive position. The motivation for this *value based marketing* system was to improve the overall quality of beef within the sector by sending more accurate market signals and improve the flow of information from consumer to producer. Under the grid pricing system the value is calculated by multiplying the carcass weight by the sum of the base price plus premiums and discounts for weight, quality grade and yield grade. Factors used to make the yield grade calculation include (a) rib fat thickness, (b) fat distribution, (c) rib eye area, (d) carcase weight and (e) kidney, pelvic and heart fat. Some of the characteristics used to assign a quality grade relate to eating quality and as such convey a measure of eating quality assurance within the grade. To assign a USDA quality grade the carcase is evaluated 24 to 72 hours post mortem after cutting the carcase at the 12/13th rib point and exposing the loin muscle. The grader evaluates the colour and texture of the exposed eye muscle, the amount of marbling and degree of ossification of the back bone (physiological maturity). Level of maturity is then related to marbling content to assign a grade.

The grades in declining quality order are Prime, Choice, Select, Standard, Commercial, Utility, Cutter and Canner. The top 3 grades are often split into sub grades e.g. USDA High Prime, Prime or Low Prime dependant on degree of marbling. The Standard grade normally represents manufacturing beef only with the majority of retail product ranging from Select to High Choice. USDA Prime carcases must exhibit at least 8% intramuscular fat (slightly abundant marbling) and show low levels of ossification at ribs 7-12. This generally correlates with cattle under 30 months old. Only 2-3% of US cattle meet this top specification. Most young cattle in the US grade either USDA Choice or Select which



corresponds to moderate and slight levels of marbling. The other 5 grades tend to be for cows or bulls. Bulls are excluded for the higher grade. Dark cutters lower the meat by one full grade.

In effect only the striploin is graded although the entire carcase or all the individual cuts within the carcase receive the same grade. Any correlation from grade to eating quality expectation is therefore heavily reliant on an assumed knowledge of the cut relativity, e.g. Choice striploin is priced very differently from Choice tenderloin.

The USDA system influences the American beef industry to produce to common endpoints and has resulted in a much more uniform production system. The USA cattle industry produces a relativity uniform product with 95% coming of feedlots of similar carcase weight, age and fatness. Virtually all USA beef is derived from young cattle in feedlots to achieve moderate to high marbling levels. This helps to provide processing and distribution efficiencies.

Evaluation analysis undertaken by Fausti, Qasmi and Diersen (2008) suggests that while overall beef quality at the sector level in the US exhibited initial improvements following the shift to the grid pricing mechanism this appeared to plateau in the 2000s. This is partly explained by the continued widespread use of average pricing. An important barrier to greater adoption of grid pricing is the concern that this system is a riskier marketing alternative compared to average pricing if producers are uncertain about the quality of the cattle they are selling (Johnson and Ward, 2006).

In addition, Johnson and Ward (2006) questioned the effectiveness of market signals transmitted by the grid pricing system in the US by quantifying the monetary incentives linked to the grid pricing system, including quality grades. The analysis demonstrated the presence of different market signals for higher and lower quality cattle. For higher quality cattle, weight sent a stronger market signal compared to improving animal quality. Thus, for these animals there is a greater incentive to add weight to cattle rather than attempting to improve animal quality further. In contrast, the market signals for quality were greater for lower quality animals. These animals could earn more via other market channels, e.g. average pricing, and thus there is an incentive to physically sort cattle and not market the lower quality animals using the grid pricing mechanism. The authors computed changes in premium/discounts that would be necessary to provide producers more of an incentive to improve the quality characteristics of animals.

Augmented Grid Pricing System

Some authors within the US have recommended augmenting the grid pricing system to incorporate further quality characteristics which better reflect consumers' needs. In particular, tenderness is regarded as one of the most important attributes affecting consumer eating experience for beef products. Within the existing grid pricing system beef tenderness is not strongly related to quality grade. Since producers are not rewarded for producing desired attributes such as tenderness or penalised for producing inferior ones, they have no price incentive to produce the desired level of tenderness.



In an academic study, Riley *et al.* (2009) developed a tenderness-augmented grid pricing system that generated price differentials for cattle with varied beef tenderness levels. The analysis demonstrated that frequently tender and tough carcasses are undervalued or overvalued using the current grid pricing mechanism and the tenderness-augmented grid system would substantially reorder the value of carcasses relative to the traditional grid system. Implementing the augmented price grading system would provide producers with a greater incentive to adopt management practices that influence tenderness, e.g. through genetic selection strategies and animal feeding regimes.

Q Mark system (New Zealand)

The New Zealand Beef and Lamb Quality Mark or QMark system is based on a "best practice" scheme involving optimisation of post-slaughter processing and the setting of a minimum post-slaughter aging time. The New Zealand system is based on simple pass and fail classifications with rules to be passed. These segregate whole carcasses into those which will provide good eating quality beef from those where the quality will be lower than consumer expectations.

The Quality Mark may be used on carcases, parts of carcases, cuts, boneless product, whole muscle table meat or value-added specialty cuts, e.g. marinated. The target monitoring muscle as with the MLC Blueprint, is the M. longissimus dorsi (striploin). In order to qualify for the Quality Mark, product must be derived from animals of New Zealand origin, free from growth promotants, traceable back to farm and with no evidence of TB. All categories of steers, heifers, veal, lamb and hogget can qualify for the Quality mark. In the New Zealand context, where electrical stunning of sheep and cattle is common, carcase processing must involve appropriate levels of electrical stimulation, chilling and ageing regime to ensure a defined level of tenderness is achieved by the time the product is on sale. A tenderness standard defined as a mean shear force (mechanical tenderness) value of 8 kg of force or less or at least 95% of all samples to have a shear force of less than 11 kg of force is set.

Mutton, cow and bull beef are excluded from the system as is beef with an ultimate pH of 5.8 or over (unless processed using an extended ageing period). The system requires regular shear force testing of meat (using the New Zealand Tenderometer device) together with checks on electrical stimulation, chilling and ageing regimes to ensure they generate product that complies with the tenderness standard. Quality Mark beef and lamb cannot be presented to the customer until its Retail Ready date i.e. the date at which the meat will have reached acceptable tenderness. Retail Ready times will differ from plant to plant because their operating systems will differ. In the QMark system, the important end result is the target quality rather than the means of getting to that quality.

The Meat Standards Australia Grading System

The Meat Standards Australia (MSA) grading system is a voluntary program that was developed as a cooperative effort between government bodies, industry and university research to improve the eating quality consistency of Australian beef and sheep meat. Prior



to its inception traditional red meat grading and methods of sale description (Aus Meat) were seen as ineffectual with regards to eating quality and confusing to consumers at the point of retail.

The current system is based on almost 700,000 consumer taste tests by over 100,000 consumers from nine countries and takes into account all factors that affect eating quality from farm to plate (Thompson, 2002). Only those factors that significantly impact on eating quality are included in the scheme. The consumer sensory testing involves the evaluation of a piece of cooked meat for the key eating quality parameters of tenderness, juiciness, flavour and overall liking. Using these responses, a consumer meat quality score (CMQ4) on a 0-100 scale is calculated for each piece of meat. The CMQ4 score is derived from 40% tenderness, 20% flavour, 10% juiciness and 30% overall liking. Analysis of consumer sensory scores and their interactions using all available knowledge on eating quality factors both known and developed sets the basis for MSA grades. The grade is assigned using a statistical prediction model which estimates a composite consumer (MQ4) score for each muscle - cooking method outcome. All traits that contribute to eating quality are assigned a value used in the model as either a variable or an absolute value.

The eating quality factors of key importance in the MSA system include: muscle, position within muscle, hanging method, % Bos Indicus breed, use of growth promoters, marbling, maturity (as estimated by ossification), carcase weight, rib fat cover, meat colour, ultimate pH, ageing and cooking method. Other processes such as pre-slaughter handling and post mortem processing have absolute requirements to ensure optimum conditions for maximising palatability e.g. meat plants have to meet requirements to minimize handling stress and to ensure that the electrical stimulation/chilling regime will allow an appropriate pH decline against temperature.

Marbling has been shown to have an increasingly positive effect on eating quality as it increases, whereas ossification in contrast has an increasingly negative effect on eating quality as it increases. pH has an absolute maximum of 5.7 where anything above this level is ungraded.

Given the huge effect of muscle type and method of cooking on eating quality, each individual muscle type is graded. The MSA system assigns one of four eating quality grades (Unsatisfactory, 3 star, 4 star and 5 star) to individual carcase muscles cooked by up to six alternative methods. The system makes it possible that cuts from the same carcase may have different grades and that each individual cut can be upgraded based on intervention e.g. a striploin from the same carcass may start as three-star graded but upgrade to a four-star grade after 21 days of aging. Meat quality traits impact differently on individual meat cuts with marbling having a greater impact on striploin than on topside. Traits are also interactive e.g. post mortem ageing by muscle vary for difference hanging methods such as tenderstretch or achilles hung carcases.

Qualified graders measure the pH, temperature and marbling of the rib eye muscle in addition to , ossification, rib fat depth and hump height (% Bos Indicus) 24 hours post mortem. Data is entered into a Data Capture Unit and a carcase grade for boning run purposes is computed.



The MSA model has been tested internationally with consumer tests being held in a number of countries including Ireland (North and South), Korea, the USA, France and Japan. Results from international consumer testing have established an overwhelming consensus with regards to beef eating quality. Results from trials conducted at AFBI in Northern Ireland comparing Australian consumers with Northern Irish consumers (both groups tasting the same Australian beef together with local beef), showed essentially similar results for consumers from both countries. An adapted MSA grading model reflecting cattle types, production systems and consumers in Northern Ireland was found to predict the eating quality of NI beef with good accuracy and precision (Farmer et al. 2010)

The MSA program has acted as a catalyst for substantial change in all sectors of the Australian beef industry encouraging and facilitating research and commercial industry cooperation (Polkinghorne *et al.*, 2008). This has led to better industrial practices and a general improvement in beef eating quality even where some participants have not formally adopted the MSA procedure. The relative importance of pre and post slaughter factors in delivering predictable eating quality has highlighted the importance of viewing industry segments as inter-related elements of a single production chain and the value of cooperation and clear communication between all segments of the chain. Producers, processors, retailers, and restaurants that use the MSA system and display the MSA symbol and "guaranteed tender" promise must be registered with MSA and agreed to be audited to assure they are following procedures. The removal of beef predicted to be unsatisfactory to the consumer via the grading model has improved general product performance and generated premiums within the wholesale and retail trade for beef cuts underpinned by MSA grades. In 2015 there were 110 MSA licensed brands for MSA beef and/or lamb in the marketplace.

Although the MSA system is complex to apply, the grade outcome is simple, providing a cut by cooking method. With international testing, the MSA database has grown allowing MSA the chance to continue to refine their prediction model and test its potential to provide a consumer guarantee in multiple markets. The MSA model continues to be updated, growing in scope and accuracy. The system is more complex than the USDA system, provides more information to the buyer and seller, and places greater emphasis on eating satisfaction. A key point of difference is that the system produces a prediction for a specific piece of meat, cooked by a specified method as eaten by the end consumer. A further refinement is to separate cuts into 3 star, 4 star and 5 star with differential pricing while retaining traditional description. This is a huge step beyond placing a single grade on a carcase.

Japanese Meat Grading Association

The JMGA began grading pork and beef in 1976. All beef carcases are assessed for both yield and quality grade score. The carcase loin muscle is exposed by ribbing at the 6th/7th ribs and quality and grade assessed by a qualified meat grader. No uncoupling of grades is allowed. Both a yield and quality grade are assigned. Each carcase is given a score for yield grade, A, B or C and a score for meat quality grade, 1-5. The final grade is reported combining the two scores e.g. B2.



Meat quality is assessed in terms of (a) marbling, (b) meat colour and brightness, (c) firmness and texture, (d) colour and lustre of fat. Yield is determined as an estimated percentage by an equation that includes four carcase rib measurements: rib eye area, rib thickness, cold side weight and subcutaneous fat thickness.

As with the USDA system, the JMGA grading system is largely a carcase trading mechanism. However unlike the EUROP system, both the USDA and the JMGA do, to a certain extent, segregate carcases on eating quality. Unlike MSA grading, individual muscles are not graded, there is no provision for hanging method, carcase pH temperature, time parameters or cooking method.

3.1 (d) Technology within Grid Pricing Systems

Establishing and evaluating accurate, reliable and objective techniques for measuring or predicting carcass and meat eating quality in beef cattle and sheep is a key step to the development of value-based marketing systems, genetic improvement programmes, and management systems to enhance product quality. Conventional analyses of sensory, technological and nutritional meat qualities are slow, costly and destructive, so are unsuited to routine use by processors. Methods developed using spectroscopy are of particular interest, being reliable, rapid, non-destructive and chemical free. Some of them can be easily implemented on-line in abattoirs on a large number of animals. Spectroscopy can be defined as the study of electromagnetic interactions between atoms and molecules. It has long been known that food constituents and their properties can be measured by absorbed or emitted radiation at different wavelengths. Techniques such as X-ray, ultraviolet, NIR and microwave spectroscopy derive their names from the use of the portion of the electromagnetic spectrum and can be categorised according to the particular wavelength used.

Near Infrared Spectroscopy (NIRS)

One of the most promising techniques for assessing meat quality is near infrared reflectance spectroscopy. NIRS technology has not only the ability to assess chemical structures through the analysis of their molecular bonds in the near infrared spectrum but also to build an optical model characteristic of the sample which behaves like the finger print of the sample. By constructing calibration models between NIRS spectra and chemical or quality tests, the NIRS technique can offer an accurate prediction of some complex quality attributes. It can predict fatty acid profiles, colour and sensory characteristics, such as texture, juiciness, flavour, and has the potential to be used on-line at the abattoir for fast and relatively inexpensive estimation of meat eating quality characteristics. This can assist carcase sorting prior to boning if it can provide a useful prediction of quality. Many studies have investigated the potential of NIR for predicting meat quality.

One of the most important applications of spectral characterization is in a rapid screening system that will differentiate between meat samples that originate from different feeding systems. The NIRS technique has the potential to predict accurately fatty acid



profile under abattoir conditions, which can be used to determine meat quality in a valuebased marketing system and in breeding programmes to genetically improve fatty acid profiles of meat. Some promising results have been obtained when comparing spectra with tenderness as measured by meat mechanical resistance like Warner Bratzler shear force (Park et al. 1998, Roehe et al. 2016).

Hyperspectral Imaging

A disadvantage of NIRS is the small area sampled in heterogeneous materials such as meat.

Hyperspectral imaging can improve the predictive accuracy of NIR, with the ability to introduce spatial discrimination and focus on the areas of the sample more likely to relate to the quality attribute of interest. Hyperspectral imaging uses both video image analysis (VIA) and near-infrared spectroscopy and can capture both muscle structure and biochemical properties of meat. Hyperspectral imaging provides both the high spatial resolution of VIA and the high spectral resolution of NIR spectroscopy. This method distinguishes between fat and lean through different spectral responses produced at different wavelengths. Publications in this research area have greatly increased in recent years (Elmasry et al. 2012).which implies the strong potential of hyperspectral imaging as a promising detection technique for food quality and safety control.

Raman Spectroscopy

Raman spectroscopy is excellent for biochemical analysis of tissue. The technique can provide information about concentration, structure and interaction of biochemical molecules with intact cells and tissues non destructively. Raman spectroscopy is well known for its ability to determine the degree of saturation in fatty acids and high correlations have been established with the iodine number of oils. Since there is increased interest in fat composition, especially on the ratios of saturated, monounsaturated and polyunsaturated fatty acids, there is value in transferring this application to intact meat. Workers at AFBI Northern Ireland have demonstrated potential for Raman spectroscopy to determine beef quality parameters, including tenderness, but at present this has been using cooked meat samples (Beattie et al. 2004).

CAT Scanning

In live lambs, X-ray computed tomography (CT scanning) gives the most accurate predictions of carcass composition and also of intramuscular or marbling fat (a contributing factor to eating quality traits like juiciness and flavour), although no strong associations have been identified between in vivo CT measurements and other meat quality traits (e.g. tenderness, meat pH). This fast and non-invasive method provides accurate predictions of weights of trimmed primal cuts in beef and lamb without damaging or devaluing the carcass. Moreover, CT-measured muscle density is moderately correlated to intramuscular fat



content and its fatty acid composition. CT predictions of carcase composition have been used in commercial UK sheep breeding programmes over the last two decades. These results could be used to genetically select beef cattle and sheep with lower levels of carcass fat and potentially favourable fatty acid profiles. Widespread use of genotypes with these attributes would reduce waste resulting from excess fat trim during processing, as well as resulting in healthy, high quality meat products.

Genetic Methods

Meat quality can be enhanced by producers through controlling breeds and genetic inputs. Research has shown that genetic improvements in traits such as carcass quality through selective breeding of animals with desired characteristics leads to cumulative and permanent gains that could translate into substantial economic benefits for the livestock industries. Managing tenderness creates opportunities to add value to cattle and beef by consistently providing consumers with a pleasurable eating experience. Tools to assist in selection for improved tenderness include expected progeny differences (EPDs) and commercially available gene markers.

Genetic evaluation data gathered from sources such as abattoirs and other national databases are suitable for producing beef genetic evaluations for the traits farmers are paid for. Breed heritability have been found for carcase traits such as fat class, weight in relation to age and conformation indicating breeding for these traits using commercial carcase data is possible. Using this data allows Estimated Breeding Values (EBVs) for carcase traits to be developed providing a measure of the breeding potential of farm animals for a specific trait. Longer-term impacts may be realized by selection for tenderness within breeds (Amer *et al.*, 2015).

Technology Discussion

The feasibility of implementing pricing systems that incorporate additional quality characteristics is dependent upon technology to measure characteristics at line speed in plants. If this technology is not available, spot markets will fail to accurately reflect consumer preferences and hence producers will not receive incentives to produce the desired characteristics (MacDonald *et al.*, 2004). In this case, it may be necessary to pursue more formal vertical coordination mechanisms, as elaborated in Section 3.1(e). Nevertheless, developments in technology may make this more practical within the spot market in the future.

Processors may be reluctant to invest in such technology due to concerns about adversely impacting the level of throughput, particularly if there is uncertainty as to whether consumers expressions of preference for higher quality are backed up by sufficient consumer willingness to pay the necessary cost to pay for the technology or whether they are only willing to pay commodity prices (Lawrence and Hayenga, 2002). If consumers are not prepared to meet these higher costs, producers will be reluctant to deliver changes in quality characteristics and will supply processors who do not measure these characteristics.



3.1 (e) More Formal Vertical Coordination Mechanisms

Changes in Contracting Over Time

Formal means of vertical coordination, such as contracts, have increased in recent decades. For example, within the US the number of farms with contracts grew from 5 per cent in 1969 to 9 per cent in 2013 (Figure 4). Despite this relatively modest increase, the share of the value of agricultural production covered by contracts in the US grew more markedly, rising from 11 per cent in 1969 to 35 per cent in 2013. This reflects the fact that production shifted to larger farms, with these larger farms being more likely to use agricultural contracts.



Figure 4: Agricultural Contracting in the US

Differences in Evolvement Across Meat Sectors

While closer forms of vertical coordination have become more widespread, spot markets still remain an important means of signalling consumer preferences to producers and thereby coordinating production decisions within the supply chain. For example, approximately 60 per cent of the value of agricultural production was marketed through spot markets in the US in 2008 (MacDonald and Korb, 2011). The use of different forms of coordination varies across commodities. For example, in the US contracting is substantially more prevalent in the poultry and pigs sectors compared to beef (see share of the value of



production by commodity US in 2013, Figure 5). The reasons for the evolvement of different means of coordination within the meat sector are discussed below. Drawing on the transaction cost and risk sharing explanations set out in Chapter 2, reasons include 'asset specificity', 'production characteristics' and 'quality uncertainty'.



Figure 5: Contract Production Share by Commodity in the US, 2013

Asset Specificity

The level of investment in specialised assets varies across sectors. In the US poultry sector, producers invested heavily in specialised production facilities beginning in the 1950s as a means to benefit from scale economies. The pig sector in the US followed the developments within the poultry sector, with production shifting to highly specialised, large scale farms from the 1980s (Martinez, 2002). In addition to production facilities, these sectors made significant investments in specialised technologies such as genetics. These investments have limited alternative uses and users and thus leave trading parties vulnerable to opportunistic behaviour by other parties. In order to safeguard these investments supply chain participants sought alternatives to spot markets and hence the use of contracts became more widespread. Contracts provide a means to enforce greater process control, with firms benefiting from predictable throughput and prices (Lawrence and Hayenga, 2002).

Production Characteristics

Differences in production characteristics across the sectors have implications on marketing channel choices. In particular, due to the biological production cycle the time period from conception to market is significantly shorter for the poultry sector compared to the pig sector, which is shorter compared to the beef sector. The shorter the biological process, the easier it is to predict profits from biological changes such as genetic

Source: MacDonald (2015)



improvements and hence the greater the incentive to implement tighter coordination strategies (Oklahoma Cooperative Extension Service, 2005). The genetic diversity in the poultry sector, and to a lesser extent, the pig sector, is narrower compared to the beef sector. Due to the shorter production cycle in the poultry and pig sectors genetic changes can be made more quickly. The narrower genetic base favours closer coordination strategies since it reduces processing costs and enhances the ability to produce consistent products for consumers (Oklahoma Cooperative Extension Service, 2005). The longer production cycle in the beef sector means that it is more time consuming to learn whether genetic changes result in better meat eating quality.

Within the UK, the Red Meat Industry Forum commissioned a value chain analysis of the red meat industry. This highlighted that since the lifecycle of beef producers' *in situ* flock is six to seven years it is difficult for producers to respond quickly to market demands. Consequently, the forum stressed the importance of transmitting a consistent and unambiguous message of consumer demand during this period (Simmons *et al.*, 2003). The development of the BOVIS database in Northern Ireland provides a means to determine the genetic merit of individual animals and respond to market signals.

A further factor that increases the complexity of vertical coordination within the beef sector is the multiple stages of production, with cattle potentially being transferred to several farms prior being sold to market. Moreover, a significant proportion of calves from dairy cows are finished as beef. It is difficult for beef finishers to enter long-term contracts that contain quality specifications as they do not fully control their supply chain (Lawrence and Hayenga, 2002). In addition to the multiple stages of production, the beef sector is characterised by a large number of producers. The greater number of decision makers contributes to higher costs of coordinating the supply of cattle from producers and results in considerable variability in quality.

Quality Uncertainty

Overtime consumers have exhibited increased preferences for improved quality, consistency and assurances on issues such as food safety, animal welfare and environmental factors (Lawrence and Hayenga (2002) and Bansback (2014)). As discussed in Chapter 2, consumers incur costs in assessing meat attributes. Tighter vertical coordination strategies have become more widespread in order to reduce consumer measurement costs. For example, processors can reduce measurement costs for attributes of a live animal or carcass that are costly to measure by controlling farm inputs through contracts or vertical integration (Martinez, 2002).

Another means to reduce measurement costs is through branding. *Branding* is a costmitigating device to summarise information transmitted to consumers. The brand can be used to reduce consumers concerns and measurement costs about purchasing an unsatisfactory product (Raynaud *et al.* (2009) and Martinez (2002)). The increased focus on quality means that the brand is an increasingly important component of competition among firms. Branded products require more uniform product supply and standardisation in quality. Firms need to undertake steps to protect the brand as they are costly to develop and carry the reputation of the firm (Lawrence and Hayenga, 2002). Within the agri-food



sector, the heterogeneity of the raw material means that brand owners require vertical coordination mechanisms to control for quality along the supply chain (Raynaud *et al.*, 2009). Quality price grading and quality standards may be sufficient in some circumstances. However, some attributes demanded by consumers may be difficult to monitor at line speed in plants, e.g. tenderness, while others such as how the animal was raised cannot be measured at the plant. In order to meet these demands, tighter forms of vertical coordination may be required to assure product specifications are met (Lawrence *et al.*, 2001).

Branding has been a notable feature of the poultry and pig sectors. This has been facilitated through the use of contracts, which for example may stipulate specified breeding stock/genetics resulting in uniform products with desirable characteristics. Branding has been slower to develop in the beef sector. This partly reflects the broader genetic base and lack of control over quality across the supply chain (Lawrence and Hayenga, 2002). An example of branding in the beef sector is that employed by the French retailer Carrefour; see Box 1.

Branding requires substantial investment. Brands are essentially intangible assets. Tarnishing of a brand means loss of investment for the brand owner. Therefore, branding provides a credible signal to consumers on certain aspects of the product³. Quite often, this concerns the high quality of the product. However, it may at times concern the homogeneity of the quality of the product. Gonzalez-Diaz *et al.* (2003) separate superiority and consistency as two different dimensions concerning product quality. The McDonald's hamburger is given as an example of branding for quality homogeneity. In the same study, branding is also categorised from a different aspect based on the party that invests in branding (and therefore owns the brand). There are two types of brands in this regard:

- Private brands; and
- Publicly-controlled brands.

The latter refers to the Protected Denomination of Origin (PDO) and Protected Geographical Indicator (PGI) system in the EU, in which "a public or governmental institution can guarantee consumers the quality of the product" and "a company sells its product sheltered by the prestige of some specific geographical spheres and/or production methods related to a superior product quality" (Gonzalez-Diaz *et al.*, (2003)). The authors raise and test a hypothesis:

- If a brand focuses more on the homogeneity of product quality, *coordination* is an important consideration and therefore the supply chain takes more of a hierarchical governance structure;
- In contrast, if a brand focuses more on the superiority of product quality, the *incentive* is a more important consideration and therefore, the supply chain takes more of a market structure.

³ Branding is regarded as an implicit self-enforcing contract on quality with consumers in economics literature (see Raynaud *et al.* (2005) for more in-depth literature).



Box 1: Branding in the beef sector: Carrefour Quality Chains (The following case study is based on Raynaud *et al.* (2009))

The French retailer Carrefour developed a branding strategy for beef in an effort to restore consumer confidence following the outbreak of BSE in the mid-1990s. Carrefour is the largest retailer in Europe and created its own private label for beef, called 'Carrefour Quality Chains'. The branding emphasises its organoleptic quality (specifically the tenderness and colour of meat) and meat safety. Prior to the development of the branding strategy, Carrefour sourced its supply from the spot market and informal agreements with abattoirs. However, following the development of the brand Carrefour secured its supply of beef through trilateral contractual agreements between the retailer, slaughtering plants and farmer associations. As part of the contract agreement, Carrefour controls for meat safety and quality attributes through stipulating a list of specifications and quality control planning. In addition, the retailer requires producer associations, abattoirs and feed suppliers to participate in a national certification scheme, which undertakes audits across the supply chain. The pricing formula used within the contract is based on a 'cost-plus' system, with abattoirs paid on the basis of slaughtering and traceability costs, plus a negotiated margin. Abattoirs are provided a guarantee of a minimum amount of yearly sales through exclusive deals and receive bonuses to fulfil guality specifications. Cattle farms are paid at the local/national price for the type of animal and an additional price premium.

An interesting aspect of these contracts is the promotion and/or creation of large farmers' associations, who negotiate with Carrefour on the list of specifications and quality control planning. While the creation of these producer associations reduces the bargaining power of the retailer, this is more than offset by:

- the implementation of a collective traceability program;
- economies of scale in the management and assessment of inputs quality;
- reduced costs of dealing with one instead of several agents;
- ability of producer organisations to adapt to unpredicted contingencies.

Moreover, it is hypothesised that private brands usually fall into the first category and public-controlled brands the second. A comparison of the different private and PGI brands of fresh beef in Spain supports this hypothesis. In terms of governance, the beef chains under the private brands (two supermarket brands that integrate backwards and one cooperative brand that integrates forward) control mainly the slaughtering, process and packaging stages of beef production. The only on-farm requirement is natural feeding. In contrast, the beef chains under PGI mainly concern the breeds, origins, and the ways cattle should be raised. There are some requirements at the slaughtering stage, but not further.



Price data show that PGI beef have a clear price premium over the private brands. Price differences are much smaller within category (private vs. public) than between categories. A later study by Raynaud *et al.* (2005), which covers three agri-food sectors from seven European countries, supports this hypothesis as well.

Raynaud *et al.* (2005) also stress the importance of good management of the PGI labels as the credibility of these public-controlled brands builds on the *ex ante* and *ex post* monitoring. This is not to say that PGI labels come free. Similar to private brands, there are costs to the establishment, management and promotion of the PGI labels. The difference is that these costs are borne by the public rather than a specific private party. This "public good nature" of the PGI labels may then benefit areas largely dominated by small producers/processors, where no single producer/firm has the capacity to develop private brands (Raynaud *et al.*, 2005)).

What does the above literature imply for the meat supply chain in Northern Ireland? With regards to brands of a private nature, its development and focus are in the hands of the brand owner (whoever makes the investment), with a view to maximising their own profits. Public-controlled brands may be an alternative that the government can take the lead in pursuit. Within the EU, the most common system of public-controlled brands, the Protected Denomination of Origin and the Protected Geographical Indicator, is based on geographical area. In Scotland, Scotch Beef and Scotch Lamb obtained PGI status early in 1996. Welsh Beef and Welsh Lamb were granted PGI status in 2003. So far, there is no PGI in the beef and lamb sector in Northern Ireland. As it has been discussed earlier, these schemes can be beneficial to local producers/processors if they are successful. However, the development and implementation of these schemes and promotion of the brands entail costs and the tasks are challenging. In an earlier study on the food processor sector in Northern Ireland by Wu *et al.* (2012), point out that "As a country with a devolved government, NI may not have advantage of using diplomatic routes to promote products and services abroad".

Consumers also increasingly require assurances about *credence* attributes, which reflect both individual consumer concerns, e.g. health/nutrition, and collective concerns, e.g. the environment (Henchion et al., 2014). Products that can deliver these credence attributes can potentially offer a competitive advantage in the marketplace. These can potentially be met through certification schemes within the spot market. However, certification schemes require substantial investments in testing and monitoring. These costs can be reduced through vertical coordination mechanisms by controlling production practices and by requiring investments in information and measuring at the stages where they are most effective (MacDonald et al., 2004). Within the UK, the LEAF Marque is a farm assurance scheme based on promoting sustainable agriculture. Under this scheme farmers are required to undertake a LEAF audit, which covers an integrated approach including animal health and welfare, nutrient management and energy efficiency as well as social and landscape factors. Within Ireland, sustainability audits are undertaken as part of the Origin Green programme. This scheme increases the visibility of higher environmental standards and is being used to as a selling point for marketing purposes.



Empirical Evidence of Producer Attitudes to Vertical Coordination

Why do producers choose one marketing channel over the other? This section considers the results of some empirical studies specific to the red meat sector.

Using a transaction cost approach, Boger (2001) examined the use of vertical coordination arrangements in the Polish pig market during a period of transition, with the emergence of more high-quality markets. Cluster analysis of survey data identified four different types of farmers:

- i. Non-investors Producers in this group have not made large investments in production facilities. They receive the lowest average prices, based on weight class, rather than quality attributes, and sell low-quality pigs.
- Contractors These producers have made significant investments in production facilities and technology (quality improving assets) and rely on formal written contracts to safeguard their investment. They sell high quality pigs and use the EUROP grading system. They command higher prices, compared to (i) and (iii).
- iii. High-investors These producers have also made substantial investments in quality improving assets but similar to non-investors markets their pigs based on weight rather than quality attributes and do not use formal contracts. They command higher prices compared to the non-investors, but lower than the other two categories.
- iv. Bargainers Relative to (ii) and (iii), these producers have not made substantial investments as they are able to make use of existing facilities. They do not use contacts but are able to command higher prices than the other categories. This highlights the importance of informal relationships, perhaps reflecting the transitional nature of this market during the period of analysis.

Given their investments, the 'High-investor' producers are vulnerable to unforeseen hazards and opportunistic behaviour. The authors predicted that these producers would shift to more formal contacts to protect their investments as the market evolves and quality-based pricing became more widely established.

While the transaction cost literature emphasises that tighter vertical coordination will occur to protect investments and reduce uncertainty, within a study of the New Zealand lamb industry Bensemann and Shadbolt (2015) found that there are also wider factors that result in a producer choosing a certain marketing channel. These wider factors include:

- Strategic orientation, e.g. orientation towards the consumer market;
- Selling behaviour, e.g. how the producer perceives the level of bargaining power, leadership and openness to new marketing plans;
- Values, e.g. how conscientious a producer is in making marketing decisions and the extent to which they are prepared to produce according to preferred specifications; and
- Relationship status, e.g. quality of producer's relationship with downstream parties.

As a result, producers do not act in a homogenous manner. In general, the results indicate that the decision regarding the choice of marketing channel is influenced by the producers



ability to deal with uncertainty and how active or passive they are in making selling decisions. The implication of this heterogeneity is that contractual agreements should be varied to meet different producers' perceptions.

Steiner *et al.* (2012) explored the motives of cow-calf producers in Canada towards vertical coordination. The results indicated that specialised cow-calf farms are less likely to participate in coordination schemes compared to mixed farm operations. In contrast, producers with larger beef cow herds and those who have experience of retained ownership were more likely to participate. With regards to producer age and education, it was found that younger and more educated producers were more likely to participate. This suggests that older and less educated producers are less receptive to the adoption of novel marketing mechanisms.

The analysis also sheds light on contractual design characteristics that are important to cow-calf producers. The results suggest that beef producers prefer to sell animals directly to the next alliance member rather than retain ownership. This was attributed to the producers' aversion to risk since retained ownership implies delayed and possibly more volatile revenue streams. However, beef producers expressed a preference for profit sharing alliances with bonuses for animal performance downstream, compared to non-profit sharing alliances. While producers displayed a preference for lower membership fees, this has to be jointly considered with non-monetary incentives such as the profit sharing element. Greater participation within alliances cannot merely be solved through reduced membership fees. Surprisingly, specific production protocols (restrictions on vaccination, use of antibiotics and minimum number of animals required for alliance participation) did not significantly influence producers' preference for different marketing channels.

In a survey of LEAF Marque farmers in the UK (farm assurance scheme based on promoting sustainable agriculture), Elliott (2014) found that these farmers generally had strong relationships with supply chain buyers. Farmers' relationship with buyers and participation within the scheme was enhanced by a secure market; a premium price; increasing the visibility of the environmental work conducted within their farms; and good feedback. Farmers within the survey emphasised the importance of the strong level of dialogue relating to standards and the value of ensuring a long-term relationship in which risks and rewards are shared. This is in keeping with the risk literature, which demonstrates that farmers are generally risk adverse and seek to minimise risks in order to maintain stability for their well being and income (Just and Pope (2013) and De Pinto, Robertson *et al.* (2013)).

In general terms, Sprigs *et al.* (2001) found that producers in the UK recognised the need for greater coordination in the supply chain. Indeed, the survey results, which focused on beef producers, indicated that there was greater acceptance for the need of vertical coordination mechanisms in the UK compared to Canada. The authors suggested that this may be a response to the devastating impact of animal disease outbreaks in the UK on consumer demand, which have created an awareness of the need to adopt coordination strategies. As a result, producers within the UK have been receptive to development of quality assurance schemes as a mechanism to provide reassurances on the safety and quality of food, thereby lifting consumer confidence. However, farmers value their independence and tend to be resistant to stricter forms of vertical coordination (Fearne (2008) and


Schulze, Spiller and Theuvsen (2006)). Attitudes towards vertical coordination differ across sectors. A survey across six different EU countries, including the UK, showed that formal relationships (includes both contractual agreements and financial participation agreements) are less prevalent in the beef sector (accounts for 5 per cent of relationships) compared to pigmeat (51%) beer (45%) and bread (15%) sectors (Fischer *et al.*, 2008). As a result of this resistance, the widespread uptake of contracting within the red meat sector may remain limited, largely focusing on smaller market segments with above average quality requirements for specific brands or credence requirements e.g. animal welfare. As discussed in the next section, non-contractual long-term relationships may provide a more flexible means to secure the benefits associated with tighter forms of coordination.

Non-Contractual Long-term Relationships

Non-contractual long-term relationships have emerged to provide a middle ground between the extremes of spot markets and tighter forms of vertical coordination. Essentially, this refers to the development of long-term relationships between two or more parties based on trust and mutual understanding, without the use of contractual obligations While both partners remain substantially independent, there is a (Fearne, 1998). commitment to stable long-term relationships. This may entail the sacrifice of short-term advantages that arise from market exchanges, but offers several benefits that arise over time (Schulze, Spiller and Theuvsen, 2006). Following Fearne (1998), these include improved market access, e.g. development of partnerships between producers, abattoirs and supermarkets provides producers and processors guaranteed access to a high volume market. In addition, the partnerships provide a means to enhance chain-wide information flows, which can lead to improvements in production planning and changes in feeding and/or breeding regimes to meet eating quality requirements. Such improvements can in turn have a favourable impact on profit margins through the development of added-value products, where the benefits are shared across the supply chain.

The development of mutually beneficial long-term relationships wherein no partner feels under threat requires the utilisation of trust-building measures that encourage collaboration. This could, for example, involve the introduction of a "code of ethics", which demonstrates the commitment of the entire organisation, not just individuals, of downstream partners to farmers (Schulze, Spiller and Theuvsen, 2006). In addition, communication is regarded as central in building trust and enhancing the performance of the supply chain (Leat and Revoredo-Giha, 2008). Within the survey undertaken by Fischer *et al.* (2008) across six EU countries, noted in the previous section, good communication was found to be the most important factor to the sustainability of business relationships in the agri-food supply chain. Underlying good communication, it was found that adequate communication frequency and high information quality were very influential. Communication within the supply chain can be greatly enhanced through information sharing technology. A Scottish case study illustrating the use of information technology to improve communication between a retailer, a beef processor and beef producers is provided in Box 2.

Interconnected with good communication, Fischer *et al.* (2008) showed that the existence of personal bonds, especially at the farmer-processor level, and the retention of



key staff have a beneficial impact on the sustainability of supply chain relationships. A value chain analysis of the GB red meat supply chain on behalf of the Red Meat Industry Forum indicated that the rotation of staff with retailers had a negative impact on the continuity of trading relationships with processors and represented a barrier to coordination within the supply chain. The evaluation team called for mechanisms to be put in place that will guarantee that partnerships continue to be maintained even when key personnel depart or move another division within the firm (Simmons *et al.*, 2003). This is termed "trust institutionalisation."

A further important consideration is the alignment of business objectives, wherein all chain members should be involved in the planning process if a chain's potential is to be realised (Peterson *et al.*, 2000). A major issue raised by the value chain analysis of the GB red meat supply chain is the wastage caused by insufficient interaction of retailer and processor information systems, especially with regards to promotions. The authors recommended that promoted products are controlled by cross-company teams, with the development of collaborative planning initiatives that bring together actual sales and production systems (Simmons *et al.*, 2003).

The Scottish case study also revealed that the perception of equal power distribution has a positive impact on maintenance of long-term relationships. Given the unequal distribution of market power within the agri-food supply chain, this suggests that the sustainability of relationships may be enhanced by organising farmers into groupings, such as producer groups or co-operatives, in order to engender a perception of enhanced market power and facilitate communications. The issue of horizontal coordination is discussed further in the next section.

A major feature of the UK red meat sector since the 1990s has been the development of dedicated supply chains, which are based on collaborative supply chain relationships between producers, abattoirs and retailers. These dedicated supply chains are highly directed and regulated by the supermarkets and thereby lock partners into a common vision. The competition between supermarkets within a product category is increasingly based on their respective dedicated supply chain systems (Leat and Revoredo-Giha, 2015).



Box 2: Introduction of a Performance-Related Communication System within the McIntosh Donald Beef Supply Chain

(The following case study is based on Leat, Revoredo-Giha and Kupiec-Teahan (2008))

In collaboration with Tesco, the Scottish beef processor McIntosh Donald introduced a performance-related communication system to its Beef Producer Club members in 2005. The Producer Club members receive weekly information on the physical performance of their animals compared to the average results for the plant, including weight, conformation score, fat score average value and deadweight/liveweight gain per day. In addition, the system assesses the financial consequences of alternative on-farm management decisions through the provision of information on how much would have been earned on animals for a range of feeding costs. The system enables farmers to make management improvements, such as assessing the quality of a particular source of store cattle or reviewing feeding rations to try to achieve better weight gain and earlier finishing.

In terms of the beef processor, the performance communication system should have a positive impact on the amount of cattle meeting their specification requirements in terms of weight, fat and conformation. This should provide major cost savings, e.g. an overfat animal yields 2% less saleable meat. In terms of the retailer, Tesco views the system a success, helping them to improve the overall quality of animals entering the supply chain.

Overall, the information sharing system has helped to improve the level of trust and strengthen relationships by increasing the level of transparency and encouraging interaction across the supply chain.



3.1 (f) Horizontal Collaboration

The horizontal collaboration of producers has been an established feature of the agriculture sector, where producer cooperatives have long existed to enable farmers to join forces. The first producer co-operative in the UK was established in 1867 to supply seeds and fertilisers to its members (Spear, Westall and Burnage, 2012). In general, the main role of producer cooperatives has been to provide producers a means to expand their marketable output and thereby meet the volume requirements of major customers. As value added markets have become more important, producer cooperatives have also played a role in members sharing the costs associated with developing new products and adopting new technology (Fearne, 1998).

One of the primary benefits of cooperatives is that it enables producers to improve their bargaining position and thereby offset to some extent the power of large processors and retailers. However, this only applies if cooperatives are successful in creating added value by:

- i. reducing the transaction costs associated with obtaining supply; or
- ii. improving the quality of the product supplied (Hayes *et al.*, 1997).

A further benefit of cooperatives is that they can ensure that the production methods of the members meet consumer requirements and thereby improve their position in the market place (COGECA, 2014). They also provide members a means to exchange production performance information and hence lift overall performance levels (Leat and Revoredo-Giha, 2013). Finally, many producer cooperatives also play a role in undertaking marketing activities so as to maximise the commercial market opportunities for its members (Hayes *et al.*, 1997).

The governance structure of cooperatives covers a wide range of business models, including one-tier and two-tier management systems. Essentially, the more simplified one-tier system refers to systems where elected producers take-on executive roles and tend to be used to deal with commodities and less complicated decision making. The two-tier system occurs where elected members govern a professional management board to handle more elaborate marketing and business strategies (COGECA, 2014). Following the International Cooperative Society, theoretically membership of cooperatives is open and voluntary. However, open membership cooperatives may suffer from coordination problems by encouraging all farms to join even though their objectives may vary widely. Consequently, in reality the membership of some cooperatives is restricted.

The contribution of cooperatives varies across sectors (Figure 6). While cooperatives provide an important means of marketing livestock in the pig sector within the UK, they play a less important role within the beef and lamb sectors. Based on 2005 data, Cox, Chicksand and Palmer (2005) reported that 80% of livestock were marketed through cooperatives within the pig sector, compared to 10% and 15% in the beef and lamb sectors. This is partly attributed to higher levels of consolidation, higher degrees of vertical integration and the intensive nature of production in the pig sector, which has resulted in a more homogenous commodity. In addition, beef and sheep farmers in the UK have a long established independent mindset, with the result that they tend to be resistant to



collaborative relationships (Fearne (1998), Cox, Chicksand and Palmer (2005) and EFFP (2014)).





Source: Plunket Foundation (2001), from Spear, Westall and Burnage (2012)

Nevertheless, producer organisations have emerged in recent years as an alternative form of horizontal collaboration. Similar to cooperatives, a producer organisation is a voluntary association of producers who join together to increase their marketable output and provide a mechanism to increase their bargaining power with downstream parties. However, in order to be recognised as a producer organisation, specific legal entities must be fulfilled, including having a minimum number of members and cover a minimum volume or value of marketable production (EFFP, 2014). In addition, producer organisations tend to have a narrower remit, with a focus on organising production rather than investing capital in value-adding activities such as processing, innovation and branding. The number of producer groups in the UK has increased in recent years in response to the development of dedicated supply chains as these require processors/retailers to engage with large groups of farmer suppliers. By organising production of its members, producer groups can offer these dedicated supply chains significant volumes of a consistent, reliable supply of highquality produce (Fearne, 1998). In addition, producer organisations within the UK have benefited from the provision of government support to encourage greater collaboration within the agri-food industry (Cox, Chicksand and Palmer, 2005). Similar to cooperatives, producer organisations need to generate benefits to producers in order to be successful.

Note, some dedicated supply chains do not necessarily require farms to join together in formal groups (EFFP, 2014). Survey results from leaders of cooperative/producer organisations in England and Wales indicate that important factors in the successful collaboration between different parties in the vertical supply chain include: trust, equitable mechanisms to share risks and rewards and the attitude of the retail sector (Figure 7). With specific regards to the livestock sector, the retailer Morrisons stressed the following in terms



of their dedicated supply chain for beef which has a collaborative relationship with a beef improvement club:

"the need for organisation and a professional management structure to make such organisations work and also to the fact that membership of such groups does not deliver a premium per se but is intended to deliver efficiency gains within the supply chain that can be shared by all." (EFFP, 2014)

Figure 7: Survey results from EFFP survey of England and Wales Coop/Producer Organisation leaders: How important are the following to making vertical supply chain collaboration work? (coop/PO response)



Source: EFFP (2014)

An example of horizontal and vertical collaboration within the Scottish pork sector is provided in Box 3.



Box 3: ASDA Porklink Supply Chain

(The following case study is based on Leat and Revoredo-Giha (2013))

The ASDA Porklink supply chain commenced in 2009 and consisted of a collaborative relationship between three stages of the vertical supply chain: a pig marketing cooperative (Scottish Pig Producers), a processor (Vion Halls) and a retailer (ASDA).

Under this scheme, the cooperative secured a large market supply through a contractual agreement. The contractual agreement operated on a rolling annual basis with one year's notice required for any changes, providing some degree of market continuity. Prices were set on a transparent basis, linked to the weekly updated deadweight average pig price, with bonuses for carcasses of preferred quality. During the escalation of feed costs in 2011 ASDA paid a temporary feed cost supplement to farmers to provide some financial relief to producer members. The cooperative also provided insurance to its members against non-payment and ensured members are paid promptly. A further feature of the scheme was the emphasis placed on supplier development with ASDA attending producer meetings, producer access to benchmarking data on enterprise productivity and efficiency and the provision of knowledge exchange information from two monitor farms for pigs.

From the retailer's perspective, this collaborative relationship provided a means to meet their large scale supply commitments. In addition, the large scale nature of the processor reduced the risks of supply interruption as the processor could potentially source supplies from elsewhere in the event of problems with the cooperative, e.g. poor weather. In addition, the retailer was able to provide reassurances to consumers about husbandry practices and welfare standards through third party verification organisations (Quality Meat Scotland's Farm Assurance scheme and Scottish SPCA).

Overall, the collaborative arrangements sought to reduce market risk for the pig producers and supply risk for the chain as a whole.

Despite the success in establishing a long-term collaborative relationship and the commitment to maintain the relationship, the relationship can still be vulnerable to changes in parties along the chain. In this example, the scheme was suspended in 2013 after the multi-national Dutch processor Vion Halls sold its UK operations and stopped supplying ASDA. While ASDA's Porklink scheme was relaunched with a Yorkshire based processor, their links with pig producers in the north east of Scotland were severed due to the closure of the processor.



What factors influence farmers' willingness to join a cooperative or producer organisation?

Further survey evidence from EFFP (2014) suggest that attitudes towards horizontal collaboration within the UK is changing, with 60% of respondents indicating that farmers are more willing to join a cooperative/producer group now than they were five years ago. The primary reason underlying this apparent change according to survey participants is the recognition by producers that they 'need to gain more power in the market place' (Figure 8(a)). It is also noteworthy that 'UK POs/Coops proving that they can be successful' is ranked highly. This is in keeping with the positive impact of social capital, with the consequences of trust and commitment in the form of collaboration deepening the levels of trust between the relationship partners, thereby encouraging more collaboration in the future.

Figure 8: Survey results from EFFP survey of England and Wales Coop/Producer Organisation leaders:

(a) Rank why farmers are now more willing to join a coop or PO (coops/PO response)

(b) Rank why farmers are now less willing to join a coop or PO (coops/PO response)



Source: EFFP (2014)

With regards to barriers of farmers choosing to participate in horizontal collaboration initiatives, the survey results indicate that 'high profile producer organisation/cooperative failures' and 'investment costs' are important disincentives (Figure 8(b)). In addition, the independent mindset of farmers is an important barrier with a 'perceived loss of autonomy' being ranked as the most significant barrier. This suggests that farmers need to be persuaded that the benefits of collaborating exceed the risks. Within a German study of the factors influencing the success of cooperatives in the pig sector, Theusven and Franz



(2007) demonstrated that cooperatives that appealed more to farmers offered a broader range of services that meet members' needs and offer an added value to farmers. Thus, in addition to providing traditional services such as 'bargaining with abattoirs', 'organising transport' and 'supervising of slaughtering', cooperatives may need to offer additional services to convince farms of the advantages of joining a cooperative, such as 'supporting members with the introduction of quality assurance schemes', 'developing recommendations for improving profitability on farms' and 'smoothing conflicts between different parties across the vertical supply chain'.



3.2 Dairy

3.2 (a) Industry Structure

There is a strong cooperative tradition in the dairy sector. Today, four out of ten largest cooperatives in the EU are dairy (by turnover in 2013) (Copa-Cogeca, 2014). Excluding farm supply cooperatives, within the largest ten cooperatives there are five dairy ones plus a multi-purpose one that covers the dairy sector (Copa-Cogeca, 2014). Raw milk marketing is one of the main functions of dairy cooperatives. The quantity of raw milk collected by cooperatives is substantial in certain regions. The prominent example is Fonterra, the biggest dairy cooperative in New Zealand, which collects over 90% of the nation's raw milk. In Northern Ireland, the largest dairy cooperative is United Dairy Farmers. The second largest, Ballyrashane, merged with the Town of Monaghan Co-op in 2015 to form a cross border dairy cooperative, with a new name LacPatrick. Several Irish dairy cooperatives (e.g. Glanbia) are also active in the region. Quite frequently, dairy cooperatives process raw milk as well, which as discussed below ultimately forms the basis of competition (a simple illustration of the dairy chain presented in Figure 9). The dairy cooperative is a key component in the dairy supply chain and this is reflected in the discussion below.





The dominance of cooperatives in the dairy sector is often explained using the framework of transaction cost economics (see for example, Manchester and Blayney, 2001). Since raw milk is perishable and milk delivery is frequent (every day or every other day), transaction costs are greatly reduced if dairy farmers have some control over the marketing and immediate downstream processing of raw milk. Continuous access to the market also protects the up-stream on-farm investment. This gives rise to the dairy cooperative. To engage in raw milk marketing, processing and dairy product manufacture, capital is built up, which belongs to the members in both allocated and unallocated ways. The amount, type and quality of the capital are key to the capacity of processing is profitable, returns are generated, which belong to the members and consequently allocation mechanisms must be decided, e.g. retaining for reinvestment and distribution to member farmers. In other



words, by joining and selling milk to cooperatives, receipts to member farmers consist of two different parts:

- milk price; and
- return from the capital.

Ambitions like "highest possible milk price" or "premium price" are often found in cooperative objectives, the premium part of which is essentially generated from the return of the marketing and processing activities. The literature highlights the importance of distinguishing these two parts (Van Bekkum 2001, 2008). This is because the milk price is the market signal to farmers concerning their milk production decision and a return inclusive milk price interpreted as just the milk price will distort these decisions. Furthermore, while the milk price represents a revenue stream to farmer members, it is a cost to the processing business of the cooperative. The following discussion firstly addresses the capital issue, followed by the milk price issue.

3.2 (b) Capital

Dairy cooperatives are generally becoming larger, often through merger. For example, the two largest dairy cooperatives Friesland and Campina in the Netherlands, which together processed about 75% of milk produced in the country, merged and became FrieslandCampina in 2008 (LTO International Comparison of Producer Prices for Milk, 2007). In New Zealand, Fonterra is the result of a merger of the two largest cooperatives in 2001. In the US, although there is no single cooperative as dominant as the previous examples given the vast market size of the country, the trend of consolidation is nevertheless apparent (Gould 2010). Reasons for dairy cooperative mergers include capital constraints, achieving greater economies of scale and scope etc. (Richards and Manfredo, 2003; Gould 2010). The growth and capital expansion issue has been noted extensively in the literature (see for example, Van Bekkum 2001, Jansik et al. 2014). Externally, cooperatives generally lack access to the equity market (*i.e.* the stock market).⁴ Internally, it is not straightforward to line up the objectives of farmer members and the cooperatives. To achieve capital expansion internally, returns need to be retained rather than distributed and therefore income to member producers is reduced in the short run. This also applies to dairy cooperatives that remain a similar size over time as there are investment needs for these cooperatives as well (e.g. update of capital stock, research and development of new products etc.). Van Bekkum (2001) provides a detailed discussion, which is briefly presented here.

The investment problem is multifaceted. Firstly, there is a common property problem, manifested by the free rider issue. There are two types of free rider issue: internal and external. The internal free rider issue occurs where old members contribute to the unallocated capital within the cooperative but not the new members who still benefit from it. The external free rider issue happens when a particular cooperative leads the table of

⁴ An exception is in Ireland, where there are the Glanbia Cooperative Society and Glanbia plc. Glanbia plc. is listed in the Dublin and London stock exchange. Glanbia Cooperative Society has been the biggest share owner of Glanbia plc., despite that the holding reduces over time from over 50% in 2000 to around 40% in 2015 (van Bekkum 2001, http://www.morningstar.co.uk/uk/news/AN_1431621617262864000/glanbia-shareholder-plans-approved-to-cut-stake-in-company-to-365.aspx). Members of the cooperative may further own the shares individually.



regional milk prices since their prices include returns from processing. Non-member farmers benefit from the prevailing "inflated" regional milk prices. This may in turn exert negative impacts on other processing firms within the region. Secondly, there is a horizon problem, which concerns the disparity of interests among the members themselves and in relation to the board of directors and management due to the inter-temporal distribution of costs and benefits of investment. For example, members close to retirement may be reluctant to bear the cost of financing long-term investment. In addition, there is a portfolio problem, similar to the horizon problem but with disparity of interests arising due to differences in risk attitudes of different entities within the cooperative. Van Bekkum (2001) emphasises the importance of matching the capital structure and features with the strategies and governance of the cooperative itself. Various arrangements have been devised to solve these issues. Take the internal free rider problem as an example. Nowadays, it is not uncommon that a cooperative charges new joining members a high entry fee. For example, in Germany, a figure of 4 cent/kg (i.e. €4 per 100 kgs) is mentioned (Jansik *et al.*, 2014); Frieslandcampina, the largest dairy cooperative in the Netherlands, charges €15 per 100 kilograms (up from €10 in 2015) of expected annual milk supply.⁵

The competitiveness of dairy cooperatives can have further sectoral implications. A prominent example is New Zealand. Its largest cooperative, Fonterra, collects more than 90% of the national milk supply. The milk prices of Fonterra largely determine milk prices in New Zealand given its sheer size. However, there are complaints from processors in the country, some of which actually purchase milk from Fonterra, that the "inflated" milk prices have negative impacts on their product competitiveness on the international markets (Cossar and Chant, 2011).⁶ In regions with less prominent cooperatives, this problem can still happen as long as the cooperatives are influential in the milk price determination process. This leads to the following discussion of pricing of raw milk.

3.2 (c) Pricing of Raw Milk

Raw milk is allocated to the most valuable use first; or in other words, not every part of the milk production has the same value. The allocation of raw milk on the basis of diminishing marginal value has profound ramifications in the dairy sector.

There are two broad usages of raw milk: fluid versus manufacture of dairy products (processing). In terms of processing, the value of raw milk depends on its components. Milk for fluid use attracts a premium. This premium is necessary to ensure raw milk is allocated to the liquid market rather than the processing market. As a consequence, milk for manufacture sets a price floor for milk for fluid use. A detailed look at the milk marketing structure in the US is helpful in advancing the discussion. In the US, milk is priced depending on its use (class). There are four classes:

- Class I for beverage;
- Class II for soft manufactured products, such as yogurt;
- Class III for cheese making; and

⁵ http://www.farmersjournal.ie/frieslandcampina-to-increase-entry-fee-for-new-suppliers-183141

⁶ In fact, Fonterra has become so dominant that there is no competitive process to determine the farm gate milk price in New Zealand. Fonterra determines its farm gate milk prices following procedures used in the natural monopoly sectors (such as water) (Cossar and Chant, 2011). Questions around this monopoly structure of cooperatives are important on their own; however, it is beyond the scope of this paper.



• Class IV for dry milk products and butter.

The Federal Milk Marketing Order (FMMO) specifies minimum prices for all the different classes of milk based on assumptions of standard contents of components. The Federal Milk Marketing Order also specifies minimum prices for milk components (Jesse and Cropp, 2008). Milk of Class III and Class IV are priced completely on components: butterfat, protein and solids non-fat. Class II price is tied to Class IV, plus a premium. Class I is essentially the higher of Class III and Class IV, plus a premium. The premium is specified for each county where the processing plants are located.⁷ Similar to the milk prices, these premiums specified in and regulated by the Federal Milk Marketing Order are the minimums. In markets where there is no such regulation, the magnitude of the fluid premium varies more freely depending on supply and demand. If switching milk buyers is possible, a powerful retailer sector should not be able to eliminate the premium (but could probably reduce it).

With regards to the pricing of raw milk for manufacture, multiple component pricing is popular in Europe, US and Oceania. This is because the value of milk in processing depends on the content of its multiple components. Moreover, the relative values of different components change with consumer preferences (based on their choices in dairy products) through time (Atsbeha *et al.*, 2015). The desirability of this method in the UK was stressed by the Milk Development Council early in 2005. Since component contents are linked to breeding of dairy cows and on farm management practice, component pricing sends market signals to the farm gate. Borthwick *et al.* (2014) discusses the case of genetic selection techniques in the dairy, beef and sheep sectors in Scotland. Fat, protein and sometic cell count are among the main traits in calculating the Estimated Breeding Values (EBVs), along with milk yield, fertility and others. This indicates that component pricing has implications on farm management and also further up the supply chain (such as breeding). Compared to the beef and sheep sector, the measurement of these raw milk quality indicators is easier as they can be objectively measured.

However, this is not to say that devising the component pricing is an easy task. Using the Federal Milk Marking Order example in the US, in addition to the minimum prices for the milk components and the different classes of milk, minimum producer prices paid by processers excluding dairy cooperatives are also specified. In what follows, these minimum producer prices are called order prices. Producers' order prices are determined by the following formula:

Order price_i = Producer price differential + Protein price as in the FMMO* Protein content_i + Butterfat price as in the FMMO* Butterfat content_i + Other solids price as in the FMMO* Other solids content_i + Somatic cell adjustment

⁷ Generally, the further the county to the milk shed in the Mid-West the higher the premium. The idea is to provide higher milk prices for milk supply deficit areas. However, the value of this premium is more controversial if deficit is less of an issue. The FMMO dates back to the 1930s, a time during which milk supply was much less abundant than today. The FMMO has three objectives. One of them is "to assure consumers of an adequate supply of wholesome milk for beverage purposes, at a reasonable price" (Jesse and Cropp, 2008). The FMMO has changed a lot over time; however, how the regulation structure (e.g. spatial structure of the fluid premiums) has been shaped by this objective can still be seen today. The other two objectives are "to promote greater producer price stability and orderly marketing" and "to provide adequate producer prices to assure an adequate current and future Grade A milk supply" (Jesse and Cropp, 2008). Note: Grade A milk refers to milk eligible for use as fluid milk, which represents 99% of total milk produced in US in 2006.



where i refers to a particular producer and producer price differential is determined by sum[(Class I price-Class III price)*Class I utilization, (Class II price-Class III price)*Class II utilization, [(Class IV price-Class III price)*Class IV utilization].

Following the Class I premium, the producer price differential is specific to each county and captures the general deviation in the milk value from Class III milk for each of the county (Jesse and Cropp, 2008). Essentially, the producers' order price does not depend on the specific usage of its own milk but rather the general usage mix of the county the processor is located in. In other words, within the order price, which is the minimum price a producer will receive, the fluid premium is shared among producers supplying the same county (although processor specific premium can be added on).

Moreover, under component pricing the market value of any additional component supply is fully reflected as return to the producers in the FMMO formula. Although the market value of the components can be derived from market prices of the bulk dairy commodities, the determination of their values at the individual dairy plant level is less straightforward. This is because dairy products are often joint products. An increase or decrease in demand for one product can easily upset the balance among the utilisation of the components and therefore the component value at the plant level can positively or negatively deviate from the market.⁸ Furthermore, as demands for the various dairy products vary over time (rather quickly in many circumstances), so do the values of these components. In Europe, different practices are adopted. According to LTO International Comparison of Producer Prices for Milk report in 2014:

"Until 2013 all dairy companies maintained a fixed ratio between the prices paid for fat and protein, except for Arla and frieslandCampina. Hameenlinnan Osuusmeijeri, German and French companies, as well as Granarolo, even applied fixed prices for fat and protein."⁹

Furthermore, raw milk is always allocated to the most profitable processing activity first. In occasions where raw milk is over supplied, the additional supply tends to lower the overall return even before process capacity is exhausted. This is sometimes termed "marginal milk" (van Bekkum, 2001). Therefore, even though more milk (at a given price level) is always preferred by farmers, it is not uncommon that cooperatives devise mechanisms that aim to restrict the additional milk supply. At the end of 1990s, faced with rapid milk production expansion, delivery rights during the peak season were proposed by the New Zealand Dairy Group, one of the predecessors of Fonterra. The delivery rights aimed to restrict milk supply during peak seasons. If farmers wish to deliver more than their recent historic level, they need to purchase more delivery rights, which are then used to finance new processing capacity (van Bekkum, 2001). ¹⁰ Starting in 2011, Sodiaal in France introduced a similar two-price system, in which an A-price is the regular price for the first part of milk supplied (given % of the milk quota held by a farmer), while a B-price applies

⁸ The FMMO method is somehow rigid in this regard. If component value at the plant level negatively deviates from the market, the difference needs to be absorbed by the processor. However, this can be offset by the positive deviations of other components. The FMMO only regulates the total price. The formula is shown as an example of the component pricing.

⁹ All refer to dairies covered by the report (country is indicated in the bracket here): Hameenlinnan Osuusmeijeri (Finland), Granarolo (Italy), FrieslandCampina (the Netherlands), DOC cheese (the Netherlands), Dairy Crest-Davidstow (UK), First Milkcompositional (UK), Arla (Denmark), Bongrain (France), Sodiaal ((France), Danone (France), Lactalis (France), DMK (Germany), Muller (Germany), Glanbia (Ireland), Kerry (Ireland), Milcobel (Belgium).

¹⁰ It is not clear whether this policy had been implemented at the time. However, it should be noted that the time was not long before the merger, which resulted in the creation of Fonterra in 2001.



to the additional supply, which is based on the prices of butter and skimmed milk powder (LTO International Comparison of Producer Prices for Milk, 2011). Since then, the A-B price method has been adopted by other dairy cooperatives and companies. In the beginning of 2016, again faced with increased milk supply, the Dutch dairy cooperative FrieslandCampina rewarded farmers whose milk supply did not exceed their December 2015 level with higher milk prices.

Within the UK dairy sector, one notable feature is the existence of numerous types of contracts across the country. This, to some extent, reflects the recommendations by the Milk Development Council early in 2005, which stressed that processors should match their input uses with the output structure. For example, the component pricing method is recommended for milk for manufacture and the cost based pricing method for milk for fluid use.

AHDB-Dairy regularly publishes milk price league tables. The milk price contracts can be roughly grouped into three tiers:

- aligned liquid milk contracts;
- standard liquid milk contracts; and
- standard manufacturing contracts.

Data for March 2016 extracted from the AHDB-dairy milk price calculator are presented in Table 3 as an example.

This table clearly shows the price premiums for liquid contracts. The standard liquid contracts pay 2.46 pence per litre more than the standard manufacturing contracts on average. Furthermore, depending on the arrangements of the specific dairy cooperative, the premium is sometimes shared among all the members, which to some extent resembles the order prices under FMMO in the US.¹¹ With regards to milk for manufacturing, the bonuses for additional protein of 0.02% per litre (keeping other components constant) range between 0.05 to 0.09 pence. In contrast, there is little price difference in the fluid contracts.

The table also contains the average price for the processor Graham's, which applies the A&B pricing method. The individual A and B prices are not provided in the table. According to the NFU Scotland website, Graham's, faced with surplus milk supply, cut it's A price to 23.75 pence per litre, with the B price halving to 7 pence per litre in July 2015.¹² It should be kept in mind that the B price is designed to move more closely with the market price than the A price; therefore, the ranking between the A and B prices will vary according to market conditions.

The final point to be noted is the aligned liquid contracts. These contracts emerged in the last decade, during which declining milk production trends, increasing input prices, increasing price volatility have together contributed to destabilise the supply of raw materials to the dairy business. Aligned liquid contracts provide a means for retailers to secure supply for liquid milk (Irish Famers' Association, 2015). The objective of this development closely resembles that of the FMMO in the US. The main difference is that the

¹¹ Source: http://dairy.ahdb.org.uk/market-information/milk-prices-contracts/milk-calculator-and-contracts/retail-activity-factsheet-farmer-impact/#.VzL2GYQrLcs

¹² Source: http://www.nfus.org.uk/news/2015/july/dairy-farmers-face-blow-following-milk-price-cut-graham-s-family-dairy



aligned contract is a private solution to assure adequate milk supply for liquid use, while the FMMO is a governmental solution. The aligned contracts are offered to small groups of dedicated producers.¹³ The milk prices in these contracts are based on production costs plus a small profit margin.¹⁴ However, when milk prices are generally low the price difference among the different contracts can be rather large. For example, aligned contracts pay a premium of more than 7 pence per litre on average compared to the standard liquid contracts as shown in Table 3. This has caused some controversies in the industry. The tension arises partly because choices of contracts for a particular dairy farmer are in reality much more limited than those as shown in Table 3. Due to the perishability and bulkiness of raw milk, farmers are largely constrained to processors close to their farms. This once again highlights the importance of competitiveness at the processor level.

¹³ There is no official statistics on how many producers are on these contracts, but different sources give estimates of a small percentage (e.g., 1% as in http://www.adas.uk/News/delivering-producer-and-buyer-benefits-with-cost-of-production-contracts, 5% as in https://www.fginsight.com/news/could-aligned-dairy-contracts-be-pitching-farmer-against-farmer-10132). However, as it is more cost effective to contract with large producers, the percentage in terms of milk supply can be much larger. The Irish Farmers' Association report (2015) estimates around 24% of the milk produced in GB during the 2010/11 milk year was purchased on retailer-aligned contracts (roughly 22% if total milk production adjusted to the 2015 total).



Table 3: Milk Price League, March 2016

		2016 March		
Туре	Contract	AHDB Standard Litre	Customised Litre	e Difference
Arla Foods - Sainsburys	Aligned Liquid Milk	29.89	29.89	0.00
Müller Direct Milk - M&S (Profile)	Aligned Liquid Milk	31.84	31.85	0.01
Müller Direct Milk - M&S (Seasonal)	Aligned Liquid Milk	31.84	31.85	0.01
Müller Direct Milk - Sainsbury (Profile)	Aligned Liquid Milk	30.27	30.27	0.00
Müller Direct Milk - Sainsbury (Seasonal)	Aligned Liquid Milk	30.27	30.27	0.00
Müller Direct Milk - Waitrose (Profile)	Aligned Liquid Milk	30.62	30.62	0.00
Müller Direct Milk - Waitrose (Seasonal)	Aligned Liquid Milk	30.62	30.62	0.00
Müller Milk Group - Booths	Aligned Liquid Milk	32.09	32.09	0.00
Müller Milk Group - Co-operative	Aligned Liquid Milk	27.52	27.52	0.00
Müller Milk Group - M&S	Aligned Liquid Milk	31.07	31.08	0.01
Müller Milk Group - Sainsbury	Aligned Liquid Milk	30.46	30.46	0.00
Müller Milk Group - Tesco	Aligned Liquid Milk	31.02	31.02	0.00
Average (Aligned Liquid Milk)		30.63		
	Standard Liquid Milk	24 49	24 69	0.00
Nüller Direct Milk, Core Formula (Brofile)	Standard Liquid Milk	24.00	24.00	0.00
Müller Direct Milk - Core Formula (Frome)	Standard Liquid Milk	24.97	24.97	0.00
Müller Direct Milk - Liquid (Drefile)	Standard Liquid Milk	24.97	24.97	0.00
Müller Direct Milk - Liquid (Profile)	Standard Liquid Milk	22.69	22.09	0.00
Muller Direct Milk - Liquid (Seasonal)	Standard Liquid Milk	22.69	22.69	0.00
Muller Milk Group - Formula	Standard Liquid Milk	22.42	22.42	0.00
Muller Milk Group - Partnersnip	Standard Liquid Milk	23.48	23.48	0.00
UK Arla Farmers Liquid	Standard Liquid Milk	21.21		
Average (Standard Liquid Milk)		23.39		
Arla Direct Manufacturing	Standard Manufacturing	15.74		
Barber A.J & R.G	Standard Manufacturing	21.87	21.94	0.07
Dairy Crest cheese - Davidstow (Profile)	Standard Manufacturing	21.55	21.60	0.05
Dairy Crest cheese - Davidstow (Seasonal)	Standard Manufacturing	21.55	21.60	0.05
Dale Farm - GB	Standard Manufacturing	21.90		
Dale Farm - NI	Standard Manufacturing	17.77		
Glanbia - Llangefni	Standard Manufacturing	18.41	18.47	0.06
Lactalis - Caledonian Cheese	Standard Manufacturing	20.44	20.52	0.08
Lactalis - Caledonian Cheese (Profile)	Standard Manufacturing	20.94	21.02	0.08
Lactalis - Caledonian Cheese (Seasonal)	Standard Manufacturing	20.44	20.52	0.08
Parkhams Farms	Standard Manufacturing	30.46	30.55	0.09
Pattemores Dairy Ingredients	Standard Manufacturing	21.00	21.06	0.06
South Caernarfon Creameries	Standard Manufacturing	18.40	18.46	0.06
UK Arla Farmers Manufacturing	Standard Manufacturing	21.47		
Wensleydale Creamery	Standard Manufacturing	21.96		
Wyke Farms	Standard Manufacturing	21.03	21.10	0.07
Average (Standard Manufacturing)		20.93		
Graham's Dairy (A&B)	A&B	22.9		
Based on				
Butterfat %		4.10	4.10	
Protein %		3.26	3.28	
Scc /ml		163000	163000	
Bactoscan /ml		28000	28000	

3.2 (d) Volatility in the Dairy Sector



Price volatility is a key issue in the dairy sector. Volatile prices result from the inelastic supply in the short term in relation to demand changes. Within the EU, milk prices used to be less prone to fluctuations compared to world prices due to the combination of the milk quota system and other support policies. Volatility has become more of a problem in recent years as the internal market has become more integrated with the world market. Starting from April 2015, the EU milk quota system was completely abolished. The timing of the abolishment coincided with a fall in global dairy prices (after a surge in prices 1-2 years beforehand). The topic of volatility and risk management has received a lot of attention from both academics and industry stakeholders.

Types of risk management tools include risk transfer (futures, options) and risk pooling (insurance schemes). As operational risk management tools in the EU dairy sector are limited, the discussion below is mainly based on the US example.

Futures, Options and Forward Contracts

Futures and options can be used to hedge against price volatility. Essentially, buyers of futures/options lock-in a price to limit financial loss caused by price changes. Future contracts are standardised, legal contracts. In terms of standardisation, quality and quantity of the commodity are specified and do not vary from one contract to another. Trading is cleared and settled by clearing houses; in other words, there is no need for buyers or sellers to identify the particular counter party of their trading. Futures offered on the Chicago Mercantile Exchange (CME) in the US covers milk (Class III and Class IV), butter, cheese, non fat dry milk and *etc*. Direct use of futures/options by farmers can be difficult. One milk class III futures contract on the CME is 200,000 pounds. With average monthly production per cow just below 2,000 pounds (USDA data), this means many small and medium size farms will face the problem of lumpiness even utilising one contract.

Another problem that farmers face in directly utilising futures is basis risk. This arises as class III milk is dedicated for cheese manufacture, while milk from a particular farm is more likely (almost certain if marketed through cooperatives) to be used in multiple ways and producers receive an average milk price. Basis risk is a recurring factor in Wolf and Widmar (2014), which examines the impact of farm characteristics on the adoption of milk and feed forward pricing methods by dairy farmers in the US. Farmers in regions with more milk dedicated for cheese is more likely to use forward pricing methods. In the same study, when farmers are asked to list reasons of not adopting the forward pricing methods, "cost of using these instruments" and "basis risk" rank third, following "lack of knowledge and the perception that marketing milk and accompanying price negotiations to be the job of their milk marketing cooperative."

Forward contracts provide producers a means to lock-in the output price and benefit from price certainty. This enhances the ability of farmers to plan and to obtain continued or new financing. Forward contracts are similar to futures in the sense that prices are determined at the time of the contract well before the delivery of the commodities. However, unlike futures contracts, forward contracts are much more flexible in the terms of the trading commodities as forward contracts are private contracts. In other words, it only requires the agreement between the seller and the buyer on quality and quantity of



the commodity among others (such as delivery date). This in turn implies that forward contracts always involve two counter parties (sellers and buyers). In the case of milk forward contracting, farmers' willingness is necessary but not sufficient. This is supported by Loughrey *et al.* (2015), who examined the demand of milk forward contracting among Irish dairy farmers. However, this is based on experimental questions as the first forward contract scheme (from a single cooperative) just started prior to the survey. The results largely depend on perceptions of the farmers. As shown by Wolf and Widmar (2014), real demand depends on the actual design of the contracts. Furthermore, as demonstrated in the same study (Wolf and Widmar, 2014), for farmers in the US, where future and forward contracts have existed for a long time, lack of knowledge is still the most important barrier of utilising the contracts. This suggests that education, training and the extension service are crucial in the development of these new programmes.

The cooperative potentially plays an important role in providing dairy farmers risk management tools. For example, the cooperative can act as a broker for farmers to participate in the futures market and therefore the transaction cost may be lowered. Or the cooperative can offer forward contracts to member farmers, which essentially transfers the risk from members to the cooperative. A common unit used in forward contracts offered by cooperatives in the US is 25,000 pounds (Wolf and Widmar, 2014), which is significantly smaller than the 200,000 pounds of a futures contract. The utilisation of forward contracts has income implications on both sides. Manfredo and Richards (2007) investigate the effectiveness of cooperative risk management strategies based on a cooperative specialising in cheese making in the US. A total of 14 strategies are simulated. Some of these strategies involve risk management at the cooperative level only and others involve cooperative offering strategies to its members. The baseline strategy is the spot market price for milk as input and the spot market price for cheese as output. The strategies are compared based on their impacts on the distributions of milk revenue and profits (i.e. milk revenue plus return from cheese making) and they are ranked on the mean, standard deviation, coefficient variation, value at risk, certainty equivalence and semi-variance measures. When forward contracts are offered to members, the cooperative can either forward hedge in the futures markets or not. Forward hedging is found to be more desirable than not. This result is not surprising as risks from price change are not idiosyncratic and therefore when they are pooled at the cooperative level, without being transferred further, the risk at the cooperative level is amplified.

The extent to which cooperatives can offer its members risk depends on its ability of managing the risks on its output side. Forward contracts of milk may be hard to obtain in the UK, but not impossible with some milk purchasers (AHDB-Dairy, 2016). In Ireland, Glanbia offers fixed price forward contracts to its milk suppliers in recent years and the proportion of milk that was bought through this system was around 15% of the total (Irish Farmers' Association, 2013). Ultimately, cooperatives require strategies that reduce their reliance on the commodity market and hence output price volatility, for example, contracting with restaurant chains, developing branded cheese *etc*. The risk management tool set could be broadened if the futures market develops from its current infant state. However, given the typical futures contract size in existence elsewhere, it will not be easy for milk producers, particularly small ones, to directly participate and again cooperatives will be an important intermediate.



US Insurance Scheme

In the US, there is an insurance scheme called Livestock Gross Margin Insurance-Dairy (LGM-Dairy) and another insurance-like scheme called Dairy Margin Protection Program (DMPP). The Dairy Margin Protection Program is described as insurance-like in the sense that farmers pay to enrol and receive indemnification only when pre-determined loss occurs. The two programs differ in the following aspects.

- i. The Livestock Gross Margin Insurance-Dairy charges an actuary fair payment (i.e. premium) albeit subsidised, while the payment charged in DMPP is not based on actuarial rules. Rather, under the Dairy Margin Protection Program, different fixed payment rates are charged depending on the levels of gross margin to be protected, ranging from \$0.010 at \$4.50/cwt of milk production to \$0.475 at \$8/cwt for the first 4 million pounds of milk covered (no payment is charged for margin protection level at \$4.00). Furthermore, the payment rates are two-tiered depending on milk production, i.e. a higher rate is charged for over 4 million pounds. In other words, the program is designed to be cheaper for smaller producers.
- ii. In calculating the gross margin, a single formula and a single set of reference prices are used in the Dairy Margin Protection Program across the whole nation, while producers are allowed to set coefficients to reflect their individual feeding regimes in Livestock Gross Margin Insurance-Dairy.

Each dairy operation can enrol in either program but not both. Since these programs take into account both output and input prices, the task of risk management for producers is greatly eased. It should also be noted that milk prices used are not farm-gate prices but the average price of milk marketed in the United States as reported by NASS, called "the all milk price". These prices are transparent and easy to verify.

However, one set of prices for the country means the scheme is providing insurance against systemic risks, which is not fully compatible with the basic insurability criterion. The scheme is not possible without government support.

Latest Risk Management Developments in the European Dairy Sector

This section lists the latest developments and innovative arrangements available to the dairy industry and/or farmers to mitigate the impacts of milk price volatility.

The European Energy Exchange Europe has started to offer butter, skimmed powder, whey futures, which are based on price indices (some kind of average of the French, German and Netherland prices) from May 31, 2010.¹⁵ The volume of one contract is five metric tons, which is just more than half of one CME contracts (20,000 pounds) but still entails a significant volume of milk. SMP futures contracts are also available on NYSE Liffe with a

¹⁵ https://www.eex.com/en/products/agricultural-markets/dairy-products



contract size of 24 tonnes. However, these markets are "best described as being in their infancy" (AHDB-Dairy, 2016), and trading volumes are low.

Starting from 2012, Milk Price Guarantee Certificates are offered to dairy farmers in the Netherlands by Dairy Trading Online BV (DTO). "The milk price guarantee certificate is a financial product. Each contract comprises a volume of 50,000 kg of milk. In February (of 2012), the first certificate are negotiated for a period of one year and a fixed price of 34 cents per kg of milk. Each month, the difference between this fixed price and FrieslandCampina's variable guaranteed price is credited or debited" (LTO International Comparison of Producer Prices for Milk, 2007).

Another innovation is the "Glanbia MilkFlex Fund" in Ireland. It was introduced in 2016, following a period of milk price decline. It is a 100 million euro loan programme jointly provided by Glanbia, the Ireland Strategic Investment Fund, Rabobank and Finance Ireland. The fund aims to provide loans to dairy farmers with flexible repayment schedules based on the level of milk prices.

3.2 (e) Measuring Productivity and Competitiveness in the Dairy Sector

The previous section discussed the obstacles to improving the dairy supply chain and the major concerns in the chain, as well as tools and examples to address these issues. In this section, studies that empirically measure the performance of the sector, in terms of productivity and competitiveness, are reviewed.

Recent empirical analyses on measuring the productivity in the dairy sector include Kimura and Sauer (2015) and Jansik *et al.* (2014). Both studies are cross-country analyses within the EU but focus on different stages of the supply chain (Figure 10). Kimura and Sauer (2015) measures the total factor productivity of the dairy farming sub-sector at the sectoral and farm levels in the Netherlands, UK (England and Wales) and Estonia. The farm level data have further enabled disentangling the drivers of the changes in total factor productivity. It found little, if any, growth in productivity in the UK dairy sector over the past decade. While some productivity gains were achieved due to the exit of smaller farms, little progress had been made with regard to key productivity drivers including adoption of new technology and efficient management of inputs.

The International Farm Comparison Network (IFCN) is an ongoing international benchmark exercise in the dairy sector. It measures milk prices and on-farm production costs in various regions around the world. The method is developed in such a way that global comparisons are possible. Participating farms are chosen to be representative of their own region. In terms of measuring the costs, both variable cost and the costs of labour, land and capital are calculated. This enables the comparison of the composition of different costs in milk production. There are participating farms in England and Republic of Ireland. So far, Northern Ireland is not a part of the network.

Focusing more broadly on the whole chain, Jansik *et al.* (2014) measures the partial productivity (namely, labour productivity) and total factor productivity at the aggregate



level for both the farming and the processing stages of the sector in Sweden, Finland, Denmark, Germany, Estonia, Latvia, Lithuania and Poland. The results shed light on the interaction of farm structure and the productivity measurements. Having the largest farm size among the eight countries studied, Denmark has the highest labour productivity (measured by cows and/or milk output per worker) and the highest growth; however, if measured in total factor productivity its growth trend is similar to those of other countries. This in turn implies the considerable substitution of labour by capital and that the higher output growth is largely driven by more input use. Although progressing the fastest, Denmark is not unique in farm expansion and more intense capital use on farm. This trend is widespread, including within Northern Ireland. Large farms enjoy economies of scale and have different cost structures from smaller farms. In the case of Denmark, farm expansion and additional capital are largely financed by debts and therefore the question about sustainability arises. Also, larger farm size may require better management of grassland to continue to take advantage of grazing. At the individual farm level, the most important question is profitability.

Another point to note is that in dairy product sales, Germany, Sweden and Finland (three out of the four old Member States in the study) have experienced falls on the domestic market during 2000-2012, although the growth in export markets are large enough to offset these drops, resulting in a positive total growth for Germany and Finland. These figures indicate the fierce competition in the EU dairy markets and again highlight the importance of exports. In relation to this, dairy exports from Germany are found to be increasing quickly in the past decade, primarily due to the growth in low cost product export. This is linked to the success of the German discount store chains throughout Europe and therefore bringing the German processed private label dairy product to new countries. German processors are capable of meeting the tight price targets of the private labels of these chains. In some sense, the German dairy processors are "trained" to be cost effective by the competitive domestic market, which has had long-term beneficial impacts. This development implies local dairy processors face international competition even in the absence of export.

Within Northern Ireland, Wu *et al.* (2012) calculated the gross value added in the dairy sector. This analysis demonstrates that gross value added in the dairy sector is lower than its neighbouring regions (ROI and Scotland). However, the calculation is based on data of one year only. It is difficult to know whether this is a persistent issue. An earlier study by the Food Chain Centre on the UK dairy chain suggests considerable scope of improving efficiency at the processing level and also from coordination across the supply chain (Food Chain Centre at IGD, 2007).



Figure 10: Cross-Country Productivity Analyses





3.3 Fruit and Vegetables

3.3 (a) Background

Horticulture has around 542 growers, with a farmgate value of around £71.7m. The sector has a combined turnover of £221m and employs an estimated 2,000 people. Sales of product outside Northern Ireland accounted for 61% of total sales, but sales beyond the British Isles accounted for less than 1%.

The Going for Growth Review indicated that growers need assistance to enable them to develop their businesses and ultimately to be able to supply processors in this sector. This requires investment in plant, machinery and equipment, as well as in people, with the provision of training in agronomy, business skills, and effective benchmarking. Factors such as health, convenience and the demand for premium products continue to present opportunities for processors.

The Fruit and Vegetable task force was established by the UK Government to look at issues affecting this section of the food industry and the force reported in August 2010. The objective of the task force was to identify how the uptake of fresh fruit and vegetables could be increased in low income families, and that by improving their diet, the pressures on the NHS could be reduced. Three subgroups were established to look at production, supply chain and consumption.

The supply chain group recommended that the government make EU assistance programmes for horticulture easier to access, that growers get better data on market conditions, that incentives for supply chain efficiencies be developed for growers and that 'Best practice in ordering time tables to be drawn up' by the retailers.

The report found that the margin of 2.5% return on capital investment was insufficient to justify reinvesting in fruit and vegetable production - creating an exodus from the industry. Research based on project commissioning had failed and the research base had been significantly weakened (a failed process currently being replicated by DARD). The establishment of Producer Organisations had resulted in too many weak PO's being established which had now resulted in significant problems for this type of support. The current initiative (DARD/UFU) to establish Producer Organisations for the vegetable and top fruit sectors is therefore unlikely to succeed given the relative size of these sectors. NI plc needs one Producer Organisation to cover all sectors.

The report noted the weakening of the grower and the 'increased efficiency' of the retailer, but at no point were the two connected.

In relation to the local supply chain, none of the problems identified in 2010 have been addressed, indeed they have been magnified. Trust is basically nonexistent now in the fruit and vegetable supply chain in NI.

The problem of power shifting up the food chain from grower to end supermarket is not unique to the UK. But where PO's function properly in Europe and elsewhere, it has been possible to get fair and reasonable returns with shared risk along the supply chain.



3.3 (b) Incentive Instruments Used Elsewhere

A reasonable starting point to look at supply chain issues is the paper by Hueth *et al.* which was published in 1999. The paper was titled 'Incentive Instruments in Fruit and Vegetable Contracts: Input Control, Monitoring, Measuring and Price Risk.'

Introduction

Commentaries on the continuing industrialisation of agriculture typically refer to the increasing use of contracts as opposed to markets for mediating exchange between producers and the people or firms who buy their products. In California, contracts with growers have long been the primary means of procuring raw product in processing and canning industries. Examining the nature of these relatively mature contractual arrangements provides some insight into the future organisation of commodity markets in which contracts are relatively novel (e.g. NI).

How do first handlers (processors or wholesalers who act as intermediaries) address the challenges associated with quality management?

First handlers contract for produce from farmers and supply products to a variety of resale outlets including supermarkets, restaurants, institutions, terminal markets or other processors or wholesalers.

What happens at the field and farm level?

It is typically first handlers who design the contracts that farmers sign, and it is first handlers who have the most immediate interest in influencing the activities of farmers. It is therefore of interest to develop a detailed understanding of how first-level handlers interact with growers.

Due to confidentiality issues, cross-commodity empirical observation and comparison of contract provisions is scant.

This paper reports on contract provisions for a sample of commodities from California fruit and vegetable markets (which therefore gives a baseline for fruit and vegetable markets in N Ireland).

Contracts and Quality Management

Contracts in agriculture play three roles.

- i. Contracts introduce predictability into production systems and allow people to allocate resources with greater confidence.
- ii. They allow market participants to share risk
- iii. They are used to motivate performance

Signing a contract with an intermediary so that, for example, some portion of total compensation is paid independent of realised yield and market price can help establish the certainty needed to make efficient production decisions. Likewise, an intermediary who can promise downstream buyers timely delivery of quality produce is better able to satisfy



its customers and can possibly get a higher price. Thus contracts permit a first handler to act as both a marketing agent and as an insurer and to increase profits accordingly.

In a world with perfect information and perfectly enforceable contracts, a contract could specify exactly the actions of the farmer and of the intermediary, and could provide for efficient risk sharing. In the real world, first handlers cannot specify actions because they cannot monitor the farmer so as to ensure conformance with the contract. The farmer knows his own actions which the first handler does not, creating asymmetric information. This creates an opportunity for emergence of an institution to mitigate the 'moral hazard' presented to farmers for taking self-interested actions which may not be in the interest of the intermediary.

Quality is important because product differentiation, value adding strategies, and better control of the character of inputs seem to have emerged as important factors in the restructuring of agro-food systems. Quality is particularly important for fruit and vegetables as it is usually assessed by consumers in their primary form. Quality is still important in the processed form where factors such as sugar content, acidity or consistency amongst others are valued in the market place.

Co-ordination Strategies

1. Firm boundaries and organisations

The organisation of production, distribution, and marketing of agricultural commodities is often characterised in terms of the degree of integration across segments of the production process - integrated, coordinated and spot (the spot does not usually apply in Northern Ireland).

A fully integrated firm would produce, pack, distribute and market its produce to the final customers. More commonly a firm will produce, pack and distribute to supermarkets. Alternatively a firm can buy on the spot markets and then pack and distribute to the final sellers. Usually a firm may sell produce in many types of markets, some closer to the final consumer than others, may grow a percentage of what it sells and may purchase some of its produce via contract and the rest in the spot market.

2. Contracts with Growers

Fundamentally for a contract to really exist, there must be some type of cost associated with failing to honour ones obligation - such as financial penalty or loss of reputation to either party.

3. Incentive Problems and Solutions

The quality of a given growers produce is dependent on a variety of factors: genetics, environmental context, cultural practice, and finally harvest, storage and transport. The component which the primary producer is responsible for is that of cultural practice. The producer has better information regarding quality and this area than the first handler. Direct observation of the product growing by the first handler can redress the balance. Monitoring combined with some portion of the growers payment contingent on realised



quality or payment based on downstream price - making the grower residual claimants for their actions.

There are four instruments or mechanisms by which the intermediary might influence the behaviour of his growers:

- i. direct monitoring;
- ii. quality measurement;
- iii. input control; and
- iv. residual claimancy.

Intermediaries employ these as tools of inference to address challenges associated with coordination within contractual relations.

Unobservable variables impose a cost on the intermediary because they give the grower greater latitude for shirking or for claiming that a particular activity is more expensive than it really is.

a. Monitoring

Regular visits by fieldsmen to update the grower on market and industry developments and technology transfer issues will be of value to the growers and reduce the cost of monitoring which the visit will also log. Thus if there is a problem later, there is plenty of information available to the intermediary to ensure a reasonable outcome.

b. Input control

Methods such as providing certified seed of a specified variety can eliminate a range of quality issues. Supplying a consultant to help with decision making can help the grower. But imposed costs on the grower will need to be proven if the contract is to be implemented.

c. Quality Measurement

Quality measurement provides direct evidence on realized quality outcomes. However, quality measurement is an imperfect indicator of grower effort - particularly where pooled growers produce are spot evaluated. There may be important quality characteristics that don't become apparent until the commodity has travelled further downstream so they cannot be measured at harvest or delivery or at the time of exchange between the grower and his intermediary.

Nevertheless, there are a variety of ways that quality measurement might be used to provide incentives. The key question for the intermediary is the scale of the investment will match the detail which the system will provide. An intermediary can use a crude scale or not monitor quality at all or use a third party to measure.

d. Residual Claimancy

By making the farmers payment contingent on prices that are downstream from the intermediary (e.g. supermarket price), the farmer can be made directly responsible for poor expression of important quality attributes. Ideally, the intermediary would like to hold the farmer responsible for quality issues which are under the grower's control.



Designing a mechanism that allows an intermediary to partition price variation into its various components requires considerable information on market supply and demand conditions and an elaborate model relating price movements to market conditions and variation in idiosyncratic quality attributes. Such a mechanism my prove too costly, and so the intermediary may simply let the farmer bear some portion of total price risk - but by doing so the first handler to some extent forfeits the profits that can be earned from acting as an insurer.

Evidence from California

Because of the confidentiality of contracts, little evidence is forth coming and therefore information must be teased out carefully. The surveys were characterised as an effort to study 'quality management and coordination strategies' rather than contracts. It was quickly realised that much of what governs relations between growers and their intermediaries is not part of the formal contract, but instead exists as a set of tacit rules and contingencies understood by both parties.

With respect to the first instrument, input control, the majority of intermediaries supply or specify seed or varieties, provided pruning or thinning, or harvesting services. Input control is also central for temporal co-ordination (ensuring a programmed supply to the factory). The majority used field men to provide logistical support in addition to policing grower behaviour but there was significant differences between the number of visits and the quality of the fieldsmen.

Grades and standards are central to the process and range from simplistic to very complicated, from third party investigators to sophisticated in house processes. The quality of the information required was reflected in the quality of the standards imposed.

The range of quality definitions depends on the crop - cabbage standards can be simple, apple standards have many parameters to check. The more information required, the more complex the standards/evaluation process becomes in order to overcome information problems.

The majority of fresh-market intermediaries used some form of residual claimancy whereas only one processor did so. It is noteworthy that agricultural marketing co-operatives that do use the profit sharing element which should promote producer quality production-have a notoriously difficult time monitoring the quality of their members production.

Of the four incentive instruments available, 86% used field visits, Quality measurement 59%, input control 55% and residual claimancy 36%. Within this both fresh market and processors used the same level of field visits, however, in relation to residual claimancy, fresh market intermediaries scored 53% with processors scoring 18%. Processors use quality measurement more (64% v 46%) and input control (64% v 53%) respectively.

Without exception, all the processors use detailed measures of quality to adjust grower payments. In contrast, fresh market intermediaries relied on USDA grades and apart from forfeiting payment on culled produce, payments to growers are rarely adjusted according to measured quality. The difference in importance of quality measurement as a



mechanism to determine grower compensation as paid by fresh-market and processing intermediaries is mirrored by the apparent difference in the use of residual claimancy as a coordination strategy. The fact that there is an identifiable pattern between the use of quality measurement and residual claimancy in fresh-market and processing industries is consistent with the notion presented in our theoretical discussion above that these instruments can be substitutes. It is important to note at this point that the majority of NI processors are also primary producers in their own right and therefore have an excellent understanding of production issues.

Determinants of Institution Form

Four sets of variables potentially influence the types of coordination instruments observed in agricultural contracts: commodity attributes, local history, government regulation and technology. Variation in the environment along these dimensions will influence the type and intensity of information problems. Firms will recognise that the utility and cost effectiveness of each instrument vary, and will make decisions regarding which instrument to use accordingly.

1. Commodity attributes

The biophysical characteristics of a commodity including the degree to which quality can be measured, the crop production cycle, and crop physiology are all commodity characteristics that might influence the relative cost effectiveness of each instrument. Further, the extent to which quality is a function of grower effort, rather than attributable to genetics, production environment, and post-harvest conditions will positively influence the value of the information and lead to investment in one or more of the instruments.

2. Local history

Cultural backgrounds and the way of doing things can lock systems into place, making change difficult and this has to be recognised. The collective bargaining power of a co-operative with its centralised price discovery eliminates 'transaction costs' for the grower.

3. Government regulation

Legal or regulatory constraints may affect the structure of contracts. Health and safety requirements could encourage down stream buyers to monitor production of upstream suppliers. Suppliers could lobby for legislation to protect them from dumping, to ensure that they get paid for their goods etc.

4. Technology

Tecnological innovation can alter the relative cost and effectiveness of each instrument, and thereby influence contractual arrangements. Technologies are anticipated that allow for automatic sorting which will allow the application of numerous quality classes - and thus payment for quality. Individual suppliers of high quality will be managed as individuals.



Conclusions

A detailed analysis of the instruments of control in agricultural contracts is useful for understanding how co-ordination is achieved and how power is exercised in agricultural production systems. Quality control motivates downstream firms to take an interest in upstream production. There are four different instruments whereby middle stream businesses to monitor their producers. The first instrument is monitoring the quality of the farming, secondly the insistence of the use of particular genetics and farming programmes, thirdly - direct measurement of produce quality and finally exposure of farmers to price risk (farmers compensation tied directly to the price achieved at sale).

Because producers tend to be risk averse there is a role for intermediaries to act as insurers. However, the higher the insurance, the less residual claimancy available to the intermediary and thus the greater the quality measurements and associated incentive payments need to be.

3.3(c) Implications for the Fruit and Vegetable Sector in Northern Ireland

While contracts have a long established history for fruit and vegetable supply in the US, they are few and far between within the Northern Ireland. Since intermediaries cannot get enforceable supply contracts from supermarkets, there is no advantage in having contracts with growers; indeed there would be a significant disadvantage. Local businesses that used to have field operatives to insure good management and quality of field produce, have let them go.

Furthermore, suppliers have expressed difficulties in challenging supermarkets as they may be threatened with delisting. This is contrary to the Groceries Code Adjudicator Act 2013, which specifies that delisting is only possible for commercial reasons and on reasonable notice.¹⁶ Given the limited contracts, the coordination system resembles the spot market. The problem is exacerbated by the perishable nature of fruit and vegetables, which means that after harvest growers have limited bargaining power and the price can be driven down.

Producers want a contract to guarantee them a price for their produce, while retailers want guaranteed quality for their customers but without an enforceable contract with their suppliers guaranteeing prices.

The customer wants quality at the cheapest price possible but what is meant by quality?

The horticultural supply chains comprise various stake holders with differing perspectives. Their view on quality evaluation, accordingly, varies greatly when it comes to determining the particular requirements a horticultural product has to meet (Shewfelt, 1999). As a consequence, a universal definition of quality is required; one that takes into account the various quality concepts of all stakeholders. The International Organization of

¹⁶ http://www.lexology.com/library/detail.aspx?g=3517d5d3-de6d-4ced-9b9d-6c46caca96f0



Standardization (ISO) defines quality "as the sum of all characteristics, properties and attributes of a product or commodity which is aimed at fulfilling the established or presumed customer requirements" (ISO 8402, 1989). The ISO definition regards as customer the target group of each level of the food supply chain, hence including also the consumer as final customer of the chain. This might be the most popular definition of quality agreed upon by almost all stakeholders of the horticultural supply chains (Van der Voort *et al.*, 2007). An equally accepted but more pragmatic quality definition claims that a satisfactory degree of quality is achieved when "the customer returns and the product does not". However, a shared understanding of the diverse quality perspectives is an essential pre-requisite for a successful cooperation within the horticultural supply chain that is based on mutual trust (Ludwig-Ohm and Dirksmeyer, 2012). Within Northern Ireland there is little evidence of trust between the retailers and fruit and vegetable sector suppliers.

A uniform consumer with consistent preferences does not exist. There is no single consumer type whose preferences are perfectly defined (Schreiner et al., 2013). In reality, the horticultural supply chains face a diverse range of consumer types characterized by various demands and desires (Schreiner, 2009). Consumer preferences are also strongly affected by social-political changes and hence are very dynamic (Karmasin, 2007). Both an increased health awareness and environmental consciousness are examples of such dynamics that lead to new demands and new product requirements - especially in the food market but also in all other areas of life. At present, socio-demographic criteria insufficiently explain consumer behavior and preferences, which, like demand in general, are increasingly determined by non-economic variables such as lifestyles and fashions rather than socioeconomic ones such as income and education (Gatterer et al., 2012). Lifestyles, however, may change over the course of a consumers' life time. In fact, the individual consumer often changes his or her lifestyle according to personal preferences - and increasing individualization tendencies further encourage this development (Dziemba et al., 2007). The consumer satisfies these shifting preferences by an adjustment of the actual individually favoured food quality. Consumer requirements are therefore permanently in a state of flux due to changes in these individual, but also social value systems. In order to satisfy consumer needs, the various consumer preferences first have to be identified. But it is equally important to identify a corresponding quality profile of the product itself and hence its quality attributes. To satisfy the numerous consumer needs, several partly contradictory food trends have been established in the food sector, the most important of which are functional food, convenience food, organic, regional or slow food (Allrecipes Trend report, 2013). In this context, vegetables and fruits are increasingly fashionable, not only for vegetarians and vegans but also for adherents of so-called LOHAS lifestyles (lifestyles of health and sustainability) (Schreiner, 2009; Heller, 2010; Raisfeldand Patronite, 2010). These developments are characterized by a deeply natural-based human biophilic desire for natural green and for a healthy environment which can be increasingly observed. Life in the outdoors enjoys an immense popularity again, and the same is true for urban or "guerilla" gardening, which are both symptomatic not only of a desire for home-grown vegetables and fruits, but of a general need to slow things down (e.g. Alaimo et al., 2005). These are key issues that are increasingly discussed in news articles and on internet forums and that demonstrate an upcoming shift in consumer requirements.

The predominant food trend regarding fruits and vegetables is the development, design and production of plant-based health food. Gatterer *et al.* (2012) pointed out that



particularly middle-aged and elderly consumers are often concerned about their health and well-being, realizing that a healthy diet plays an important role in an overall healthy lifestyle. According to Bondarenko and Hörmann (2007) these consumer types are defined as "quality buyers" and "health conscious buyers". Inverse associations between fruit and vegetable intake and the development of chronic diseases, such as various types of cancer, diabetes and cardiovascular disease, have been demonstrated in numerous epidemiological studies (e.g.Erdman *et al.*, 2009; Ma and Lin, 2010; Story *et al.*, 2010). The plant compounds that are at least partly inducing this health-promoting effect are the secondary plant metabolites that can be found in vegetables, fruits, herbs and edible flowers (e.g. Schreinerand Huyskens-Keil (2006) and Verkerk *et al.* (2009)). As a consequence, part of the population in wealthier parts of the world is willing to include more vegetables and fruits in their daily diet. All these aspects lead to a huge demand for high quality fruit and vegetable products (Huang, 2004). The EU's Common Agricultural Policy tar-gets the production of these high quality products as a means to meet consumers' expectations and to contribute to the competitiveness of agricultural producers in the EU (Regulation (EU) No1151/2012).

A major change has occurred over the last twenty years as the politics of global warming have gained traction and the issue of sustainability (to help reduce the impacts of global warming) has become more relevant as illustrated by the Going for Growth headline:

"Growing a sustainable, profitable and integrated Agri-Food supply chain, focused on delivering the needs of the market."

There is only one supply chain. This fact requires a new approach and a change of mindset to ensure all parts work more closely together to deliver a clearly defined outcome. The entire chain must ensure that each partner is working towards the same goal delivering a product that meets the needs of the marketplace rather than producing a product for which a market is subsequently sought.

Sustainability Overview

Agri-Food has been focused on the expansion of supply, global sourcing and reduction of costs. In many cases this has resulted in very complex and extended supply chains, as well as issues around food quality and sustainability. There is now an increased focus on food security, sustainable supply and food quality in the context of a rising global population and finite resources. Northern Ireland has the ability to be a hugely efficient and sustainable food region from our natural advantages of land quality, abundant water, proximity to market and a high quality, committed workforce, with a track record of excellence in food production and supply. To be sustainable at farm level, the industry must be profitable throughout the supply chain and seek to target market segments offering better returns in a more effective and efficient manner. Recently, pressures on productivity and costs have been relentless as the marketplace has demanded ever cheaper food, driving short term decisions around survival, and, in the process, eroding the long term capacity of our farmland to sustain its environmental integrity and productive capacity.

However, all of that has the potential to change as society has recognised that our health status, our ability to feed a rising world population and our climate are driven by



how well we manage our land and its produce. We have the potential to change this dynamic through development of a more holistic approach to farming, with the goal of being one of the world's most carbon efficient regions for the production of natural, wholesome food from land rich in biodiversity. By doing so, we avoid off-shoring agricultural production to less environmentally efficient and, as recent food scare events have shown, less safe regions of the world. Sustainability requires more than efficient production on-farm and along the total supply chain. The optimum use of the animal and/or its output requires the maximisation of the value of the entire carcase, which, in turn, will maximise the value that can be returned to farmers, helping underpin their viability. Developing channels to market food rather than treating by-products as waste streams going to landfill requires the identification of the appropriate markets for by-product components together with access to those opportunities, and investment in innovation, marketing and further processing facilities. This highlights the benefits from aligning policy and activities and will create complementary rather than conflicting goals of economic and environmental sustainability.

An excellent example of a focused attempt at developing a system wherein growers can ensure that they are producing in a sustainable and economic fashion is illustrated by the project 'The New Zealand sustainability dashboard (Benge *et al.*, 2015). The project is designed to develop an integrated model which will identify sustainable practices for growers and processors to optimise the four pillars required for the process to work: good governance, economic resilience, agro-environmental integrity and social well being. The overarching goal for each pillar is identified, followed by:

Outcomes: the critical components for reaching the goal is identified;

Objectives: key factors contributing for targeted outcomes; Indicators: parameters that can be addressed in relation to an objective; and finally

Measures: information gathered to inform indicator.

The project reviewed a large number of models and selected the Food and Agriculture Organization (FSO)'s Sustainability Assessment of Food and Agricultural Systems (SAFA) as the most comprehensive and flexible approach that could be applied NA primary sectors. Many elements of the NZSD framework match the SAFA guidelines (FAO, 2014). The construction of the social well being component would have significant bearing on supply chain operations in NI.

Apple Industry Peculiarities

Apples rank third in global fruit production. Over the past decade, considerable growth has been experienced with production increasing from 58 million tonnes in 2001 to 75 million tonnes in 2011 (FAOstat, 2013). Historically apples were harvested every six months alternating between the northern and southern hemispheres, giving year round supply. But with improvements in storage technology, fruit from either region can be supplied 12 months of the year, so there is significantly more competition (Garming, Strohm and Dirksmeyer, 2015). The same authors report a gradual increase in farm size over time with specialised apple farms being more profitable than smaller semi-specialised farms.



German farms which have higher running costs than Italian farms, make more profit because German consumers prefer local food with guaranteed provenance and quality assurance.

Apple farming however, is a riskier business compared to general farming. An evaluation of risk preference and risk perception of German apple producers demonstrated that although farmers are generally risk averse (Nielsen et al., 2013), apple growers are less so (Rohrig and Hardeweg, 2015). Weather and disease-related reductions of yield and quality make open field production a risky business. Furthermore, volatile prices are common in the trade for fresh horticultural products. The topic of uncertainty becomes even more relevant, when we consider perennial cultivation systems, such as apple production. Here, short term adaptions are difficult to realise, because decisions have consequences for many years to come. Time served in growing apples generates the experience required to take a significant financial decision such as the large capital investment required for the establishment of a new orchard; the low capital returns during the years required for the orchard to develop and finally the full financial returns when the orchard is mature (7-10) with a subsequent potential yield for another 15 years intermingled with crop failures and market crashes. One of the significant factors regarding apple growers and supply chain issues, which is common across many cultures, is the use of family labour. This is never costed properly and is of significant help when there cash flow issues (Garming, Strohm and Dirksmeyer, 2015). It is reasonable to extrapolate that the increasing UK Bramley market share held by Northern Ireland producers is due to family labour being used to undercut the more commercially based farms in Kent.



Chapter 4: Business Improvement Measures applicable to Agribusiness Supply Chains

(Professor Bob Bansback, Visiting Professor, Harper Adams University)

'If you can't measure it, you can't improve it'. Lord Kelvin (1824 - 1907)

This section outlines the way that business improvement techniques have evolved in industry and agri-business; it describes the practical applications of some of the techniques in the agri-business sector; finally it draws conclusions from the experience gained in their application based on insights from Professor Bob Bansback who chaired the Red Meat Industry Forum (RMIF), which was set up to improve the performance of agri-food supply chains in the UK.

4.1 Introduction

Industry in general was deploying more modern business improvement practices in the 1950s and 1960s through some of the strategic management approaches being developed in business schools with pioneer individuals such as Michael Drucker. Subsequent to this, Michael Porter from Harvard Business School developed his 'four competitive forces' framework of:

- the bargaining power of buyers and sellers
- the threats of new entrants
- the availability of substitute products
- the competitive rivalry of firms in the same industry

Porter (1980) demonstrated that all these forces affected a company's ability to raise its prices as well as influence the cost of its inputs for its various processes. However, as pressures on profitability and global competition intensified, companies focussed increasingly on improving services to customers, eliminating waste and enhancing the overall quality of their products or services in a more quantifiable way. The two most prominent techniques that have been used to do this have been Lean Management and Six Sigma, although several other variations have also been developed in recent years.

The origins of *Lean Management*¹⁷ came to prominence following the impressive progress made by the Toyota company who adopted this approach in becoming the dominant force in the automotive industry in a comparatively short space of time. Their management applied the five lean principles of:

¹⁷ http://www.businessballs.com/sixsigma.htm



- Value specifying what does and does not create value
- **Value Stream** identifying steps necessary to maximising value across the whole chain
- Flow making those actions which create value flow without any waste
- Pull only providing what is required by the customer
- *Perfection* striving on a continuous basis for perfection particularly by eliminating waste

Six sigma (3) is a set of techniques and tools for process improvement. After earlier pioneering in the Motorola company, Jack Welsh¹⁸, when CEO of General Electric (GE) made it a key feature of his business strategy and it has now become common practice in a large number of companies and organisations. It seeks to improve the quality of the output of a process by identifying and removing the causes of defects and minimizing variability in the business process.

Common to both of these techniques is the ability to measure in a precise way the progress being made and to quantify the financial returns. Flowing from this, management decisions can be made on the basis of reliable data with statistical analysis and also contribute towards a growth in trust in leadership. The additional access to Big Data techniques in recent years has further enhanced the analytical power which can be deployed.

Agri-business companies have generally been slower to make use of some of these frameworks. This has partly been due to the fact that agriculture has certain features that make it different from manufacturing industry. This includes the fact that production processes are potentially more subject to the vagaries of the weather, animal disease and occasional food scares. The fundamental political importance of food supply for society has also meant that regulatory (including Global, EU, UK and Northern Ireland) policies have a much bigger impact in agri-business than in many industry sectors. Finally, there is a more complicated supply chain involved for many parts of agriculture - particularly the livestock sectors, where the final product from a meat plant, for example, results from a *disassembly* rather than the *assembly* process which is a common feature of a manufacturing plant.

Improving efficiency levels has become increasingly important for agribusiness throughout Europe due to the reduction in farm support levels under the CAP; also from the prospect of more intensified competition from outside the EU partly resulting from the prospect of a greater number of Free Trade Agreements (FTAs) involving reduced EU protection from cheaper third country imports. The consequential need for improved performance of agri-food supply chains resulted in a number of UK initiatives focussing on business improvement in the early part of the last decade. Some of these have taken place within individual companies and supply chains; in addition, some specific organisations were set up to encourage increased uptake of such measures.

¹⁸ http://www.lean.org/WhatsLean/


These included: the Food Chain Centre (FCC) - set up by the Institute of Grocery Distribution (IGD) in 2002 following the recommendation of the Curry Commission report (Policy Commission, 2002); the Red Meat Industry Forum (RMIF), established by the Meat and Livestock Commission in 2001 and the Cereals Industry Forum (CIF), established jointly by the Home Grown Cereals Authority (HGCA) and the FCC. Although FCC, RMIF and CIF no longer exist, some elements of their various initiatives and their legacies have continued due to subsequent initiatives by producers, individual companies and levy boards. The three organisations successfully pioneered business improvement techniques in their respective sectors. The remaining part of this report draws heavily on this experience in outlining the techniques involved and some of the lessons learned from the most successful initiatives.

4.2 Types of Business Improvement Measure Applicable to Agribusiness Supply Chains

The focus of this report is intended to be on the livestock sector. As there was no equivalent in the dairy sector and the work of the RMIF related to beef, sheep and pigs, most of the examples quoted will relate to red meat. The major participants in the supply chain are livestock producers, first stage processors (abattoirs in relation to the meat sector), further manufacturers, retailers and food service operators. This is not to downgrade the importance in some sectors of feed and input suppliers, livestock traders, auctioneers and wholesalers. The measures outlined below mainly relate to one or more of these groups. In relation to each business improvement technique, there will be:

- an identification of which sector or sectors of the chain are involved
- an outline of its overall objective with a description of how it works
- an evaluation of the advantages and disadvantages together with any limitations
- an indication of the improvement in performance achieved by the use of the measure concerned or conclusion on value

4.2.1 Farm Business Improvement Clubs (using web-based benchmarking)

Supply chain sector: all types of livestock producer

Outline: This programme aimed initially to encourage individuals as well as group members in a business club to compare their business performance against those with similar enterprises - with the aim of identifying areas for improvement. In the RMIF scheme a webbased benchmarking model was developed taking in both physical and financial performance. Participants were then able to see on-line how they compared with their most appropriate reference group. In a business group discussion with a good facilitator, further lessons could be learnt for improving profitability. All individual information was treated confidentially. **Evaluation**: There was no guarantee that any individual producer would change as a result of the benchmark information. The participants might not have the resources (financial or time) necessary to carry out the change or may just wish to carry on as before. Nonetheless, the experience was that anyone keen enough to take part in the club was likely to be strongly motivated to improve their on-farm situation.

Conclusion: Evidence shows that such activity can be very effective for those producers who are highly motivated for business improvement. There are effective benchmarking arrangements for livestock producers in place in Northern Ireland through CAFRE working with the Countryside Agri-Rural Partnership. The benchmarking is linked to a CAFRE Adviser making a farm visit. The service is free of charge and has historically received funding through the 2007 - 2014 Rural Development Programme (RDP). In the new RDP for 2016 - 2020, Business Development Groups (BDG) are to be introduced alongside the benchmarking schemes. Although the uptake of the benchmarking arrangements currently covers 45 - 50% of NI pig production, for dairy production the figure is 20 - 25% and for the red meat sector is reported to be only 5%. The more sophisticated BOVIS system for beef and dairy cattle, developed by AFBI, collates information from APHIS along with associated data from the processing industry; an online benchmarking tool has been developed from this and further uses are currently being explored. AFBI are using this for knowledge transfer as well as research purposes.

4.2.2 Benchmarking of Typical On-farm Performance of Species Enterprises for the Country as a whole against Comparable Performance elsewhere in the world (*agri benchmark*, *IFCN*)

Supply chain sector: livestock producers and over-arching bodies who can make use of this information for business advice and knowledge transfer

Outline: The agri benchmark approach¹⁹ is to take a sample of typical farms from each member country which cover the main breeding / finishing systems. It then records full costings and performance data for the farm as a whole (i.e. not just the specific livestock enterprise costing information). International comparisons are then made between all the countries concerned. Each year those involved from participating countries meet together in one of the member locations to discuss the variations and detailed conclusions. *Agri benchmark* covers beef, sheep and pigs - and is based in the Thünen Institute in the University of Brunswick in Germany. All participants in the benchmarking have to attend a training session and there is a rigorous approach aimed at achieving maximum accuracy in

¹⁹ http://www.agribenchmark.org/home.html



the data. *IFCN* carry out a similar exercise for the dairy sector. *Interpig* information provides scope for international comparisons in the pig sector on a different basis. Although Interpig membership is mainly from European countries it also has USA, Canada and Brazil participants.

Evaluation: At present, AHDB Beef and Lamb and TEAGASC in Ireland actively participate in agri benchmark for beef and sheep together with representatives from 28 other countries. AHDB Pork participates in Interpig.

Conclusion: Participants in GB and elsewhere report great value from participation in an international network.

4.2.3 Periodic Benchmarking of Processor Performance on a Country Basis against Major International Competitor countries

Supply chain sector: processors or over-arching bodies

Outline: Although access to individual meat plant data is difficult to obtain, private consultancies and at least one food service operator do collect data to enable some performance comparisons to be made. This is then used to suggest improvements in performance for the companies concerned. RMIF was able to collect aggregated average performance data for slaughtering plants in different countries to enable the table in Appendix B to be compiled. Representatives of different countries were able to meet together and discuss the information at a subsequent workshop (Red Meat Industry Forum, 2008).

Evaluation: Inter-firm comparisons of meat plant performance can be very valuable for individual companies. However, companies can understandably be very protective of their own commercial information in what is such a highly competitive environment. There is also fear about exposing too much information to their retail or food service customers. It is possible to collect information on an aggregate basis - but even this can be difficult and costly in some circumstances. In addition, the experience of RMIF was that there were not enough changes from year to year in the type of information collected in Appendix 1 to make it useful to collect the information on an annual basis.



Conclusion: There would need to be commitment from NI companies to providing commercial data to an independent third party if any progress on this could be achieved. Another approach might be to follow the USDA example which requires information to be collected. This is subsequently published in the annual Meat and Poultry Facts publication from NAMI (the National American Meat Institute). (North American Meat Institute, 2008).

4.2.4 Masterclasses²⁰

Supply chain sector: processors and further manufacturers and some categories of producer

Outline: Masterclasses are a product of the Society of Motor Manufacturers and Traders (SMMT) Industry Forum which aimed to achieve world class performance in the automotive sector. In essence, it is a structured process improvement approach where a team of employers from different levels in a company led by an experienced process engineer (facilitator) conduct a practical change event to drive through improvements. It normally involves a six step structure in the following sequence:

a) a pre-diagnostic involving senior managers

b) preparatory work where planning for the event and selection of the cross functional participants takes place

c) a diagnostic session where a full understanding of the process takes place - as well as understanding where performance shortfalls exist

d) a check day to ensure everything is in place for the workshop

e) the workshop itself, which normally takes place over five days when the skilled engineer encourages improvements through a 'learning by doing' approach

f) appropriate follow-up to ensure relevant lessons are applied

Evaluation: Companies who engaged in Masterclasses not only referred to the value of the process improvement and savings made but also the improvement in *communication and motivation within the company*

Conclusion: There are a number of pre-requisites to Masterclasses being successful. These include skilled facilitation, commitment from the very top of the company and a willingness to find time to give to the process. Where all of these ingredients were present, the company invariably found the Masterclass a valuable process.

²⁰ https://www.industryforum.co.uk/expertise/manufacturing-operations/process-improvement/masterclass/



4.2.5 PROBE

Supply chain sector: processors, further manufacturers, retailers and food service operators

Outline: PROBE²¹ was initially developed in the early 1990s by the London Business School and IBM Consulting with the objective of benchmarking UK manufacturing companies against their European competitors. The initials stand for 'Promoting Business Excellence' and trained facilitators offer their services to carry out PROBEs for individual companies and organisations. For the purposes of the red meat sector it was necessary to adapt and simplify the full version of PROBE to make it more 'user-friendly' and appropriate. It is essentially a diagnostic tool involving a team of company employees being taken through a self-evaluation questionnaire covering the whole range of processes, practices and outcomes. When completed, the company is benchmarked against other comparable companies in their sector as well as against a broader database of UK businesses. From these evaluations, areas for improvement can be identified. Ideally, a repeat PROBE is carried out twelve months or more after the initial one - to identify if action has been taken to improve the business.

Evaluation: PROBE provided companies with a chance to look at five performance areas in particular: leadership, people, customer service, performance management and material processing. The majority of those who responded in the evaluation of the RMIF programme indicated that they were going to embark on improvement projects and several organised a follow-up day. Over two thirds stated that the changes made had a positive impact on operating costs and sales. In the RMIF programme, PROBE was deployed in several sectors of the red meat supply chain; however, it was seen to be most effective in the abattoir and processing sectors.

Conclusion: Of all the measures deployed in the RMIF programme, PROBE was the most effective tool for the processing sector. In order to benchmark with other red meat sectors outside the UK, some North American companies also went through the PROBE process. Again the expertise of the facilitator was vital to the success in implementing it.

²¹ http://www.comparisonintl.com/products/sustainability/



4.2.6 Value Chain Analysis

Supply chain sector: all parties in the chain working together including retailers and food service operators

Outline: Value Chain Analysis (VCA) has been defined as a process where a supply chain identifies its primary and support activities that add value to the final product and then analyzes these activities to reduce costs or increase differentiation. Michael Porter introduced the value chain analysis concept in his 1985 book 'The Competitive Advantage' (*Porter, 1980*). It is based on the lean management principle and focuses particularly on identifying waste in the supply chain and on identifying ways in which time and resources can be better spent in adding value. Like PROBE it is a diagnostic tool - but the essential difference is that it is looking at all aspects of the supply chain. An expert facilitator works with a group that is representative of all stakeholders in the supply chain; together with analytical tools, they map the chain from farm to fork - estimating the amount of time spent in each process. Having carried this out they categorise each process as:

- added value (as perceived by the consumer);
- necessary but not added value; and
- waste, either in terms of physical material or use of resources.

After identifying changes that can be made to the processes and having had discussion with appropriate stakeholders, a future state map is produced alongside an action plan. As with PROBE, the RMIF process involved making adaptations for use in the red meat sectors.

Evaluation: A significant advantage of the VCA approach is that it enables all sides to see the totality of the supply chain. This can quickly generate ideas for improvement - and a generally better understanding of problems faced by other players in the chain. At the same time it works much better in situations where the principles of lean management are well understood and where techniques such as PROBE and Masterclasses (or similar approaches) have already been applied. It requires a great deal of trust between all players in the chain - also considerable expertise from the expert facilitator (in the case of the RMIF initiatives, experienced team members linked to Cardiff Business School were involved). ²²

Conclusion: It requires much time and effort to get a whole supply chain to agree to setting up a VCA. In some cases with the FCC and the RMIF, the retailer or food service operator insisted that other participants in their chain took part - not always an easy situation. It takes more time to execute and will probably be more expensive as the expertise of the facilitator is absolutely essential. Nonetheless, comments from those who went through all

²² http://www.ifm.eng.cam.ac.uk/research/dstools/value-chain-/



stages of the process were along the lines of 'the savings we made through PROBE and Masterclasses were small compared with those resulting from the VCA'.

4.3 Summary of Key Requirements for an Effective Business Improvement Programme

The best managed UK companies are committed to a continuous improvement process - which includes many of the types of measures described above. Although most of these are more applicable to larger companies who can afford to employ staff to manage business improvement measures, many of the processes can be (and have been) adapted for use by SMEs and smaller enterprises. In Northern Ireland, there are already examples of best practice in the agri-business sectors. However, there is always scope for improvement with the international market place getting more competitive.

It is also important to make maximum use of information collected from the supply chain by Government for food safety, animal health or other reasons. The FSA/AHDB CCIR system is attempting to do this in GB and APHIS data is also available in Northern Ireland.

Some argue that business improvement is the sole preserve of the private sector acting on a within-company basis. In agri-business, the experience of bodies like FCC, RMIF and CIF suggests that there can be a useful role for outside bodies with appropriate expertise to provide encouragement and skilled advice for companies and organisations as well as for the farming sector. However there are some important lessons from the experience gained by such organisations. Some of these are:

- In working with companies, it is essential to have the full-hearted commitment (and preferably involvement) of the Chief Executive and top management.
- In work involving the whole supply chain (e.g. VCAs), the full support of the most powerful participant (usually the retailer or food service operator) is vital. In addition, an atmosphere of trust is critical for effective supply chain activity.
- It is important to have experienced outside facilitators when initiating some of the techniques. Specialist industry knowledge, though helpful, is not as important as experience, aptitude and the right personality.
- In the early days of introducing new concepts, it can be important to offer resources (including expert facilitators, explanatory materials etc) at a subsidised rate or even for free. Some of the techniques involved absorb a lot of time for key managers and other staff and if there is a sizable price to pay on top of this, there may be reluctance to get involved. However, once the programme has passed successfully through a significant number of trial companies or supply chains, businesses will be more willing to pay for external assistance or to employ an appropriate business improvement staff member because of its positive influence on their bottom lines.
- Business improvement measures should not be seen as a substitute for R&D and Knowledge Transfer. All of these aspects are important ingredients of successful business developments and they should be 'feeding' off each other.



- Top management needs to exercise some flexibility in the way business improvement techniques are applied. The RMIF experience was that adjustments were necessary to the individual frameworks and even then that it was necessary to avoid a 'one size fits all' approach.
- There is an important interface between Government policies and the introduction of business improvement measures. In this context it is interesting to note the Scottish Government's introduction of a Beef Efficiency Scheme for suckled calf producers in the latest round of CAP measures.
- Finally, companies need to avoid the new initiative being seen as 'not another new idea from top management'.

4.4 Concluding Comments

If a new Northern Ireland Business Improvement Programme is to be introduced, it is important to monitor and measure its effectiveness. It would be better to get an external dispassionate person or organisation to do this rather than another staff member as it will be necessary to get feedback from all levels of the company or organisation. There will frequently be resistance from some parties to pursuing the programme for their company or organisation. However, it is important to understand that the end objective is to introduce a continuous improvement culture into the business. The true measure of successful implementation within the agri-business sector is when individuals and companies are willing to fund the cost of carrying out the various measures because they are convinced it makes good business sense.



Chapter 5: Implication for UK Meat Supply Chains from Current Global Developments

(Professor Bob Bansback, Visiting Professor, Harper Adams University)

The World Meat Congress in Uruguay in November 2016 on the imaginative theme of 'Many Voices, One Melody' brought together over 700 delegates from over 36 countries to discuss the key themes of strategic importance for the worldwide meat industry. In this chapter, Professor Bob Bansback reports some of the themes covered in Uruguay and looks at their implications for the UK meat supply chains.

The three themes that are tackled are as follows:

- Changing Global Meat Market and Trading Situation;
- Evolving Consumer Attitudes and Preferences for Meat; and
- Critical but Changing Role of Primary Livestock Production in the Supply Chain.

5.1 Changing Global Meat Market and Trading Situation

World meat consumption has been rising steadily. According to FAO, total consumption in 2016, at 319 million tonnes was 6% higher than five years earlier and had increased by over a third since 2000 (implying that an additional 85 million tonnes of meat per annum was being consumed compared to the situation at the turn of the century). Consumption is projected to increase further, albeit at a somewhat slower rate than in the recent past; the latest OECD/FAO projections indicate a rise of 16% over the next ten years - well in excess of the projected 1% per annum rise in the world population. There are different trends for the various meat categories: the most marked growth has occurred in the poultrymeat sector and there has been a significant increase in pigmeat consumption; these two meats together account for 72% of world meat output. Beef and sheepmeat have shown the least growth and now only amount to a quarter of the total market.

The key drivers of future meat demand growth include further **population growth** (especially in Africa), a general rise in **incomes**, the increased proportion of the population **reaching middle-class standards of living** in emerging economies - and **urbanisation**. In addition to these well documented factors, other factors highlighted at the Congress were the **greater availability and affordability of meat** resulting from improved supply chain productivity, new technology and better alignment with consumer needs; also the **more pleasurable eating experiences** by consumers of particular meat categories and finally, the **improved marketing of the product** in many countries with more emphasis on safety, convenience and better customer differentiation and segmentation.



In recent years, over four fifths of the increase in the world meat market has occurred in emerging and developing economies, where income elasticities of demand for meat are still relatively high. In several of these markets, consumption increases have exceeded the production growth of their domestic industries in recent years. The country where this trend has been most marked has been China, where the overall meat market has risen fourfold since the 1980s and continues to expand. Up to the middle of the last decade, this major growth in Chinese meat consumption had comparatively little impact on global developments because meat production was growing at the same fast rate as consumption, with China remaining virtually self-sufficient.

However, in the past decade domestic production, although continuing to rise at a striking rate, has not kept pace with the increase in consumption. As a consequence, China has now become the world's largest importer of meat, with 2016 estimates amounting to over 5 million tonnes. Not only this, Chinese imports of each of the four categories - beef, sheepmeat, pigmeat and poultrymeat - exceed import volumes from any other country. Li Shuilong, the President of the China Meat Association, confirmed that increased meat imports would continue when he announced at the Congress that Chinese imports would double between now and 2020, when they would amount to 10 million tonnes. If this proves anything like a correct prediction, it will have a dynamic influence on the world meat economy - particularly in relation to world trade. Similar trends are forecast in other parts of Asia as well as in Africa and Central America.

Supply Chain Implications for the Changing Global Meat Market and Trading Situation

- These trends are important for the European (and the UK) meat economies. This is because the traditional trade flows are likely to be changing meat imports into China and other Asian markets which were less than 40% of world imports in 2006 have now risen to 55% and by 2020 may well have increased to over 65%. The same pattern could also arise in future years in Africa, where strong income growth in many countries is likely to result in higher meat consumption in excess of what can be supplied by domestic industries. Some of these rapidly increasing export opportunities are important for UK suppliers, with *big implications right down supply chains which have traditionally been geared to servicing British retailers*.
- A further implication of this is that there is a big demand in these growing Asian markets for some product categories for which there is little demand from UK consumers. This is particularly true for 'fifth quarter' offal products, which are very highly valued by Asian consumers. A truly effective *supply chain needs to secure the best value for each part of the animal regardless of whether that be in the home or an overseas market*. Indeed, there is already evidence that exporting offal products from UK plants can make a significant difference to the profitability of supply chains at all levels. In the case of specialised pig plants in the UK, a limited number are currently approved for exporting pig's heads to mainland China; these plants were able to gain approximately double the price for pigs' heads compared with those who are not Chinese-approved plants (mainly multi-species plants). At



present, the UK is not approved to sell beef offal to China - but as soon as this hurdle is cleared a similar situation could apply in the beef sector, with important implications for beef processors.

- Another factor for UK supply chains arises out of the Brexit situation that the UK now faces. Major meat exporting countries talk about the vital gain they have had in export markets resulting from the Free Trade Agreements they have secured with China and other Asian markets. With the constraints of EU membership, UK has not been free to negotiate FTAs that link in with their national exporting interests. However, as soon as the UK is able to negotiate its own deals there will be opportunities for securing advantages in some of these rapidly growing markets.
- Finally, *major companies are looking more strategically at the balance of advantage between (a) exporting and (b) overseas investments*. Denmark, for example, is planning to invest in a major pig plant in China to supply Chinese consumers with high quality products. This will enable the Danish industry to benefit from this growing market even when there are trade disruptions due to various reasons. Major exporting countries, such as New Zealand and Denmark, look at overseas investment working in a positive way for their domestic industries with benefits down the supply chain.

5.2 Evolving Consumer Attitudes and Preferences for Meat

The market for meat is becoming more complex. This is partly because meat is increasingly seen, through consumer eyes, as part of a larger market for protein food products. At the Congress, Rabobank highlighted some of the challenges this provided for the meat industry; traditionally, analysts would look at the main competition for red meat as coming from the poultrymeat sector; they now see the red meat sector as having to face competition from two further sources of cheaper protein - aquaculture and alternative proteins. The more important challenge comes from the aquaculture sector, which has increased significantly in recent years; estimates from OECD indicated a global growth rate of over 5% per annum in the last decade compared with 1.5% for meat. Asia alone accounts for over 85% of all farmed fish production in the world and it remains to be seen how much further substitution with meat products will take place. The aquaculture industry is forecast to grow by 3% per annum in the next decade - but experts point to a number of challenges faced by the sector including lack of access to suitable sites for farming, antibiotic use, adverse environmental impacts and traceability issues. Alternative proteins provide the other competition to meat, with growing interest in vegetable-based products as well as insects and even lab-based meats. However, the levels of production are extremely low at present and experts suggest that for the most part, these alternative protein items will remain as niche products largely confined to consumers in North America and Europe.

Consumer demand for meat is also becoming more complex in other ways. Although this mainly relates to the major industrialised countries, it is also apparent in some of the emerging economies. Consumers are demanding far greater sophistication in their purchase preferences in areas such as sustainability, antibiotic-free, gluten-free and high welfare standards. They are looking for value rather than price in their purchases which can mean redefining quality in terms of simplicity, authenticity and trust factors alongside the more traditional themes of price and basic eating experience.

Consumer trust in safety and authenticity issues for the meat industry has emerged as a major factor in recent years with many examples quoted at the Congress. The 'horse-gate' scandal in the UK and adverse experiences in other countries rapidly become reported nation-wide as well as throughout the world as a result of the growing importance of social media. One speaker spoke about the experience of a growing number of people who enjoyed eating meat but were made to feel guilty by media stories conveying negative messages about the role of meat in the diet as well as the way it was 'damaging the planet'. There were comparatively few positive stories on social media sites which counteracted these views. Recent surveys had been indicating a general declining trust by consumers in the food industry, regardless of size of enterprise; one recent survey had shown that only 50% of consumers had found it difficult to trust any grocery business or brand. The meat industry has not addressed the challenge presented by social media as effectively as it should have done.

Supply Chain Implications for the Evolving Consumer Attitudes and Preferences for Meat

- With the growing competition from cheaper sources of protein, such as poultrymeat and farmed fish, the red meat sector needs to recognise that for most of its products (although minced beef might be seen as an exception), it *has to 'justify' its higher price levels for consumers* who are seeking good value. It must seek additional attributes and add value in ways that are in line with consumer preferences. This might mean focussing on more product development which could in turn make use of knowledge fed back from different parts of the supply chain. For British beef and sheep producers there is an additional challenge resulting from the fact that the UK is not the world's lowest cost producer and the industry, increasingly in a post-Brexit situation, will have to compete with lower priced imported product from different parts of the world. However, even in this situation, there is strong loyalty to locally or home produced product, so long as it represents value for money. A greater involvement in all levels of the supply chain will become more essential in this environment.
- There was also an even greater need for meat supply chains to have effective *traceability at all levels*. Historically, this has not been apparent in many parts of the supply chain because of the added complication and cost involved. It is particularly difficult to apply in some processed meat products which involve raw material supplies sourced from many different animals sometimes originating from a variety of meat plants; it was also complicated to enforce in some parts of the food service sector. However, if statements relating to provenance, ethical standards, sustainability and health are made for a product, they must be able to stand up to close scrutiny if consumer lobby groups or hostile NGOs put in challenges.
- The growing importance of social media has been exploited by many of the anti-meat lobby groups and others with misleading messages about the industry. However, too frequently the industry does not recognise that *social media can also be used in a positive way*. If this is to be effective it needs to be making use of all parts of the supply chain. The more hostile media will wish to exploit the weakest part of the supply chain hence the vital need to have a strong and transparent supply chain, which has eliminated any weaknesses.

• Finally, in Box 4 below there is an example of a Canadian meat company, well-known for operating its efficient marketing, taking action to restore consumer trust with its consumers. In order to be effective, this action had to involve *buy-in from all parts of the supply chain* - with positive consequences for all concerned.

Box 4: A Positive Response from Canada to a Consumer Trust Crisis

Maple Leaf Foods emerged stronger and more trustworthy than before from a Listeria incident that involved several deaths. The transformation started with a clear public acceptance of full responsibility and assurance that the victims and their families would be well looked after; there was also a transparent account of what happened and how things would change so it could never happen again. The company decided to be known for producing the safest meat in the world. It closed its old plants and built new ones which are state of the art in meat processing and hired a world leader in food safety, giving him complete control of production, and invested heavily in research. The transformation was extraordinary and the brand today is considered the gold standard in Canada, market share has grown, profitability is up and the stock price at an all-time high.

5.3 The Critical but Changing Role of Primary Livestock Production in the Supply Chain

Market power in many UK supply chains frequently resides with a major retailer or food service operator. They may in turn be supplied by two or three meat processors, who will have obtained their animals for slaughter from a large number of livestock producers. Although producers do experience periods when they are *price-makers* in their dealings with meat plants in situations when there is a shortage of cattle, more often they are price takers in their negotiations with meat plants, who in turn are under extreme price pressure from their retailer. Figure 11 below illustrates two separate beef supply chain situations. Situation 1 illustrates the situation for the Alberta beef industry in Canada; Alberta is Canada's major beef producing province exporting its prime beef both to other Canadian provinces as well as to a wide number of export markets. In this situation, the farmers working through major packers are geared to the objective of supplying customers at home and overseas. The supply chain is simple and focussed with market power more evenly shared along the chain. Situation 2 shows a more typical beef supply chain in the UK, which is more complex and where the retailer (or food service operator) working through its major processor is able to exert power to those lower down the chain. They can switch to increasing imports if the domestic price or supply is unacceptable; the opportunities for alternative export outlets are frequently limited in this supply chain situation.

There is some evidence, however, that the Situation 2 position is changing. In particular, the livestock production sector is growing more important and able to exercise more power for a number of reasons:

- The increasing concerns of British consumers in areas such as antibiotics and animal welfare means that all parts of the chain are in need of the knowledge base on such matters for dealing effectively with consumer demands and tackling queries.
- Supply chains are becoming less complex with greater price pressure.
- Export volumes are growing and likely to continue increasing providing alternative outlets for their product.
- At the same time, Brexit discussions could make it more difficult for Irish beef to access freely into the British market. Major retailers will therefore be keen to link up more closely and be more loyal to their domestic producers.

• Volatility in livestock and meat prices has increased in recent years - much of which relates to the producer level; this needs to be managed throughout the chain

Supply Chain Implications for the Critical but Changing Role of Primary Livestock Production in the Supply Chain

- The greater need for companies to develop new markets will result in an increasing incentive to have more effective *supply chains to work together in areas such as market development*. These development activities are likely to involve far more pro-active relationships throughout the chain, including notably at the producer level
- Effective biosecurity is going to become of increasing importance in future years - particularly with the increasing number of zoonotic diseases affecting the global industry. In New Zealand, it is notable that an initiative in enhancing biosecurity is one of the three main governance initiatives being taken forward by Beef & Lamb New Zealand
- If more attention is to be devoted to adding value rather than chasing lower prices, *feedback right down the chain* takes on a far more pivotal role
- The ruminant meat sector has been notably slow in its uptake of new technology and improvements in efficiency at the livestock producer level. A more efficient supply chain will be motivated to ensure that *be.ef and sheep producers speed up their rate of efficiency improvement*
- Finally, greater producer involvement will be essential if future flexibility is required for *coping with price volatility as well as with risk management*.

5.4 Conclusion

The global meat economy is changing and becoming a more difficult and complex environment in which companies have to operate. At the same time, the UK is coming to the end of a period during which it has operated within the structure of the EU's Common Agricultural Policy. New patterns of trade and trading relationships will need to be developed over the next ten years. In this period, improvements in supply chains are necessary in order to maximise the outcomes for the various players in the industry. It was noteworthy that the concluding comments from Justin Sherrard, Rabobank's Global Strategist in Animal Protein, at the World Meat Congress were that 'opportunities in the global animal protein market will favour companies' that are:

- Well attuned to market dynamics
- Agile
- Have strong supply chains

Chapter 6: Summary and Conclusions

It is evident from the review that agri-food supply chains have evolved in response to changes in consumer preferences and attitudes to food safety, quality and the environment. In general, there has been a trend towards tighter forms of coordination, such as contracts. More compact market structures provide components of the supply chain closer to the consumer, e.g. retailers and processors, a means to enforce a greater level of control compared to spot markets. However, the trend towards tighter forms of coordination differs across sectors and tends to be more prevalent in the pig and poultry sectors. This trend partly reflects the high level of investment in specialised assets in the pig and poultry sectors, such as production facilities, which needed to be safeguarded. In addition, the narrower genetic base in the pig and poultry sectors favoured closer coordination strategies since it reduced processing costs and enhanced the ability to produce consistent products. Moreover, branding has been a more notable feature of the pig and poultry sectors, which has been facilitated through the use of contracts. Branding has been slower to develop in the beef sector, partly due to the broader genetic base and lack of control over quality across the supply chain. Contracts also play an important role in the fruits and vegetable sector as it provides a means to control quality as these commodities tend to be observed by consumers in their primary form.

Many producers within the UK value their independence and tend to be resistant to stricter forms of vertical coordination. Non-contractual long-term relationships have emerged to provide a middle ground between spot markets and tighter forms of vertical coordination. The literature suggests that the sustainability of long-term relationships is dependent on the development of trust-building measures that encourage collaboration such as good communication, alignment of business objectives and the perception of equitable power distribution. The latter may be enhanced by organising farmers into groupings, such as producer groups or co-operatives, in order to engender a perception of enhanced market power and facilitate communications.

Despite the emergence of these alternative strategies, spot markets will continue to play an important role within the agri-food supply chain, particularly in the beef and sheep sectors. In many circumstances, price signals within spot markets provide an effective means of coordinating production decisions to fulfil demands for product attributes. The extent of spot markets in the future will depend, in part, on the degree to which spot market pricing systems can keep up with changes in product attributes and consumer demand (MacDonald, 2004). Within the red meat sector, price differentials have been added to the grid pricing system to reflect retail specifications. This encompasses factors such as weight and grade, but does not take into account key consumer quality attributes such as tenderness. In addition, a significant proportion of carcases do not meet retail specification requirements, partly reflecting continued allegiance to the 'production concept' where animals are pushed onto the market based on what farmers have traditionally produced on their farm or what they believe to grow best there, rather than a more consumer oriented approach

The efficiency of the spot market may be facilitated through the development of more sophisticated grading systems, which better reflect consumer preferences. Enhanced pricing systems provide producers with incentives to produce desired product attributes. A leading example of a supply chain system that has been developed to identify and control processing factors that affect meat eating quality is the 'Meat Standards Australia' (MSA) grading system. Factors related to meat eating quality taken into account within the Australian system include: muscle, position within muscle, hanging method, % Bos Indicus breed, use of growth promoters, marbling, maturity, carcase weight, rib fat cover, meat colour, ultimate pH, ageing and cooking method. Other processes such as pre-slaughter handling and post mortem processing have absolute requirements to ensure optimum conditions for maximising palatability. The 'Meat Standards Australia' program has acted as a catalyst for substantial change in all sectors of the Australian beef industry encouraging and facilitating research and commercial industry cooperation. This has led to better industrial practices and a general improvement in beef eating quality even where some participants have not formally adopted the 'Meat Standards Australia' procedure. The relative importance of pre and post slaughter factors in delivering predictable eating quality has highlighted the importance of viewing industry segments as inter-related elements of a single production chain and the value of cooperation and clear communication between all segments of the chain. Consumer trials comparing Australian and Northern Irish consumers showed essentially similar results for consumer preferences for beef eating quality from both countries. Moreover, an adapted MSA grading model reflecting cattle types, production systems and consumers in Northern Ireland was found to predict the eating quality of NI beef with good accuracy and precision.

The feasibility of implementing such enhanced pricing systems is partially dependent upon technologies to measure attributes within a commercial environment. Moreover, in order to make investments in new technologies processors require reassurances that consumers are willing to pay for specific quality attributes. There has been a reluctance to introduce new pricing system technologies for fear of losing throughput due to concerns that suppliers would move to less stringent competitors. In addition, consumers also increasingly require assurances about credence attributes, which reflect both individual consumer concerns, e.g. health/nutrition, and collective concerns, e.g. the environment (Henchion *et al.*, 2014). Products that can deliver these credence attributes can potentially reduce the quality uncertainty of buyers. These can potentially be met within the spot market through industry-wide certification schemes.

Within the dairy sector, component pricing, whereby the price of milk depends on the content of different components, is increasingly popular within Europe, US and Oceania. This pricing system provides a means to send market signals to the farm gate by linking the relative values of component contents to breeding and on-farm management practices. Component pricing is more relevant to milk for manufacture compared to milk for fluid use. As a result, milk for manufacture contracts tend to show some price variation according to underlying components, e.g. protein content, but this is less evident for fluid contracts. In terms of fluid contracts, there is a notable price differential between supermarket aligned and non- aligned contracts in the UK, with the former receiving a premium, particularly when milk prices are generally low. However, the aligned contracts are only available for a small proportion of dedicated producers. This contrasts with the system in the US, where

the Federal Milk Marketing Order ensures that premiums do not accrue to a limited number of producers.

Price volatility is a major issue for the dairy sector. Futures and options are widely used to hedge against price volatility in the US, but these markets have struggled to develop in the EU. Within the EU there has been some limited development of forward contracts, wherein producers can lock-in the output price with a cooperative and benefit from price certainty. This enhances the ability of farmers to plan and to obtain continued or new financing. Forward contracts have existed for a longer time period in the US. The empirical evidence in the US indicates that lack of knowledge regarding forward pricing is an important barrier to the uptake of these contracts. This suggests that education, training and the extension service are crucial in the development of these new programmes.

The extent to which cooperatives can offer its members risk management tools depends on their ability to manage risks on their output side. Ultimately, cooperatives require strategies that reduce their reliance on the commodity market and hence output price volatility, for example, contracting with restaurant chains, developing branded cheese *etc.* The risk management tool set could be broadened if the futures market develops from its current infant state. However, given the typical futures contract size in existence the US, it will not be easy for milk producers, particularly small ones, to directly participate and cooperatives will be an important intermediate.

A range of business improvement measures applicable to agri-business supply chains were reviewed based on the experience of the Red Meat Industry Forum in GB. These include: farm business improvement clubs using web-based benchmarking; international benchmarking; benchmarking of processor performance on a country basis against international competitor counties; evaluation of processes, practices and outcomes within individuals companies, which are then compared with other comparable companies (PROBE); and identification of activities that add value across the entire supply chain (Value Chain Analysis). The experience of the Red Meat Industry Forum demonstrated that these techniques can be applied to smaller businesses but require the full commitment of top management.

The review of the literature concludes with some of the key themes covered in the 2016 World Meat Congress and their implications for the UK meat supply chains. In particular, it was highlighted that demand from emerging and developing economies will become increasingly important, with strong income growth in Asia, Africa and Central America resulting in domestic consumption outstripping domestic production. This growth presents export opportunities for UK suppliers, which have traditionally been geared to servicing British retailers. Of particular importance will be *'fifth quarter'* offal products, which are of minor value in UK markets but high value in Asian markets. A truly effective supply chain needs to secure the best value for each part of the animal regardless of whether that be in the home or an overseas market. More opportunities may emerge for securing advantages in some of these rapidly growing markets if the UK is successful in negotiating Free Trade Agreements following Brexit.

Within the World Congress meeting, It was also emphasized by Rabobank that meat is increasingly being seen through consumer eyes as part of a larger market for protein food products, with greater competition from aquaculture and alternative protein sources. The

aquaculture sector in particular has increased global production at a rate of over 5% per annum in the last decade compared with 1.5% for meat. With the growing competition from cheaper sources of protein the red meat sector needs to respond strategically, *e.g.* seek additional attributes and add value in ways that are in line with consumer preferences.

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Appendix A: Factors Affecting Eating Quality

Pre-Slaughter Handling

Improper pre-slaughter handling of live beef animals can impact negatively on eating quality by bringing about an increase in the level of what is known as Dark Cutting Beef. Acidification occurs in normal carcase muscles post-mortem due to the breakdown of glycogen (muscle sugar) to lactic acid which lowers the muscle pH from an initial value of 7.2 to a final pH (pHu) of approximately 5.4. Where glycogen has been depleted prior to slaughter, the ultimate pH may not achieve this pH fall. Muscle with a high pHu (\geq 5.8) causes the meat to have a dark and dry appearance with a firm texture (DFD) and is a result of an inadequate supply of muscle glycogen in the animal at slaughter. Muscle glycogen at slaughter is a function of resting muscle glycogen 'on-farm' minus the quantity of glycogen lost during the pre-slaughter period. Depletion of muscle glycogen occurs when an animal is exposed to stress both physical (hunger, fatigue) and psychological (social regrouping). The sex of an animal and its stage of development can also affect the incidence of dark cutting meat, with bulls often having the highest levels of dark cutting due to their behavioural activity pre-slaughter (butting, mounting and fighting) reducing the level of muscle glycogen.

DFD meat is most commonly seen in beef but can also be seen in pig meat and, rarely, lamb. Meat from carcases with a pHu greater than 5.8 has a darker colour, shorter shelf life, bland flavour, variable tenderness and it resists cooking, thus impacting on degree of doneness (Ferguson et al. 2001). The colour of meat is the primary tool used by consumers to predict quality therefore dark cutting severely affects purchasing decisions. Due to its negative impact on quality, beef producers are routinely penalised financially for providing carcases with dark cutting beef and it remains one of the largest problems affecting meat quality world-wide. Considerable research over the past few decades has increased knowledge of the causes of dark cutting enabling beef producers to put in place best preslaughter management practices to minimise its incidence. These include minimizing preharvest stress which results in calmer cattle that produce more tender beef. Producers are advised to avoid aggressive handling, excitement, or physical activity of cattle before, during, or following transportation to the processing facility. Mixing of cattle from different pens is discouraged.

The prevention of DFD in meats relies mainly on measures to avoid stress in animals prior to slaughter, however, there are still variations in pHu within a herd from the same pre-slaughter environment causing DFD meat which can only be attributed to intrinsic physiological differences between animals.

Animal Gender

Evidence from trials conducted by the Meat and Livestock Commission (MLC Blueprint, 1990) have shown little difference in eating quality between steers and heifers. The main issue for consideration with regard to cattle gender is the treatment of bulls. It is generally accepted that bull beef is tougher than that of steers and heifers. In an AFBI study (Moss et al. 2010) compared the meat quality of bulls, heifers and steers selected at random at a

commercial abattoir and found the meat quality of bulls to be poorer with significantly lower tenderness, juiciness, flavour and overall liking than that of steers and heifers. Results of research to develop the MLC Blueprint led to the conclusion that young bulls can produce quality beef provided they met some additional requirements to those of steers and heifers (i.e. bulls to be less than 15 months of age at slaughter and the meat aged for a minimum of 14 days between slaughter and retail sale). It is therefore feasible to include young bulls in a quality specification provided ageing is extended to ensure tenderness is maximised. AFBI studies conducted using light-weight young bulls (Farmer et al. 2004, Moss et al. (2005) have shown that young bulls of only 300-550kg live weight can give good quality meat.

For lamb meat quality, flavour is usually a greater concern when gender effects are discussed but tenderness and juiciness are also important. Results from a number of trials suggest that flavour intensity and possibly the incidence of off-odours from ram meat is becomes more apparent with heavier and older rams. In the case of meat tenderness, a number of studies have reported that meat from ram lambs is, on average, slightly less tender. Okeudo (2008) reported that on an equal weight basis, meat from rams was tougher than ewe meat.

Animal Breed

On average, most cattle breeds are quite similar in meat tenderness with more variation occurring within each breed than amongst the various breeds (Wheeler et al. 2010) Breed effects do not impinge on eating quality to a major extent within the normal production systems of Northern Europe unlike other areas where Bos indicus type cattle are prevalent (Zebu or Brahmin) which is known to produce tougher meat. Within the Bos taurus (European) breeds, if a breed effect does exist, it may arise from associated factors like fatness or rate of maturity, although there is some evidence for an effect mediated by differences in muscle fibre composition. In response to British concerns that the increasing penetration of lean, late maturing continental breeds may contribute to a deterioration in eating quality, the MLC conducted trials studying the effect of sire genotype and fatness on the eating quality of progeny from dairy dams (Homer et al. 1997). It showed that genotype and fatness had little effect on the eating quality of steaks of progeny from dairy dams across six sire breeds (Hereford, Aberdeen Angus, Charolais, Limousin, Belgian Blue and Piedmontese).

There are conflicting reports in research literature regarding meat quality from dairyorigin animals. Dairy beef is regarded by the industry as of lesser quality than that from beef breeds. It gives a lower yield per animal and is therefore frequently downgraded by the EUROP grading system. Sinclair et al. (2001) noted that purebred Holstein steers achieved poorer sensory ratings relative to Angus steers. In contrast, studies at AFBI have consistently demonstrated a better eating quality of beef from dairy breeds than from beef breeds and beef from the dairy herd has the potential to be of very high eating quality. Lively et al. (2005) has demonstrated that meat from Holstein steers is more tender relative to Charolais steers sourced from the suckler herd. A recent AFBI study investigating the eating quality of pure dairy breed cattle versus dairy cross beef clearly demonstrated a consumer preference for dairy bred beef (unpublished work). It is speculated that higher levels of intramuscular fat and dairy genetics may contribute to the improved tenderness

and flavour of beef from the dairy herd. These results clearly indicate there is potential to develop a market to make use of the smaller but desirable steaks and other joints from the dairy herd. Dairy beef production may also be better suited to integrated supply chains with the all year round calving pattern of many dairy herds suited to a production system compared to the highly seasonal calving pattern of national beef suckler herds.

Animal Age

Generally older animals are tougher with increasing age associated with decreasing tenderness (Xiong et al. 2007). Collagen in the muscles of older animals has a higher degree of maturity, resulting in increased toughening (Robins et al. 1973).

The original MLC lamb Blueprint was aimed specifically at older lambs because of evidence of a toughness problem. Recent research provides further evidence for a general tendency for older lambs to be tougher (Martinez- Cerezo et al. 2005) and, in particular, for lambs slaughtered in the autumn and winter to be tougher than those finished in summer (assuming spring birth). Others (Veiseth et al. 2004) have found that tenderness declines as lambs get older (up to 10 months of age).

Animal Diet

Animal diet affects the flavour of muscle foods. The primary focus on diet and flavour acceptability has been on comparing pasture-fed animals to grain-fed animals. A wide range of results have been reported indicating that consumers consider meat obtained from pasture raised animals to be different from that obtained from concentrate fed animals especially in terms of flavours (Keane and Allen 1999). Animal diet is largely a function of production system and in the UK systems for lamb and beef are largely grass based.

The consumer's preference for different flavours is dependent on previous experience and culture (Sanudo et al. 1998). In the United States, grass-finished beef is considered less acceptable for its flavour than grain-finished beef (Mandell et al. 1998) whereas British and Irish consumers seem to prefer the flavour of grass finished animals which Americans find to be high in off-flavours. Both consumers and producers consider lamb feeding as the most important production aspect related with lamb quality. Important differences in flavour, odour and texture of lamb meat can be found in lamb from grass feeding compared with those from concentrate feeding which in turn affects consumer acceptability of lamb meat. Cultural background or consumption habits also play an important role in this acceptability (Sañudo et al. 2007).

Nutritional value is an important dimension of beef quality and this is reflected with efforts to improve the polyunsaturated fatty acid (PUFA) composition of beef and in particular increase the amount of conjugated linoleic acid (CLA) and the n-6 to n-3 PUFA ratio both of which contribute to cardiovascular health (Baublits et al. 2006). How cattle are managed may affect fatty acid composition since this is closely related to the fatness level (Barton et al. 2007). These authors report that feeding grass and or concentrates-containing linseed or fish oil can result in important beneficial responses in the content of

n -3 PUFA and CLA in beef. Ireland produces a unique grass-fed (steer) product for the European market which contrasts with the indigenous intensively fed young bull (or cull cow) in mainland Europe and this natural grass-based image is a unique selling point to retailers and consumers. The development of foods with functional properties is a major growth area and this is likely to continue as consumers demand more foods which offer scope in helping to promote health and prevent disease. In this respect, meat and meat products (including beef) have an important role to play. However, consumers are unlikely to compromise on the taste of functional foods for health benefits and hence these foods must seek to deliver health benefits with neutral or positive impact on taste (Verbeke et al. 2006).

Carcase Suspension

The tenderness of many major cuts in the carcase can be significantly improved simply by hanging the carcase by the aitch bone (pelvis) instead of the usual Achilles tendon (hock) at slaughter. Known as tenderstretch, this technique has been shown to improve the tenderness of both loin and leg muscles. Muscle will contract (shorten) naturally as it goes into rigor mortis if it is not restrained from doing so. A shortened muscle will have shorter sarcomere lengths, i.e. shorter repeating units within the contractile myofibrils and a greater overlap between the contractile filaments. Shorter sarcomere lengths are generally associated with tougher meat. Tenderstretch keeps many of the hindquarter muscles from shortening while the carcase undergoes rigor mortis ("sets") in the hours following slaughter. Stretched muscles are more tender to eat. The main tenderising effect appears to be from the physical stretching of the muscle fibres.

Tender stretching carcase sides is now an important element of quality enhancing programmes in several countries. Meat quality research at AFBI comparing achilles and tenderstretch muscles have shown a significant increase in all eating quality attributes from hip hung animals (Lively et al. 2005).

In Ireland and the UK pelvic suspension forms part of numerous retailer specifications often in combination with a slow chilling regime or in combination with electrical stimulation. The need for ageing is reduced, as tenderstretched beef is already more tender. Tenderstretched carcases retain their eating quality better when outside the optimum pH/temperature window, i.e. they are more tolerant of variable processing conditions. The industry cites some drawbacks however including the requirement for more chiller space, demands for greater labour input and the distortion in shape of some muscles.

Chilling Rate and the pH Temperature Decline

The rate of pH and temperature decline of a carcase can significantly affect eating quality. Incorrect chilling of carcases and/or inappropriate application of electrical stimulation can give rise to muscle toughness through shortening of the muscle contractile unit (sarcomere). The muscle pH of a carcase declines post-slaughter from 7.2 to approximately 5.4 due to the conversion of muscle glycogen to lactic acid. If the rate of pH decline is slow and the chilling rate is too fast (high pH at low carcase temperature), cold

shortening may occur. Cold shortened meat is tough or even inedible. If the rate of pH decline is too fast or the post mortem chilling is too slow, heat shortening may occur. Heat shortening does not produce the extreme toughness of cold shortening but does impact negatively on meat quality through increased drip loss, poor colour stability and a failure to improve with ageing. Various temperature and chilling rates regimes have been suggested to avoid or reduce both cold and heat shortening. The clearest guidelines currently available come from Meat Standards Australia which state that the temperature should be between 18 and 35°C when the pH drops below 6. This is known as the pH temperature window. Meat whose pH temperature decline passes through the window often has better overall eating quality than meat which does not (Thompson, 2002). This often requires methods to either slow the fall in muscle temperature or speed up the pH decline. The latter can be achieved through applying an electrical current to a carcase shortly after death and prior to chilling (electrical stimulation). Severe muscular contractions are induced which depletes the energy reserves (glycogen) in the muscle causing a faster rate of pH decline. Application of excessive electrical stimulation especially when cold shortening is not a risk may result in heat shortening with a very rapid pH fall early post-mortem with the carcass temperature still high. Processors participating in the Meat Standards Australia (MSA) program for beef and sheep meat are required to measure and control systems to achieve the pH-temperature window.

An AFBI evaluation of the pH/temperature relationship in commercial beef slaughtering facilities in N. Ireland demonstrated that heat shortening was a common occurrence. Communications with international scientists indicate that this is true in many countries. The AFBI study confirmed that where electrical stimulation is applied, chill rate and pH fall need to be carefully managed to avoid detrimental effects. Advice was given on a plant by plant basis.

Meat Ageing

It is a long standing practice to age or mature meat to improve its tenderness (and flavour). Post-mortem aging for the appropriate periods of time at the appropriate storage conditions can improve tenderness in cuts that are low in connective tissue.

Tenderization is caused by muscle enzymes (the calpain system) degrading proteins (proteolysis) that are involved in supporting the muscle structure. Once these proteins are degraded, the muscle is weakened resulting in a reduction of muscle resistance to chewing i.e. tenderization. In general, ageing meat is beneficial although there can be differences in response by muscle (Aalhus et al. 2004). The method of ageing can also influence the effect (Jeremiah & Gibson, 2003). Tenderization occurs at the same rate for vacuum packaged meat as it does for dry-aged cuts and will occur faster at higher temperatures. It does not occur at all in frozen meat. Ageing should be carried out in vacuum packs unless there is a specific requirement for dry aged beef. High oxygen packaging should be avoided for prolonged storage since they can damage both flavour and tenderness of beef (MLC Technical Division, 2006). It is a combination of the variability in the tenderization process and variability in the amount of aging time allowed before the sale of meat that results in much of the inconsistency in tenderness at the consumer level. Ensuring a high degree of proteolysis improves the consistency of meat tenderness as long as the beef carcase or

muscle is aged for at least 10 to 12 days. Meat ageing attracts capital cost (of chillers) and a cost in weight loss.

Muscle Type and Cooking Method

The parameter with the greatest effect on eating quality is the cut or muscle. It should be noted that even within a muscle there can be large differences in eating quality, and that different muscles are influenced by different parameters. This provides opportunities to select high eating quality cuts/muscles by selecting appropriate muscles from appropriate carcases.

Differences between muscles are reflected in the choice of cooking method for good eating quality. In general minimal and rapid dry cooking methods are used to cook the more tender cuts of meat, whereas poorer quality cuts rich in connective tissue are better suited to longer, slow wet cooking procedures to gelatinise the tough collagenous connective tissue.

Marbling

Marbling is the intramuscular fat which appears as fine flecks within the muscle. It is important because it contributes to flavour, juiciness & tenderness. Large consumer studies with cooked beef confirm that marbling improves eating quality (O'Quinn et al. 2012). This is especially true for the grilling cuts and to a lesser extent roasting cuts of beef. Some cattle have the genetic ability to favour the development of marbling within the muscle. Marbling develops readily in animals with the right genetics, when given the right nutrition. Without the genetic potential, cattle will not develop marbling no matter how long, or how well they are fed. Marbling is a key component of the USA grading scheme for primal cuts.

Appendix B: Comparison of Average Slaughtering Plants' Performance in Different Countries

Cattle

Global Compete	Argentina	Australia	Brazil	France	Germany	Holland	UK	Uruguay	USA	Botswana
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Results										
Avg Plant hd/wk										
Top 5 plant size										
hd/wk										
Top 5										
rop 5										
concentration %										
Capacity										
Utilisation										
%with modern										
slaughter lines										
Slaughter										
weight (kg dw)										
<i></i>										
% prime grade										
Fifth quarter										
income/bd										
incomerna										
Slaughter										
cutting cost										